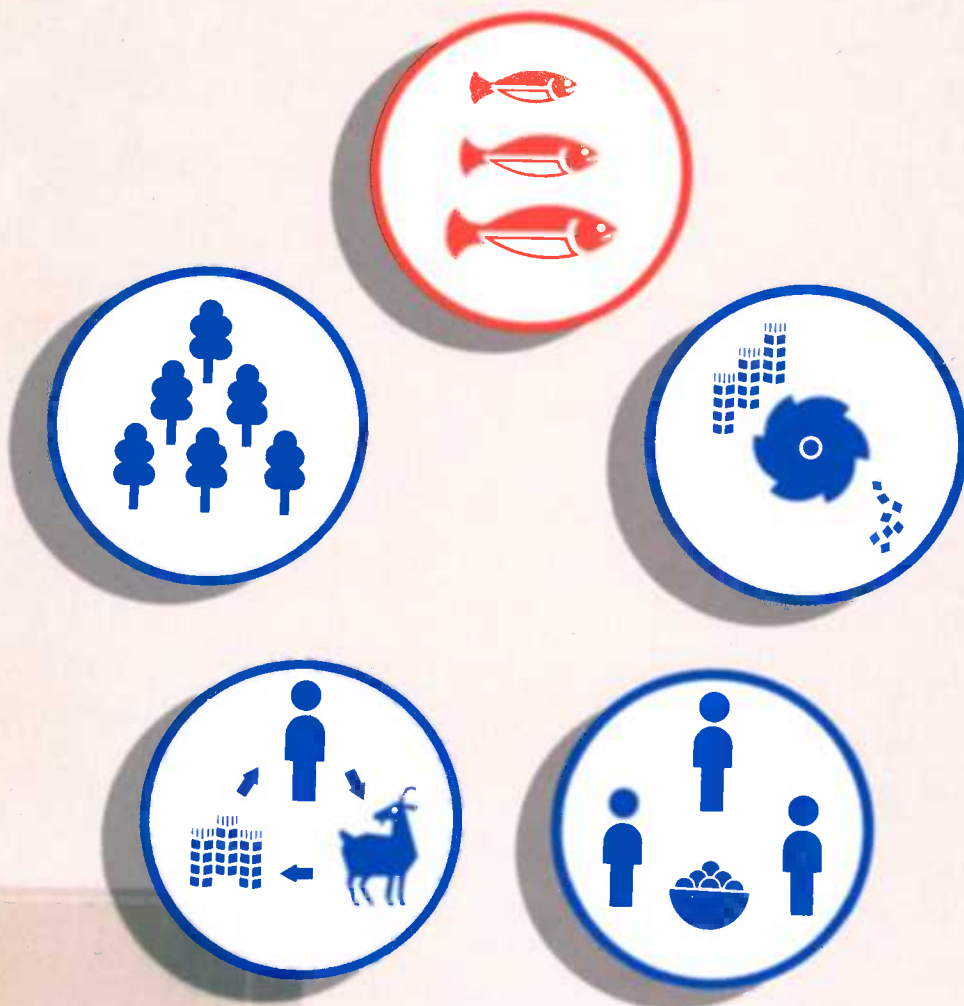


Fisheries Program



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La edición española de esta publicación también se encuentra disponible.

Fisheries Program

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Foreword

This booklet is intended to familiarize researchers and research-funding agencies with the scope of research supported by the Agriculture, Food and Nutrition Sciences Division of the International Development Research Centre (IDRC). It also provides information on how IDRC works with scientists in identifying research priorities and on the kind of support provided to researchers for developing and executing projects in the field of fisheries research.

In recent years, agricultural research has become increasingly international in scope, often with the participation of numerous institutions from several countries, each contributing its own particular expertise. At the same time, Canadian universities and research organizations have become increasingly interested in the agricultural problems of developing countries. As a result, these Canadian groups have strengthened the scientific capabilities needed to participate in the research efforts that are critical to ensuring sustainable agriculture and an equitable distribution of its products. We hope that this booklet will help to explain IDRC's role as a research-funding agency in this increasingly interconnected agricultural research environment.

The production of this booklet was a team effort by various IDRC staff members. The assistance of two people, in particular, is gratefully acknowledged: Brian Davy, Associate Director responsible for IDRC's Fisheries Program, and Liliana Wagner, Executive Scientific Assistant for the Division, who coordinated the writing of this series, which includes four other booklets.

Hubert G. Zandstra
Director
Agriculture, Food and Nutrition Sciences Division
International Development Research Centre

The International Development Research Centre

The mission of the International Development Research Centre (IDRC) is to contribute to development through research and research-supporting activities. The Centre aims to assist in promoting the indigenously determined social and economic advancement of the developing regions of the world, with particular focus on the poorest people of those regions.

Within this mission, IDRC has two principal objectives: first, to support research of direct relevance to Third World development and having direct, demonstrable links to the basic needs of the poor; and, second, to assist developing countries to build indigenous research and research-supporting capacity, mainly at the national, but also at the regional, level and mainly in terms of human resources.

IDRC aims at these objectives by focusing its activities in six main areas: agriculture, food, and nutrition sciences; communications; earth and engineering sciences; health sciences; information sciences; and social sciences. IDRC also funds training in all these areas.

The Agriculture, Food and Nutrition Sciences Division

The world food situation is generally more positive than it was a decade ago. Food production is increasing at about 2.6% per year, slightly faster than the growth of the population but still below the increase in demand for food. More importantly, however, a considerable proportion of the world's population continues to receive much less than the minimal nutritional requirements. Technological innovation in food production has largely been concentrated in East Asia. Recent efforts to duplicate this achievement in Africa have been less successful because many of the prerequisites for success are not yet present there.

The Agriculture, Food and Nutrition Sciences (AFNS) Division's mission within the Centre is to contribute to agricultural development through specific research and research-supporting activities designed to make adequate food available to the individual and to improve the production, protection, preservation, processing, distribution, marketing, and utilization of agricultural commodities of plant and animal origin from land- or water-based systems, including forests. The scope includes the transformation of these commodities and the development of related industrial technologies to generate employment and income to enable people to purchase food. It also includes improving the use of land resources and protecting natural resources for future agricultural production.

The Division gives high priority to dissemination of research results and training of research staff in developing countries. On average, 2-5% of the project funds are now allocated to publications and dissemination workshops. Most AFNS projects contain a specific training component, which averages 10% of the project budget.

The Division's strategy is to support indigenous applied research carried out in close association with rural households, which make up 70% of the people in developing countries and who are to use and benefit from the research. Because effective research requires international linkages for evaluating germ plasm, exchanging information, training, and developing technology, AFNS also supports more advanced research in international and regional research centres, as long as such work is directly relevant and complementary to specific research projects or networks with national programs. Similarly, when Canadian institutions offer relevant expertise, the Division funds cooperative projects that are undertaken jointly by Third World and Canadian scientists.

AFNS supports research projects through five programs: Agricultural Economics, Crop and Animal Production Systems,

Fisheries, Forestry, and Post-Production Systems. This booklet reviews recent activities and outlines the future directions of the Fisheries Program. Brief reviews of the other four AFNS programs begin on page 27.

The Fisheries Program

Introduction

Fish is a source of high-quality protein that can be produced more cheaply than any other animal protein for human consumption.

Capture fisheries were once regarded as the great food resource of the future with potential for an almost unlimited increase in yield. Today, however, wild fish resources are considered to be exploited at their maximum sustainable levels throughout most of the world. Increased benefits, however, can be derived from more efficient resource management and fisheries remain an important option for higher food production in developing countries.

The Fisheries Program of IDRC was established in the early 1970s to increase the production of fish for the benefit of the poor through applied research. To meet this objective with the limited available resources, the Program chose aquaculture (including mariculture) and artisanal fisheries as the two main subprograms for support and designated commercial and industrial fisheries as low priorities for assistance.

Although aquaculture contributes only about 10% of world fish production at present, it has tremendous potential for making fish more available of fish in developing countries. For example, aquaculture production has grown about 10.5% per year over the last 11 years.

Artisanal fisheries employ about 20 million people worldwide and provide a significant portion of the total available animal protein in large areas of the developing world.

Many of the fisheries issues are the same all over the world, but priorities are often very different at the national and regional levels. This became clearly evident as the Program evolved in its three priority regions: Africa and the Middle East, Latin America and the Caribbean, and Asia.

This booklet outlines the development of the Program, the changes that have occurred in the field of fish production since the Program's inception, and describes proposals for its future direction.

Fisheries is a multidisciplinary field, the Program therefore depends on important inputs from several IDRC divisions in the areas of socioeconomic analysis of fisheries issues, fisheries data and information systems support, wastewater and environmental issues, scholarships, and results dissemination. Within AFNS, fish-processing projects are handled by the Post-Production Systems

Program. Also, microeconomic aspects of fisheries production systems are addressed in association with the Agricultural Economics Program.

Background

Fish Production

Fisheries is an important sector in the economy of many developing countries although it rarely attains the high profile of agriculture or manufacturing.

About 12 million people are employed directly in fishing worldwide and an equivalent number in fish processing, marketing, and other related activities.

Since about 1970, the annual world catch of fish has stabilized at about $70-80 \times 10^6$ t. Projections of the future output range from no growth in the catch to a maximum of 100×10^6 t/year, leaving much room for debate as to what changes can be expected in the economics of fishing and the marketing of fish in the next decade.

The world catch of fish is shared among Asia, which holds slightly less than half of the total; Europe, 19%; USSR, 13%; South America, 11%; and North America and Africa about 6% each. Many developing countries rank high among fishing nations: China, for example, is 3rd; Chile, 4th; Peru, 6th; India, 7th; South Korea, 8th; Thailand, 9th; Indonesia, 11th; Philippines, 12th; North Korea, 13th; and Mexico, 15th (FAO 1985 data). Since the 1960s, the developing countries have been increasing their share of the world catch of fish and this trend is expected to continue under the new conventions of the Law of the Sea.

The fisheries sector is divided into three major subsectors: industrial and artisanal fisheries, which together make up the capture fisheries, and aquaculture.

Industrial fisheries are large scale, highly organized (similar to agroindustrial firms), relatively capital intensive, providers of higher incomes for both boat owners and crew than artisanal fisheries, suppliers of most canned and frozen fish, and producers of most fish marketed for discount sale and export.

By contrast, artisanal fisheries are smaller; dispersed and often fragmented in organization; sometimes part of other overlapping activities such as agriculture, animal husbandry, and aquaculture; and highly labour intensive and low in capital investment. They are often equipped with motorized boats but not generally with mechanized gear. Because they use only simple handling and processing techniques, they suffer significant post-harvest losses that could be avoided with more sophisticated technology. They harvest stocks of small overall biomass containing a large variety



of species suitable for domestic consumption and are suppliers of most of the local cured fish and fresh fish.

Artisanal fisheries are virtually the sole source of animal protein for several hundred million people in the developing world. In countries such as Bangladesh, Guyana, Indonesia, Nigeria, Tanzania, and the Yemen Arab Republic, they supply at least 75% of the domestic demand for fish. The activities of artisanal fishermen are also essential to the local economy of coastal areas providing employment and income for millions of people. Although artisanal fisheries can be organized for supplying export markets with high value seafood such as shrimp, mussels, and specialty fish, their advantage is in harvesting fish stocks from coastal waters for local consumption.

Aquaculture, the rearing of aquatic animals and plants, is a husbandry practice much like land-based agriculture in contrast to the hunting approach used in industrial and artisanal fishing. Aquaculture is a traditional practice in Southeast and South Asia where between two and three million fish farmers rely on small culture operations to produce 10–15% of the total fish supply. Aquaculture is limited in Africa and Latin America but its potential there is high and development efforts have been intensive over the past 40 years.

In general, aquaculture production is rising. This subsector offers the best opportunity for increasing the fish supply because the factors affecting productivity are potentially under human control.

Fish Consumption

In 1982, 70% of the world catch of 77×10^6 t was used for human consumption, the remaining 30% was processed for animal feed and other applications. Of the portion served to humans, 28% was fresh, 32% was frozen, 21% was cured, and 19% was canned. This distribution pattern has been relatively constant since 1978 but shows a marked change from the early 1950s when almost 50% of fish consumed was fresh.

The average annual consumption of fish in the developing world varies nationally and regionally, ranging from less than 5 kg/person to at least 30. Worldwide, the average of 13 kg/person in 1972 rose to 16 kg/person in 1985. Demand is expected to exceed production by a significant margin in the foreseeable future. As a result, prices will rise sufficiently to eliminate fish from the diet of the poor, unless there is a major increase in fish supply.

Major Issues

Resource Management

Industrial and artisanal fisheries use a renewable but limited resource. Although the proportion of the fish resource that can be harvested economically cannot be defined with accuracy, present levels are estimated to be near that limit. This resource must be better managed to ensure that it is harvested and used for maximum benefit. This will demand a more thorough examination of socioeconomic issues together with national policies for food production, employment, and foreign exchange generation.

Fish stocks are usually managed as a common property resource. Traditionally, large numbers of coastal people have fished as an occupation because access is relatively easy and few alternative employment opportunities exist. Development programs to improve the status of poor artisanal fishermen must attempt to solve the problem of a decreasing fish resource — a problem that is usually made more serious because other opportunities for employment are limited. Research on resource management and allocation will be needed in the future.

Extended Economic Zones

Under the new conventions of the Law of the Sea, some developing countries have gained new, potentially large opportunities for increased fish production, others may experience relative declines. The effect of this reallocation is not yet clear. Those with room for growth in fish production in the future seem ill prepared to take advantage of it in the short term. Many development options are open.

Political considerations play an important role in fisheries. Many fish species are migratory and move between different



national exclusive economic zones (EEZs). Fishing rights are bought and sold in various forms and for various concessions. Regional cooperation on sharing fish stocks is developing through regional fishery management bodies, often established with the assistance of the Food and Agriculture Organization (FAO) of the United Nations and other donors. The level of regional cooperation is improving but far from the ideal.

Scientific Data Base and Methodology

Scientific management of fishery stocks has progressed considerably in recent decades, mostly in temperate waters where species diversity is low and research resources have been relatively plentiful. Tropical fisheries, however, are often based on a wide range of species, ecology, and population dynamics that have been studied very little.

Collection of statistical data on fish catches, fishing effort, etc. is essential for effective management and policy decision-making. Because collecting such data, especially from dispersed artisanal fisheries, is expensive and difficult, statistics from developing countries are often unreliable.

Expansion of many types of aquaculture is seriously restricted by the supply of "seed," or juvenile fish, to be grown in production facilities. Reproduction in captivity has been achieved in less than half of the 300 or so species currently adapted for aquaculture. In temperate regions, research is advanced on controlled breeding and the related aspects of hormonal and environmental manipulation, sperm preservation, broodstock and hatchery management, and larval rearing methods, but much remains to be done for tropical species. The case is similar for other factors in aquaculture such as nutrition, engineering, system management, disease control, and genetic improvement. All will require applied and strategic research inputs before the existing major constraints are overcome.

Research in Fisheries Development

Exact data on the levels of research support (local and donor funds and personnel) provided for the various subsectors of fisheries are not readily available. Clearly, increased support for research is essential, but the optimum sectoral and geographical focus of such support is open to question and analyses relating needed support to the present or potential value of the resources, as are carried out in agriculture, are needed.

National or regional fisheries institutions often fail to distinguish between research and development activities: thus, a major impetus for fisheries research is often lost in projects on overall fisheries development. At the national level, fisheries is usually the smallest sector of a large ministry such as agriculture or rural development, yet its scale of production and value of the product should earn it much greater recognition.

Oil Prices

The industrial fishing subsector is energy intensive. The soaring of oil prices in the 1970s and early 1980s caused shifts in the economics of fish production by favouring smaller vessels (less than 25 m long) that operate closer inshore. This shift results in overexploitation of the coastal resources and makes aquaculture more competitive. Any future increases in oil prices will probably have the same effect.

Objectives and Priorities

The prime objective of the Fisheries Program is to increase fish production by methods that will benefit the poor. In addition to the direct benefit of producing more fish or fish products, every project supported by the Program seeks to develop institutional research capabilities by training staff and providing research experience. This is an important step in developing long-term solutions for the problems facing developing countries. Today, research priorities, for example, are defined in consultation with regional researchers, and executed with donor agencies through discipline-specific and region-specific workshops and other information-exchange meetings.

Other underlying objectives include developing and highlighting new fisheries opportunities for future large-scale development or implementation through extension services on a national or regional level. Every effort is made to encourage regional exchange of all information and technology developed with the Program's support.

These objectives have remained essentially the same during the life of the Program, but the relative emphasis on fisheries subsectors in different geographical regions has changed. Originally the Program was subdivided into Aquaculture and Fish Processing with major emphasis on the former. In 1980, the subdivision of the Program was changed to Aquaculture and Mariculture, and Artisanal Fisheries to include by-catch projects.

Aquaculture and Mariculture

The Aquaculture and Mariculture subsector includes all types of fish husbandry in fresh, salt, and brackish waters. The fundamental advantage of aquaculture is that the environment can be manipulated to increase fish production. The cultured types of fish can be divided into two major groups according to complexity of culture system, feed, and the value of the product on local and export markets. As there is no agreed-upon system of subdivision of aquaculture, these groups are here referred to as Extensive and Intensive (Types A and B; Table 1). Extensive aquaculture in this definition includes integrated crop-livestock-fish farming systems that are typical of many small-scale aquaculture enterprises.

**Table 1. A tentative system of classification of aquaculture types
using Asian examples.**

<i>Extensive (Type A)</i>	
Fish species	Species that feed low on the food chain In fresh water: carp, tilapia, and certain native species In brackish water: milkfish, mullet, oysters, mussels, and cockles
Feed	Either no supplementary feed or only fertilizer, mostly low-valued, low-protein agricultural by-products such as rice bran, coconut cake, animal manures, or green plants
Market price	Generally low; these species often serve the local market
Culture system	Usually small-scale, more labour-intensive, operated as part- or full-time family business
<i>Intensive (Type B)</i>	
Fish species	In marine or brackish water: shrimp, lobster, tuna, crab, and possibly seabass, grouper, and snapper In fresh water: marble goby, freshwater prawn, snakehead, trout, and salmon
Feed	High-protein complete diet often containing a high component of fish meal or trash fish
Market price	High; aimed at export and direct restaurant markets
Culture system	Often large-scale operations, capital-intensive, managed as major commercial food-production enterprises

Most IDRC support has gone to Extensive aquaculture, which produces food that is affordable by the poor, but some aid has been directed to Intensive aquaculture because of its potential to generate income for poor people. No policy on the relative allocation of support to the two types of aquaculture has been established because this would require much more detailed analyses than now available of the number of people, culture units, and benefits involved.

Aquaculture can also be divided into such components as nutrition, engineering, systems management, disease control, and genetic improvement, but here again allocation of research resources to individual elements is complex and depends on regional needs.

Artisanal Fisheries

The reasons for supporting artisanal fisheries are quickly apparent: most of the poor coastal people are involved in this sector, the catch is almost totally used for direct human consumption, and the technology is very simple.

Components of research in this subsector include identifying and assessing biomass and sustainable yields of stock, management systems for optimum sustained yield to target populations, improved handling and processing, socioeconomic aspects of harvesting and processing, and developing alternative employment opportunities.



Industrial Fisheries

To date, the Fisheries Program has not supported any industrial fisheries activities for four main reasons. First, IDRC's mandate is to assist the rural poor, a group more affected by artisanal fisheries than by industrial fisheries; second, research for deep-water industrial fisheries is very costly because of the need to purchase or rent large research vessels; third, a large percentage of the production from industrial fisheries is reduced to animal feed and only a small proportion of the fish catch is directly eaten by people, clearly a waste of protein resources; and, fourth, major bilateral and multilateral donors such as the World Bank, the Asian Development Bank, and FAO/UNDP (United Nations Development Programme) provide substantial support to this subsector.

Cooperative Research

Although research is generally best carried out in the developing countries it intends to serve, inputs from Canadian institutions can help significantly in resolving problems and developing local institutions. Several subjects, such as breeding, nutrition, diseases, and genetics, demand long-term research and, in these areas, cooperative projects involving Third World scientists with their Canadian colleagues are funded by IDRC have been especially useful.

Review of Activities

From 1979 to 1985, IDRC allocated about 13.3 million CAD to 53 fisheries research projects throughout the developing world. These projects were carried out in various ecological and socio-economic environments. Their results contribute to the on-going assessment of priorities for the Program and help to define the directions for future support.

In the following sections, Artisanal Fisheries and Aquaculture-Mariculture are discussed in relation to existing conditions in the countries where projects were sponsored. Despite their differences, capture and culture fisheries represent two options for increasing the benefits of aquatic resources for the poor. Cage culture in reservoirs or along sea coasts may be a viable option for artisanal fishermen faced with the growing demand for access to a limited wild resource. The integration of the two activities may be the important result of fisheries research.

Artisanal Fisheries

Africa and the Middle East

Artisanal (including subsistence) fisheries are an important source of food and income in Africa and the Middle East. Between one and two million people earn at least part of their living from fishing and about another half million people participate in processing and marketing of fish and related products. For many, this is part-time work as they occasionally or seasonally move to agriculture, wage jobs, or unemployment. Statistics, although imprecise, suggest that about 40% of the total fish catch from the ocean is harvested by artisanal fisheries; the proportion in inland waters is almost 100%.

Development programs in the early 1970s converted artisanal fisheries to motorized boats and nets woven of artificial fibre. This increased efficiency together with high demand for the catch have generally exploited available resources up to or beyond sustainable yields. Resource management to ensure sustainable harvesting and higher efficiency in using the product is a research priority in the future. Additional overall increases in yields may be obtained from reservoir development, which is one of the few new fisheries resources available.

Fisheries research has a strong tradition in some areas of Africa and the Middle East such as in the large fish-bearing lakes of East Africa and Egypt. Continued effort, however, is needed for training research personnel and strengthening institutions in all regions.

The research and management environment is difficult in Africa at present because resources, in terms of both funds and trained personnel, are generally lacking. Fishery management

systems that are largely self-sufficient should be the goal of research to derive maximum benefit from available resources.

In the past, artisanal fisheries research received little support from IDRC in Africa and the Middle East. A rural fisheries project in Ghana developed new harvesting and processing techniques to increase the efficiency of resource use. An aquacultural project in Turkey helped to establish and develop fishery stocks in a large reservoir.

This subprogram will receive increased support in the future because of its importance for food supplies and the many problems it must overcome (overexploitation and uncontrolled introductions of fish). Highest priority will be given to lake and reservoir fisheries, which have high overall production and potential for expansion. Projects on other systems such as rivers and marine fisheries will be considered if they make a substantial contribution to national objectives and assist the poor.

Latin America and the Caribbean

In 1981, fish production in Latin America and the Caribbean amounted to about 11% of the total world catch. Trawling and artisanal fisheries provide most of the fish including prawns (penaeids), tuna, pelagics, and groundfish for local consumption and the export market.

Except in coastal areas, fish is not an essential component of the popular diet: annual consumption averages 7.4 kg/person. Fisheries, therefore, is not an important economic sector in the total national production of most Latin American countries.

Not surprisingly, fisheries research also has a low priority in the overall funding of research. Fish marketing and distribution systems in the Caribbean and the less-developed Latin American countries are generally poor and landing statistics are nonexistent or unreliable. This is due largely to the lack of qualified personnel in most of the countries; however, the situation improves noticeably in regions where adequate development aid has been available.

In Latin America, aquaculture has been given only limited importance because of the richness of fish resources in marine waters. Only the culture of valuable species such as prawns and oysters for export markets is attracting private investors. Fresh-water inland fisheries are not significant in terms of overall production and contribute only about 3% of the total catch for the continent.

The artisanal fisheries subprogram has a high priority for the Program in this region because of recommendations from several regional workshops and a review of Program activities in relation to local conditions. Artisanal fishermen harvest most of the fresh seafood for local and export markets. Resources most accessible for artisanal fisheries are those nearest the coast, which are most likely to be overexploited. Management measures must, therefore,

be implemented urgently and mariculture technology developed to protect and expand these resources. Artisanal methods of exploitation are labour intensive and sometimes inefficient.

Poor product handling and rudimentary processing decrease the value of the final product and this is reflected in a low cost-benefit ratio. This tends to perpetuate the generalized poverty in the artisanal fisheries.

The activities supported by the Fisheries Program to improve these conditions have two objectives.

First, the Program will evaluate the artisanal fisheries in a multidisciplinary approach that will consider four factors:

- Status of fishery resources available to the artisanal fishermen (description, level of exploitation, management, etc.);
- Evaluation of the technology used in the production process (extraction, handling, and processing);
- Analysis of the socioeconomic conditions that affect the artisanal fishing families and suggestions for their improvement (housing, education, health, and community development); and
- Study of the marketing system and role of the artisanal fishermen in the commercialization process.

Second, based on this study, it is intended to create an integrated model for the development of coastal communities that will benefit the artisanal fishing family by improving their living and working environments.

The second objective will be achieved by implementing pilot projects in typical coastal communities where the artisanal fisherman will be assisted in the organization and technological improvement of fisheries and alternative activities such as mariculture, basic processing, and marketing of fishing products. These pilot projects will serve as on-the-job training centres for fisheries researchers (biologists, economists, and sociologists) and extension staff.

Such projects are underway in two different ecological environments: warm latitude (Colombian and Caribbean) and colder latitude (Chilean, Peruvian, and Pacific). They are linked by a regional artisanal fisheries network that provides coordination, exchange of information, and training. These project activities also create a framework for collaboration between various AFNS programs, such as Post-Production Systems and Agricultural Economics, and IDRC divisions, such as Information Sciences, Social Sciences, and Fellowships and Awards.

Asia

In the 1970s, artisanal fisheries was recognized to be an important regional issue by national governments and donor agencies. However, development efforts to date have often been disap-



pointing. Socioeconomic and sociocultural issues were suspected to be the main constraint, but detailed information was lacking. Resources available to the artisanal sector proved to be limited and increasingly frequent incidents of competition and confrontation between artisanal and industrial fisheries occurred. Many governments of the region gave priority to the development of their industrial fisheries despite their interest in the artisanal sector. The wish to produce high-priced seafood products for export continued to direct major financial and infrastructural support toward rapid development of the industrial fisheries.

As the development of major new fish resources in this region appears to be limited, most effort was and will be spent on the rational management and allocation of existing resources. One example is the broadly based long-term project that led to the development of the Asian Fisheries Social Science Research Network. This network project, which examined economic aspects of artisanal fisheries and later aquaculture, was initially supported by the Social Sciences Division but later broadened to include financial support from both the Fisheries and Agricultural Economics programs of AFNS.

Artisanal fisheries in freshwater, such as the inland fisheries projects in Indonesia and Malaysia (Sarawak), were initiated specifically for the rivers, lakes, and swamps of these regions. Here, aquaculture is being tested as a technology for artisanal fishermen in areas where the existing resource does not generate sufficient income to earn a living.

Most of ANFS' support in this region will continue to be given to aquaculture, but more support will also be made available for artisanal fisheries as new socioeconomic data dictate priorities for further biological research. Such studies will concentrate on gaining a better understanding of tropical fish species and their response to improved management systems. The aquaculture and artisanal fisheries sectors are expected to work more closely in evaluating coastal aquaculture as an alternative employment and fish-production system for artisanal fishermen.

Aquaculture and Mariculture

Africa and the Middle East

Aquaculture is not a traditional practice throughout most of this region, although fishing systems that approach aquaculture have evolved in certain areas (the *acadja* system in lagoons in Benin and the *howsha* system in Egypt's delta lakes). The potential for increasing fish supplies is tremendous, however, and significant efforts to achieve this have been made over several decades.

Freshwater fish culture was introduced in Central and East Africa by colonial authorities in the 1930s and 1940s and spread widely throughout the continent in the 1950s and early 1960s. Despite this long-term effort, aquaculture yields are low, only about 10 000 t/year.

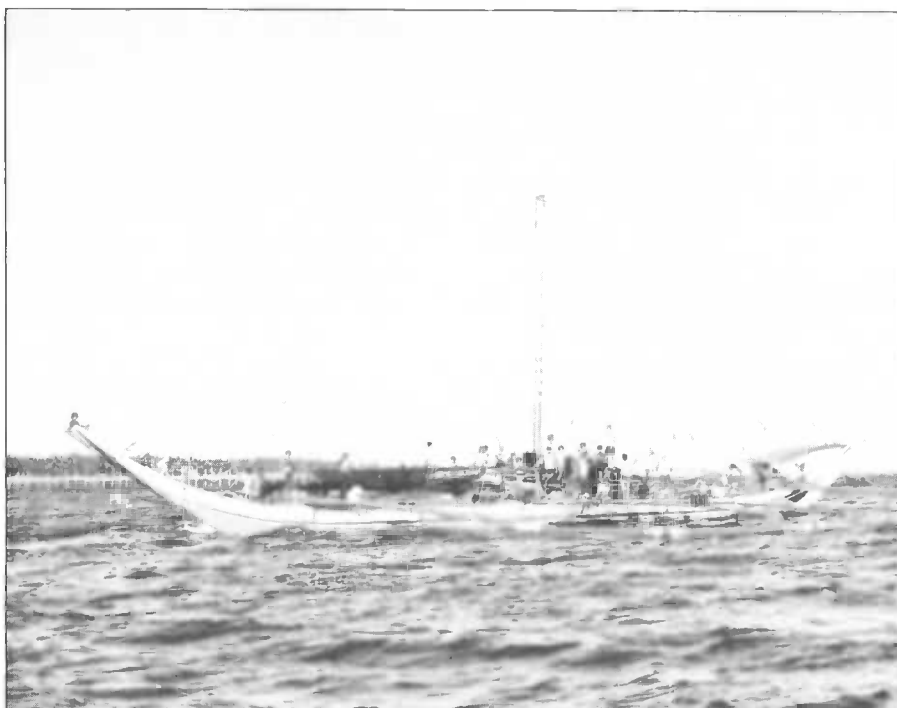
One reason for this lack of success is the shortage of extension service resources. As well, the aquaculture systems put into operation are not fully adapted to local conditions. Thus, uptake has been slow despite significant extension inputs. Research is needed to adapt systems developed at research stations or elsewhere and to improve the efficiency of existing aquaculture operations.

Various aquaculture systems have been evaluated in the region. Freshwater pond culture using one or more tilapia species shows the greatest promise but the stunted growth of fish because of early reproduction is a major problem that remains to be overcome. Cage and pen culture in fresh and marine waters have been tested in many areas. Technically, these systems are effective, but economic results are variable.

Molluscs show excellent potential in culture trials as they are filter feeders and grow efficiently. It is difficult, however, to produce a cultured product more cheaply than the mollusc can be harvested from the wild.

Limiting factors to higher aquaculture production include lack of seed, low levels of fertilizer and feed inputs, high capital costs for ponds, and low economic return.

Eight aquaculture projects were supported by IDRC in the region up to 1985. In the two Sudan and Rwanda projects, the objective was to improve the efficiency of pond-culture systems.



Cage-culture systems were researched in Egypt, Togo, and Turkey. The stunting of tilapias was studied in Kenya in attempts to develop strains and hybrids that would grow more quickly but mature later. In Sierra Leone, mangrove oysters were grown as a food product and on the Red Sea coast of Sudan cultured mother-of-pearl oysters were produced as an income source for desert dwellers.

The research capacity in aquaculture in this region is limited and must be improved if significant benefits from this technology are to be obtained. Much of the research to date has been carried out by expatriates whose expertise is not permanently available.

Support for aquaculture research under the Program will be maintained and if possible increased. The key problems in aquaculture must be defined to obtain maximum benefits from the research input. More attention must be given to social and economic factors influencing aquaculture production systems and to interactive adaptive research in which fish culturists are included.

Freshwater pond culture is the highest priority for research because the system is widespread, can be operated in inland areas where fish supplies are low, and can be integrated relatively easily with agriculture. Research in cage culture, mollusc culture, and other approaches will be supported if results will contribute significantly to national objectives.

To advance aquaculture research in this region, small-scale projects will receive high-priority support to evaluate problems, to

explore the ecological or socioeconomic environment for aquaculture, or to research solutions to problems peculiar to small-scale operations.

Latin America and the Caribbean

Aquaculture is relatively new to the Latin American region. The first aquaculture operations were based on introduced fish species such as carp, tilapia, and trout using imported seed or fry; and on indigenous oysters, mussels, and other molluscs whose biological cycles and culture technology were well known. Indigenous species were produced from seed collected from the wild.

More recently, various indigenous species have been the subject of research and development of culture technology. In most cases, the principal limitation is the wild seed supply. The aquaculture projects supported in the region by IDRC emphasize both the production of seed and technical aspects of culture systems.

Two projects, on mariculture in Peru and oyster culture in Jamaica, have been moderately successful in raising larvae into adulthood. In Peru, scallop-culture experiments had to be suspended because of ecological changes related to the effects of El Niño. The fish-culture project, on mariculture in Panama, succeeded in producing selected fish larvae by induced spawning and is now trying to develop an integrated fish-shrimp farming system suitable for small-scale farmers.

Freshwater ponds seem to offer the most promise in fish-culture projects in Brazil, Ecuador, and Panama. Cage culture has shown little success in the Dominican Republic because materials and construction are expensive. Reservoir-, lagoon-, and coastal water-culture systems were evaluated in Colombia, the Dominican Republic, Jamaica, Peru, and St Lucia, and the natural marine environment proved to be the most successful to date.

Freshwater aquaculture research has concentrated on a limited number of indigenous species (*Colossoma* and *Dormitator*) for which there is an existing market.

With the decline in artisanal fisheries, IDRC has given high priority support to mariculture systems to be operated by artisanal fishermen in coastal areas.

One form of support by IDRC has been through a regional aquaculture network with the objectives of

- Increasing the availability of wild seed and larvae by improving collection technology and reducing mortality;
- Enhancing reproduction under laboratory conditions (induced spawning, control of metamorphosis, and larval and juvenile feeding) to optimize fry production as a basis for extending culture;
- Searching for and evaluating indigenous species suitable for intensive commercial culture;



- Exchanging information and training through the regional network of aquaculture projects; and
- Studying cost-benefit ratios and marketing (actual and potential) of aquaculture products in coordination with the Agricultural Economics Program.

Asia

Support from IDRC for Asian aquaculture has been considerable, particularly in Southeast Asia.

Several major technological successes have been achieved by IDRC-funded projects in fish breeding. In the Philippines, milkfish was induced to spawn in a culture environment for the first time anywhere in the world in 1977. This technology has been applied throughout the Philippines and other countries in the region. In Malaysia, three types of introduced Chinese carp and several local carp species were similarly induced to spawn. This seed-production technology is now being adapted to larger scale hatchery production systems. In Singapore, the marine and estuarine groupers, sea bass, and golden snapper were induced to breed under controlled conditions and a hatchery system for improved larval rearing has been developed. The seed-production systems must be further refined and developed. Possibilities have been opened for genetic strain selection, a research subject that is now under study in the developing network of projects funded by IDRC.

The Malaysian project has developed experimental feed for sultan fish, catfish, and Chinese carp. Improved feeds for brood-stock that result in higher seed production have also been produced. The fish-culture project in Singapore developed experimental pelleted feed for grouper species.

Important refinements in cage-culture systems have been achieved in marine waters by the Singapore project and in fresh water by the Malaysian. In India, significant advances have also been made in applying composite fish-culture technology in farmer-operated ponds.

Several projects demonstrated that raft and rack mollusc culture (of oysters in Sabah and mussels in Singapore) is not only biologically possible but also potentially economically attractive in tropical Asia. Uptake by private sector interests is now in progress.

Project results to date are sufficiently encouraging to justify increased support in this subprogram. Development of national and regional institutions capable of presenting training courses has progressed and should receive additional support. In the future, greater emphasis should be placed on socioeconomic analyses of projects to develop technology.

Fish species and culture systems are being evaluated on the basis of both national and regional suitability with priority given to native species that are already adapted to the local environment. Because biological data for many such species are limited, more practical research on this subject is needed. In addition, fish-culture systems integrated with small-farmer agriculture are now showing excellent development possibilities and more support is likely.

Future support will be broadened to include Intensive culture systems (Type B; Table 1), provided that small-scale fish farmers reap some benefits. An economic analysis of both types of culture has shown that the potential returns for Intensive systems are higher than for Extensive and, therefore, the technology uptake may be faster. Some access to credit must be considered for the high capital investments required for Intensive system projects.

Inland fisheries offer new options for fish production especially where reservoirs are created. Current surveys show that reservoir construction is increasing in many countries. Reservoirs are attractive for large-scale fish production using natural stocks caught in the reservoir or cultured stocks from cages and other systems. Expansion of research for this sector would allow site-specific data and overall research methodologies for the region to be developed more rapidly.

Demand for fish and fisheries research is expected to rise in Asia in the near future. Many fisheries-research establishments are understaffed and underfunded relative to the economic importance of the sector and the value of the resource. Aquaculture production is increasing faster than the other fish sectors. Governments, especially in those countries that have lost traditional fishing grounds



through the new conventions of the Law of the Sea, are placing greater emphasis on aquaculture. It is hoped that, once their growing pains have been overcome, recently created regional fishing organizations will become leaders of regional activities. This will create greater opportunities for regionally focused projects. Such regional cooperation is absolutely essential to meet the projected increases in demand for fish and the need for inter-regional trade.

Future Directions

Fish protein will become increasingly more important to the lives of more and more poor people in developing countries over the next few years. Demand will soar, but supplies from wild stocks are peaking now. Wild stocks must be exploited more efficiently to maximize their yield, but the large increases in production will have to come from aquaculture and new water bodies such as reservoirs.

Several common themes emerge from this review of IDRC's Fisheries Program. Aquaculture will continue to be the highest priority for the Program although the research emphasis may differ either geographically (mariculture in Latin America versus fresh-water culture in Africa) or by subject area (component technology such as feed and breeding in Asia versus development of technology systems in Africa). The development of aquacultural systems should, where possible, be integrated with artisanal fisheries to provide employment opportunities for poor fishermen faced with depleting natural stocks.

Artisanal fisheries are the next highest priority for support and can expect to receive increased funding. Management of wild fish stocks is scientifically and operationally difficult, but, because these fisheries are so important for food and employment, research must be directed toward optimizing yields.

The importance of studying social and economic aspects of fisheries together with fish production yields has been emphasized throughout this review. Many technically promising capture and culture systems have failed because of social and economic factors; the failures might have been avoided, solved, or eliminated with socioeconomic research. Several initiatives in this field have been supported and more will be funded in the future.

Fish producers, including processors and marketing agencies, must be involved in designing, testing, and evaluating new or modified capture and culture technologies. Again, many technically promising system developments have failed because they were not fully adapted to the users' needs. Experiments in which acceptability to the producer is a variable are an essential link between technical development and extension.

Networks are widely used as a research-support system in projects sponsored by the Fisheries Program and this will continue and be expanded to increase cooperation and linkages between national fisheries programs.

The main thrust of the Fisheries Program has been to assist fish producers to increase efficiency and to derive maximum benefits from resources. That effort will continue but additional emphasis will be placed on marketing and on providing consumers with a quality product at a reasonable cost.

Other Programs of AFNS

Agricultural Economics

The Agricultural Economics Program was created in 1984. It is concerned with the production, distribution, and consumption systems in which rural households function. The three research areas identified for support are

- Natural resource production and utilization systems;
- Technology introduction to increase the efficiency of the practices used to introduce technology; and
- Resource allocation in agricultural research, which concentrates on improving research management and organization.

The emphasis is on projects that are an integral part of the research program of an institute that will become directly involved in the generation and dissemination of technology. Many of these projects complement, or are joint activities with, other programs of IDRC.

Crop and Animal Production Systems

The overall objective of the Crop and Animal Production Systems (CAPS) Program is to support research on crop and livestock production with priority to research that will benefit small-scale farming families. Increased access by the poor to food and other basic necessities is given priority over research aimed at increasing agricultural productivity per se. Although there is a strong research bias toward increasing smallholder food production, other commodities are not neglected when they can make an important contribution to alleviating rural poverty.

CAPS gives special attention to semi-arid tropical regions, which are home to many of the world's poorest people. These areas have also benefited the least from past achievements of agricultural research.

Projects supported by CAPS are often linked in networks in which the various participants are encouraged to interact to their mutual advantage. Scientists working on common problems meet regularly to exchange information and ideas.

CAPS attaches special importance to applied research that is likely to have a rapid effect at the farm level. More basic or strategic research is also needed, however, and many of the biological advances of recent years have much to offer the developing world. In such cases, scientists in developing countries may be linked, with advantage, to their counterparts in Canada to make use of the special expertise in Canadian institutions. Such cooperative projects account for about 20% of CAPS' current budget.

CAPS encourages a systems approach to research. In this approach, multidisciplinary teams of scientists work closely with the farming communities to help identify their actual problems and needs and to ensure that interventions designed to solve them are appropriate to the specific circumstances. Special attention is paid to the needs of disadvantaged groups such as the rural landless and women.

Research on cropping systems has been particularly successful in Asia where the increasing use of short-duration rice cultivars has opened a range of possibilities for increasing smallholder productivity. Similar research on cropping systems in Africa and Latin America is also starting to be effective.

Research on livestock emphasizes management, especially feeding systems, rather than animal breeding or diseases. Research on animal-production systems has been supported for several years in Latin America and is the focus of a regional network. Ruminants are given priority over nonruminants because they are better able to utilize poor quality feed. Systems involving cattle, and to a smaller extent buffalo and camelids, are given highest priority. However, research on sheep and goat production is expanding in recognition of their value to the poorer livestock producers. Among the non-ruminants, small species such as rabbits, guinea pigs, ducks, poultry, and bees offer promising research opportunities that could benefit some of the world's poorest people and the landless.

Most small farms in developing countries are mixed; therefore, the interactions between crops and livestock must be understood in designing appropriate improvements. CAPS attaches special importance to research on such farming systems.

Crops provide about 80% of the total value of agricultural production. CAPS support of crops research focuses on a limited range of crops: in general, those that are not commonly studied but are important in the diets of and as source of income for the rural poor. In cereal research, CAPS has given a lower priority to the major cereals — wheat, maize, and rice — because of the major support from other donors and national governments and has concentrated on such species as sorghum and millet, which are staple crops for large numbers of people in semi-arid regions. In grain legumes, support has concentrated on cowpeas, groundnuts, and other tropical species in Africa and Asia, and on temperate pulses such as chick-peas, lentils, and faba beans in the Middle East and West Asia. Future funding will be increasingly allocated to such species as lathyrus and peas that do not have support from any international agricultural research centre.

Annual oilseed crops such as sesame, safflower, sunflower, rapeseed, mustard, linseed, and niger have also been neglected in the past, although vegetable oil is in short supply in many developing countries. CAPS focuses its support for research on these crops through a network of projects in eastern Africa and South Asia.

Support for root-crops research, especially cassava, has shifted away from Latin America and is now concentrated mainly in East and West Africa and Asia. Special attention is also given to the biological control of pests of cassava.

Perennial crops are important in many smallholder systems in the tropics and subtropics. CAPS support has gone mainly to banana and plantain, including funding to establish the International Network for the Improvement of Banana and Plantain. Coffee research is also of interest and other perennial crops for smallholders are expected to be supported in the future.

A small informal research network has been established with CAPS support for Andean crops such as quinoa, *kaniwa*, oca, and ullucu. Vegetables are gaining in importance because of their nutritional value and as source of income for smallholders with access to markets.

Research on increasing supplies of animal feed focuses on the improvement of forage and pasture production and the utilization of agricultural by-products. Pasture research is of particular importance in Latin America where CAPS supports a network of projects linked to the Centro Internacional de Agricultura Tropical (CIAT), and in Africa where another network, the Pasture Network for Eastern and Southern Africa, is coordinated by the International Livestock Centre for Africa (ILCA). By-product research is concentrated mainly in Africa and the Middle East. CAPS supports several national programs and the ILCA-coordinated African Research Network for Agricultural By-products in these regions.

Rapidly expanding populations are increasing pressure on land and water resources in many parts of the world. In recognition of this, CAPS is giving greater attention to research on such important topics as fertilizers, soil erosion, tillage, soil-moisture conservation, and small-scale supplementary irrigation.

Forestry

During the past decade, the importance of forests and trees has been increasingly recognized in many developing and industrialized countries. However, expenditures on forestry research are small and mostly directed to the industrial sector, despite the fact that 80% of the wood harvested in developing countries is used for fuel.

The Forestry Program continues to emphasize integrated rather than industrial forestry and to reflect change in the research needs of the developing world, as well as change in the environment. The aim is to achieve a balanced mix of projects with emphasis on recipients who can be relied on to deliver and disseminate their research results.

Establishing growing trees is a top priority in the dry zones of Africa and South America, where expanding agriculture and the

need for fuelwood have lead to destruction of the natural forests. Aside from the selection of the best-suited species, research support emphasizes the development of simple techniques to establish and manage woodlots with village-level implementation.

An interdisciplinary approach is taken in supporting agroforestry research, involving both the Crop and Animal Production Systems and Agricultural Economics programs. In the field of forest-product utilization, research has helped to determine and improve the functional properties of secondary and unknown timber species for their use in construction.

Research support for tree improvement and breeding concentrates on bamboo and rattan in Asia and on propagation methods and cultural techniques for widely used multipurpose species such as *Leucaena*, *Prosopis*, and *Paulownia*.

In the field of environmental forestry, the Program has supported a network of four research projects on shelterbelts in Africa to measure the effect of trees on the microclimate and the production of food crops.

Post-Production Systems

The Post-Production Systems Program deals with the technology, appropriateness, efficiency, and nutritional implications of post-harvest activities for the benefit of low-income people. It covers a wide range of disciplines including engineering, biochemistry, entomology, nutrition, food science and technology, and economics and marketing.

The broad objectives of the Program are to make more and better food available to poor rural and urban consumers at the same time as augmenting employment and income. Food systems are the focus of the Program rather than specific commodities, technologies, or processes. Main activities are food processing and utilization; nutrition; food handling, drying, and storage; and equipment design, adaptation, and testing.

The Program also aims to strengthen village enterprises in the food and agricultural sectors. High priority is given to promoting and disseminating dehullers in rural milling systems, drying of staple foods and preserving perishable foods such as fish, fruits, roots, and vegetables. In all these sectors, training and Institutional development are of considerable importance.

Of special concern to the Program is Improving nutrition for low-income consumers, especially for such vulnerable groups as young children and pregnant and lactating women. Emphasis will continue to be on access to and supply of appropriate and acceptable foods for these groups. Close collaboration with the Health Sciences and Social Sciences divisions of IDRC on related activities is encouraged.

Head Office

IDRC, P.O. Box 8500, Ottawa, Ontario, Canada K1G 3H9

Regional Office for Southeast and East Asia

IDRC, Tanglin P.O. Box 101, Singapore 9124, Republic of Singapore

Regional Office for South Asia

IDRC, 11 Jor Bagh, New Delhi 110003, India

Regional Office for Eastern and Southern Africa

IDRC, P.O. Box 62084, Nairobi, Kenya

Regional Office for the Middle East and North Africa

IDRC/CRDI, P.O. Box 14 Orman, Giza, Cairo, Egypt

Regional Office for West and Central Africa

CRDI, B.P. 11007, CD Annexe, Dakar, Senegal

Regional Office for Latin America and the Caribbean

CIID, Apartado Aéreo 53016, Bogotá, D.E., Colombia

Please direct requests for information about IDRC and its activities to the IDRC office in your region.