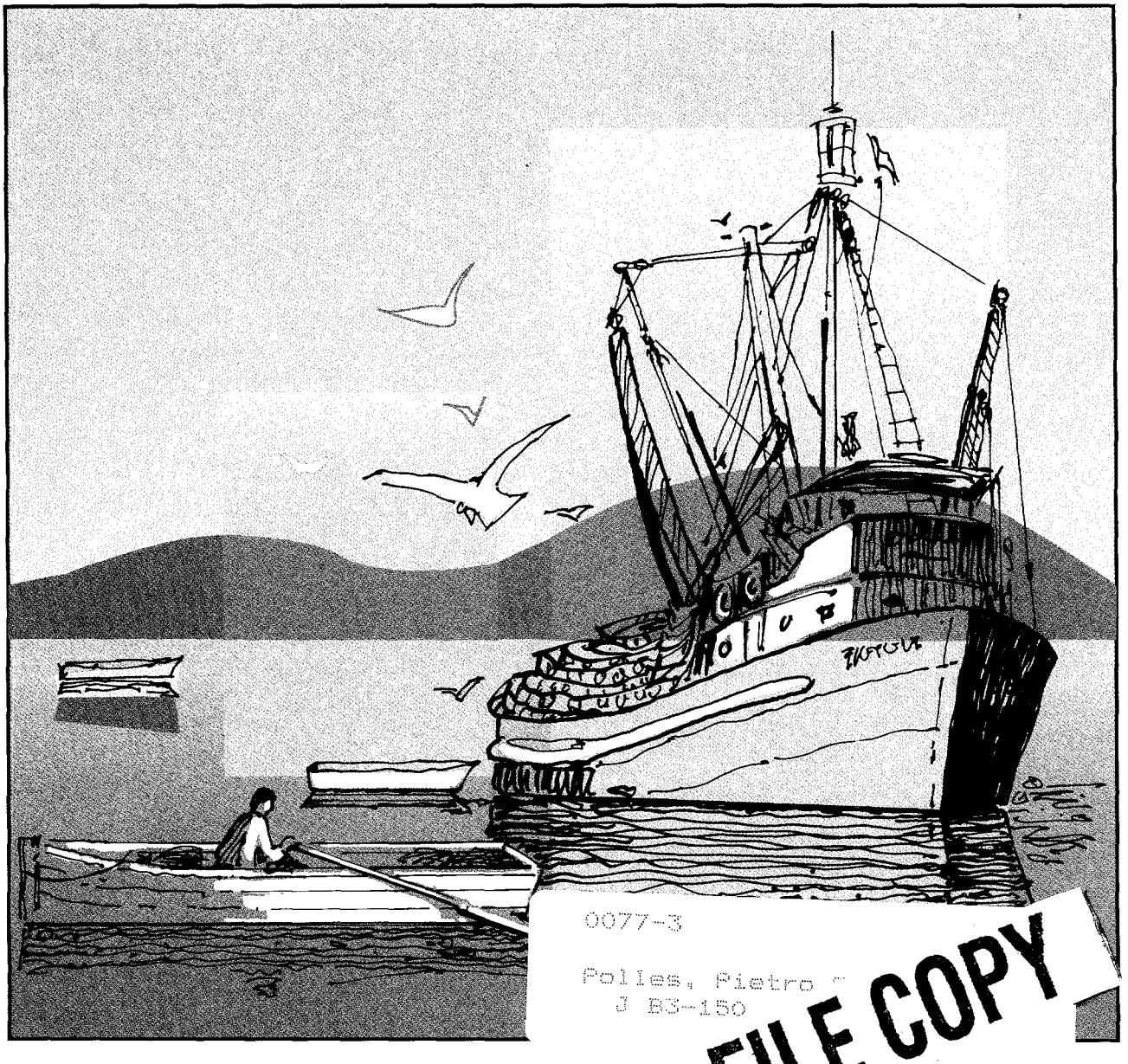
WORLD BANK TECHNICAL PAPER NUMBER 153
FISHERIES SERIES

WTP- 153

Small Pelagic Fish Utilization

Research Needs

The World Bank/United Nations Development Programme/Commission of the European Communities/Food and Agriculture Organization



RECENT WORLD BANK TECHNICAL PAPERS

No. 89 Nankani, *Techniques of Privatization of State-Owned Enterprises*, vol. II: *Selected Country Case Studies*

No. 90 Candoy-Sekse, *Techniques of Privatization of State-Owned Enterprises*, vol. III: *Inventory of Country Experience and Reference Materials*

No. 91 Reij, Mulder, and Begemann, *Water Harvesting for Plant Production: A Comprehensive Review of the Literature*

No. 92 The Petroleum Finance Company, Ltd., *World Petroleum Markets: A Framework for Reliable Projection*

No. 93 Batstone, Smith, and Wilson, *The Safe Disposal of Hazardous Wastes: The Special Needs and Problems of Developing Countries*

No. 94 Le Moigne, Barghouti, and Plusquellec, *Technological and Institutional Innovation in Irrigation*

No. 95 Swanson and Wolde-Semait, *Africa's Public Enterprise Sector and Evidence of Reforms*

No. 96 Razavi, *The New Era of Petroleum Trading: Spot Oil, Spot-Related Contracts, and Futures Markets*

No. 97 Asia Technical Department and Europe, Middle East, and North Africa Technical Department, *Improving the Supply of Fertilizers to Developing Countries: A Summary of the World Bank's Experience*

No. 98 Moreno and Fallen Bailey, *Alternative Transport Fuels from Natural Gas*

No. 99 International Commission on Irrigation and Drainage, *Planning the Management, Operation, and Maintenance of Irrigation and Drainage Systems: A Guide for the Preparation of Strategies and Manuals* (also in French, 99F)

No. 100 Veldkamp, *Recommended Practices for Testing Water-Pumping Windmills*

No. 101 van Meel and Smulders, *Wind Pumping: A Handbook*

No. 102 Berg and Brems, *A Case for Promoting Breastfeeding in Projects to Limit Fertility*

No. 103 Banerjee, *Shrubs in Tropical Forest Ecosystems: Examples from India*

No. 104 Schware, *The World Software Industry and Software Engineering: Opportunities and Constraints for Newly Industrialized Economies*

No. 105 Pasha and McGarry, *Rural Water Supply and Sanitation in Pakistan: Lessons from Experience*

No. 106 Pinto and Besant-Jones, *Demand and Netback Values for Gas in Electricity*

No. 107 Electric Power Research Institute and EMENA, *The Current State of Atmospheric Fluidized-Bed Combustion Technology*

No. 108 Falloux, *Land Information and Remote Sensing for Renewable Resource Management in Sub-Saharan Africa: A Demand-Driven Approach* (also in French, 108F)

No. 109 Carr, *Technology for Small-Scale Farmers in Sub-Saharan Africa: Experience with Food Crop Production in Five Major Ecological Zones*

No. 110 Dixon, Talbot, and Le Moigne, *Dams and the Environment: Considerations in World Bank Projects*

No. 111 Jeffcoate and Pond, *Large Water Meters: Guidelines for Selection, Testing, and Maintenance*

No. 112 Cook and Grut, *Agroforestry in Sub-Saharan Africa: A Farmer's Perspective*

No. 113 Vergara and Babelon, *The Petrochemical Industry in Developing Asia: A Review of the Current Situation and Prospects for Development in the 1990s*

No. 114 McGuire and Popkins, *Helping Women Improve Nutrition in the Developing World: Beating the Zero Sum Game*

No. 115 Le Moigne, Plusquellec, and Barghouti, *Dam Safety and the Environment*

No. 116 Nelson, *Dryland Management: The "Desertification" Problem*

No. 117 Barghouti, Timmer, and Siegel, *Rural Diversification: Lessons from East Asia*

No. 118 Pritchard, *Lending by the World Bank for Agricultural Research: A Review of the Years 1981 through 1987*

No. 119 Asia Region Technical Department, *Flood Control in Bangladesh: A Plan for Action*

(List continues on the inside back cover)

FISHERIES SERIES

Technical Paper Series

No. 147 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Asia: Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region.* Francis T. Christy Jr., David James, et al.

No. 148 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Latin America: Studies of Uruguay, Argentina, Chile, Ecuador, and Peru.* David de G. Griffith, Jean-Paul Troadec, et al.

No. 149 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Africa: Studies of Kenya, Malawi, Mozambique, Zimbabwe, Mauritania, Morocco, and Senegal.* Daniel Pauly, Francis Poinsard, et al.

No. 150 The World Bank/UNDP/CEC/FAO, *International Cooperation in Fisheries Research.* Jean-Paul Troadec, et al.

No. 151 The World Bank/UNDP/CEC/FAO, *Tropical Aquaculture Development: Research Needs.* P. Edwards, E.A. Huisman, et al.

No. 152 The World Bank/UNDP/CEC/FAO, *Small-Scale Fisheries: Research Needs.* Francis T. Christy, Jr., et al.

No. 153 The World Bank/UNDP/CEC/FAO, *Small Pelagic Fish Utilization: Research Needs.* David James, et al.

Discussion Paper Series

No. 135 A Strategy for Fisheries Development

Policy and Research Series

No. 19 A Study of International Fishery Research

Booklet

Study of International Fishery Research: Summary Report

WORLD BANK TECHNICAL PAPER NUMBER 153
FISHERIES SERIES

Small Pelagic Fish Utilization

Research Needs

The World Bank/United Nations Development Programme/Commission of the European Communities/Food and Agriculture Organization

The World Bank
Washington, D.C.

Manufactured in the United States of America
First printing September 1991

Technical Papers are published to communicate the results of the Bank's work to the development community with the least possible delay. The typescript of this paper therefore has not been prepared in accordance with the procedures appropriate to formal printed texts, and the World Bank accepts no responsibility for errors.

The findings, interpretations, and conclusions expressed in this paper are entirely those of the author(s) and should not be attributed in any manner to the World Bank, to its affiliated organizations, or to members of its Board of Executive Directors or the countries they represent. The World Bank does not guarantee the accuracy of the data included in this publication and accepts no responsibility whatsoever for any consequence of their use. Any maps that accompany the text have been prepared solely for the convenience of readers; the designations and presentation of material in them do not imply the expression of any opinion whatsoever on the part of the World Bank, its affiliates, or its Board or member countries concerning the legal status of any country, territory, city, or area or of the authorities thereof or concerning the delimitation of its boundaries or its national affiliation.

The complete backlist of publications from the World Bank is shown in the annual *Index of Publications*, which contains an alphabetical title list (with full ordering information) and indexes of subjects, authors, and countries and regions. The latest edition is available free of charge from the Publications Sales Unit, Department F, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A., or from Publications, The World Bank, 66, avenue d'Iéna, 75116 Paris, France.

ISSN: 0253-7494

Library of Congress Cataloging-in-Publication Data

Small pelagic fish utilization : research needs / the World Bank ... [et al.].
p. cm. — (Fisheries series) (World Bank technical paper, ISSN 0253-7494 ; no. 153)
ISBN 0-8213-1857-8
1. Fish as food. 2. Fishery processing. I. International Bank for Reconstruction and Development. II. Series. III. Series: World Bank technical paper, no. 153.
TX385.S63 1991
664'.94'072—dc20 91-28102
CIP

ABSTRACT

This Working Party Report deals with the research needs for Small Pelagic Fish Utilization. It starts out with an analysis of the demand for fish and the ways of filling the supply-demand gap. It then proceeds to discuss the utilization of pelagic fish and product development with particular reference to Japan and Peru. On this basis, the reports examines research objectives as well as opportunities for fundamental and adaptive research.

ACKNOWLEDGMENTS

The Members of the Mission are grateful to the following agencies for supporting this study:

Multilateral Agencies: (Steering Committee) The World Bank; United Nations Development Programme; Commission of the European Communities; and Food and Agriculture Organization.

Bilateral Agencies: DANIDA — Danish International Development Agency; AIDAB — Australian International Development Assistance Bureau; ICOD — International Centre for Ocean Development (Canada); NORWAY: ICEIDA — Icelandic International Development Agency; SIDA — Swedish International Development Authority; ODA — Overseas Development Administration (United Kingdom); ITALY; FRANCE; USAID — United States Agency for International Development; THE NETHERLANDS; GTZ — Deutsche Gesellshaft fur Technische Zusammenarbeit (Germany).

FOREWORD

This Technical Paper is one of seven mission and working group reports prepared during the Study of International Fishery Research (SIFR) in 1989-90. The juxtaposition of potentially high socio-economic benefits from fisheries and the relatively low level of success achieved in fisheries development projects has been a matter of serious concern and challenge to the donor community as well as to national fishery administrations. In view of this, the First Fishery Development Donor Consultation held in 1986 decided to undertake a Study of International Fishery Research to determine ways in which research could bring about improvements. This comprehensive effort has now been completed, thanks especially to the effective financial support of a group of multilateral and bilateral donors and the essential intellectual contributions made by virtually hundreds of professionals from academia, fishery administrations and donors who were associated with various stages of the Study.

The objectives of the Study were to identify the specific constraints to fisheries management and development (including aquaculture) posed by the lack of information or the inaccessibility of existing knowledge; to determine high priority research needs; to examine the capacity of developing countries to undertake research; and to propose a strategy and an action plan for improving donor support. It was carried out through a series of missions and by four working groups which addressed specific research topics under the direction of a Study Team Leader and a Deputy. SIFR identified a number of key strategic research areas which are vital for the future development of the sector. Institutes in developing countries may not immediately be able to carry out all of this research, but the Study clearly identifies them as the ultimate beneficiaries of its thrust. In the meantime, countries with important fishery resources and the willingness to further develop their research for improved management and sustainable use of their resources should be assisted in drawing up national research agendas and building up their capacities. In this context, the findings of regional missions are a useful starting point. This volume contains the report of the Working Party on "Small Pelagic Fish Utilization: Research Needs" and is intended as background information to support the main study which is being published as "Study of International Fishery Research".

I wish to express my sincere thanks to the fisheries researchers, and fishery administrators in developing countries, as well as the leaders and members of the missions and Steering and Advisory committees for their vigorous effort and thoughtful contributions. It is my sincere hope that these Technical Papers will prove stimulating and provide practical guidance to donors, research institutions and fishery administrations in making progress toward sustainable resource utilization and the realization of new opportunities from fisheries and aquaculture in developing countries.

Michel J. Petit

Director, Agriculture and Rural Development Department

ACRONYMS

SIFR	Study of International Fishery Research
FAO	Food and Agriculture Organisation, Rome
FPC	Fish Protein Concentrate
SPAAR	Special Programme for African Agricultural Research

Table of Contents

SMALL PELAGIC FISH UTILIZATION: RESEARCH NEEDS

Small Pelagic Fish Utilization: Research Needs

WORKING PARTY:

Aberdeen, 2-4 October 1989

MEMBERS:

David James, FAO (Convener)

John Disney (UK)

K. Gopakumar (India)

Hector Lupin (FAO)

Sumpeno Putro (Malaysia)

Amadou Tall (Senegal)

Shun Wada (Japan)

John Watmough (Peru)

Kevin Whittle (UK)

1. INTRODUCTION

The Working Party on Research Needs for Small Pelagic Fish Utilization was held at the Torry Research Station, Aberdeen, Scotland, U.K. during 2-4 October 1989. The assistance of the Torry Research Station in organising the meeting is gratefully acknowledged.

The Working Party met as part of a Study of International Fishery Research needs financed by a group of international agencies and donors. The brief was to examine the extent to which research could contribute to encouraging the utilization of increased quantities of small pelagic fish for direct human consumption.

2. BACKGROUND TO FISH CONSUMPTION

THE DEMAND FOR FISH

Conventional wisdom suggests that by the turn of the century the demand for fish will exceed the currently available supplies, leading to rapidly increasing prices and an intensified search for alternative sources. Higher prices for the preferred species are already a fact in many developed and developing country markets, where the consumer price indices for these species have been rising faster than those for the overall cost of living.

Estimating future demand with any degree of accuracy is inherently difficult as it is conditioned by so many soccial and economic factors. FAO attempts to keep track of demand projections based on trends of three main parameters: population growth, increased incomes and higher prices. In order to maintain present *per capita* consumption at 12.0 kg on a global basis, the 6.1 billion world population in the year 2000 will require an additional 19 million tons of fish. The effect of increased incomes, following the current Development Report of the World Bank, could account for a further requirement of 10 million tons. The effect on demand of higher prices is more difficult to quantify. The diversification to less popular species is already apparent and in the future will be assisted by technology and modern marketing methods. Although in overall terms higher relative prices could have a dempening effect on demand, there are other interacting factors that could introduce significant changes. One of these is the publicity surrounding the perceived health benefits to the individual of eating more fish. For instance, fish consumption in the USA is rising sharply for this reason and is expected to double before levelling off. The strengthened demand from developed countries will have a direct effect on supplies available in developing countries, particularly for the poor. Already each person in a developed country has access to three times the global *per capita* availability. Trends in population growth tend to further disadvantage the developing countries, whose populations will increase to about 74 to 80 percent of the total. As a result they will generate the bulk of the demand which is likely to be unsatisfied; in fact, avilability has been reduced in a number of developing countries. There are serious implications when one considers the extent to which people in developing countries rely on fish as a source of animal protein. 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 at number 13).

The "gap" that is emerging between supply and demand has the following characteristics:

- The bulk of the demand for an additional 29 million tons of fish by the end of the century will be from developing countries(particularly Asia).
- Developed countries will continue to import fish than theyexport but, given reasonable economic growth, the trade between developing countries should increase.
- The implied demand relates almost entirely to existing consumers and does not encompass the potential benefits to the undernourished from increased fish consumption.
- Conventional resources are unlikely to be capable of sustaining demand in the year 2000 unless they are better managed.

It is postulated that in the future, demand for fish products will become increasingly stratified. The preferred species of finfish, crustaceans and moluscs will become luxuries and will be drawn to the high-value markets in developed countries.

At a second level there is a range of processed products, frozen, canned, cured, etc., based either on traditional species or, in an increasing number of cases, from previously underutilized resources. This follows the pressure to diversify.

Recently there has been a very strong trend to a third level of products which makes use of fish protein, often in an unrecognizable form. This involves the use of technological processes which upgrade lower-cost raw material to give products which simulate high-cost articles. The best examples are reformulation of pieces of tissue cut from small fish into fillet shapes, and the more fundamental restructuring of muscle by the surimi process. The Japanese have used this more radical approach to produce a whole range of analogue products.

FILLING THE SUPPLY-DEMAND GAP

The most obvious means of generating increased supply for the table, even without the need for increased landings, is by reducing the post-harvest loss of what is presently caught. These losses vary greatly from one fishery to another but are significant, amounting to up to 10 percent of food fish supplies. Investment in infrastructure coupled with education and training would be necessary to reduce them. The technology is largely available but needs further economic assessment prior to application.

The technology for increasing supplies by aquaculture is also becoming rapidly available. Assuming that the economic equations are positive, the limitations appear to be availability of feed and suitable growing areas.

A third possibility which has been subject to much consideration, but where progress has been slow, is the trawl by catch taken in association with shrimp. From 5 to 16 million tons per year is considered to be available. It is a potential resource but the technological and economic limitations of full production are great.

3. UTILIZATION OF PELAGIC FISH

DISPOSITION

The one single resource that has a potential greater than the three prospects mentioned above is, however, the small oily shoaling pelagic species. These made up 41.5 million tons of the 91 million ton world catch in 1986. Under half is used for direct human consumption, the balance going to fish meal and oil (Table 1). There is thus, in global terms, the possibility of an additional 20 to 30 million tons of fish being made available for direct human con sumption - at least as much as 50 percent of the present food fish catches and enough to close the supply-demand gap. With such a demonstrated potential what are the constraints to making use of it. Or, alternatively, if not making full use, at least ensuring that the species make a better contribution to nutrition in developing countries where much of the resource is found.

Table 1

	Million tons *1987*
Total world catch	93
of which:	
For human consumption	67
For fish meal + non-food uses	26
Small Pelagic Species	41.5
of which:	
For human consumption	17.5
For fish meal	24
Additional potential	5-15

Source: FAO Database.

SMALL OILY PELAGIC SPECIES AS FOOD FISH

On the plus side the resources are available, the species are generally highly nutritious and very much appreciated as fresh or frozen fish, or after processing by curing or canning. It is encouraging to see that the increase in total annual catches in recent years has been sustained. A high proportion of the increase has been the small pelagic species and the proportion used for direct human consumption has also risen. This is probably a response to demand and has been brought about by the redeployment of the considerable distant water freezing capacity, constructed in the last twenty years, to this resource following the change of management in extended economic zones.

However, on the negative side, there are many problems to contend with. The resources are invariably highly seasonal, both in terms of quantity and composition (oil content), landings are characterized by periods of glut followed by long periods of low, or no, availability, making the development of a consistent processing and marketing strategy difficult.

In addition, most small pelagic species are fragile and easily crushed; they are difficult to store and deteriorate rapidly, their high oil content making them susceptible to rancidity. The small size and many small bones reduce their appeal to some consumers. Some species have a characteristic strong flavor which also reduces their appeal.

As well as seasonal variations, there are long-term variations in abundance due to over fishing and to partly understood biological, oceanographic or meteorological factors. This is exemplified by historical variations of herring stocks in the Baltic, the collapse of the Atlanto-Scandian herring, the Peruvian anchoveta as well as sardine stocks in Japan, California and Chile.

As a result of the unreliability of the resource, it has always been difficult to determine investment levels to ensure that the expensive infrastructure that is inevitably required is fully utilized. It is for this reason that most of the excess catches have traditionally been diverted to the fish meal industry. It is this industry that controls the utilization of the small pelagic species. When fish meal prices are down, as a result of competition with soya protein, the industry looked anxiously for direct human consumption opportunities. However, the fish meal industry collectively is very conservative and reluctant to change and before research and product development work was complete the demand for fish meal rose again. At present there is little interest in direct human consumption, unless of course it could be shown to result in much increased profits. It is interesting that increase in demand results from growth in aquaculture where for maximum growth a higher qualtiy meal, dried at low temprature, is required (LT Meal). By implication LT Meal requires fresher raw material and it appears that the fish meal industry will start to land raw material of human consumption quality. This will remove the major constraint of making food use of fish meal catches. Perhaps in the future it will be possible for governments to increase the role of fish in their national food strategies through policy directed to these landings. The important role of fish meal in food production should not be overlooked. In addition to use in aquaculture it is extremely important in improving the feed efficiency and biological value of other protein sources for poultry and pigs. For maximum efficiency fish meal cannot be totally replaced with vegetable protein and for this reason the fish meal industry will continue, perhaps diversifying in the future to the huge latent stocks of mesopelagic species. Concurrently there will also be a continuation of the search for alternative, competitively priced, protein sources with emphasis on single cell protein.

GEOGRAPHIC DIFFERENCES

There is a broad geographical division in the resource which conditions its end use and therefore the research requirements. On one hand are the extremely large volumes characteristic of Latin America and Japan, where local demand is not strong and the result has been fish meal production. On the other hand in Africa and Asia small pelagics are used for human consumption, at least by coastal people. Local demand is increasing and the problem is to apply technology to extend shelf-life or to process in order to widen the circle of distribution. For the most part this implies concentration on the products that are traditional, but about which little is known. Conversely for the large volumes, complex industrial processes are necessary and these require major efforts to research both new products and processes.

4. TRADITIONAL UTILIZATION

The main barrier to development of the resource for traditional utilization is not lack of knowledge, or an immediate requirement for more research, but the lack of an effective infrastructure for handling, processing and marketing in developing countries. There is a wide range of products including fresh, canned, salted, dried, smoked and marinated that are produced in various countries. Production everywhere would be stimulated by the availability of better quality raw material. This implies on-board chilling. A massive extension effort is necessary but little adaptive research. If raw material cannot be chilled until landing, then a certain loss of quality must be accepted.

The part of the catch that is not consumed fresh or frozen must be processed and here there is a requirement both for basic and adaptive research. The various traditional processes need to be studied from the point of view of food science and optimized. It is not necessary to industrialize but to understand the basic process in order to maximize yields, assure safety and ultimately to transfer product technology from one country to another. Another basic problem is understanding the mechanism of fat oxidation leading to rancidity. This could result in the development of suitable antioxidants, preferably from natural sources. Biotechnological aspects of fat content, in relation to suitability for various processes, could lead to more appropriate processing methods.

Research products of a more adaptive nature are required to prevent post-harvest losses such as the reduction of insect infestation of dried fish by the use of insecticides, and fumigants, although the toxicity of such compounds must be emphasized. Investigation of the mechanics of smoking and drying to develop fuel efficient furnaces for driers would contribute to the economy of the fishing communities and reduce environmental degradation by firewood cutting. There is also much potential for the study of fermentation processes to enable preservation at lower levels of salt than are currently used, and for processes to hasten fermentation of the traditional fish sauces.

In some areas there is scope to move away from traditional products, for instance to greater production of sterilized products. While canning is expensive and requires a lot of capital, the new generation of flexible containers that can be heat sterilized promises to reduce costs but research and development is required.

5. INDUSTRIAL PROCESSES

For the major resources, such as the west coast of South America and Japan, the quantities are so large that it is unlikely that they can be handled by conventional technology. If a political decision were taken to use them for direct human consumption this would probably be with an international perspective, but would have to be backed by an integrated research and development programme. Assuming that a better knowledge of the resource and its potential was available there would be need to develop methods of catching, handling, processing and marketing. Of particular importance would be product development and its relationship to consumer appreciation. Interesting work is underway in Japan and Peru but much remains to be done.

JAPAN

At present almost a half of Japan's 9.5 million ton catch is sardine and the Japanese Government has run a six-year research project on its utilization. There is now a Food Sardine Association sponsored by the private sector attempting to make use of sardine in non-traditional ways. The traditional products were mainly dried. More attention has been focussed on sardine because of its oil; rich in n-3 fatty acids, fish oil is responsible for a reduction in cardiovascular and other diseases.

Most effort has been put into industrial processes where the integrity of the fish is destroyed. As the oil is also extracted and only the protein used the specific health benefits of the oil are lost. Surimi for production of fish jelly products has been made from sardine by addition of pyrophosphate to the washing water to retain gel-forming capacity and removal of oil by vacuum washing. The quality of this surimi is lower than that from Alaska pollack but it can be used for some products, including fish balls, noodles, fish sausage and fish burger. However, the yield is low and the waste is a potential pollution problem. It should be noted that attempts to make surimi from menhaden in the United States were technically sucfcessful but abandoned because of low yield.

A red meat extender or substitute - marine beef - has also been developed in Japan. This is a rational direction in a country with little pasture land and a growing demand for meat as a result of changing lifestyle. However, there seem to be some limitations in the technology for solvent recovery and recovery of by-products from the waste stream that affect the economics. Apart from a plant that has been built in Peru and since closed, there are no commercial plants operating. It appears that there is still a need for a research programme.

PERU

In Peru, as elsewhere on the west coast of South America, fish meal is the overwhelming end use of small pelagic. There is, however, a growing canning industry but the proportion of the raw material used is small. These enormous quantities could not all be directed to human consumption but a proportion could be incorporated in infant food as has been done experimentally or used in dry products, with or without fish taste.

When one reviews the development in the world food industry over the last fifteen years, one can only look back on the failure to develop successful fish protein concentrates (FPC) in the late 60s and early 70s with amazement at the mistakes that were made. FPCs were dry powders, with no functional properties, and were made from whole fish, so failing to satisfy the requirements of regulatory agencies like the US Food and Drug Administration. Finally, no consideration was given to the characteristics FPCs would have to have to incorporate them into the traditional food habits in poor countries or to satisfy the requirements of developed country markets.

If those responsible for the FPC projects had not ignored the experience of the food industry and the production and export realities of the leading fishmeal producing countries, FPCs might have been a success and the present utilization of small pelagic species would be quite different. For these reasons a serious effort should be made to develop the second generation of FPCs.

Some impressive work has already been done in this field. In Peru, a textured FPC, Peskarne, has been developed with none of the limitation of the Japanese marine beef. Peskarne consists of cream coloured, dry chunks that can be made in a range of sizes and shapes. Peskarne is made from small pelagic fish, all the process by-products are recovered, and there are not significant solvent losses. A further advantage of Peskarne is that the chewing characteristics can be varied to simulate chicken or a range of red meats. The chemical characteristics of Peskarne make it compatible with commercially available flavourings. Tast panel tests run in the United States demonstrated that Americans failed to detect that Peskarne was not beef.

A plant to produce Peskarne has been built in the north of Peru. At present the owners are struggling to complete the plant in a gravely disturbed national economy. Future development will be watched with interest. Market acceptability and sustainability have yet to be demonstrated.

The reasons why fishmeal companies have not developed FPCs comparable to marine beef and Peskarne is that the fishmeal industry is very conservative and until it is demonstrated that the second generation of FPCs is a commercial success it is very unlikely that these companies will show any interest in these new products. For this reason any effort to develop new high-value FPCs should include

the building and operation of a plant to demonstrate the technical and commercial feasibility of producing the second generation of FPCs.

6. RESEARCH OBJECTIVES

It is apparent that until recently research into utilization of small pelagic fish has been technology-led rather than responding to the market. There are a number of indications that the position is changing and that to a greater extent the various technological options are being viewed from the market place and from the point of view of the consumers.

Before attempting to establish research objectives and definitions the working group considered it useful to attempt a separation of the long-term basic research programmes, pursued to generate a full understanding of the raw material, from the short-term adaptive research of supplying a technological process to a problem.

The overall aim of the proposed programme is to identify the research necessary, post harvest, to enable the small pelagic fish resources in different parts of the developing world to be brought into significantly greater utilization for human consumption. This is the most challenging problem in post-harvest technology facing fishery scientists, but we believe it can be achieved with commitment and perserverance. Greater utilization can ge considered in three basic ways:

(i) Diversification of resources currently used for reduction to meal and oil to be used instead for human consumption, to benefit from the nutritional advantages of high quality protein and the colorific value of the fat.

(ii) Reduction of post-harvest handling, processing and distribution losses where the fish is harvested for food largely by means of traditional products which will continue to have a role to increase the amount available to the consumer and hence the food yield from the fishery.

(iii) Enhancement of the value of the resource, and the revenue generated, by development of products with a greater cash return.

By definition, such research is close to development or application and some, which reorientates previous approaches to new problems, may be appropriately termed adaptive research.

However, the most characteristic and fundamental problems which seriously obstruct utilization of the small fatty pelagics are:

(i) the susceptibility to rapid spoilage and autolytic deterioration;

(ii) more importantly, the susceptibility of the fish and derived products to hydrolysios of the fats, oxidation and development of unpleasant, rancid flavours, and

(iii) development of biogenic amines due to improper handling and storage of wet fish.

A better understanding of the nature and the mechanisms of all these deteriorative processes, and the interactions between the factors affecting their rates of change, is urgently required with the aim of identifying new and more effective methods of control of the processes. This type of work can be described as more basic or fundamental research required to underpin further development of the use of the raw materials beyond serious limitations of current solutions.

A further major limitation is mechanical fragility, resulting in damage even with mild handling. Although a basic understanding is required, and this must be based on long-term detailed studies, the engineering development required to produce new machinery is more in the nature of adaptive research.

7. RESEARCH OPPORTUNITIES FOR FUNDAMENTAL STUDIES

A focussed research programme to divert small pelagics to human consumption would, as noted, depend on a policy decision. It would require an integrated effort in a number of centres. Some of the elements which are presently not being investigated are set out below.

COMPOSITION

The selection of process and storage conditions and the ultimate uses to which pelagic fish raw material can be put depends primarily on a knowledge of the composition of the raw material and the extent of natural or seasonal variations with the raw material.

There is a lack of such accurate basic compositional information for pelagic species, particularly from African and Asian sources, which represents a barrier to development of use of the resources. The composition and variability of the lipid components, especially the contribution of the polyunsaturated fatty acids, which can be of special significance for vulnerable groups of malnourished people (e.g. pregnant and lactating women) are important. A detailed knowledtge of the composition and properties of the myofibrillar and sarcoplasmic proteins are essential prerequisites to assessment of the potential functional properties of fish gels and identification of protein isolates with specific properties, or with properties which might be modified by structural change, for use as food ingredients, e.g. in the fortification of beverages.

SPOILAGE CHANGES

In general fresh fatty fish deteriorate more rapidly than demersal fish and rejection of chilled fish is the result of unpleasant flavours which develop as a result of autolytic and oxidative changes rather than bacterial spoilage. For example, the packaging of herring and mackerel in modified atmospheres based on carbon dioxide does not contribute significantly to extension of shelf-life because control of bacterial growth and spoilage is not the key determinant of quality loss.

The interactions between the deteriorative processes, the products formed in these processes, and the effects of external factors influencing their rate of change are extremely complex and not fully understood. As the push towards greater utilization of the pelagic develops through more outlets and via more sophisticated products, research needs are evolving and it becomes increasingly more important to understand the basic processes as fully as possible to provide a firm basis for the technology, and identify critical points at which greater success may be achieved in coantrolling quality deterioration and functional properties in order to provide a firmer basis for predictive methods of quality deterioration. This research should elad to rapid methods of quality determination that can be applied at a field level.

Spoiled fish are consumed in some areas and there is concern that consumers should not be exposed to products of spoilage processes which could cause toxic effects.

OXIDATION

The fatty pelagic fish rich in polyunsaturated fatty acids are prone to oxidative processes, most obviously manifest in the development of unpleasant, rancid flavour in products and flavour resersion in doedorized oils. Control of oxidation is without doubt the key factor obstructing the use of these species more widely for food as whole fish, as processed products, e.g. dried, smoked, canned, marinated and so on, or as oils or lipid fractions used as food ingredients or for other purposes.

Our current understanding of the complex oxidative mechanisms operating during processing and storage and the interaction between the factors affecting their rates and of the potential damaging effects on health of lipid oxidation products, is far from complete. The methods available for measurement of the changes are limited in applicability.

Sophisticated barrier packaging and glazes are important methods available for control of oxidation under certain conditions but, as greater use for more sophisticated food products from the resource is encouraged, a better understanding of the ioxidative mechanisms is essential to enable, for example, better methods of control by addition of acceptable, economic antioxidants, preferably naturally occurring substances, suitable for incorporation at various process stages, to control specific oxidation changes.

8. RESEARCH OPPORTUNITIES FOR ADAPTIVE RESEARCH

Technology is encouraged by the underpinning of basic scientific research but more attention must be given to its adaptation and application. There are several broad areas for consideration but it is clear that, in a modern context, a much closer integration is required between the various disciplines involved.

PACKAGES OF TECHNOLOGY

So much of the technology is available and at the same time there have been so many spectacular failures that more investigation is required on how the various technologies could be packaged together. There are basically three systems of utilizing small pelagic fish for human consumption:

(i) The Mediterranean - relatively small-scale landing of fresh fish usually with ice) for fresh consumption or canning.

(ii) The Scandinavian - large vessels using refrigerated sea water and bulk handling systems but still landing fresh fish for consumption fresh, canned or marinated.

(iii) The Dutch - large-scale freezing at sea landing frozen blocks as raw material for processing.

These systems have all been tried and have failed in developing countries. A reassessment of the parameters is required to ensure that the basis for planning of industries and development projects is sound. In this regard socio-economic considerations must be taken into account as outlined below.

SOCIO-ECONOMICS

Fisheries development projects have been evaluated in recent years by a number of development agencies. One of the deficiencies was found to be an inadequate level of base-line data, particularly in terms of the socio-economic implications of the project.

In future there will be a greater need to involve socio-economic analysis in project preparation and this argument also applies to fisheries research. At the initiation of research proposals the need for socio-economics as well as technological research should be recognized because they are mutually supportive. Furthermore, a sound case can be made for independent socio-economic research providing the basic deata in reaching decisions as to the need for technological research.

This principle is particularly relevant in the field of product development research. In the past this has tended to be technology led rather than market led and this trend must be reversed if the research is to be effective. Far more attention must be paid to market research and assessment of the needs of the consumer. Attention to this kind of socio-economic research should pay handsome dividends in ensuring that the technological research is properly targeted.

There is a considerable wealth of technology available which can be put together to suit particular needs but these needs must first be properly identified by specific investigations including socio-economic considerations. This is not to imply that technological research is not required but there may be more need to adapt existing knowledge rather than develop new technologies if the need is more spefcifically identified.

An example of the way in which technology has led can be seen in the second generation FPCs and the search for an intermediate surimi-based product. The technological options have been reviewed but now

there is a requirement to go to the consumer and determine how the products are appreciated. These results must then be fed back to the pilot plant.

More concentration on socio-economic matters inevitably means that there must be much better policy guidelines laid down by government. In turn this brings full utilization very much more into public discussion.

ENVIRONMENT AND HEALTH

Waste from manufacturing processes associated with high technology approaches to utilization is likely to cause environmental problems if it cannot be treated for economic reasons. The returns from recovery of waste products are likely to exceed the costs.

In relation to traditional products the risk of environmental degradation as a result of overuse of firewood has been noted. There are also product safety constraints such as the high levels of histamine (and other biogenic amines) found in the scombroids. Poor storage can also lead to the formation of highly carcinogenic aflatoxin from fungi in dried fish. There are also possibilities that traditional processing methods could cause unacceptable contaminants to be present in final products (e.g. 3-4 benz pyrine) or that the food chain could be contaminated by concentration of toxins (e.g. ciquatoxin, PSPs).

INFORMATION

The lack of research capability in many developing countries is compounded by the ineffective use of the knowledge produced. Much information is never committed to paper and that which is tends to be poorly disseminated even within the country of origin. There is a considerable volume of "gray" literature which is not available to the scientific community at large and relatively few publications reach the internationally referred journals. Despite some notable exceptions this is the general situation for fisheries research institutions in the developing world. Furthermore, there tends to be too little contact between institutions at the national, regional and

international level for the exchange of information and experience. Again, there are exceptions and some valuable coordination/networking schemes are in operation but there is considerable scope for more effort in this area.

All development agencies now accept that the dissemination of research findings is an integral part of the research project or process. Unfortunately this policy is slow to implement and finance since the approval of funding for research projects is often limited to the research itself and there is no insistence on dissemination of the findings.

If research in fisheries development is to be more effective in the future this situation must change. The problem has been recognized in the field of agricultural development and action has been taken such as the Special Programme for African Agricultural Research (SPAAR) which includes a substantial effort on the collection, coordination and dissemination of research. A similar initiative is needed for fisheries research either on a regional or international basis.

What is required is the development of existing network arrangements (such as the FAO/IPFC Fish Technology Research Network) and the establishment of further networks, particularly in Africa. A general data base on post-harvest research projects and their results should also be considered. However, the fundamental issues is the need to emphasize in all funding arrangements that means must be found to disseminate the findings of research. Without this insistence the value of the research is seriously eroded.

9. WORKING PARTY MEMBERS

John Disney
Animal Products and Feeds Department
ODNRI
Central Avenue, Chatham Marine
Chatham
Kent ME4 4TB, UK

K. Gopakumar
Joint Director, CIFT
Willingdon Island, Matsyapuri PO
Cochin 682029, India

David James
Fish Utilization and Marketing Service
Fisheries Department
FAO, Via delle Terme di Caracalla
00100 Rome, Italy

Sumpeno Putro
Technical Adviser
INFOFISH
1st Floor Wisma Pkns
Jalan Raja Laut
50350 Kuala Lumpur, Malaysia

Amadou Tall
No. 32
HLM Gibraltar
Dakar, Senegal

Shun Wada
Department of Food Science and Technology
Tokyo University of Fisheries
5-7 Konan-4, Minato-ku
Tokyo 108. Japan

John Watmough
Concentrados Marinos S/A
PO Box 4441
Lima, Peru

Kevin Whittle
Torry Research Station
135 Abbey Road
Aberdeen AB9 8DG, UK

Distributors of World Bank Publications

ARGENTINA
Carlos Hirsch, SRL
Galeria Guemes
Florida 165, 4th Floor-Ofc. 453/465
1333 Buenos Aires

AUSTRALIA, PAPUA NEW GUINEA, FIJI, SOLOMON ISLANDS, VANUATU, AND WESTERN SAMOA
D.A. Books & Journals
648 Whitehorse Road
Mitcham 3132
Victoria

AUSTRIA
Gerold and Co.
Graben 31
A-1011 Wien

BAHRAIN
Bahrain Research and Consultancy Associates Ltd.
P.O. Box 22103
Manama Town 317

BANGLADESH
Micro Industries Development Assistance Society (MIDAS)
House 5, Road 16
Dhanmondi R/Area
Dhaka 1209

Branch offices:
Main Road
Maijdee Court
Noakhali - 3800

76, K.D.A. Avenue
Kulna

BELGIUM
Jean De Lannoy
Av. du Roi 202
1060 Brussels

CANADA
Le Diffuseur
C.P. 85, 1501B rue Ampère
Boucherville, Québec
J4B 5E6

CHINA
China Financial & Economic Publishing House
8, Da Fo Si Dong Jie
Beijing

COLOMBIA
Infoenlace Ltda.
Apartado Aereo 34270
Bogota D.E.

COTE D'IVOIRE
Centre d'Edition et de Diffusion Africaines (CEDA)
04 B.P. 541
Abidjan 04 Plateau

CYPRUS
MEMRB Information Services
P.O. Box 2098
Nicosia

DENMARK
SamfundsLitteratur
Rosenoerns Allé 11
DK-1970 Frederiksberg C

DOMINICAN REPUBLIC
Editora Taller, C. por A.
Restauración e Isabel la Católica 309
Apartado Postal 2190
Santo Domingo

EL SALVADOR
Fusades
Avenida Manuel Enrique Araujo #3530
Edificio SISA, 1er. Piso
San Salvador

EGYPT, ARAB REPUBLIC OF
Al Ahram
Al Galaa Street
Cairo

The Middle East Observer
8 Chawarbi Street
Cairo

FINLAND
Akateeminen Kirjakauppa
P.O. Box 128
SF-00101
Helsinki 10

FRANCE
World Bank Publications
66, avenue d'Iéna
75116 Paris

GERMANY
UNO-Verlag
Poppelsdorfer Allee 55
D-5300 Bonn 1

GREECE
KEME
24, Ippodamou Street Platia Plastiras
Athens-11635

GUATEMALA
Librerias Piedra Santa
5a. Calle 7-55
Zona 1
Guatemala City

HONG KONG, MACAO
Asia 2000 Ltd.
6 FL, 146 Prince Edward Road, W.
Kowloon
Hong Kong

INDIA
Allied Publishers Private Ltd.
751 Mount Road
Madras - 600 002

Branch offices:
15 J.N. Heredia Marg
Ballard Estate
Bombay - 400 038

13/14 Asaf Ali Road
New Delhi - 110 002

17 Chittaranjan Avenue
Calcutta - 700 072

Jayadeva Hostel Building
5th Main Road Gandhinagar
Bangalore - 560 009

3-5-1129 Kachiguda Cross Road
Hyderabad - 500 027

Prarthana Flats, 2nd Floor
Near Thakore Baug, Navrangpura
Ahmedabad - 380 009

Patiala House
16-A Ashok Marg
Lucknow - 226 001

INDONESIA
Pt. Indira Limited
Jl. Sam Ratulangi 37
P.O. Box 181
Jakarta Pusat

ITALY
Licosa Commissionaria Sansoni SPA
Via Benedetto Fortini, 120/10
Casella Postale 552
50125 Florence

JAPAN
Eastern Book Service
37-3, Hongo 3-Chome, Bunkyo-ku 113
Tokyo

KENYA
Africa Book Service (E.A.) Ltd.
P.O. Box 45245
Nairobi

KOREA, REPUBLIC OF
Pan Korea Book Corporation
P.O. Box 101, Kwangwhamun
Seoul

KUWAIT
MEMRB Information Services
P.O. Box 5465

MALAYSIA
University of Malaya Cooperative Bookshop, Limited
P.O. Box 1127, Jalan Pantai Baru
Kuala Lumpur

MEXICO
INFOTEC
Apartado Postal 22-860
14060 Tlalpan, Mexico D.F.

MOROCCO
Société d'Etudes Marketing Marocaine
12 rue Mozart, Bd. d'Anfa
Casablanca

NETHERLANDS
InOr-Publikaties b.v.
P.O. Box 14
7240 BA Lochem

NEW ZEALAND
Hills Library and Information Service
Private Bag
New Market
Auckland

NIGERIA
University Press Limited
Three Crowns Building Jericho
Private Mail Bag 5095
Ibadan

NORWAY
Narvesen Information Center
Book Department
P.O. Box 6125 Etterstad
N-0602 Oslo 6

OMAN
MEMRB Information Services
P.O. Box 1613, Seeb Airport
Muscat

PAKISTAN
Mirza Book Agency
65, Shahrah-e-Quaid-e-Azam
P.O. Box No. 729
Lahore 3

PERU
Editorial Desarrollo SA
Apartado 3824
Lima

PHILIPPINES
International Book Center
Fifth Floor, Filipinas Life Building
Ayala Avenue, Makati
Metro Manila

POLAND
ORPAN
Palac Kultury i Nauki
00-901 Warszawa

PORTUGAL
Livraria Portugal
Rua Do Carmo 70-74
1200 Lisbon

SAUDI ARABIA, QATAR
Jarir Book Store
P.O. Box 3196
Riyadh 11471

MEMRB Information Services
Branch offices:
Al Alsa Street
Al Dahna Center
First Floor
P.O. Box 7188
Riyadh

Haji Abdullah Alireza Building
King Khaled Street
P.O. Box 3969
Dammam

33, Mohammed Hassen Awad Street
P.O. Box 5978
Jeddah

SINGAPORE, TAIWAN, MYANMAR, BRUNEI
Information Publications Private, Ltd.
02-06 1st Fl., Pei-Fu Industrial Bldg.
24 New Industrial Road
Singapore 1953

SOUTH AFRICA, BOTSWANA
For single titles:
Oxford University Press
Southern Africa
P.O. Box 1141
Cape Town 8000

For subscription orders:
International Subscription Service
P.O. Box 41095
Craighall
Johannesburg 2024

SPAIN
Mundi-Prensa Libros, S.A.
Castello 37
28001 Madrid

Libreria Internacional AEDOS
Consell de Cent, 391
08009 Barcelona

SRI LANKA AND THE MALDIVES
Lake House Bookshop
P.O. Box 244
100, Sir Chittampalam A. Gardiner Mawatha
Colombo 2

SWEDEN
For single titles:
Fritzes Fackbokaforetaget
Regeringsgatan 12, Box 16356
S-103 27 Stockholm

For subscription orders:
Wennergren-Williams AB
Box 30004
S-104 25 Stockholm

SWITZERLAND
For single titles:
Librairie Payot
6, rue Grenus
Case postale 381
CH 1211 Geneva 11

For subscription orders:
Librairie Payot
Service des Abonnements
Case postale 3312
CH 1002 Lausanne

TANZANIA
Oxford University Press
P.O. Box 5299
Dar es Salaam

THAILAND
Central Department Store
306 Silom Road
Bangkok

TRINIDAD & TOBAGO, ANTIGUA BARBUDA, BARBADOS, DOMINICA, GRENADA, GUYANA, JAMAICA, MONTSERRAT, ST. KITTS & NEVIS, ST. LUCIA, ST. VINCENT & GRENADINES
Systematics Studies Unit
#9 Watts Street
Curepe
Trinidad, West Indies

UNITED ARAB EMIRATES
MEMRB Gulf Co.
P.O. Box 6097
Sharjah

UNITED KINGDOM
Microinfo Ltd.
P.O. Box 3
Alton, Hampshire GU34 2PG
England

VENEZUELA
Libreria del Este
Aptdo. 60.337
Caracas 1060-A

YUGOSLAVIA
Jugoslovenska Knjiga
P.O. Box 36
Trg Republike
YU-11000 Belgrade

RECENT WORLD BANK TECHNICAL PAPERS *(continued)*

No. 120 Plusquellec, *The Gezira Irrigation Scheme in Sudan: Objectives, Design, and Performance*

No. 121 Listorti, *Environmental Health Components for Water Supply, Sanitation, and Urban Projects*

No. 122 Dessing, *Support for Microenterprises: Lessons for Sub-Saharan Africa*

No. 123 Barghouti and Le Moigne, *Irrigation in Sub-Saharan Africa: The Development of Public and Private Systems*

No. 124 Zymelman, *Science, Education, and Development in Sub-Saharan Africa*

No. 125 van de Walle and Foster, *Fertility Decline in Africa: Assessment and Prospects*

No. 126 Davis, MacKnight, IMO Staff, and Others, *Environmental Considerations for Port and Harbor Developments*

No. 127 Doolette and Magrath, editors, *Watershed Development in Asia: Strategies and Technologies*

No. 128 Gastellu-Etchegorry, editor, *Satellite Remote Sensing for Agricultural Projects*

No. 129 Berkoff, *Irrigation Management on the Indo-Gangetic Plain*

No. 130 Agnes Kiss, editor, *Living with Wildlife: Wildlife Resource Management with Local Participation in Africa*

No. 131 Nair, *The Prospects for Agroforestry in the Tropics*

No. 132 Murphy, Casley, and Curry, *Farmers' Estimations as a Source of Production Data: Methodological Guidelines for Cereals in Africa*

No. 133 Agriculture and Rural Development Department, ACIAR, AIDAB, and ISNAR, *Agricultural Biotechnology: The Next "Green Revolution"?*

No. 134 de Haan and Bekure, *Animal Health in Sub-Saharan Africa: Initial Experiences with Alternative Approaches*

No. 135 Walshe, Grindle, Nell, and Bachmann, *Dairy Development in Sub-Saharan Africa: A Study of Issues and Options*

No. 136 Green, editor, *Coconut Production: Present Status and Priorities for Research*

No. 137 Constant and Sheldrick, *An Outlook for Fertilizer Demand, Supply, and Trade, 1988/89–1993/94*

No. 138 Steel and Webster, *Small Enterprises under Adjustment in Ghana*

No. 139 Environment Department, *Environmental Assessment Sourcebook,* vol. I: *Policies, Procedures, and Cross-Sectoral Issues*

No. 140 Environment Department, *Environmental Assessment Sourcebook,* vol. II: *Sectoral Guidelines*

No. 141 Riverson, Gaviria, and Thriscutt, *Rural Roads in Sub-Saharan Africa: Lessons from World Bank Experience*

No. 142 Kiss and Meerman, *Integrated Pest Management and African Agriculture*

No. 143 Grut, Gray, and Egli, *Forest Pricing and Concession Policies: Managing the High Forests of West and Central Africa*

No. 144 The World Bank/FAO/UNIDO/Industry Fertilizer Working Group, *World and Regional Supply and Demand Balances for Nitrogen, Phosphate, and Potash, 1989/90-1995/96*

No. 145 Ivanek, Nulty, and Holcer, *Manufacturing Telecommunications Equipment in Newly Industrializing Countries: The Effect of Technological Progress*

No. 146 Dejene and Olivares, *Integrating Environmental Issues into a Strategy for Sustainable Agricultural Development: The Case of Mozambique*

No. 147 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Asia: Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region*

No. 148 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Latin America: Studies of Uruguay, Argentina, Chile, Ecuador, and Peru*

No. 149 The World Bank/UNDP/CEC/FAO, *Fisheries and Aquaculture Research Capabilities and Needs in Africa: Studies of Kenya, Malawi, Mozambique, Zimbabwe, Mauritania, Morocco, and Senegal*

No. 150 The World Bank/UNDP/CEC/FAO, *International Cooperation in Fisheries Research*

No. 151 The World Bank/UNDP/CEC/FAO, *Tropical Aquaculture Development: Research Needs*

No. 152 The World Bank/UNDP/CEC/FAO, *Small-Scale Fisheries: Research Needs*

The World Bank

Headquarters
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

Telephone: (202) 477-1234
Facsimile: (202) 477-6391
Telex: WUI 64145 WORLDBANK
RCA 248423 WORLDBK
Cable Address: INTBAFRAD
WASHINGTONDC

European Office
66, avenue d'Iéna
75116 Paris, France

Telephone: (1) 40.69.30.00
Facsimile: (1) 40.69.30.66
Telex: 640651

Tokyo Office
Kokusai Building
1-1 Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan

Telephone: (3) 3214-5001
Facsimile: (3) 3214-3657
Telex: 26838

United Nations Development Programme

One United Nations Plaza
New York, NY 10017, U.S.A.

Telephone: (212) 906-5000
Facsimile: (212) 826-2057
Telex: 125980 UNDEVPRO NYK

Commission of the European Communities

Rue de la Loi 200
B-1049 Brussels, Belgium

Telephone: (32-2) 235 1111
Facsimile: (32-2) 235 2992
Telex: 21877 COM EUR B

Food and Agriculture Organization of the United Nations

Via delle Terme di Caracalla
00100 Rome, Italy

Telephone: (39-6) 57971
Facsimile: (39-6) 578-2610
Telex: 610181 FAO I

ISBN 0-8213-1857-8