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Fisheries and Aquaculture Research Capabilities and Needs in Africa

**Studies of Kenya, Malawi, Mozambique, Zimbabwe,
Mauritania, Morocco, and Senegal**

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

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ABSTRACT

This Technical Report contains the results of two missions. One mission deals with the state of fisheries and aquaculture research as well as research needs in four countries in Southeastern Africa: Kenya, Malawi, Mozambique and Zimbabwe. Following an analysis of relevant criteria for evaluating fisheries and aquaculture research, an account is given of the factors affecting the effectiveness of research in the four countries covered by the mission and also more generally in subsaharan Africa. A discussion of how such constraints could be addressed forms the subject matter of the next section. The Report then provides a description of a successful fishery research institution in Mozambique and analyzes the possible reasons for its success. The comprehensive annexes provide the mission's country-specific findings.

The second mission report deals with fisheries and aquaculture research capabilities and usefulness in Northwest Africa: Mauritania, Morocco and Senegal. The report starts out with a description of the importance of northwest African fisheries for national economies. It then examines research needs and priorities taking into account past experiences and research objectives. Following this, the report deals with the ways and means of developing successful research. General conclusions on the status of fisheries and aquaculture research as well as priority areas for international aid are also presented.

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

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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 reports of missions to Kenya, Malawi, Mozambique, Zimbabwe, Mauritania, Morocco and Senegal 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

ASFA	Aquatic Science and Fisheries Research Abstracts
CCCE	Caisse Centrale de Cooperation Economique, France
CECAF	FAO Committe for East Central Atlantic Fisheries
CIDA	Canadian International Development Agency
DIFMAQ	Diploma Course in Fishery Management and Aquaculture
FAO	Food and Agriculture Organization
IFAD	International Fund for Agriculture Development
ICLARM	International Center for Living Aquatic Resources Management
IDPE	Institute for the Development of Small Scale Fisheries, Mozambique
IIP	Instituto de Investigacao Pesqueira
IUCN	International Union for Conservation of Nature and Natural Resources
JFRD	Joint Fishery Research Organization
KMFRI	Kenya Marine and Fisheries Research Institute
ODA	Overseas Development Administration
SADCC	Southern Africa Development Co-ordination Conference
SIFR	Study of International Fishery Research
UNDP	United Nations Development Program
WWF	World Wildlife Fund

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**Fisheries and Aquaculture Research
Capabilities and Needs
in Southeastern Africa:
Studies of Kenya, Malawi,
Mozambique and Zimbabwe**

MISSION:

7-26 January 1990

MEMBERS:

Daniel Pauly (Leader)

Taddeus O. Acere

Chris Newton

Michel Vincke

EXECUTIVE SUMMARY

This document, an input to the Study of International Fishery Research (SIFR¹), is a report on the state of fisheries research and fisheries research needs in four countries in Southeastern Africa: Kenya, Malawi, Mozambique and Zimbabwe. It is based on field visits of a mission from 7-26 January, 1990:

Messrs. D. Pauly,	ICLARM ² , Manila, Philippines, Fishery biologist, Mission Leader,
T.O. Acere	UFFRO ³ , Jinja, Uganda, Fishery biologist,
C. Newton,	Department of Fisheries, FAO, Rome (Italy) Fisheries economist,
M. Vincke	Department of Fisheries, FAO, Rome, Italy Aquaculture biologist.

Following a brief presentation (Chapter I) of relevant criteria for evaluating fisheries and aquaculture research, an account is given (Chapter II) of the factors affecting the effectiveness of research in the countries visited and, more generally, in Subsaharan Africa. Some conventional and unconventional schemes through which such constraints could be reduced are presented. They are all structured around the concept that fishery research is a scientific endeavor, performed by skilled individuals, rather than by the institutions that employ them. Chapter II concludes with a description of an effective fishery research institution, the Instituto de Investigacao Pesqueira (IIP) in Maputo, Mozambique, and a brief tentative analysis of possible reasons for this achievement.

A comprehensive set of Annexes is provided. They give details on the mission's country-specific findings.

(i) Kenya

The ambiguous role of the Marine and Fisheries Research Institute (KMFRI) and its location in a ministry different from that of the Department of Fisheries raise questions on the effectiveness of fishery research. The research agendas and structure of KMFRI do not seem to match adequately national research needs and opportunities: although 90% of Kenya fisheries catches stem from inland waters, especially Lake Victoria, most human resources are concentrated in the Mombasa Headquarters, where "basic" research of dubious relevance to present fishery problems is conducted; at the same time, the Kisumu station on the Lake Victoria is starved of direction and means.

(ii) Malawi

The fisheries and aquaculture research conducted in that country appears appropriate, but is clearly donor-driven. It is not obvious that, in the future, local staff and funds will be available to maintain current activities. Furthermore, owing to lack of means, important research opportunities, e.g. on prospects and ways to enhance the Lake Malawi fish production, are not addressed.

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- 1 For a presentation of SIFR, the reader is invited to refer to: SIFR, 1898 - "Assessing Fisheries research needs in Developing Countries. An Approach and a Framework". First meeting of the Advisory Committee, Washington, DC, USA, 15-17 May 1989.
 - 2 International Center for Living Aquatic Resources Management
 - 3 Uganda Freshwater Fisheries Research Organization, Jinja, Uganda.

(iii) Mozambique

The number of qualified graduates staffing the various fishery research institutions in that country appear to be, besides the security situation, the major factor limiting fisheries and aquaculture research. On the other hand, the mission identified the Instituto de Investigacao Pesqueira (IIP) in Maputo as an effective fishery research institution and indicates several factors explaining its effectiveness.

(iv) Zimbabwe

The major factors limiting fisheries and aquaculture research appear to be the administrative tug of war between various governmental departments, involved in fisheries research and development, the limited supply of graduates, and the lack of a clear-cut aquaculture development plan.

(v) Uganda

An Annex on fisheries research in Uganda is added. Although the country was not visited by the mission, it is where one mission member spent his working life. National research capabilities have been severely affected by the recent political instability and violence. They still are seriously constrained by a general lack of means.

1. INTRODUCTION

MISSION PURPOSE AND IMPLEMENTATION

The present report is a contribution to the Study of International Fishery Research (SIFR⁴), whose objective is to assess: (i) the fisheries research needs in developing countries, (ii) the capacity of those countries to undertake the investigations that are needed, and (iii) ways and means to improve the effectiveness of international aid to fishery research in the Third World.

The Study assessed the research capacities of developing countries through a series of field missions. The present report presents the findings of a mission which visited Kenya, Malawi, Mozambique and Zimbabwe, from the 7th to 27th January 1990 (see Annex I for itinerary). It analyzes, in the light of the mission's terms of references (Annex II), the information collected by the authors on the state of fishery research⁵ in the four countries.

The SIFR did not undertake a census of fisheries research conducted in all developing countries. Rather, for each developing continent, two groups of countries thought to be representative of a broader region were selected. The four countries visited in Southeastern Africa include two with marine fisheries and two that are landlocked. In all of them, inland and small scale fisheries are particularly important, on both social and economic terms.

Just as the "sample" of four countries visited is intended to represent a larger region (Southeastern Africa), the information gathered during the short visits may be viewed as a small "sample" of what could have collected, had the mission been longer in the field.

In addition to relying on consensus statements resulting from various recent conferences, the mission relied on the direct experience that several of its members had of the state of research in the area to correct for unavoidable biases in its sample. Indeed, the mission did not hesitate to inject, throughout the document, its own views and interpretations, since there was no other way to make sense of the limited information collected.

The mission does not consider, however, this approach to be a questionable aspect of its work. Scientific research is complex and, thus, difficult to evaluate, guide or improve. It may well be that a subjective, but reasoned argument, will end up being more relevant than an inexperienced interpretation of a mass of quantitative data.

Criteria for Evaluating Fisheries and Aquaculture Research

The following suggestions were made ahead of this mission by Mr. Jean-Paul Troadec, SIFR Team Leader, to the Mission Leader. These may be viewed as giving focus to the mission's term of reference:

- (i) "The chief purpose of the mission is to assess the potential contribution of research to development, and the ways and means to enhance such conditions in the context of the region; it is not to assess the conditions of development as such".

4 Study of International Fishery Research: for a general presentation of the Study, please refer to the following document;

SIFR, 1989 - "Assessing Fisheries Research Needs in Developing Countries. An Approach and a Framework". First Meeting of the the Advisory committee, Washington, DC, USA, May 15-17 1989.

5 In this document, fishery research refers both to capture fishery and aquaculture research; which meaning is meant will be obvious from the context.

- (ii) "If research contributes to development, it is also an output of the latter. Conditions for effective research are difficult to create in Africa. In several countries, there has been a downfall of research capabilities. The reasons are many, some within our reach, some outside. The mission should give particular attention to these aspects and come, if possible, to innovative but sound proposals on ways (national, regional, international) to effectively strengthen African research capabilities in the field of fisheries and aquaculture".

The mission found these points rather useful and shall return to them throughout its report, and particularly in Chapter II which presents the mission's general conclusions.

Before presenting the major findings and conclusions of the mission, a brief introduction on the potential role and contribution of fisheries research to development will be given. Research needs differ between capture fisheries and aquaculture, if one goes beyond the trivially true point that research and hence, knowledge are "good things". The aim here is to narrow down the long "checklist for evaluation of research programs" provided to the mission (Annex III) and to make evaluation criteria explicit.

Fisheries

Capture fisheries exploit living and, hence, renewable resources. In the overwhelming majority of cases, fisheries resources are "common property". In many cases, they are also "open access" - i.e., fishing licenses are not needed, or available at nominal fees, or other entry limitations are not effectively enforced. Open and free access generally implies competition for the resources which, in an unregulated fishery, leads ultimately to biological and economic overfishing. The former has different effects (growth or recruitment overfishing with regard to single species, ecosystem overfishing with regard to a multispecies resource).

Economic overfishing is also multifaceted. When one considers the first boat operating in a fishery, "trouble" actually begins when a second unit starts fishing and, thus, reducing the biomass (and hence, catch/effort and, hence, economic returns) available to the first unit. The process of progressive reduction of the resource culminates when there are so many units in the fishery that fishing boats cannot manage in average to break even and fishery operators clamor loudly for subsidies (e.g., in the form of tax reductions on fuel or gear, subsidies for the renewal of fishing boats. or even in the form of more research and management).

At the level of society, trouble begins when the difference between the total revenue in a fishery and the total costs of fishing - i.e., the net economic yield or resource rent, starts to decline. Fisheries resources rents can be considerable, but are dissipated in unmanaged fisheries. This classical form of economic overfishing is discussed at length in manuals on fisheries economics. It puts emphasis on fishing units - generally an "industrial" vessel and, hence, economic returns to capital. Recently, the need has emerged, in conjunction with development conditions in poor countries, to define and use a concept of overfishing relating to what happens because of massive rural poverty and landlessness: "Malthusian overfishing" refers to the effects on coastal marine and inland fisheries of rapid increase of fisherfolk⁶ due to population growth, landlessness and internal migrations.

The points above imply a general task for public fishery research institutions to provide their paymaster, i.e., the government, technical advice for managing the country's fisheries (in order of importance):

- (i) maintaining the productivity of fish stocks since, when there is no stock left, there is no fishery, no need to bother with its optimization;

⁶ "Fisherfolk" refers to both fishermen and fisherwomen: in shallow water systems, artisanal fisherwomen and children often catch or glean a substantial part of the communities production.

- (ii) maintaining the economic profitability of the fishery: developing countries cannot afford to subsidize their fisheries - i.e., to transfer financial resources from other economic sectors to fisheries; on the contrary, because their economies are little diversified, the major source of investments available to them for developing new economic sectors and the building of infrastructure - including education or health, comes from the exploitation of their natural resources; it is, therefore, critical that such exploitation be efficient;
- (iii) matching the activities of the fishery sector with the country's overall development plan - e.g., via the elaboration of local fish processing capacities, or fish export ventures, of fisherfolk community development schemes, etc.

Some fisheries resources of Southeastern Africa appear to be underexploited - particularly in inland water bodies in which a combination of factors (remoteness, lack of suitable gear and craft, lack of markets, or insecure conditions) have affected the building of fishing capacities. To account for such cases, the above list of tasks of research institutes must also include:

- (iv) the evaluation of the potential yields of underutilized water bodies, taking the need for resource conservation into account;
- (v) the adoption and improvement of suitable fishing gear and craft combinations (e.g., through fishing trials), as well as of processing methods and marketing;
- (vi) technical assistance for the formulation of development schemes that allows a phased growth of the fisheries, and readjustments of sustained yields and corresponding levels of effort.

Aquaculture

In Africa, numerous earlier ventures have failed because they were not integrated into the rural and agricultural economy surrounding them. This observation, and the recommendations made in a number of missions and conferences reports identify the following three areas as priorities for freshwater aquaculture research in the region:

- (i) integration of aquaculture with agriculture: research on freshwater aquaculture in Southeastern Africa should have farmers as the ultimate target groups; this should be reflected in the planned schemes for fingerling supply, processing, marketing, etc.; it implies also that the relevant investigations should be performed, not only by biologists, but involve economists, rural sociologists, and experienced agricultural extension officers;
- (ii) for a successful integration of aquaculture to agriculture, farms must have readily available by-products of agricultural production (e.g., maize bran) for direct feeding of the stocked fish, or wastes (e.g., manure) for pond fertilization. Investigations on feeding protocols is a priority.
- (iii) to fulfill the above conditions, the choice of suitable species and strains, either for single species or multispecies culture, is critical; constraints in this respect come from legislation on imports, previous introductions, and the difficulties inherent in conducting genetic research; species selection and genetics are other important areas of research in support of small scale aquaculture development.

Research priorities (i.e., evaluation criteria) will not be presented for marine aquaculture (mariculture), because this sub-sector is too heterogenous to warrant such treatment. In addition, it concerns two of the visited countries only. Instead, the mission attempted to assess local needs and opportunities for mariculture research by comparison with similar systems elsewhere.

2. ON RESEARCH FOR FISHERIES AND AQUACULTURE SUPPORT IN SOUTHEASTERN AFRICA

THE STATE OF FISHERY RESEARCH

The majority of institutions in charge of fisheries research in the four countries visited by the mission (and in Uganda) do not perform the tasks outlined in the above chapter. Specifically, fishery management options are not identified and quantified, nor are fishery management plans formulated. Certain development opportunities are not investigated. As for aquaculture research, fisheries research has failed to have a local impact in all countries visited. Most fishery or aquaculture research consists of isolated projects, largely disconnected from the sectors major needs, and from the mainstream of fishery science in general.

Specific examples are given in Annexes V and VI of this document. Many reasons could be given for the apparent failure of fishery research to take root and perform a useful role in national development. In the following, we shall address some of the constraints which have contributed to the present situation.

MAJOR CONSTRAINTS

Although short, the mission was able to identify the following factors as major impediments against research effectiveness:

- (i) problematic institutional arrangements and policies,
- (ii) lack of trained personnel and questionable personnel policies,
- (iii) lack of operating funds, and
- (iv) a basic misunderstanding among most fisheries administrators of what fishery research is and can do, leading to an attitude which may be called "anti-research".

In the following section, we expand on and illustrate items (i) to (iv), above dealing with constraints to research, and then present some ideas, some conventional, some less so, which, if implemented, could help overcome these constraints.

Institutional Arrangements

Foremost among the constraints facing fisheries research in Southeastern Africa are inappropriate institutional arrangements, resulting in a lack of cooperation or even competition among governmental research institutions.

For the conduct of effective research programs, a critical mass of scientists must be built up, either within an institution or by pooling the resources from several institutions. Competition between research groups may be viewed as being one of the strength of research in developed countries. However, in developing countries with very limited scientific means, such competition cannot only have a devastating impact when it occurs between small groups, each of which is too small for a sustained qualified research effort.

In at least two countries visited by the mission, strong evidence of the crippling effect of interagency competition was observed.

One specific form of institutional cooperation that appears crucial is that between universities and the institute in charge of fishery research (or analogue) within the Department of Fisheries (or analogue).

Only in one country (Mozambique), did we find university-institute relationships leading to a positive impact on research - i.e., institute staff lecturing at the university and acting as "field supervisors" of students working on research topics related to fisheries.

In the other countries visited by the mission, there appears to be a serious communication gap between universities and fishery research institutions, ranging all the way down to the perception that the universities function essentially as playgrounds for would-be Ph.D.s and whose "basic" research is by definition irrelevant to fisheries research and management - or national economic development for that matter.

Personnel

The four countries visited by the mission do not suffer from the same personnel problem as far as junior technical staff is concerned. Thus, Kenya, whose university has been producing aquatic biology graduates for quite a while, has a much larger pool from which to recruit fishery research personnel, than Zimbabwe or especially Mozambique, where graduates are a rare and precious commodity, carefully allocated between different government departments, and nurtured by those departments which received them.

However, all the four countries visited by the mission suffer from the same dearth of Ph.D.-level scientists contributing on a sustained basis to the scientific and development literature.

The extent to which this problem is addressed, or even recognized, varies considerably between and within the various countries visited, ranging from the view that Ph.D.-level research is "useless" to a clear recognition of this problem, matched by well-structured programs of staff development.

From this diversity of views, the mission concluded that the SIFR should be wary of simply restating the need for "more" personnel, but that it should deal instead with the more thorny issue of the development of top-level researchers, and of the institutional, career, financial and other arrangements which would enable fisheries research institutes to attract and retain good scientists. This point explains why the report deals at some length, further below, with the Instituto de Investigacao Pesqueira, in Maputo, Mozambique, and the need to support individual scientists, rather than the institutions that house them.

One aspect of personnel development that may appear as a side issue, but is still worth mentioning, is the retirement age of scientists. It can be as low as 50 years in some countries of the region visited by the mission. Certainly, such early retirement of experienced, well-trained staff should not be mandatory, and the option should exist for such staff to continue to be productive, at least into their 60s.

Funding

One doesn't really need a field mission to know that funding for fisheries research may be too low in Southeastern Africa for investigations to be effective, since this is a situation prevailing throughout the developing world.

Some important points specifically relevant to this report are:

- (i) Over 30 countries in Africa are implementing structural readjustment programs promoted by the World Bank, the IMF, and other international agencies. These programs are designed to improve the output of the productive sectors, particularly exports, while emphasizing fiscal restraints through cuts in public expenditures on health and social programs, primary education, research and higher education. Some governments have openly declared that education and research are not priorities in their development programs.

- (ii) Fisheries research receives a very small share of the national budgets and also from the donor agencies, given that about 50% of the animal protein consumed in the area covered by the mission comes from fish.
- (iii) The separation of fisheries research institutions from the sectoral fisheries ministries forces donors to deal exclusively with the national fisheries departments for the identification and funding of research projects. These arrangements are not operational and have led to continuous losses in scientific leadership and personality conflicts.

Anti-research Attitudes

The strong words in this heading are used to describe a mind set, encountered among several fisheries administrators in the countries visited by the mission, which not only do not appreciate the potential contribution of research to the sector development, but actually cripple research by assigning its execution to non-scientific personnel (technicians, extensionists), providing marginal means to research investigations and then blaming "the researchers" for not delivering anything useful.

The mission found this attitude quite widespread among fishery administrators, and considers this mind set to be one of the key reasons why fishery research is not progressing in the region and contributing to the sector's economic progress. The problem is compounded by the ease with which one can - at the verbal level - distinguish between basic (i.e., "useless") and applied (i.e., "useful") research.

Indeed, most of the mission's interlocutors condemned "basic" research for its utter uselessness, which "our country cannot afford", and stressed the need for "practical and useful research", such as needed "to feed our growing population". These are ritual incantations which hide the key feature of fishery research as presently conducted throughout the region - i.e., the fact that it is largely bad research, conducted in isolation from the mainstream of the relevant scientific disciplines and based on paradigms and methods that are often several decades old.

When poorly conducted, "applied" research which aims to develop implementable solutions is as "useless" as decidedly basic research. Basic research that deals with long-resolved issues is, on the other hand, probably less instructive than high school science experiments.

The key issue here is that contemporary fishery research, whether basic or applied, ought to be quantitative - i.e., refer to state and/or rate variables whose values are estimated from appropriate fisheries data - and relevant - i.e., address to major opportunities and constraints for economic and social development. Computers needed to perform quantitative analyses appear to be available throughout most institutions in the region. KMFRI, for example, has six in its Mombasa headquarters (but only one at Kisumu). The reason why quantitative analyses are not performed in sufficient numbers, and/or are not of adequate standard, is related to the lack of high calibre scientists who could guide their younger colleagues into such analyses.

The IIP of Maputo has partly resolved this problem by maintaining close contacts with experts abroad, and by inviting them to review its research programs. Schemes of this type ought to be promoted throughout the region. This would imply new modes of operation for some research institutions and some donors.

THE NEED TO SUPPORT INDIVIDUAL SCIENTISTS

The Logic

For representatives of donor institutions which aim at supporting research in developing countries, it is natural to support research institutions

Thus, laboratories are built, equipment purchased, and reports then written which document how research has been boosted. However, research is conducted by individuals. Somebody has to see a need for a given piece of investigation, formulate a hypothesis, and design an experimental protocol and a sampling scheme. Somebody has to conduct the experiments or to collect the samples. Somebody has to analyze the data. Somebody has to interpret them and write up the conclusions, and make sure that the report is appropriately published and disseminated. "Anonymous", the most common author in the scientific literature, has never been shown anywhere to be capable of doing any of these tasks. Only real persons can actually conduct these tasks.

The notion that improving research institutions is sufficient for improving research implies that the heads of institutions in question are really interested in seeing their younger staff conduct investigations and publish findings. But often enough, this is not the case.

Indeed, the preponderance of senior scientists as authors of scientific publications and their near-exclusive access to international scientific gatherings is one feature by which active and productive research institutions in many developed countries differ from those in developing countries. Clearly, there is a role there for external donors to support the professional development of young researchers.

Potentially Useful Support Schemes

A tool that could be used to augment the output of fishery researchers in the region is individual research fellowships, such as those granted by the International Foundation for Science or the Asian Fisheries Society Research Fellowship Awards. An equivalent African Fisheries Research Society does not exist yet.

The following paragraphs, reproduced from a brochure of the Asian Fisheries Society, provide some details on this scheme:

"Fisheries Science in Asia"

Active fisheries research in Asia began less than half a century ago and scientific data and publications from this research are limited. An analysis of recent publications in the Indo-Pacific region reveals that only one-fifth of the overall literature consists of scientific articles, the majority of which deal with taxonomy, distribution, ecology and other biological topics. Biotechnical and socio-economic research work is scanty. There is little significant measurable impact of fisheries research on fisheries development at the present time. The lack of clear direction in conducting strategic and basic research to resolve fundamental problems encountered by the industry and inadequacy in research design and methodologies are two of the major causes. These issues need to be addressed if Asian fisheries scientists are to be in the forefront of the industry.

"Asian Fisheries Society Research Fellowship Scheme"

The Asian Fisheries Society Research Fellowship Scheme has the sole objective of upgrading the quality of research of young fisheries scientists in developing nations in Asia. Research fellowships will be awarded each year to a limited number of deserving young scientists to enable them to conduct well-designed, properly planned research which will produce measurable outputs and add to the wealth of scientific knowledge of relevance to fisheries development.

The Society encourages young scientists to embark on hypothesis-based, problem-oriented fisheries research with technical assistance from members of a Panel of Scientific Advisers - eminent senior scientists of the Society, whose functions are to critically assess research progress of the awardees and to provide technical advice. Proposals are examined by a Research Proposal Review Committee, consisting of senior scientists in the region. The Committee reviews applications each year to assess

and approve new applications or renewals. The Review Committee also monitors research progress of Research Fellows and recommends ways to improve the Research Fellowship Scheme.

One of the visible outputs of the scheme is the development of a pool of professionally trained, scientifically oriented fisheries scientists made up of alumni of the Research Fellowship Scheme. It is hoped that this group of scientists will grow in number and make positive contributions to fisheries research in the region. Outstanding Research Fellows whose research work could lead to further work can be recommended by the Society for additional financial support from other donor agencies.

"The Fellowships"

Young scientists from nations in Asia are invited to submit research proposals for funding under the Scheme. Awarding of fellowships is based on the nature and quality of the research proposals on a competitive basis. Research projects should be up to one year duration. Extension of research fellowships is possible for another year for longer projects and/or pending satisfactory performance but not for more than a total of two years. The amount awarded will depend on the research proposal but will not exceed US\$10,000 per year. The selected scientists will be able to obtain regular advice and assistance from at least two senior scientists whose field of specialization can help improve the research work of the selected candidate. A member of the Review Committee or the Panel of Scientific Advisers may visit the Research Fellow to assess and assist the progress of the research. Fellows are expected to publish their Asian Fisheries Science. Outstanding Fellows may also be selected to present their work at the triannual Asian Fisheries Forum.

The main target applicants are new Ph.D. or M.Sc. graduates. Applications from postgraduate students doing research work leading to the Doctor of Philosophy or Master of Science degree are also welcome.

"Criteria for Selection"

The proposed study must meet the following criteria:

- scientific merit,
- significance to fisheries research & development,
- uniqueness or innovative nature.

Competence of proponents is likewise considered and research capability of mother agency (in terms of existing research facilities, etc.)

A similar scheme would be immensely useful in the African context, in which research funds are even scarcer than in Asia. As might be noticed, the fellowship scheme illustrated above is operated by a professional society, the Asian Fisheries Society. Africa would immensely benefit as well from a well-organized stable professional society, which would eventually run a scientific journal meeting international standards (as does the Asian Fisheries Society, whose journal, called "Asian Fisheries Science", is now in its third year).

Remarks on Academic Fellowships

Some remarks regarding academic fellowship to degree-granting institution are also appropriate.

Students from African countries are encouraged to seek higher degrees in Europe and North America, and sometimes in Asia. However, some of the receiving institutions are not really capable of fully accommodating the students they receive. To offer optimal conditions, receiving institutions should:

- (i) have at least one permanent faculty with a professional interest in tropical fisheries research;
- (ii) allow students from developing countries to return to their respective countries for field data collection - i.e., not involve them in research projects of local interest, e.g., on salmon or cod;
- (iii) have limited, or staggered residence times, which fully take into account the course work performed by the students before they started their studies abroad.

Justifications of the first two points are self-evident, although they are often overlooked. The last point is particularly important for students from developing countries who tend to be older than their counterparts in developed countries, and who are frequently married. In the case of married women (especially those with small children), residence time in excess of a semester at a time is not feasible, a feature often ignored in planning curricula, which thus, unintentionally discriminate against married women.

SOME NEW ARRANGEMENTS FOR SUPPORTING FISHERIES RESEARCH

Research Contracts

While some of the fishery research institutions and international arrangements supporting fisheries research in the four countries visited do appear to work, future improvements of fishery research in the region would depend on new arrangements. Research contracts are an example of such arrangements. None of the research institutions in the region appears to execute research investigations on contract for third parties (e.g., parastatal agencies, or the private sector). On the other hand, most research institutions in developed countries have such contracts, and seek to augment their contribution to their total budget.

International funding agencies should investigate the possibility of supporting African fisheries research institutions through allocation of research contracts. This would be particularly appropriate in those countries where basic equipment is available, but is not maintained due to lack of operating funds.

On the part of the donor agency, such contracts would involve:

- (i) the identification of worthwhile research projects and of the basic requirements for their execution;
- (ii) the assessment of proposals from the research institutions potentially capable of executing the contracts;
- (iii) the provision of scientific supervision - e.g., via scientific consultants, and auditing of expenditures.

Beyond the research findings, the key output of such contracts would be that the group of researchers completing the contract would have learnt to perform in a project-oriented environment, in which concise, defensible results must be presented within a certain time frame.

Changed Status for Research and Development Projects

Another example of new arrangement that could usefully be considered would be for externally funded fishery research and development projects to enjoy in the host country a status similar to that of private firms which can recruit their own staff. This would allow the research projects, which would have to extend over a period of at least a decade, to qualify and motivate their staff irrespective of civil service regulations. Such research staff, upon completion of the project, would join either the government service, universities,

consulting firms, or NGOs, for which there is a great need in Africa where governments monopolize all science-related activities.

On Recruiting Non-biologists to Do Fisheries Research

In several countries visited by the mission, the supply of biology graduates is one of the factors hindering fisheries research, and prospects for increased supply of qualified hydrobiologists and fishery biologists in the next decades is not necessarily bright. This statement has two implications.

First, fisheries research institutions in the region should begin to enlarge the scope of their research agendas, and hire social scientists - especially resource economists and sociologists. As described in Chapter I, because fisheries and aquaculture research aims at enhancing the sector contribution to national economies, it needs to have an important social science component which can be addressed competently only by social scientists. This component has largely been overlooked so far. This has resulted in imbalances in research agendas which must be redressed.

Second, fisheries institutes should also consider hiring engineering or other graduates with a strong quantitative background for positions in fisheries research. The reason for this suggestion is that engineers usually have a much better background in applied mathematics and use of technical apparatus than fishery/aquatic biologists. This enables them to absorb quickly the important quantitative elements of fishery science, something which is not easily done by fishery biologists, whose output is often descriptive and of limited use for resources management. This applies also to aquaculture research, in which zoologists predominate. This suggestion is derived, among other things, from the observation that one of the leading fisheries research institution in the world, Denmark's Marine and Fisheries Research Institute, has a significant number of scientific staff with backgrounds in engineering and related disciplines.

A FUNCTIONING LABORATORY: THE INSTITUTO DE INVESTIGACAO PESQUERIA IN MAPUTO (MOZAMBIQUE)

Among the research institutions that the mission visited, the Instituto de Investigacao Pesqueira (IIP) in Maputo, Mozambique, is performing the bulk of the tasks that can be expected from a functioning fisheries research institution (see Chapter I). Some of the factors of the IIP success are discussed, since they give clues on ways and means to improve fishery research effectiveness in developing countries.

Institutional Aspects

IIP is placed directly under the Subsecretariat for Fisheries (SEP) which is the sole body in charge of fisheries assessment, development and management in Mozambique. In several of the other countries visited, the responsibility for fishery research and that for management are in distinct departments of the same ministry, or even in different ministries, and coordinating mechanisms are weak or non-existent.

Assigned Tasks

IIP's task of assessing the (marine large scale) fisheries of Mozambique is clear and undiluted by subsidiary tasks, such as performing biological oceanographic research, or dealing with pollution issues. This is in stark contrast to Kenya Marine Fisheries Research Institute in Mombasa.

Staff Education and Cohesion

The senior scientific staff consists of a group of colleagues who have studied and graduated together, and to whom the departure of Portuguese researchers following independence has offered unique opportunities for professional development. They have thus stayed at the Institute, while gradually picking up increasing responsibilities. This group now provides the Director, other senior staff, and leaders of key research projects. They also serve as mentors for junior staff.

Financial Incentives

IIP staff salaries are not particularly high. However, they are competitive with other job opportunities in the country. Moreover, the Institute has an ongoing program to provide cars for senior staff, and this appears as a strongly motivating factor, considering the lack of alternative options to acquire vehicles in Mozambique. Staff can also effectively attend workshops and conferences abroad, as well as shorter training courses.

There is an ongoing fellowship program for all staff to acquire additional degrees and this includes Ph.D.'s (the first Ph.D. candidate will probably be leaving for the U.K. in 1991).

There appears to be no discrimination against females. Indeed, the senior staff of IIP consists predominantly of females. This is in strong contrast to other institutions visited by the mission, where women were largely invisible or held traditional roles (secretaries, clerks, etc.).

External Contacts

Another clearly identifiable factor for the success of IIP is the quality of the professional advice it received from NORAD. Particularly notable were:

- (i) the scientific competence of the experts that were sent from Norway and who did their job, together with their Mozambican counterparts;
- (ii) the integrity of those experts, who did not take the opportunity to use the consultancy in Mozambique to further their own research interests, but rather concentrated on the problems that were considered key issues in Mozambique.

The Lesson to be Learned

The case of the IIP illustrates that, while external support may still be important for an African institution to thrive, key factors for effectiveness in research include:

- (i) support to well-trained, properly paid individual scientists to do their job well;
- (ii) institutions with a clear mandate, in close contact with the fishery sector, and free from a tug-of-war with agencies in other governmental departments.

Annex I Mission Itinerary

Date	Kenya	Malawi	Mozambique	Zimbabwe
Jan. 06	Pauly			
07	Newton, Pauly			
08	Pauly	Newton		
09	Pauly	Newton		
10		Acere, Newton		Pauly
11		Acere, Newton		Pauly
12		Acere, Newton		Pauly
13		Acere, Newton		Pauly
14		Acere, Newton		Pauly
15		Acere, Newton		Pauly, Vincke
16		Acere, Newton	Pauly, Vincke	
17			Pauly, Vincke	Acere, Newton
18			Pauly, Vincke	Acere, Newton
19	Acere, Newton		Pauly, Vincke	
20	Acere, Newton			Pauly, Vincke
21	Acere			Pauly, Vincke
22	Acere, Pauly, Vincke			
23	Acere, Pauly, Vincke			
24	Acere, Pauly, Vincke			
25	Acere, Pauly, Vincke			
26	Acere, Pauly, Vincke			
27	Acere, Vincke			

Annex II

General Terms of Reference of Missions to Assess Countries Research Capacities

A - Terms of Reference

The assessment will cover the following aspects:

- relevance of research programs;
- means available: staff, equipment, budget;
- status of scientific personnel: salaries, role;
- cooperation (and mechanisms for) with the:
 - scientific community - national level (basic, agricultural, food research, ...); regional level (fisheries research); international level (advanced institutes, universities);
 - national administrations (fisheries, environment, agriculture, plan);
 - national fishing industry (harvesting, farming, processing);
 - small-scale fishing communities;
 - development and aid agencies.

The assessment will cover national institutes, regional centers, regional cooperative mechanisms.

B - Mission Composition

Each mission will include in principle:

- 1 biologist (fisheries or aquaculture),
- 1 technologist (fishing or fish technology),
- 1 economist,

of which one will be from the country(ies) to be visited.

C - Places to Visit

- Ministries in charge of fisheries and research,
- Directorates of fisheries,
- Planning administration,
- Fisheries and agriculture research institutes,
- Food technology research institutes,
- Regional research institutes,
- Regional fisheries bodies.

D - Missions

- Morocco, Mauritania, Senegal;
- Kenya, Malawi, Mozambique, Zimbabwe;
- Ecuador, Chile, Peru;
- Argentina, Uruguay;
- India;
- Indonesia, Malaysia, Philippines, Thailand;
- Small island states.

Annex III

Checklist for Evaluation of National Research Agendas

1 - Description of current and future research programs

1.1 - Current programs

- Description of current research activities; costs, manpower, duration;
- Changes over past activities and reasons for changes;

1.2 - Future research activities, planned and anticipated

- Short run;
- Long run;

1.3 - Evaluation

- Adequacy between research programs and research needs;
- Relative importance, applied and innovative research;
- Research strategy;
- Allocation of topics between public institutions and private sector;

2 - The formulation of national research programs

2.1 - Sources of ideas

- Internal thinking;
- Exchange of ideas with potential research users (administrations, industry, small-scale fishing communities, international aid agencies);
- Exchange of ideas with the foreign fishery research community through regional and international mechanisms, with the national scientific community (universities, agricultural research, food technology institutes.);

2.2 - Processes for formulating and adopting national research programs and their funding:

- Internal mechanisms, including programs and staff pre and post evaluation procedures;
- External mechanisms with the funding administrations;

2.3 - Existence of national long-term fishery and research policies.

3 - The implementation of research programs

3.1 - Means

- Staff
 - number, distribution by disciplines;
 - training of scientists and technicians;
 - recruitment capacities;
 - status;
- Budget
 - investments and operating funds;
 - outside resources;
 - long term funding guarantees;

- Equipment
 - computers;
 - laboratory equipment;
 - research vessels;

3.2 - Data base

3.3 - Research effectiveness

4 - The transfer and use of research findings

4.1 - Formal structures and mechanisms for transmission to users

- National administrations;
- Industry;
- Small-scale sector;
- Potential investors;
- Aid agencies, etc.;

4.2 - Actual use of research findings

4.3 - Causes of lack of effectiveness

- Relevance;
- Inadequacies of mechanisms and media.

5 - Regional and international cooperation

5.1 - Regional cooperation

- Areas: scientific cooperation, management of shared stocks;
- Existing mechanisms: effectiveness and weaknesses;

5.2 - International cooperation

- Areas: institution building, development of new research disciplines, scientific back-stopping;
- Forms of cooperation: training abroad, local projects, cooperative programs, consultancies, funding (including equipment);
- Effectiveness and limitations.

6 - Ways and means to improve research contribution

6.1 - Internal capabilities

- Means and status of research;
- Administration of research (programming, evaluation, procedures);
- Cooperation with national scientific community (e.g., as a way to strengthen innovative targeted research in countries where fishery research institutes can only have limited medium and long term research capabilities);

6.2 - Use of research

- Completing the expertise of research users to increase their capacity to use research findings;
- Developing cooperative mechanisms between each kind of user and research institutions;

6.3 - Strengthening regional and international cooperation in research

- Issues which could be better investigated at regional or international levels;
- Need for regional research activities:
 - scientific library and fishery research magazines;
 - dissemination of information to potential users
 - joint research programs - networking;
 - regional research institutions;
 - international research institutes, by fields;
- Mechanisms to improve N/S cooperation
 - twinning arrangements, exchanges of scientists;
- How to improve the use of international aid (multi and bilateral).

Annex IV Names and Affiliations of Contacted Persons

A - Kenya

Mr. N. Odera	Director of Fisheries, Ministry of Regional Development
Mr. P.N. Kamande	Deputy Director of Fisheries, Ministry of Regional Development
Mr. B.W. Oduor	Assistant Director of Fisheries (Marine)
Mr. J.O. Keoro	Planning Officer, Ministry of Regional Development
Mr. R.M. Nzioka	Deputy Director, Kenya Institute of Marine and Fisheries Research
Mr. Peter Eigen	Resident Representative, The World Bank
Mr. John MacGregor	The World Bank, Nairobi
Dr. Edgardo C. Quisumbing	The World Bank, Nairobi
Mr. Larry K. Ngutter	National Program Officer, UNDP

B - Malawi

Mr. S.B. Alimoso	Department of Fisheries
Mr. J.H. Magasa	Department of Fisheries
Mr. N. van Zalinge	FAO
Mr. John Balarin	ICLARM/GTZ Malawi Project
Dr. Barry Costa-Pierce	ICLARM/GTZ Malawi Project
Mr. Dennis Tweddle	Overseas Development Administration (UK)

C - Mozambique

Mr. M. Sulemane	Director, External Relations, Secretary of State for Fisheries
Mr. Joaquin Russo de Sa	Director, Marine Fisheries Management, Secretary of State for Fisheries
Mr. David Sumbana E.	Chief, Human Resources (Division), Institute for the Development of Small Scale Fisheries

Ms. Christina Silva	Director, IIP
Mr. Fernando Laforte Ribeiro	Aquaculturist, IIP
Ms. Barbara Palhade Sousa	Fisheries Biologist, IIP
Ms. Lizette Palha de Sousa	Fisheries Biologist, IIP
Mr. Rui de Paula e Silva	Fisheries Biologist, IIP
Ms. Maria Celeste Gasper Mondego	Director, Biology Faculty, Eduardo Mondlane University
Mr. Agostinho Pontes	Chief of Finance Division, Societad de Fomento Pesqueiro
Mr. Nils O. Tcheyan	Resident Representative, the World Bank
Mr. Hugo Eloy Garcia	Mozambique/Nordic Agriculture Program
Mr. Oscar do Porto	Improvement of Salted Fish and Dry Fish Production, FAO project TCP/MOZ/8953

D - Zimbabwe

Mr. R. Fenner	Director, Department of Research and Specialized Services, Harare
Mr. Pazvakavamba	Director, Department of Agricultural Extension, Harare
Mr. G.N. Pangeti	Assistant Director, Department of National Park and Wildlife Management, Harare
Mr. S. Chimbuya	Chief Ecologist, Department of National Park and Wildlife Management, Harare
Dr. J.M. Gopo	Chairman, Biological Sciences Department, University of Harare
Ms. Fortune Feresu	Graduate student in fish genetics, Biological Science Department, University of Harare also National Parks and Wildlife Department
Dr. B. Marshall	Department of Biological Sciences, University of Zimbabwe, Harare
Dr. James H. Howard	University of Zimbabwe Frostburg State University (Maryland, U.S.A.)
Mr. C. Nobbs	Chief of Animal Husbandry, Agritex
Dr. C. Machena	Officer-in-Charge,
Lake Kariba	Fisheries Institute, Kariba
Mr. J. Langeman	Manager, Kariba Prawn Farm, Kariba

Dr. D. Lewis	Project Coordinator, Zambia-Zimbabwe-SADCC Fisheries Project, Kariba
Mr. H. Masundire	Graduate student, University of Zimbabwe Kariba Research Station
Mr. P.K. Pohland	Deputy Resident Representative, World Bank Mission, Harare
Mr. W.C. Chidawanyika	Program Officer, World Bank Mission, Harare
Mr. Jan Winderickx	Senior Program Officer, FAO, Harare
Mr. A. Andreasson	Project Manager, Aquaculture for Local Community Development Program, Harare
Mr. B.A. Haight	Aquaculturist, Aquaculture for Local Community Development Program, Harare
Mr. Felipe Butlig	Support of Small Holder Irrigation Project, DANIDA
Mr. C.J. Nugent	FAO/UNDP, Harare

Annex V

Mission Findings by Countries

1. KENYA

GENERAL BACKGROUND

Kenya has an area of 582 644 km², and ranges from 34°E to 41°E longitude and from 4°N to 4°S latitude, straddling the Equator. Kenya has about 640 km of coastline, but a very narrow shelf, not extending beyond 50 miles at the widest point. Of the shelf area, 3224 km², i.e., 11 092 km², are trawlable. This area compares to that of freshwater lakes in Kenya (10 900 km²) which, however, provided over 90% of the total national fish production (131 000 tonnes in 1987).

In Kenya, fisheries and aquaculture research is handled mainly by the Kenya Marine and Fisheries Research Institute (KMFRI), which presents itself as follows:

"The Kenya Marine and Fisheries Research Institute was established in 1979 by the Science & Technology (Amendment) Act, and was charged with the responsibility of carrying out Scientific Research in the field of Marine and Freshwater Fisheries, Aquatic Biology including Environmental and Ecological studies, marine research including Chemical and Physical Oceanography. The research programs of the Institute are divided into two major groups namely the marine sector research and freshwater sector research.

The main objective of the marine sector situated at Mombasa is to collect and consolidate all available fishery resources data. In addition and with realization of the importance of environmental factors the Mombasa Laboratory carries out research programs on the physico-chemical parameters. Of particular importance is research on the effects of pollutants of hydrocarbon origin on the environment and associated animal life. Other research activities include coastal aquaculture, particularly the cultivation of shrimp in aquaria. This work includes *Artemia* production with aid from Belgium. The Biological Oceanography Program which is a Kenya/Belgium Cooperation covers biological and chemical studies of the inshore waters, mangroves ecosystems as well as oyster culture in the creeks.

Few major coordinated continental shelf programs are being undertaken, yet these are the type of programs that are important in making scientific advances and assisting in the management of near shore resources. Few deep-sea projects are being carried out because of lack of ocean-going research vessels.

The freshwater sector has two major Laboratories, Kisumu and Turkana, and two sub-stations of Kisumu, namely Sangoro and Gogo Falls. In Kisumu Laboratory, research programs have been directed towards the biological studies of fishes in Lake Victoria. Environmental studies particularly in the rivers which enter the Lake and are subject to a lot of pollution are being carried out. It is also in Kisumu laboratory where a project has been lodged to utilize the by-products of Nile perch. The established substation Sangoro on River Sondu is involved in breeding techniques of the most important species especially *Labeo* and *Barbus* spp.

The Turkana station at Lake Turkana is carrying out aquaculture studies on tilapia at the shores of the lake with aid from NORAD. Limnological studies are also incorporated in the aquaculture project."

FISHERIES RESEARCH

The information presented in this section was obtained in three meetings, in Nairobi and Mombasa, with representatives of the Department of Fisheries (Ministry of Planning and Development) and of KMFRI. It

may be mentioned that the first of these discussions began with a reference to a recently conducted mission by a Nordic donor, whose representatives talked "only with volunteers", and not with "real experts". The mission was told that it could write what it wanted, but that it should be helpful and not criticize.

The view given of fisheries research in Kenya was extremely positive. Thus, the mission was told that there is an abundance of well-trained graduates, and both the Department of Fisheries and KMFRI have the means to hire them at salaries (equivalent to US\$ 225/month for a B.Sc. degree holder) that are competitive with those offered by universities (and higher than those of civil servants). Also, the promotion of young scientists is based on their publication output, and support is provided for publication in foreign journals, attendance of conferences abroad, etc.

Coordination between the Department of Fisheries - the user of fisheries research findings - and the KMFRI - the provider of such results - is assured via a committee which meets every three months, or through ad hoc meetings when required. The major factors hampering fishery research were reported as "lack of equipment" and "lack of operating funds".

The picture presented to the mission appears too optimistic. Indeed, the mission found various aspects of Kenyan fishery research to be quite problematic, ranging from its very definition to the institutional set up to the distribution of research activities.

At the conceptual level, fishery research was repeatedly described by Department of Fisheries representatives as something that can and should be done by extension officers, as a "practical" side aspect of their extension work. University-based "academic" research, on the other hand, was described as what academics do "to get their Ph.Ds", utterly irrelevant to development or extension.

This conception of research is probably due to the ambiguous role played by KMFRI, which attempts to deal with both "basic" aquatic (oceanographical and limnological) and with "applied" fishery management-oriented research. Because of this dual role, KMFRI does not contribute as much as might be wanted. Indeed, by monopolizing resource the way it does, KMFRI may be hindering the growth of an effective fishery research capability in the country.

This is particularly evident with the marine (fisheries) activities. The following quote, relating to the significance of a research project from a list of current KMFRI projects, illustrates this point:

"Little is known of the systematics and ecology of tropical planktons in East African waters, which is necessary for understanding primary and secondary productivity and hence, vital for managing the fisheries resources".

The Mombasa office of the KMFRI is the host institution of RECOSCIX-WIO, an information project supported by Belgium and the IOC for "Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean Region", and essentially devoted to the dissemination of abstracts extracted from the ASFA (CD ROM disk version). It will be interesting to see if this will lead to the KMFRI researchers now initiating research activities on topics that are current and relevant to the Kenyan fisheries.

The only quantitative evaluation of the Kenyan marine resources potential conducted to date stems from NORAD and other foreign-sponsored activities. With regard to the freshwater sector and the explosive growth of the Lake Victoria Nile perch fishery, this development was, and still is, driven by the private sector, with little research input from KMFRI.

Indeed, locating the headquarters of a fishery research institution where less than 10% of the catch is taken, and maintaining only a branch at Kisumu where nearly 90% of harvests take place, is indicative of a serious imbalance in the research agendas.

There is a lack of effective mechanisms for transmitting research requirements to KMFRI. The coordinating committee mentioned above, where the "Directors meet to coordinate research" does not appear to have met in the last three years. Also, KMFRI researchers appear to interact rarely with fishermen and boat operators, and very few of their current research projects are based on data collected from an existing fishery.

AQUACULTURE RESEARCH

Freshwater aquaculture research started in Kenya during the colonial period, with the introduction of trout (*Salmo gairdneri* and *S. trutta*) from 1910 to 1921. Experimental work with indigenous species (*Tilapia nigra*) was initiated later, in 1924.

At present aquaculture research, both in freshwater and marine sectors, comes directly under the responsibility of KMFRI, even though some applied research activities are in progress at the freshwater Sagana Fish Culture Station, under the Fisheries Department of the Ministry of Regional Development.

Some investigations are conducted at the Kenyatta University, Nairobi. At the University of Nairobi, the Department of Zoology and the Gecaga Institute of Fish Endocrinology have research programs in aquatic biology, fisheries and aquaculture. There are also ongoing programs on improvement of tilapia strains for aquaculture and also trials on rice-cum-fish culture. The University of Nairobi uses the facilities at the Sagana Fish Culture Station for the implementation of its field experiments.

The major activities in freshwater aquaculture research are taking place in the KMFRI substations at Kisumu and Songoro on Lake Victoria, and Kalokol on Lake Turkana. Songoro is the main Freshwater Aquaculture Centre, since the Kisumu station is mainly involved in the study of the Lake Victoria fisheries and the Nile perch limnology, and the Kalokol Station with the Lake Turkana fisheries.

Research activities at the Songoro Station are related to induced breeding of *Labeo victorinus* and *Clarias gariepinus*, and feed formulation using Nile perch processing wastes and Azolla weed.

The UNDP/FAO project KEN/77/014 "Development of Coastal Aquaculture" has set up in 1978 the first experimental coastal shrimp farm at Ngomeni, near Mombasa. Culture trials and experimental hatchery operations were carried out during the period 1978-1985 on *Penaeus indicus* and *P. monodon*.

Globally, the results of aquaculture research in Kenya are meager. Both the University of Nairobi and KMFRI have little field facilities for aquaculture research. Collaborative arrangements between the University of Nairobi, the Department of Fisheries and KMFRI exist, but it has proven difficult to coordinate a single program involving all these institutions, notably because facilities are widely distributed. No coordinating mechanism appears to exist at present to ensure the smooth running of combined collaborative programs within the country. The Sixth National Development Plan (1983-1993) indicates some broad policy objectives, but there is no national plan for aquaculture development.

The need for a national plan for aquaculture development, identifying research needs, both in freshwater and marine sectors, is obvious. The lead in these matters should be taken by the Fisheries Department who has the primary responsibility for fisheries and aquaculture management and development in the country.

Considering research needs, a comprehensive aquaculture research program should be prepared under the leadership of KMFRI, but in very close collaboration with the Fisheries Department, the University of Nairobi and the Lake Basin Development Authority (LBDA), making use of all aquaculture research facilities available in Kenya.

During previous FAO missions, aquaculture research priorities were identified as follows:

- (i) refinement of techniques for the production of tilapia fry and all-male tilapias;
- (ii) nutrition and feed formulation;
- (iii) development of integrated crop-livestock-fish culture systems;
- (iv) improvement of pond fertilization practices and use of compost;
- (v) trials on polyculture of tilapias and *Clarias gariepinus*.

Fisheries and aquaculture training is given in the Naivasha Wildlife and Fisheries Training Institute. The institute was built with a World Bank Loan and has very good physical facilities. The Institute offers basic courses for Game Rangers and Fish Scouts, certificate courses for Fisheries and Game Assistants, and Industries courses for new graduate Fisheries Officers and Assistant Game Wardens. The Institute had proposed to run a Diploma course in fisheries management and aquaculture (DIFMAQ), but this proposal has not been implemented so far. The syllabi of both the certificates and diploma courses in fisheries management, include aquaculture as one of about ten subjects covered.

While the Institute has good physical facilities at the main campus, the fisheries complex off the campus is not yet developed. The laboratories and library are well-designed, but have no adequate equipment. The library has very few books on fisheries and aquaculture matters. The personnel available do not have adequate qualifications for running a full fisheries program, and one in aquaculture.

There is no other training or retraining facilities in fisheries in the Department of Fisheries, even though there is a need for training at all levels. The extension work would be improved by such training. The Sagana fish farm has the best field facilities in the country, but because available accommodation and laboratory facilities are insufficient, those are not fully used. However, the Sagana farm has recently conducted some local training courses in aquaculture at the lower level. This should be encouraged. Staff trained at ARAC could be assembled at Sagana to conduct effective training courses and short-term programs. If technical facilities, staffing and accommodations were improved, studies on applied aquaculture research could be conducted at Sagana.

The University of Nairobi gives aquatic biology and fisheries/ aquaculture oriented training at the B.Sc. and M.Sc. levels. There are a few competent staff to teach these programs. Again for training in aquaculture research, field facilities are 80 km away from Sagana.

2. MALAWI

GENERAL BACKGROUND⁷

Malawi is a land-locked country with an area of 118 484 km², of which waters extend over 24 405 km². The 1987 fish production was estimated at 88 000 tonnes, of which 80 000 came from the traditional fishery and 8 164 from commercial operations. Recorded fish exports and imports are negligible. The above production is a record high, the highest since the 1972 peak of 84 000 tonnes, after which it kept declining to the lowest level of 51 300 tonnes in 1981. In the early 1980s, production stabilized between 62 000 and 65 000 tonnes, to reach 72 800 tonnes in 1986. The variations in production levels seem to reflect normal fluctuations in stock reproduction, perhaps influenced by climatic conditions - notably rains as far as the floodplain fishery is concerned. On the other hand, fluctuations may also be enhanced by heavy fishing pressure.

The bulk of production comes from Lake Malawi, whose largest portion is under Malawi's jurisdiction. Other important water bodies include Lake Chilwa (2 500 km²), Lake Malombe, Lake Chiuta, and the Shire River and its flood plain. Lake Chilwa dries out almost totally during certain years, but becomes exceptionally productive on refilling. With such large water areas, fisheries play an important role in the national economy.

Total catches from the Lake Malawi fisheries are stable. They are still as in the 1970s when trawling and intensive fishing with ringnets and other gears started. Catches per unit of effort have, however, declined, and changes in the species composition of harvests have taken place. The Labeo fishery has disappeared with the decline of the species.

In purely economic terms, fisheries contribute some 4% to the national GDP and give permanent employment to some 20 000 artisanal fishermen, and a further 1 000 in the commercial sector. Another 20 000 people work ashore as fish traders, boat builders, net makers and in other support industries. The fishing industry is the major occupation along the lakeshore and other major fish producing areas such as Lake Chilwa. Despite the contribution fish makes to the GDP, the development budget allocated to fisheries was only 1.3% of the Government's total expenditures for the years 1984-1986.

The fisheries sector falls under the responsibility of the Fisheries Department. The Department was created in 1965 under the Ministry of Forestry and Natural Resources. The Department is headed by a Chief Fisheries Officer (CFO) stationed in Lilongwe, supported by an Assistant Chief Fisheries Officer, a Principal Fisheries Officer, two Fisheries Officers and several technical and support staff. Compared to the neighboring countries, the Malawi's Department of Fisheries has a relatively substantial cadre of professional and technical staff.

HISTORICAL BACKGROUND ON FISHERIES RESEARCH

The first fishes from Lake Malawi to be collected and preserved date from the expeditions of Dr. Livingstone. Prior to 1939, research on the lake fisheries was restricted to taxonomic studies of preserved collections in natural history museums. In 1939, the first fisheries survey of the lake was conducted.

The next study on the "Chambo" tilapia fisheries was a survey of the southeastern arm of Lake Malawi, conducted in 1945-47.

In the 1950s, emphasis shifted to northern Lake Malawi where the Joint Fisheries Research Organization (JFRO) of Northern Rhodesia (Zambia) and Nyasaland (Malawi) established the Nkata Research Station in

⁷ Adapted from SADCC/EEC Regional Fisheries Survey. Final report. Gopa Consultants (1989).

1954. A major report on the initial studies from 1954-55 included hydrological data from the lake and affluent rivers, studies on invertebrates, an annotated checklist of the fishes, and notes on ecological zonation, observations on the biology of commercially important fish species, results of experimental fishing programs and descriptions of traditional fisheries. A detailed study of "Mbuna" (rock-dwelling cichlids) was also conducted at that time.

Investigations continued at Nkata Bay until 1962, when laboratories were created at Monkey Bay. Results of the Nkata Bay studies (hydrology, planktivorous "Usipa" - biology and fishing experiments) are published in the JFRO annual reports.

At Monkey Bay, early investigations were conducted on the biology of "Nchila" and "Kampango". Extensive gillnetting trials were carried out. Research on trawling started in 1968 and successful techniques were developed. The exploitation of virgin stocks of cichlid species previously unknown justified taxonomic research and investigations into cichlid biology. Data collected from 1968 onwards proved valuable when detailed stock assessment studies were later undertaken by FAO.

Since 1966, the Fisheries Department research section actively participated in a 10-year Lake Chilwa Coordinated Research Project, a multidisciplinary University of Malawi study on the Lake Chilwa ecosystem.

EXTERNAL SUPPORT TO RESEARCH

Project for the Promotion of Integrated Fishery Development Stock Assessment Program (1972-76; funding: UNDP; implementation: FAO)

Recommendations made on trawl catch and effort levels have enabled the fishery to be successfully managed since the project was completed.

The traditional fisheries were surveyed in detail and a functional recording system established in 1976; it is still in use. Investigation into the ringnet fishery for "Chambo" tilapia was conducted and potential yield assessed.

Investigations of environmental effects of the proposed Chintche pulp mill were started in this project and continued in 1977-82, in the follow-up FAO project.

Fisheries Extension Project (1977-82; funding: UNDP; implementation: FAO)

This project aimed at establishing a reasonable forecast of the pelagic fish stocks and their potential yield in Lake Malawi, and continued investigations into the environmental effects of the proposed Chintche pulp mill.

The overall findings were that the pelagic fish resources in the northern lake are insufficient to support a large mechanized fishery and that much of the production was going into lake flies rather than fish.

Traditional Fisheries Assessment Project (1986; funding: Overseas Development Administration (UK)/Malawi Government)

Aerial and ground coverage check surveys were conducted for the whole of Lakes Malawi and Malombe and the linking Upper Shire River.

Fishing programs and detailed chirimila and seine net surveys were conducted to obtain baseline data for future monitoring of changes in the fisheries.

Papers on "Usipa" and "Chambo" fisheries in the southern area were published, and experiments in gillnet selectivity conducted.

Demersal Fisheries Assessment Project (1989; funding: ODA and the Malawi Government)

This was a repeat of the experimental trawling surveys of the early 1970s, using identical gear at the same stations, to reassess the biomass of the trawl-caught cichlids and determine if any changes have taken place in the intervening period. Investigations on the species composition of catches to assess the effects of the increase in minimum mesh size introduced in 1977 are being undertaken.

Ornamental Fish Trade Assessment Project (1975-83; funding: South Africa)

The results of this study have led to several recommendations - i.e., a closed season; not more than three licenses with no overlap in licensed areas; quota restrictions for certain popular but vulnerable species; prohibition of introduction of species to areas where they do not occur naturally; establishment of ornamental fish farms; phasing out of exploitation in Lake Malawi National Park.

The research revealed that approximately 200 species of "Mbuna" (Haplochromines) occur in Malawi waters. Most of them have very restricted distributions and are, therefore, vulnerable to over-exploitation. The great diversity of species on any rock habitat is maintained by resource partitioning between the species. It is not a result of super abundance of food as previously believed.

Conservation of Threatened Fish Communities in Lake Malawi National Park (1984-86; funding: IUCN/WWF)

It appeared that no single endemic species of "Mbuna" was in immediate danger of extinction, as a result of introduction of exotics. It is probable that, in time, a state of equilibrium will be reached in terms of the exotic-endemic balance.

This research project is being followed up by a development and extension project in the park.

Bangula Lagoon Study (1975-76; funding: ODA)

The study examined most aspects of the lagoon ecology - i.e., hydrology, vegetation, soils, algae, water chemistry and zoobenthos, substrate zoobenthos, invertebrate fauna and the food of fish, fish-eating birds and fisheries. It was concluded that Bangula Lagoon represents a complex ecosystem which undergoes profound seasonal changes in water volume and quality. Local fishermen have responded with ingenuity to changes in fish populations that are well exploited. Productivity is considerably increased by the presence of 3 000 heads of cattle in the area.

Feeding Ecology of Cormorants on Lake Malawi (1978-81; funding: ODA)

This was a study of the feeding ecology of the cormorants in the southern part of Lake Malawi, and a determination of the impact of the cormorant population on exploited fish stocks. Approximately 10 000 cormorants were estimated to live on Lake Malawi, consuming about 1 000 tonnes of fish per year. However, there was no reason to suppose that cormorants have appreciable impact on commercial fishing, as carried out at present on Lake Malawi.

It was recommended that improved protection be given to the cormorants and their habitat, with local fishermen firmly discouraged from cutting down the bird-nesting trees, because of the attraction of the bird colonies to lakeside tourists.

Other Externally Funded Projects

Other investigations have been conducted, under various sources of funding, on various aspects of Lake Malawi ecology. They include:

- the ecology of fishes of the sandy shores of Lake Malawi;
- zooplankton studies;
- fish taxonomy;
- electrophoresis;
- interactions of fish and snail populations, etc.

FISHERIES DEPARTMENT RESEARCH PROGRAMS UNDERTAKEN WITH EXTERNAL FUNDING

Lower Shire Fisheries Research Project (1970-78; funding: Malawi Government and ODA

The research into the biology of the fishes of the Lower Shire River and marshes revealed that of the 62 species recorded by Tweddle and Willoughby (1977), three make up 90% of the fishermen's catch.

The ecology of the important commercial fishes revealed that populations are strongly influenced by environmental factors and the operation of the barrage at Lilonde on the Middle Shire River. Recruitment is influenced by the degree and extent of flooding in the rainy season as the two catfishes, *Clarias gariepinus* and *C. ngamensis*, which make up 75% of the commercial catches, spawn in flooded grasslands and marsh vegetation. Thus, high river levels and consequent large expanses of flooded terrain yield large catches in subsequent years. There are two peaks in the catch per year.

Karonga Baseline Survey (1978-81; Funding: Malawi Government and ODA

The research program at Karonga, the northern part of Lake Malawi, covered all fisheries aspects in the area. Gillnetting experiments showed generally low catch rates, correlating well with estimates obtained for the traditional fisheries by the beach recording system. The gillnet fishery for the migratory "Mpasa" (*Opsaridium microlepis*) around the mouth of the North Rukuru River area demonstrated a gradual build up in catches during the rainy season to a peak at the end of the rains in April and May. Catches in this localized fishery were greatly underestimated by the current recording system.

Few areas in the north could sustain a commercially viable operation.

Shallow water pair-trawling is uneconomical in the area because of the limited area available. However, deepwater trawling using the fisheries research vessel "E. Trewavas" gave more encouraging results.

Lake Chilwa Coordinated Research Project (1966-76; funding: Leverhulme Trust/University of Malawi/MG/ODA/WENELA/...)

Three species out of 30 positively identified in the Lake Chilwa catchment area are important in the lake's catches and the ecology of these species have been studied in detail.

The recovery of the fish populations after total dessication of the open lake in 1968 was extremely rapid with catches reaching former levels after three years, a cycle which was repeated after the less severe lake recession in 1973. The fish population are, therefore, highly resilient and can clearly sustain heavy fishing pressure.

A shallow water pair-trawling technique was developed. Pair-trawling was initially successful, but has since become uneconomic as rises in fish prices have not kept pace with increased fuel and engine maintenance costs.

The results of this research are being used in the planning and implementation of a fisheries development project for the Chilwa/Chiuta Basin.

ONGOING INTERNAL RESEARCH PROGRAMS

Commercial Fisheries Studies

This program is effectively the long-term continuation of commercial fisheries assessment following on from the UNDP/FAO Project (# 2.3.1 above). Catches of commercial fishing firms are monitored and stock assessments carried out for determining effort quotas on a regular basis.

Breeding seasons are staggered and, hence, regulation of effort by imposing a closed season during the peak breeding season is not feasible. Other results covered the influence of newly-introduced small-meshed gear on commercial "chambo" catches; the influence of lake level changes and changing gear efficiency on "chambo" catches; and general reviews of "chambo" biology and of Malawi's fisheries.

Taxonomic Research

The taxonomy of the Lake Malawi cichlid fauna is extremely complex and the present best estimate for the number of species occurring in the lake is between 500 and 1 000. A major step forward has been achieved with the publication of a recent revision of all the known haplochromine cichlids. The *Lethrinops* species of importance in the trawl industry in the south have been described. But, still, many species of other genera remain to be formally described. Confusion in the naming of fish for the aquarium trade has been tackled, and the genus *Labidochromis*, with its species, has been described. The genera of "mbuna" have been revised and new groupings proposed. Further studies on "mbuna" taxonomy are being conducted in other institutions.

"USIPA" Studies

A considerable amount of data has been collected on the fluctuations of fisheries in the Monkey Bay area. However, the information on the pelagic zone of the lake remains to be analyzed.

Lake Chiuta Studies

Data on physical characteristics, water chemistry, vegetation, plankton, fish and fisheries collected on a number of brief visits, have been published.

A haplochromine species discovered during an electrofishing survey of the lake has been formally described as *Astatochromis tweddlei*.

"Mpasa" (*Opsaridium microlepis*) Research Program

The general biology (breeding habitats, growth rates, etc.) of "mpasa" is now fairly well known. However, information is still lacking on juveniles in the transitional stage from riverine/inshore to offshore habitats and on the impact of the fisheries on the breeding success and migrations of both adults and juveniles.

Investigations, undertaken following the drastic declines in catches in the early 1970s, have shown that catches are closely related to river levels, both in the year of capture and in the year when the fish were spawned. A succession of high rainfall years has led to excellent catches and very healthy stocks in the rivers in the 1980s. The need for clean gravel and well-oxygenated running water for spawning illustrates the importance of the Nkhotakota Game Reserve in protecting the "mpasa" spawning grounds in the Bua River. It was recommended to conserve the wooded catchments of the important "mpasa" rivers - e.g., the Linthipe/Lilongwe, Bua, Luweya, North Rukuru and Songwe Rivers.

Fisheries Bibliography Compilation

A list of all scientific papers, books and reports ever published on all aspects of Malawi waters was compiled to provide a primary source of reference for all future research. The bibliography contains over 1 700 references. New references are added to a file to be published periodically in the future.

River Fisheries

Information is collected, as opportunities arise, on the fish and fisheries of lesser known rivers in Malawi.

Anadromous Fisheries Study

Preliminary investigations have been made into the run of migratory cyprinids up the Nkhandwe Stream near Monkey Bay when the stream is in flood. A trap has been made which has proved successful in catching migrating fish, despite torrential flood conditions. Although "nchila", the main target for the proposed cyprinid aquaculture project, has not yet been reared, another cyprinid "tamba" (*Barbus litamba*) has been successfully reared to fingerling size.

AQUACULTURE RESEARCH

The Malawi center for aquaculture is in Domasi, 15 km from the town of Zomba. There are 45 employees of all categories; three of them are expatriate researchers.

A project funded by the Federal Republic of Germany (GTZ) and implemented by ICLARM is also based at Domasi. This project, "Research for the development of tropical aquaculture technology appropriate for implementation in rural Africa", has two components: one is directed towards the growing of two native tilapiines and *Cyprinus carpio* in low tropical environments; the second towards trout farming in the colder waters of the upland areas.

Facilities include staff offices, a student laboratory, a food store, a storeroom, a garage, and a storage compound. The new research facilities consist of 36 x 200 m² ponds in a securely fenced area, 36 x 5 m² bioassay tanks and 78 x 500 l experimental tanks. Pond construction was done manually. The task force of 100 laborers was drawn from the local community. The workers gained experience in pond building during the six-month construction period, a skill which may benefit them as aquaculture expands in Malawi. The library houses the Africa Aquaculture Information Component of ICLARM's Selective Fisheries Information Service, which is coordinated from Manila. Telefax communication and Aquatic Science and Fisheries Abstracts (ASFA) on CD-ROM have been installed to facilitate speedier communication and responses to enquiries from African researchers. In 1989, an ICLARM librarian spent eight months organizing fisheries information systems and training national librarians. A considerable quantity of scientific literature has been distributed through the project to African researchers and libraries.

These developments have turned the DEFF into one of Africa's leading aquaculture research centers.

In May 1981, ICLARM signed a cooperative linkage agreement with the University of Malawi. The first joint endeavor was the establishment of a Master's level scholarship scheme. Four students were registered with the Biology Department and one with the Sociology Department at Chancellor College. Their thesis research projects complement the main program underway at the DEFF and they gain valuable hands-on experience. This cooperative linkage agreement has also facilitated a number of collaborative studies with University staff. Data gathered as background information to help in the formulation of these various studies will be used in the context of a monograph to be published in 1990 by ICLARM and GTZ.

As of February 1990, ICLARM has three professional aquaculture staff members in Malawi, two based in Zomba/Domasi and one at the Bunda College of Agriculture. Other aquaculture activities in Malawi includes a recently initiated major project supported by the Commission of European Communities in the northern region and projects by Nordic countries in cooperation with the SADCC, the Malawi Fisheries Department, Lilongwe, and the University of Malawi.

CONSTRAINTS IN FISHERIES RESEARCH

There is a major manpower shortage. Presently, five scientists are currently doing research on Lake Malawi. Three of them are Malawi citizens, the other two are expatriates. Two others Malawian researchers are undergoing training. There are 20 technicians and/or technical assistants.

There is a drain on the research staff as researchers are transferred to carry out administrative duties for the Fisheries Department. Salaries for local research scientists are very low compared with those paid to those teaching in the university. This results in a lack of continuity in staffing, leading to recurrent recruitment and training.

The price control imposed on the sale of fish hinders the collection of catch statistics.

The lake fisheries have been well nurtured through the "conservation" ethic of the Department's Ministry. The creation of national parks around the watershed areas of the lake have provided protection for the fisheries, and the country's attitude toward wildlife protection as undertaken by the Ministry applies also to fisheries. This is further demonstrated by Government policy prohibiting the introduction of non-native fish species. There are, however, conflicts between logging and watershed preservation potential, and a new one has emerged with the pulp mill project.

Much of the knowledge on the fisheries has been acquired through research, which can be credited for the successful way those are managed, but the infertility of the northern lake remains an outstanding area for research. Although there is a national awareness of the role that research has played, and can play, necessary means have not been provided for by Government. In fact, historically, most research inputs came from donors and expatriates and one would have liked to have seen an increase in national capacity

to undertake such research. It is, of course, recognized that scientific skill is a scarce commodity in many developing countries and this is particularly the case for a small country such as Malawi.

The water space in the northern part of the lake is unproductive, although ranching or cage growing could, in terms of space, offer development significant opportunities. Investigations directed at determining the limiting factors that cause the situation in the northern part of the lake would offer significant economic benefits. However, such task is clearly beyond the existing research capacity of the Department, as well as beyond current levels of aid.

Perhaps, fisheries science is presently beyond the capacity of this country, in which case donor support will be required if the limiting factors of the northern part of the lake are to be properly identified. This will become especially important when the IMF structural adjustment programme requires reductions in civil service staffing, which is intended to be met by lowering retirement age to 50 - in effect removing both the fisheries research officers at Monkey Bay who will be 50 next year.

FISHERIES ADMINISTRATION

Within the Ministry of Forestry and Natural Resources, the Department of Fisheries is one of five departments. The others are forestry, parks and wildlife, geology, and mining. The staff in the Department of Fisheries is small: there is a Chief Fisheries Officer, with a Deputy and an Assistant Chief Fisheries Officer. The Deputy is responsible for statistics and administration, whereas the Assistant coordinates the three senior fisheries officers who are each located in a region and are in effect the regional officers. The remaining staff are fisheries technicians and administrative category staff.

Although staffing for the fisheries administration was not provided to the mission, it is clear that the scientific requirement for the lake is not accorded much priority and that less than a minimum cadre of research officers is provided. This can be understood within the context of a stable, well managed fishery whereby most of the duties for managing the fishery are of an administrative and routine nature.

However, there is no career advancement within the research arm of the Department. Officers can only receive career advancement in the administrative side of the unit. The Chief Fisheries Officer is in fact a former research officer. Given this level of staffing for fisheries research, the donor community continues to provide necessary support to research for the lake, ODA consistently, and more recently FAO.

There was, unfortunately, no time to visit an agricultural research station to compare with Monkey Bay in order to evaluate government policy toward agricultural research in general, and compare staffing and operational budgets.

CONCLUSIONS

The so far successful maintenance of the commercial and traditional fisheries catches is a direct result of past and present research efforts. Statistics are regularly collected on the commercial fisheries, as well as on the traditional fisheries (since 1976). Their analysis provides a sound basis for management.

There is no inter-governmental mechanism for managing the lake's resources, since Mozambique, disrupted by war, has little fishing effort. This is also the case for Tanzania which, due to the boundary with Malawi following the northern shoreline, should, in theory, not have access to the lake's resources.

Whereas limnological observations commenced with earlier research efforts, it is regrettable that these have not been maintained, given the potential benefits to be gained from developing production in the northern part of Lake Malawi. Perhaps in time, as agricultural practices intensify, nutrient loading of the lake from agricultural run-offs may enhance production.

Foreign support has sustained fisheries research for a considerable period of time. However, part of the funds have been used to cover the costs of expatriate researchers, while insufficient attention was given to the promotion of national expertise. This shortcoming should not be repeated in the provision of foreign assistance for the promotion of aquaculture research.

3. MOZAMBIQUE

GENERAL BACKGROUND⁸

The history of fisheries in Mozambique can be separated into two phases, the periods before and after independence. Whereas a subsistence fishery has been existent for a long time, the large scale fisheries only date back to the late 1950s when commercial operations began to increase very slowly under the colonial order (trawling in Mozambican waters was then prohibited, the supply of fish being based on imports from Angola and Portugal).

No Mozambicans were involved in the development of the commercial (mainly shrimp) fisheries which started in 1965. All activities within the sector (i.e, the fishing, the service industries, sale and distributions, etc.) were operated and managed by Portuguese or other foreign interests. The collapse of the fishery sector was therefore inevitable when Portuguese emigrated massively after independence.

The Mozambican rejuvenation of the fishery sector began in 1976, with the formation of an incipient fisheries administration within the Ministry of Industry and Commerce. From its start, the administration faced a number of acute problems such as a restoration of the commercial fisheries and other basic subjects - legislation, stock assessment, fisheries education, development of artisanal fisheries, etc.

In the early 1980s, the fishery administration had managed to implement a basic reorganization of the sector, which was reflected in steadily increasing catch figures. Within the last years, further national and international efforts have been made to secure a continuous development of the sector, which has gained even more economic and nutritional importance after independence.

Fishery resources of Mozambique are estimated to be able to support an annual catch of approximately 300 000 tonnes, of which 40 000 may stem from fresh waters. The country also has a good natural potential for aquaculture, both marine and fresh waters.

Since 1977, a number of surveys have been made to assess the marine fish resources of Mozambique. Vessels from the USSR, GDR, Norway and FAO have participated and the work has mainly been concentrated on the continental shelf and slope. No surveys have so far been made of the shallow waters (10 meters depth), amounting to some 3-4 000 km² and which are mainly exploited by artisanal fishermen and, to some extent, by the shrimp fleet.

The continental shelf (down to 200 m) covers an area of about 70 000 km². Most of the shelf is in the central and southern part of the country. In the north, the shelf is very narrow, often only a few hundred meters wide, coral-edged and with submarine canyons. Off the mouth of large rivers, the shelf receives considerable quantities of silt.

The relatively warm waters of the Mozambican current have lower primary production than upwelling regions, such as off West Africa and South America. Still, there is potential for increasing the catches of fish from the present 70 000 tonnes.

Mozambique has one of southern Africa's largest lake and river systems, amounting to 20 000 km² (lakes 60%, rivers 25% , and flood plains 15%). The largest lake, Lake Nyassa (i.e., Malawi, see # II above) covers an area of more than 30 000 km², of which 6 500 km² is under Mozambican jurisdiction. The coastline in Mozambique (approximately 400 km) is very different from that in Malawi, as there is almost no shelf on the Mozambican side.

⁸ Based on "Nordic Support to the Fisheries in Mozambique. A Sector Study". National Swedish Board of Fisheries, Gothenburg, 1986.

The second largest lake is the man-made one of Cabora Bassa, which covers an area of 2 700 km² and has a coastline of 1 000 km. There are also many other lakes and some large rivers - the Zambezi, Rovuma and Limpopo, of respectively 820 km, 650 km and 560 km length in Mozambique.

Fish catches from the Cabora Bassa were estimated (1982) at 4 300 tonnes of table fish. 1 200 fishermen are operating. The average yield is, thus, ca 350 kg/fisherman/year. Based on calculations and experiences from other African lakes and inland waters, the Mozambican inland fishery potential yield is estimated at:

Water Bodies	Potential Yield	Present Catch (1985)
Lake Cabora Bassa	10 000 t (37 kg/ha)	2 000 t
Lake Nyassa	10 000 t (13 kg/ha)	2 000 t
Other areas	20 000 t (18 kg/ha)	1 000 t
Total	40 000 t (20 kg/ha)	5 000 t

The most important commercial groups include: *Alestes*, *Clarias*, *Engraulicypris*, *Entropheus*, *Haplochromis*, *Hydrocynus*, *Labeo*, *Lethrinops* and various *tilapias*.

FISHERIES RESEARCH

The Instituto de Investigacao Pesquiara (IIP)

In Mozambique, fisheries research is conducted exclusively by the Instituto de Investigacao Pesquiara (IIP), which was created 15 years ago as a Portuguese "overseas mission". Its present staff was recruited in two batches: in 1975, as a group now representing the senior staff, and in 1980. They all have "licenciatura" - i.e., a thesis degree acquired after five years of study in general biology, with a marine biology orientation in the final (thesis) year.

Four IIP technicians were trained in Cuba. Of these, one was subsequently trained in Bergen.

The mandate of the Institute covers both marine and freshwater (e.g., Cabora Bassa Lake, Lake Nyassa). Small freshwater bodies are kept by default under the authority of the Department of Agriculture, but may be put under that of the Subsecretariate of State for Fisheries (SEP) and, hence, can be studied by IIP wherever requested. Presently, the IIP does not appear to be interested in expanding its research into such water bodies, however.

The IIP headquarter is in Maputo, with branch laboratories in Beira (biological and statistical data collection, some works on shrimps) and Quelimane (statistical data collection). IIP is structured in five divisions:

- (i) Oceanography,
- (ii) Resource assessment,
- (iii) Aquaculture,
- (iv) Documentation publication,
- (v) Electronic Data Processing (Computer).

The resource assessment Department is by far the most important. Its activities are divided into site-specific (e.g., "Maputo Bay") or resource-specific (e.g., deep-water shrimp) projects, of which there are about half a dozen.

The IIP sees its main role in providing advice for fishery management. Its advice is provided in the form of assessments updated twice a year for major fisheries, plus annual catch quotas for the national joint venture and foreign vessels. Quotas have been rather stable since 1985.

For the highly valuable coastal (penaeid) shrimp fishery, which produce 7-8 000 t/year, a longer (plus one month) season has recently been proposed, along with an increased mesh size; results are still pending. This fleet discards its (fish) by-catch.

For deep-water shrimps, which support a 3 000 t/year fishery but for which detailed stock information is lacking, the assessments are still strategic, not operational. Effort (increasing 10-15%/ year) and catches are closely monitored (by onboard observers).

Demersal food fishes are caught off Mozambique by two fleets, (i) the MOSOPESCA and (ii) four GDR trawlers operating near Beira. The latter's operation is part of a cooperative agreement with the Fishery Research Institute in Rostock, which has outposted one of its staff member in Beira.

The IIP obtains the data it needs for assessments from (i) logbooks supplied to the fleets, (ii) observers' catch records, and (iii) port landing records. (Tasks (ii) and (iii) are conducted by institute staff with primary school education.)

The observer program is presently being intensified. Also, a new fishery law is being formulated which will transfer all authority concerning fishing operations from the Department of the Merchant Marine to the SEP and to fisheries "holdings" (= "combinados", see later).

Licensing of foreign firms will be completely phased out by 1992-1993, and all fishing firms operating along the Mozambique coast will be national firms, or joint ventures (at least 51% Mozambican). This implies renegotiations with firms from the German Democratic Republic, South Africa, the Soviet Union and other countries.

Up to now, the IIP has not operated a research vessel (although it has access to and sometimes uses the "Canopus", a small vessel formerly operated by FAO and now belonging to a nautical school). This decision was deliberately taken by the institute which preferred to make, instead, maximum use of ships of opportunity. This decision may now be revised, and NORAD's offer of a small research vessel may be accepted, although a sharing arrangement with Tanzania and Angola (plus Namibia, eventually) in the framework of SADDC may also be considered. Ships of opportunity included a number of Soviet and East German vessels, as well as the R/V Fridtjof Nansen, whose various surveys off Mozambique represent milestones.

For the Oceanographic Department, working up data from ships of opportunity (i.e., preparing data volumes and maps) still represents the main activity. Indeed, the only field-based activity appears to be a small project on the physical and biological oceanography of Maputo Bay (an earlier field-based activity, conducted by a Norwegian scientist, allowed the establishment of a relationship between the outflow of the Zambezi River and shrimp catches off Mozambique).

The Oceanographic Department presently consists of Mr. Antonio Mubangco Hogueane (who will soon leave for Bangor, Wales, U.K. to obtain a first degree in Physical Oceanography), Mr. Domingo Zafanias Gue (a tuna biologist) and Mr. Jan-Erik Steen who will leave the IIP in late 1990 or 1991. This section may become temporarily inactive when Messrs. Mubangco and Steen leave Maputo. Physical oceanographic work, although it is assumed that it will become useful ultimately, is not perceived as urgent, and a lull of activity, thus, not considered to be a great loss. Eventual reinitiation of activity may be around the processing of remote sensing data (SPOT imagery).

All equipment purchases abroad are via NORAD. Interestingly, the IIP's allocation for equipment tends to remain underutilized, because of the Institute's emphasis on analysis of fisheries data and on data from ships of opportunity.

Study groups and laboratories devoted to biological oceanographic studies (e.g., plankton studies, or studies on the food and feeding habits of exploited species) are entirely absent at IIP. This makes this institution unique among fishery research institutions in Southeastern Africa (as compared to KMFRI in Mombasa notably).

Scientific priorities are determined by the institute staff in conjunction with SEP. They generally correspond to the assessment of opportunities to develop new fisheries.

The quality of investigations is controlled via:

- (i) national seminars, where results are presented, with external experts invited (next seminar planned for early 1991);
- (ii) involvement of knowledgeable researchers from abroad (i.e., scientifically credible experts), especially from Norway, Denmark and Portugal (and never in contexts where conflict-of-interests situations could emerge);
- (iii) regular publications by staff of cruise reports, data volumes, description of fisheries and other documents (in Portuguese);
- (iv) regular publications of scientific contributions in English (in the Rev. Invest. Pesq. and starting soon in international journals).

Perceived problems in research are related to:

- (i) the reluctance of national fishing companies to supply detailed catch data (this is a problem of IIP which does not insist strongly enough on these data, probably because it may not really have the staff to process them all);
- (ii) the observers' program needs strengthening (it is not only a cost problem; there are not enough graduates for the available observers' positions).

The Institute for the Development of Small Scale Fisheries

The Institute for the Development of Small-Scale Fisheries (IDPE) depends also on the SEP, but is devoted to the management of small-scale fisheries (as opposed to the IIP, which basically looks only at the large scale sector).

The history of this relatively new institution is quite convoluted and needs not be recalled here. Important is perhaps the fact that it emerged from the split of a previous entity devoted to all aspects of small-scale fisheries - ranging from the provision of infrastructure to the development of gear and improved fishing and processing methods. This all-encompassing approach was abandoned in 1987, in the frame of the Economic Rehabilitation Program. The operational aspects of small-scale fisheries are now concentrated in "holdings", which organize various groupings of small-scale fishermen (there appears to be about one holding per province, but their successful operation or even existence is very doubtful, given the present security situation in all but a few areas of the country).

The mandate of the IDPE appears to be one of extension and coordination. However, the institution appears to be more or less completely adrift, and clearly followed no comprehensive plan. Indeed, the

small-scale fishermen's development activities presently conducted in Mozambique appear to be determined largely by various bilateral agencies and NGOs. Various projects are implemented in different parts of the country on motorization schemes, fish processing, community development, and IDPE is unable to coordinate or even to monitor these activities. IDPE receives no input from research, which is very regrettable given that first signs of Malthusian overfishing (see Chapter I), with attendant resources and habitat destruction as well as conflicts with the commercial fisheries, are beginning to appear along the Mozambique coast.

The Department of Biology in the E. Mondlane University

The education of personnel for IIP and for other fisheries-related institutions is the task of the Department of Biology in the Eduardo Mondlane University, the only university in Mozambique. The University, which now has 2 800 students, was closed between 1980 and 1985, because of a lack of students from the secondary school sector. The first batch of graduates produced since 1985 will soon be released. Of these, five (1/3) will be retained as faculty members of the Biology Department. The Department teaches in the following areas:

- (i) marine and fisheries biology;
- (ii) agriculture, wildlife and forestry;
- (iii) health and microbiology.

A full study course consists of four years of theoretical and practical studies, plus one year devoted to writing a thesis. Some students are from neighboring countries, having been sent under bilateral agreements. The Department of Biology presently has four research projects. Of these, four are funded by SAREC (Sweden) and NORAD (Norway):

- (i) marine ecology of Inhaca Island,
- (ii) flora of Mozambique (plus seed exchange project),
- (iii) mangrove ecology,
- (iv) ecology of terrestrial habitats of Inhaca Island.

AQUACULTURE RESEARCH

Freshwater Aquaculture

Freshwater aquaculture research started in Mozambique in the beginning of the 1950s on a very small scale. The aim of this research was to test local species for pond fish farming, but the results were not documented.

Three freshwater fish farming stations were constructed by the colonial administration to stock ponds and reservoirs, using the indigenous *Oreochromis mossambicus* and *T. rendalli* (= *T. melanopleura*).

Initial attempts to develop freshwater fish farming through stocking small dams, reservoirs and ponds were undertaken at the end of the 1950s by large-scale commercial farms, missions and commercial enterprises. All these activities, and particularly research, came to a standstill in 1975, at the time of independence when the Portuguese research personnel left the country.

In 1978-79, the government expressed a renewed interest in freshwater fish farming, particularly as a means to supply fish to rural populations suffering from animal protein deficiency and beyond the reach of existing marine and freshwater fish distribution networks. Under the authority of the SEP, two experimental fish farms were rehabilitated at Umbeluzi (Maputo Province) and Sussundenga/Chizizira (Manica Province), and development research reinitiated.

The main research topics were:

- (i) reproduction techniques of *O. mossambicus* and *O. niloticus* (the latter species was introduced from Kenya in 1981);
- (ii) pond culture of *O. mossambicus* and *O. niloticus*, integrated with animal husbandry (pigs and ducks).

At the same time, fry production for small-scale fish farmers and cooperatives was initiated, and fish farmers and extensionists trained.

Since the government policy gave agriculture production the highest priority, fish farming was, in 1983-1984, considered as a secondary activity and became more or less neglected, particularly in state farms and cooperatives.

In October 1984, the freshwater fish farming was transferred from the SEP to the Agriculture Ministry (Departamento de Piscicultura (DdP), under the National Directorate of Animal Husbandry or DINAP). Since 1985, the IIP takes care only of marine aquaculture. However, research both in marine and in freshwater is still the responsibility of the IIP. Research programs are prepared by the IIP in cooperation with DINAP.

Due to the insecurity prevailing in large parts of the country, freshwater aquaculture research is only carried out at the Umbeluzi Experimental Fish Farm. Some experimental work is done on reproduction of *O. niloticus* and induced spawning of common carp (*Cyprinus carpio*) which was introduced from Zimbabwe in 1986.

Mariculture

Mariculture research started in Mozambique only in 1977, with the experimental culture of the mussel *Perna perna* in the bays of Maputo and Inhambane. Growth rate was between 7 and 9 mm/month. Insufficient spatfall was the main constraint for commercial production, and trials are presently conducted at IIP to artificially produce spat in laboratory conditions. Since 1985, the SEP has given mariculture a high priority.

IIP research aims at promoting investment by the commercial sector into two major potential aquaculture resources: bivalves - specially mussels, oysters and clams, and marine shrimps (*Penaeidae*). At present, research programs focus on shrimp culture.

Mozambique has more than 170 000 ha of tidal swamplands, which have a high potential for shrimp farming. This area is exclusive of some 680 000 ha of mangrove which should remain as natural nursery grounds for various marine species, including shrimps, whose recruitment is critical for the marine fisheries. At the request of the Government, a pilot project for coastal shrimp culture was prepared by FAO in 1986-87. This UNDP-funded project (MO2/86/033) was signed in 1988 and started in January 1989 at Costa del Sol, 6 km north of Maputo, in an abandoned salt pan area of 18 ha. One of the activities of this project is applied research on the following topics:

- i) testing technical feasibility and economic profitability of coastal shrimp farming in Mozambique, using the local species (*Penaeus indicus*, *P. monodon* and *Metapenaeus monoceros*);
- ii) determining the availability of natural stocks of post-larvae and juveniles to stock the shrimp ponds and the availability of natural food organisms growing inside the ponds as feed for shrimps;
- iii) assessing basic culture parameters, such as growth and survival rates of shrimps under local conditions, using fertilizers and artificial feeds.

The results of this three-year project should allow the formulation of an investment program for the development of coastal shrimp farming in Mozambique.

In the meantime (1987), the government of Mozambique negotiated with the French Ministry of Cooperation the assessment of commercial marine shrimp farming opportunities in Mozambique. This study, financed by the CCCE (Caisse Centrale de Cooperation Economique, France) was executed by a consortium of three French consulting firms under the leadership of FRANCE AQUACULTURE. Field surveys were carried out in 1987-88. The results were submitted to the SEP in July 1989 for comments and review. The proposals have no research components. Two pilot projects are recommended: one in the region of Beira, the other in the vicinity of Quelimane. Only hatchery-reared *P. monodon* will be grown in semi-intensive conditions. Each pilot project will consist of a hatchery, 300 ha of production ponds. The expected annual production is 750 tonnes of whole shrimp by pilot project, with a yield of 2 500 kg shrimp/ha/year.

According to available information, the proposed technology for commercial shrimp culture, evolved in Asia, the Pacific and Latin America, has not yet been successfully demonstrated in Africa.

Due to the high prices of meat and poultry, there is a readily increasing demand in Maputo and other coastal cities for mussels and clams which are sold at lower prices than meat.

The availability of fry for stocking ponds and reservoirs is a problem, hampering freshwater fish farming development.

There is an urgent need to prepare a national plan for aquaculture development in Mozambique, covering both the freshwater and the marine sectors. Such a plan should include:

- (i) the assessment of freshwater aquaculture and mariculture prospects;
- (ii) the identification of systems and sites suitable for development;
- (iii) the evaluation of the need for rehabilitation of existing experimental fish culture stations;
- (iv) planning manpower training for the implementation of the national aquaculture development plan.

Based on the research needs identified during the preparation of the national plan, a detailed aquaculture research program should be prepared by the IIP, in close cooperation with DINAP. The means needed for implementation should clearly be identified (funds, equipment, facilities and qualified personnel).

According to experience acquired in other African countries with similar ecological and socio-economic conditions as Mozambique, the following research topics could have an impact on future aquaculture development, once adapted to the local conditions:

- (i) polyculture in ponds of tilapia with common carp at different stocking densities;

- (ii) polyculture of tilapia and common carp, combined with animal husbandry (pigs, ducks, chickens and rabbits);
- (iii) trials on year-round induced spawning of common carp and production of all-male *O. niloticus* fingerlings;
- (iv) comparative trials on use of manures and compost for pond fertilization, with and without supplemental feeding;
- (v) testing of locally available agro-industrial by-products as feeds for fish;
- (vi) rice-cum-fish culture in irrigation schemes;
- (vii) trials on stocking and management of existing small water bodies - e.g., barrage ponds and reservoirs (culture-based fisheries).
- (viii) pilot project for the culture of mussels and clams, to assess the technical and economic feasibility of such cultures.

However, if more trained and qualified personnel at all levels are not available, research would not be able to contribute effectively to aquaculture development. At university level, biologists (general biology) are trained (5 years) at the Faculty of Biology of the Eduardo Mondlane University of Maputo, but there is no specialized training in aquaculture.

Technicians are trained in several Agriculture Colleges and receive on-the-job training in the government fish farms. A group of eight technicians will be trained in shrimp culture during the implementation of the UNDP/FAO pilot project "Coastal Shrimp Culture". Furthermore, ALCOM (Aquaculture for Local Community Development Program, Project GCP/INT/436/SWE) will train nine medium level technicians as fish culture extensionists.

4. ZIMBABWE

GENERAL BACKGROUND⁹

Zimbabwe is a land-locked country with an area of 390 308 km². Its population in 1986 was 9.1 million, and according to population projections, it may reach 13.8 million by the year 2000 (at a medium growth rate of 3.0%). The 1986 GDP was about Z\$ 4 billion (two Z\$ correspond to about one US\$). Agriculture and forestry contributed 13.6% to GDP.

There are no natural lakes in Zimbabwe, but in addition to the artificial Lake Kariba, there are about 8 000 dams with several more constructed recently or under construction, primarily for the purpose of irrigation and water supply. Approximately 6 500 dams with a total surface of about 35 000 ha are privately owned. The number of dams ranging between 10 and 100 ha is approximately 1 500. However, many of them are in the low rainfall area and suffer from erratic water levels. It is estimated, that if properly managed, the small dams could produce more than 3 000 tonnes of fish a year, at a rate of some 150 kg/ha/year. There are about 50 dams exceeding 100 ha producing approximately 2 000 tonnes of fish a year, with yields around 50 kg/ha/year. Lake Kariba accounts for approximately two-thirds of total fish production. The main resource exploited is the "kapenta" (*Limnothrissa miodon*), a clupeid. The inshore fishery relies on some 40 species, of which 7 are commercially important. The 1986 production was 16 000 tonnes of kapenta and 1 500 tonnes of other fish. In 1987, the production of kapenta was 15 824 tonnes and the total national fish production grew to 21 000 tonnes.

The approximate retail value of the 1987 fish production was as follows:

kapenta dried (approx. 4 750 tonnes)	Z\$ 23 600 000
other fish fresh or frozen	Z\$ 35 000 000
Total	Z\$ 58 600 000

This represents the fourth of the value of livestock meat, milk and butterfat production in 1986. The fish production is, therefore, of great importance to the national economy.

The kapenta fishery provides jobs to 900 fishermen and 5 500 people work ashore. The number of artisanal fishermen is approximately 600-800 on the Kariba Lake and 100 in other fisheries. The total employment in fishing and shore-based fish handling amounts to about 7 200 persons. In addition to that, a large number of persons find employment in fish trading, transport, fishing gear manufacturing and other related activities. The natural fishery resources potential of Zimbabwe does not offer much scope for production increases relative to projected trends in population and demand growths. Present catches are approaching the level of potential estimates. Further production increases will probably have to come from aquaculture. The Aquaculture Section of the National Parks Department, Division of Aquatic Ecology, is promoting a number of fish farming projects, but there is, as yet, no overall plan for long-term aquaculture development, nor is its potential known. The division of responsibilities for aquaculture development among ministries adds difficulties in developing a coherent, objective plan. Development programs, and especially external technical assistance, experience difficulty due to the dispersed responsibilities and conflicting interests, although the primary responsibility for fisheries development rests with the Ministry of Natural Resources and Tourism.

This Ministry has the overall responsibility for fisheries in Zimbabwe. The Ministry has four subject matter departments: Natural Resources, Forestry, Parks and Wildlife, Zimbabwe Tourism Development Corporation. The direct responsibility for fisheries rests with the Department of Parks and Wildlife. The Chief Ecologist (Aquatic) of the Department is the de facto head of the national fisheries administration. Actually,

⁹ Adapted from SADD/EEC Regional Fisheries Survey. Final Report. Gopa Consultants (1989).

the Division of Aquatic Ecology is a small unit within the Research Branch of the Department of National Parks.

The staffing of the Division of Aquatic Ecology comprises 16 graduates and 7 non-graduate officers. Graduate officers are stationed at the Lake Kariba Fisheries Research Institute, Nyanga Trout Research Centre, Matobo Fisheries Research Station, Lake Kyle Fisheries, Lake McIlwaine Fisheries, Sebakwe Fisheries and Henderson Research Centres. The Ministry of Natural Resources and Tourism is the only government body to have at least a nucleus of qualified staff. Some limnological research is being carried out, additionally, by the University of Zimbabwe Research Station at Kariba.

The Division of Aquatic Ecology has established management groups in the following areas:

- (i) kapenta management group,
- (ii) fisheries (other than kapenta) management group,
- (iii) aquaculture management group,
- (iv) pre-impoundment (limnology group).

The responsibility for collecting and compiling statistics is dispersed among the various research units. The central office in Harare does not compile fishery statistics on a national basis. The situation is further aggravated by the fact that the units collecting statistics do not circulate them to other units or to a central office. As a result, no consolidated fishery statistics on Zimbabwean fisheries are available.

FISHERIES AND AQUACULTURE RESEARCH

The background material presented in the preceding section briefly alluded to one of the two major factors hindering fisheries research in Zimbabwe, i.e., the conflict between the Department of National Parks and Wildlife Management (of the Ministry of Natural Resources and Tourism), and two powerful departments of the Ministry of Agriculture - Agritex and the Research and Specialized Services (RS & S) Department.

Conflicts among these three entities appears to shape all fishery research plans and their execution. Unless this institutional problem is resolved, it appears difficult to conceive Zimbabwean fisheries research forcefully moving ahead, and attracting substantial external funding. Indeed, the relatively successful research program on Lake Kariba "sardine" or "kapenta" conducted to date under the sole authority of the Department of National Parks and Wildlife suggests that Zimbabwean fisheries research can produce scientifically founded, implementable management advice, when and where the problem of overlapping competence is resolved.

The other factor hindering Zimbabwean fisheries research, although apparently less so than the above mentioned problem, is the legacy of the "Rhodesian" past. Before independence, virtually all agricultural research (inclusive of fisheries research) was devoted to the "commercial" segment of the agricultural sector, as opposed to its "communal" segments. In the colonial context, "commercial" and "communal" were euphemisms for "white" and "black".

In fisheries research, this expressed itself in an emphasis on "sport" fishing - still a major industry in Zimbabwe, and on commercial trout farming as a topic for aquaculture research. This legacy is now gradually being overcome and present research and development plans give major emphasis to the many small water bodies (artificial and natural) scattered throughout the country, which will be used for aquaculture and culture-based fisheries by the communal segment. Both types of use will include stocking, mainly with *Oreochromis mossambicus* fingerlings. (There is a policy not to import the better performing *O. niloticus* into the country, although both *O. niloticus* and *O. aureus* have already been introduced into

several commercial farms). "Henderson's farm", a famous research station which became derelict and which has been recently rehabilitated in the frame of a FAO/TCP project, will play a crucial role in this scheme, as the main supplier of fingerlings.

In addition to the two limited factors mentioned (conflict of competence between institutions, gap between "commercial" and "communal" sectors), the production of a sufficient number of graduates in the appropriate disciplines appears to be the third major constraint to the growth of fishery research in Zimbabwe. The Biological Science Department of the University of Zimbabwe does not yet have a regular course in hydrobiology (although plans are being debated to establish one), and appears to have presently only two graduate students with specializations in fisheries-related fields (one in zooplankton dynamics, the other in tilapia genetics).

In-the-field training by executive agencies and externally-funded projects (e.g., the Sweden-funded Aquaculture for Local Country Development Program which just transferred its regional office from Lusaka to Harare) will thus continue to be important in Zimbabwe.

THE ZAMBIA-ZIMBABWE SADCC (LAKE KARIBA) PROJECT¹⁰

In February 1982, at the first SADCC subcommittee meeting on fisheries and wildlife held in Malawi, SADCC member states were requested to prepare proposals for regional projects to be carried out jointly by neighboring countries. Consequently, Zambia prepared a proposal for a project aimed at coordinating fisheries research and development activities on Lake Kariba. The project was to be conducted jointly by Zambia and Zimbabwe. Zambia's fisheries are estimated to produce 70 000 tonnes of fish per year and to provide direct or indirect employment to approximately 300 000 people. Fish accounts for approximately 55% of the animal protein consumed in Zambia and the fishing industry is the country's third largest source of employment after agriculture and mining.

Zimbabwe's lack of large natural water bodies has meant that, historically, fisheries have assumed a minor role in the country's economy. The damming of the Zambezi to form Lake Kariba in the late 1950s gave Zimbabwe its first potential fishery of significant size, though the lake's fish stocks were initially seen primarily as a recreational facility rather than a major source of protein and employment. It was only when the Lake Tangarika sardine, *Limnothrissa miodon* or "kapenta", was successfully introduced in the 70s that a productive fishery developed. The rapid growth of the kapenta fishery in the Zimbabwean section of the lake (from about 1 000 t in 1977 to over 18 000 t in 1988) transformed the status of the Zimbabwean fisheries sector, and kapenta now contributes significantly to the protein consumption of low income groups.

The artisanal fishery, based on inshore demersal fish, is an important source of employment and income in the lakeshore region and 2 830 fishermen (1940 in Zambia and 890 in Zimbabwe) are currently involved in fishing activities. A recent survey indicates that the traditional fishery is growing in both countries. Between 1985 and 1988, the number of people actively fishing increased at a rate of 5.8% per annum in Zimbabwe and by 7.9% per annum in Zambia. In terms of fish production, the artisanal fishery is considerably smaller than the commercial kapenta fishery and is estimated to be currently yielding about 6750 t/year. On the eastern part of the Zimbabwean shore, most fish is marketed fresh by major food companies who buy from the fishermen but, over the rest of the shoreline, the greater part of the catch is smoked or dried and distributed by small traders. The artisanal fishery, thus, generates considerable ancillary employment, and over 800 traders make a living from the fishery on the Zambian side alone.

Lake Kariba supports a demersal fish population which is concentrated around its shallow perimeter, and a single pelagic fish population which occupies the open waters of the lake. However, the Zam-

10 Adapted from Zambia-Zimbabwe SADCC Fisheries Project. Project Proposal. Kariba, May 1989.

Annex VI

Note on Past Activities and Present State of Fisheries Research in Uganda

HISTORICAL BACKGROUND

Uganda is a small landlocked country in sub-Saharan Africa with a population of about 16 million people. The country is endowed with good rainfall, fertile land and a large number of water bodies, including Lake Victoria (shared with Kenya and Tanzania), Lakes Albert and Edward (shared with Zaire), George, Kioga Complex, Wamala, Kachera, Nakivale, Kijanebola, Bunyonyi, plus minor crater lakes, dams, rivers and swamps.

The major fish groups are the cichlids, Nile perch (*Lates niloticus*), catfishes, characids, many of which are endemic to the different habitats. They are exploited by artisanal fishermen. Fish contributes more than 50% of cheap animal protein intake, with a per capita consumption of about 13 kg per person per year. Cattle, the other source of animal protein, have virtually disappeared from eastern and northern Uganda and so there is a greater demand for fish.

Fisheries research in Uganda dates back to the 19th century when European explorers and subsequent scientific expeditions in the early 20th century collected fish specimens for identification in various natural history museums in Europe. Papers and books were written by several authors, such as Gunther, Boulenger, Poll, etc., on the taxonomy of various fish species. The lakes were also charted. Worthington undertook the Cambridge expedition to Lakes Albert and Kioga in the 1920s and 1930s, and identified the fish species of these lakes. Belgian scientists also worked on Lakes Albert and Edward.

In 1927, Graham determined the status of the Lake Victoria fisheries, following the decline in catch per unit effort in the fishery for *Oreochromis esculentus*. A minimum gillnet mesh was established at 127 mm (5 in) in 1933.

In 1947, the East African Fisheries Research Organization (EAFRO) was established at Jinja, with the responsibility to do research on Lake Victoria. In the same year, the Lake Victoria Fisheries Service was started and based in Kisumu to control fishing effort and collect the necessary statistics for the management and monitoring of the fishery. The Lake Victoria Fisheries Service was disbanded in 1959 and its responsibility handed over to the Fisheries Departments of the three riparian countries. Up to the 1950s, the management of Uganda's fisheries was handled by the Game Department which came into existence in 1925, and in 1960, a separated Fisheries Department was created.

In the 1950s, there was intensified research activity on fish ecology and taxonomy. The biology of *Oreochromis esculentus* was studied in detail by Lowe. The food and feeding habits of the non-cichlid fishes was studied by Corbet, while Fryer busied himself with fish and invertebrate ecology. Greenwood worked on the haplochromiine cichlids.

In a second attempt to halt the declining catch rates in Lake Victoria in the mid 1950s, Garrod, Lowe and Beverton tackled the dynamics of the fisheries, particularly of *Oreochromis esculentus* and *O. variabilis*. They strongly recommended maintaining the minimum mesh size of 127 mm (5 in) and, thereby, sacrificing the catches of *O. variabilis* in order to save *O. esculentus* from biological and economic overexploitation. However, their recommendation was not taken seriously by the colonial management in the three riparian territories. The legal mesh size of 127 mm was abolished by Uganda and Tanganyika (now Tanzania) in 1957, and by Kenya in 1960. It was argued that the minimum mesh could not be enforced and that there was not enough manpower to patrol the lake. This resulted in untold damage to the fisheries of Lake Victoria. The mesh size below 127 mm caught immature *O. esculentus* and other non-cichlids. The end of the 1950s saw the dissolution of the Lake Victoria Fisheries Service and ushered in a partial collapse in data collection in the lake.

The 1950s was a decade when the species composition of Lakes Victoria, Kioga, Kijanebolola, Wamala, dams and minor lakes was affected by the introduction of Nile perch, *Oreochromis niloticus*, *O. leucostictus* and *Tilapia zillii* by the Game Department. This was done ostensibly to improve and increase fish production in the different habitats. These introductions were later to strongly impact fish yields, particularly in Lakes Kioga and Victoria. The fisheries section of the Game Department was busy experimenting with tilapiines, catfishes and carp (*Cyprinus carpio*) at Kajansi for aquaculture, which yielded good results. Fish farming spread across the country as a result of the aquaculture research in Kajansi.

The 1960 decade of independence brought about partial africanization of research in Uganda. Science graduates from Makerere, Nairobi and also overseas universities were recruited. EAFFRO was africanized.

There was a reappearance of Nile perch in Lake Victoria in 1960 and subsequent official introduction in 1962/63. The 1960s were good years for aquaculture research and fish farming practices, in which Uganda was the leading country in the region. Aquaculture research led to monosex culture of tilapia hybrids and also fish farming for minor carp (*Cyprinus carpio*). The polyculture of *Bagrus docmac* with tilapia was investigated. Pond studies on Nile perch were conducted to assess the proposed introduction of Lates into Lake Victoria to crop haplochromiines. The Regional Fisheries Officers in charge of various lakes made research observations on various fish species and other aquatic organisms, besides monitoring the state of the fisheries in their respective lakes. The Fisheries Department carried out experimental bottom-trawling in an attempt to can or produce fish meal from the abundant haplochromiines. The canned product was very expensive, and the experiment terminated.

At EAFFRO, the research activities were extended to also cover Lakes Kioga, Edward and Albert besides Lake Victoria. The work on Lake Albert was largely devoted to studying the distribution, food and feeding habits of Nile perch, *Lates niloticus*, whose feeding habits were also investigated through aquarium experiments. Okedi and Gee looked at the introduced Nile perch in Lakes Victoria and Kioga. Okedi also looked at the mormyrids in detail. Welcomme dwelt on the cichlids in pools and a small stream flowing into Lake Victoria and the effects of the high rise of the lake level. Gee then turned his attention to haplochromine taxonomy, while Chilvers pursued studies on growth of *Bagrus docmac*. Ssentogo examined the dynamics of *Oreochromis niloticus* in Lakes Edward, Albert and Wamala. Talling pursued limnological work on Lake Victoria.

The International Biological Program (IBP) started a research project on Lake George, with a team of young British scientists under the supervision of Prof. Beadle of the Makerere University. For a long time, the team comprised only expatriates, until eventually one Ugandan science graduate from Makerere University College was recruited to handle stock assessment. Unfortunately, the efforts by the Fisheries Department to send at least one departmental scientist to work with IBP were resisted and, consequently, at the end of the program, there was no Ugandan to continue similar work. Beadle published the results of his studies on Ugandan swamps and small crater lakes in the western region of the country.

The UNDP/FAO/EAFFRO project on Lake Victoria started in 1968 and continued until 1972 when the expatriate staff left after the expulsion of Indians from Uganda. The project involved stock assessment of Lake Victoria in waters deeper than 5 m by bottom-trawling, using the research vessel "IBIS" which was purchased for the work. The results of these bottom-trawling cruises indicated that there was a standing stock of fish of 600 000 tonnes, 80% of which was composed of haplochromiines. These results also showed that bottom-trawling was the best and most feasible method of harvesting the abundant haplochromiines. Bazigos developed a catch data system. Some work was also done on limnology.

However, the estimates of biomass for other exploited fish species, such as *O. esculentus*, were questioned by G. Fryer as they were much lower than what continued to be harvested by the artisanal fishermen annually. The vital statistics of the various species were not provided. Thus, critical parameters other than catch of standing stock estimates (which were also incorrect) were not taken into consideration. It is no wonder that haplochromiines were not able to support a fish meal plant established by Tanzania in

Mwanza. Fryer summarized the results of the bottom trawling operations as a waste of time and money as they did not lead to any meaningful management strategies.

The 1970s were a decade of political instability and violence. Expatriate research scientists were withdrawn by the development agencies such as UNDP/FAO. East African researchers, fearing for the safety of their lives, were transferred from Jinja to the sub-stations at Kisumu and Mwanza. Every lake shore became a "security zone". Even research activities on Lake Victoria had to be cleared with the army before any cruise could be undertaken. The purchasing power of the population was greatly reduced. The research scientists based in Jinja preferred to carry out work in either Kenya or Tanzania.

However, some research continued to be done on Lake Victoria. Marten in the 1970s analyzed data from the artisanal fishermen catches and made predictions on the continued use of beach seines, mosquito seines and small gillnets, which was destructive to large fish species and would be economical only for a short term. He recommended the use of large-meshed gillnets and hooks, which he predicted, would lead to increased sustained yields.

During the East African Community days, UNDP, USAID, CIDA (Canada) and ODA (UK) were the major external funding agencies for EAFFRO research. The three partner states also contributed to the Community's budget which, among others, included research and social services. After the breakup of the Community in June 1977, UFFRO (formerly EAFFRO) was placed in the President's Office and had no source of external funding. So UFFRO could only afford to carry out limited research in the nearby waters of Lakes Victoria and Kioga, with occasional trips to Lake Albert.

During the civil war (1978-79), research activities came to a halt, especially in 1979. The research vessel "IBIS" was stripped of its accessory generators and navigational aids.

PRESENT SITUATION

The early 1980s saw the return to a civilian government. UFFRO and other former research institutions were placed in the Ministry of Regional Cooperation which, however, manifested limited interest in regional research issues. The few funds which went to UFFRO sustained research activities for Lakes Kioga and Victoria only. The other lakes remained unattended. From this limited research work, several papers were published in the proceedings of the meetings of the CIFA Sub-Committee for the Development and Management of Lake Victoria. The research vessel "IBIS" continued to render trawling facilities until 1986. In the last half of the 1980s, there was no water-borne transport at UFFRO.

In 1986, there was a change of government and UFFRO was transferred to the Ministry of Animal Industry and Fisheries. This was a welcome move as UFFRO scientists could then interact directly with the managers in the Fisheries Department.

In 1987, the International Development Research Center of Canada (IDRC) accepted to fund a Nile perch study covering Lakes Victoria, Kioga and Albert. The Center also provided various equipments and textbooks. The Center has also sponsored project scientists to attend CIFA meetings and undertake study tours abroad for both short and longer periods. This aid has boosted morale and encouraged research activities.

The International Fund for Agricultural Development (IFAD) started work on Lake Kioga. Two expatriates and two Ugandan counterparts have carried out stock assessment and statistical data analysis of Lake Kioga. However, the ongoing insecurity in the area north and east of the lake has hindered the IFAD program. The only major recommendation is that the bays and gulfs in the lake should be utilized for "acadja-type" culture by individual fishermen.

In 1987, EEC provided funds for one UFFRO scientist to carry out an artisanal fisheries resources study which involved collection and analysis of old catch statistics and compilation of published material. This scientist subsequently visited ICLARM in April-June 1988. So far, two bibliographies, one on Lake Victoria and the other on Lates niloticus, have been completed. A third bibliography on Lake Edward is also ready for publication. Bibliographies for Lakes Albert and Kioga are in progress.

In 1988, EEC funded a catch assessment of Lakes Victoria, George, Edward, Albert, Wamala and Kijanebolola by UFFRO scientists. EEC has also committed funds for stock assessment in Lake Victoria and rehabilitation of the "IBIS" and other facilities at UFFRO.

MAJOR CONSTRAINTS

Present constraints to fisheries research in Uganda are:

- (i) insecurity, which also scares away donor agencies;
- (ii) insufficient operating funds for research from the national budget; most researchers are unable to attend seminars and meetings outside Uganda;
- (iii) inadequate land and water-borne transport;
- (iv) very low salaries; therefore, researchers are unable to concentrate on their jobs;
- (v) a general shortage of everything, from stationery to laboratory equipment.