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IMBO / ICLARM Research Cooperation

Project. No. 6 ACP SL 07

Management of the Fishery Resources in Sierra Leone:

Assessment and Recommendations

Project Report

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This document is the final report on activities and achievements realized in the context of a Research Cooperation between the Institute of Marine Biology and Oceanography (IMBO), Fourah Bay College, University of Sierra Leone, and the International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines.

The views and assessments presented in this report are solely the responsibility of the author. They do not necessarily reflect the opinion of any of the cooperating institutions, namely IMBO, the Department of Fishery, or the West North West AFCOD Program, nor that of the Delegation of the European Commission to the Republic of Sierra Leone.

Acknowledgement

I wish to express my gratitude for the support given to me during my stay with IMBO. The work achieved would not have been possible without the friendly assistance of so many - in fact too many to name them all.

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Contents

List of Abbreviations

CECAF	Fishery Committee for the Eastern Central Atlantic
CPUE	Catch per Unit of Effort
DFMR	Department of Fisheries and Marine Resources
DOF	Department of Fisheries
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
GTZ	Gesellschaft für Technische Zusammenarbeit
ICLARM	International Center for Living Aquatic Resources Management
IEZ	Inshore Exclusion Zone
IMBO	Institute of Marine Biology and Oceanography
MCS	Monitoring, Control, and Surveillance
WAFRI	West African Fisheries Research Institute
WNW AFCOD	West-North-West Artisanal Fishery Community Development Programme

Executive Summary

The IMBO/ICLARM Research Project

Background

1. In line with its policy to develop appropriate strategies for the management of its marine resources, the Government of Sierra Leone initiated in 1991 a project of research cooperation between the Institute of Marine Biology and Oceanography (IMBO) and the International Center for Living Aquatic Resources Management (ICLARM). IMBO is an institute of the Fourah Bay College, University of Sierra Leone. ICLARM is an international, non-governmental, non-profit center, with headquarters in Manila, Philippines. It carries out research, training and information activities in developing countries in the fields of capture fisheries management, aquaculture and coastal resources management.

2. The project started in April 1991, with a planned duration of two years. At the end of the two-years period, the project was extended by another 15 months and thus ended in September 1994. Funds were provided by the European Development Fund, in the context of an ongoing EC fisheries project, the "West-NorthWest Artisanal Fisheries and Community Development Programme" (WNW AFCOD), which also provided logistics and technical support. Close collaboration between the project on the one hand, and WNW AFCOD, respective the Department of Fisheries (DOF) on the other hand were an essential part of the project agreement.

3. The main objectives of the project were to evaluate the present status of the fisheries in Sierra Leone and to make recommendations of possible management strategies in the light of the priority proclaimed by the Government of Sierra Leone to give preference to local fisheries, particular artisanal and semi-industrial, over foreign fisheries. Further, the project was to device a permanent system of fisheries data collection and to train Sierra Leonean personnel in the handling of computerized fisheries database systems.

Project Achievements

4. In the course of the project data from fishery research, industrial fishery and artisanal fishery were classified and appropriate database systems developed using a commercial database software package.

5. In terms of research data, large data sets were available from the joint Sierra Leone - USSR research cruises and from a frame survey of the artisanal fishery carried out in 1990. Catch and landing data from the industrial fishery were provided by the DOF, while a broad range of data on the catch, effort and the economy of the artisanal fishery was collected as part of the monitoring and evaluation activity of the WNW AFCOD Programme.

Sierra Leone - USSR Fishery Research Data

6. The database developed for the data of the joint Sierra Leone - USSR research cruises contains the information from a total of 900 research stations with together more than 14,000 catch records. In addition to the catch records, 740 sets of length frequencies are available, as well as nearly 500 sets of biological data with more than 6,000 records dealing with sex ratio and the relationship between size and maturity, fatness and stomach contents. A built-in "Species Catalogue" holds 434 entries of valid

species names pertaining to 153 different families. as well as about 100 synonyms. This catalogue thus represents a very comprehensive list of marine fish species occurring in water depths between 10 and 200 meters off Sierra Leone.

Artisanal Fishery Frame Survey

7. The Institute of Marine Biology and Oceanography conducted a frame survey of the artisanal fishery in Sierra Leone in 1990. Main objective of this survey was to take inventory of the artisanal fishery (crafts, gears, motorization, demography of the fishery population). In addition, a wide range of fishery related topics were covered in individual interviews that were meant to obtain information e.g. on educational level, ownership, credit schemes, economic returns, influence of fishery development projects, and others.

8. Analysis showed that while the number of fishing crafts had dropped by about 1,000 (mainly smaller) units within the last ten years to roughly 5,700 canoes in 1990, number of gears and employment level had remained fairly constant during the same period.

Industrial Fishery

9. With the introduction of a dedicated MCS system in 1990, collection of data from the industrial fishery improved considerably. In 1992 the project suggested modifications to the then existing catch report forms to make them more appropriate for fishery management, and a database was developed to receive the information contained in these forms.

10. Though the return of the filled-in fishing logs was satisfactory, the efficient use of the database was severely hampered by administrative constraints (lack of centralization) and the unavailability of appropriate computing facilities at the DOF office in Kissy. It was finally conceded that it would need a major reorganization of the statistical unit of the DOF and provision of more computing equipment, to realize the expected benefits from the database. As this was outside the scope and means of the present project, the DOF was advised to seek additional funding for a separate project that would provide assistance in the establishment of a fisheries database for the monitoring of the industrial fishery.

Artisanal Fishery

11. During the extension phase of the project more emphasis was given to the conceptualization of strategies for monitoring the activities of the artisanal fishery in Sierra Leone. A proposal was presented to the DOF with a new approach to data collection in the artisanal fishery. The basic idea was to suggest a system that would be accurate enough to identify trends in the artisanal fishery, while in the same time being appropriate for the DOF in the light of financial and staff-related constraints. The DOF has taken steps to implement the system first on a trial basis in selected fishing villages before expanding it along the whole coast.

Support for WNW AFCOD

12. Throughout the project life cooperation between the IMBO/ICLARM project and the WNW AFCOD Programme was excellent. Assistance to the WNW AFCOD Programme consisted in the conceptualization and design of a number of database applications, covering fishery statistics, use of water wells and performance of primary health centers by the Monitoring & Evaluation Section, store-keeping and performance evaluation by the Engineering Section, modeling by the Credit Section, and accounting. On the other hand, the WNW AFCOD Programme provided the logistics and the necessary

support to acquire and maintain the computer hardware used by the WNW AFCOD Programme, the IMBO/ICLARM project and the Department of Fisheries.

13. Main support provided to the WNW AFCOD Programme consisted of assistance in the design, implementation and computerization of a data collection scheme for the artisanal fishery in the project area . As a result, the M&E Section of the WNW AFCOD Programme has collected extensive data on landings and the economics of fishery operations in selected villages in the Programme area. The data were used in a number of project reports such as the "Statistical Fisheries Bulletin", or to provide baseline information for other sections of the Programme.

DOF Library

14. The library of the Department of Fisheries in Sierra Leone was established in the 1950' as part of the West African Fisheries Research Institute (WAFRI). For many years, the library served well the needs both of the fisheries administration and the academic clientele. However, due to the lack of a trained librarian and proper maintenance the library had de facto ceased to function in the late 1980'

15. Given that access to relevant information is a major pre-requisite to advances in marine resources management, the project identified the rehabilitation of the fisheries library at Kissy Dockyard as an important component in the strengthening of institutional capacity at the DOF. In the same time it would also benefit the research activities to be carried out at IMBO. As a consequence, the budget for the extension of the IMBO/ICLARM project included an allocation of slightly over 17 Million Leone for the rehabilitation of the library.

16. Rehabilitation comprised improvement of the existing building, and the construction of a small annex to provide office space for a librarian and house a small archive for the reprint collection. A librarian was employed by the project who supervised the rehabilitation work, and organized the repair/binding of some 5,000 items of the original library holdings. In addition computer hardware was purchased for the library and the librarian was trained in the use of specialized software for storing and retrieval of library titles. This system complements the usual library catalogue, and will give convenient access to information contained in the library. It will especially allow to make better use of the large reprint collection of the library which so far is completely undocumented.

17. In order to make the rehabilitation of the library a permanent success the project strongly recommends the continuation of the employment of a librarian and the provision of a budget for recurrent expenditures and acquisition of new material for the library.

Research Support

18. Strengthening the research capacity at IMBO was achieved through extensive training in computer-assisted data analysis, lectures on tropical fisheries biology, supervision of thesis work, and the organization of a workshop on advanced methods in stock assessment. In many of these activities, staff of the DOF and the WNW AFCOD were also included.

FiSDaS

19. The experience gained from the analysis of the Sierra Leone - USSR research data in the context of thesis supervision was the basis upon which a software was developed, that provides access to this important data set by means of a fully menu-driven program, named "Fishery Surveys Database System" (FiSDaS). With FiSDaS, existing data can be routinely analyzed using any of the almost 300 programmed routines, and data from new research cruises can be added to the database.

20. As a novelty in this kind of approach, FiSDaS contains the Low-Level Geographic Information System "SIERRA". This software was developed in-house at ICLARM's headquarters in Manila specifically for use with fisheries data originating from Sierra Leone. It is fully integrated into FiSDaS, and allows to display on-screen geographically referenced information from the fisheries.

21. FiSDaS is fully documented in two volumes. One volume is a "User Manual", which leads the inexperienced user through the various options provided by the software. The second volume is a "Technical Reference Handbook" that contains necessary information of how to install and run the software, as well as a detailed listing and a thorough documentation of all the routines developed for FiSDaS. It allows any experienced programmer to implement modifications where necessary, or to easily integrate new routines into the existing system. This greatly enhances the flexibility of FiSDaS and makes it future use to the maximum possible independent of the present IMBO/ICLARM project.

Status and Management of the Fisheries in Sierra Leone

22. The project has used the available information to derive an assessment of the present status of the fisheries in Sierra Leone, both in the industrial and the artisanal fishery sector. The general conclusion is that the marine resources of Sierra Leone can not be considered under-exploited, as they start to exhibit typical signs of a fishery near or already beyond sustainable exploitation.

23. It is felt that future policies for the management of this important sector should emphasize on the preservation of the existing resources, rather than envisage any large-scale expansion of fishing capacities. It is argued that Sierra Leone is a typical example for the need of re-orientation in the approach to fisheries management to bring it in line with a wider ecosystem understanding of the resource basis and the resulting exploitation pattern necessary to minimize resource conflicts and maximize societal benefits from the resource.

24 Analysis of the situation in the artisanal fishery clearly shows that the problems in this sector are in no way different from many other such fisheries: uncontrolled access to the marine resources on the one hand has provided employment opportunity for large parts of the rural population in the coastal region. On the other hand, resource limitations seem to have hindered the expected increase in overall productivity during the past ten years, despite technological innovations brought about by a series of internationally funded development projects. Instead emphasis on capital-intensive technologies has increased economic inequalities in favor of those best able to invest in these powerful technologies.

25. **Management Recommendations - Industrial Fishery**

- "freezing" of the number of licenced fishing vessels to initially not more than 80 vessels per year with a fixed allocation of licences to the various types of fishery, in order to contain fishing pressure on the stocks and create favorable investment conditions in this sector;
- efficient control and surveillance of the fishery, coupled with improved data collection which emphasizes on the monitoring of trends in key factors considered essential to assess the performance of the fishery;
- exploration of potentially under-utilized resources in the south and further off-shore;
- enforcement of modified gear design in the shrimp fishery to reduce wastage of by-catch, respective better utilization of the by-catch.

26. **Management Recommendations - Artisanal Fishery**

- gradual change from a "top-down" approach to a participatory system where coastal fishing communities are involved in the management of adjacent resources;

- establishment of a network of regional fishery offices with the objective to support an awareness program directed towards community based fisheries management;
- give priority to community development aspects in fishery development projects to strengthen civic structures within the community that can support future responsibilities in community based fisheries management;
- give priority to those technological innovations in the artisanal fishing sector that allow to redirect some of the fishing effort towards resources that are presently not accessible to artisanal fishing crafts, or that lead to improvements in the post harvest quality of the products;
- maintain the established Inshore Exclusion Zone reserved for the artisanal fishery and improve its protection by the widespread placement of fish aggregating devices that effectively prevent illegal trawling while improving the catch of stationary gears used in the artisanal fishery;
- introduce the proposed monitoring system of the artisanal fishery for better assessment of trends and performance in this sector.

Status and Prospects of Fishery Research in Sierra Leone

IMBO

27. IMBO is plagued with budgetary constraints that do not allow the Institute to operate on a level appropriate for a research institution. This does not only affect the applied research but also the educational level of those trained in marine sciences. Reason for this is the rapidly deteriorating situation at the University of Sierra Leone, which has resulted in unrealistically low budget allocations for institutions like IMBO. Poor facilities, uncertain employment perspectives, isolation from the international scientific community, unwillingness to return of those sent abroad on Master or Ph.D programs, are but a few of the consequences of an insufficient operational budget.

28. IMBO is presently in a position to maintain, at best, a basic teaching and training program in marine science. In its approach to applied research, there is no medium- or long-term strategy apparent as to what should be the primary goals to achieve. In the light of this some suggestions made earlier by the project have been taken up and discussed during IMBO staff meetings. They resulted in practical proposals. Their implementation and necessary follow-up, though, will largely depend on the degree of personal commitment of IMBO's senior staff.

DOF

29. The majority of the senior DOF staff are well-trained fisheries officers, who had their perception of fisheries management shaped mainly during the past decade by attending regional conferences and workshops or training courses in Europe or North-America sponsored by international donors. Thus, they are familiar with traditional concepts of fisheries management and probably open for (though not necessarily aware of) new concepts and strategies in this sector. However, at present most of these fisheries officers seem to be preoccupied with administration and other technical aspects of the fisheries, leaving little (if at all!) time for strategic planning.

30. Presently some effort is being made by the DOF to revive the statistical data collection scheme that in the past was either completely abandoned or left with the externally funded development projects. In this context there is a clear need for more trained fishery scientists. However, none of the fishery biologists trained by IMBO during recent years has been employed by the DOF, with little hope

that this might change in the near future. Budget constraints are given as major explanation for not recruiting new staff.

31. In summary, the DOF seems to have sufficient basic capacity upon which to build a revived fishery research unit with a clearly defined scope. Its readiness to accept IMBO as a partner will largely depend on IMBO improving its performance and reputation as a national research institution.

Recommendations for Fishery Research

32. In order to improve on fisheries research in general, and on the cooperation between the two institutions involved, it is felt that the role of both institutions need a clear concept of their respective responsibilities:

- **IMBO** as a research institution is the link to the regional and international fisheries science community. It should keep abreast with new developments and concepts in the field of fisheries management. By means of teaching and organizing seminars this information is channeled through IMBO to the scientific community and the DOF in Sierra Leone. In close cooperation with the DOF strategies for implementing and testing new concepts are being developed and assistance in the formulation of general fishery policies is provided.

- **DOF** as an implementing institution is responsible for the formulation and enforcement of agreed fishery policies. To this end opportunities for regular exposure to developments in the area of fisheries science has to be provided for DOF staff through close links with the national research institution. The DOF ensures a continued monitoring of the performance in the fishing industry (both artisanal and industrial) against which can be measured the success (or failure) of selected management options.

33. It is suggested to use the upcoming EEC-funded Regional Maritime Database (BDRM) project as a starting point to revive collaboration between the two institutions. It should be ensured that any BDRM activity always involves DOF and IMBO personnel together, and that IMBO staff has free access to the computer hard- and software to be provided to the DOF as part of the BDRM package.

34. It is further suggested that IMBO seeks external funding for a three to four years project which will provide assistance in the reorganization of the Institute in terms of research, training and administration and the establishment of institutionalized links between IMBO and DOF. There should be a small but sufficient budget available to provide the Institute with basic equipment, carry out small, but well focused research projects, hire suitable candidates as research assistants, and enable the staff to attend conferences and training courses in the region and other tropical countries.

35. It is recommended that the DOF should use the BDRM project to build up a well functioning statistical unit, with sufficient staff and equipment to fulfill their mandate. This unit could become the point of entry in the career of fisheries officers, thus exposing them to the whole complex of information management necessary for sound planning and policing in the fisheries sector.

Part I

Activities and Achievements of the IMBO/ICLARM Research Project

36. The first part of this report deals with the specific activities of the IMBO/ICLARM Research Project and the achievements realized during the project period. As most of the points to be mentioned here have already been described in detail in a series of intermediate project reports, only a summary will be presented in this report. Appendix 3 contains a complete list of all documents that have originated from this project, including the various project reports.

1. Setting the Stage: Documentation of the Fishery in Sierra Leone

37. Fish plays an important role in the national food supply of Sierra Leone, accounting for about 75% of total animal protein intake (Kamara 1991). This fish is almost exclusively provided through the marine fishery sector, which consists of an artisanal fishery and a largely foreign-dominated industrial fishery. The artisanal fishing fleet plays a crucial role in providing fish at affordable price to the local markets, while the industrial fleet is primarily export-oriented with only a small amount of the capture being actually landed in Sierra Leone.

38. A general overview of the fisheries in Sierra Leone has been given by Vakily (1992). A detailed account was presented by Payne & Coutin (1988) of the development especially in the industrial fishery from its very beginning in the early fifties to the mid-eighties. The latter authors describe the industrial fishery during these thirty years as steadily increasing both in fishing effort and diversification. Starting from a nationally based fleet of a few Italian wooden trawlers, the fishery rapidly expanded in the early seventies through the establishment of joint venture agreements with foreign countries which brought in especially the distant water fleets of the Soviet Union and Korea.

39. In the same time advances in boat and gear technology lead to a shift in fishing effort from the near-shore Sciaenid fauna to the more valuable offshore stocks of Sparids, Serranids, Carangids and Cephalopods, as well as the species of the inshore Sciaenid fauna with deeper distribution (Payne & Coutin 1988). Fishing pressure on the inshore demersal stocks was nevertheless kept on a high level throughout all these years because of the increasing number of shrimpers operating in the near-shore waters since the early eighties.

40. The general trend of increased effort in the fishery of Sierra Leone is contrasted by another trend: that of the decreasing availability of information on the actual status of the fishery. Table 1 presents a list of identified publications that contain in one or the other way information on catch and/or effort related to the fishery in Sierra Leone. Also shown is (are) the decade(s) to which this information pertains.

41. The listing in Table 1 makes it apparent that documentation of the fishery in Sierra Leone has had two productive phases: one in the early 1960s, probably connected to research activities carried out at the West African Fisheries Research Institute (WAFRI) in Freetown, and another one in the late 1970's up to 1986. The later reflects the attempt by FAO to stimulate fishery research and to provide a means of communication for the West African coastal countries through the Fishery Commission for the Eastern Central Atlantic (CECAF) with its technical secretariat in Dakar, Senegal. It is therefore of little surprise that the gradual reduction of the CECAF project activities in the late 1980's has deprived

countries like Sierra Leone of an important forum for which to generate, and where to present, up-to-data analysis of its fishery.

Table 1 List of publications containing information on catch and/or effort for the fishery in Sierra Leone from the early 1950s up to 1990. Reference years denote the range of years to which the information is related.

Author(s)	Reference Years			
	55-65	66-75	76-85	86-90
Watts 1962	X			
Longhurst 1963	X			
Fisheries Department Reports 60-66	X			
Turner & Hudson 1966	X			
Williams 1963	X			
Talarczak 1976		X	X	
Brainard 1980		X	X	
Caverivière 1980		X	X	
Bouberi 1983		X		
FAO 1983			X	
Ssentengo & Ansa-Emmim 1986		X	X	
Payne & Coutin 1988	X	X	X	X
FAO 1992			X	X

42. The apparent lack of publications on the status of the fisheries since the late 1980's does not necessarily mean that no investigations have been carried out, but it definitely shows that its proper documentation has been much neglected. As a consequence, valuable information buried in internal or project reports are - technically seen - not "existent", as their identification (and actual retrieval!) becomes a matter of chance.

43. The formulation of development and management strategies requires, however, the availability of data which allow the overall evaluation of the actual status of the fishery. Management advice without scientifically well-founded analysis of available information risks to either be ignored or, worse, lead to decisions that might prove counter-productive to the declared objectives of fisheries management. It thus should be of foremost importance to any fishery administration, to ensure a continuous flow of basic data of a fishery as a fundamental prerequisite for developing and managing a national fishery.

2. The IMBO/ICLARM Project

2.1 Background and Rational

44. The Government of Sierra Leone has set the frame for a policy towards fishing management and resource allocation and conservation by entering into force "The Fisheries Management and Development Act, 1988". The Act envisages the preparation of management and development plans based on proper resource assessment and a policy in favor of sustainable exploitation and conservation.

45. The continental shelf off Sierra Leone has been subject of a series of resource surveys. The first exploratory fishery surveys were carried out in the 1950's, followed by the comprehensive Guinean Trawling Survey in the 1960's, which covered the whole of the West-African shelf with standardized transects at 40-miles intervals.

46. The various other surveys undertaken during the last 20 years comprised the surveys conducted by the R/V "Dr. Fridtjof Nansen" in 1981 (FAO 1984) and 1986 (Strømme & Saetersdal, n.d.) and research cruises jointly organized by Sierra Leone and the (then) USSR. The latter surveys started in 1976 as part of a general fisheries agreement between the two countries and were carried out at least once a year until 1990. These cruises generated a considerable amount of data on the biology and abundance of the fish off Sierra Leone.

47. In addition to resource surveys, data have been collected from the artisanal fishery either in the context of ongoing fisheries development projects or independently in the form of frame surveys.

48. Thus, a wealth of information exists in respect to the marine resources of Sierra Leone. This information, however, is not necessarily available in a form suitable for the formulation of development and management strategies. Major constraints encountered are:

- data on fishery and related aspects are collected by different organizations (both national and international) concerned with fisheries research and development; little coordination regarding the communication between the institutions involved results in the loss of valuable information;
- historic data are scattered over a number of publications, some of which are no more available in Sierra Leone or are written in languages other than English;
- reduction of data collected in-country seldom goes beyond basic statistical analysis; as the data are not computerized, any attempt to analyze existing data material using different approaches becomes prohibitive because of the sheer amount of work involved in reorganizing and recalculating the data;
- without the availability of computer facilities, data and their analysis are usually presented as rather complex tables; more elaborate (and thus time-consuming) forms of presentation are reduced to a minimum; however, visualizing of data and their trends in time and space in form of e.g. graphics, distribution charts, etc., is an important part of the presentation of results.

49. In line with its keen interest to develop appropriate strategies for the management of its marine resources, the Government of Sierra Leone initiated in 1991 a project of research cooperation between the Institute of Marine Biology and Oceanography (IMBO) and the International Center for Living Aquatic Resources Management (ICLARM).

50. IMBO is an institute of the Fourah Bay College, University of Sierra Leone, with a mandate to undertake marine research and to train students of Fourah Bay College in marine science. ICLARM is an international, non-governmental, non-profit center, with headquarters in Manila, Philippines. It carries out research, training and information activities in developing countries in the fields of capture fisheries management, aquaculture and coastal resources management.

51. The project started in April 1991, with a planned duration of two years. At the end of the two-years period, the project was extended by another 15 months and thus ended in September 1994. Funds were provided by the European Development Fund, in the context of an ongoing EC fisheries project, the "West-NorthWest Artisanal Fisheries and Community Development Programme" (WNW AFCOD), which also provided logistics and technical support. Close collaboration between the project on the one hand, and WNW AFCOD, respective the Department of Fisheries on the other hand were an essential part of the project agreement.

2.2 Project Objectives

52. The objectives of the project were as follows:

- To evaluate the present status of the fishery in Sierra Leone and the level of exploitation in both the industrial and artisanal sector.
- To make recommendations of possible management strategies in the light of the priority proclaimed by the Government of Sierra Leone to give preference to local fisheries, particular artisanal and semi-industrial, over foreign fisheries.
- To device a permanent system of fisheries data collection and computer-assisted handling of data for analysis and presentation.
- To train Sierra Leonean personnel in the handling of a computerized fisheries database system.
- To publish the results of this work and to disseminate these in Sierra Leone, other countries bordering the Gulf of Guinea, and to agencies and institutions with interests in fisheries development, particularly those working in West-African countries.

53. These objectives were to be achieved through the gathering, analysis and interpretation of existing data relevant to the fisheries in Sierra Leone, and the provision of facilities for - and training in - computerized data management. Expected results were the computerization of the majority of existing research and other fishery-related data in order to prevent the further loss of relevant data and to make them readily accessible for analysis required for the refinement of national policy and strategic plans for fisheries development.

54. The extension phase was primarily meant to consolidate achievements made during the first phase of the project. Further objectives were as follows:

- To assist in the implementation of recommendation that emanated from the research carried out during the first phase.
- To strengthen IMBO's capabilities to carry out research into the marine resources of Sierra Leone.
- To assist in the rehabilitation of the statistical unit of the Department of Fisheries.
- To improve the availability of and access to existing literature in the library of the Department of Fishery.

55. The documents related to the project's stated objectives, activities and work plans are presented in Appendix 1. A summary of the major activities carried out during the project, and listed by institutions involved, is given in Appendix 2.

3. Achievements of the IMBO/ICLARM Project

3.1 Fishery Databases

56. Fishery data in Sierra Leone originate basically from three sources:

- Fishery Research
- Industrial Fishery
- Artisanal Fishery

57. Each source represents a category of data with its own structure and, thus, also with its own way of analysis. Within a category, though, the structure of data is often similar, allowing also similar approaches of analysis.

58. In the course of the project the fishery data available for Sierra Leone were classified and appropriate database systems developed using a commercial database software package, DataEase, V. 4.5[1].

59. In terms of research data, large data sets were available from the joint Sierra Leone - USSR research cruises and from a frame survey of the artisanal fishery carried out in 1990. Catch and landing data from the industrial fishery were provided by the Department of Fisheries (DOF), while a broad range of data on the catch, effort and the economy of the artisanal fishery was collected as part of the monitoring and evaluation activity of the West-North-West Artisanal Fishery and Community Development Programme (WNW AFCOD).

3.1.1 Joint Sierra Leone - USSR Research Cruises

60. From 1976 to 1990 a total of 39 research cruises were accomplished in the waters of Sierra Leone (see Table 2). Nine cruises were acoustic surveys, one cruise was devoted to experimental longline fishing and two surveys were carried out in the context of a shrimp survey. The remaining research cruises were all trawl surveys, the majority of which (20) being exclusively bottom trawl surveys, while seven cruises also included a few stations where a pelagic net was used.

61. The information usually recorded during the trawl surveys comprised technical details of the trawl station (time, position, depth, duration, etc.), catch composition, and - for selected species - length frequencies and biological data. Data were entered into specifically designed forms, which, however, are all held in Russian language.

62. Out of the 27 trawl surveys, data from 18 research cruises were available in-country, though data sets were not always complete. Through official contacts and with the assistance of ICLARM HQ in Manila data from another six research cruises were obtained directly from AtlantNIRO, the institute in Kaliningrad (former USSR) that was in charge of the scientific planning and technical realization of the fishery surveys.

63. Designing the database for the survey data was a straightforward process, as data recording during the surveys was done in a standardized, well structured form. Main components are the trawl logs, the catch records, length frequencies, biological data and hydrological data. A diagram depicting the structure of the database is presented in Figure 1.

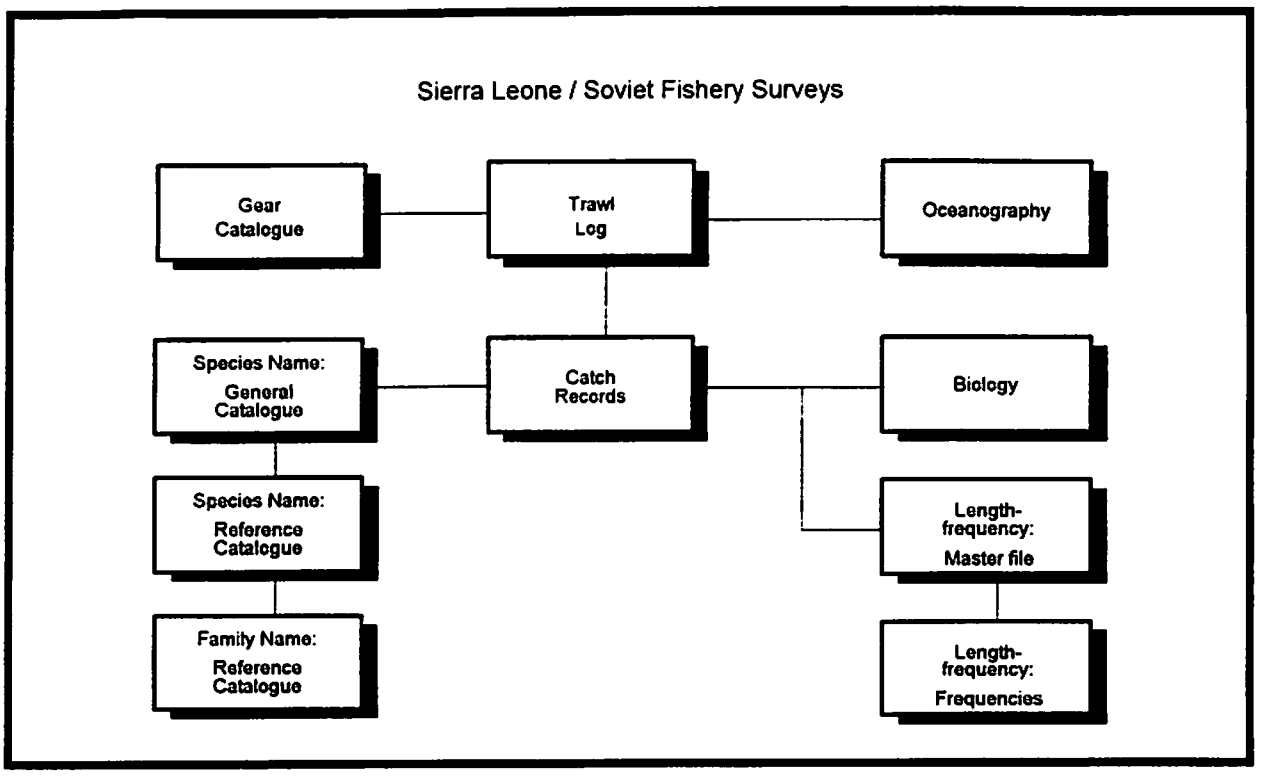
64. The component "Trawl Log" comprises all information pertaining to a haul, such as date, station number, position and time at shooting respectively hauling the net, as well as general data on water depth, temperature, salinity and nature of the bottom. The component "Catch Records" contains a list of all species caught during a haul, providing information on number and weight (both actual and raised to the catch per hour), length range, as well as some general information on biological parameters such as gonad index, fatness and stomach fullness. Biological data collected individually from large sub-samples of selected species, are contained in the database components "Biology" and "Length Frequency".

[1] DataEase is a registered Trademark of DataEase International, USA

Table 2 List of research cruises carried out in the context of the joint Sierra Leone - USSR fisheries surveys between 1976 and 1990. Indicated is the type of survey (BT = bottom trawl, PT = pelagic trawl, SS = shrimp survey, AS = acoustic survey, LL = longline survey) and whether the respective research data are available in Sierra Leone ("Y") or not ("n").

Vessel	Cruise No.	Date of Survey	Type of Survey	Trawl Data	Length Frequencies	Biological Data
Prognoz	76/1	09.76	BT	Y	Y	Y
Vykhma	76/2	12.76	BT	Y	Y	Y
Evrika	76/3	12.76	BT	Y	Y	Y
Prognoz	77/1	06.77	BT	Y	Y	Y
MCP 305	77/2	06.77	SS	Y	n	n
MCP 304	77/3	06.77	SS	Y	n	n
Saturn	78/1	01.78	BT	n	Y	Y
Vykhma	78/2	02.78	BT	n	Y	Y
Langust	79/1	06.79	BT	n	n	n
Prognoz	80/1	02.80	BT	Y	n	n
Vykhma	80/2	06.80	BT	Y	Y	Y
Belogorsk	-	02.81	LL	-	-	-
Belogorsk	81/2	02.81	BT	Y	Y	Y
Belogorsk	81/3	07.81	BT	Y	n	n
Quant	-	07.81	AS	-	-	-
Belogorsk	82/1	02.82	BT	Y	n	n
Belogorsk	82/2	07.82	BT	n	n	n
Evrika	83/1	06.83	BT	Y	Y	Y
Belogorsk	83/2	06.83	BT	n	n	n
Monocrystal	-	01.84	AS	-	-	-
Monocrystal	-	05.84	AS	-	-	-
Evrika	84/1	06.84	BT	Y	Y	Y
Bakchisarai	85/1	02.85	BT/PT	Y	Y	Y
Monocrystal	-	02.85	AS	-	-	-
Bakchisarai	85/2	07.85	BT/PT	Y	Y	Y
Bakchisarai	86/1	02.86	BT	Y	Y	Y
Otcher	-	03.86	AS	-	-	-
Monocrystal	-	09.86	AS	-	-	-
Bakchisarai	86/2	10.86	BT	Y	Y	Y
Otcher	-	11.86	AS	-	-	-
Monocrystal	-	03.87	AS	-	-	-
Atlantida	87/1	05.87	BT/PT	Y	Y	Y
Belogorsk	88/1	02.88	BT	Y	n	n
Monocrystal	88/2	04.88	BT	Y	Y	Y
Atlantida	88/3	10.88	BT/PT	Y	Y	Y
Atlantida	89/1	04.89	BT/PT	Y	Y	Y
Monocrystal	-	12.89	AS	-	-	-
Atlantida	89/2	12.89	BT/PT	Y	Y	Y
Atlantida	90/2	07.90	BT/PT	Y	Y	Y

Figure 1 Structure of the database for the Sierra Leone - USSR Fishery Surveys



65. The systematic key applied followed the one proposed in FAO's latest publications on West African marine resources. The "Species Catalogue" contains 434 entries of valid species names pertaining to 153 different families. To this ads another 47 entries of species that in the cruise records either have been identified to the genus only, or are merely classified in broad terms such as family or groups (e.g. "cuttlefish"). Also, the database contains about 100 synonyms used in the catch records for various species. This catalogue thus represents a very comprehensive list of marine fish species occurring in water depths between 10 and 200 meters off Sierra Leone.

66. The data entered into the database represent the information from a total of 900 research stations with together more than 14,000 catch records. In addition to the catch records, 740 sets of length frequencies are available, as well as 498 sets of biological data with more than 6,000 records dealing with sex ratio and the relationship between size and maturity, fatness and stomach contents.

3.1.2 Frame Survey

67. The first artisanal fishery frame survey was conducted in Sierra Leone in 1972 (Fergusson 1974). The Fisheries Division, MANR&F carried out another frame survey in 1981. This second survey yielded detailed information on the number and types of boats, fishing gears and the fishing population. In 1984, a fishing gear inventory survey was undertaken by the Fisheries Pilot Project Tombo in selected landing sites along the Sierra Leonean coast. Results of these surveys, for which funds were provided by the German Agency for Technical Cooperation (GTZ), were presented in FAO (1983), Jones (1984), and Jarchau (1988).

68. The latest frame survey of the artisanal fishery in Sierra Leone took place in 1990. It was conducted by the Institute of Marine Biology and Oceanography, University of Sierra Leone, and funded by the Commission of the European Communities (CEC) through the WNW AFCOD

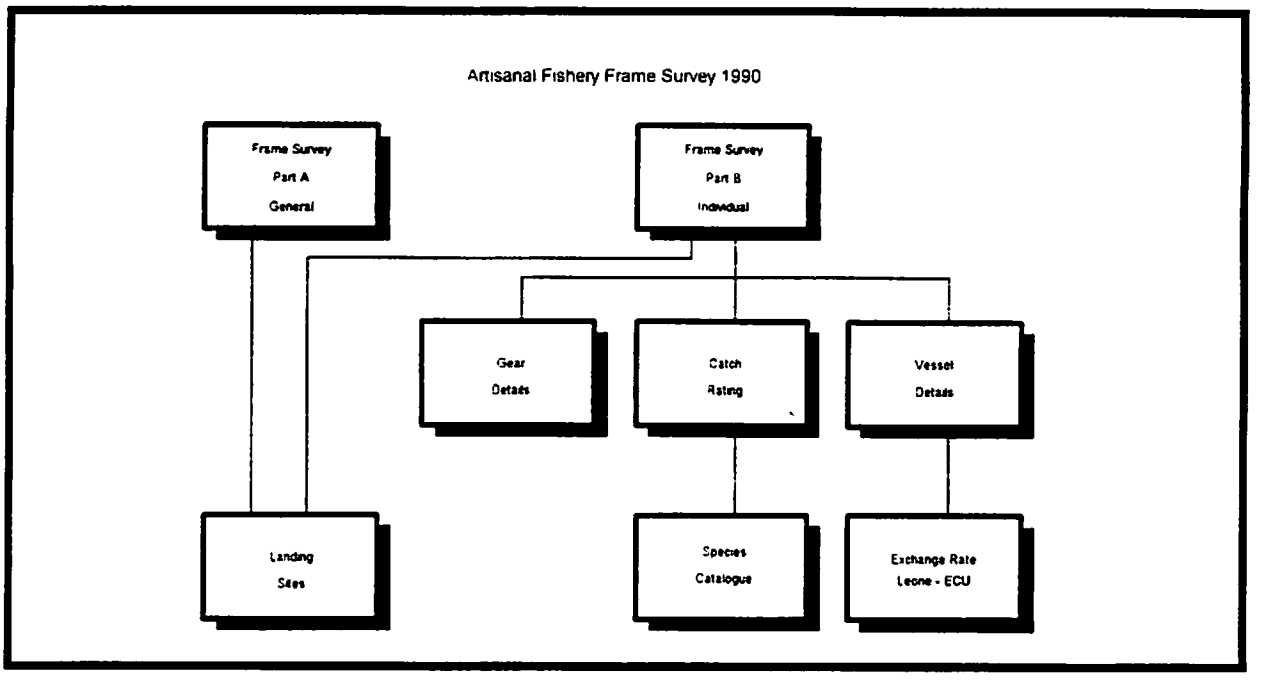
Programme. Main objective of this IMBO administered frame survey was to take inventory of the artisanal fishery (crafts, gears, motorization, demography of the fishery population). In addition, a wide range of fishery related topics were covered in individual interviews that were meant to obtain information e.g. on educational level, ownership, credit schemes, economic returns, influence of fishery development projects, and others. In order to investigate seasonal influence on these topics, the frame survey was carried out twice: the first phase in the dry season (April/May 1990), the second phase during the rainy season (August 1990). Ultimately, it was expected that such information could serve as a guide for proper planning and management of the artisanal fishery.

69. The result of these two surveys are close to 3000 filled-in questionnaires, each with around 50 single questions.

70. First attempts were made in 1990 and 1991 to summarize part of the data (IMBO 1990, 1991). Given that no facilities for advanced data processing were available at the Institute of Marine Biology & Oceanography at that time, analysis was necessarily limited to descriptive statistics of key items in the general census.

71 Using the experience gained by IMBO staff with the first analysis of the frame survey data, a relational database system was developed, the general structure of which is shown in Figure 2.

Figure 2 Structure of the relational database used for the processing of the data from the artisanal fishery frame survey 1990.



72. Information entered into the database comprises both the general census and the slightly over 1400 individual questionnaires from the survey carried out during the dry season. From the survey that took place during the rainy season only the Part A data (general census) have been entered, as it had become obvious that the methodology applied did not really allow to quantify differences in the artisanal fishery that are related to prevailing weather conditions in the respective season. The very limited use of a comparison of the two data sets would in no way have justified the considerable staff

and computer time necessary to enter all the data from the individual questionnaires of the survey carried out in respect to the rainy season.

73. Analysis of the general census of crafts, gears and employment in the artisanal fishery has been finalized. It was found that roughly 5,700 canoes existed in 1990 in the artisanal fishery. These comprised around 4,500 small crafts (Kru and Standard 1-3), 1,000 medium to large size boats (Standard 3-5, Standard 5-10), and 220 Ghana boats. Around 10% of the canoes were motorized with outboards ranging from 8 to 40 HP. The most dominant gear in number was the gill net (5,000), followed by hook & line gear (2,450), cast nets (720), and beach seines (480). Though comparatively small in number, ring nets (330) represent probably the most important type of gear in the artisanal fishery in terms of catch volume. Around 15,700 persons derive their main income from going out fishing, while 2,200 persons exercise this metier on a part-time basis.

74. The results summarized above have been presented in detail by Vakily et al. (1993). This report gives a break-down of the figures obtained on chiefdom and district level, as well as a critical assessment of the methodology applied.

3.1.3 Industrial Fisheries

75. During the 1980s a yearly average of 190 fishing vessels had been licensed to fish in Sierra Leonean waters, most of them of foreign origin represented ashore by local agents. Licensed vessels comprised trawlers, purse seiners and shrimpers, and to a much smaller extent tuna boats, longliners and motherships. In addition to the actually licensed vessels an unknown, though substantial number of trawlers and shrimpers were fishing illegally in Sierra Leone waters, taking advantage of the factual inability of the local authorities to effectively control activities in their territorial waters.

76. In 1990, the Government of Sierra Leone signed an agreement that authorized a foreign-based company, the Maritime Protection Services - Sierra Leone (MPSSL), to issue fisheries license and to enforce fishery regulations. This led in 1991 to a drastic reduction in fishing effort as only around 91 vessels applied for a license under the new regime. In 1992, the number increased to 120 vessels, but then dropped again to 86 vessels in 1993 (DFMR 1994).

77. Poaching was effectively reduced due to the constant presence of a patrol vessel on the fishing grounds. Another positive effect was the enforcement of banning industrial fishing vessels from operating in a clearly defined five mile inshore area reserved for artisanal fishery. From a political point of view, however, this arrangement turned out to be a rather sensitive issue. It became even more a matter of concern when the projected financial benefits did not materialize in the way the Sierra Leonean Government had anticipated. As a consequence, the services of MPSSL were discontinued in 1993.

78. During the years 1991 and 1992 catch records were reported by the fishing vessels on forms designed by the MPSSL in accordance with suggestions from the Department of Fisheries. Though in general appropriate for the purpose intended (knowledge of total catch to determine royalties), it was later decided that it would be more appropriate for fishery management, if the catches were reported on a haul by haul basis, and not as catch per 24 hours without any information on the related fishing effort, as it was the case with the MPSSL forms.

79. As a consequence the project designed new fishing logs for the different fishing operations (trawler, shrimper, purse seiner), very much along the line of the old forms, making however provision to enter the details of each haul individually.

80. "Blue prints" of these new fishing logs were prepared for the Department of Fisheries, where they were reproduced in large numbers and then distributed to the fishing vessels.

81. For various reasons, the expected close cooperation between the IMBO/ICLARM Project and MPSSL did not take place. This cooperation was meant to develop a common strategy and the necessary structure for a constant flow of data from the fishery via MPSSL to the Department of Fisheries for final analysis. It was, however, only in December 1992, that MPSSL handed over the catch reports that had accumulated over the months.

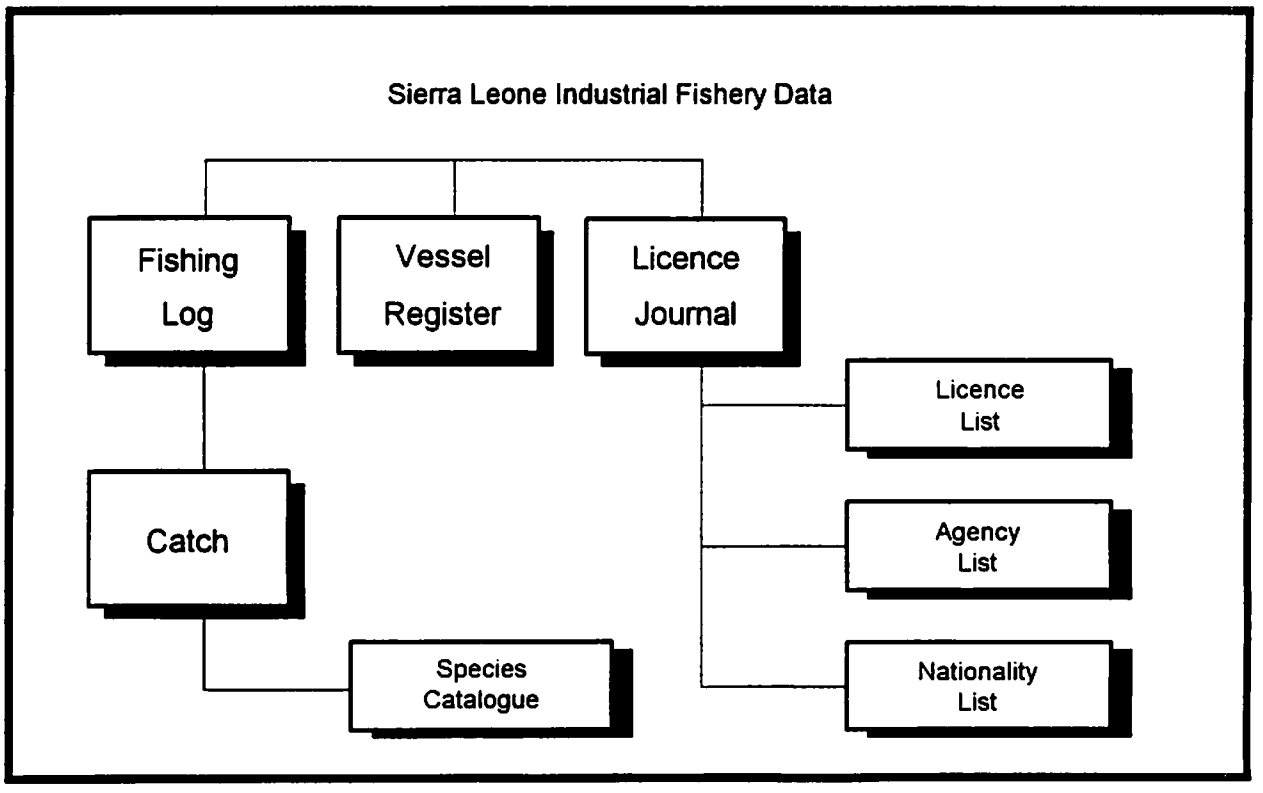
82. With these data available and after a series of discussions with the Department of Fisheries, a preliminary version of a database system was developed that was to fulfill the following purposes:

- keep record of all licensed vessels
- assist in the procedure of licensing, and monitor the licence status of all vessels registered
- receive and analyze catch reports from the licensed vessels for the preparation of monthly and/or annual reports.

83. The general structure of this database is depicted in Figure 3. Its major components are "Vessel Register", "Licence Journal", and "Fishing Log".

84. The central "Vessel Register" receives the specific information that identifies a vessel (name, call sign, port of registration, etc.), as well as all technical details concerning performance and equipment of the ship, that might be necessary to determine the type of licence and amount of fee to be paid.

Figure 3 Structure of the relational database for the storage and processing of industrial fishery data.



85. "Licence Journal" is the form in which all details concerning the licensing of a specific vessel are entered. Sub-components of the database system keep track of licences, registered agents, and nations taking part in the exploitation of the marine resources off Sierra Leone.

86. The component "Fishing Log" together with its sub-form "Catch" are meant to receive the catch records from the fishing vessels. These consist of information on the reporting vessel, location, time and duration of the fishing operation, and a breakdown of the catch by species or group of species, depending on how the catch is sorted on board. Sorted species are identified by their local names, and selected from a list in the auxiliary form "Species Catalogue". This list also contains for each vernacular name its corresponding scientific name on species, genus and/or family level. This allows to present summaries of the catch records according to FAO standards.

87. Though the return of filled-in fishing logs improved markedly in 1993, the efficient use of the database was severely hampered by administrative constraints (lack of centralization) and the unavailability of appropriate computing facilities at the DOF office in Kissy. It was finally conceded that despite all the effort displayed by the DOF staff, it would need a major reorganization of the statistical unit of the DOF and provision of more computing equipment, to realize the expected benefits from the database. As this was outside the scope and means of the present project, the DOF was advised to seek additional funding for a separate project that would provide assistance in the establishment of a fisheries database for the monitoring of the industrial fishery.

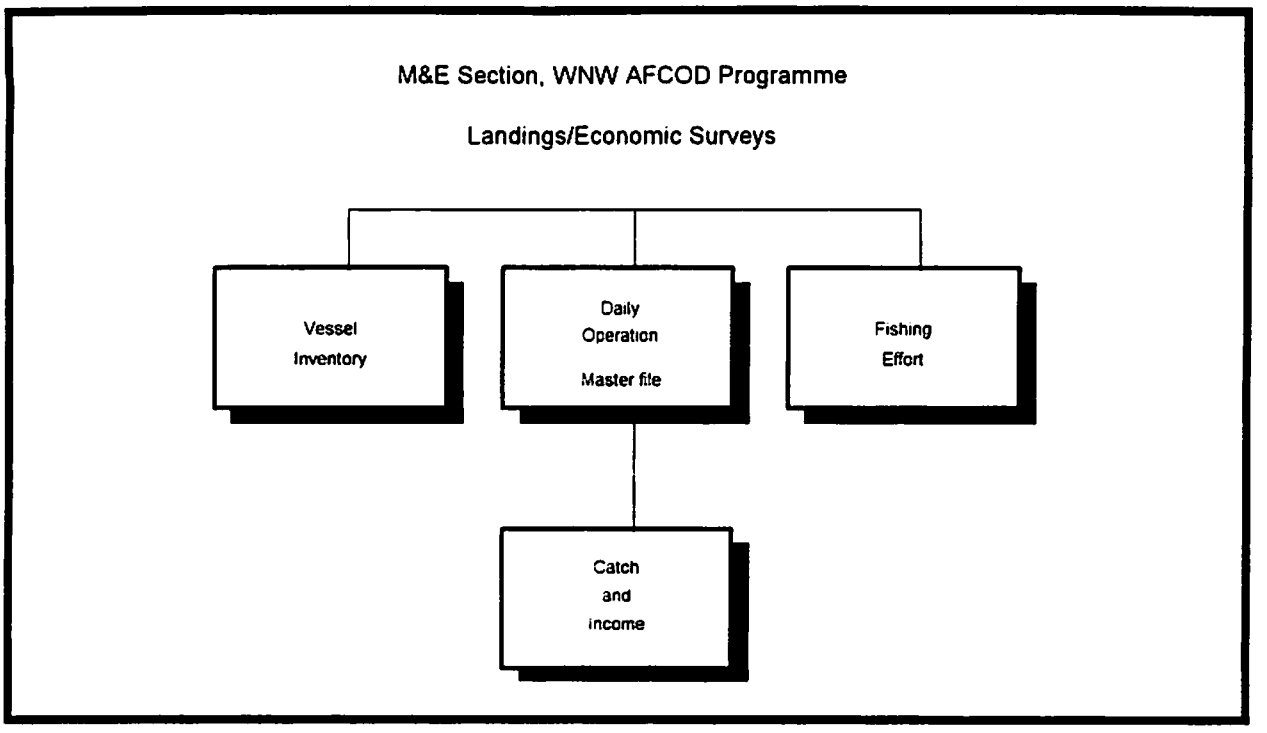
3.1.4 WNW AFCOD Artisanal Fisheries Statistics

88. Throughout the project life cooperation between the IMBO/ICLARM project and the West-North-West Artisanal Fisheries and Community Development Programme (WNW AFCOD) was excellent. Assistance to the WNW AFCOD Programme consisted in the conceptualization and design of a number of database applications, covering fishery statistics, use of water wells and performance of primary health centers by the Monitoring & Evaluation Section, store-keeping and performance evaluation by the Engineering Section, modeling by the Credit Section, and accounting. On the other hand, the WNW AFCOD Programme provided the logistics and the necessary support to acquire and maintain the computer hardware used by the WNW AFCOD Programme, the IMBO/ICLARM project and the Department of Fisheries.

89. Main support provided to the WNW AFCOD Programme consisted of assistance in the design and implementation of a data collection scheme for the artisanal fishery in the project area . As a result, the M&E Section of the WNW AFCOD Programme has collected extensive data on landings and the economics of fishery operations in selected villages in the Programme area. From the point of view of fisheries management, these data are of potential interest for the design and implementation of a general data collection scheme for the artisanal fishery in Sierra Leone.

90. In order to facilitate the analysis of around 150 boat operations monitored every day a database system was developed for the M&E Section, whose main components are "Daily Operation" and "Catch and Income" (see Figure 4). These components receive the bulk of information collected on fishery-related activities, daily expenditures, income and catch by species. Linked to these are the components "Vessel Inventory" and "Fishing Effort". The first contains details on each vessel identified in the Programme's area such as type and name of a boat, fishing gear used, motorization. The latter receives the information on number of fishing days per week, by locality and type of vessel, recorded on special forms handed out to boat owners.

Figure 4 Structure of the database for the artisanal fishery landing statistics in the WNW AFCOD Progamme area



91. Analysis of the data was the responsibility of the M&E Section of the Programme. The data were used in a number of project reports such as the "Statistical Fisheries Bulletin", or to provide baseline information for other sections of the Programme (e.g. price evaluation of major species in the landings).

92. As in many cases, the database of the WNW AFCOD landing statistics contains potentially more information than actually needed within the scope and framework of the Programme. In this respect, the database is probably underutilized. As it can, however, not be expected, that a project uses limited staff time to engage in research activities not covered by the project's objectives, it was suggested to make the database available to other interested persons working on the artisanal fishery in Sierra Leone.

3.2 Rehabilitation of the DOF Library

3.2.1 Background

93. The library of the Department of Fisheries in Sierra Leone was established in the 1950' as part of the West African Fisheries Research Institute (WAFRI), then located at Kissy Dockyard. It was taken over by the DOF after independence. With IMBO also being housed at the same premises, the library served well the needs both of the fisheries administration and the academic clientele.

94. Until 1978 the library was headed by a trained librarian who maintained a proper classification and filing system. However, after her resignation, the duty to take care of the library was assigned to various employees of the DOF. Lacking the proper training and without any financial assistance, these

persons were not in a position to maintain the library at its high standards. As a consequence, the library had de facto ceased to function in the late 1980'.

95. Given that access to relevant information is a major pre-requisite to advances in marine resources management, the project identified the rehabilitation of the fisheries library at Kissy Dockyard as an important component in the strengthening of institutional capacity at the DOF. In the same time it would also benefit the research activities to be carried out at IMBO.

96. As a consequence, the budget for the extension of the IMBO/ICLARM project included an allocation of slightly over 17 Million Leone for the rehabilitation of the library. A breakdown of the expenditures is presented in Table 3.

Table 3 Summary of expenditures (in Leone) occurred in connection with the rehabilitation of the library at the DOF, Kissy Dockyard.

Total Budget			**17,050,000**
Expenditures			
	Construction	7,933,100	
	Book Repair / Binding	4,379,350	
	Library Equipment	618,832	
	Air Conditioning	950,000	
	Librarian	946,000	
	Computer system	1,600,000	
	Miscellaneous	587,663	
	Total Expenditures	*17,014,945*	**- 17,014,945**
Budget Balance			**35,055**

3.2.2 Implementation

97. In June 1993, an architect was contacted to.draw up a plan for the planned repair, respective improvement of the existing building, and the construction of a small annex through which the library is accessed. This annex was to also provide office space for a librarian and house a small archive for the reprint collection.

98. After going through the usual procedure of bidding, a contractor was selected and construction work started in December 1993, once all material had been removed from the existing building.

99. Parallel to the construction work all material from the library was sorted and prepared for binding, respective repair. This was done under the supervision of a graduate from the Institute of Library Studies, Fourah Bay College, who had been hired by the project to oversee the rehabilitation work, to re-establish the library catalogue and to ensure that the library becomes once again a place that can serve the needs of its customers.

100. The rehabilitation work was faced with a number of constraints, the most severe among them being the limited choices when it came to book binding. Basically, only the bindery of the Fourah Bay College was still in a position to provide the type of quality binding required for this purpose. However, this institution was plagued with a number of problems, the more severe being the lack of electricity

and low staff motivation. It was only when the bindery acquired a generator and after the project introduced an output-related incentive system that performance improved and the targeted repair/binding of some 5,000 items could be met in time.

101. Another major expenditure was the purchase of computer hardware for the library. The librarian was trained in the use of specialized software for storing and retrieval of library holdings. Once completed, this system complements the usual library catalogue, and will give convenient access to information contained in the library. It will especially allow to make better use of the large reprint collection of the library which so far is completely undocumented.

102. The library was reopened to the public in July 1994 in an impressive ceremony, attended by representatives of the fisheries administration, the University and the EC Delegation. The library has quickly become the focus of renewed interest into studying the well presented reference material.

3.2.3 Recommendations

103. It is most obvious that the main reason for the deplorable condition, in which the library has been over the past couple of years, is the absence of a trained librarian. The assignment of a "caretaker" is in no way a viable alternative.

104. In the context of the present Project, much effort and financial means have been invested into the rehabilitation of the library. However, without the continued presence of an experienced librarian, the library is most likely to revert to its state of non-usability within not too long time. Thus, only the continuation of the employment of a librarian (preferably the one presently in charge of the library) will make the rehabilitation of the library a full success.

105. The Director of IMBO has indicated his readiness to follow-up on this matter, and to request the allocation of money for the position of a librarian in IMBO's next fiscal year.

106. Payment of the librarian's salary is though but one aspect of the maintenance of the library. There also has to be a budget for recurrent expenditures (stationary, mailing, printer ribbons, future binding, maintenance etc.), as well as acquisition of new publications for the library. An estimate of a basic annual budget for the library is given in Table 4. It is felt that this amount should be budgeted for by the Department of Fisheries as a match to the expected input from IMBO (librarian's salary) which amounts to about 1,500 US$ per year.

Table 4 Estimate of a minimum budget to cover annual running costs of the library at the DOF, Kissy Dockyard

ITEM	COST (in US$)
Publications	400
Binding / Book Repair	100
Library Maintenance	140
Miscellaneous (stationery, transport)	360
TOTAL (US$, per year)	1,000

107. In respect to the budget item "Publications" meetings should be held at least twice a year between the directors of the DOF and IMBO on the one hand, and the librarian on the other hand, to discuss and decide on the purchase of needed literature. Increasing the allocation for "Publications" would of course be of benefit to the library's clientele.

3.3 The DOF Statistical Unit

108. Throughout the project much support was given to the staff of the DOF dealing with the analysis of data from the fisheries sector. This included computer training, assistance in the design and analysis of a fishery household survey and of a monitoring survey of fish market prices. Main impact, however, was achieved in the design of new fishing logs for use in the industrial fishery, and in the establishment of a preliminary database to receive the incoming data (see 3.1.3 "Industrial Fisheries").

109. During the extension phase of the project more emphasis was given to the conceptualization of strategies for monitoring the activities of the artisanal fishery in Sierra Leone. In co-authorship with a member of the DOF a working paper was presented to the Intra-Project Management Meeting on "Harmonization of Fishery Statistics". The basic idea was to suggest a system that would be accurate enough to identify trends in the artisanal fishery, while in the same time being appropriate for the DOF in the light of financial and staff-related constraints. A copy of the submitted proposal is included as Appendix 4.

110. The proposal was received with much interest during the meeting. After evaluating its contents, the DOF has embarked on implementing the suggested system on a trial basis in the Tombo area. Other projects were asked to comment on its practicability and the prospect of introducing it in their respective project area until the DOF can assume sole responsibility for its implementation. The WNW AFCOD Programme has already decided to implement the system at its own project sites.

3.4 Training and Research Support

3.4.1 Computer training

111. At the beginning of the IMBO/ICLARM project none of the staff neither at IMBO, nor at the WNW AFCOD Programme, nor at the Department of Fisheries, had had much (if any!) experience in working with computers. Thus, introducing staff to the various software packages ordered together with the computer hardware for this project required a major training component, which consisted of formal training courses at the start of the project, followed by a continuous and intensive on-the-job training for all those directly involved in the use of the various database systems described above.

112. The formal training courses were held in August/September 1991. It began with a general presentation of available computer hard- and software to a broad audience combined with an introduction to the potential use of the various programs in the area of research and project management. This was followed by a one-day course devoted to general aspects of working with computers, such as connecting peripherals, starting the computer, calling-up a program, saving data in files, and to strategies of how to organize one's work on a computer.

113. A selected number of participants then attended an eight days training program on the use of spreadsheet software. The course was organized in a way to give all participants ample time to gain "hands-on" experience in entering and analyzing data with the help of this spreadsheet program. In addition, much emphasis was laid on discussing general matters in the planning of surveys, organizing of research data and presentation of results in form of tables and graphics. By the end of the course, participants were in the position to create tables with built-in mathematical functions, do basic statistics and regression analysis, and present results in various forms of graphs.

114. Training in the use of the database software was exclusively "on-the-job". Rational for this was the experience from previous training courses that the concept of a "Relational database" is very abstract for most people unfamiliar with modern information technology. One approach to this problem

is to have the trainees learning the basics of database management by working individually on topics from their own professional background at their own pace. This is of course very time-intensive for the instructor, but promises to produce the best results at the end.

115. Altogether, around 20 staff members of the three institutions involved have undergone formal computer training in the context of this project and are now regularly using computers in their daily work. The actual number of beneficiaries is even larger, as the trained people often do work for other colleagues who do not have enough time to familiarize themselves with the computer programs.

3.4.2 Lectures

116. Upon request from the Institute of Marine Biology & Oceanography a lecture was given at IMBO two hours per week for Hons. 1 and Hons. 2 students entitled "Introduction to Tropical Fish Population Dynamics". It started in the second term of the university year 1991/92 and extended into the third term. Topics covered comprised bio-statistics, sampling theory, as well as growth, mortality and recruitment of fish. Also dealt with were general approaches in fisheries management and a discussion of the problems related to their implementation. Emphasis was given to those models and methods that can readily be applied to tropical fish stocks. This course was also made subject of the final examination for the B.Sc. degree, which the students passed with good results.

3.4.3 Thesis supervision

117. A very important part of the educational component of the project was the supervision of research work at B.Sc. and Ph.D. level. Various research topics were exclusively based on the analysis of the fishery research data available through the database systems established in this project. A list of all thesis work supported by the project is included in Appendix 3.

118. A first successful application of the database with the Sierra Leone - USSR research data was a B.Sc. thesis on carangids. The thesis used the data to obtain (and compare) estimates of biomass of an economically important fish family (Carangids), applying traditional methods of stock assessment. The author was able to show - among others - the wide variation of such estimates. Irrespective of whether these variations reflect biological variability, migration or shortcomings in the data sampling design, their message is obvious: relying only on the findings of research cruises isolated in time and space can either lead to wrong assumptions concerning the stock size or be of only little value for any long term prediction of sustainable catches. As such the findings emphasized the need for a reliable and continuous data collection scheme in a national fisheries. The thesis was well received by the external examiner, and was later awarded a price for the "Best Dissertation" in the Life Science Division of the University of Sierra Leone for 1992.

119. Another B.Sc. thesis was completed in June 1993, which dealt with the distribution of sciaenids, an economically important family of demersal fish. The thesis followed a similar pattern as the one mentioned above, and clearly underlined the preference of this fish for coastal waters. They thus represent a resource that is also of great importance to the artisanal fishery.

120. A third B.Sc. thesis exclusively based on data from the Sierra Leone - USSR research cruises was presented in 1994. It comprised an investigation into the distribution and biology of *Sardinella*.

121. In addition to the research directly related to the Sierra Leone - USSR fishery research database, assistance was also provided to other students at IMBO, dealing with topics such as the growth of mudskippers, the biology of the West African Clupeid *Ilisha africana*, analysis of the spatial distribution of temperature, salinity and oxygen content in the coastal waters of Sierra Leone, and a computerized database system for students' records at Fourah Bay College.

Table 5 Extrapolation of total catch per month at the level of landing site (TCL), statistical area (TCA), and at national level (TCN).

Parameter	Definition	Formula
Total Catch at Landing Site (by gear, per species $TCL_{(G,S)}$	Average total catch (by gear, per species) multiplied with the total number of a given type of gear based at a landing site.	$TCL_{(G,S)} = TC_{(G,S)} \cdot n_{L_{(G)}}$ with: TC: average total catch (by gear, per species) n_l : total number of a gear based at a landing site
Total Catch in a Statistical Area (by gear, per species $TCA_{(G,S)}$	Average total catch (TC, by gear, per species) multiplied with the total number of a given type of gear based in a statistical area.	$TCL_{(G,S)} = TC_{(G,S)} \cdot n_{A_{(G)}}$ with: TC: average total catch (by gear, per species) n_A: total number of a gear based in a statistical area
Total Catch at National Level (by gear, per species $TCN_{(G,S)}$	Sum of all total catch per statistical area (by gear, per species), multiplied in each area with a correction factor cf_a representing an estimation of the catch of those gears that were not sampled.	$TCN_{(G,S)} = \sum_{i=1}^{i=n} TCA_{i_{(G,S)}} \cdot cf_{a_i}$ with: TCA: total catch in a statistical area (by gear, per species) cf_a: correction factor for gears not sampled in a statistical area

Table 4 Monthly calculated parameters: computational procedure, Level II.

Parameter	Definition	Formula
Catch per Unit of Effort (by gear, per species $CPUE_{(G,S)}$	Monthly average catch per day of a given type of gear (per species), multiplied with the monthly average usage coefficient of the said gear. (Note: If the monthly average usage coefficient is set equal to one, average catch per unit of effort is equal to average catch per day.)	$CPUE_{(G,S)} = \overline{C}_{(G,S)} \cdot \overline{U}_{(G)}$ with: C: average catch per day (by gear, per species) U: average usage coeficient (by gear)
Total Catch (by gear, per species $TC_{(G,S)}$	Monthly average catch per unit of effort for a given type of gear (per species), multiplied with the monthly average fishing effort of the said gear.	$TC_{(G,S)} = CPUE_{(G,S)} \cdot \overline{F}_{(G)}$ with: CPUE: average catch per unit of effort (by gear, per species) F: average fishing effort (by gear)
Coefficient of Average Fishing Activity (by gear) $CFA_{(G)}$	Total number of fishing days in a month divided by the average number of days a given type of gear has been used for fishing in the respective month.	$CFA_{(G)} = \frac{fd}{\overline{F}_{(G)}}$ with: fd: total number of fishing days in a month F: average fishing effort (by gear)

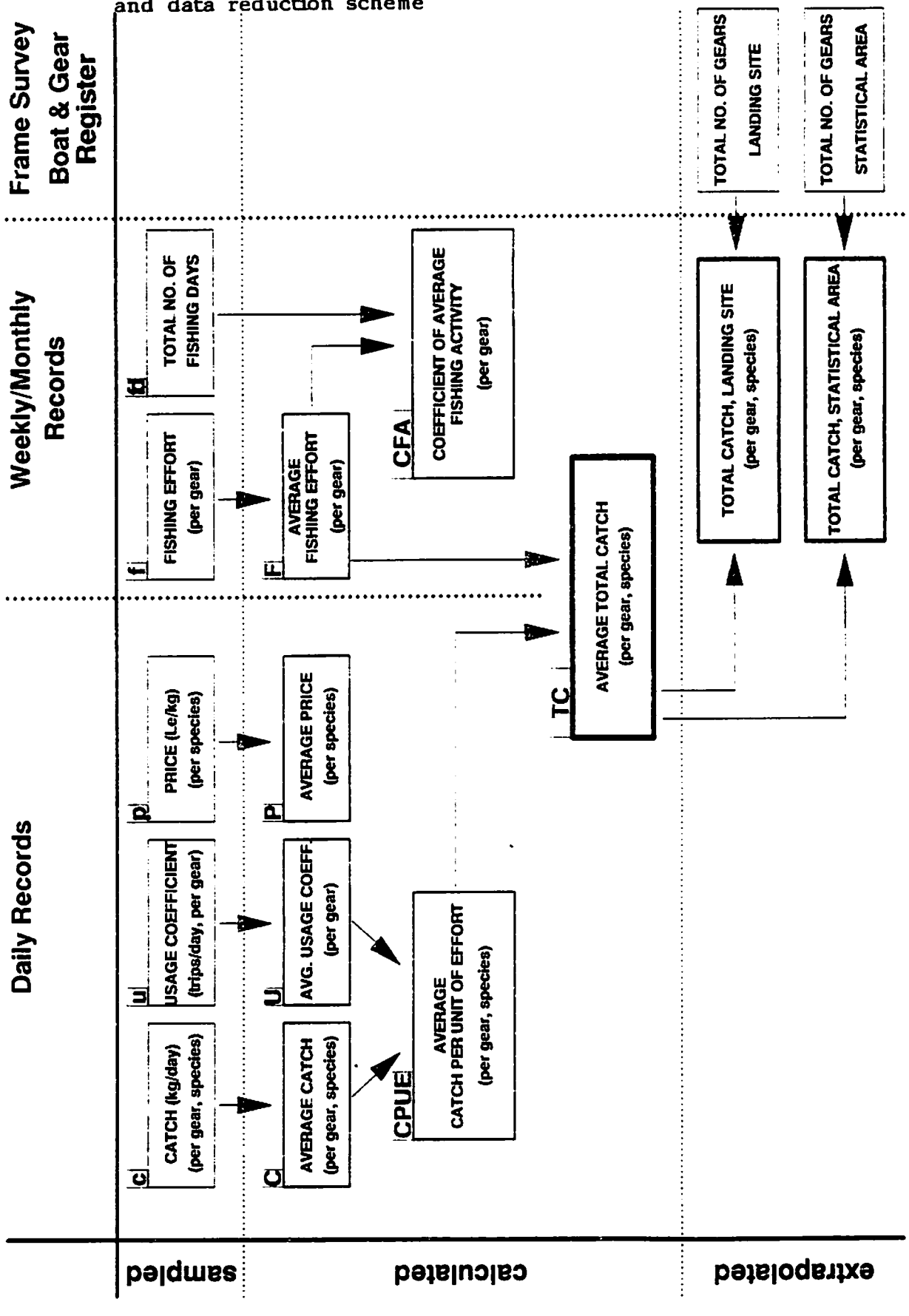
Table 3 Monthly calculated parameters: computational procedure, Level I.

Parameter	Definition	Formula
Average Catch (by gear, per species) $\overline{C}_{(G,S)}$	Arithmetic mean of all catches per day recorded for a specific type of gear (per species).	$\overline{C}_{(G,S)} = \frac{1}{n} \cdot \sum_{i=1}^{i=n} c_{i(G,S)}$ with: c_i: observed catch (by gear, per species) n: number of observations
Average Usage Coefficient (by gear) $\overline{U}_{(G)}$	Arithmetic mean of all records for a specific type of gear on number of fishing trips (= landings) per day. (Note: under normal conditions, one fishing trip per day is assumed.)	$\overline{U}_{(G)} = \frac{1}{n} \cdot \sum_{i=1}^{i=n} u_{i(G)}$ with: u_i: observed number of trips per day (by gear) n: number of observations
Average Price (per species) $\overline{P}_{(S)}$	Arithmetic mean of all records on price per kg for a given species (in Leone)..	$\overline{P}_{(S)} = \frac{1}{n} \cdot \sum_{i=1}^{i=n} p_{i(S)}$ with: p_i: observed price per kg (per species) n: number of observations
Average Fishing Effort (by gear) $\overline{F}_{(G)}$	Arithmetic mean of all records on number of days fished in a month for a specific type of gear	$\overline{F}_{(G)} = \frac{1}{n} \cdot \sum_{i=1}^{i=n} f_{i(G)}$ with: f_i: observed number of days fished in a month (by gear) n: number of observations

Table 2 Daily or monthly sampled parameters: definition and critical assumptions

Parameter	Definition	Critical Assumptions
Catch (**c**)	Amount of fish caught by a gear during one fishing trip and put up for sale (in local units, but then converted to kg).	Amount of fish discarded while on sea or given to crew for personal consumption is negligible. (If payment to the crew in kind ["WAAP"] is a standard feature, appropriate correction factors have to be applied to the total catch estimates.)
Usage Coefficient (**u**)	Number of fishing trips per fishing day of a given gear, with one fishing day set equal to unit of effort . (Typically, this number will be "1", meaning one trip per fishing day.	The average number of fishing trips of a gear during a day is representative for the degree of activity typical for the said gear in the statistical area
Price (**p**)	Amount (in Leone per kg) paid by the first buyer for all or part of the catch	Price fluctuations during a day are randomly distributed. (If prices are found do change consistently with e.g. increasing number of landings, enumerators have to ensure that their sampling is spread over an extended period of the day.)
Fishing Effort (**f**)	Number of days in a month that a specific type of gear has been used for fishing.	If sampled from a large number of operators at the landing site, the average number of days a gear is used in a month is representative for the degree of activity typical for the said gear in the statistical area. Gears of the same type inflict the same fishing effort on the stocks, respective existing variation in gear size is randomly distributed and thus balanced by the random data collection scheme.
Total Number of Fishing Days (**fd**)	Number of days per month, on which fisher - in a statistical area, operating a certain type of gear - go out fishing. By default this number is 26 days (30 days minus 4 holidays), but can be further reduced, if in a given month other generally observed holidays occur, or if weather conditions prevent fisher from leaving the shore.	Days without fishing are generally observed by all fisher in a statistical area.

Figure 1 Monitoring the artisanal fishery in Sierra Leone: Information flow and data reduction scheme



procedure to establish the weight, will invariably over-stress the willingness of the fishing community to cooperate and, thus, will lead to the data not being collected at all.

Conclusions

A concept of "Selective Sampling" according to importance of landing sites and gears is presented in this paper. This approach is expected to enable the Department of Fisheries to re-establish its own monitoring system of the artisanal fishery, independent of externally funded development projects.

The concept is based on the cognition that the information needs in fisheries management are geared towards the detection of trends rather than the establishment of total production figures. A data collection and analysis scheme is presented that is meant to keep a balance between the need for reliable data useful for management, and the cost of achieving this goal.

The system proposed has the advantage that even its partial implementation would already yield useful results if maintained over an extended period of time. Its requirements in terms of personnel and infrastructure can be accommodated even in view of the existing budget constraints at the Department of Fisheries. The volume of data generated by the sampling scheme will not exceed the data processing and analysis capacities of the Department of Fisheries. These factors combined will be a minimum guarantee for the sustainability of the proposed monitoring system, which, if properly implemented, will strengthen the capabilities of the Department of Fisheries in the management of the marine resources of Sierra Leone.

Field Work

The practical realization of the proposed sampling scheme would require the stationing of one enumerator each in the seven villages to be sampled. Their field work would consist of both daily routine sampling of landings and additional task to be carried out at larger intervals.

A. *Daily routine sampling*

i) Each fishing day two types of gear are sampled in alternating sequence,
e.g. Day 1: ring net, gill net bottom-net
Day 2: beach seine, gill net surface-set.

ii) For each of the two types of gear monitored three landings are randomly selected at the given sampling day (i.e. a total of six landings per day).

iii) For each landing of a gear the following information is recorded:

- catch by species in local unit
- conversion factor local unit to kg for each species
- effort (fishing trips per day)
- value of transaction (per species)

B. *Weekly/monthly routine sampling*

i) Number of actual fishing days during the week
(7- (Sunday/Friday + any special holiday))

ii) Collect from a large number of boat operators the information of how many days their gear(s) was (were) used during the week/month. This should also include fisher operating gears other than the one sampled.

C. *Additional tasks of less regular character:*

i) Assist the village authorities in the establishing and maintenance of a "Boat and Gear Register"

ii) Carry out two to three times a year a survey of landing sites regarding number and type of boats/gears based in those villages. Each enumerator will have responsibility for a specified area along the cost adjacent to the village where he is based.

As can be seen from point A. iii), conversion of local units of transaction into actual weight is an important part of the enumerators routine work. For this purpose all enumerators have to be provided with simple hand-held spring balances that will allow them to quickly weigh a number of samples of ten fish each of all the species landed. The type of scale most appropriate for this task seem to be those used by sport fisher to weigh their catch. These balances might not be accurate to the last gram, but this is largely offset by their ease-of-use which allows a more frequent and especially more regular data recording. As with all artisanal fisheries, fisher in Sierra Leone do not appreciate any interference that delays the commercialization of their catch. Setting-up a bulky precision-balance at the beach with a time consuming

Computational Procedure

A graphic outline of the whole process of data reduction is presented in Figure 1, showing the flow of information from the sampled parameters to the final result at the level of Statistical Area. The diagram represents a matrix in which the process of data analysis is arranged horizontally (sampling, calculation, extrapolation), whereas the source of information (daily records, weekly/monthly records, frame survey) is organized vertically.

Table 2 summarizes definition and critical assumptions in respect to the five basic parameters collected in the field (catch, effort, price, days fished, total number of fishing days).

Table 3 presents the first level of calculated parameters, their definition and the formulas used to calculate the results. These are simply arithmetic means of the data sampled during a month on catch, effort, price, and days fished. On the second level of computation, these results are further reduced to obtain catch per unit of effort and total catch of a "typical gear" (of a certain type) for a month (Table 4). Beside, at this level a "Coefficient of Fishing Activity" is computed for each gear, to obtain for every month a comparable indicator of the average activity of each gear.

The computed **Average Total Catch Per Gear** is the focal point of the analysis. The result obtained must be looked at as the "typical total catch" of a "typical type of gear" (e.g. a ring net) achieved at the sampled landing site in a given month. If random selection principles were maintained in the selection of boats arriving at the landing site, this figure is most probably still fairly reliable. It will definitely be reliable enough to reveal trends in the distribution of either catch per unit of effort or fishing effort, and thus serve the intended purpose, i.e. providing information for the management of the fisheries.

Table 5 summarizes the computational procedure necessary to extrapolate from the computed average total catch to Total Catch at Landing Site, Total Catch in Statistical Area, and Total Catch at National Level. This is achieved by combining the figure for average total catch with information obtained from frame surveys or a Boat & Gear Register on number of gears of a certain type used at a landing site respective in a statistical area. A frame survey has been carried out in 1990 and its results are available, a Boat & Gear Register should be established and maintained by the enumerators at each landing site.

The results from the seven Statistical Areas taken together represent in a way the total national catch of the artisanal fishery in Sierra Leone, which, however, has to be adjusted by a certain factor to account for the catch of those gears that were not sampled. As already mentioned in the introductory remarks, this result is of limited interest in terms of fishery management, but could easily be used e.g. for generally assessing the national fish production, or for FAO statistics.

Additional parameters obtained from infrequent observations, frame surveys, area surveys, boat and gear registers, etc. will be:

- **Number of boats** used for fishing with a specific type of gear, by landing site, by statistical area.
- Catch volume of **gears not monitored**

It is mandatory that the amount of data obtained every month is matched by corresponding facilities and staff time at the Department of Fisheries' headquarters for processing and analyzing of the data. Far too often, this side of the monitoring process is overlooked. Ambitious sampling schemes generate quickly vast amounts of data, which are too much to be handled by the staff available. Invariably, the consequence of such a mismatch is the collapse of the whole system, as the decision makers will not receive the information they expected, and thus be tempted to withdraw their support (both political and financial), because they will not see its further usefulness.

Table 1, therefore, also gives an indication of the amount of information in terms of single observations that can be expected from the suggested sampling scheme. This is about one third of the data volume that would be generated by a typical standard random sampling scheme applied to the whole of the artisanal fishery in Sierra Leone.

Table 1 Summary on the various statistical entities to be sampled, the number of observations for each entity, and the accumulated total number of observations generally obtained within one month.

	Statistical entity	No. of entities to be sampled	Accumulated no. of observations
A)	Landing sites (Yeliboya, Konakridee, Goderich, Tombo,. Shenge, Nginga, Sulima)	7	7
B)	Gears (ring net, beach seine gill net bottom-set, gill net surface-set)	4	28
C)	Sampling days per gear (30% of potential fishing days)	12	336
D)	Landings per gear	3	1,008
E)	Species components (assuming that on the average data on at least two species have to be recorded for each landing)	2	2,016

statistical area, and the national level. Based on the observations of the enumerators appropriate adjustments will be made for the catch of gears not sampled.

Major advantage of the proposed system is that
(i) the results would reflect trends in the fishery
(ii) the logistic problems coupled with its implementation are minimized and
(iii) even a partial implementation already would yield useful information.
Its major disadvantage is that the extrapolation of the data will make the results for total production on the national level very approximate.

Methodology

The artisanal fisheries of Sierra Leone is characterized by the fact that the majority of fishing activities is concentrated at just a few fishing villages along the coast. These are (from north to south) **Yeliboya**, **Konakridee**, **Goderich**, **Tombo**, **Shenge**, **Ngianga**, and **Sulima**). It is estimated that about 70% of the total catch of the artisanal fishery is landed in these villages. Thus, a proper sampling scheme, which covers at least the mentioned villages, should be able to reveal trends in the fishery that are fairly representative of the whole sector.

A large number of different gears exist in the artisanal fishery of Sierra Leone. But not all of them contribute in the same manner to total landings. Among the more important ones are: **ring net**, **gill net bottom-set**, **gill net surface-set**, and **beach seine**. These combined might land as much as 80% of the total catch, the rest being caught by cast net, channel net (illegally!), hook and line, long lines, and others. It seems justified to lay emphasis in sampling on the first mentioned gears, while monitoring of the other gears could be done at less frequent intervals to assess their contribution to the fishery as a whole.

Table 1 presents a summary of the suggested monitoring system. Main statistical entities are:

- **Site Stratum:** seven landing sites along the coast;
- **Gear Stratum:** four types of gears at each landing site;
- **Sampling Days:** twelve sampling days per gear per month;
- **Landings:** three landings per gear per sampling day.

Basic parameters monitored on a regular basis will be:

- **Catch:** landing by species, in local units, converted to weight;
- **Usage:** fishing trips per day;
- **Price:** value of transaction at first selling point, by species;
- **Activity:** combination of observations on actual fishing days and days fished, by gear.

Basic considerations applied in this contribution to the design of an appropriate and sustainable monitoring system for the artisanal fishery are as follows:

Knowledge of total landings from the fishery sector is useful in that it indicates the contribution of that sector to national food production. In terms of fisheries management, however, it is not so much absolute figures that matter, but rather the significant changes over time implied by these figures. Thus, an essential requirement for fisheries management is the availability of data that reflect trends in the fishery sector.

An example: The information that the artisanal fishery in Sierra Leone with a fleet of 6,000 canoes has landed a total of 15,000 tons of fish in 1993 would not be of any help in the formulation of an appropriate fisheries management strategy. In contrast, the information that over the past five years total landings have decreased by ten percent while the number of canoes has remained more or less the same, indicates a trend in the fishing sector which might need corrective measures from the fisheries administration. Of course, revealing a trend in the fisheries sector does not yet give an explanation for the cause of the trend, but it limits the search for it.

In summary, this means that highest priority has to be given to continuity in data collection. Continuity is most likely achieved, if the data collection scheme is well adapted to the organizational and financial capacities of a fisheries department. Over-ambitious approaches might look good from a scientific point of view, but are very likely to be abandoned sooner or later, simply because a fisheries department can not afford it!

With this in mind, a sampling strategy for the artisanal fishery is proposed that is based on the concept of "Selective Sampling", a more cost-effective approach to the gathering of information compared to the traditional concept of "Stratified Random Sampling". It tries to reconcile reliability and accuracy of the information obtained with the cost of achieving this goal.

Selective Sampling - Basic Principles

The principle idea behind the suggested monitoring scheme consists of selecting seven major landing sites along the cost of Sierra Leone as sampling sites (**Site Stratum**) and limit data collection at the selected sites to the four most important types of gear (**Gear Stratum**). Within each stratum, data collection will be done according to standard random sampling procedures.

To each Site Stratum will be assigned a **Statistical Area** which includes landing sites not considered for routine sampling. Five of these seven Statistical Areas will be identical with the five coastal districts, while the Western Area is made up of two Statistical Areas (Goderich and Tombo).

At each landing site will be posted an enumerator of the Department of Fisheries, who has responsibility for daily routine data collection at the landing site, and for obtaining background information from the surrounding Statistical Area.

Data collection and analysis will concentrate on obtaining reliable figures for **Average Total Catch by Gear** complemented by information on species composition, economic value, and average fishing activity. Information on number of boats using a specific type of gear from a "Boat and Gear Register" (to be established) or from frame surveys will be used to extrapolate total catch figures to **Estimated Total Production** at the level of the landing site, the

Monitoring the Artisanal Fishery in Sierra Leone:
Proposal for a Cost-effective Sampling Strategy for Implementation by the Department of Fisheries, DMR

by

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Introduction

Effective management of the artisanal fishery in Sierra Leone requires the availability of base-line data upon which to build decisions. These data should enable the Department of Fisheries

a) to determine the present status and the direction of development of the artisanal fishery;

b) to assess the interdependency of the artisanal fishery vis-a-vis other contenders in the exploitation of the marine resources;

c) to assess the impact of management strategies on the resource itself in order to ensure overall sustainability of the exploitation of the marine resources.

This technical paper presents for discussions a system that should be part of a National Fishery Statistics Program and will allow to obtain management oriented base-line information from the artisanal fishery of Sierra Leone in respect to point a) and b). A more detailed version of this paper will be prepared later with an in-depth discussion of the ideas presented as well as proposals for activities in the context of a National Resource Survey Program to accomplish fishery management tasks stated under point c).

Aims and Objectives

Over the past years routine sampling of data from the artisanal fishery sector has been mainly left with externally funded development projects. It is only very recently that the Department of Fisheries is making efforts to regain control over this important aspect of the management of its marine resources. Whether these efforts will succeed depends to a large extent on the question whether the monitoring system applied is sustainable. It can only be sustainable, if its logistics and financial requirements match the existing organisatorial and budgetarian frame set forth by the Department of Fisheries.

Appendix 4

Artisanal Fishery Monitoring Proposal

3.2 Thesis (supervised)

Jalloh, A. 1992. Estimation of the biomass of carangids in Sierra Leone waters, based on joint Sierra Leone - Soviet fishery surveys 1976 to 1990. B.Sc. Thesis. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone. 47 pp.

Conteh, A.S. 1993. The distribution of sciaenids in Sierra Leone waters based on the Sierra Leone - USSR fishery research cruises data (1976-1990). Thesis. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone. 74 pp.

Jalloh, K. 1994. Investigation into the maturity stages of Sardinella in the Sierra Leone waters based on the Sierra Leone - USSR fishery research cruises data (1976-1990).

3.3 Thesis (assistance provided)

Turay, I. 1993. Investigation of various aspects of the biology of the mudskipper, *Periophthalmus koelreuteri*. Thesis. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone. 40 pp.

Cham, A. 1994. The biology of the West African clupeid, *Ilisha africana*, (Block, 1795) off Goderich and Hamilton coasts, Sierra Leone. Thesis. Department of Zoology, Fourah Bay College, University of Sierra Leone. 70 pp.

Labor, R.I.A. 1994. A computerised database system for students' records - Fourah Bay College. Thesis. Institute of Public Administration and Management, University of Sierra Leone. 131 pp.

Vandy, E.P.J. 1994. An analysis of the spatial distribution of temperature, salinity and oxygen content in the coastal waters of Sierra Leone, based on the data from the Sierra Leone - USSR research cruises. Thesis. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone. 59 pp.

3.4 Technical Project Reports

Preparatory Mission Report	(6-15 September 1990)		
Start-up Report	(April 1991	-	June 1991)
Progress Report No. 1	(April 1991	-	September 1991)
Progress Report No. 2	(October 1991	-	March 1992)
Progress Report No. 3	(April 1992	-	September 1992)
Final Report, Phase 1			
Progress Report No.4	(June 1993	-	November 1993)
Progress Report No. 5	(December 1993	-	May 1994)
Final Report			

3.1 Publications/Reports

Vakily, J.M. 1992. Assessing and managing the marine fish resources of Sierra Leone, West Africa. Naga, The ICLARM Quarterly 15(1): 31-35 (also published in the EC Fisheries Cooperation Bulletin 5(2): 22-24. 1992.)

Labor R., A. Jalloh and J.M. Vakily. 1993. Artisanal fishery frame survey 1990 in Sierra Leone: Data compendium. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone, Freetown. 150p.

Showers, P.A.T., 1993. Length-weight relationships of five species of the family Sparidae in the Gulf of Guinea. Naga, The ICLARM Quarterly. 16(2-3): 32-33

Vakily, J.M., 1993. Solar systems and computers: How to become independent of electricity supply. Naga, The ICLARM Quarterly, 16(1): 19-20

Vakily, J.M., 1993. Dynamite fishing in Sierra Leone. Naga, The ICLARM Quarterly 16(4): 7-9

Vakily, J.M. and I.W.O. Findlay (editors) 1993. Bulletin of the Institute of Marine Biology and Oceanography. Special Edition 98 p. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone, Freetown, Sierra Leone, and International Center for Living Aquatic Resources Management, Manila, Philippines.

Vakily, J.M., I.W.O. Findlay, R. Labor and A. Jalloh. 1993. Artisanal fishery frame survey 1990 in Sierra Leone: Summary of a general census of boats, motorization, gears, and employment in the artisanal fishery. Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone, Freetown. 27p.

Vakily, J.M. 1994. Sierra Leone Fishery Surveys Database System (FiSDaS). Volume 1: User Manual. International Center for Living Aquatic Resources Management, Manila, Philippines. 72 p.

Vakily, J.M. 1994. Sierra Leone Fishery Surveys Database System (FiSDaS). Volume 2: Technical Reference Handbook. International Center for Living Aquatic Resources Management, Manila, Philippines. 310 p.

Vakily, J.M. and D. Pauly. 1994. Seasonal movements of Sardinellas off Sierra Leone. Paper included in the Proceedings of a Workshop on "Dynamics and Uses of Sardinellas resources from Upwelling off Ghana and Côte d'Ivoire. Accra, 5-8 October 1993. (in press)

Vakily, J.M. and M.B.D. Seisay. 1994. Monitoring the artisanal fishery in Sierra Leone: Proposal for a cost-effective sampling strategy for implementation by the Department of Fisheries, DMR. Paper presented to the Intra-Project Management Meeting on "Harmonization of Fishery Statistics" in February 1994.

Vakily, J.M. and S.E. Pedro. 1994. Sierra Leone Fishery Library - A Case of Sleeping Beauty. Naga, The ICLARM Quarterly 17(3): 22-23 (also to be published in the EC Fisheries Cooperation Bulletin)

Appendix 3

Summary of Project Documents

- Practical introduction of enumarators in the field to the modified data collection approach.

1992

- Permanent implementation of modified data collection scheme.
- Development, testing and implementation of a database for the artisanal fishery data collected by the Programme.
- Assistance in revising the Programme's Statistical Bulletin

1993

- Continous support to the M&E Section in the maintenance of the database on artisanal fishing activities in the project area.
- Assistance in the design and computerization of the monitoring and evaluation of the diesel outbord component.

1994

- Continous support to the M&E Section in the maintenance of the database on artisanal fishing activities in the project area.

2.3 Supported Institution: Department of Fisheries (DOF)

1991

- Setting-up of computer hardware: computer training for DOF personnel, both formal (8 day training course) and on-the-job (about 4 persons).
- Assistance in the conceptualisation and computerisation of the "Fishery Household Survey", requested by WNW AFCOD and carried out by DOF personel (Mr. R. Jones).

1992

- Design and handing-out for trial of new cach reporting forms for the industrial fishery.
- Assistance in design, computerization, and analysis of fish market surveys (project later discontinued by DOF).
- Establishment of contacts with MPSSL with ensuing transfer of industrial fishery catch reports from MPSSL to DOF.

1993

- Finalisation of new fishing logs and their introduction in the industrial fishery for improved catch reporting.
- Design of a database system for monitoring the industrial fishery.
- Transfer of previously by MPSSL collected data into the new database system.
- Planning and contract tendering for the refurbishment of the DOF library.

1994

- Refurbishment of the DOF library (renovation of building, repair/binding of books).
- Proposal to the Intra-Project Management Meeting of a cost-effective monitoring of the artisanal fishery in Sierra Leone.
- Implementation of the suggested monitoring system by WNW AFCOD (full scale) and the DOF (on a trial basis).
- Continued support to the industrial fishery database with a revision of the original database layout in order to reduce required computer time.

2.1 Supported Institution: IMBO

1991

- Setting-up of computer hardware; computer training for IMBO personnel, both formal (8 day training course) and on-the-job (about 5 persons).
- IMBO Frame Survey: Re-evaluation of questionnaires and computerization of data
- Conceptualisation of a database for the Russian Fishery Surveys

1992

- Lecture at IMBO on "Introduction to tropical fish population dynamics."
- Entering of data from Frame Survey and Russian Fishery Surveys in newly developed databases
- Supervision of a B. Sc. Thesis on the distribution and biology of carangids (based on Russian Fishery Survey data).
- Support mission of Dr. D. Pauly, ICLARM

1993

- IMBO Frame Survey: Final report and compilation of a data compendium.
- Compilation and editing of a Special Edition of the Bulletin of the Institute of Marine Biology and Oceanography.
- Continued assistance in the producing of a Ph. D. Thesis on sparids in Sierra Leone waters (partly based on Russian Fishery Survey data).
- Support mission of Dr. D. Pauly with involvement in a workshop (one week) on advanced concepts in tropical fisheries management, with introduction of participants to FiSAT, FishBase, and the Russian Fishery Survey database (24 particapants from IMBO, DOF, WNW AFCOD)
- Supervision of a B.Sc. Thesis on the distribution and biology of sciaenids (based on Russian Fishery Survey data).
- Establishment of contacts with ORSTOM, Guinea, which lead to the extension into the waters of Sierra Leone of a total of three acoustic survey programs, with the active participation of Sierra Leone scientists.
- Development of a strategic plan for the revival of IMBO research activities.

1994

- Finalisation of the computerisation of the Russian Fishery Survey data into a product now called "Sierra Leone Fishery Surveys Database System" (FiSDaS), a fully menu-driven software, with about 300 pre-programmed routines for retrieving and analysing the data, as well as a built-in Geographic Information System (GIS).
- Supervision of a B.Sc. Thesis on the distribution of Sardinella species in Sierra Leone waters (based on Russian Fishery Survey data).

2.2 Supported Institution: WNW AFCOD Programme

1991

- Setting-up of computer hardware; computer training for WNW AFCOD staff, both formal (8 day training course) and on-the-job (about 10 staff, from M&E, Credit & Cooperatives, Accounting, Secretariat).
- Revision of the existing data collection scheme and development of a modified approach to the monitoring of catch and effort in the project area.

Appendix 2

Summary of IMBO/ICLARM Project Activities

1.3 Financial Summary: Project Budgets

Phase 1 (April 1991 to March 1993)

Date of Contract signed: 12 November 1990

a) Lumpsum (ICLARM)	ECU	204.000	
b) International Travel	ECU	16.000	
TOTAL (Phase 1)			**ECU 220,000**

Bridging Phase (April 1993 to May 1993)

Date of Rider signed: 23 July 1993

a) Lumpsum (ICLARM)	ECU	17.000	
TOTAL (Bridging Phase)			**ECU 17,000**

Phase 2 (June 1993 to September 1994)

Date of Contract signed: 23 July 1993

a) Lumpsum (ICLARM)	ECU	161.460	
b) International Travel	ECU	16.500	
c) Library	ECU	25.000	
d) Contingency	ECU	22.040	
TOTAL (Phase 2)			**ECU 225,000**

1.2 IMBO / ICLARM Project Extension 1993-94

Project Objectives

- To consolidate achievements made so far during the first phase of the project.
- To assist in the implementation of recommendation that emanated from the research carried out during the first phase.
- To strengthen IMBO's capabilities to carry out research into the marine resources of Sierra Leone.
- To assist in the rehabilitation of the statistical unit of the Department of Fisheries (DOF).
- To improve the availability of and access to existing literature in the library of the DOF.

Activities

- To finalise the contents and documentation of the Sierra Leone - USSR Fishery Research database.
- To supervise research work at IMBO on the Ph.D.-, Master-, and B.Sc.-level.
- To assist IMBO in the planning of future research activities.
- To further develop a computer-assisted system for licensing, monitoring, and catch-reporting in the industrial fishery for use by the Department of Fisheries.
- To assist the Statistical Section of the Department of Fisheries in the organisation of a continuous documentation on the status of exploitation of its marine resources.
- To refurbish the existing DOF library at Kissy

Work Plan

Based on the experience gained from the use of the Sierra Leone - USSR Fishery Research database in the context of thesis projects, standard query routines will be implemented in the database and documented for future use by other researchers. Flexibility and "user friendliness" will have to be prominent features, so as to allow even inexperienced researchers to efficiently work with the database.

Support will be given to students at IMBO in the conceptualisation and conduct of their research with the aim to have accomplished by the end of the project one Ph.D., one Master, and one B.Sc. thesis. IMBO will be assisted in the definition of a medium-term research agenda, needed to secure the necessary financial means for future activities.

Significant changes have taken place since the contract with a private company in charge of monitoring and surveillance of the marine resources off Sierra Leone was revised. Thus, the database developed to assist in the licensing, monitoring and catch-reporting of the industrial fishery needs to be modified. A new data collection scheme had already been proposed to the Department of Fisheries and corresponding forms developed and distributed. A proper reporting system will have to be established to ensure continuous flow of information. The existing database will be modified so as to allow its use for licensing of fishing vessels. Personnel from the statistical unit of the Department of Fishery will be trained to use the database to produce monthly routine reports.

The existing library of the Department of Fishery, which is also used by students and researchers of IMBO, needs urgent action in order to prevent its further deterioration. To this end, all publications will be removed from the library and sent for repair, respective maintenance, to the University's Library Institute. The existing building and facilities will be refurbished. A Sierra Leonean librarian will be employed to ensure that the returning literature is properly catalogued. The librarian will also be given training in the use of computer software to improve the accessibility of information in the library.

the project. If desired and necessary, assistance will be provided for the development of efficient strategies in continued data collection.

A database system will be developed to accommodate incoming fisheries data. The system will be designed as to facilitate routine analysis to a maximum for the preparation of regular fisheries statistics reports (e.g. in the form required for FAO Annual Reports). On the other hand, it will be flexible enough to be used for all kinds of data analysis that might evolve from specific requirement in fisheries management.

The database system will be used to provide the data necessary for input in a Geographical Information System (GIS), a computer-assisted mapping tool that has turned out extremely useful for resource assessment, planning and management. It can carry out a number of analytical functions as to optimize resource allocation, it is integrative and spatial and can be updated at any time. GIS will be used for the development of efficient off-shore fisheries strategies (e.g. "fish density maps") and for coastal resource management.

Activities

All computer-related work will be matched by training of IMBO and FD personnel on the use of micro-computers both in general terms and in the application and development of specific software relevant to fisheries.

The last six months will be spent mainly in analysis and interpretation of the data gathered and in preparation and publication of a detailed report. Depending on the recommendations of the report, a proposal for follow-up activities will be prepared.

During the final phase of the project, a workshop will be held for all institutions/organizations concerned with fisheries development to present and discuss the results of the project. The proceedings of the workshop will be published as a joint IMBO-FD-ICLARM publication.

Activities

- To collect data, information and opinions relevant to the establishment of a fisheries database for the assessment of the fisheries in Sierra Leone by means of searching published documents and archives both *in-country* and abroad.

- To propagate the concept of - and create appropriate conditions for - the steady flow of information between all organizations and institutions involved in fisheries development in Sierra Leone.

- To analyze and interpret all information gained from literature searches, interviews and frame surveys so as to evaluate the history and the present status of both the industrial and the artisanal sector of the fishery in Sierra Leone and recommend appropriate measures for the rational use of the marine resources, with emphasis on improvements in the small-scale fishery.

- To publish the results of the project in a form appropriate for use by Sierra Leonean policymakers, scientists, and extension organizations, and attend to disseminate the results as widely as possible within Sierra Leone and among agencies and donor possible interested in funding follow-up activities.

Work Plan

During an initial phase of the project, organizations and institutions relevant to fishery in Sierra Leone will be identified and working relationships will be established. This will help locate sources of data and information required for the establishment of a fisheries database. The sources will be published and unpublished reports turned out by government offices (such as the statistical services of the Fisheries Division of MANR + F (FD) and Sierra Leonean institutions (such as IMBO of the University of Sierra Leone). Further sources will be interviews in fishing communities, industrial fishing companies, and fisheries development projects of international, respective non-governmental organizations (EC,FAO, GTZ, etc.)

Valuable sources of fisheries data not available in Sierra Leone will be identified and copies obtained through the assistance of the ICLARM library service.

Data retrieved from the literature or made available by cooperating institutions/organizations are collected at IMBO and computerized. The necessary hardware (microcomputers, printers) and software will be bought for

Program Duration

Two years, commencing April 1991

Project Objectives

The objectives of the project are as follows:

- To evaluate the present status of the fishery in Sierra Leone and the level of exploitation in both the industrial and artisanal sector;
- To make recommendations of possible management strategies in the light of priority proclaimed by the Government of Sierra Leone to give preference to local fisheries, particularly artisanal and semi-industrial, over foreign fisheries;
- To device a permanent system of fisheries data collection and computer-assisted handling of data for analysis and presentation;
- To train Sierra Leonean personnel in the handling of a computerized fisheries database system;
- To publish the results of this work and to disseminate these in Sierra Leone, other countries bordering the Gulf of Guinea, and to agencies and institutions with interests in fisheries development, particularly those working in West-African countries.

Scope of Work

Personnel

ICLARM will assign a Project Leader skilled in tropical stock assessment and management and familiar with computer applications and design for analysis of fisheries statistics. The Project Leader will work with the IMBO fisheries resource personnel and be supported by experts at ICLARM headquarters, Manila, for advice on methods of data analysis and interpretation.

IMBO will provide a resource specialist to be the ICLARM's scientist's fulltime counterpart and a Technician for assistance in database handling.

distribution data from surveys as well as catch and effort data from the industrial and artisanal fisheries. This will be complemented by the gathering of information on socioeconomic and sociocultural factors that, directly or indirectly, influence production and marketing of fish in Sierra Leone. Detailed analysis is also required of available information on the ecology of the fish stocks off Sierra Leone, especially with respect to those that might extend their distribution into the waters of neighboring countries.

This agreement has been prepared following a request from the Government of Sierra Leone that the Institute of Marine Biology and Oceanography (IMBO) of the University of Sierra Leone establishes links with the International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines, in order (i) to gather, analyze and interpret existing data relevant to the fisheries development in Sierra Leone; (ii) to provide training and facilities for computerized data management, analysis and presentation; and (iii) to provide recommendations for the future development and management of the fisheries resources off Sierra Leone, thereby paving the way for successful development projects. The cooperation between the two institutions will extend to collaboration with the statistical services of the Fisheries Division as appropriate for the fulfillment of their mandate.

This agreement covers a project phase of two years duration, towards the end of which proposals may be made, subject to indication of further data requirements, for specific research activities in the industrial and/or artisanal fisheries sector. These should help filling information gaps made apparent by the initial evaluation of the available database, and assist in the refinement of national policy and strategic plans for fisheries development.

Participating Institutions
IMBO and ICLARM

IMBO is an institute of the University of Sierra Leone, Freetown, Sierra Leone, mandated with study and research on the oceanography and marine resources of Sierra Leone.

ICLARM is an international, nongovernmental, nonprofit center, with headquarters in Manila, Philippines. It carries out research, training and information activities in developing countries in the fields of capture fisheries management, aquaculture and coastal resources management.

The two institutions will closely collaborate with the Fisheries Division, particularly its statistical services, for the fulfillment of their mandate.

It can be concluded that a wealth of information exists on the past and present status of the marine resources in Sierra Leonean waters. This information, however, is not available in a form suitable for the formulation of development and management strategies. Major constraints are:

- data on fishery and related aspects are generally collected by a number of different organizations (both national and international) concerned with fisheries research and development projects; poor coordination regarding the communication between the institutions involved results in the loss of valuable information;

- historic data are scattered over a large number of publications, some of which might not be available in Sierra Leone;

- even if available in published form, some data are presented in foreign reports written in languages other than English;

- reduction (i.e. analysis) of data collected in the country and accumulated as hard-copies in files often does not go beyond basic statistical summaries; if the data are not computerized, any attempt to analyze existing data material using different approaches becomes prohibitive because of the sheer amount of work involved in reorganizing and recalculating the data;

- without the availability of a computer, summary data are usually presented as rather complex tables; more elaborate (and thus time-consuming) forms of presentation are reduced to a minimum; however, visualizing of data and their trends in time and space in form of e.g. graphics, distribution charts, etc., is an important part of the presentation of results, especially if a public is addressed that is not very familiar with the subject.

In the light of the keen interest of the Government of Sierra Leone to develop appropriate strategies for the management of its marine resources, it is essential to compile all existing information relevant to the exploitation of the marine stocks off Sierra Leone. With these data available in form of a computerized database, an assessment of the present status of the fishery in Sierra Leone can be attempted. This will provide the basis for the formulation of management strategies regarding the regulation of the national fisheries sector. It will also help identify possible research needs to fill key information gaps and indicate the sort of data flow that must be maintained to ensure the database's continued usefulness for the further development and management of the Sierra Leonean fisheries management.

This will involve a detailed analysis of all relevant data available both in Sierra Leone and abroad. The information searched for will comprise catch

Background and Rationale

The marine resources of Sierra Leone are exploited both on industrial and artisanal scale. The fleet of industrial fishing vessels comprises trawlers, longliners, purse seiners, and shrimpers. A substantial part of the fleet operating off Sierra Leone is foreign-based. Industrial fishing in shallow waters within 5 miles of the shore line is prohibited by law. These inshore resources are exploited by an artisanal fishery using simple fishing crafts and a variety of fishing gears, such as gill nets, cast nets, beach seines and long-lines.

The Government of Sierra Leone has set the frame for a policy towards fishing management and resource allocation and conservation by entering into force "The Fisheries Management and Development Act, 1988". The Act envisages the preparation of management and development plans based on proper resource assessment and a policy in favour of sustainable exploitation and conservation.

The formulation of development and management strategies requires the availability of data which allow the overall evaluation of the actual status of the fishery. Management advice without scientifically founded analysis of available information risks either to be ignored or, worse, to lead to decisions that might prove counter-productive to the declared objectives of fisheries management.

The continental shelf of the Gulf of Guinea has been subject of a series of resource surveys from 1950 to 1966. These surveys also included the waters now under jurisdiction of Sierra Leone. The most comprehensive one, the Guinean Trawling Survey, organized by the Commission for Technical Cooperation in Africa covered the West-African shelf with standardized transects at 40-mile intervals. The result of these surveys are published and thus available.

In addition to various surveys carried out independently between 1979 and 1984 by the vessels R.V. Capricorne, R.V. Dr. Fritjof Nansen, and R.V. Menocrystal, the fish stocks off Sierra Leone were also regularly surveyed during the last years by joint Sierra Leone/USSR research cruises.

With roughly one third of the total registered catch originating from the artisanal fishery, this subsector makes an important contribution to the country's total marine production. A frame survey of the artisanal fishery funded by the German Agency for Technical Cooperation (GTZ) was conducted in 1981; however, its results were not published. At present, the IMBO is undertaking a new survey for the whole of the Sierra Leonean artisanal fishery. This information combined with the result from the first survey, should yield valuable insight into the general trends that have taken place in the artisanal fishery within the last ten years.

ESTABLISHMENT OF A FISHERIES DATABASE FOR THE DEVELOPMENT AND MANAGEMENT OF THE NATIONAL FISHERIES RESOURCES OFF SIERRA LEONE

Agreement on Technical Cooperation between the Institute of Marine Biology and Oceanography, University of Sierra Leone (IMBO) Freetown, Sierra Leone and the International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines.

4. Either party may terminate this agreement by written notice to the other party. This agreement however, will remain effective for 90 days from the issuance of such notice.

Executed for:

INSTITUTE OF MARINE BIOLOGY AND OCEANOGRAPHY
University of Sierra Leone

Director

Executed for:

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

KENNETH T. MACKAY
Director General

2. To develop research, development, and resources management programs and related activities as may be of mutual interest to both institutions;

3. To enlarge and strengthen the capacities and capabilities of each institution through the cooperative use of materials and facilities which are supportive of the mutually agreed programs.

ARTICLE II
ELEMENTS OF THE AGREEMENT

To implement the Memorandum of Understanding, it is mutually understood and agreed that the areas of research to be addressed under this agreement are:

a. The analysis of data on the coastal fisheries of Sierra Leone with emphasis on determining: i) patterns and trends of management significance; and ii) their relation to biotic, environmental, and exploitation factors;

b. The conduct of field studies directed towards elucidating patterns and trends of management significance to the coastal multispecies fisheries of Sierra Leone; and

c. The development of management options appropriate to the social, economic and biological context of Sierra Leone.

ARTICLE III
GENERAL PROVISIONS

1. The activities outlined in Article II will be funded from a Third Party, and IMBO and ICLARM shall assist each other in obtaining such funding.

2. The activities in Article II may require the outposting of a qualified ICLARM staff at IMBO and visits by ICLARM headquarters staff to IMBO.

3. This Memorandum of Agreement shall have a term of three (3) years from the date it is signed by both parties.

1.1 IMBO / ICLARM Project, Phase I 1991-93

MEMORANDUM OF UNDERSTANDING

BETWEEN

INSTITUTE OF MARINE BIOLOGY AND OCEANOGRAPHY,
University of Sierra Leone
Freetown, Sierra Leone

AND THE

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
Manila, Philippines

WHEREAS, the Institute of Marine Biology and Oceanography, University of Sierra Leone (IMBO) is giving major research attention to the marine resources in Sierra Leone and the International Center for Living Aquatic Resources Management (ICLARM) is devoted to support such research throughout the tropics; and whereas IMBO and ICLARM are mutually interested in collaboration in research on marine coastal resources, and in identifying and formulating management options for the sustained use of such resources and related activities; and

WHEREAS, the parties wish to embark on a collaborative research and formulation of management options for the coastal marine resources of Sierra Leone.

NOW, THEREFORE, the parties hereto do hereby record their understanding as follows:

ARTICLE I

The purpose of this Memorandum of Understanding is to further the following objectives:

1. To develop cooperative and collaborative activities in furtherance of the mutually reenforcing interests of the two institutions;

Appendix 1

Project Baseline Documents

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capability of the two institutions to work together. Justification for this would be the computerization of the research data from the SL/USSR cruises done at IMBO, which will definitely form an important part of the future BDRM in Sierra Leone.

288. If this is agreed, it has to be ensured that any activity in the context of BDRM (evaluation missions, training courses, etc.) always involves DOF and IMBO personnel together, and that IMBO staff has free access to the computer hard- and software to be provided to the DOF as part of the BDRM package.

289. If this leads to a satisfactory arrangement, it might be useful to consider external assistance in the form of regular visits two to three times a year to Freetown by a fishery scientist connected to the BDRM Project to discuss further applications of the BDRM and provide additional training and assistance.

3.2 Long-term Strategies - IMBO

290. Any long-term strategy has primarily to aim at improving the performance and the funding situation at IMBO. Improvements in performance will invariably mean some changes in the IMBO staffing. Increase in available funds should ultimately come out of a national budget, but some intermediate solution as suggested below might fill the gap.

291. Suggested here is a three to four years project with IMBO, funded by EDF under the keyword "Institution Building", which basically consists of having an expert with managerial skills and a broad experience in tropical fisheries research based at IMBO. His/her TOR will be the reorganization of the Institute in terms of research, training and administration and the establishment of institutionalized links between IMBO and DOF. He/she should have a small but sufficient budget available to provide the Institute with basic equipment, carry out small, but well focused research projects, hire suitable candidates as research assistants, and enable the staff to attend conferences and training courses in the region and other tropical countries as described above.

292. Ultimately, the strategy should be to make IMBO operational again in a way that Government recognizes its value in the domain of fisheries research and the formulation of fishery policies. It is only than that the point can be made that Government has an interest to keep it on this level and, thus, should make a contribution to IMBO's budget of e.g. 5 % of the annual revenue from the fisheries resources, which is presently estimated at three to four million Dollar.

3.3 Long-term Strategies - DOF

293. The long-term strategy for the DOF should be to use the BDRM project to build up a well functioning statistical unit, physically located close to the Director of DOF (not at Kissy, as it is presently the case), and with sufficient staff (enumerators and observers) and equipment (computers) to fulfill their mandate. This unit could become the point of entry in the career of fisheries officers, thus exposing them at least once in their life to the whole complex of information management. As with IMBO, a well functioning statistical unit should quickly proof its value, and thus convince Government to allocate a proper budget for its activities, which could be again something like 5-10 % of the annual revenue from the fishery resources.

280. Thus, it should be a general policy of IMBO to regularly send especially younger members of the staff to conferences and meetings (preferably in the region) and to organize seminars in Sierra Leone where the major results of such conferences are presented and the applicability to Sierra Leone of emerging new (or already established) concepts is discussed. Not "conference-tourism" but a cost-effective participation of the Sierra Leonean scientific community in the general development of marine science is the ultimate goal.

281. With such activities being consequently pursued, IMBO has every chance to be accepted once again as a partner in the formulation of policies for the management of the marine sector.

2.3 The Role of the DOF

282. The DOF is a government agency and as such responsible for formulating fishery policies and ensuring their proper implementation. The formulation of fishery policies should reflect modern approaches in fisheries management, which itself requires a regular and institutionalized exchange with IMBO as the National Research Institute (provided IMBO plays its role as described above). Thus, attendance of seminars by DOF personnel as well as specialized courses organized by IMBO for DOF field workers should be common practice.

283. The main contribution of DOF to fisheries research will be a sustainable system for the continuous collection and analysis of fishery-relevant data. Such a system should enable the DOF to assess at any moment in time the performance of both the industrial and the artisanal fishery, very much along the line established right now for the industrial fishery and proposed recently for the artisanal fishery.

284. Major advantage of the availability of time series of data from the fishery sector will be the possibility to better assess the impact, certain measures taken by the fishery administration will have had on the socio-economic situation of the fishers affected. This monitoring is a prerequisite, in the absence of which sound fishery management is barely thinkable. However, collection of data is expensive, and should thus be done in a model-driven fashion, an area, where again the cooperation with a scientific institution like IMBO could be of help.

285. Given that DOF personnel tends to be largely preoccupied with administrative and technical tasks, cooperation with a national research institution such as IMBO should be considered as a cost-effective way of having access to innovative research methodologies and management strategies.

3. Institution Building - Practical Steps and General Strategies

286. The concept of shared responsibilities for fisheries research presented above seems to be illusory, when compared to the present situation especially at IMBO. However, there are certain elements that allow a more optimistic view. The most promising one is the upcoming BDRM (Regional Marine Database) project, which might allow to push for a cooperation between IMBO and DOF.

3.1 Short Term Measures

287. As the basis for any new orientation it is suggested that a meeting should be arranged between DOF and IMBO to stress the need for cooperation and to come perhaps to a formal agreement somehow along the line described above. One way to achieve this could be the construction of an (actually not really existing!) link between the inclusion of Sierra Leone in the BDRM project and the

275. It might, therefore, be worthwhile to consider including such a budget in the possible extension of the WNW AFCOD Programme as a contribution of the DOF to the success of its revived library. Beside continuing to furnish the library with its own periodicals, ICLARM's library service will be most willing to assist the DOF/IMBO library in establishing an appropriate list of publications that could/should be ordered within a given budget frame.

276. Ultimately, it is hoped that the institutions using the library will once again be convinced of the usefulness of such an investment and thus be willing in not too distant a future to provide the necessary funding out of a national budget.

2. A Concept for the Organization of Institutional Fisheries Research

2.1 General Outline

277. Given the present situation at IMBO there is a slight chance of the DOF pursuing its own capacity development with little regard to what is happening at IMBO. To efficiently counteract such a tendency one needs to have a clear concept of what role should play each of the institutions involved, given their comparative advantage. Very briefly the role of each institution could be formulated as follows:

- **IMBO** as a research institution is the link to the regional and international fisheries science community. It should keep abreast with new developments and concepts in the field of fisheries management. By means of teaching and organizing seminars this information is channeled through IMBO to the scientific community and the DOF in Sierra Leone. In close cooperation with the DOF strategies for implementing and testing new concepts are being developed and assistance in the formulation of general fishery policies is provided.

- **DOF** as an implementing institution is responsible for the formulation and enforcement of agreed fishery policies. To this end opportunities for regular exposure to developments in the area of fisheries science has to be provided for DOF staff through close links with the national research institution. The DOF ensures a continued monitoring of the performance in the fishing industry (both artisanal and industrial) against which can be measured the success (or failure) of selected management options.

2.2 The Role of IMBO

278. IMBO has a comparative advantage as a research institution as it can easily interact with other research organizations. This situation defines its role as being the major link between the scientific community in Sierra Leone broadly interested in marine science and the international scientific community. In order to fulfill its role, IMBO must ensure that its staff is up to international standard. This means that IMBO staff have to expose themselves and their work to the critical judgment of their colleagues in other countries. This is achieved by doing research, presenting results in publications and at meetings, attend workshops and training courses, and invite foreign specialists to Sierra Leone.

279. These measures, of course, have to be complemented by in-house training (lectures, seminars, given by IMBO staff), where the experience and the new insights gained abroad are disseminated to a broader audience in Sierra Leone.

1.2 DOF

267. The majority of the senior DOF staff are well-trained fisheries officers, who had their perception of fisheries management shaped mainly during the past decade by attending regional conferences and workshops or training courses in Europe or North-America sponsored by FAO and other international donors. Thus, they are familiar with traditional concepts of fisheries management and probably open for (though not necessarily aware of) new concepts and strategies in this sector. However, at present most of these fisheries officers seem to be preoccupied with administration and other technical aspects of the fisheries, leaving little (if at all!) time for strategic planning.

268. Presently some effort is being made to revive the statistical data collection scheme that in the past was either completely abandoned or left with the externally funded development projects. The activities in this context comprise the processing and analysis of data from the industrial fishery by means of the software developed by the IMBO/ICLARM project and the implementation on a trial basis of a new system for the monitoring of the artisanal fishery developed in cooperation between the IMBO/ICLARM project and the DOF.

269. In terms of cooperation between DOF and IMBO, there is not much to report. There are institutionalized links: the Director of DOF serves ex officio on the Board of IMBO, and the Director of IMBO participates in DOF meetings on resource management. On request, the DOF provides IMBO with a small boat to carry out research in the estuaries.

270. However, none of the fishery scientists trained by IMBO during recent years has been employed by the DOF, with little hope that this might change in the near future. Budget constraints are given as major explanation for not recruiting new staff.

271. In summary, the DOF seems to have sufficient basic capacity upon which to build a revived fishery research unit with a clearly defined scope. Its readiness to accept IMBO as a partner will largely depend on IMBO improving its performance and reputation as a national research institution.

1.3 Library

272. A major result of the present IMBO/ICLARM project was the revival of the DOF library at Kissy. The achievements do not only comprise the rehabilitation of existing books and facilities but also the identification and employment of a reliable and committed librarian. The continuation of his employment is an absolute prerequisite for the library to become again an important tool in fisheries research. To leave the library once more without a professional taking care of it would make futile all the effort spent on its rehabilitation.

273. Continued employment of the librarian is to be achieved through IMBO. It seems that the University has agreed in principle. However, given the reputation of the University's administration, there is a chance that the actual employment of the librarian might be delayed. If this is the case, some emergency measures should be planned for, to ensure the continuation of the librarian's work.

274. It should be noted that the employment of a librarian is but one side of the successful revival of the library. The other side involves the availability of an operational budget. This is necessary to cover running expenditures (such as stationary, printer ribbons, mailing, etc.) but also to make available to the library some basic documents for tropical fisheries research, e.g. recent books, subscription to one or two periodicals and to the Aquatic Science and Fisheries Abstracts (ASFA). As a rough estimate (see Table 4, Page 20), such a budget could amount to around US$ 1,000 annually, definitely far beyond what IMBO could shoulder.

Part III

Status and Prospects of Fishery Research in Sierra Leone

1. Present Situation

260. Fisheries-related research work in Sierra Leone involves two institutions: the Institute of Marine Biology and Oceanography (IMBO) and the Department of Fisheries (DOF). IMBO is part of Fourah Bay College, University of Sierra Leone. The DOF is the sole Department in the newly created "Department of Fisheries and Marine Resources" (DFMR), the equivalent of a fishery ministry.

1.1 IMBO

261. IMBO is located at the premises of the DOF at Kissy Dockyard. It has a small staff, comprising the Director, two lecturers, four technicians and a clerk. The Director also serves as lecturer for Marine Chemistry. The positions of one Research Fellow and three Research / Teaching Assistants have been vacant for some time now, but there is little prospect that the University will provide the necessary funds to fill these positions. Facilities consist of a laboratory, a lecture room, and three offices. The courses taught lead to a B.Sc. Degree, but research on M.Sc. level and Ph.D. level is also being carried out. On the average, five students per year prepare for - and obtain - a B.Sc. Degree.

262. IMBO is plagued with budgetary constraints that do not allow the Institute to operate on a level appropriate for a research institution. This does not only affect the applied research but also the educational level of those trained in marine sciences. Reason for this is the rapidly deteriorating situation at the University of Sierra Leone, which has resulted in unrealistically low budget allocations for institutions like IMBO.

263. Poor facilities, uncertain employment perspectives, isolation from the international scientific community, unwillingness to return of those sent abroad on Master or Ph.D programs, are but a few of the consequences of an insufficient operational budget. In a vicious circle, these consequences are then becoming the very reason again for aggravating the situation.

264. It is obvious that IMBO does not play any more the role it used to play in national (and regional) fisheries research. As a consequence, IMBO has de facto ceased to be considered by the DOF an authority to which they may turn to for management advice.

265. In summary: IMBO is presently in a position to maintain, at best, a basic teaching and training program in marine science. In its approach to applied research, there is no medium- or long-term strategy apparent as to what should be the primary goals to achieve. Little coordination exists between the various disciplines for maximum efficiency in the use of the limited funds.

266. The Director of IMBO is in principle aware of the range of problems IMBO is beset with. Some suggestions made in the Phase I Final Report of the IMBO/ICLARM project have been taken up and discussed during IMBO staff meetings. They actually resulted in practical proposals. Their implementation and necessary follow-up, though, will largely depend on the degree of personal commitment of IMBO's senior staff.

257. Assistance under a) would include practical measures to improve the DOF's capacity to collect, process, and analyze data from the fishery, establishment of decentralized administrative units in rural areas, exposure of both researchers and administrators to regional developments (conferences, study tours, training courses) with the aim to strengthen cooperation between West African countries.

258. Assistance under b) would comprise all forms of community development that strengthen social mobilization of the various interest groups with the aim to make them aware of the need - and actually receptive - for new approaches in fisheries management.

259. Finally, of course, should international donors emphasize on integrated approaches to coastal development, by considering fisheries only one of the factors in a broader context of sectoral development and by ensuring a better coordination of the various development efforts within a coastal sector.

5.4 Scope for Future Development

250. Irrespective of any technological advances, the question whether the artisanal fishery remains a viable industry or becomes a sink for subsidies and lost investments will solely depend on a society's ability to stop the uncontrolled access to this sector.

251. Necessary action has to be undertaken both within the sector and from outside. Fishery communities have to be empowered - within given limits - to take over responsibility for the management of their adjacent fishing grounds, involving questions such as access and user rights. The Government has to provide the appropriate legal framework to implement this participatory approach. It also has to harmonize the interests of the artisanal fishery as a whole vis-à-vis other contenders in the exploitation of the marine resources.

252. Ultimately, though, Government has to understand that development of the artisanal fishery is but one facet of a complex coastal sector program that needs an integrated approach to rural development. Simply spoken, migration into the fishery is best averted by creating employment opportunity in the rural area.

6. The Role of International Donors

253. International donors have played (and still continue to play) an important role in determining the course of fisheries in developing countries. They have been instrumental in providing the technological know-how and the financial means that have lead to the drastic production increase in the 1960' and 1970'. However, with the rapidly increasing depletion of resources and stagnating world production figures in the fishery sector, the production-oriented approach in support programs to the fishery sector can no longer be maintained.

254. Sociologists have long argued that outside intervention in the artisanal fishery sector can easily lead to distortion of traditionally grown social structures that used to benefit the community as a whole without necessarily fitting into the pattern of a "modern" economy (Bailey 1988). Internationally funded development projects were often - albeit not intentionally - supporting such evolvement , as their primary role was to open new opportunities for private sector entrepreneurs by introducing new technologies, providing extension services, subsidizing credits and offering tax preferences. Those participating had to play "by the rules" if they wanted to take full advantage of the opportunities provided, and, as a consequence often abandoned practices not considered "profitable".

255. Moreover, the emphasis on capital-intensive technologies (improved boats, propulsion, more efficient gears) has been usually to the advantage of those best able to invest in these powerful technologies and thus gain competitive advantage. This has often increased economic inequalities rather than creating the intended general improvement of the well-being in rural fishing communities.

256. Thus, international donors have to re-define their role. While no general concept can be offered here, it seems justified to suggest that international donors in Sierra Leone should consider technological development objectives of low priority and rather emphasize on:

a) aspects that strengthen institutional capacities of both the research sector and the administration to better monitor and assess trends and developments in the fisheries sector and to introduce innovative concepts of fisheries management;

b) support for the creation of sustained structures on the village level that lead to a participatory approach in fisheries management, very much in line with the declared policy of the Sierra Leone Government to give priority to the artisanal fishery.

"snapper boats" used before in Sierra Leone, these boats can stay at sea for more than a day to fish further offshore for high-value species like snappers.

242. Ultimately, improved boat building design and diesel inboard technology could lead to the development of a class of semi-industrial fishing boats, destined to exploit the resources further offshore and to supply the local market with good- to high-quality fresh fish at affordable prices.

5.3.4 Cooperation with scientific institutions

243. Implementation of policies geared towards a closer cooperation between the administration and the fisher will require the availability of trained fishery biologists to fill the positions at the various fishery stations. Planning for the mobilization of fisher communities will require staff with a strong academic background rather than mere enumerators.

244. In this respect the DOF has to communicate its future needs to IMBO for the development of an appropriate curriculum. If necessary this has to be complimented by outside expertise.

5.3.5 Establishment of protected zones

245. The need for the establishment of protected zones recognized as breeding grounds for many fish species has long been accepted. The establishment of an "Inshore Exclusion Zone" (IEZ) reserved for the artisanal fishery has been one of the few actual measures directly geared towards giving preference to the artisanal fishery at the expense of the industrial (shrimp-) fishery. However, enforcement of the ban proves difficult and would require the almost constant presence of a patrol vessel in the area. In addition, pressure from the industrial fishing sector is immense and has lead in the past - at least temporarily - to an erosion of the otherwise clearly defined limits of the IEZ.

246. A practical solution to this problem could be the establishment of a large number of "Fish Aggregating Devices" (FAD) in the areas to be protected. These could be made up of the countless car wrecks found all over Freetown as well as of any other scrap metal, after, off course, these materials have been cleared of any component potentially hazardous for the environment. This would not only relief Freetown of a number of unsightly objects, but also make the relevant area inaccessible to trawling operations. The FADs usually attract a wide range of large fish species, which could be exploited with selective gears, like Hook & Line.

247. Further, and in line with the recommendations made in respect to introducing local resource management, it should be made a policy that these FADs are being assigned to fishing villages and exclusive user rights be given to the local fisher community.

5.3.6 Monitoring and Evaluation

248. The newly established policy regarding the requirement of registration and payment of license fees for artisanal fishing crafts is a useful measure (even if charging license fees for dug-out canoes seems little practicable). If this is combined with an appropriate data collection scheme for catch and effort data (as has been proposed recently) a much more reliable evaluation of the performance of the various gears in the artisanal fishery can be undertaken.

249. In order to improve the quality of the data, fisher should become more involved by regularly feeding back to them results obtained from the data. The above proposed awareness program could very well be the forum to discuss with the fisher the implications of the results obtained.

5.3 Policy Recommendations for Immediate Implementation

5.3.1 Awareness program for local fishing communities

235. Any fundamental change in the sector requires the awareness of the people involved of the need for these changes. Given the isolation and remoteness of many fishing communities, purely administrative measures will not have much effect.

236. In this respect, the DOF could consider to establish itself as a "partner" to the fisher, i.e. as a government agency that does not only collects taxes, but also responds to the needs of the community and improves their livelihood. This is no easy task to achieve and demands a clear separation of repressive and supportive functions. One of the major objectives could be to initiate the transition from the presently prevailing "top-down" approach in fisheries management to a broader approach, that focuses on community participation in relevant areas of fisheries management, such as resource allocation, access rights, etc..

237. Means to achieve these objectives could include among others:

- establishing (again) a network of regional fishery offices with competent staff who are perceived as such and have good communication skills;
- entrust these regional offices with the development and implementation of training programs that will make local fishing communities aware of the need for resource conservation and management;
- identify areas with a low potential for conflicts where fishing villages could start practicing community-based fisheries management (resource allocation, quota, enforcement of restrictions, etc.);

5.3.2 Emphasis on community development aspects

238. The role of "partnership" as described in the previous section is presently played to a large extent by externally funded development projects. The two main fishery projects (WNW AFCOD and Shenge) have strong components in the area of community development. These are essential in furthering the concept of "civic development" in rural communities.

239. The WNW AFCOD Programme has been successful in forming viable fishery cooperatives. These institutions are geared towards self-help among fishers. The general interest in this kind of organization could thus be used to also instill basic principles and measures of resource management, preferably in close cooperation with DOF personnel.

5.3.3 Technological development

240. Technological aspects of development projects should in future concentrate on two main aspects:

a) possibilities to re-direct some of the fishing effort in the artisanal fishery towards less heavily exploited resources, and

b) improve post-harvest handling to increase the economic value of the catches.

241. An example for a) is the use of the advanced bout building techniques introduced by the WNW AFCOD Programme to build stronger canoes with a small insulated fishhold. Similar to the so-called

227. In summary, the adoption of new management strategies for the artisanal fishery and defining of corresponding policies will be the urgent task of the next decade for countries like Sierra Leone, which depend to a large extent on this sector for national food supply.

5.2 Status of the Artisanal Fishery

228. From what has been said under Section 5.1 the formulation of fishery policies for the artisanal fishery sector will depend largely on the answer to the following question: Can the resource be considered under-utilized, or is it already fully exploited respective over-fished? If the former applies, there is still a scope for growth and development, access limitation will eventually be required but is not a matter of urgency. If the latter applies, urgent measures are required.

229. Into which direction these measures should aim largely depends on the declared priorities of Government: If it is e.g. to preserve or improve the livelihood of the existing fisher, measures should be taken to prevent as much as possible new entries into the fishery. If - on the other hand - employment is a top priority for Government, than it might opt for giving support to labor-intensive small-scale operations at the expense of more capital-intensive fishing operations. However, it is clear that the range of options becomes increasingly narrower when the resources are threatened with overfishing.

230. In the case of Sierra Leone, under-exploitation of the resources is very unlikely to apply. The analysis of the 1990 artisanal fishery frame survey (Vakily *et al.* 1993) suggested the existence at that time of around 6,000 fishing crafts in the artisanal fishery of Sierra Leone. Some 15,000 full-time fisher and 2,400 part time fisher were counted. When compared to an earlier frame survey carried out in 1981, the number of boats recorded was about 1,000 less than in 1981, while employment in this sector and number of gears used were at comparable level. The reduction of number of boats was primarily due to the lower number in 1990 of small canoes, operated by 1-3 fisher.

231. Data on catch of the artisanal fishery compiled by the DOF suggest a fairly regular annual production of about 45 to 50 thousand tons since the early 1980'. Even though the accurateness of these data can be questioned, they do at least not show any obvious up- or down-wards directed trend. The two sources taken together seem to portray the artisanal fishery as having reached some sort of ceiling, both in capacity and in production. The last decade of fisheries development projects seem to have brought little change to the overall productivity of the artisanal fishery in Sierra Leone, neither in a positive nor in a negative way.

232. The comparison of the 1981 and 1990 frame survey data (reduced number of smaller fishing crafts, unchanged number of fisher) might indicate, though, that a certain degree of "proletarization" has taken place in the artisanal fishery: quite a number of fisher seem not to own any more their means of production, i.e. a fishing canoe, but rather work as labor on the larger canoes, especially the Ghana boats. Such shift in class status from owner-operators to workers operating on a share basis has also been described for other heavily exploited fisheries (Bailey 1987).

233. Another factor indicating fundamental problems in the sector is the increasing willingness of fisher to use destructive fishing methods. Observations by DOF personnel has revealed a drastic increase in the use of nets with very small mesh sizes: "Channel nets" (which were banned in 1993) and "Mina nets". This, together with the observed practice of dynamite fishing in the Freetown area (Vakily 1993), should be taken as a clear indicator of fisher trying to counter trends in declining catch rates.

234. It is therefore suggested here to consider the artisanal fishery in Sierra Leone as fully exploiting the resources available to it. In order to preserve its viability, urgent measures, therefore, have to be taken to limit access to this sector. A possible increase in a sustainable overall production could only be achieved by diverting some of the effort to resources further offshore.

activity coefficient of 66% (about 240 fishing days per year), will result in a total catch of 36,000 tons of fish landed by the artisanal fishery in a year!

221. This disregard for the possibility of over-exploitation is often paired with the general attitude of fishers to perceive the marine resources available to them as practically unlimited. Many of them started their profession when effort and efficiency were indeed low and small technological improvements usually resulted in better catches. Declining catch rates are quickly attributed to reasons that lie in the sphere of superstition and are countered by "appropriate" means (change of a boat's name, merit-making ceremonies). When unfavorable conditions persist, the next step is that part of the fishing community resorts to the use of destructive fishing methods, such as small mesh sizes and dynamite fishing. Hardly ever is the reason for declining catches sought in the fact that too many fisher compete for too few fish.

222. The Study of International Fishery Research (SIFR), supported by 16 public and one private donor, such as e.g. the World Bank, UNDP, CEC, and FAO, has come up with a comprehensive analysis of what has happened to especially the tropical fisheries and has called for a reappraisal of the relevance of conventional fishery development and management strategies. Rather than dealing with the symptoms of over- exploitation and over-capitalization in the artisanal fisheries, the study urges to address the cause of it which it sees in the "open access" nature of this sector.

223. Open access refers to the fact that unlike in the agricultural sector, where ownership of land is usually to some extent formalized and thus limits the access to the resource "land", no such mechanism exists in the (artisanal) fishery. If the general economic conditions in a country worsen, the fishery sector is customarily considered (and actually used) as a means of last resort, increasing the pressure on often already fully exploited stocks. It is interesting to note, though, that numerous accounts exist of customary use rights in traditional fisheries that regulated access to the resource. Most of these regulating mechanisms, however, finally succumbed to external pressure.

224. The problem of fishing as a means of last resort has added to the traditional concepts of overfishing (growth-, recruitment-, ecosystem- and economic overfishing), a new dimension of potential overfishing, now commonly called "Malthusian overfishing" (Pauly 1994). The phenomenon leads to the paradox that any further assistance to the sector (subsidies, technological improvements, credit facilities) will not result in a corresponding growth, unless it is coupled with the possibility to access new resources, formerly not exploited. The more likely effect will be a drop in overall production due to overfishing. Increase in income by some fisher will attract more new entrants, the general income level in the fishery will tend again towards a minimum that is more or less equal to the opportunity cost of labor in this sector.

225. Obviously, the solution lies in limiting access to the resources. Interesting enough, this concept is not new to fisheries manager, because it is exactly what led to the extending of the Exclusive Economic Zones to 200 nautical miles offshore, limiting international open access to the countries' coastal resources. This concept should now be taken one step further to provide some form of exclusive use rights for local fishing communities.

226. Introducing local access controls is of course not without problems: governments are often reluctant to relinquish power over the exploitation of national resources to local user groups; allocation of use rights - and thus access to income - is essentially a political decision; in the short term unemployment would increase. However, in the long run, there is no alternative to some sort of access control. Its positive effect will be not only sector-specific (increase in the net economic revenues of those who remain in the fishery, and an increase in production of fish for national consumption) but benefit the rural economy as a whole because fishers earning enough will farm out ancillary services and work. Money circulation and a certain wealth will permit that other professions and social services can exist and be paid for.

213. Though no solution exists to completely eradicate this problem, two approaches are recommended here:

a) the introduction of more selective gear, which has proven useful in similar circumstances e.g. in the USA part of the Gulf of Mexico shrimp fishery (Watson & Seidel, 1980) and in the Arafura Sea in Indonesia (Sujastani 1984);

b) better utilization of existing by-catch.

214. Option a) relates to enforcing sometime in the not too distant future the use of a different type of net which allows a better escapement for fish and other marine animals (e.g. sea-turtles) while still retaining the bulk of the shrimp catch. Such a change can not be introduced from one day to the other, but if it is made clear to the shrimp industry that e.g. from-on 1998 the use of such a net is mandatory for the issuing of a shrimp license, the industry will comply by having these nets ready for use.

215. The second approach is to make better use of that part of the by-catch, which would normally be discarded. This would require small transport canoes to regularly visit the shrimpers and take over the by-catch. Once brought to shore, further use would depend on the condition and the species contained in the catch. Some might be sold through the normal market channels for fresh fish, while the rest could be used to fuel a new processing industry: that of fermented fish products.

216. Introduction of such a processing technology would require a long-term project (perhaps in the context of the on-going regional post-harvest project of the EU) that looks both into the technical feasibility and the economic viability of marketing the ensuing products.

217. It should be noted that the idea of a better use of the by-catch is to some extent already practiced by shrimpers in Sierra Leone through the (illegal!) selling of fish to canoes of the artisanal fishery. Local fishery agents oppose this practice, because of the diversion of income into the pockets of the crew. The DOF could play here a useful role by legalizing these transactions, while in the same time instructing its observers on board to monitor and report the sales.

5. Recommendations for the Management of the Artisanal Fishery

218. Though the general management strategies as described in Chapter 3 do apply to the artisanal fishery too, special conditions exist that distinguish this sector from the industrial fishery and that warrant a more detailed analysis of the effects of conventional development policies on the artisanal fishery.

5.1 Development Policies - Need for a Change

219. Over the past two decades many artisanal fisheries in developing countries have been the subject of development programs. These programs usually emphasized improvements in supply and technology with the overall objectivity to increase productivity in this sector.

220. Little concern had ever been given to the question to what extent the resources exploited by the artisanal fishery would support the intended increase in production. This might be partly due to the fact that (especially to "outsiders" from developed countries!) artisanal fisheries often appear to be poor, of low efficiency, their individual catches negligible. What is overlooked is the tremendous number of fishing units contributing to the overall production. Thus, an average catch of e.g. 30 kg per day, per gear (about a mid-size basket full of fish), when realized with 5,000 gears and assuming an average

4.2 Recommendations for Future Development

4.2.1 General

206. A number of publications (B.Sc. thesis) on the families of carangids, sciaenids and sparids, as well as the *Sardinella* species have demonstrated that the database developed for the SL/USSR research data allows to derive fairly comprehensive pictures of the spatial and temporal distribution of the major commercial fish species. This could be used in future, if the DOF wants to direct fishing effort towards specific species assemblages, especially of the demersal stocks.

207. It should be clear, though, from what has been said so far that in general "development" can not simply mean augmentation in production. Rather, the analysis of the SL/USSR research data suggest that fishery policy in Sierra Leone should aim primarily at preservation of existing resources.

208. There are, however, two areas where applied research could lead to substantial changes in the future. One is the development of fisheries for resources that are so far not at all or only little exploited. The other one concerns the shrimp fishery.

4.2.2 Exploration of potentially under-utilized resources

209. Most of the fishing activities off Sierra Leone concentrate on the broad shelf in the northern part of her territorial waters. South of Bonthe Island, the shelf becomes very narrow. It might be worthwhile to look into a possible exploitation of the waters in the south by different methods, such as e.g. a squid fishery or a fishery for large pelagics.

210. A hindrance to this, though, at present is the non-existence of a true national fishing fleet that would profit of any such research. The vessels presently operating under joint venture agreements are usually of very low technological standards, making it quite difficult to operate far off-shore. From this point of view, one might conclude that Government should also provide the necessary incentives - and create a favorable investment climate - for the gradual build-up of a viable national fishing fleet that would exploit a wider range of different stocks and eventually replace at least partially the foreign fishing fleet.

4.2.3 Technological changes in the shrimp fishery

211. The other area with a scope for improvements concerns the shrimp fishery. It is common knowledge that shrimp fisheries tend to have an adverse effect on fish stocks. The problem is inherent to the fishing operation: In every catch of a shrimper, the shrimps make up only 20-30 % of the total catch, the rest being fish. Because shrimper are allowed to use smaller mesh sizes than ordinary fish trawlers, they tend to catch large amounts of small fish, which in many cases are the juveniles of high-quality large fish species. On the other hand, the economic value per unit weight of shrimp is much higher than for fish. Thus, shrimpers have little interest to use their limited storage capacity onboard for keeping low-value fish. As a consequence, shrimp and larger, high-value fish are retained, the bulk of the catch consisting of small fish is discarded.

212. This practice represents an enormous loss, both in terms of nutritional and economic value, because many of the discarded fish could have made a valuable contribution to the catch of demersal fish trawlers if only they were caught at a later stage in their life cycle.

agreements with local agents have to bear the brunt of deteriorating conditions in this sector, invariably resulting in the **loss of scarce capital** of local investors.

- Though the biological "recover capacity" of tropical fish stocks is much faster than of those in temperate waters, this type of exploitation pattern has usually a negative impact on the **bio-diversity** and the ecology of the resources. As has been discussed earlier heavy exploitation of the resources may lead to a shift in species composition in which the longer-lived, larger species are replaced by fast-growing, smaller species of usually lower economic value. On a long term the resource looses gradually in value and, thus, reduces the potential economic rent from the resources available to society.

4.1.2 Surveillance

199. It is obvious that any attempt to implement a fishery policy can only be successful, if all parties involved comply with the established regulations. To ensure this to the maximum possible, Sierra Leone has to set up an effective system of surveillance, coupled with a clearly defined procedure for the speedy prosecution of anyone found to violate the regulations.

200. Surveillance is costly, but in the long run both Government and the private sector will profit from it: the former, because it is a necessary prerequisite for sustained and stable income generated from the marine resources; the latter, because it protects the invested capital from unfair competition by illegally operating fishing vessels.

201. **Possible consequences of not surveying the fisheries and enforcing fishery policies:**

- Short-term gains by saving on the cost for a surveillance system, thus reducing Government expenditures.
- Uncontrolled increase in illegal fishing activities with negative repercussion on the viability of especially the artisanal fishery.
- In the long run deterioration of the resources and diminished returns to Government.

4.1.3 Monitoring

202. As mentioned earlier any formulation and implementation of a fishery policy should be accompanied by a regular monitoring of the performance in the fishery sector. Trend analysis will allow to assess the impact of a given policy and to make recommendations as to which direction future development strategies should take.

203. The present system of observers on board of the vessels and the catch reporting system now established are a good starting point. DOF should however try to improve on the qualification of those observers through appropriate training, in order to make better use of their presence on board for routine work such as catch composition and biological analysis of major species.

204. One area so far completely neglected by the DOF is the inclusion of economics in the monitoring program. This could address issues such as value of the catches on the international market (important for determining license fees and royalties), appropriate levels of fines, and analysis of demand and supply for local markets (to establish appropriate landing quotas).

205. **Possible consequences of not monitoring the fisheries:**

- No possibility to assess trends in the fishery and thus determine the direction into which future fishery management should lead.

192. It is important that Government understands that the (legitimate) demand of dues for the use of the marine resources has to be balanced by conveying predictable rights and conditions onto the operators. In this respect, establishing an annual licence limit could have a stabilizing effect on the actual number of licences realized every year, which itself is an important aspect for Government's interest in stable income levels for proper household budgeting.

193. Such policy would send the signal to the fishery sector, that Government is concerned about the economic profitableness of the fishing operation. It could eventually set into motion a change in perception, wherein operators would conceive fisheries regulations and MCS not only as measures directed against them, but as a means to protect their rightful investment against unfair competition. This would be a first, but important step towards introducing self-regulation aspects into fisheries management, ultimately the goal for a sustained and cost effective resource management.

194. The instrument of limiting number of licences could also be used to give preferences to national licences (as opposed to foreign licences). Because of the higher percentage of fish that has to be landed in Sierra Leone by local licence holder, this measure could be used to better control the supply of fish to Freetown, either for local consumption of to stimulate some degree of processing for regional export.

195. The second option, to raise licence fees and other dues to very high levels, would make fishing profitable for but a few only. If accepted by parts of the fishery sector, it would generate a high level of income to Government, but on an unpredictable basis, as Sierra Leone would face even stronger competition from other countries along the West-African coast. If such a policy is not flanked by stringent measures such as "Exclusive Rights" it seems to have little chance to generate the desired level of income to Government.

196. Though it is impossible to give at present an accurate figure for appropriate fishing effort in the industrial fishery, it is suggested that for the next three to four years the number of fishing units licensed in Sierra Leone should not exceed 80, which is about half the fishing effort prevailing in the mid 1980'. About 50 % of these could be shrimpers (which also catch fish!) 25 % demersal and pelagic trawlers, and 25 % others such as purse seiners, tuna boats and long-liners. These numbers are given under the assumption that the technological level of the present fishing vessels does not change markedly.

197. In the same time a working system has to be established that allows efficient monitoring of the performance of these fishing vessels (see below). Once this is operating satisfactorily, the DOF could consider a slight increase in fishing effort of e.g. 10 % in two-years interval, still accompanied by close monitoring of the performance in the sector. This should allow to determine a level of exploitation that is in agreement with the resources available and thus will protect the financial interests of those who have invested in this sector and therefore expect an economically viable return from their investment.

198. **Possible consequences of not limiting fishing effort in the industrial fishery:**

- In the short term an uncontrolled increase in number of licenses would result in a **higher revenue** to Government through increased collection of license fees and royalties.
- In the long run this source of revenue would be exposed to **large fluctuations**, that would make long-term planning in this sector extremely difficult. The fluctuations would be the consequence of vessels leaving the fishery, when too much competition reduces profits to unacceptable low levels, and coming back after some years when the reduction in fishing effort has had positive effects on the recovery of the stocks.
- The vessels most likely to move to other fishing grounds pertain to the highly mobile fishing fleets from Europe and other developed countries, whereas those vessels operating under joint venture

186. Ultimately, a re-orientation in the approach to fisheries management is needed. For too long now, fisheries scientists and managers have witnessed the decline of one resource after the other, either because managers could not translate into practical policy the advice given by scientists, or scientists did not have the proper tools to lay open the discrepancies between declared policies and practical measures taken by Government to manage a fishery. This however is necessary in order to move fisheries management away from political lip-services or focusing on single-factor aspects such as MSY, and bring it in line with a wider ecosystem understanding of the resource base and the resulting exploitation pattern necessary to minimize resource conflicts and maximize societal benefits from the resource.

4. Recommendations for the Management of the Industrial Fishery

4.1 Policy Recommendations for Immediate Implementation

187. The following policy recommendations are based on the postulation that Government will continue to consider the industrial fishery - and here especially the shrimp fishery - primarily as a source of access to foreign exchange, while the artisanal fishery will play a vital role in the supply of fish products for local mass consumption.

188. Basically, this is an acceptable concept, especially in view of the current economic situation in the country. Fish produced by the industrial sector tends to be of higher quality, but also of higher price, making it affordable to only a small part of the population, primarily in the urban area. Thus, even though there is a demand for high quality fish products, it is doubtful, whether the markets in Sierra Leone can absorb large quantities of landings by the industrial fleet in addition to what is produced by the artisanal fishery. This leaves no other choice but to export the bulk of the production from the industrial fishery.

4.1.1 Fishing effort

189. A major result of analyzing the historic fishery data from Sierra Leone has been the recommendation to maintain fishing effort at a lower level compared to the 1980'. There are basically two possibilities to keep the number of licenced vessels at the presently lower level: (i) per Decree which stipulates an upper limit for the annual number of licences, or (ii) by maintaining a scheme of a fairly elevated level of licence fees.

190. In both cases, though, Government must be aware that - especially among the mobile foreign fleets - the decision of taking up licences in Sierra Leone will also depend to a large extent on conditions prevailing in neighboring countries. In this respect the present EU-supported initiative of African ACP member countries bordering the Atlantic ocean to establish a regional maritime database (BDRM) could be a valuable step towards closer regional collaboration in setting appropriate licence fee levels.

191. From an entrepreneurial point of view, taking a fishing licence is part of an investment that has to produce a certain return on the invested capital. In a resource-limited situation as the fisheries of Sierra Leone is, any additional entry into the fishery is a potential competitor, who most likely is to reduce the net return on the investment. Thus, if Government undertakes measure that limits competition to an acceptable level, investors in the fishery sector (especially when dealing with mobile fleets) are more likely to renew their investment (i.e. licence) every year, rather than searching elsewhere for better profits.

3. Basic Concepts of Tropical Fisheries Management

179. Ultimate goal in fisheries management is to determine (and enforce) a level of exploitation of the marine resources that ensures sustainability, while in the same time optimizes the economic rent from the resources.

180. Sustainability is achieved if a certain portion of the resources' productivity can be removed over a (theoretically unlimited) long period of time without endangering the very basis of this productivity: the necessary abundance of the stocks, bio-diversity, as well as ecological and environmental continuity.

181. The economic rent from the resources reaches an optimum level, when the balance between cost and returns of all components contributing to the exploitation of the marine resources generate a maximum profit for society (and not necessarily for the single fisher!). These components could include - beside fishing - e.g. coastal transport, coastal mining, employment, tourism, mariculture, etc.

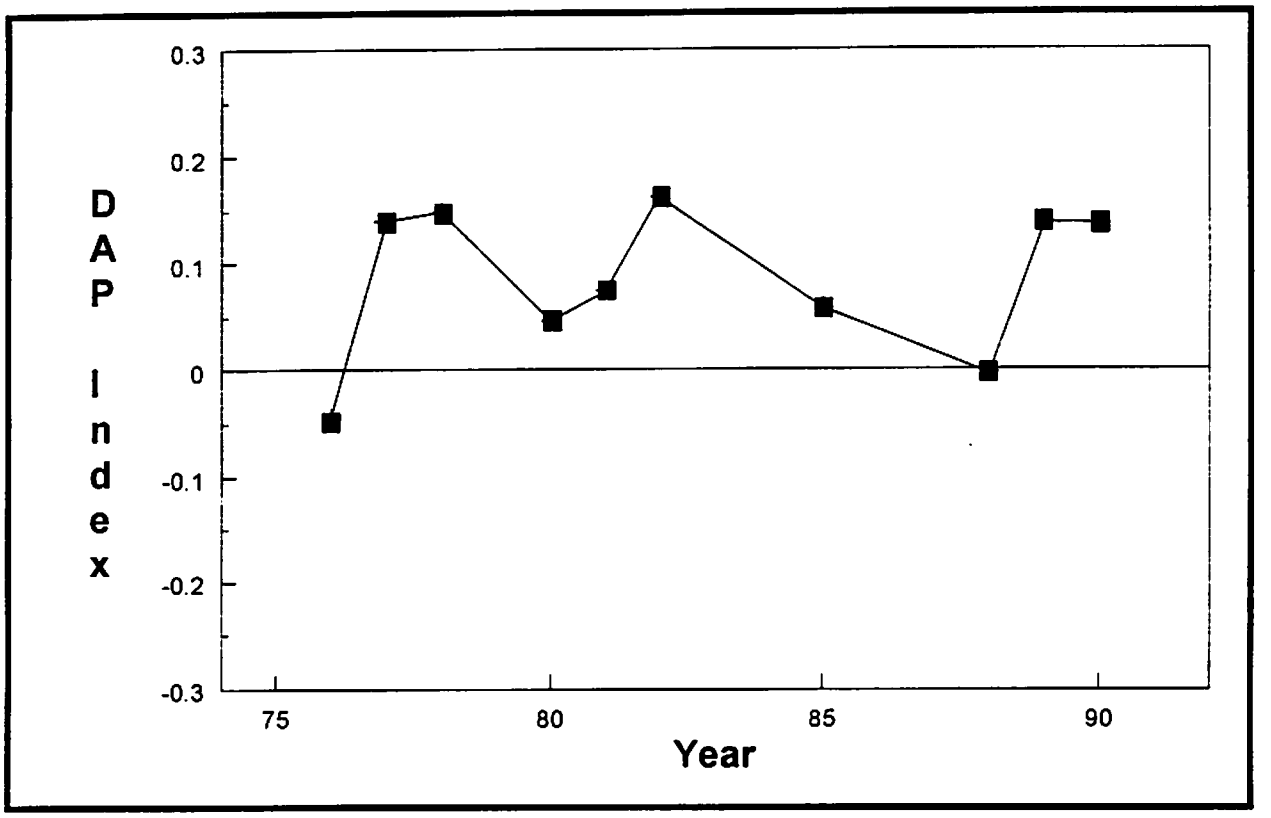
182. Even though this concept applies in principle to any fishery, approaches to its implementation differ widely between fisheries in the tropics and those at high latitudes. Traditional methods in fish stock assessment developed for the "single species" fisheries in temperate waters are of little use for practical management of tropical fisheries. However, because of the way many of the fisheries officers, who are now in leading positions, received their formal education in the late 1970' and early 1980', these concepts still tend to influence the decision and policy making process of fisheries administrations in many developing countries. Typical example for this are attempts to establish figures for biomass, MSY (Maximum Sustainable Yield) or TAC (Total Allowable Catch). These concepts completely ignore the complex relationships in tropical marine ecosystems as well as the fact that fishing operations in the tropics are in no way as selective as they tend to be in the fisheries of higher latitude.

183. The comprehensive analysis of the data from the Sierra Leone / USSR fishery research cruises has demonstrated very convincingly the limited applicability of these concepts to tropical fish stocks. While the isolated analysis of data from one or two cruises - as done before - seemed to produce acceptable results, a comparison of these results over a longer series of years showed enormous fluctuations of biomass estimates. Even if accepted as technically correct, these results would render management advice for MSY or TAC either useless or - worse - dangerously wrong.

184. In the light of the shortcomings mentioned above, it is suggested here that in the future "trend analysis" of the performance in the fisheries sector becomes an integral part of a fisheries administration's regular work in order to allow a better assessment of the success - or failure - of fisheries policies implemented. Performance in this context would mean any indicator that relates the level of benefit from the fishery (e.g. catch, absolute or in terms of economic value, income generation, employment) to the corresponding level of input (no. of vessels, fishing days, fuel consumption, etc.), commonly subsumed under the term "fishing effort". The basic idea behind this is that in the transition from under-exploitation to over-fishing any such indicator of performance would have a maximum which, at least broadly, would define (analogue to the MSY concept) the level of input appropriate for the resource in question.

185. Clearly, such a concept can not be implemented in the short-term, as it is complex and requires the inclusion of other disciplines beside the traditional fisheries biology, such as economics and sociology. Multi-disciplinary research is yet in its infancy in Sierra Leone. However, small steps could be undertaken that would allow to define at least the major factors to be monitored e.g. landings, value of landings, average species size, fishing inputs (effort, gear, labor), etc.. An option definitely worthwhile considering is the inclusion of such initiatives in a regional research program under the new ACP-EU Strategic Fisheries Research Initiative, because of their importance not only for Sierra Leone, but for many other fisheries in the region as well.

Figure 7 Distribution of DAP Indices for the periods 1976 to 1990 for demersal species abundance and numbers derived from the research data of the Sierra Leone - USSR fishery surveys.



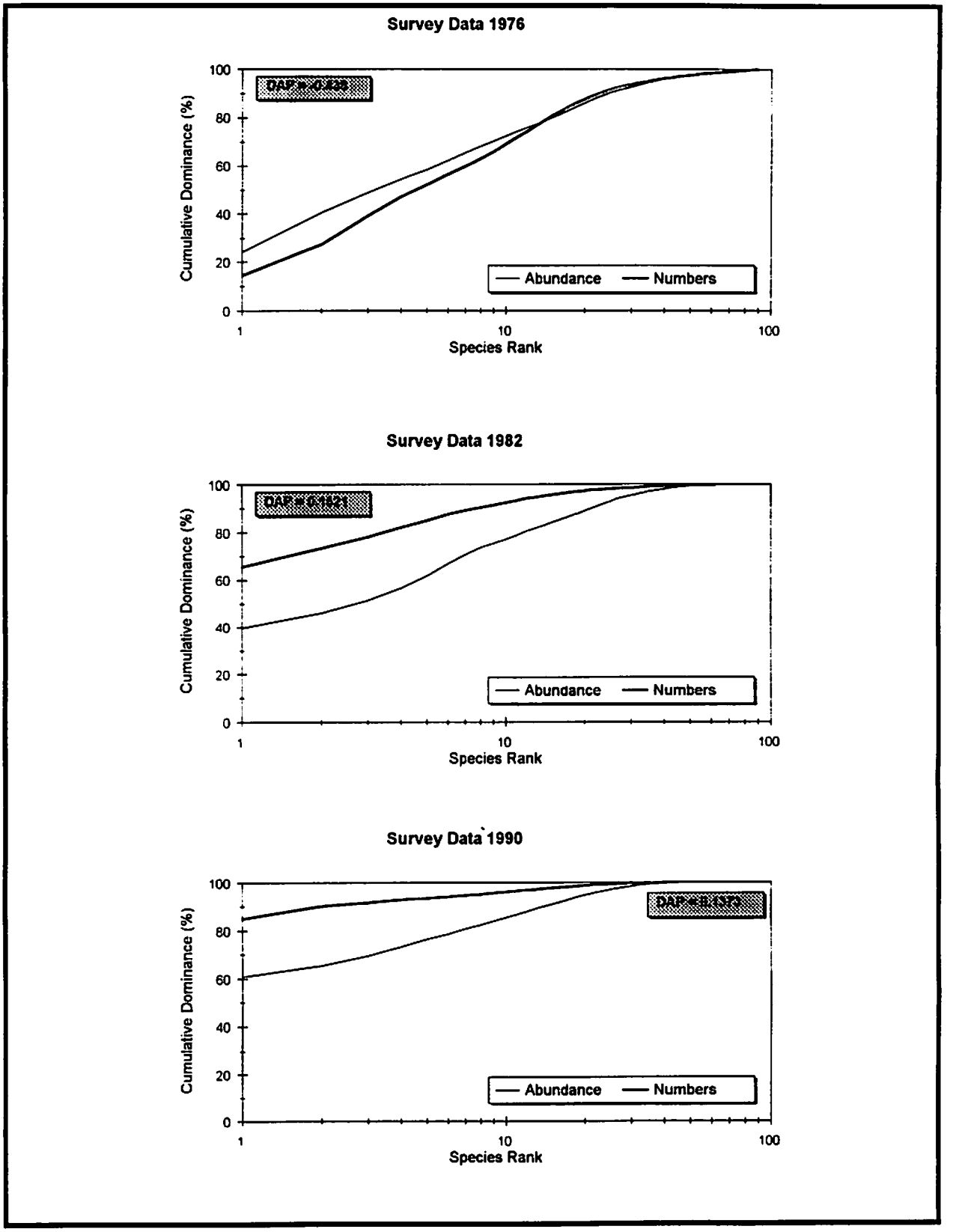
2.3 Conclusions

176. Already the information available in 1988 from Payne & Coutin (1988) would have justified a very conservative stand in respect to possibilities of increasing fish production from the Sierra Leone marine resources by means of additional fishing effort. The analysis of the available data from the Sierra Leone - USSR research cruises seems to underline this general conclusion from an ecological point of view.

177. Thus, at the end of the last decade, advice to fisheries management in Sierra Leone would have been to reduce fishing effort, to avoid any further erosion of the resource basis, i.e. the ecological equilibrium of especially the demersal stocks. Rather unexpected, this is exactly what happened with the introduction of the monitoring and surveillance system in 1991. Number of vessels operating in Sierra Leone waters have since then been in general less than 100. This year (1994) the number of license has reached so far only 50 (35 shrimpers, 9 demersal trawlers, 6 tuna seiners).

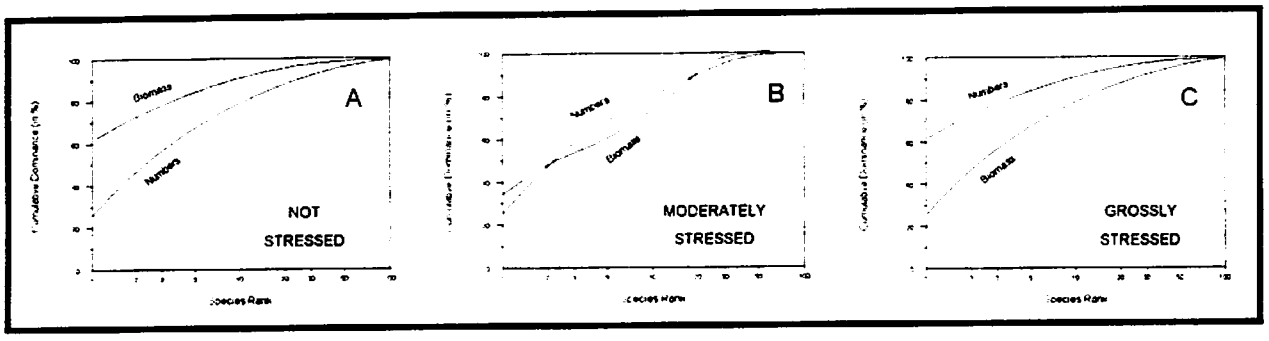
178. While the reduction in number of fishing licences could be regarded by Government primarily as a loss in revenue, it is argued here that this is also a unique chance for Sierra Leone to introduce new strategies in fisheries management now, without having to go through the difficult process of determining who is to be removed from the fishery in order to bring fishing effort back to a more sustainable level.

Figure 6 Selected dominance curves for demersal species abundance and numbers derived from the research data of the Sierra Leone - USSR fishery surveys



curve above "number" curve). Under moderate pollution the large dominant species are eliminated, reducing the inequality in size between the numerical and biomass dominants (("moderately stressed" condition in Figure 5B, "biomass" and "number" curve are close together). Under grossly polluted conditions, the "number" curve is expected to be throughout its length clearly above the "biomass" curve (Figure 5C), indicating that the community is increasingly becoming dominated numerically by one or few very small species.

Figure 5 Hypothetical dominance curves for species biomass and numbers showing a "not stressed" condition (A), "moderately stressed" (B), and "grossly stressed" (C). Adapted from Warwick (1986).



172. McManus & Pauly (1990) took this concept one step further by noting that the model described could be applicable to tropical multispecies stocks and the stress caused by fishing pressure. In addition, they suggested a method to quantify the degree of eveness between biomass and numbers. The method calculates the Difference in Area by Percent (DAP) between the area under the biomass curve and the one under the number curve. The resulting index (DAP Index) can theoretically range from -1 to +1, with positive values indicating stressed conditions.

173. This new concept was applied to research data of the Sierra Leone - USSR surveys, limiting it to the species that are usually living close to the bottom (demersals) and to an area from 8° to 9°N latitude. For each year a data set was extracted and plotted graphically. The DAP Index was computed using a software provided by the authors of the above mentioned publication. Instead of biomass, abundance was used assuming a fairly even distribution of the species over the said area. Resulting curves for the years 1976, 1982 and 1990 are shown in Figure 6.

174. These curves show the history of a fish community that seemed to be moderately "stressed" in the mid 1970' where the "abundance" curve was even laying above the "number" curve, but the two closely together, thus depicting a situation as described in Figure 5B. In 1982, and also in 1990, the course of the curves suggests that the demersal fish community has been under quite some stress resulting in a high number dominance.

175. Figure 7 is a plot of computed DAP indices for the years 1976 to 1990 showing that for almost the entire period the stocks displayed signs of moderate stress of varying intensity.

1980', fishing licences in Sierra Leone (and elsewhere in the region) were relatively cheap. This meant that foreign vessels simultaneously held licences for various countries and would move along the coast to take advantage of the seasonal migration/occurrence of the targeted species groups. Though no figures exist that would allow the assessment of the real fishing effort during this period, it can nevertheless be safely assumed that it was much higher than in the 1970'.

2.1.2 Sierra Leone - USSR Fishery Surveys

166. The data from the SL/USSR fishery research cruises have been subject to various forms of specific analysis using traditional approaches in resource assessment (see list of research papers in Appendix 3). A general analysis of the results seems to indicate that irrespective of various fluctuations there has been an overall decline in the "catch per unit of effort" (CPUE) of the research gear during the last decade. However, the results are not convincing enough to withstand a rigorous statistical test.

167. It is even not necessary, that increased exploitation should invariably result in a decreased CPUE. Tropical fish resources are known to react to increased fishing effort - within certain limits - by a change in species composition: larger species, which are usually less abundant , but contribute significantly to the weight of the catch because of their size, are successively replaced by small, fast growing species, which are abundant in number. The latter thus still contribute significantly to the overall weight of the catch, simply because of their abundance. Thus, in order to assess the effects of fishing on the marine resources, ecological models could give a much better insight into the dynamics of species composition and abundance. Such an approach has been taken using the available research data from the Sierra Leone - USSR fishery surveys, and explained in more detail below (see Chapter 2.2).

2.1.3 Payne & Coutin Report

168. Between 1984 and 1986 a research program was carried out on the inshore stocks of Sierra Leone coupled with a general appraisal of the status of the fishery in Sierra Leone. Results from this excellent research work were presented in a comprehensive report to Government (Payne & Coutin, 1988). The extensive field work undertaken by the researchers in collaboration with IMBO covered a wide range of fish species caught in the industrial fishery and included the analysis of both catch and biological data.

169. The report indicates that quite a number of the commercially exploited fish species showed signs of overexploitation in 1986. The authors reiterate that catches of demersal species had increased ten fold between 1959 and 1986, but that during the same time a significant drop in catch per unit of effort has occurred. The recommendations in their report comprise the call for a diversification of the fishery to re-direct some of the fishing effort to the offshore resources, and the recognition that collection of fishery statistics urgently needs to be improved. They did not foresee any option for large-scale increase of fish production.

2.2 Measuring Ecological Stress as a New Approach to Resource Assessment

170. As mentioned earlier, models describing changes on the ecological level might be very suitable for the assessment of fisheries resources, provided extended time-series on species composition are available. Such a model had been proposed by Warwick (1986), originally intended for detecting pollution effects on marine bottom-living communities.

171. Basically the model's concept implies that for communities in unpolluted conditions, and when approaching equilibrium, the biomass will become increasingly dominated by one or a few large species, each represented by rather few individuals; ("not stressed" condition, Figure 5A, "biomass"

1.2 Artisanal Fishery

159. The artisanal fishery in Sierra Leone has all the typical characteristics of this kind of fishery in tropical developing countries:

- a multitude of crafts and gears catching a wide range of different fish species.
- low degree of mechanization and motorization.
- labor intensive and very diversified, thus being the major source of income for a large part of the coastal rural population,
- primary contributor to the national food production in terms of the least expensive protein.

160. Beside the artisanal fishery exploiting the marine resources, there is also a substantial, though largely undocumented, utilization of the inland waters by part-time fisher, mainly in addition to farming.

161. Apart from a general ban of so-called "channel nets" and the stipulation of minimum mesh sizes, the artisanal fishery is not subject to any other regulations on the national level. Customary laws reported from the 1920' (Hornell 1928) have since long ceased to exist, with the exception of some locally enforced ban of beach seining.

162. As an (indirect) consequence of the various fisheries development projects in Sierra Leone with their project-oriented data collection schemes, the DOF has lost the necessary infrastructure for an effective monitoring of activities in the artisanal fishery. In order to redress this situation, the DOF has very recently introduced a boat registration system, coupled with the payment of annual license fees. A proposal for an appropriate data collection scheme for the artisanal fishery to be carried out under the responsibility of the DOF was proposed by the IMBO/ICLARM project in collaboration with DOF personnel. This proposal is currently under consideration.

2. Status of the Fishery Resources of Sierra Leone

2.1 Information Available

163. Any attempt to assess the past and present status of the fisheries in Sierra Leone relies primarily on three sources of information:

- national statistics
- Sierra Leone - USSR research surveys, 1976 - 1990
- Payne & Coutin report on demersal stocks in Sierra Leone, 1988.

2.1.1 National Statistics

164. From the few official statistics available it is apparent that the period between 1976 and 1990 has seen a considerable increase in fishing activities in Sierra Leone. This was mainly due to the fishery agreement with the (then) USSR distant water fleet. According to information from the DOF the number of licensed vessels went as high as 308 in 1987 (Anon. 1994).

165. It should be noted, though, that the figure on licenced fishing vessel per se is not a very suitable indicator to assess the increase in fishing effort in real terms, e.g. in hours fished. During the

Part II

Status and Management of the Fisheries in Sierra Leone

1. The Fisheries of Sierra Leone

152. The main components contributing to the exploitation of the marine resources of Sierra Leone are the industrial and the artisanal fishery. Open canoes, planked or dug-out, with or without motorization, and with a total length not exceeding 60 feet are classified as artisanal fishing crafts. All other fishery-related vessels fall into the category of industrial fishery.

1.1 Industrial Fishery

153. The industrial fishing fleet comprises primarily trawlers (fish and shrimp), purse seiners, long-liners, tuna vessels and supporting vessels for trans-shipment.

154. Basically, there is no genuine national fishing fleet. All vessels are of foreign origin, mainly from Asian and European countries. They are subject to the regulations contained in the Fisheries Act of Sierra Leone. These regulations concern, among others, mandatory licensing, paying of fees and royalties, equipment and gear to be used, and the disposal of catch.

155. All licensed vessels are obliged to be represented by a local agent. Most of the vessels operate under a joint venture agreement with their local agent. Until very recently, these vessels were licensed as "concessionaire". The latest amendments to the Fisheries Act, however, removed this category. This has led to many of these vessels now being registered in Sierra Leone, in order to qualify for the category "local" in the licensing system as opposed to "foreign". A "local" license is cheaper, but carries more restrictions in respect to the exporting of the catch.

156. The industrial fishing vessels can operate freely within the Exclusive Economic Zone (EEZ) of Sierra Leone, with the exception of an Inshore Exclusion Zone(IEZ) reserved for the artisanal fishery. This area, though frequently called "5 Mile Exclusion Zone" is, as a matter of fact, an area marked by straight lines connecting clearly defined coordinates on the sea-chart along the coast of Sierra Leone.

157. In principal, each vessel should have an "observer" on board, who is employed by the DOF. The observer has the duty to report any activity by the fishing vessel that is not in accordance with the license granted (e.g. use of unauthorized gear, intrusion into protected areas, illegal trans-shipment, etc.). In addition, the observer is also responsible for filling in the DOF's catch report forms .

158. After the collapse of the surveillance program initiated in 1990/91, the navy is presently in charge of patrolling the fishing grounds. Efforts are being made to have a new MCS system in place by 1995.

145. This procedure results in reducing the data set to one value for each square where information was available. These values are than displayed on-screen using a color code. The colors represent seven classes of values. The user is free to determine the class intervals as it seems fit. Thus, SIERRA provides a convenient way to visualize data by means of different colors, giving a good impression of the distribution of intensities.

3.5.3 Documentation

146. FiSDaS is fully documented in two volumes. Volume 1 is the "User Manual", which leads the inexperienced user through the various options provided by the software. It contains step-by-step instructions and examples of screen outputs for all routines accessible through the built-in menus.

147. Volume 2 is the "Technical Reference Handbook" that contains necessary information of how to install and run the software. It also explains the structure of FiSDaS and the security system implemented. The bulk of Volume 2, however, is a detailed listing and a thorough documentation of all the routines developed for FiSDaS. It was considered necessary to provide the possibility for an experienced programmer to quickly analyze the structure of the programs, so as to make modifications where necessary, or to easily integrate new routines into the existing system. This greatly enhances the flexibility of FiSDaS and makes it future use to the maximum possible independent of the present IMBO/ICLARM project.

3.6 Publications

148. A substantial amount of reports and other scientific publications have been produced by the project. A complete list is given in Appendix 3. Many of the articles have been published in NAGA, the ICLARM Quarterly, and thus found a wide distribution among fishery scientist in developing countries. The topics covered range from the biology of important species to dynamite fishing, solar power and computers, and the rehabilitation of libraries.

149. Important documents of direct use to the fisheries research in Sierra Leone are the report on the Artisanal Fishery Frame Survey 1990, the analysis of the distribution of Sardinellas in Sierra Leone waters (included in the proceedings of a workshop on "Dynamics and uses of Sardinella resources off Ghana and Ivory Coast"), and the various thesis' prepared by IMBO students.

150. In order to revive IMBO's interest into the documentation of its research work, a special volume of the "Bulletin of the Institute of Marine Biology and Oceanography" was edited and produced in large numbers that contained all articles of the earlier issues of this Bulletin, which has ceased to appear since the early 1980'. IMBO is presently preparing the next issue with new material.

151. Another major product of the project are- as already mentioned - the two volumes prepared to document the computer software "FiSDaS". The first volume is meant to serve as a user manual for every-day use. The other one contains on more than 300 pages a detailed description of the software and the program routines. This will allow experienced programmers to easily make modifications to the software, which is essential if FiSDaS is meant to remain up-to-data.

138. The second cruise started as scheduled late February 1994, but had to be canceled the second day, when the ship was attacked and ransacked by pirates just a few miles off Conakry.

139. The research vessel visited Freetown again on May 27, 1994 and left the following day with a DOF officer joining the cruise while in Sierra Leone waters. It is planned to repeat the canceled February cruise in 1995, again with Sierra Leone's participation. All results of the three cruises will be made available to Sierra Leone. Reports will be published both in French and English.

3.5 FiSDaS

140. The experience gained from the analysis of the Sierra Leone - USSR research data in the context of thesis supervision was the basis upon which a software was developed, that provides access to this important data set by means of a fully menu-driven program, named "Fishery Surveys Database System" (FiSDaS). With FiSDaS existing data can be routinely analyzed, and data from new research cruises can be added to the database. Provisions have been made to prevent inexperienced users from potentially disastrous alterations to the database, while a knowledgeable system manager can modify existing routines or add new ones.

3.5.1 The Software

141. FiSDaS contains almost 300 routines to process data. Processing can be either in the form of pre-defined analysis routines (e.g. cruise summaries, abundance, biomass) or by extracting sub-sets of data for further analysis outside FiSDaS. Analysis and extraction of data can be fine-tuned using a series of pre-defined selection criteria (e.g. season, year, taxonomy, ecology). Output can be routed either to a printer or to popular file formats for use with other software.

142. As a novelty in this kind of approach, FiSDaS contains the Low-Level Geographic Information System "SIERRA". This software was developed in-house at ICLARM's headquarters in Manila specifically for use with fisheries data originating from Sierra Leone. It has in common with other Geographic Information Systems (GIS) the fact that geographically referenced information can be displayed on screen, but is different from the usually more complex commercial GIS packages in that the data requirements are much less demanding. It is fully integrated into FiSDaS, meaning that the necessary data files are created from the database and then displayed in SIERRA without the need to leave FiSDaS first and start another program.

3.5.2 SIERRA

143. SIERRA's main feature is a grid system laid upon the territorial waters of Sierra Leone. The grid system divides the latitude and longitude ranges in squares and comes in two resolutions: 15' by 15' and 5' by 5'. The first resolution corresponds to the grid system established by the DOF for management and monitoring purpose. This resolution is available for the whole Exclusive Economic Zone (EEZ) of Sierra Leone up to the 200 nm boundary. The second resolution generates squares of about 5 nm length, and is available only for the main fishing ground off Sierra Leone, i.e. from Bonthe Island (7°15'N) northwards to the Guinea border and from the coast offshore to the 200 m depth contour (14°35'W).

144. Using the SIERRA software consists of providing the program with a set of values (e.g. catch per hour, total trawling hours, etc.) together with the corresponding geographic reference points (latitude, longitude). The program then sorts the values into the grid squares according to the grid scale selected. In a next step, the values within each grid are processed, either averaged or summed up, depending on the options selected by the user.

DOF: 5, Students: 9, WNW AFCOD: 2) were provided with length frequency data of *Sardinella maderensis*, extracted from a thesis presented at IMBO in 1991. The participants formed working groups to analyze the data, and were than shown of how to compare their own results with those in the literature, by using the information contained in FISHBASE.

130. Finally, the participants were familiarized with the type of data contained in the Sierra Leone - USSR database and with the range of options these data could potentially be used for.

131. The workshop was an important milestone in the course of the project, as it demonstrated to a large number of interested scientists, fisheries manager, and especially students that even under the difficult conditions under which IMBO is presently operating, useful and significant research can be done by simply using existing data and investigate them with new and more powerful tools now available in fisheries research.

132. As a direct result of the workshop, one participant agreed to submit his findings on the length/weight relationship of sparids for publication in the FISHBYTE section of NAGA, the ICLARM Quarterly. One senior staff member of IMBO showed interest to collect available information on fish larvae from Sierra Leone and other countries along the West African coast for inclusion in FISHBASE. Finally, three students applied for membership in the ICLARM-administered "Network of Tropical Fisheries Scientists", which will provide them with free copies of NAGA and easy access to required literature.

3.4.6 Acoustic Survey (ORSTOM)

133. During a fishery conference in Dakar, Senegal, attended by the ICLARM Project Leader and his counterpart in 1993, possibilities of a better cooperation between West-African countries were discussed. One such possibility of cooperation emerged when fishery scientists from Conakry, Guinea, disclosed that the French research organization ORSTOM planned to organize a research cruise in Guinean waters. Guinea and Sierra Leone share many fish stocks, especially among the pelagic species. Thus, extending such a survey beyond the borders of Guinea into the waters of Sierra Leone would be worthwhile.

134. As a consequence of these preliminary talks, and after the DOF in Freetown had given its general approval, the Project was informed in October, that the French Development Bank had agreed to finance the extension of the research cruises into Sierra Leone. The whole program was to comprise three cruises.

135. The research program entitled "Evaluation and Monitoring of the Pelagic Resources of the Guinea EEZ Accessible to the Industrial Fishery" was meant to improve knowledge of the species exploited and allow a better assessment of the pelagic resources off Guinea and Sierra Leone. The program consisted primarily of acoustic surveys along standardized transects. A pelagic trawl was also available on board for experimental fishing.

136. The first cruise took place from November 13 to 15, 1993. One fisheries officer of the DOF joined the crew of six scientists from Guinea and France while the vessel was in Sierra Leone waters. The echo signals recorded during the acoustic surveys were to be analyzed with advanced computer software.

137. During a meeting with representatives of ORSTOM in Dakar in February 1994, the continuation of cooperation between the DOF and ORSTOM was confirmed in respect to the acoustic survey program covering the shelf of both Guinea and Sierra Leone. It was disclosed that the first cruise in November 1993 had not yielded tangible results, as the new equipment still needed tuning and adjustment.

122. Nearing its completion is a Ph.D. thesis on sparids in Sierra Leone waters, which will present a comprehensive picture of the distribution and biology of this family. The analysis of individually collected field data will be complemented by a thorough evaluation of the data contained in the Sierra Leone - USSR database.

3.4.4 FishBase

123. Availability of - and access to - information is a key factor in all aspects of management and research in (not only!) the fishery sector. Experience, however, shows that in many developing countries, and Sierra Leone is no exemption to this, it is exactly this element that usually represents a major constraint. Lack of funds and necessary infrastructure, such as a well-maintained library and/or modern communication facilities, often hinder the researcher/manager of taking stock of what information is already available. This leads to a situation where scarce funds available to research in the fishery sector risk to partly be spent on work the result of which could have been extracted from published literature at a fraction of the cost incurred.

124. Many attempts are made to alleviate this situation through international cooperation. One such project is FISHBASE, the bold attempt to make available to any researcher, resource manager, or other interested person, the bulk of what is known about all species of fish in the world. This is achieved through providing a computer-based database system that contains both qualitative and quantitative data on fish covering a wide range of aspects such as nomenclature, distribution, ecology, morphometrics, population dynamics, reproduction, diseases, genetics and aquaculture. Detailed information on this database, developed by ICLARM in close cooperation with FAO and funded mainly by the Commission of the European Communities, has been given by Pauly & Froese (1991).

125. While feeding of data into the database at ICLARM is a continuous process, it is ICLARM's policy to give, whenever possible, priority to countries and/or areas where ICLARM maintains national or regional projects. It was, therefore, an important task of the IMBO/ICLARM project to provide the FISHBASE working group in Manila with important information pertaining to the fishes in Sierra Leone.

126. Thus, the species catalogue produced from the Sierra Leone - USSR research cruises was incorporated in FISHBASE as an occurrence file. Similar, lists of vernacular fish names in the various local languages of Sierra Leone have been entered, together with their scientific nomenclature. Much effort has been made at ICLARM to identify and incorporate information on the two major fish species of the artisanal fishery in Sierra Leone, namely *Ethmalosa fimbriata* ("Bonga") and *Sardinella maderensis* ("Herring").

127. A hard disk version of FISHBASE is now available at IMBO, but it is hoped that IMBO will later be included in the distribution of a more up-to-date version on CD-ROM together with an appropriate disk reader, a project for which funds still have to be made available.

3.4.5 Workshop

128. From January 28 to February 3, 1993, a workshop was organized for staff and students of the Institute of Marine Biology and Oceanography, and for staff of the Department of Fisheries. The workshop was meant to provide participants with hands-on experience in FISAT, a software jointly developed by ICLARM and FAO for use in fisheries science, introduce them to FISHBASE with emphasis on Sierra Leone data, and present to them the major database system developed in the present project and its potential use in research.

129. The course was jointly given by Dr. Daniel Pauly (ICLARM's Director of the Coastal Resource System Program) and the IMBO/ICLARM Project Leader. The 24 participants (IMBO: 8,