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REPORT OF THE SIXTH MEETING OF THE LTR COORDINATION COMMITTEE

by
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(eds.)

FINNISH INTERNATIONAL DEVELOPEMENT AGENCY

FOOD AND AGRICULTURE ORGANISATION
OF THE UNITED NATIONS

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PREFACE

The Research for the Management of the Fisheries on Lake Tanganyika project (LTR) became fully operational in January 1992. It is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Finnish International Development Agency (FINNIDA) and the Arab Gulf Program for the United Nations Development Organization (AGFUND).

LTR’s objective is the determination of the biological basis for fish production on Lake Tanganyika, in order to permit the formulation of a coherent lake-wide fisheries management policy for the four riparian States (Burundi, Tanzania, Democratic Republic of Congo and Zambia).

Particular attention is given to the reinforcement of the skills and physical facilities of the fisheries research units in all four beneficiary countries as well as to the build-up of effective coordination mechanisms to ensure full collaboration between the Governments concerned.

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GCP/RAF/271/FIN PUBLICATIONS

Publications of the project are issued in two series:

* a series of **technical documents (GCP/RAF/271/FIN-TD)** related to meetings, missions and research organized by the project;

* a series of **manuals and field guides (GCP/RAF/271/FIN-FM)** related to training and field work activities conducted in the framework of the project.

For both series, reference is further made to the document number **(01),** and the language in which the document is issued: English **(En)** and/or French **(Fr)**.

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ACKNOWLEDGEMENTS

We wish to acknowledge the hard work of all LTR personnel, both national and international, in all LTR research stations around Lake Tanganyika as well as in numerous Universities and Research Institutes in Finland. We also wish to record the efforts of Ms. Gatungane in the preparation and translation of all meeting’s documentation.

In addition, we wish to acknowledge the effective assistance of Mr. Dagg, Drs. Kapetsky and Gréboval in drafting the adopted report and the effective assistance of Mr. G. Mburathi, FAO Representative in Zambia, and his staff for their assistance in organizing this meeting.

Lastly, we wish to record the effective and constructive participation of all members of the LTR Coordination Committee and, above all, the effective chairmanship of Mr. T.W. Maembe.

REPORT OF THE SIXTH MEETING OF THE LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

1 The Sixth Meeting of the Coordination Committee of the Project GCP/RAF/271/FIN "Research for the Management of Fisheries on Lake Tanganyika" (LTR) was held from 22 to 23 June, 1998 in Lusaka, Zambia.

ITEM 1. OPENING CEREMONY AND ELECTION OF THE CHAIRMAN

2. The Zambian delegate, Mr. I. Kaliangile, welcomed the participants and observers and called the meeting to order. The list of participants is given in Annex 1.

3. Mr. G. Mburathi, FAO Representative in Zambia, welcomed all participants and observers on behalf of the Director General and the Assistant Director General of Fisheries.

4. The meeting was officially opened by Mr. A. K. Banda, Director of Economic and Market Development, Ministry of Agriculture, Food and Fisheries. His speech appears as Annex 2.

5. The Tanzanian delegate, proposed by Zambia and seconded by Burundi and the DRC, was elected Chairman.

ITEM 2. ADOPTION OF THE AGENDA

6. The agenda (Annex 3) was adopted as proposed by the Chairman.

ITEM 3. LTR COORDINATOR'S REPORT: SUMMARY OF LTR'S ACTIVITIES (DECEMBER, 1996 TO JUNE, 1998) PROGRESS ON RECOMMENDATIONS OF THE FIFTH SESSION

7. The LTR Coordinator presented details of project activities carried out during the last 18 months, as amplified in Annex 4. Key highlights were:(1) successful completion of LTR's Scientific Sampling Programme (SSP), including resolution of the acoustic studies; (2) details concerning the utilization of RN Tanganyika Explorer, including its re-delivery to her owners on 28/4/98; (3) details concerning the successful completion of the socio-economic studies; (4) successful completion of the inter-agency agreement between UNOPS and FAO, whose final report entitled "Flow, Thermal Regime and Sediment Transport Studies in Lake Tanganyika" was distributed to all participants; (5) cooperation with the UNDP/GEF Project RAF/92/G32 "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika"; (6) details concerning the project's reporting activities; (7) details on the FINNIDA evaluation mission; (8) details of LTR personnel movements; and (9) details concerning the LTR Work Programme for 1998-1999.

8. The Chairman congratulated the LTR Coordinator and staff for their achievements, re-emphasizing the need for effective coordination during the remaining period of the project and

expressing the hope for continued support by the key donor agency. The delegate of DRC supported the Chairman’s statement, expressing his satisfaction with the achievement made by the project during the last 18 months. He requested clarification concerning financial arrangements for the charter of R/V Tanganyika Explorer. The delegate of Burundi expressed his concern about the project’s budgetary constraints during the last 6 months, and expressed the hope that the project would be able to provide necessary funding for the upcoming national execution phase.

9. The delegate of Zambia re-emphasized the statement made by the delegate of Burundi, further stressing the need to establish clear terms of reference for the officers in charge of the field stations. The Chairman and delegate of the URT requested the LTR Coordinator to propose the terms of reference and complementary modalities in order to ensure the effective continuation of the project under its national execution phase.

10. The Country Project Officer of the project clarified that the selected Officers-in-Charge (OICs) of field stations are technically responsible to their respective governments. He further suggested that the transfer of project equipment currently located at field stations should be initiated as soon as possible.

ITEM 4. LTR SCIENTIFIC COORDINATOR’S REPORT

11. The Scientific Coordinator presented an advanced draft summary of the Final Scientific Report, as shown in Annex 5. His presentation highlighted results and conclusions of all major research components of the Scientific Sampling Programme (SSP), i.e.: hydrodynamics, limnology and primary production; phytoplankton primary production; bacterioplankton; community respiration; zooplankton; fish biology; fish stock assessment; and trophic structure and carbon flows. He concluded his presentation by remarking on the implications of SSP results for management planning.

12. The Chairman thanked the Scientific Coordinator for the achievements under the SSP.

13. Observations by delegates brought to light the need to clarify the effect that the findings may have on existing fishery legislation. Also, the need to avoid attempting to specify a total allowable catch was brought out. This is because of the patchy distribution of the stocks and of fishing activity, combined with the seasonal and inter-annual variations in the availability of resources.

ITEM 5. FRAMEWORK FOR THE FISHERIES MANAGEMENT PLAN FOR LAKE TANGANYIKA

14. A framework was introduced for the fisheries management plan, based on the Code of Conduct for Responsible Fisheries (CCRF) and the indicators provided through results of LTR investigations from 1992 to the present. These latter include

results of: the Catch-per-Unit-of-Effort (CPUE) study; the production dynamics and biomass estimations; the study of pelagic fish distribution and ecology; the socioeconomics survey; and the studies on institutional and legal issues. The framework summary appears in Annex 6.

15. Framework recommendations were proposed that deal with: the adoption of the CCRF as the foundation for development of management policies for shared resources; phasing out of beach seining; reduction of purse seining effort by retirement or reallocation of units to other zones and off-limits areas; ceilings on liftnet fisheries in the north based on licensing; adoption of licensing as a means to control individual entry; assignment of use rights on a zone basis to communities; and development of community-based management.

16. In order for the framework plan to become operational accompanying measures will be required. These include institutional and legal provisions, development initiatives, and research and monitoring.

17. The institutional arrangement is the key element because all accompanying measures will need coordination and structure that will satisfy donor agencies. Further, the structure should be simple and based on national institutions.

18. The Committee recommends that FAO and the LTR assist the riparian countries in establishing an institutional framework for a working Group and Protocol Agreement" to facilitate execution of national and regional activities in a coordinated way.

19. The discussion revealed that the pooled information from all of the project activities is sufficient to point out the lake's fisheries management problems and the species and sub-basins involved, in the form of a general framework of proposals. However, at this time the institutional capacity for lake-wide management is insufficient. In order to overcome this weakness, the Committee endorsed the framework as proposed, further providing approval to carry out lake-wide referenda in order to secure the input of the local stakeholders. In addition the Committee lent its full support to the accompanying measures in order to make the management plan operational, including exploration of possibilities for financial support from the AfDB, the FAO project promoting the CCRF, and the FAO Technical Cooperation Programme.

20. With regard to accompanying measures related to development as well as institutional and legal aspects, the Committee urged the project to seek additional funding, and in particular to investigate the possibility of obtaining FAO and the Finnish International Development Agency (FINNIDA) support, for the development of viable short-term and long-term institutional arrangements.

ITEM 6. LTR MONITORING PLAN PROPOSAL

21. A monitoring plan was proposed that is to go hand in hand with the management plan, as is amplified in Annex 7. The proposal is to monitor indicators among four broad categories including physical, biological, statistical, and socio-economic.

22. It was emphasized that a monitoring programme provides the basis for evaluation of management initiatives and that continuity in the collection of data is essential.

23. From the viewpoint of the donor, the Monitoring Programme provides an opportunity for continued applied research for the long term, which is critical for the management process. The donor will be requested to give financial support and to ensure basic equipment requirements at the field stations plus transport for data collection for up to 3 years. However, the condition placed on this is the full commitment of the lakeside institutions to carry out the field monitoring activities.

24. The Committee made a firm commitment to provide the field staff required for the Monitoring Programme. Restoration of the degree-level fisheries training earlier supported by FINNIDA and implemented by the University of Kuopio, is again seen as important in light of the need for such training in the respective countries.

25. The next step is making a more detailed programme that includes a detailed budget, taking into account that some of the equipment will have to be replaced.

ITEM 7. INDICATIVE LTR BUDGET PROPOSAL FOR 1998-1999

26. In light of the overall objective to ensure the successful conclusion of project activities, and effective national responsibility for the implementation of the proposed Monitoring Programme, the following budget is proposed.

27. Two field activities are planned for the remainder of 1998: (1) the lakewide community referenda exercises; and (2) field testing of the proposed Monitoring Programme. An estimated $20,000, to be earmarked for operational expenses of the respective lakeside research stations in support of these two activities, will be required.

28. For 1999 budget provision is needed as follows. (1) Initiation of the Monitoring Programme under direct national execution will require an estimated $10,000 per country, with funds being allocated in several installments according to the workplan to be specified. (2) It is suggested that the Monitoring Programme and the envisaged accompanying measures will be coordinated on a rotating basis by a Regional (National) Coordinator, to whom an operational budget will be made available. The Regional (National) Coordinator will operate under terms of reference to be prepared by the Scientific Coordinator in consultation with the LTR Coordinator, and distributed for comments and approval by members of the Committee, not later than December 1998. Indicatively, the

annual operating budget (mainly covering travel and communications) will be in the region of $10,000 per year. It is suggested that the host country of LTR Headquarters be designated to provide the first Regional (National) Coordinator.

29. The following equipment will be required in order to ensure effective implementation of the Monitoring Programme: (1) One vehicle per field station; (2) two computers per field station; and (3) spare parts for automatic recorders, chemicals, and miscellaneous items. An estimated $150,000 will be allocated for 1999 to cover the equipment items.

30. Further budget provision will be required to cover the participation at the Seventh Joint Meeting of the LTR Committees.

31. The Committee agreed that project equipment which is obsolete and/or surplus to requirements be disposed of according to standard FAO procedures.

ITEM 8. ANY OTHER MATTERS

The Eighth Session of the CIFA Sub-Committee for Lake Tanganyika

32. It was agreed that the Eighth Session of the CIFA Sub-Committee for Lake Tanganyika and the Seventh Joint Meeting of LTR Coordination and International Scientific Committees will be held, back to back, from 18 to 21 May, 1999, in Lusaka, Zambia, at the kind invitation of the Government of Zambia.

Resolution Proposed by the Scientific Coordinator

33. The Committee received and deliberated a resolution proposed by the Scientific Coordinator, shown as Annex 8.

34. The resolution was enthusiastically supported by the countries. The Chairman requested the delegate of Burundi to bring this resolution to the attention of his Minister, who, in turn, should request the required approval by the Director General of FAO.

ITEM 9. ADOPTION OF THE REPORT

35. The Coordination and International Scientific Committees adopted the report on
23 June 1998.

34. The Chairman thanked all participants for their contributions and constructive debate. He also thanked members of the secretariat, the FAO, and the delegation from Finland for their attendance and good work.

36. The delegate of Zambia thanked the Chairman for his effective leadership and wise guidance throughout the deliberations.

37. The Chairman declared the meeting closed.

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

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Annex 2

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

OPENING SPEECH BY MR. ABEDANIGO K. BANDA DIRECTOR OF ECONOMICS AND MARKET DEVELOPMENT MINISTRY OF AGRICULTURE, FOOD AND FISHERIES

The Chairman of the Coordinating Committee
The FAO Representative
Distinguished Ladies and Gentlemen

Let me start by welcoming you and the participants to this session of the LTR Coordination Committee.

Mr. Chairman, the fisheries sector in Zambia plays a very important and critical role in the economy of the country. Fish as one of the cheapest source of protein, accounts for 55% of the total animal protein intake. The sector also contributes significantly to employment. It is estimated that there are 30,000 artisanal fisher persons and about 50 commercial companies in the country. In addition, over 300,000 people are directly or indirectly employed in the fisheries sector. This makes the fisheries sector the third largest after agriculture and mining. With the above facts, the fisheries sector will continue to receive special attention in this country.

Mr. Chairman, as you may be aware, Lake Tanganyika extends over 32,000 km^2, and has valuable fisheries and pelagic stocks, which are apparently not exploited to their full capacity. The lake’s fish resources are shared by the Democratic Republic of Congo (45%), Tanzania (41%), Burundi (8%), and Zambia (6%).

In this regard, the importance of close regional cooperation for the management and exploitation of these common resources can not be overemphasized. Previous National Research and Development projects showed that independent uncoordinated research programmes could not provide the required knowledge and data. It was against this background that this project came into existence.

Mr. Chairman, Lake Tanganyika is particularly important to the riparian four states, as a fishery and source of employment and income for Lake shore communities. Most of the fish from the Zambian side of Lake Tanganyika, is caught by artisanal (60%) while the remainder is by industrial companies. Over 800 households along the Zambian shores of Lake Tanganyika are earning their livelihood from fishing. In addition, there are twelve industrial companies with the potential to increase their fishing effort on the Lake.

As fishing and other economic activities expand on the Lake, it is very obvious that other activities on one section of the Lake will have effects on other parts of the Lake, which may lie, in other countries. These spill over effects call for coordinated efforts in the management and exploitation of the fishery resource. Coordination is one way of ensuring that the resource is sustainably exploited to the benefit of the economies of the four countries and more importantly the lake shore communities. It goes without saying therefore that our governments are committed to uplifting the living standards of the rural communities, which include lake shore communities.

Mr. Chairman, as you may be aware, the tool of the Zambian Government through the Ministry of Agriculture, Food and Fisheries has chosen for agricultural development issues is the Agriculture Sector Investment Programme (ASIP). Under ASIP, there is a Fisheries Sub-programme which is charged with the mandate of developing fisheries resources for the attainment of sustainable self-sufficiency in fish production and the need to improve nutrition through the adopted policies and strategies. In order to facilitate implementation of new fishery policies and strategies, changes in fisheries legislation have been suggested. The Draft Fisheries Act is being prepared taking full account of the changes and developments, which are taking place within the fisheries sector at both local and international levels. Some of these changes are:

1. the need to decentralise some fishery management responsibilities from the Central Government to local communities in fishery areas,
2. the need to involve rural communities, non governmental organisations, traditional institutions and even private individuals in fisheries management and
3. the need for co-operation with neighbouring states in the management and development of fisheries in conformity with the international agreements such as the Code of Conduct for Responsible Fishing and the SADC treaty for shared water resources.

Mr. Chairman, my speech would be incomplete without appreciating the roles played by various bodies in making this meeting a reality. I would like to thank the Government and the people of Finland for their collaboration in responding to the needs of our four countries. It is hoped that with the close collaboration of the riparian states and though the assistance of FAO, Finland and the international community at large, we will be able to acquire most skills and knowledge that will lead to better utilisation of the resources of Lake Tanganyika. While attempting to satisfy the present needs, we should not lose sight of the future institutional requirements for sustainable development of the fisheries of Lake Tanganyika.

It is my hope that during the next few days of your deliberations you will endeavour to work out ways though which Lake Tanganyika will benefit all the four riparian states.

Mr. Chairman, with these remarks I now wish to declare this important meeting officially open. I thank you.

Annex 3

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

AGENDA

Item 1: Opening ceremony and election of the Chairman.

Item 2: Adoption of the Agenda.

Item 3: LTR Coordinator's Report: summary of LTR's activities (December 1996-June 1998) and review of progress on recommendations of the Fifth Joint Meeting of LTR Committees.

Item 4: LTR Scientific Coordinator's Report: summary of LTR Scientific Report.

Item 5: Framework Fisheries Management Plan for Lake Tanganyika.

Item 6: LTR Monitoring Programme: proposal.

Item 7: LTR budget proposal for 1998-1999 and behind.

Item 8: Any other matters.

Item 9: Date and venue of the next meeting

Item 10: Adoption of the report.

Annex 4

LTR/98/2

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

LTR Coordinator's Report: Summary of LTR's Activities (December 1996 – June 1998)

INTRODUCTION

1. During this reporting period LTR closely followed the recommendations of the Fifth Joint Meeting of LTR Committees and took all required actions to meet them. These and other activities are now detailed hereafter.

RESULTS

Scientific Sampling Programme

2. The three full years of LTR Scientific Sampling Programme (=SSP) were completed on 2 July 1996. The initial summary of the scientific report was presented during the 5th Joint Meeting of LTR Committees. During the last 18 months considerable efforts were devoted to the consolidation of the SSP results. I am happy to report that the LTR's only weakness *i.e.* hydroacoustics studies was resolved during this reporting period. All previously collected data were recovered and two additional lake-wide acoustics cruises successfully executed. As the results of this and other complementary studies became available only last month only an advanced version of the LTR Scientific Report will be presented as LTR/98/3 as the Final LTR Scientific Report is now due to be published later this year.

R/V Tanganyika Explorer

3. A total of 11 lake-wide cruises was executed during this reporting period as follows:

cruise No. 10 (15-26.11.1996): hydrodynamics
cruise No. 11 (3-12.2.1997): time-charter to project LTBP
cruise No. 12 (15-25.2.1997): time-charter to University of Arizona
cruise No. 13 (27.2-7.3.1997): time-charter to University of Arizona
cruise No. 14 (6-18.4.1997): hydrodynamics
cruise No. 15 (1-22.7.1997): socio-economics studies
cruise No. 16 (18.8-5.9.1997): hydrodynamics
cruise No. 17 (21.11-12.12.1997): hydroacoustics
cruise No. 18 (5-31.1.1998): time-charter to LTBP/University of Arizona
cruise No. 19 (3-21.2.1998): hydroacoustics
cruise No. 20 (11.3-17.4.1998): multi-disciplinary

Immediately after completing the last cruise the vessel returned to her homeport in Bujumbura. The majority of the scientific equipment was removed and the vessel underwent her last maintenance and clean up. Mr. Turner, Senior Fishery Industry Officers (Vessels) arrived to Bujumbura on 25.4.1998 and completed all necessary documentation required for the re-delivery of the vessel to her owners. The Certificate of Re-delivery was signed without reserve on 28.4.1998, a good testament of both the qualities of the vessel and the crew who had handled and maintained her to the highest standards. I now wish to record that this three-year long charter was successfully executed under a very difficult socio-political climate in the region and represents an important achievement for the LTR.

Socio-economics studies

4. All scheduled activities under this component were executed. These included the following: (a) organization and execution of two Socio-Economic Planning Workshops (Kigoma, 22-30.4.1997 and Bujumbura, 1-7.7.1997); (b) a lake-wide socio-economic survey (SE) (July and August 1997); (c) the input of SE data (over 14 MB) (August and September 1997) and (d) extensive reporting was completed under supervision of Dr. E. Reynolds, LTR consultant on socio-economy (August to October 1997) and (e) seven Technical Documents were published. The timely and successful execution of all tasks under this project's component represents one of the major accomplishments of LTR.

Inter-Agency Agreement between the UNOPS and FAO

5. The following activities were carried out during this reporting period: (a) analyses of the field data was carried out at all LTR field stations (Bujumbura, Kigoma and Mpulungu); (b) the last two lake-wide research cruises, executed exclusively under this IAA, were carried out during 6-18.4.1997 and 18.8-5.9.1997; (c) the data analyses, including a very demanding computer modeling, was completed at the Regional Environmental Agency of Häme, Tampere, Finland; and (d) the Final Report, entitled 'Flow, Thermal Regime and Sediment Transport Studies in Lake Tanganyika' was published.

Cooperation with the UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP)

6. With the intensification of the LTBP activities, now including the francophone countries, the cooperation between the two projects registered a considerable improvement. All our research stations continue to receive a large number of colleagues from LTBP and the interaction among the staff of both projects is considerable and beneficial to both parties.

LTR Publications

7. The following publications were produced since the Fifth Joint Meeting of LTR Committees: (a) 29 Technical Documents; (b) 17 Reports of Travel; (c) 3 Progress Reports; (d) 4 Final

Reports by APO’s; (e) a Catalogues of LTR’s First 100 Publications and (1) 6 LTR Newsletters.

OTHER ACTIVITIES

LTR Joint Review

8. Took place in at FAO HQ in Rome from 13 to 15. 10. 1997. A number of operational and technical aspects was discussed and many important decisions taken. The most important are the following: (a) the duration of LTR was officially extended to the end of December 1999 and (b) the LTR Work Programme for 1998-1999 was proposed and agreed upon.

FINNIDA Evaluation Mission

9. The Department for International Development Cooperation of the Finnish Ministry of Foreign Affairs fielded Evaluation Mission whose task was to evaluate all FINNIDA funded project in Africa. LTR was selected and its station in Kigoma was visited by the mission on 16 and 17.2.1998. The Mission’s members were Prof C. Windstrand (leader), Prof A. Kajumulo Tibaijuka and Ms. P. Uski. HE The Ambassador of Finland in Tanzania, Mr. I. Rantakari, joined the mission.

LTR PERSONNEL

10. The membership of the LTR Coordination Committee remains basically the same during the last seven years. The exception is a change in the delegation of Zambia where Mr. I. Kaliangile, the recently appointed Director of Fisheries, replaced Mr. H.G. Mudenda. I would now like to acknowledge the important contribution made to LTR by Mr. Mudenda.

11. There were numerous changes in LTR field staff during this reporting period. Dr. J. Craig left the project at the end of 1996. In addition, the contracts of all LTR’s remaining Associated Professional Officers expired on 28.2.1998 and thus Misses. Bosma and Paffen and Messrs. Langenberg and Verburg all left the project on that date. Lastly and following the re-delivery of *R/V Tanganyika Explorer* on 28.4.1998, all four officers of *R/V Tanganyika Explorer i.e.* Messrs. Kimosa, Makere, Chale and Suleiman left the project on 30.4.1998. Consequently, the LTR field staff is now reduced to one international expert i.e. the LTR Coordinator, still on post in LTR HQ in Bujumbura, where he is supported by only one secretary and one driver.

In order to ensure the continuity of timely and effective delivery even under the above described limitations, the LTR undertook the following actions: (a) re-employed, under Author Contracts arrangement, the ex-LTR personnel (Messrs. Coenen, Plisnier and Mannini) who all helped in consolidation of SSP results by producing important reports for LTR; (b) recruited two key consultants i.e. Dr. Joanna Szczucka (on hydroacoustics) and Dr. Eric Reynolds (on socio-economy); and (c) formed two LTR Working Groups, the first on Fisheries Management and the other on Monitoring Programme. All work is done exclusively by e-mail and thanks to free input by numerous colleagues in Finland, in FAO HQ and many ex-LTR staff

It should be clear from the above that with the departure of LTR's APO's at the end February 1998 there is a negative impact on two LTR research stations i.e. in Kigoma (Tanzania) and in Mpulungu (Zambia). While the national execution of both stations was proposed some time ago, the formalization of recruitment of Messrs. Chitamwebwa, as 0-i-C of LTR/Kigoma and that of Mr. Mwape, as 0-i-C of LTR/Mpulungu, is expected in the near future. As there are important field activities scheduled both for September-October 1998 (=lake-wide referenda to obtain the reaction and input on Fisheries Management Plan for the lake) and particularly to field test and start the LTR Monitoring Programme in January 1999, it is hoped that a considerable number of our national colleagues will re-enter the LTR in the near future.

I now wish to record the dedication and hard work of LTR's national counterparts and that of LTR international staff Last but certainly not least it is my pleasure to recognize, record and acknowledge the effective backstopping by both the University of Kuopio and by both the technical and operational services of FAO noting the operational ones are now handled by Accra (Ghana) based Regional Operations Branch for Africa (RAFR).

LTR WORK PROGRAMME FOR 1998-1999

12. The key objectives of LTR Work Programme for 1998 and 1999 were agreed upon during the LTR Review (Rome, 13-15.10.1997). There are two key objectives for 1998 *i.e.* (1) to finalize the LTR Final Scientific Report and (2) to propose the Lake Tanganyika Fisheries Management Plan. As apparent from previous sections of this report a large number of activities was already executed this year and/or is scheduled for the remainder of this year to meet fully the both objectives. While further details will be presented to you in documents LTR/98/3 and LTR/98/4 I wish to underline the importance of this meeting since one of the key reasons of organizing this Committee meeting is to (1) review and modify as appropriate the Framework Fisheries Management Plan and (2) decide on the most effective and practicable way of presenting the Draft Plan for review and comment by members of local fishing communities in all four participating States.

The second key objective of this Meeting is to decide how to put our Management Plan in place. One of the conclusions of the LTR Working Group on Management is that a plan a such is not enough and that 4 types of 'Accompanying Measures' will be required. Specifically, it is proposed that once the Lake Tanganyika Fisheries Plan is completed, after ensuring the input of local reactions to and alternative suggestions for the management measures being proposed in the Lake Tanganyika

Fisheries Management Plan, all of this to be completed by the end of 1998, the first 3-4 months of 1999 are devoted to strengthen the Plan by elaborating and specifying the earlier mentioned ‘Accompanying Measures’. These are the following: (1) institutional; (2) legal; (3) developmental and (4) research and monitoring. While the LTR has already proposed and or will propose the (1), (2) and (4) above it is our suggestion that, in order to put the Fisheries Management Plan for Lake Tanganyika effectively in place, the elaboration of the developmental ‘Accompanying Measures’ is essential. Specifically this means to field a multi-disciplinary mission, composed of fisheries development specialist (boats, fishing gear, infrastructure, marketing, etc), in early 1999, in order to prepare, according to the development banks standards and procedures, a host of fisheries development projects, on national or regional level, to compliment the different management measures proposed by the Fisheries Management Plan. As the above has important budgetary implications and further requires the full support of both our key donor and all four participating States, I now invite the members to comment on the above and, particularly, to assist to specify the required inputs for 1999 so that the LTR budget can be proposed and agreed upon by this Committee.

CONCLUSIONS

13. The LTR has successfully completed its execution phase. In addition, most of the scheduled activities of the LTR extension phase were also successfully executed and the vast majority of the collected data fully analysed and reported. The additional support by the donor and the four participating States is now needed to ensure that the maximum benefit on investment made is realized.

Annex 5

LTR/98/3

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

LTR Scientific Coordinator's Report: Advanced Scientific Summary

1. INTRODUCTION

The objectives of the Lake Tanganyika Research Project's (LTR) Scientific Programme were introduced initially by Lindqvist & Mikkola (1989) and formulated in the Project Document (1992) as follows: *The project aims at the determination, through implementation of a modern scientific research programme, of the biological basis for fish production on Lake Tanganyika.* The Programme, divided into eight subcomponents, was expected to provide an adequate reference basis *for formulation of a lake-wide fisheries management policy, aiming at the maximum sustainable utilisation of the pelagic fish stocks, so as to supply high-protein food for the human populations of the four riparian States.*

The mid-term review of the project stated further that .... *a proper understanding of the limnological and hydrological mechanisms present in the lake is essential in order to develop a coherent management plan and procedures. There are obvious gaps in understanding the lake dynamics behind highly fluctuating fish yields....* (Mid-term Review, Helsinki, 1997:7).

Thus the entire scientific work has focused not only to the fundamental hydrophysical, limnological and biological features to describe the structure and function of the pelagic ecosystem in Lake Tanganyika, but also by such an analysis and the ecosystem approach to address the practical problems in fisheries development and management in large. The need for such comprehensive study has been a common conclusion in ten earlier national fisheries development projects executed by FAO.

The scientific programme aimed specifically at studying (Lindqvist & Mikkola, 1989, annual LTR scientific summaries):

1. Modelling the lake hydrodynamics, standard meteorology, major upwellings/downwellings and currents affecting the water circulation, stratification and nutrient/energy flows;

2. Pelagic food webs, their dynamics and vertical migrations, production and composition, and the basis of pelagic fish production; efficiency of energy

pathways to fish;

3, Fish biology and population structure, recruitment and population size, prey-predator relationships;

4. Stock size and biomass distribution affecting the fish yields and utilisation.

The scientific results have also lead into the lake environment and fishery Monitoring Programme (see LTR/98/5) the implementation of which will rely on the accompanied institutes at the lake. Throughout the project duration, the personnel of the research institutes have been trained to take full responsibility of field research, monitoring and reporting as part of the lake-wide Fisheries Management Plan. This ensures greatest possible institutional sustainability in the future.

The total lake-wide catches seem to be still increasing (Hanek, 1994; Coenen, 1995), but during the latest years decreasing catches per unit effort both in the Burundi sector in the north and in the Mpulungu (Zambia) waters in the south have aroused concerns about possible over-fishing (Roest, 1992; Coenen & Nikomeze, 1994, Coenen et al. 1998). On the other hand, there is still considerable local pressure to increase fishing effort to acquire more fish protein. Fishing activities have recently moved from the north to the middle and southern parts of the lake which, in turn, calls increasingly for regional strategic planning.

2. BACKGROUND

There are two main seasons within a year in the Lake Tanganyika region. The wet season extends from October/November to May, and is characterised by weak winds, high humidity, considerable precipitation and frequent thunderstorms. The dry season from June to September/October has moderate precipitation and strong, regularly southerly winds, The seasonal changes of weather and winds result from austral and boreal trade winds, which determine the dynamics of the Inter-Tropical Convergence Zone (ITCZ) and its active wet zone movement (Huttula et al. 1996). These major climatic patterns and particularly the winds regulate the seasonal thermal regime of the lake (Coulter 1963, Coulter and Spiegel 1991), evaporation (Coulter and Spiegel 1991), water flows (Well and Chapman 1976), and the vertical mixing and transport of water masses (Degens et al. 1971, Tietze 1982). Hydrophysical phenomena are primarily regulating the spatial and temporal patterns of the biological productivity, and therefore were paid major attention also in the LTR project.

Lake Tanganyika is known for its productive pelagic fishery, which is reported to yield higher catches per unit area than in most great lakes of the world (Coulter, 1981, 1991; Hecky et al., 1981; Lindqvist & Mikkola, 1989; Hecky, 1991; Roest, 1992). Ultimately, the fish yield is a function of primary production, which in turn depends on solar radiation and nutrient inputs from the drainage area. The fisheries yield in lakes usually ranges between 0.02 and 0.2 % of primary production (e.g. Morgan et al., 1980), while marine coastal seas often show an order of magnitude higher values (Nixon, 1988). For Lake Tanganyika, a preliminary estimate of 0.45 %, resembling those in the marine systems, has been given in the literature (Hecky et al., 1981; Hecky, 1984, 1991).

Several hypotheses have been presented to explain the high productivity of the pelagic fishery in Tanganyika (Hecky et al., 1981). Hecky (1991) noted that the food web of Tanganyika has a marine character. As in many productive marine systems, the primary grazer is a diaptomid copepod, and the dominant primary planktivores as well as the piscivores belong to predominantly marine fish families. The phytoplankton and bacterial biomasses are low but the growth rates are high. Organic carbon is not accumulated in the plankton but is canalized into fish biomass and collected away as fish yield. The long geological history of the lake, combined with the special ecological conditions of a deep, continuously warm tropical lake, may have resulted in the evolution of a trophic structure consisting of highly efficient species (Hecky, 1984). As another explanation Hecky et al. (1981) proposed that the flux of dissolved organic matter (DOM) from the anoxic hypolimnion might complement phytoplankton primary production; however, later analyses of available data have not supported this hypothesis (Hecky, 1991).

The earlier assessments of system structure and fish production efficiency were based on fairly limited data. New data have now been collected within the framework of the LTR Project which enable us to answer the question whether the present fish catches from Tanganyika are on a sustainable basis and whether there are as yet unused possibilities to increase the yield by developing the fishery. In Lake Tanganyika, as in other large and deep clear-water lakes, primary production of phytoplankton is expected to be the major source of energy to higher pelagic trophic levels, including fish. Knowledge of the trophic structure of the lake and the transfer efficiencies in the food chain is thus of interest for assessing the fishery potential, and also for comparison with other lakes.

3. IMPLEMENTATION

The scientific study was implemented in the three full years Scientific Sampling Programme (=SSP, preliminary summary by Craig, 1997, limnology by Plisnier et al., 1996) that included physical, chemical and biological sampling weekly or fortnightly at the three field stations. The study is unique in that it has been carried out continuously over an extended period, and at three main locations spread over the lake. Thus seasonal conclusions areal comparisons can be made and to some extent also areal comparisons are possible but the five-year project duration is still too short for any reliable long-term observations. During the studied period the water level has been lowest since 1959, and if the declining trend of the past years persists the lake may be facing a new closed period in the near future (Verburg 1997). To record annual fluctuations and inter-annual patterns requires a continuous monitoring of physical and biological parameters after the intensive three-year SSP period.

A total of 17 lake-wide cruises with *R/V Tanganyika Explorer* was executed for hydrodynamic, limnological, fish biological and hydroacoustic studies. Such cruises equipped with modern sampling and navigation device were also of unique nature. Sampling schemes on these surveys were as multidisciplinary as possible in order to combine the physical and ecological observations and to analyse the interactions between the trophic levels, Primary data on these cruises and SSP have been published in numerous LTR Technical Documents.

Hydrodynamic measurements were conducted on the cruises, with automatic water level and current recorders, current profilers, as well as land-based and on board meteo stations. The hydrodynamic modelling was completed under the IAA-agreement between the FAO and UNOPS and summarised by Huttula (1997). NOAA AVHHR based remote sensing was used for lake surface surveillances and the results were combined with the hydrodynamic modelling in particular (Tuomainen et al. 1997).

The synthesis of carbon and energy flows in the pelagic food web was compiled by the sub-component leaders and summarised by Sarvala et al. (1998; to be published separately in Hydrobiologia/ Lindqvist et al. eds, 1998). This analysis is the basis of the enclosed scientific summary and completed with the conclusions of each sub-component. Due to delayed obtaining of the research vessel, and the general socio-political problems in the region, the studies on fish stock sizes and biomass distribution, could be completed very recently only. The latest results of fish biology and hydroacoustic became available during the preparation of this document; thus an advanced summary is presented now, and the Final LTR Scientific Report is to be published later this year.

4. RESULTS AND CONCLUSIONS

4.1 Hydrodynamics

The earlier studies by Coulter and Spiegel (1991), Hecky & Bugenyi (1991) and Hecky et al (1981) on upwelling and the related biological production in Lake Tanganyika were now completed with a comprehensive climatic, hydrophysical and modelling work by Huttula et al, (1994). Huttula & Podsetchine (1994), Kotilainen et al, (1995), Podsetchine et al, (1995), and Verburg et al, (1997 a, b).

Huttula (1997) has concluded the following hydrodynamic patterns of Lake Tanganyika:

- The upwelling was observed both in 1996 and 1997 in the south, though less intensive than in 1993. In Kigoma the thermal stratification was not broken at all.

- The water temperature revealed tilting of thermocline along the main axis of the lake, in accordance with Coulter (1963, 1968). Heating of deep waters and the deepening of certain isolines due to climatic changes was claimed by Plisnier (1997).

- Transversal tilting in the Kalemie strait during dry and wet seasons was observed in connection with the uninodal internal seiching.
- Internal wave motion with a periodicity of 23.4 d during the dry season and of 34.8 d during the wet season was found with automatic devices for the first time.
- High and variable current speeds were measured at surface waters down to 20-40 m whereas the water flows below this level were more steady but showed clear seasonal variations.
- ADCP current measurements were used in validating the barotopic flow models and in applying the HTRLAM Meteorological Forecast Model
- Discharge of silted materials in the dry season is fairly limited to the river mouths and narrow littoral zones only, but during the rainy season, the turbid waters distributed over a wider range showing longitudal, elongated shapes due to wind-induced flows.
- Wind driven currents initiate and maintain upwelling events in Lake Tanganyika, but not only in the southern end as primarily underlined by Spiegel & Coulter (1991) but secondarily everywhere along the eastern and western coast.
- At present the 3D-thermal current model of Lake Tanganyika has been combined with oxygen data, and once verified, it will allow to apply the model to more precise assessment of the nutrient or organic particle fluxes and distributions.

4.2 Limnology and primary production

The limnological studies concerned with physical processes in the lake and how these influence factors such as light, nutrients and chlorophyll *a*. A typical' limnological cycle within one year included during the dry season, starting in May-June, south east winds driving the surface water towards north. This caused accumulation of warm water and deepening of the thermocline in the north (down to 70-90m in Bujumbura). At the south end of the lake the winds cooled the surface water by convection and wind mixing first deepening the thermocline and finally breaking it by August. After the SE winds ceased in September or October the vertical stratification was re-established by November (Plisnier et al. 1996, Plisnier 1996, Langenberg 1996).

The tilting thermocline results in a density imbalance that acts as a store of potential energy. During the decreasing wind the water masses will move towards equilibrium. The degree of wind shear stress on the lake surface (measured as the Wedderburn number W) in Mpulungu was low as expected during the dry, windy seasons indicating thermocline tilting, mixing and possible upwelling. Towards the southern end of the lake, the lower metalimnion boundary approached the depth of 300 m (Plisnier et al., 1996).

The seasonal changes in the physical limnology of the lake affected its water chemistry and the nutrient regime. Weekly sampling at the main stations indicated internal waves with a period of c. 33 days throughout the year. The vertical distribution of nutrients was influenced by the meromictic condition of the lake. In general epilimnic concentrations of phosphate, nitrate, ammonia and silica were very low compared to those in the hypolimnion, probably due to uptake by autotrophic organisms (Plisnier et al. 1996, Plisnier 1996, Langenberg 1996).

According to Langenberg (1996) the chlorophyll *a* concentrations were lowest from August to mid-September, increasing after this, and highest in November- December both in Bujumbura and Kigoma. In Mpulungu the upwelling period from August to mid-September showed a cool water pulse, low in nutrients but high in chlorophyll *a*, whereas the other two periods were less productive in terms of chlorophyll *a* concentrations.

The access of nutrient rich deep waters to the productive euphotic layers doesn’t as such directly lead into increased primary production. The different vertical distribution of temperature, dissolved oxygen and nutrients (particularly the position of thermocline, oxycline and chemocline, and the relation between mixing depth and euphotic depth) may lead to the replenishment of the corresponding mean for extracted chlorophyll *a* was 1.0 mg m^{-3} (n = 27). The average chlorophyll in the uppermost 40 m (calculated from fluorescence) was 2.2 mg m^{-3} in October-November 1995 (n = 76) and 2.8 mg m^{-3} in November 1996 (n = 27). Seasonal average values obtained from the first five months of weekly chlorophyll samples from off Bujumbura, Kigoma and Mpulungu were 0.6-1.6 mg extracted chlorophyll *a* m^3 (Langenberg, 1996).

Incubator measurements of primary production at different irradiance levels resulted in relatively flat photosynthesis-irradiance curves, showing that the Tanganyika phytoplankton was capable of efficient photosynthesis even at the low irradiance levels obtaining in deep water at 30-40 m depth. No signs of photoinhibition were observed up to the highest experimental irradiance level of 512 mmol photon $m^{-2}s^{-1}$.

DIC determinations resulted consistently at 72 mgC l^{-1}. Average primary production assimilation numbers variedfrom 2.1 mgC (mg chl)$^{-1}$ h^{-1} during the April-May 1995 whole-lake cruise to 3.2 mgC (mg chl)$^{-1}$ h^{-1} during the October-November cruise in 1995. The assimilation number obtained from *in situ* incubations in

December 1994 off Kigoma (3.0 mgC (mg chl)$^{-1}$ h^{-1}) was similar to the latter value.

In the **incubator experiments** in October-November 1995 the chlorophyll-specific productivity *vs.* irradiance curves were practically identical from 1 to 30 m depth, allowing the use of common photosynthetic parameters for these depths.

The similar light responses suggest that phytoplankton in the uppermost 30 m had an identical history of light exposure, probably due to only partial mixing within the epilimnion. Indeed, vertical temperature profiles often showed secondary discontinuities at various depths above the major thermocline at 50-70 m (Salonen & Sarvala, 1994; Huttula et al., 1994). At least down to a depth of 5 m, occasionally even down to 9-10 m the photoinhibition was likely for several hours per day.

In April-May 1995, multiplication of the average assimilation number by the average surface chlorophyll value resulted in an estimate for the overall lake-wide primary production rate of 2.0- 2.1 mgC m^{-3} h^{-1} , or, approximately 20-21 mgC m^{-3} d^{-1}. Applying these values to a water layer of 40 m, the depth-integrated daily primary production would have been 0.80-0.86 gC m^{-2} d^{-1}. In October-November 1995, the corresponding production rate would have been 7.0 mgC m^{-3} h^{-1} , resulting in a daily productivity of 2.8 gC m^{-2} d^{-1} Averaging these estimates would yield an annual production of 662 gC m^{-2} a^{-1}.

The average simulated ***in situ*** production was 1.06 gC m^{-2} d^{-1} for the dry season and 2.49 gC m^{-2} d^{-1} for the wet season. Assuming a 6-month duration for both seasons, these values resulted in an annual production estimate of 647 gC m^{-2} a^{-1} for the whole lake. nutrients into the euphotic zone stimulating biological production. (Langenberg 1996).

During upwelling at Bujumbura, the concentrations of silicate, nitrogen and phosphate increased, N:P ratios were relatively high and chlorophyll a concentrations increased shortly after. This suggests that for most phytoplankton production, nitrogen and phosphorus were limiting. Results from nutrient enrichment studies by Järvinen et al. (1996) also showed that phytoplankton production was stimulated by combined additions of these nutrients rather than by separate additions.

4.3 Phytoplankton primary production

Total solar irradiance was recorded along with other weather variables at automatic meteostations. In vivo fluorescence of chlorophyll *a* at different depths (down to 100 m) and horizontal positions was measured with field fluorometer off Kigoma and Bujumbura in 1994 (Salonen & Sarvala 1995) and onboard *R/V Tanganyika Explorer* in 1995 and 1996 (Järvinen et al 1996, Salonen et al 1998). Fluorescence readings were calibrated against determinations of extracted chlorophyll *a*., which was determined spectrophotometrically or using a fluorescence spectrophotometer. Phytoplankton primary production was assessed with the radiocarbon method in situ in 1994 off Kigoma, and since August 1995 at the three main sampling stations, and during the lake-wide cruises in an on-board incubator.

The average diurnal pattern of total solar irradiance was very similar at the northern and southern ends of the lake, although slightly lower values were recorded before noon in Bujumbura. This may be due to the shading effect of the mountainous terrain or to more frequent clouds in the north end of the lake. In Bujumbura, the average total irradiance in January-October 1995 was 230 Wm^{-2}; off Mpulungu the average for May-November 1995 was 256 Wm^{-2}. The 1993 annual average of total irradiance at Kigoma airport, some kilometres east of the lake shore, was 206 Wm^{-2}, but higher values would be expected on the lake, because clouds tend to be more common over the land in this area. The irradiance levels experienced in different parts of the lake seem to be quite homogeneous.

Fluorescence and chlorophyll profiles showed values approaching 1 mg m^{-3} down to 50-60 m depth, in sunny weather a surface depression around noon, and often a maximum in fairly deep water at 30-40 m (Sarvala & Salonen, 1995; Järvinen et al., 1996; Salonen et al., 1998). In connection with local bluegreen blooms, much higher values (tens of mg m^{-3}) were observed immediately below water surface. Likewise, primary production had its maximum usually at the depth of 10-20 m, and measurable production down to 40-50 m. During the first cruise in April-May 1995 the average fluorescence in surface water (excluding the midday depression) indicated a mean chlorophyll a concentration of 1.4 mg m^{-3} for the whole lake (Salonen et al., 1998). For the uppermost 40 m the fluorescence-derived overall mean value was 0.96 mg m^{-3} (n = 53) and

Third, completely independent estimate for primary production was obtained from the weekly *in situ* radiocarbon measurements done since August 1995 at the three permanent sampling localities in different parts of the lake. The highest values were found off Bujumbura and the lowest off Mpulungu (the mean values (± 95 % CL) for the whole measurement period were 2.6±0.9 gC m^{-2} d^{-1} (number of measuring dates = 14), 1.3±0.5 (n = 9) and 1.1±0.8 (n = 7) for Bujumbura, Kigoma and Mpulungu, respectively). An overall average for the whole lake would be 1.7 gC m^{-2} d^{-1} or 608 gC m^{-2} a^{-1}; variability of the *in situ* measurements suggests that the 95 % confidence belt of this estimate might be about ±30 %. Although the weekly data did not yet cover the whole annual cycle, they were based on a higher number of independent field measurements than the other estimates, and therefore we tentatively accept this figure as the best estimate for lake-wide primary production in Lake Tanganyika during the first half of the 1990s.

4.4 Bacterioplankton, community respiration and DOC

Bacterioplankton production

Bacterioplankton production was assessed with the leucine incorporation method (Kirchman, 1995) during two cruises (April-May 1995; Järvinen et al., 1996, and October-November 1995, Salonen et al., unpubl.). Total respiration of the plankton community was measured as oxygen consumption in a pilot experiment off Kigoma in April 1994 (Salonen & Sarvala, 1994), using glass bottles and the Winkler titration method.

In April-May 1995 (Järvinen et al., 1996) the bacterial biomass production was in average 2.8 mgC m^{-2} d^{-1}, or slightly more than 20 % of the average phytoplankton primary production measured during the same cruise (13.6 mgC m^{-2} d^{-1}). In Oct-Nov 1995, the highest values usually occurred in the upper water layers, although at one site the maximum values were recorded below the thermocline. Bacterial production correlated positively with the chlorophyll level of the same samples (r^2 = 0.76, n = 23; Fig. 8). During this cruise, bacterioplankton production amounted on an average to 20.9 % of phytoplankton production estimated from chlorophyll and the average assimilation number.

DOC determinations and total community respiration

Dissolved organic carbon (DOC) was determined from two vertical series from 0 to 80 m depth on 30 April and *5* May 1995 at the southern and northern ends of the lake (Järvinen et al., 1996).The mean concentration of DOC varied between 2.2 and 2.9 mgC l^{-1}, and was highest close to the surface (Järvinen et al., 1996). Based on oxygen consumption by the whole plankton community in the uppermost 30 m, the community respiration would be 1.6-2.5 gC m^{-2} d^{-1} in a 0-50 m water column, representing the fully oxic epilimnion. This daily carbon consumption rate is less than 2 % of the DOC storage, but it is almost in balance with the phytoplankton primary production estimated for the season, suggesting efficient carbon cycling within the epilimnion.

4.5 Zooplankton

Zooplankton abundance and composition for the one calanoid species *(Tropodiaptomus simplex)* and the cyclopoids as a group (divided into developmental stages) was monitored weekly or fortnightly at the three field stations. Three replicate hauls from 100 m to surface were taken with a 100 µm plankton net. *Limnocnida tanganyicae* medusae, decapod shrimps and fish eggs or larvae were also counted (Kurki et al., 1998b). Nets with mesh sizes of 50 and 100 µm were compared, (Vuorinen & Kurki, 1994, Kurki et al, 1998b,) and vertical migration studies were made with Limnos-sampler down to 140 m off Bujumbura and Kigoma and to 220 m off Mpulungu (Vuorinen et al., 1998). Individual carbon contents of the main crustacean zooplankton species were determined according to Salonen (1979) from preserved samples. Zooplankton production was calculated with the instantaneous growth rate method (Downing & Rigler, 1984; Kimmerer, 1987). Development times for *T. simplex, Mesocyclops aequatorialis* were derived from the literature on same or related species in the tropical lakes (Hart, 1994, Irvine & Waya, *1995)* or from the LTR own rearings in Kigoma (Hyvönen, 1997)

Zooplankton communities

According to weekly samples from the three main stations, the northernmost end of the Lake is characterised by higher numbers of Cyclopoida, while in the southern end calanoids and cyclopoids were more or less equally abundant (Kurki *et **al.*** 1998a). Over two years, cyclopoids comprised 73%, 83% and 63% of the total number of post-naupliar copepods in Bujumbura, Kigoma and Mpulungu respectively. In biomass, the areal differences diminished, because the small cyclopoids, which were dominant in the north, had a minor role in the south. The difference between calanoids and cyclopoids as clupeid food is significant: a calanoid nauplius is comparable with a small cyclopoid adult in biomass. In Lake Tanganyika calanoids probably are more vulnerable to predation than cyclopoids owing to their larger size. High numbers of zooplankton in the northernmost part of the lake (Kurki *et al.* 1998a) supported the finding of Hecky & Kling (1981), that the water mass in the northern end is characterised by different biological properties from water in the main basins. Plankton abundances also showed higher variability in the north (Kurki *et al.* 1998a).

Moreover medusae predominated the macrozooplankton in the northernmost part of Lake Tanganyika, while the southern pelagic ecosystem was distinguished by predominance of shrimps. The shrimp abundances in the weekly samples 1993-1995 off Bujumbura were 2.8, in Kigoma 6.0 and Mpulungu 11.9 individuals m^{-3}, while the abundance of medusae in Bujumbura were 79, in Kigoma 25 and Mpulungu 25 individuals m^{-3} These values suggest a whole-lake mean biomass of 665 mgC m^{-2} for *Limnocnida* and 605 mgC m^{-2} for the shrimps. Especially the latter value may be an underestimate, because of possible net avoidance; a considerable part of the shrimp population may also have stayed deeper than 100 m at the time of routine sampling (Kurki et al*.* 1998b).

However, zooplankton data from lake-wide cruises indicate more even distribution and minor differences in zooplankton community between different parts of the lake (Kurki 1998, in prep.). Only the northernmost Bujumbura sub-basin and the Mpulungu sub-basin in the southern arm differed from the main basins (North, Kalemie shoal, and South), which showed relatively homogeneous zooplankton community composition and abundance (Kurki 1998, in prep.). Such differences seem understandable, because the area off Bujumbura is subject to considerable inflow from the Rusizi river and human influence from the town, and the area nearest Mpulungu is more strongly affected by the dry season winds than the main lake.

Differences in the plankton community are reflected also in the fish biology; according to fish stomach analysis and simultaneous zooplankton sampling the shrimps were highly selected as prey for clupeids in all areas, though they are more common in the plankton towards the southern arm of the lake (Lensu 1998). In the stomach contents of the centropomid *Lates stappersii* there were more shrimps both in percentage and frequency in Mpulungu area in the south than in Kigoma area in the north where the diet of L. *stappersii* contained bigger proportion of copepods (Kurki *et al.* 1998b). Based on catch studies (Mannini *et al.* 1996), the northern end of the lake was dominated by young *L. stappersii* and clupeids whereas no adult *Lates* fish occurred in catches. The catches in the southern end of the lake consisted mainly of adult *L. stappersii* and various stages of the clupeids. These food chain differences probably arise basically from different patterns of mixing due to seasonal winds and orientation of the lake relative to wind. The effect of seasonal mixing was clearly seen also in the vertical distribution and migration (Vuorinen *et al.* 1998) as the planktonic community of the southern end occupied the water into the depth of around 220 m, which is about twice as much as the vertical space utilised by zooplankton in the north. Deep mixing may have two-fold effects on zooplankton production: the physical forces may enhance the predator-prey encounter rates between fish and zooplankton as previously suggested for tropical lakes (Nixon, 1988), and for coastal sea areas (Nixon, 1988, Haury *et* al. 1990, MacKenzie & Legget 1991, Archer, 1995, Landry *et al.* 1995), but it may also decrease the production in the case where the food of zooplankton is widely dispersed due to mixing and the animals are forced to feed in such diluted environment.

4.5. Zooplankton production

The zooplankton biomass and production estimates calculated from the vertical migration data and from the weekly sampling series were expected to be somewhat different, because of the different sampling sites, mesh sizes and water column depths sampled. Comparative tests with 50 µm and 100 µm net hauls and different samplers were made: 100 µm mesh retained all copepodids and adults and most of the nauplii of T. *simplex,* but most of the small cyclopoid nauplii passed through. In contrast, the 100 µm net seemed more effective than a 50 µm net in capturing the adult copepods.

Off Bujumbura and Kigoma, the volume-specific biomass estimates for *T. simplex* obtained from the vertical migration studies were higher than those from the weekly time series. Off Mpulungu, both calanoid and cyclopoid biomass in the weekly series was higher than in the vertical migration series, probably reflecting higher zooplankton abundances in the shallower part of the southern end. For cyclopoids, the large biomass difference between the data sets off Kigoma was especially due to the different retention of the cyclopoid nauplii by the 50- and 100-µm meshes. In area-specific biomass estimates the differences between the data sets became even more pronounced, because notable numbers of zooplankton were found deeper than 100 m.

Production calculations showed the importance of copepod nauplii in the crustacean zooplankton production. In the vertical migration data for Bujumbura, Kigoma and Mpulungu, the contribution of nauplii to the total calanoid production was 65, 27 and 14%, and to the cyclopoid production 55, 75 and *43* **%.**

For both calanoids and cyclopoids, the total biomass and production above one square metre were always highest off Bujumbura, while the order of Kigoma and Mpulungu varied between the data sets, This variation precludes further areal comparisons.

The production of herbivorous copepods off Bujumbura, Kigoma and Mpulungu was 35.3, 27.3 and 6.5, and the production of predatory cyclopoids was 4.1, 0.3 and 2.1 gC m^{-2} a^{-1}, respectively. The resulting averages for the whole lake were 23.0 and 2.2 gC m^{-2} a^{-1} for the herbivorous and predatory copepods, respectively. From these figures, the annual P/B ratios for the herbivorous and predatory copepods were 28.5 and 11.1 a^{-1}.

4.6 Fish biology

Population analyses of pelagic fish (the clupeids *Stolothrissa tanganyicae* Regan, *Limnothrissa miodon* (Boulenger) and the predatory *Lates stappersii* (Boulenger)) were based on weekly catch samples from commercial catch at three main stations and six substations around the lake (Aro & Mannini, 1995). The catch sampling covered all methods used in the traditional, artisanal and industrial fisheries (lift nets, beach seine and purse seine). Most fishing is done at night as virtually all of these methods rely on light attraction. In the first sampling year 429-443 catch samples were taken for each species. Length, weight, sex and reproductive status were recorded for each fish. Length-frequency analyses (LFA) were applied to derive growth and mortality rates from these data (Aro & Mannini, 1995). To check the growth information thus obtained, age determinations of the clupeids were also made by counting daily increment rings in the otoliths (Pakkasmaa & Sarvala, 1995). Length-specific growth rates were derived from the von Bertalanffy growth curves and converted to weight-specific rates using biomass-lengthregressions, and finally these were combined to average size distributions at each sampling locality to yield daily and annual production rates and production to biomass ratios.

Growth rates derived from the length frequency analyses and from the counting of daily otolith increments gave reasonably consistent results for *Limnothrissa* off Bujumbura at the length of about 60 mm. However, extrapolation of the von Bertalanffy growth curve from LEA to fish shorter than 50 mm obviously predicted too high lengths, and, consequently, biased growth rates. For small fish, the otolith-derived growth pattern seemed realistic, predicting zero length for a fish of zero age. The same problem applied to all species, the LFA growth curves always showing large y-intercepts. However, our production to biomass ratios were not much affected by this bias, because most of the fish in the catch were above 50 mm in length. Off Mpulungu, where very small clupeid fish were caught with the beach seines, the LEA growth estimates for the small size groups were also somewhat less biased. The mass-length regressions of all three species had exponents exceeding 3.0 (Aro & Mannini, 1995).

In fish populations exhibiting exponential biomass growth, the instantaneous mortality rate equals P/B ratio (Allen, 1971); indeed, the mortality coefficients calculated from the LFA analysis were close to, although usually slightly higher than the annual P/B rates obtained from the size distributions. The whole lake averages for the latter P/B ratios were 4.5, 2.7 and 1.6 a^{-1} for *Stolothrissa, Limnothrissa* and *Lates,* respectively.

For fish biomass we used literature data, because results from the LTR hydroacoustic cruises were not yet available or came at very recent stage. Biomass estimates obtained from FAO hydroacoustic surveys in 1973-1976 (Chapman et al., 1978; Coulter, 1991) varied from 211 to 1237 kg ha^{-1}; the largest value is unrealistically high. Roest (1977), using catch samples and acoustic estimates in Burundi waters, ended up at an estimate of 160 kg ha^{-1} (1.6 gC m^{-2}) for *Stolothrissa.* We assumed that this value was representative for clupeids in the whole Lake Tanganyika.

In the catch, clupeids accounted for about 65 % and the *Lates* species for some 30 % of total (Hanek, 1994). Assuming that similar proportions also pertained to the biomass, and using the derived P/B ratios, the production of the planktivorous pelagic fish (*Stolothrissa* and *Limnothrissa*) was 5.8 gC m^{-2} a^{-1} and that of the predatory *Lates* species 1.4 gC m^{-2} a^{-1}.

Our fish production estimates can be compared to the realized catch. According to the most recent and probably the most accurate statistics produced during the LTR project (Hanek, 1994; Coenen, 1995), the total catch was 167000 metric tones (or 51 kg ha^{-1}) in 1992. In Burundi waters the catch amounted to 94.5 kg ha^{-1} yr^{-1}, in Zambia to 69, in Tanzania to 60 and in Zaire to 34 kg ha^{-1} yr^{-1} (Hanek, 1994). Even in the most heavily fished Burundi waters the realized catch was only about 16 % of the estimated planktivorous fish production. however, the fish production estimates are too uncertain to allow any further conclusions.

4.7 Lake-wide fish stock assessment

Stock assessment was performed through hydroacoustic recordings of fish abundance combined with experimental trawl samples during the research cruises, and the results of three surveys (1995, 1997, 1998) became available only recently (Szczucka 1998). Total biomass for the lake were according to these surveys 91 193, 175 681 and 304 463 tones, respectively. The lowest estimate may be biased because of the insufficient number of samples, but, given the high variation and variances between the estimates, the recent estimates were of the range of the biomass estimations (0.4 through 2.8 mill. tn) made in the seventies. Szczucka (1998) has pointed out the enormous temporal and spatial variations in the fish abundance distributions, which makes the lake-level summarising most difficult.

Total fish production in Tanganyika was obtained using the calculated production to biomass ratios and estimates of fish biomass. Collection of fish catch statistics was done in collaboration with the local fisheries administration of each country (Coenen, 1995).

4.8 Trophic structure and carbon flows in the food web

Our results enabled a reassessment of the trophic structure of Lake Tanganyika (Table 1). The biomass estimate for phytoplankton was obtained from the average chlorophyll (0-40 m depth) by assuming a carbon:chlorophyll ratio of 35 (Sarvala et al. 1982). For bacterioplankton, we did not derive any lake-wide estimates of biomass or production, but experiments on two cruises consistently suggested that bacterioplankton production was about 20 % of phytoplankton production. Trophic level biomass declined steadily from the phytoplankton primary producers through invertebrate consumers to planktivorous fish and piscivorous fish. The medusae seem to be an important component of the system, although their trophic role remains enigmatic so far. The production figures indicated fairly low carbon transfer efficiencies between trophic groupings (Table I), especially from phytoplankton to herbivorous copepods. On the other hand, the carbon transfer efficiency from herbivorous copepod to fish production was high (25 %), which was probably at least partly caused by uncertainties in the fish biomass estimate, but partly may reflect the important role of shrimps (not included in the zooplankton production estimates) as fish food; the food of the shrimps themselves is as yet unknown. Production of piscivorous fish was likewise high *(25* **%)** compared to the production of prey fish; if this were true, the whole planktivore production would be consumed by the piscivores, leaving nothing for the pelagic fishery. The total fisheries yield in Lake Tanganyika was in early 1990s only about 0.08 % of pelagic primary production, i.e., within the range of typical values in lakes.

5. DISCUSSION

5.1 Hydrodynamics and limnology

Hydrodynamic modelling and intensive field measurements indicate that wind driven forces initiate and maintain the upwelling events on Lake Tanganyika, but not only in the southern end as shown classically but secondary along the eastern and western coast. Internal periodic wave motions as well as the amplitude of vertical mixing were recorded.

In Lake Tanganyika, the temporally and regionally variable nutrient inputs from the huge hypolimnetic store, through long-range transport via atmosphere, and from the land runoff are not only crucial to the absolute levels of production, but, by modulating the role of the microbial loop, they may also affect the efficiency of carbon transfer through the system.

The major hydrodynamic events that affect the primary productivity are in the first place the wind patterns, and then the relation of mixing layer to the productive layer as well as transport of the nutrients to the euphotic zone through turbulence, mixing and upwelling. These mechanisms are, however, very complex. Although deep mixing in principle might enhance productivity by increasing nutrient input from the hypolimnion, it simultaneously decreases primary production because light becomes limiting for phytoplankton cells forced to stay below the photic layer for most of the time. The low production levels off Mpulungu indicated by the direct *in situ* primary production measurements and the zooplankton data by LTR suggest that the negative effects of deep mixing may be dominant in southern Tanganyika. Also the horizontal currents and nutrient/ energy transport may induce the production in the three main basins, which may be locally influenced by the river inputs. The role of global climatic changes in adjusting the regional and local wind regimes has been shown, and the links of the wind and hydrophysical events with the biological production was evidenced.

5.2 <u>Sources of organic matter: primary production and DOC</u>

Our primary production estimates are based on the largest data base so far available from Tanganyika, including satisfactory seasonal coverage at three stations plus three lake-wide surveys. Further support to our results is given by the fact that the completely independent *in situ* and simulated *in situ* estimates were very similar. Moreover, variability of the *in situ* measurements was only moderate. Our calculations also took partly into account the surface inhibition caused by excessive UV radiation and possible differences in the DIC determinations. The primary production estimates of Hecky & Fee (1981) were lower than now and based on a shallower water column and included only the particulate production, while our results comprised both particulate and dissolved production.

Our results for the concentration of DOC were within the ranges given for Tanganyika by Hecky (1991) and Degens et al. (1971). Our new measurements thus confirmed the relatively low DOC levels in the surface waters of Tanganyika. Considering the general water quality in the lake, such DOC levels sound realistic, and do not suggest a major role for DOM in the planktonic food web.

5.3 Zooplankton biomass and production

The present estimates for zooplankton biomass and production (Kurki et al. 1998a, Sarvala et al. 1998) were only half of those earlier given for Lake Tanganyika by Burgis (1984) but very similar to those reported from Lake Malawi (Irvine & Waya, 1998). Our recent biomass calculations (Sarvala et al, 1998) were based on own carbon determinations, and are most accurate measures available for Lake Tanganyika. Production was calculated by developmental stage using literature-derived but locally checked development times. The resulting P/B ratios (24-26 a^{-1}) in Sarvala et al. (1998) did not differ much from those obtained for copepods in Malawi by Irvine & Waya (1998) (31 a^{-1}), or from those used by Burgis (1984) and Kurki et al. (1998a: 23-29 a^{-1}).

The present abundance data had a good temporal coverage with short-interval samples of crustacean zooplankton for two successive years, but regional coverage was insufficient with only three sampling areas. Abundance estimates from the weekly sampling suffer from at least two sources of bias. First, as shown by Vuorinen et al., (1998), some of the crustaceans were found below the routine 0-100 m net hauls in the morning when these samples were taken. Second, considerable numbers of cyclopoid nauplii and small copepodids could escape through the 100-µm mesh of the vertical hauls. These biases could be largely circumvented in the production calculations by utilizing data from the vertical migration study, which used tube sampler and a 50-µm mesh net and in which sampling was extended as deep as copepods were found.

5.4 Fish production and yield

The average production-to-biomass ratios of fish derived from our length-frequency analyses were roughly similar to the annual values calculated by Coulter (1981) for *Stolothrissa* (3.9 from the graphical Allen curve method, and 3.7 from mortality rate, assuming von Bertalanffy type growth). Growth and mortality estimations using LFA were in good correspondence with earlier analyses and were partially supported by otolith readings (Pakkasmaa & Sarvala, 1995).

The biomass estimates were the weakest point in our earlier fish data. The LTR hydroacoustic data became available very recently (Sczcucka 1998), and these results like all earlier estimates show wide variation, both spatially and temporally. Coulter (1977) estimated the virgin pelagic ichthyomass in the north end of Tanganyika at 104000-147000 tonnes (32-45 kg ha), which is only one fourth of the value (160 kg ha^{-1}) adopted here. Fish biomass values calculated with the ECOPATH model from a trophic analysis of the pelagic system in the Burundi sector (Moreau et al., 1993) were 63-181 kg/ha for the planktivorous fish and 37-102 kg/ha for the piscivorous fish in the early 1980s and the mid-1970s, respectively. Converted to carbon units, the corresponding production estimates were 3.2-7.9 and

0.3-0.7 gC m^{-2} a^{-1}. Our estimates remained within these ranges. In Lake Malawi, based on 11 full-lake acoustic surveys (Menz et al., 1995), the average pelagic fish biomass was 70 kg ha^{-1}, suggesting that the value adopted here for Tanganyika may be overestimate.

The total fish catches from Lake Tanganyika show an increasing trend. Coulter (1977) reported an annual fish yield of 73000 tones in the late 1960s, Roest (1992) estimated 85000 tones for 1987, and the LTR statistics suggest 167000 tones for the year 1992 (Hanek, 1994). It is admittedly difficult to obtain reliable catch statistics from a large lake like Tanganyika, where artisanal fisheries take the majority of the catch. However, the present estimates are based on the most comprehensive work so far, and should be the most reliable. Although the present catch figures are the highest so far reported from Lake Tanganyika, they still remain clearly lower than the potential yield levels of 380000-460000 tones (116-140 kg ha^{-1}) per year postulated in previous papers (e.g. Coulter, 1977). However, the final potential yield estimate of Coulter (1977), 100 kg ha^{-1} yr^{-1}, is close to the present realized yield in Burundi, where the fishing pressure is highest. There the catches per unit area have in fact decreased since 1967-1971 (Coulter, 1977, Coenen et al. 1998), suggesting that the sustainable catch levels are lower than previously thought. This is also supported by calculations based on the observed zooplankton production, which is lower than previous estimates. Because the primary production in Tanganyika is mainly dependent on internal nutrient cycling and mixing regimes, productivity in the large central open area may be lower than along the coasts (Ostrovsky et al., 1996).

5.5 Carbon flows and the trophic structure

A new view of the trophic structure of Lake Tanganyika is emerging from our data. Our phytoplankton production and carbon biomass figures are higher than the earlier estimates. Even higher phytoplankton carbon value would have resulted from the observed threefold higher carbon:chlorophyll ratio off Kigoma in December 1994 (Sarvala & Salonen, 1995). In contrast, our new zooplankton data indicate lower biomass and production than previously estimated. Earlier analyses by Burgis (1984) and Hecky (1984, 1991) indicated high ecological efficiencies in the pelagic ecosystem of Tanganyika. Likewise, for the 1970s, the ECOPATH analysis of the pelagic system in the Burundese waters (Moreau et al., 1993) suggested very high transfer efficiencies from phytoplankton to zooplankton (25 %), to planktivorous fish (2.4 %) and to fish yield (0.36 %). For the 1980s, the calculated efficiencies were clearly lower (13, 1.1 and 0.2 %, respectively), but still higher than our results, especially for the herbivorous zooplankton and fish yield. Thus, contrary to these earlier claims, our data shows that, compared to lakes in general (e.g. Pauly & Christensen, 1995), the trophic efficiency between zooplankton and phytoplankton or between fish and phytoplankton in Lake Tanganyika is low (the reverse were given by Burgis 1984, Hecky et al 1981, respectively). Likewise, the fish yield seems to be relatively low in comparison with the primary production, quite as in other large lakes (Oglesby, 1977; Morgan et al., 1980). According to our estimates, also the fish production in Lake Tanganyika relative to primary production falls within the normal range reported from other lakes; but here one must remember the uncertainty of the fish biomass values. The suggested role of bacterioplankton compares well with literature values (Cole et al., 1988; White et al., 1991).

High dependence of primary production on nutrient regeneration, as in Lake Tanganyika (Hecky, 1991), implicitly suggests low efficiency of carbon transfer through the food web, because nutrients are mainly regenerated by the microzooplankton, which have high respiration rates. Our tentative figures suggested relatively high carbon transfer efficiency from crustacean zooplankton to planktivorous fish. In Tanganyika, the apparently high efficiency at this step might arise because part of the fish production is based on deep-water shrimps which were not quantitatively caught with the present sampling scheme, and could thus not be included in the production calculations. The extremely simple food web structure in the open waters of Tanganyika might also enhance fish production: the food chain leading to planktivorous fish production is short. The fishery itself has simplified the food web by decimating the piscivorous fish stocks at an early stage of the commercial fishery (Coulter, 1970).

We thus conclude that the trophic efficiencies in the pelagic food web of Lake Tanganyika are not unusually high. The crustacean zooplankton production is small, but the recorded fish yields quite normal relative to the measured primary production of pelagic phytoplankton. Thus the flourishing fisheries in Lake Tanganyika are not so much based on any exceptional productivity of the system, but on the fact that most of the pelagic production is canalized into a few fish species that have short life cycles and rapid reproduction, and that are easy to catch and thus suitable targets for an economic fishery.

6. IMPLICATIONS FOR FISHERIES MANAGEMENT

The three years intensive SSP-sampling scheme on permanent stations, automatic hydrodynamic and meteorological measurements, and finally the multi-purpose lake-wide cruises all have been unique in terms of their areal and temporal coverage, research methodology and usage of modern deep-water device in Lake Tanganyika. The extensive study effort has been better managed than ever before on any other African Great Lake. As the outcome, the primary objectives of such research have been fully achieved, i.e. understanding the structure and function of the pelagic food webs became clear and the basis of pelagic fish production also has been evidenced. The major components of lake hydrodynamics and biological trophic structure were assessed and the whole picture of fishery resource distribution and vulnerability to fishing operations has become clearer. The practical implications of research outcomes on local level management is still due to practical testing and development of the coming monitoring programme.

Based on the present information, one can build forecasting models which predict the future changes of **fish stocks and fish production**:

Short-term:

(1) Studying the major weather and wind patterns, relationships between the mixing and productive layers of water masses, as well as the levels of primary nutrients, we can estimate the potential for primary production and thus the basis of secondary production (Huttula, 1998, Sarvala et al. 1998).

(2) Based on the relationships between zooplankton abundance/ production and the fish production (preliminary data so far), we can make calculations of the future fish production in the pelagic zone (Sarvala et al. 1998).

(3) By following the catch trends and the CPUE evolution, and combined with basic fish biology data, we can detect the inter-annual and regional trends in the stock sizes and fish populations (Coenen et al., 1998, Szczucka 1998, Mannini 1998). Based on most recent results, Mannini (1998) concludes the following main implications to Management of Lake Tanganyika pelagic fisheries:

- The simple pelagic fish community is dominated by two species, S. *tanganicae* and *L. stappersii;*
- All three species, including *L. miodon,* are unevenly distributed and their areal occurrences can differ dramatically, partly regulated by their food resources; This means the abundance of pelagic shrimps correlate with *L. stappersii,* on the one hand. and that of copepods with S. tanganicae, on the other;
- Nursery grounds of *L. miodon* exist more close to the shore than those of S. *tanganicae,* making the first species vulnerable to non-selective beach seining at its young stages;
- The lake-wide distribution of pelagic fish community justify to reduce the fishing effort at the northern end of the lake, and to stop or re-distribute the industrial fishing growth in the south of the lake.

4. By assessing the key indicators of fishermen behaviour, house-hold economy, and money flows (prices, markets, costs) amongst the fishermen groups, we can estimate current states and future trends of the fishing sector

(Reynolds 1998).

Long-term: Using the links between global and regional climate, lake hydrodynamics and limnology and fish biology, we are able to make predictions of 1-2 years ahead (Plisnier 1997).

To achieve all this information, the Lake Tanganyika Monitoring Programme requires regular observations both on meteorological, hydrophysical and limnological events and fish biology and fishery.

The ecosystem analysis, though underlined in this summary, should not remain as the only approach in **designing the managerial measures** in Lake Tanganyika but is meant to be complementary to other means that are more related to the fishery itself The hydrodynamics and biology of the pelagic zone of the lake was known to be most dynamic and heterogeneous in its nature, which view was merely supported in the new results. Thus the ecosystem-based (bottomup) and biologically oriented strategy in fisheries management in this lake is less appropriate. Mahon (1997) also points out that using the today's fisheries science and comprehensive stock assessment studies as key tool for fisheries management in developed countries has lead to stock assessment driven managerial efforts also in the developing countries although the personnel and research capacities are often inadequate for this. Johannes (1998) gives examples from tropical near-shore finfisheries where one can apply the 'data-less' or 'data-poor' measures though still successfully in managing the small-scale fisheries, e.g. in establishing protected areas, introducing closed seasons or restricting the gear types or mesh sizes. The highly variable pelagic stocks cause extra problems for the monitoring and management by adding process uncertainty that is driven from stochasticity in the population dynamics such as the variability in recruitment (Caddy & Mahon, 1995). The recently completed analysis on biology of the three major species, *L. miodon,* S. *tanganyicae,* and *L. stappersii* by Mannini (1998), combined with the regional assessments of pelagic stocks of these species (Szczucka 1998) form now a strong basis for establishing the future managerial strategies for the lake. The hydroacoustic surveys also indicated a remarkable variations in the mean densities obtained and very large variances between the assessments.

Therefore the future monitoring and management strategy must link understanding of the processes of physical, chemical and biological limnology with population biology, species' interactions in the fish community and the influence of human actions (i.e. environmental disturbance, fishing) (see, Craig 1998). This requires harmonised catch-monitoring (CPUE) and follow up of the socio-economic indicators of the fishery too leading into holistic management strategy where ecological, socioeconomic and economic sustainability all are considered (Charles, 1994, documents LTR/98/4 and LTR 98/5). The current scientific study gives outlines for the monitoring by showing the key factors that indicate environmental disturbances, climatic/hydrodynamic fluctuations, and productivity of biological food webs. It is important that the collection of such information is implemented regularly and in the harmonised way, in close collaboration between environmental and fishery authorities, who share the responsibility of natural resource management in large. The effective use of information and two-way information flow within the managerial bodies has to be strengthened.

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SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

REGIONAL FRAMEWORK PLANNING FOR LAKE TANGANYIKA FISHERIES MANAGEMENT

A. INTRODUCTION

A.1 Lake Tanganyika Fisheries Overview

1. Fishing in Lake Tanganyika has intensified considerably over the course of the 20th century in association with the dramatic expansion of human population and settlements around the lake and the introduction of various technological innovations, such as pressure lamps for night-fishing, synthetic netting material, and motorised craft. Modem harvest operations primarily exploit six endemic non-cichlid pelagic species. These include the two schooling clupeid ‘sardines’ (known variously as ‘ndagala’ (Burundi and DRC), ‘dagaa’ (Tanzania), or ‘kapenta’ (Zambia) along different sections of shoreline), *Limnothrissa miodon* and *Stolothrissa tanganicae,* together with their major predators, all centropomids of the genus *Lates* -- viz: *L. stappersii, L. angustifrons, L. mariae,* and *L. microlepis.* Of the *Lates* species, the latter three are incidental to the catch: the lake’s commercial fishery is essentially based on the two clupeids (ca. *65%* by weight) and *L. stappersii* (ca. 30% by weight). Annual harvest levels in recent years have been estimated to vary in the range of 175,000 - 200,000 t -- volumes that translate into annual earnings on the order of tens of millions of US dollars.

2. The lake’s present-day fisheries are conventionally classified according to gear kit into three types:
‘traditional’ (mostly gillnets, scoop nets, gillnets, handlines worked from planked canoes operated by one or two crew), ‘artisanal’ (mostly lift nets worked from catamaran (doubled up planked canoes) operated by a 4 to *5* person teams and, in the case of Zambia, also heavily comprised of night beach seine units (‘kapenta seines’) operated inshore by larger crews working in conjunction with net- laying and light-attraction boats); and ‘industrial’ (steel hulled purse seiners with auxiliary craft and crews of 20 to 40 persons).

3. LTR survey-based estimates report some 45,000 fishers as currently active on the lake, operating from a total of 786 landing sites. Such figures immediately direct attention to the important socioeconomic role played by the fisheries. The tens of thousands of boat and equipment owners/operators and crew active in the harvest sector represent a first tier of fisheries employment and income generation. Secondary fisheries-generated employment has also to be taken into account. Local processors

and traders, long-distant transporters and marketeers, and various others who provide services and support at landing sites and throughout the distribution chains are reckoned to number in the hundreds of thousands. And if the individuals tied to the families and households of all of these operators and service providers are considered as well, it can quite plausibly be estimated that some one million people living around Lake Tanganyika -- one-tenth of the estimated population of the entire lake basin -- are directly dependent on the fisheries for their livelihoods.

A.2 Project Objectives

4. LTR basically aims to facilitate a regional Lake Tanganyika fisheries management framework that is grounded in the best available scientific evidence. Under the project workplan, core activities of LTR's ecosystem research approach were organised under the scientific sampling programme (SSP), which started in July 1993 (immediately upon completion of the project's preparatory phase) and ran through July 1996[1]. The six major components of the SSP include hydrodynamics, limnology, fish and zooplankton biology, remote sensing, fish genetics, and fisheries statistics. The project's research vessel, *Tanganyika Explorer,* was used extensively as a platform for the conduct of complementary hydroacoustic studies (to develop biomass estimates) and sampling surveys related to various other SSP components (Hanek 1994; Hanek and Craig 1996). Some aspects of the SSP have been carried out in collaboration with the Lake Tanganyika Biodiversity Project (LTBP).

5. Special attention to socio-economic concerns in recent phases of project work, particularly with respect to the lakewide survey of fishing communities (map, Fig. 1) in 1997, has encouraged LTR's management thinking to develop also along more consultative fashion, by beginning to involve local resource users in problem evaluation and review of options for future actions.

6. Key management issues to be addressed were identified through reference to previous assessments of the fishery situation in Lake Tanganyika and the East African Great Lakes Region in general (e.g., Gréboval 1990, 1992; Hanek 1994; Hanek and Everett 1995; Cacaud 1996; Maembe 1996), and with close regard to management principles highlighted in the recently published FAO *Code of Conduct for Responsible Fisheries* (FAO 1995).

B. CODE OF CONDUCT FOR RESPONSIBLE FISHERIES (CCRF)

7. The Code was unanimously adopted by the FAO Conference in October 1995 (FAO 1995). It traces back to earlier international fisheries conferences (Nineteenth Session of the Committee on Fisheries (COFI) in 1991 and the International Conference on

[1]Some aspects of SSP work extended into 1998. The series of lakewide hydroacoustic and pelagic trawling surveys was interrupted in April 1996 due to a breakdown in the hydroacoustic equipment. Delays continued owing to a combination of technical problems, unavailability of scientific staff, and civil unrest within the region. Survey work was resumed in late 1997 and was completed in early 1998.

Responsible Fishing (Cancun, Mexico) in 1992) at which it was recognised that exploitation and development trends within world fisheries over recent decades either are approaching or have already overrun the limits of what can be sustained by the constituent resource bases. CCRF’s aim is to foster a fundamental reorientation of priorities, such that all aspects of world fisheries can conducted with due regard for conservation and environmental concerns, and fully take into account the various biological, technological, economic, social, and commercial factors that underlie fishing and fisheries activities. The twelve articles of the *Code,* listed under Outline 1 below, were formulated under FAO co-ordination as a model framework through which such reorientation can be effected.

Outline 1. Articles of the *Code of Conduct for Responsible Fisheries*

Article 1	Nature and scope of the Code	**Article 7**	Fisheries management
Article 2	Objectives of the Code	**Article 8**	Fishing operations
Article 3	Relationship with international instruments	**Article 9**	Aquaculture development
Article 4	Implementation, monitoring and updating	**Article 10**	Integration of fisheries into coastal area management
Article 5	Special requirements for developing countries	**Article 11**	Post-harvest practices and trade
Article 6	General principles	**Article 12**	Fisheries research

8. As noted in Article 1, the CCRF is voluntary in nature and global in its reach and content.

> [It] is directed toward members and non-members of FAO, fishing entities, subregional, regional and global organisations, whether governmental or non-governmental, and all persons concerned with the conservation of fishery resources and management and development of fisheries, such as fishers, those engaged in processing and marketing of fish and fishery products and other users of the aquatic environment in relation to fisheries [*ibid:1*]

9. An overall context is set by Article 6 of the *Code,* its General Principles, the key points of which are paraphrased in Outline 2.

Outline 2. Synopsis of 'General Principles,' *Code of Conduct* Article 6 [2]

1) *Use of living aquatic resources carries with it the obligation to do so in a responsible manner, ensuring their effective conservation and management.*
2) *Management should promote maintenance of quality, diversity, and availability of resources in sufficient quantities for present and future generations, mindful of requirements for food security, poverty alleviation, and sustainable development.*
3) *States should adhere to management measures to ensure a balance between fishing effort and sustainable utilisation of the resource base, guard against over-harvesting, over-capitalisation, and excess fishing capacity, and seek to rehabilitate resource populations as and when appropriate.*
4) *Conservation and management decisions should be formulated according to the best available scientific evidence and taking into account traditional resource and habitat knowledge, environmental and social factors. Priority should be given to research and data collection for improvement of the scientific and technical fisheries and ecosystem knowledge base.*
5) *Precautionary approaches should be applied to conserve aquatic ecosystems and resources based on the best available scientific evidence. Absence of adequate scientific information should not be an excuse for postponing conservation measures.*
6) *Conservation of biodiversity and population structures should be promoted through the use of selective and environmentally-safe fishing gear and practices. States and users should minimise wastage of target and non-target species as much as possible.*
7) *Harvesting and post-harvest treatment of fishery products should aim at maintaining their nutritional value, quality, and safety, and to reduce waste and negative environmental impacts*
8) *Critical fisheries habitats (wetlands, reefs, lagoons, nursery and spawning areas) should be protected and rehabilitated as and where necessary, with particular effort made to protect them from destruction, degradation, pollution and other human impacts that threaten the health and viability of fishery resources.*
9) *States should ensure that fisheries and resource conservation interests are taken into account in multiple use management, planning, and development of coastal zones.*
10) *Within their respective competencies and in accordance with international law, and within the framework of regional fisheries conservation and management organisations or arrangements, States should ensure compliance with and enforcement of conservation and management measures and establish appropriate mechanisms for monitoring and control of fishing vessels.*
11) *States should ensure that vessels authorised to fly their flags adhere to the proper application of this Code, respect conservation and management measures taken in accordance with international law and adopted at national, regional, or global levels, and fulfill obligations concerning fisheries data collection and provision.*
12) *States should cooperate through fisheries management organisations or other suitable arrangements to promote responsible fishing and ensure effective conservation and protection of living aquatic resources throughout their range of distribution, recognising the need for compatible measures in areas within and beyond national jurisdiction.*
13) *States should facilitate consultation and effective participation of industry, fish workers, environmental, and other interested organisations in decision making with respect to laws and policies on fisheries management, development, and international lending and aid.*
14) *International trade in fishery products should be in accordance with World Trade Organisation standards and relevant international agreements, and polices, programmes and policies should not result in obstacles to this trade, environmental degradation, or negative social, including nutritional impacts.*
1S) *States should seek to prevent fisheries disputes and, when they arise, seek to ensure their settlement in a timely, peaceful, and cooperative manner.*
16) *States should promote awareness of responsible fisheries amongst fishers and fish farmers through education and training.*
17) *States should ensure that fishing facilities, equipment, and activities allow for safe, healthy, and fair working and living conditions in accordance with standards adopted by international organisations*
18) *As artisanal and small-scale fisheries make important contributions to employment, income, and food security, States should appropriately protect the rights of workers in subsistence, small-scale, and artisanal fisheries to a secure and just livelihood, along with preferential access to traditional fishing grounds and resources lying within waters under their national jurisdiction.*
19) *States should consider aquaculture as a means to promote diversification of income and diet, and in doing so ensure that resources are used responsibly and that adverse environment and local community impacts are minimised.*

[2] A partial and unofficial synopsis only. Refer to the full *Code* (FAO 1995) for verification.

B.l Management Process Components

10. Figure 2 depicts an idealised representation of how the components of the responsible fisheries management approach are integrated into an overall process. The important point to note is that the process is designed to function in a self-reinforcing, self-renewing fashion, with its various biological and socio-economic reference points and decision-making, consultation, review, and reporting transactions constantly working in tandem to generate and regenerate desired outcomes -- i.e., the '...continued productivity of the resources and accomplishment of other fisheries objectives.'

B.2 Engaging the Process: Management Measures and Approaches[3]

11. The management process is initialised through deliberations on fisheries policy and objectives within the context of existing biological and socio-economic circumstances, including the potentialities they offer and the constraints they impose. A programme of actions to secure the identified objectives has then to be planned and implemented.

12. As observed in the 'Fisheries Management' module of the *FAO Technical Guidelines for Responsible Fisheries* (FAO 1997), these transactions must be based on the fundamental recognition that fishing mortality will have to be regulated in some fashion or other. There are a variety of options to regulate fishing, but since management inevitably involves fisherfolk and other interest groups, there are critical issues of equity and accommodation of user interests that always must be considered as well. 'Options to regulate fishing,' 'limiting access,' and 'management in partnership' serve as three key reference themes in terms of which the responsible fisheries process may be engaged.

B.3 Options to Regulate Fishing

13. Fishing regulation options include: a) technical measures for the restriction of gear and operating areas and times; and b) input and output controls.

Technical measures to regulate fishing

14. ***Gear restriction*** modalities noted in the *Guidelines* include those pertaining to: a) type of gear (e.g. gillnet); b) gear characteristics (e.g. net mesh size); and c) operation of gear (e.g. 'active' gillnetting).

15. ***Area and time restrictions*** define open and closed 'windows' for the application of fishing effort, as for example with 'no fishing zones' in known breeding and nursery grounds during particular months, or with aquatic reserves for the conservation of critical habitat and biomass. Whilst it is theoretically possible to use seasonal and spatial restrictions 'to regulate total fishing mortality on a resource' (FAO 1997: 47), their implementation may be extremely problematic. To be effective,

[3]Discussion in this section is largely extracted from Reynolds and Hanek (1997).

they must not only be established with reference to appropriate biological considerations, and with due concern for effort concentration or transfer effects (too much effort during ‘open window’ conditions or excessive effort displacement to other areas); they must also be accepted and respected by user groups.

Input (effort) and output (catch) controls to regulate fishing

16. **Input control** can be used to regulate fishing mortality through the imposition of limits on fishing capacity and effort. Typical mechanisms include licensing ceilings, individual effort quotas on fishing units, and the use of technical specifications to limit the harvesting power of vessels and/or their gear kits.

17. **Output control** is a commonly encountered management measure that theoretically ‘allows estimation and implementation of the optimal catch to be taken from a stock by a given harvesting strategy’ (FAO 1997: 50). It typically entails ‘...setting a total allowable catch (TAC) which is then sub-divided into individual quotas by fishing nation (in the case of international fisheries), fleet, fishing company, or fishermen (e.g. in the case of individual quotas)’ *(ibid).*

B.4 Limiting Access

18. As remarked in the *Technical Guidelines,* use right regimes in free-range resource exploitation systems such as fisheries can broadly be divided into open access and limited access systems. Open access is basically a ‘free-for-all’ or ‘first come, first served’ condition which, if left totally unregulated. ‘will invariably lead to over-exploited resources and declining returns for all participants’ (FAO 1997: 52). Even in situations where controls on exploitation levels are put in place, such as TACs or seasonal closures, ‘...open access systems are characterized by a race to fish in which all participants strive to catch as much of the resource ... as they can, before their competitors do so’ *(ibid).*

19. It is generally recognised that, for a fishery to be sustained, the ‘free-for-all’ situation must give way to one of access limitation in some form. In most instances where fisheries resources fall within national jurisdictions, this involves the granting of conditional use rights by the State or its management authority such that the State, whilst retaining ownership of the resources, allows their exploitation by designated communities, user groups, firms, or individuals.

B.5 Management in partnership

20. Co-management, or what the *Technical Guidelines* refer to as ‘management in partnership,’ is a central tenet of responsible fisheries. Fisheries typically involve a complex of interests which share differing or even contradictory aims. Responsible management endeavours to accommodate such interests and recognises that ‘...the efficiency and implementability of the management measures are often highly dependent on the support gained from the interested parties’ (FAO 1997:55). The *Guidelines* go on to note that:

> Management in partnership encompasses the various arrangements which formally recognize the sharing of fisheries management responsibility and accountability between a fisheries management authority and institutions either public, such as local level government, or private, such as a group of interested parties. Hence, ... [it] is likely to ... [have] a decentralized and unstandardized nature. It often reflects a concern for efficiency or equity at the State or management level, coupled with proven capacity for self-governance, self-regulation and active participation at the level of the interested parties concerned *[ibid].*

21. Depending on circumstances, co-management arrangements may feature higher or lower degrees of intervention and support by the State -- higher where local-level commitment and capabilities are weak, lower where they are strong.

C. INDICATORS FOR MANAGEMENT PLANNING: LTR INVESTIGATIONS, 1992-98

22. The assessment of management requirements and prospects for Lake Tanganyika fisheries is based on the ‘readings’ or indicators provided by the major SSP investigations and other surveys carried out to date. These include catch and effort statistic studies, work on production dynamics and biomass estimation, investigation of pelagic fish distribution and ecology, studies of institutional and legal issues, and SEC survey work.

C.1 CPUE Study

23. The LTR study of catch and effort statistics for different areas and gear assembled by Coenen *et al.* (1998) mostly draws on data collected over the three year period (7/93 -6/96) covered by the project’s Scientific Sampling Programme (SSP). Principal findings may be summarised as follows.

a) **Concentration** of fishing pressure per unit of fishing area is most pronounced in the northern and southern extremities of the lake, owing to high densities of lift net units around Uvira (north) and of combined industrial and traditional units around Mpulungu (south).

b) **Overfishing** of *L. stappersii* is clearly apparent from the CPUE analyses of the Mpulungubased industrial fishery. This trend should be understood in association with the effects of the kapenta seine fishery on *L. miodon* stocks. Indications point to the need selectively to reduce fishing pressure in the southernmost waters of the lake.

c) **CPUE provides an inconclusive measure of fish abundance** for Lake Tanganyika because of the characteristics of the pelagic stocks in question, the method of fishing, and the way CPUE indices are calculated.

d) **Environmental factors heavily condition production processes**, although the exact scope and underlying mechanisms of these influences have yet to be determined.

It seems likely in any event that they have contributed to recent declines in annual harvest levels.

e) **Collaborative lakewide monitoring** through a long-term programme is obviously fundamental to the management process. It would provide feedback on the effectiveness of new measures that the lacustrine states might introduce as part of a regionally co-ordinated effort to govern fisheries activities, as well as indications on how such measures might be adjusted or augmented.

C.2 Production Dynamics and Biomass Estimation

24. SSP studies of the complex physical, chemical, and biological mechanisms that drive production processes in Lake Tanganyika have generated a rich array of findings (Lindqvist *et at.,* in prep.). Whilst these are important in their own right, either as corroborations of or possible corrections to elements of earlier work, the broader significance of the SSP studies for management planning purposes is that they demonstrate the feasibility of constructing models which can be used to forecast changes affecting fish stocks and fish production in the lake.

a) **Estimates for potential primary production** and thus the basis for secondary production can be developed through study of major weather and wind patterns, relationships between water mass layers, and levels of primary nutrients.

b) **Calculation of future fish production in the pelagic zone** is possible through monitoring of relationships between zooplankton abundance/production and fish production.

c) **Annual regional and areal trends in stock sizes and fish populations** can be tracked through catch and CPUE monitoring, combined with analysis of fish biology data.

d) **Collaborative lakewide monitoring**, conducted through a long-term programme (as already recommended in connection to the CPUE findings above), is again indicated as a necessary measure in support of the management process. For predictive modelling purposes, such a programme would need to provide for regular observations of meteorological, hydrophysical. and limnological events as well as collection of basic data on fish biology.

C.3 Distribution and Ecology of Pelagic Fish

25. The LTR technical work on pelagic fish and shrimp distribution and species relationships within Lake Tanganyika (Mannini 1998) is based on data gathered through lakewide pelagic trawl surveys conducted as part of the SSP, and draws also on findings from previous work using commercial fishery-

dependent information (Coenen *et al.* 1998; Mannini *et at.* 1996). Results, subject to further confirmation once acoustical analyses are completed (Szczucka, in prep.), are evaluated in terms of their implications for management of the three most important commercial species -- the clupeids *Stolothrissa tanganicae* and *Limnothrissa miodon,* and the centropomid *Lates stappersii.*

a) **Environmental factors and pelagic stock dynamics.** Stocks of short-lived, high turnover species like *S. tanganicae,* with shallow population structures (one or two major cohorts), are inherently subject to dramatic negative effects induced both by environmental and fishery exploitation pressures. Also, effects of the latter may seriously compound those of the former. For example, if climatic factors cause a decline in recruitment and thus a decline in catchable stock, and if fishing effort remains constant, then recruitment overfishing occurs.

b) **High risk nature of *S. tanganicae* fishery**. Although S *tanganicae* display the highest productivity (production/biomass ratio) of the three major commercial species, and theoretically can sustain an annual catch higher than its standing stock biomass, its fishery is inherently risky. Not only is the stock liable to wide environment-induced fluctuation, but its occurrence within local fishing grounds can be very sporadic, owing in part to the patchy distribution of copepod plankton, a primary food item.

c) **Signals of possible local overexploitation of *S. tanganicae* stock** are noted for the northern end of the lake, in the form of high juvenile content and smaller mean length in catches as compared with those further south. The sustainable yield level for S. *tanganicae* may have been reached on both west and east coasts north of Karonda, making any moves towards further fishery development inadvisable. The situation for the rest of the lake seems more secure.

d) **Adverse impacts of beach seining on *L. miodon* and other stocks.** Whilst there are no indications of overexploitation pressures on late young and adult fish, it is clear that the highly unselective beach seine fishery, mostly prosecuted in Zambia, is heavily targeting juvenile *L. miodon* in their shallow, inshore nursery grounds. The seines are inflicting further untold damage upon the mainly cichlid coastal fish community. A total ban on beach seining is obviously called for. Failing this, a system of ‘beach seining prohibited’ areas would at least reduce the destructive effects of this practice.

e) **Overexploitation of *L stappersii* in southern waters** is clearly signaled by the seven-fold growth in industrial fishing effort in the last fifteen years or so (from 3 to 23 active units since 1983) in the face of a significant decline in CPUE. Fishing operations based in or around Mpulungu are dependent on in-migration of stock from areas of higher occurrence in the Moba and East Marungu sub-basins, and this should be borne in mind in considering the urgently needed curtailment of purse seining in the southernmost waters.

f) **Redistribution of industrial units** to bases in Moba and Kalemie (which would in a number of cases actually be a move back to point of origin) might well have the effect of further reducing the stock now being targeted by Mpulungu units.

g) **High exploitation pressures on *L stappersii* in northern waters**. The situation with respect to the northern end of the lake, though less explicit, warrants attention as well. This is also an area which has undergone relatively intense pelagic fishing development, first with purse seining and then with artisanal liftnetting.

C.4 Reports on Institutional and Legal Issues

26. LTR reviews of institutional and legal aspects of Lake Tanganyika fisheries Hanek (1994), Maembe (1996), and Cacaud (1996)[4] indicate that there are a number of shortcomings shared by all the lacustrine states.

27. Although there are minor differences of emphasis and content, fisheries policies of the four lacustrine states are basically orientated towards social welfare objectives. The lowest common denominator appears to be commitment to the principle that the sector should serve domestic food security needs. In Burundi, Tanzania, and Zambia, further explicit reference is made to the role fisheries should play in generating employment and income opportunities for local communities. In Tanzania there is additional direct reference to a foreign exchange earning function.

28. The Burundi, Tanzania, and Zambia policy statements also highlight sustainability as a limiting condition to the fulfillment of social welfare purposes: fisheries production and its benefits should be maximised, but only to the extent that future yields are not compromised. In other words, use must be *wise use.* DRC policy, at least on the basis of information available at the time of review (Maembe 1996; Cacaud 1996), does

[4]The latter two reports resulted from a joint mission undertaken by LTR and the FAO Fisheries Management and Law Advisory Programme, GCP/606/NOR/INT, as part of a co-operative mission with LTR.

not seem to feature the sustainability theme so explicitly. Commitment is however implied be the existence of regulations governing gear type and specifications, etc.

29 Institutional and legal frameworks are very weakly equipped to serve policy objectives effectively. Fisheries departments and research agencies are chronically underfunded, and in some cases disastrously so. Attendant problems of operational paralysis and lack of motivation amongst field personnel are rife. Existing fisheries regulations are outdated and often fail to address current realities; they are in any case widely ignored in practice.

30. The broad regional picture of institutional capacity and fisheries law development, enforcement, and compliance is therefore not very encouraging. Furthermore, it must be recognised that many of the problems afflicting the fisheries sector within each of the lacustrine countries are but particular expressions or consequences of wider, macro-level socio-economic and political circumstances, the amelioration of which will only be accomplished in gradual and possibly uneven ways.

31. This having been said, direct and immediate actions are still required to improve institutional and legal modalities in support of more effective fisheries management on Lake Tanganyika. LTR assessments identify the following key areas of need.

a) **Community based management**. Mechanisms which would allow greater participation of local stakeholders in management decision-making and regulation enforcement processes should be negotiated and implemented. Preliminary moves have already been taken in Zambia, and initiatives for other sectors of the lake should use the Zambian experience as a reference point.

b) **Destructive fishing practices**. These appear to be serious and widespread. Effective regulatory control of such practices as beach seining, the use of very small mesh sizes, and ‘active’ gillnetting would clearly be advisable.

c) **Environmental quality**. Measures for the protection and conservation of the aquatic ecosystem (e.g. pollution prevention/abatement; habitat preservation; designation of aquatic reserves, etc.) are generally weak or non-existent.

d) **Regional co-operation**. Institutional arrangements are needed to facilitate co-operation between the four lacustrine states on a range of management-related tasks. These latter include, for example: harmonisation of fisheries legislation; standardisation of data collection procedures; monitoring of shared fish stocks and fishing effort trends; reduction of fishing pressure in areas of excessive concentration through fleet unit redistribution and/or retirement; research to identify habitats, areas, and seasons critical to the maintenance of aquatic biodiversity or the protection of stock components passing through sensitive life cycle phases; and encouragement of community participation in the regulation of fishing. Possible institutional options for quadripartite regional co-operation include adaptation of existing arrangements (the CIFA SubCommittee or some similar successor body) or creation of new structures (independent Technical Committee or intergovernmental organisation). The last two options would however require ambitious -- and probably under current circumstances unrealistic -- levels of financial commitment and formal administrative support (governing organs, permanent secretariat, general service staff, etc.).

C.5 Socio-Economic Investigations

32. Results of the 1997 LTR lakewide socio-economic (SEC) survey of small-scale fishers and post-harvest operators are reported in a series of project technical documents covering each of the four national sectors as well as a lakewide overview (Reynolds and Hanek 1997). The overview synthesised information drawn from the country reports, placing particular emphasis on the implications of respondent opinions and views for management planning questions.

33. Major findings were presented in terms of the three primary management concerns for: a) regulation of fishing; b) limitation of access; and c) community participation. In order to facilitate evaluation of patterns on a lakewide basis and between different respondent sub-groupings, the attitudinal data were collapsed to show three basic levels of majority support either for or against the various propositions on regulatory options and other issues for which survey polling was conducted. The tables in Annex 1 provide examples of such summary scoring for majority views as applied to the case of propositions on gear restrictions.

34. The SEC survey findings yield a large and somewhat complicated set of management planning ‘messages.’ Local stakeholders are by no means united in their perceptions of fisheries problems and prospects, though important areas of agreement can be found both at a general level and in terms of national, fisher, and processor/trader sub-groupings.

35. SEC findings indicate a broad acceptance in principle amongst local stakeholders of the need for some sort of formal

regulation for the fisheries. This can be read from the widespread concern expressed for the state of commercial stocks and the high approval ratings on propositions to enhance official enforcement capabilities -- results which presumably would not be forthcoming if it were widely perceived that current resource exploitation patterns were without problems and there was no need for any controls whatsoever.

36. At the same time, however, there is rather weak agreement lakewide on many of the particulars that that management arrangements could entail. Where consensus is found, it tends to be of a negative sort:
moderate to heavy majorities across all the national sample groups surveyed reject the idea of imposing a prohibition on beach seining or on lift net fishing; they also reject the suggestion that an overall limit be placed on the number of fishers allowed to operate on the lake.

37. Opinion is divided, and sometimes heavily so, on a wide array of questions. Thus, differences of view are registered in response to suggestions that: a) some form of controls be placed on industrial gear, on beach seining, or on lift net operations; b) a total ban be imposed on the use of industrial gear; c) minimum mesh size specifications be applied generally, or specifically for gill nets, beach seines, or lift nets; d) the method of frightening fish into a stationary gillnet, known as 'katuli,' be completely prohibited; e) area and time restrictions be established, as for example to protect breeding or juvenile fish communities; f) access to the fishery be conditioned by certain criteria of residence or nationality; and g) government authorities retain exclusive responsibility for deciding on fishing rules.

38. The formulation of a regional framework plan for the lake's fisheries therefore faces some very considerable challenges. Not only is there divergence of fisher and post-harvest operator opinion on crucial issues between the national sector samples, but also in a number of instances between different sample groups within the same national sector. A rigidly set 'one design fits all' fisheries management 'uniform' would certainly on present readings be very uncomfortable for many local fisherfolk to wear, assuming they could be induced into trying it on at all. In the context of Lake Tanganyika, it is obvious that a management framework will have to fashioned with a good measure of 'flexible accommodation' vis-à-vis three major and closely interrelated problem areas, namely:

a) **Differing orientations towards co-management possibilities**. Many fisherfolk (especially in Tanzania and Zambia) seem to embrace the participatory approach to management, in which decision-making and enforcement responsibilities are shared between local resource user communities and official fisheries authorities. But many others (especially in Burundi and the DRC) appear to be less enthusiastic, wishing to rely instead on the more conventional ‘topdown’ arrangement that features a high degree of state intervention in local management affairs.

b) **Community outreach**. Although community outreach is integral to responsible fisheries, it is difficult to over-emphasise its importance for the lakewide management process. Environmental education and consultation and negotiation with user groups will have to figure extensively in efforts to gain local level acceptance of measures to regulate fishing (gear use, time and space restrictions, etc.) or to condition access to fisheries resources.

c) **Development options**. Finally, management initiatives that significantly curtail existing fishing practices, harvest times or places, or conditions of access to fisheries resources will in all probability involve certain costs to local stakeholders at least in the short term. However well-advised, the success of such initiatives will depend greatly on the availability of alternative technologies or other trade-offs that would be meaningful to local stakeholders in simple livelihood terms. In other words, it is quite unrealistic to expect local populations to forego usual and accustomed practices of production, trade, and consumption without any development options ready to hand.

D. PROVISIONAL FRAMEWORK FOR LAKE TANGANYIKA FISHERIES MANAGEMENT

39. The provisional regional management framework submitted here has been kept as minimal and straightforward as possible at this preliminary stage of regional agenda-setting. Thus, although LTR studies over the past six years identify a large range of possible management concerns in both the harvest and post-harvest sectors, priority attention is given to those that demand the most immediate attention in terms of implications for regional policy direction, regulation of fishing mortality, access limitation, and community participation. In regard to possible regulation of fishing, for example, attention focuses on artisanal and industrial operations rather than the traditional sector. Units of the latter are significant as a proportion of the lakewide fleet, but are far less important in terms of their contribution to overall annual catch.

40. This is not to suggest that the other management concerns are irrelevant or trivial. It is only to recognise that the construction of a regional management framework must start with basic elements and priorities, and then, through ongoing review and revision, gradually be elaborated or adjusted as appropriate.

D.1 Policy Reaffirmation, Clarification, and Amplification[5]

Assessment

41. There appears to be a general need within all four lacustrine states for a re-affirmation and clarification of fisheries policy in order to stress the mutuality of socio-economic and wise use purposes, and to foster greater public awareness of basic objectives. With regard to the shared fisheries of Lake Tanganyika specifically, there is simultaneously a need to foster policy congruence between the four states. The voluntary FAO *Code of Conduct for Responsible Fisheries* (CCRF), as the internationally recognised standard of fishery policy orientation provides an ideal vehicle for accomplishing these tasks.

Framework recommendation

42. The CCRF should be adopted as the foundation for shared policy for the shared fisheries of Lake Tanganyika.

D.2 Technical Measures to Regulate Fishing[5]

D.2.1Gear restrictions

Assessment

43. Beach seining is a particularly destructive method of fishing wherever it is practised on the lake, both because it exploits inshore fish habitats and nursery areas and because of its highly unselective nature. It is an especially serious problem in the south end of the lake, where it is clearly inflicting harm on the juvenile stock of *L. miodon,* but is at the same time the gear of choice amongst artisanal fishers. At the same time, the SEC survey data indicate that Zambian fisher views towards at least some controls on beach seining are quite positive. In Zambia as elsewhere on the lake, initiatives to restrict beach seining would require important complementary measures in the form of environmental education and the opening up of other gear and method options as viable alternatives to the practice.

44. There is clear evidence of overexploitation of L. *stappersii* in southern waters, owing to uncontrolled growth of the industrial fishery. There are also indications that high exploitation pressure being applied to *L. stappersii* within extreme northern waters, though in this case resulting from a concentration of artisanal liftnetting on top of a history of

[5]Policy characterisations are based on documentary and interview material collected in the course of LTR studies of institutional and legal aspects of fisheries management within the four lacustrine states.

industrial purse seining. SEC survey results indicate that there is considerable local sentiment in favour of stricter controls on industrial fishing.

Framework recommendation

45. Management measures should aim at the total retirement phasing out of beach seining on the lake.

46. Off-limits areas for industrial units should be considered for the sub-basins of both extreme north and the extreme south. the most northerly and most southerly (combination gear restrictions and area closure -- see below).

D.2.2Area and time restrictions

Assessment

47. See para. 43 and 44 above.

Framework recommendation

48. Provide for 'beach seining prohibited' areas.

49. Provide for industrial fishing off-limits areas as noted in para. 46 above.

D.3 Input/Output Controls to Regulate Fishing

Assessment

50. Input or effort controls are indicated with respect to the industrial purse seine fisheries in the south of the lake (overexploitation risk to *L. stappersii),* and the liftnet fisheries throughout the northern end (overexploitation risk to S. *tanganicae* on both west and east coasts north of Karonda).

Framework recommendation

51. Consider the use of licensing ceilings for both industrial units in the south and liftnet units in the north (waters north of Karonda). In the case of the purse seine fishery, effort should be reduced to levels that prevailed ten years ago. That is, licensing measures should aim at the retirement or transfer to other fishing zones of units that entered the southern fishery within the last decade.

D.4 Access Limitation

Assessment

52. Local attitude towards various forms of access limitation. On the question of allowing people to fish in waters 'outside of their own country,' for example, strong positive response is found only amongst fishers in Burundi. Moderate to strong opposition is encountered in the DRC and Zambian fisher samples and amongst Rukwa Region (Tanzania) traditionals. Slight to modest majorities of artisanals and traditionals in Kigoma Region (Tanzania) and artisanals in Rukwa (Tanzania) support the proposition. It is nevertheless the case that a 'free-for-all' or unlimited access regime will be impossible to sustain in the face of growing population pressures within the Lake Tanganyika region. Licensing mechanisms in combination with allocation of use rights by zone between individual fishing communities are would seem to be the most appropriate way of countering the 'race to fish.'

Framework recommendation

53. Use licensing as a means to control individual entry into the fishery, and assign use rights on a zone basis to particular communities.

D.5 Management in Partnership

Assessment

54. Attitudes towards co-management appear to vary by country and fisherfolk sub-groupings. For example, fishers in Zambia and the two regions of Tanzania tend to reject the proposition that 'fishing rules should only be decided by Government.' DRC and Burundi fishers, on the other hand, give it very solid support. For the post-harvest sample sets the proposition is rejected by a majority of respondents only in Zambia. It is supported by strong majorities in the DRC and Burundi. Respondents in both regions of Tanzania remain divided in their views.

55. Co-management arrangements should thus be encouraged in a somewhat flexible manner, depending on local predispositions. Community outreach activities with a strong environmental education component will be crucial for building local awareness and acceptance of responsibility in fisheries regulation decision-making and compliance processes.

Framework recommendation

56. Provide for community-based management (co-management, participatory management, partnership management) structures and operational arrangements with sensitivity to local circumstances and predispositions, possibly through pilot initiatives within selected sites/shoreline segments. Use new approaches being developed in Zambia as reference experiences.

E. ACCOMPANYING MEASURES

57. A series of supportive or accompanying measures will be required in order to operationalise the framework plan with respect to institutional and legal provisions, development

initiatives, and research and monitoring follow-ups.

E.1 Institutional

58. LTR assessments confirm that the fisheries authorities of Burundi, DRC, Tanzania, and Zambia are all strong advocates of enhanced regional co-operation for the management of Lake Tanganyika fisheries.

59. Three major institutional options for facilitating such co-operation have been identified on the basis of interviews with fisheries and other government officials in the four states. The first would involve a Working Group, as some variation on the existing CIFA Sub-Committee for the lake. It could possibly develop in the form of a successor body with similar advisory and co-ordination functions, whereas the other two would require establishment of wholly new quadri-partite entities, either in the form of a Technical Committee with a permanent secretariat, or an intergovernmental Organization along the lines of the Lake Victoria Fisheries Organization.

60. Establishment of a Technical Committee or regional Organisation would presumably garner the advantages of high level visibility and government support. But there are clear disadvantages as well. For example, operating costs are bound to be quite substantial, and institutional stability may come to depend almost entirely on donor funding. Moreover, very long lead times are required in order to set up such elaborate structures.

61. The Working Group arrangement appears the most viable option. It would provide a regional forum for information collection and exchange. Recommendations and reports would be channeled to the CIFA body. The working group would particularly attend to questions of:

1) conservation of fish stocks and aquatic ecosystems;
2) fisheries legislation harmonisation;
3) co-operation in fisheries monitoring and surveillance activities; and
4) collaborative research needs.

62. The working group type of institution would be broadly based, with a nesting structure of local stakeholder group members (fishers, traders, local fisheries and other authorities, etc.) combining into National Working Groups headed by National Co-ordinators. Each national group would provide representatives to the regional group. The latter would basically serve as an advisory body whose primary functions would be to strengthen co-operation among technical and local authorities directly involved in the management of fisheries resources on the Lake and to pursue the agenda set by an agreed framework plan.

63. Such an arrangement offers several advantages:

1) It could be developed through an existing body (the CIFA Sub-Committee).
2) Funding would be required but costs could be kept within reasonable limits.
3) It would provide a ready means of promoting community participation in fisheries management.
4) It has the potential for expansion and integration at a later stage with other institutional arrangements, either to serve expanded lake fisheries purposes or to fulfill larger cross-sectoral purposes, such as the regional environmental body envisioned by the Lake Tanganyika Biodiversity Project.

E.2 Legal

64. It is has been well demonstrated through LTR-associated studies and other appreciations of the situation that the legislative frameworks of the four lacustrine states as they apply to Lake Tanganyika appear to be incomplete and warrant significant review and revision (Bonnucci 1990; Cacaud 1996).

65. This is therefore an obvious area of concentration for framework plan accompanying measures, and requests for further assistance have already been channelled to the Development Law Service of FAO. Technical assistance possibilities are being explored and will be confirmed by the LTR Coordinator.

E.3 Developmental

66. Implementation of framework plan elements will require further technical assistance with respect to fishing technology and fisheries training/educational institutions, and project profiles are now in the process of being drafted in consultation with the Fisheries Industries (FII) division of the FAO Department of Fisheries.

67. Efforts to phase out the beach seine fishery need to be complemented by project work to develop, test, and replicate fishing methods that can be deployed by local operators as viable alternatives to seining. In the case of the extensive beach seine fishery in the southern part of the lake, technology needs to be developed and demonstrated to allow effective artisanal exploitation of waters further offshore.

68. Considerable strengthening is indicated for existing fisheries training/education institutions within the region, in order that their personnel and programmes can support the implementation of CCRF approaches lakewide. In this respect, the programme that has been developed through the TRAINFISH Network will need to be explored.

E.4 Research and Monitoring

69. Accompanying measures to be considered in connection with research and monitoring include the organisation of ‘community referenda’ and the implementation of a lakewide monitoring programme.

70. The ‘community referenda’ exercise is envisioned as a series of briefing and consultation meetings with local stakeholder groups around the lake. The object of the exercise would be to brief local stakeholder groups on the outcomes of major LTR studies and the elements of the regional management framework proposed above, and simultaneously to obtain feedback and inputs from these groups in order to strengthen the framework and foster a sense of collective participation in efforts to ensure the sustainable use of the lake’s fishery resources. It should be organised as soon as possible through the LTR, according to the draft workplan now being prepared.

71. A lakewide monitoring programme should be put in place according to the approach proposed in document LTR/98/5.

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ANNEX 1. TABLES AND FIGURES

Table 1. Sample fisher group majority views on gear restrictions*

	Burundi		DRC		Tz/Kigoma		Tz/Rukwa		Zambia	
RESTRICTION PROPOSITION	A/Fish	T/Fish	A/Fish	T/Fish	A/Fish	T/Fish	A/Fish	T/Fish	A/Fish	T/Fish
1) Gear types:										
Controls on industrial gear	+2	+2	-1	-1	-1	-1	+1	+1	+3	+3
Ban on industrial gear	0	0	-1	-2	-2	-1	-1	+1	-2	-2
Controls on beach seining	-1	-2	-3	-3	-2	-2	-3	-2	+3	+3
Ban on beach seining	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
Controls on lift nets	-2	-3	-3	-3	-3	-3	-3	-2	+3	+3
Ban on lift nets	-3	-3	-3	-2	-3	-3	-3	-3	-3	-3
2) Gear characteristics:										
General min. mesh sizes	+1	0	-3	-3	+2	+3	+3	+3	+3	+3
Min. gillnet mesh size	-1	-2	-3	-2	+2	+2	+3	+3	+3	+3
Min. beach seine mesh size	-1	-2	-3	-3	+2	+2	+2	+3	+3	+3
Min. lift net mesh size	-2	-2	-3	-3	+2	+2	+2	+2	+3	+3
3) Other operations										
Ban on *katuli* fishing	-3	-3	-3	-2	0	+1	+1	+1	+3	+3

* Scores: +/-1 = Majority for/opposed (> 50%); +/-2 = Strong majority for/opposed (≥ 65%); +/-3 = Very strong majority for/opposed (≥ 80%). 0 = Divided opinion, no absolute majority.

Table 2 Sample post-harvest group majority views on gear restrictions*

RESTRICTION PROPOSITION	Burundi P/Hvst	DRC P/Hvst	Tz/Kigoma P/Hvst	Tz/Rukwa P/Hvst	Zambia P/Hvst
1) Gear types:					
Controls on industrial gear	-1	-3	0	-1	-1
Ban on industrial gear	-1	0	-2	0	-1
Controls on beach seining	-2	-3	0	0	-3
Ban on beach seining	-3	-3	-2	-2	-3
Controls on lift nets	-2	-3	-1	0	-1
Ban on lift nets	-3	-3	-1	-1	-2
2) Gear characteristics:					
General min. mesh sizes	+1	0	+2	+2	+3

* Scores: +/-1 = Majority for/opposed (> 50%); +/-2 = Strong majority for/opposed (≥ 65%); +/-3 = Very strong majority for/opposed (≥ 80%); 0 = Divided opinion, no absolute majority.

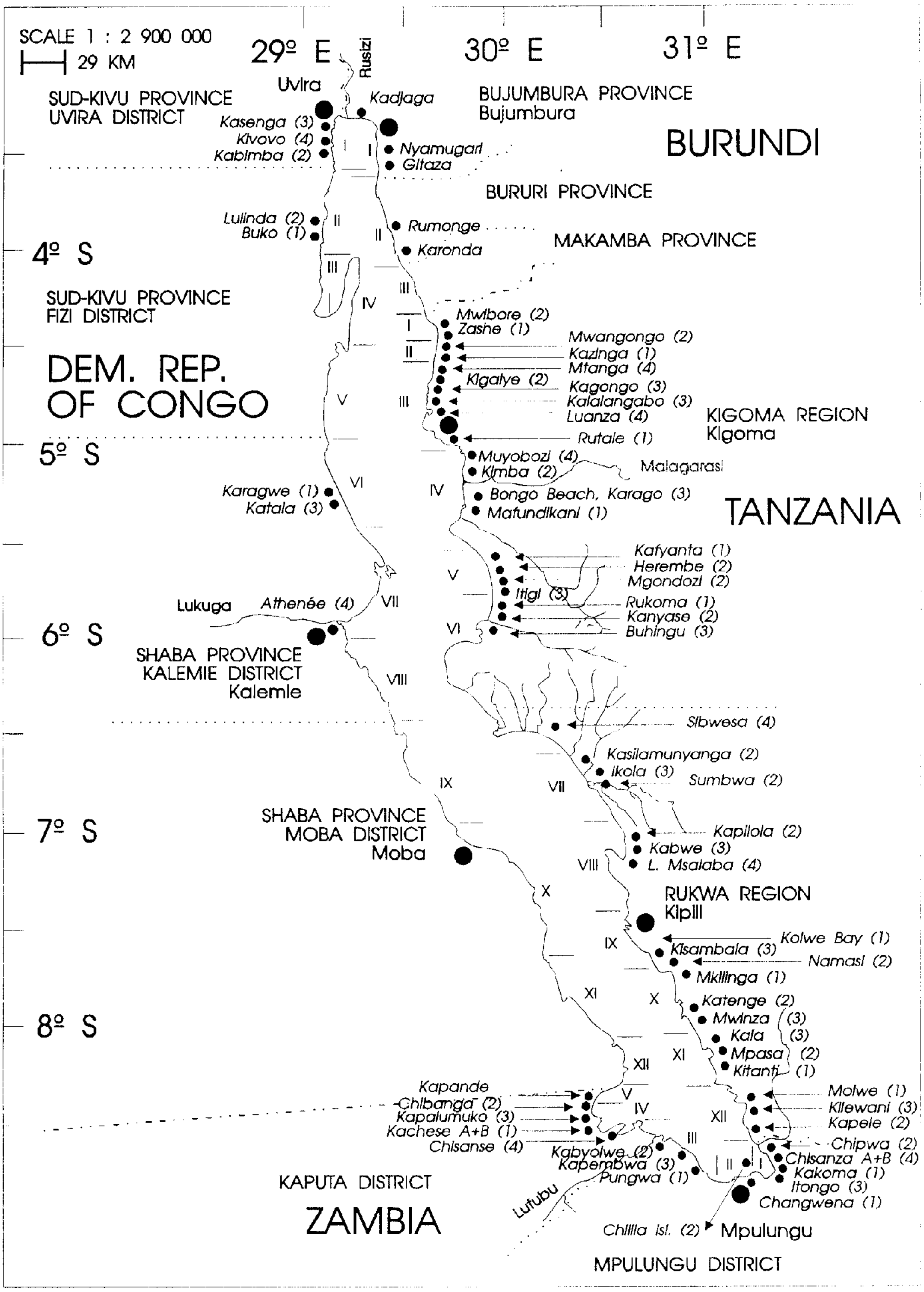

Fig. 1.1 **Lake Tanganyika.** Map showing relative locations of 1997 SEC survey sample landing sites lakewide. Geographical strata areas are indicated by Roman numerals within each national sector. Landing site class codes appear in parentheses behind village names.

LTR/98/5

SIXTH MEETING OF LTR COORDINATION COMMITTEE

Lusaka (Zambia), 22-23 June 1998

MONITORING PROGRAMME FOR LAKE TANGANYIKA

INTRODUCTION

1. The initial proposal for **a** Monitoring Programme for Lake Tanganyika was presented during the 5th Joint Meeting of LTR Conunittees (Rome, 25-26.11.1996). It was not yet put in place mainly because (a) of project's budgetary limitations and (b) the LTR Working Group on Management concluded that any Monitoring Progranune must be an integral part of the Lake Tanganyika Fisheries Management Plan and thus suggested that this document is revised accordingly and re-submitted to the LTR Coordination Conunittee and, as it has important budgetary implications, to the donor/s as well. Consequently, this document provides the background, objectives, the scope and sampling details and tentative budget only noting the full document on LTR Monitoring Programme for Lake Tanganyika will be completed on the basis of your deliberations and conclusions well before the end of this year so that its start could be scheduled for 1.1.1999.

BACKGROUND

2. The LTR has been collecting data in hydrodynamics, limnology, zooplankton, fish biology and fisheries statistics extensively during LTR Scientific Sampling Progranune (SSP) July 1993-June 1996 and, using the automatic instruments, the water level and a number of meteorological parameters, without interruption since February 1993. The vast majority of the data collected was already analyzed and published and, in turn, formed the basis of the LTR Scientific Report. The LTR has fully equipped three research stations (in Bujumbura, Kigoma and Mpulungu) and partially in Uvira, and also trained a large number of counterparts of all four riparian States in sampling methodology, data treatment and analyses.

OBJECTIVES AND PRINCIPLES

3. The key objective of a Monitoring Programme for Lake Tanganyika is to provide the required indicators of lake productivity and, in turn, to establish the procedures for managing the pelagic fish stocks of the lake. Due to the biological complexity of the Lake and in order to detect the inter-annual changes, a duration of a minimum of 10 years of regular monitoring is proposed. The nationals trained by the LTR and attached to the appropriate departments or research institutes should run the progranune at each station. In

addition the progranune should be supervised by the specialists in each discipline, on a regular basis (minimum one visit per year), in order to both provide much needed motivations and encouragement to the national colleagues and mainly to verify, maintain and/or re-calibrate the equipment used and ensure that the sampling is carried out as planned and that the data is pre-analyzed in the field and yearly sununary prepared and made available to all participating States. While the labor costs should be met by the national institutions, the operating, maintenance and supervision costs will have to be supplied by external funding.

SCOPE OF MONITORING PROGRAMME

4. The LTR Working Group on Monitoring proposed that 4 categories of indicators should be regularly monitored *i.e.* physical, biological, statistical and socio-economic. These are now detailed hereafter.

A. PHYSICAL

Justification & Objectives

5. Hydrodynamics of Lake Tanganyika play an important role in the lake ecosystem. The winds are, through upwelling, the forcing factor of nutrient input into the productive layer regulating the primary production of the lake. Other meteorological parameters give support to seasonal variation of vertical stratification. Consequently, it is essential to monitor the meteorological conditions and seasonal water stratification in and around the lake. In addition, as the lake’s water level can vary considerably and is related to vertical stratification it should be monitored as well.

Parameters

6. The following parameters are to be monitored: (1) wind speed; (2) wind gust; (3) wind direction; (4) air temperature; *(5)* relative humidity; (6) solar radiation; (7) air pressure; (8) rainfall; and (9) water level.

Sampling frequency

7. For parameters 1-8: interval of 10 minutes; for parameter 9: every one hour.

B. BIOLOGICAL

<u>Justification & Objectives</u>

8. To obtain information on water colunm stratification as it is important for the productivity of the lake (parameters 10 and 11), to obtain information on the long-term changes in primary productivity through more direct indicators (parameters 12 to 14) and to obtain information on changes in the food base for fish i.e. on the crustacean zooplankton biomass, which is the closest link to clupeid fish production in the food web (parameter 15) and on shrimp abundance (parameter 16) that is important especially for *Limnothrissa miodon* and *Lc,tes stappersif.*

<u>Parameters</u>

9. The following parameters are to be monitored: (10) vertical profile of water temperature; (11) vertical profile of oxygen; (12) transparency; (13) vertical light penetration; (14) chlorophyll a; (15) crustacean zooplankton biomass; and (16) shrimp abundance.

<u>Sampling frequency</u>

10. Two times per month at every station.

C. STATISTICAL

<u>Justification & Objectives</u>

11. It is essential to follow the fish catch and effort evolution in different areas of the lake. The riparian States where national CAS and FS systems are in place (Bunmdi, Tanzania, Zambia) should continue their efforts to produce reliable fisheries statistics for their part of the Lake. For CAS it means: annual and monthly catch — total and per species (group) — per type of fishing and per stratum. For FS it supposes — at least 2-3 years (minimum) — a total count of active fishing villages and active fishing vessels per type and per stratum.

DR. of Congo (without any regular CAS or FS in place) will have to rely on assistance by the Monitoring Programme — as was the case during SSP — for obtaining some statistics.

<u>Parameters</u>

12. CPUEs and species composition for different fishing types and fishing areas by sampling individual fishing units during fish biology sampling (as was done during SSP)

Sampling frequency

13. CPUEs: once a week at all stations.

SOCIO-ECONOMICS

Justification & Objectives

14. 'People questions' lie at the core of fisheries management issues and have thus been a major focus of concern in the LTR research programme. The 1997 lakewide sample survey enabled members of the project s socio-economic (SEC) team to chart major features of landing site communities and to profile personal backgrounds and income-generating activities of local fishers and traders. This information set a context for assessing key survey data on local attitudes and perceptions regarding the condition of the lake and the use of its resources. Such findings are absolutely crucial to the task of building a unified set of management approaches for the lake, for they fix reference points against which the effectiveness of existing management tools can be measured and provide indications of which options for improvement will be likely to command widespread community support and which will likely require special efforts to foster acceptance through public outreach programs. However, appreciation of socio-economic realities is an ongoing process requiring continual attention. Conditions within the fisheries, landing site conunununities, and larger national societies are subject to multiple changes, and these are likely to effect the way local people make decisions about acts of resource use and compromise. Furthermore, effective management is clearly something that must be developed on a partnership basis with local stakeholder groups. Feedback from regular monitoring of socioeconomic parameters will provide official administrators, researchers, and others who represent the wider public trust with indications of how this partnership is faring and the ways in which it might be made more durable.

Parameters

15. SEC monitoring should be undertaken in conjunction with CAS and FS Survey exercises (Section C, above), making use of personnel assigned to the fisheries statistical units of the four states. Much of the CAS/FS data will be of relevance to socio-economic investigations as they will provide ongoing measures of the size and scope of the fisheries (craft and gear inventories, numbers of operators, etc.), but additional information would be desirable for such areas as community population size and composition, community services/infrastructure, perceptions and attitudes regarding the fisheries, and cost/earning data for fishing and processing/trading activities. Field teams should be provided with extra training as appropriate for the collection of this additional information, which should be recorded in simple standardized format. Revised versions of the data collection forms used in the original 1997 lakewide SEC survey could be prepared for this purpose.

Sampling frequency

16. Cost/earning information should be collected at those sites and from those fishing units being monitored under the CAS *(i.e.* CPUEs once a week at all stations). In the case of processing/trading activities, contacts will have to be established with representative operators at the same sites. One or two operators per sites should suffice.

Updates of baseline information on conununity demographics, services/infrastructure, and attitudinal profiles should be carried out in conjunction with FS exercises, *i.e.* every 2-3 years as specified in Section C above.

INPUTS

Introduction

17. It is clear that the long term conmmitment of all riparian States to this Monitoring Programme is essential and is, in fact, a prerequisite to any such undertaking. It is therefore important that the Monitoring Programme is incorporated in the work progranune of all lake-side institutions concerned *i.e.* the Departments of Fisheries in Burundi, URT and Zambia, the Tanzania Fisheries Research Institute and the Centre de Recherche en Hydrobiologie (in Uvira, DRC) and the Service de l'Environnement et Conservation de la Nature (in Uvira, Kalemie and Moba, DRC). In addition, it is essential that the authorities of all four riparian States take the required actions in order to ensure that the necessary budgetary allocations are made.

A. MANPOWER

Field staff

18. As it is proposed that the Monitoring Programme is executed exclusively by the nationals of all four riparian States, it is essential that those national colleagues trained by the LTR are made available. It is thus proposed that, initially and starting as of 1.1.1999, 4 national colleagues per each station *i.e.* in Mpulungu (Zambia), Kigoma (URT) and Bujumbura (Burundi) are assigned, on a part-time basis, to the Monitoring Programme by their respective authorities. Once the situation in DRC allows, the above team should be strengthened by 4 national colleagues in Uvira and 2 each in Kalemie and Moba. Further, it is proposed that the Monitoring Programme teams in Kigoma (URT) and Mpulungu (Zambia) work under the direct supervisions of the 0-i-C's at each station *i.e.* Mr. Chitamwebwa in Kigoma and Mr. Mwape in Mpulungu while the supervision of the Bujumbura station and the overall supervision of all stations is assured, during the first full year of Monitoring Progranune by the LTR Coordinator. He must ensure that a suitable national colleague in Burundi is identified and trained in order to assume the responsibility for Bujumbura station by mid-1999. The LTR Coordinator should also make the full evaluation of the first year of the Monitoring programme and it is thus suggested that his assignment in Bujumbura is extended until 31.1.2000.

Supervision and training

19. As stated in the section 3 above, the Monitoring Programme will be implemented through joint effort of the local institutes and their international counterparts. The scientific networks between the personnel of the riparian institutions and the LTR sub-component leaders and scientific coordinators in Finland will be used for regular follow-up, evaluation and testing the practical execution of the Fisheries Management Plan and the Monitoring Programme in particular. Training of field personnel and other authorities in the respective managerial bodies, both in fisheries and environmental issues, will take place through workshops and participatory approach. The commitment of local/regional institutes and the international agencies will be assessed as agreed separately.

B. EQUIPMENT

20. The LTR fully equipment the stations in Bujmnbura, Kigoma and Mpulungu and, partially, that of Uvira. The laboratory facilities and equipment including the vessels and transport vehicles will remain on the responsibility of the institutes in-charge and should be supported partly by the host country and external funds. On this one should note that the vehicles procured by the LTR are all old and should be replaced soonest.

C. BUDGET

21. To be assessed between the riparian institutes and the donors.

—CONCLUSIONS

22. As apparent from the above it is hoped that your deliberations here will allow to finalize the scope of the Monitoring Progranune, establish the budget and, on this basis, specify both the contributions of each riparian State and that of the donors.

ANNEX 8.

Resolution Proposed by the Scientific Coordinator

"On behalf of the donor and the Scientific Coordination of this project we wish to record the crucial contribution of Dr. Hanek, LTR Coordinator, to this project. You may recall that the University of Kuopio recognized Dr. Hanek's efforts by bestowing on him the degree Doctor of Philosophy *Honoris Causa,* in 1996. His efforts since then are equally impressive and resulted in ensuring that LTR successfully completed all required field tasks, all of which were executed under very the difficult socio-political climate in the Region, to our full satisfaction. In our view it is essential and in fact conditional for further financial support from Finland that there is no change in leadership of this project and consequently that the services of Dr. Hanek are ensured until the end of January, 2000."