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REPORT OF THE FOURTH JOINT MEETING OF THE LTR'S COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

edited by

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FINNISH INTERNATIONAL DEVELOPMENT AGENCY

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

Bujumbura, November 1995

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 Programme 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, Zaïre 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 Intitutes in Finland. We also wish to record the efforts of Ms. Baricako and Ms. Gatungane in the preparation and trasnlation of all meeting's documentation.

In addition, we wish to acknowledge the effective assistance of Ms. Blessich, Dr. Kapetsky and Mr. Everett in drafting the adopted report.

Lastly, we wish to record the effective and constructive participation of all members of the LTR's Committees, that of numerous observers and, above all, the effective chairmanship of Mr. R. Kanyaru.

REPORT OF THE FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

1. The Fourth Joint Meeting of the Coordination and International Scientific Committees of Project GCP/RAF/271/FIN 'Research for the Management of the Fisheries on Lake Tanganyika' (LTR) was held from 15 to 17 November 1995 in Bujumbura, Burundi.

ITEM 1: OPENING OF THE MEETING AND ELECTION OF THE CHAIRMAN

2. The Tanzanian delegate, Chairman of the Third Joint Meeting of LTR's Coordination and International Scientific Committees, welcomed the participants and observers and called the meeting to order. The list of participants is given in Annex 1.

The Tanzanian delegate drew the attention of all present to the importance of holding such meetings regularly in the common interest of the four riparian countries. These Fourth Joint Committees were to examine the progress of the project, which was near completion of its first phase.

3. On behalf of his country, the Burundian delegate welcomed all members and participants on board the *R/V Tanganyika Explorer.* Burundi had hosted the First Joint Committee meeting, and he was happy to see all members again in Bujumbura after three years of progressive activities. He expressed appreciation for the dedication of the staff, which had contributed to the achievement of the project objectives and to the countries' efforts for the joint management of the lake fisheries.

4. The project Scientific Coordinator noted the project had reached an important stage, whereby use of the research vessel made it possible to verify the findings acquired during the first phase. He praised the colleagues from the research institutes of riparian countries for their enthusiastic participation and important contribution to the results attained. The project had been positively evaluated with a recommendation for its continuation. A follow-up phase would ensure upgrading of national capabilities to continue research for the optimum management of the lake fisheries.

5. The FAO Representative in Burundi, Mr. Joseph Tchicaya, expressed his pleasure in the attendance of all members of the Committees and for the honour and encouragement derived from the presence of H. E. Mr. Pierre—Claver Nahimana, Minister of

Agriculture and Livestock, who had agreed to personally preside at the opening of the meeting. Equally significant of the importance attached to the regional project by the Government of Burundi, was the honour paid by H. E. Mr. Sylvestre Ntibantunganya, the President, in his participation in the official launching of the *R/V Tanganyika Explorer* on 16.10.1995. The FAO Representative was confident that the four riparian countries would be capable of fulfilling their responsibilities for the rational management of the fisheries made possible by a sounder knowledge of the biology of the lake. Despite the encouraging results of the sampling programme, a massive and complex task of data analysis and interpretation was still required. In this respect the FAO would be particularly attentive to the training requirements of nationals. He therefore encouraged the members of the two committees to work for the continuation of the project and the establishment of a regional fisheries organization for Lake Tanganyika. He expressed his admiration for the endurance of all the national and international staff and for their sense of duty and dedication in a working environment that was not always easy. On behalf of FAO he conveyed his thanks to Prof. Lindqvist of the University of Kuopio and to FINNIDA for their valuable contributions. The anticipated collaboration with the Global Environment Facility (GEF) project would no doubt enhance the expected results.

6. H.E. the Minister of Agriculture and Livestock, welcomed all the participants to his country. The fact that the project now has available a well equipped research vessel which was used for opening the meeting, was evidence of continuing development. He expressed gratitude to Finland and was confident of this donor’s continued support. The ongoing biological research was necessary to allow fisheries administrations to attain an optimum management of their fisheries which would benefit the fisherfolk and populations of the four riparian countries. His Excellency supported the joint management efforts for the establishment of a regional fisheries organization. This would facilitate identification and implementation of the most appropriate solutions to the various problems inherent in the identification of management options. He was appreciative of the technical assistance provided by FAO, and with the project first phase approaching its conclusion, he requested that special attention be given to the fullest possible integration of national expertise to allow adequate continuation of activities after the end of the external assistance. H.E. the Minister declared the meeting open.

7. The Burundian delegate, proposed by Zambia and seconded by Zaïre, was elected chairman.

ITEM 2: ADOPTION OF THE AGENDA

8. The agenda (Annex 2) was adopted with a minor change on the time schedule as proposed by the Zambian delegate, and seconded by the Tanzanian delegate.

ITEM 3: LTR COORDINATOR'S REPORT: SUMMARY OF LTR'S ACTIVITIES (DECEMBER 1994 - NOVEMBER 1995) AND REVIEW OF PROGRESS ON RECOMMENDATIONS OF THE THIRD JOINT MEETING OF LTR COMMITTEES

9. The LTR Coordinator presented the details of LTR activities carried out during the last 12 months; they are amplified in Annex 3. The key highlights were: (1) successful completion of the second year of LTR's Scientific Sampling Programme (SSP) in July 1995; (2) start of the third year of SSP in August 1995; (3) acceptance of *R/V Tanganyika Explorer* in April 1995; (4) effective execution of five lake—wide scientific cruises during 1995; these were devoted respectively to hydrodynamics, primary production and zooplankton studies and acoustics and fishery biology studies; (5) organization and execution of Fisheries Statistics Coordinators' Meeting and Workshop on the Planning and Management of Lake Tanganyika Pelagic Stocks; (6) assistance to the LTR Evaluation Mission; (7) preparation and presentation of scientific papers by the LTR field staff at the First Pan African Fisheries Congress and at Kuopio Symposium on Lake Tanganyika Research; (8) continued upgrading of the LTR Documentation Centre; (9) assistance in preparation of the document for the second phase of LTR, and (10) execution of a number of training activities.

10. The Coordinator then detailed several changes in both the field staff and the membership of the LTR committees.

TRIBUTE TO DR. RAPHAEL MUBAMBA

11. A moment of silence was observed for Dr. Raphael Mubamba, Assistant Director of Fisheries of Zambia and a member of the LTR International Scientific Committee, who passed away on 6.8.1995. His presence will be sorely missed.

12. The LTR Coordinator concluded his presentation by listing all publications produced during the last 12 months and by recording (a) continuous and effective cooperation of all the four participating states; (b) hard and dedicated work of all LTR field staff; and (c) effective backstopping by both the University of Kuopio and by the FAO Fisheries Department.

13. The delegates congratulated the LTR Coordinator and all the staff for their achievements and re—emphasized the need for closer participation of young national scientists in data analysis and reporting which further underlined the need to increase training activities.

ITEM 4: LTR SCIENTIFIC COORDINATORS' REPORT: SUMMARY OF SSP RESULTS

14. The first part of this report, Annex 4, was presented by the Scientific Coordinator who illustrated some of the important findings of the research programme. The key results of

hydrodynamics included the development of the three dimensional model and the mapping of water currents. The relationship between fish yields and water levels of the lake based on long-term, historic data had been derived.

15. Remote sensing images had been verified against ground truth data on surface temperatures. There are still some problems in obtaining images on required dates.

16. It would appear that nitrogen rather than phosphorus may be a limiting factor in biological productivity. This is similar to the condition in the sea rather than in freshwater. Primary production has now been measured down to 60 m.

17. Studies on fish genetics have shown some differences in stock segregation but results are not complete and work has not continued because of lack of funds.

18. The project Biostatistician explained that the main task during the first two years of SSP had been intensive sampling. Scientific cruises did not commence until April 1995. Most of the analysis of data still needs to be carried out. It will involve a lot of work from both national and international staff. He illustrated the links between the components and explained the main elements driving lake productivity. A short synopsis was given of the results obtained so far that support the linkages. Other areas that require further research to quantify the linkages have been identified. Acoustic data will provide the much needed information on fish stock biomass.

19. The Scientific Coordinator stressed that the first quantitative data have been made available by Professor Sarvala and colleagues on carbon and energy flow between trophic levels.

20. The Tanzanian delegate stated he was impressed by the amount of data collected but queried whether the project had the capacity to analyse and interpret all the data. The project should set limits on future data collection. He was happy overall with the progress. The Zambian delegate agreed with these opinions. The Scientific Coordinator stated that all the data were stored on computer. Scientific papers were needed to present the findings of the research. Data collection was required over a long period due to the complex system of Lake Tanganyika.

21. The Tanzanian delegate expressed concern that no further studies had been made on fish genetics due to lack of funds. He wanted to know what conclusions were available. The Scientific Coordinator indicated that results so far were inconclusive and it was possible that there were no discrete stocks. It was hoped that this question might be resolved in the future but costs are high for continuing this research.

22. The project Biostatistician stressed again the need for a long term approach to the study of Lake Tanganyika due to its dynamic nature, thus requiring long term monitoring and funding. The Tanzanian delegate expressed the need for capacity to undertake this monitoring in the four countries.

23. The observer from the Institute of Freshwater Ecology said it was very important to understand the links in the food web.

24. The Scientific Coordinator gave a summary of presentations given at the Kuopio Symposium and highlighted the principal findings. The main papers will be published in a special edition of *Hydrobiologia.*

ITEM 5: SUMMARY OF LTR'S EVALUATION MISSION'S CONCLUSIONS AND RECOMMENDATIONS

25. The independent evaluation mission had taken place as scheduled from 25 April to 26 May 1995 (its summary is given as Annex 5). The ensuing report had been presented to recipient countries and to the donor in early August 1995. The mission's conclusions on the project performance had been positive and appreciative of progress despite delays that had occurred. These delays, which were beyond the control of the excellent project management, were in the procurement of the research vessel and in the rehabilitation of the research station of Kalemie in Zaïre.

26. The mission confirmed the validity of the project's scope and objectives. They were of the opinion that project formulation should have introduced the concept and options for fisheries management at the inception of the project.

27. The mission recommended a project extension for two and half additional years beginning in January 1997. They proposed that the follow–up phase should concentrate on the integration of data available from all research components, their verification and extension through lake–wide research surveys and acquisition of essential socio–economic data to form the basis for the formulation of a fisheries management plan. Essential research elements for continued national monitoring should be identified and participation by national scientists intensified to enhance the capacity of national research institutes. Action should be taken to establish the research base in Kalemie as soon as finances allowed it.

28. The mission had further recommended full collaboration with the GEF Project "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika", as well as fostering of regional collaboration through a single regional body.

29. The meeting was requested to assess the relevance of the evaluation mission's conclusions and recommendations, especially in conjunction with the design of the document for the project follow-up phase.

30. Following the intervention by the Tanzanian delegate, the meeting was informed that the mission's recommendations were fully accepted by both FAO and the Scientific Coordinators. Full implementation of the recommendations would probably not be possible, unless adequate donor financing was obtained.

31. Specific requirements for the rehabilitation of the Kalemie station of Kalemie were briefly considered and would be further discussed with the project management.

32. The meeting advised that the mission's recommendations should be used as a basis for formulation of the project's second phase. Emphasis should be placed on enhancement of national capabilities and upgrading of institutional mechanisms to implement management measures. The follow—up phase should preferably be of three years' duration.

ITEM 6: SUMMARY OF LTR'S WORKSHOP ON THE PLANNING AND MANAGEMENT OF LAKE TANGANYIKA PELAGIC STOCKS

33. This Workshop was held in Bujumbura, Burundi from 1 to 3 June 1995 (its summary is given in Annex 6). Taking part were representatives of all four riparian countries as well as representatives of the University of Kuopio, the FAO Fisheries Department and staff of LTR.

34. The most important conclusions and recommendations were the following: (1) the pelagic stocks of Lake Tanganyika are shared by all four riparian states and thus should be managed as one entity; (2) it was agreed that cooperation was required in establishing the legal framework for the management and development of fisheries and for the formulation of harmonised legislation and corresponding regulations to be adopted by each country within that framework which could be a Lake Tanganyika Fisheries Management Organization; (3) the overall objective of a fishery management plan for the Lake was conservation of the fishery resources for the economic benefit of the citizens of the four riparian states; (4) that each riparian state ensure the optimal utilisation of fish resources in its area of jurisdiction and give neighbouring states access to the surplus of the allowable catch, once determined; (5) lakeside communities and fisherfolk should be brought into the process of fishery management together with government authorities; (6) the need to monitor economic information in order to assess social and economic benefits; and (7) that funds be made available to accomplish these tasks.

35. The delegates generally endorsed the conclusions and recommendations of the Workshop. They enquired about the status of the preparation of navigational charts, noted the differences of existing legislation, lack of capacity to enforce certain regulatory measures and underscored the need for proper stock assessment. In Zambia it was confirmed that a decision had been made to promote community based management as the basis for

fisheries management. The meeting was informed that along parts of the Zaïre shore there was already some local community resource management in place. Finally, the participants endorsed the recommendations of the Workshop to seek additional funds to carry out in particular intensified collection of economic data, preparatory work necessary for setting up a body such as the Lake Tanganyika Fisheries Management Organization.

ITEM 7: PROPOSAL OF LTR SCIENTIFIC PROGRAMME FOR 1996

36. The LTR Biostatistician presented the work programme for the third year of the scientific sampling programme (SSP3) (its details are given in Annex 7). The second year of the sampling programme, SSP2, finished at the end of July, completing, with SSP1, two years of intensive sampling in hydrodynamics, limnology and zooplankton and fish biology. The planning of SSP3 was discussed at a meeting in Kigoma in July 1995. The planning was based on two scenarios depending on how long the project continued, (a) until December 1996 or (b) until December 1998. The duration of the project will determine the extent of future research and new ventures. As mentioned under Item 4, the next period would be mainly used for data analysis and interpretation and the presentation of results in reports and scientific papers. This will require more regular meetings between staff than previously held. SSP3 will place the main emphasis on basic monitoring, lakewide cruises and specific investigations.

37. Basic monitoring is the responsibility of national project staff at each station. The basic monitoring programme that has been developed covers the main components of the project.

38. Two types of cruises with *R/V Tanganyika Explorer* are planned, (a) combined hydrodynamics and limnology (including primary production studies and the collection of phytoplankton, protozoa and bacteria) and (b) fish. The frequency of the cruises will depend on money and manpower available.

39. Specific investigations identified as necessary to complete the present study plan include water current measurements in deep water, primary production estimates and the identification of phytoplankton, growth rates, turnover rates and P/B ratios of crustacea, fecundity and reproductive patterns of pelagic fish, the importance of shrimps in the food web, remote sensing concentrating on lakewide observations of surface temperature, on integration with hydrodynamic modelling and on seasonal patterns of limnology and on fish genetics and stock segregation.

40. The compilation of scientific data will follow the same format for both scenarios. Reports will be prepared at the end of the following months, December for station reports, January for draft component reports and March for final component reports. A meeting will be held each June and all documentation, reports and papers, finalised. A final science report would be

produced by the end of July 1996 or 1998 depending on the duration of the project. If the project finishes next year the field staff will not be able to undertake any new ventures and there will be limited input into cruises. With Scenario 2 data collection could continue until December 1997.

41. The Scientific Coordinator stressed that the greatest asset of the project for the coming year is the research vessel which can perform lakewide surveys. The cost benefit of fish genetics studies has to be examined. GEF may have an interest in this through biodiversity studies. Many of the national projects in operation at the time of the project inception are no longer functioning and the project has spread itself to cover these.

42. The LTR Biostatistician stressed that monitoring had been reduced to a minimum and special investigations are necessary to fill the missing links in understanding the biological system of the lake. The dynamics of the lake are complex and future work has to be concentrated where parameters show the greatest variability.

43. Concern was raised that scientists at the national level were not closely and continuously involved in data analysis. It was clarified that national staff at each station have been identified for execution of each research component including collection and recording of data and the preparation of reports. The problem of financing the programme remains. The Scientific Coordinator suggested a brainstorming session next year between national scientists, scientists from Finland and international project staff.

44. The meeting was informed that GEF/NRI intend to install a NOAA satellite receiver at Kigoma. Although Finland has invested considerable time and finances in developing an algorithm to estimate surface temperature, acquisition of data has continued to be a problem. Thus, the GEF/NRI receiver offers a solution for the real time acquisition of NOAA data, that can be processed on site at Kigoma using the algorithm developed in Finland. In Lusaka the Meterological Office has an archive of NOAA data that could be used by the project for the limnology and hydrodynamic components.

ITEM 8: PRESENTATION OF PROJECT GEF

45. The Scientific Coordinator of the UNOPS/NRI/GEF project for “Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika”, which had recently started operations, reported that the five baseline studies covered sedimentation, pollution, biodiversity, fisheries and socio-economic aspects. The drafts of these reports would be ready by end of December 1995 for circulation and comment prior to an inception workshop probably to be held in Dar es Salaam at the end of January 1996.

46. A preliminary strategy would then be discussed and more detailed studies undertaken until the end of 1997 when a final

strategy document would be presented. The project would then continue with implementation of the strategy until April 1999. The project will emphasize economic/social appraisals on human activities and the impact on the lake-basin environment. It is also planned to set up a lake—basin commission. There will be training in different forms linked to the environment in the lake basin. Cooperation will be promoted with NGO's in the area. It is possible that the project may recommend the establishment of four underwater parks in the lake.

47. The Burundian delegate expressed regret that the headquarters of the GEF project was moved to Kigoma without prior consultation with the authorities from the countries concerned.

48. The delegates from the four participating countries recommended that the coordinator of the GEF project organise a meeting on the project with the country representatives as soon as possible.

ITEM 9: PROPOSAL FOR LTR'S SECOND PHASE

49. A preliminary draft document was presented as a basis for discussion to obtain the guidance of the Committees in its finalisation. The document was for the follow—up phase to start in July 1996 or January 1997 according to funds remaining from phase I. The main objective was to concentrate on long—term monitoring of key fishery and biological parameters basic to fishery management, while continuing the research vessel surveys and the scientific support by the University of Kuopio. Other elements to be taken into consideration for drawing up the guidelines for the preparation and continued updating of a fisheries management plan were: collection of economic data, information on the impact of gear on fish stocks, monitoring fishing effort, as well as establishment of an harmonised legal framework for management and corresponding enforcement. The project would provide support for a regional approach as recommended by the 6th session of the CIFA meeting for Lake Tanganyika (Lusaka, 1993). Close collaboration with GEF was anticipated, in all fields concerned with fishery management. The second phase of the project would give attention to setting up a Lake Tanganyika Fisheries Management Organisation. Activities of the second phase would emphasize full involvement and upgrading of national personnel.

50. Following many fruitful and constructive comments, the meeting endorsed in principle the orientation of the second phase and entrusted to the project management and FAA the mandate to revise it for consideration by the donor well before the end of the current year. They requested the following elements be taken in due consideration:

— donor assistance for three years to allow appropriate transition to a post project situation;

— clear emphasis on the project new orientation towards fisheries management and immediate inception of activities in this respect as recommended by the evaluation mission;

— increase in national management responsibility especially during the last year;

— adequacy of procurement to cater for continued research;

— ensure that the International Scientific Committee functions properly;

- clarify the difference in objectives between LTR and GEF and the fields of collaboration;

- consider, within the limit of the financial allocation, an increase of the training component to include study tours outside the region, such as to Kuopio University.

51. The meeting agreed that the revised project document would be made available in both English and French to member countries at the same time as being submitted to the donor.

ITEM 10: ANY OTHER MATTERS

52. The Tanzanian Government had formally invited FAO to hold the 7th Session of the CIFA Sub-Committee for Lake Tanganyika in Kigoma. In view of the need to organize the next meeting of the LTR Coordination Committee and International Scientific Committee meetings in about one year, it was decided to hold them at the same time as the next CIFA Sub-Committee session in the month of September 1996. It was also agreed that an informal technical workshop on fishery management should be held at the same time along with a brainstorming session on the analysis and synthesis of the scientific data, the latter financially supported, in part, by the University of Kuopio. Scientists of the fishery stations around the lake would be invited to participate in the technical meetings.

53. A message stating absence with regrets and best wishes for the meeting was received from H.E. the Ambassador of Finland to Tanzania. H.E. the Ambassador expressed his wishes to be kept informed on the recommendations and conclusions of the meeting and particularly on the outcome of deliberations concerning the evaluation mission’s recommendations.

ITEM 11: DATE AND VENUE OF THE NEXT MEETING

54. Taking into consideration Item 52, the meeting was invited to hold its Fifth Joint Committees meeting in September 1996 in Kigoma, Tanzania.

ITEM 12: ADOPTION OF THE REPORT

55. The Coordination and International Scientific Committees adopted the report on 17 November 1995.

56. In his closing remarks, the Chairman expressed his gratitude to the Government and people of Finland for the continuing support of LTR and to the FAO and personnel of LTR for the effective execution of the project. He also congratulated all Committee members for their active and productive participation and lastly wished all a safe return to their respective countries.

57. The Tanzanian delegate thanked Burundi for hosting the Fourth Joint Meeting of the LTR Committees, expressed his appreciation to the Chairman for his efficient and effective chairmanship, to the FAO and LTR personnel for effective execution of the project and to the people and Government of Finland for their financial support. He also thanked all participants for taking an active role during the meeting and, lastly, wished all a safe return to their countries as well as offering them all a Season Greetings.

ANNEX 1

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

LIST OF PARTICIPANTS

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ANNEX 2

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

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 1994 - November 1995) and review of progress on recommendations of the Third Joint Meeting of LTR Committees.

Item 4: LTR Scientific Coordinators Report: summary of SSP results.

Item 5: Summary of LTR Evaluation Mission's conclusions and recommendations.

Item 6: Summary of LTR's Workshop on the Planning and Management of Lake Tanganyika Pelagic Stocks

Item 7: Proposal of LTR Scientific Programme for 1996.

Item 8: Presentation of project GEF.

Item 9: Proposal for LTR's second phase.

Item 10: Any other matters.

Item 11: Date and venue of the next meeting.

Item 12: Adoption of the report.

ANNEX 3

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

LTR COORDINATOR'S REPORT: SUMMARY OF LTR'S ACTIVITIES (DECEMBER 1994 - NOVEMBER 1995)

1. INTRODUCTION

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

2. RESULTS

2.1 SSP

The second year of LTR's Scientific Sampling Programme (=SSP) was successfully completed in July 1995. It was fully evaluated during the Third SSP Assessment Meeting which took place in Kigoma from 17 to 19 July 1995. At the same meeting, the detailed proposal for the third year of SSP (=55P3) was prepared and the 55P3 started in August 1995. The summary of SSP results will be presented by the LTR Scientific Coordinators (see LTR/95/3) and is thus not repeated here.

2.2 *R/V Tanganyika Explorer*

During initial commissioning a so called 'cavitation' (=excess noise) was detected. This problem was resolved by redesigning the vessel's skeg by LTR consultants Messrs. Turner and Veenstra and *R/V Tanganyika Explorer* was accepted by the LTR on 28.4.1995. The same day the vessel left on the first lakewide scientific cruise (=95/01) (28.4.-8.5.1995) which was devoted to hydrodynamics and primary production studies. Since than the following scientific cruises were executed as follows:

cruise 95/02 (15-30.6.1995):	acoustics and zooplankton studies
cruise 95/03 (28.8.–6.9.1995):	limnology and primary production and zooplankton studies
cruise 95/04 (23.10–3.11.1995):	hydrodynamics and primary production studies

The vessel will leave tomorrow on cruise 95/05 which will be devoted to acoustics and fisheries biology studies.

The officers and crew were selected in April 1995. All received on—the—job training on safety, seamanship, general operation and mid-water trawling by Mr. G. Pajot, LTR consultant-fisheries technologist (22.4—20.5.1995 and 11.6—5.7.1995). *R/V Tanganyika Explorer* operates according to the guidelines and procedures prepared by LTR Coordinator and Mr. Pajot (LTR Field Manuals No. 15 and 17 refer).

It should be recorded that *R/V Tanganyika Explorer* was officially inaugurated by H.E. the President of Burundi on 16.10.1995. This was the highlight of the celebrations commemorating the 50th Anniversary of FAO in Burundi.

2.3 First Fisheries Statistics Coordinators Meeting for Lake Tanganyika

Was held in Bujumbura from 12 to 13.12.1994 (see LTR Technical Document No. 28).

2.4 LTR Evaluation Mission

Took place between 25.4. and 25.5.1995. Its summary will be presented (see LTR/95/4).

2.5 Workshop on the Planning and Management of Lake Tanganyika's Pelagic Stocks

Took place in Bujumbura from 1 to 3.6.1995. Its summary will be presented tomorrow (see LTR/95/5).

2.6 Navigation charts for Lake Tanganyika

Following on one of the recommendations of the Meeting on the Planning and Management of Lake Tanganyika's pelagic stocks the initial work to prepare the navigation charts for Lake Tanganyika started: (1) contact was established with the International Hydrographic Organization (IHO), and (2) project proposal was elaborated by Mr. I.G. Nhyete, LTR consultant-hydrographer. Mr. Nhyete's proposal is now being reviewed in FAO HQ and should be forwarded to IHO shortly.

2.7 First Pan African Fisheries Congress

Took place in the UNEP HQ in Nairobi from 31.7-4.8.1995. LTR funded the participation of two national scientists.

2.8 Symposium on Lake Tanganyika Research

Funded and organized by the University of Kuopio this symposium took place in Kuopio, Finland from 11-15.9.1995. Many presentations were prepared by LTR personnel who took part in the proceedings.

2.9 LTR Documentation Centre

Thanks to the effective cooperation of FAO's Fisheries Department Library as well as that of many friends our Documentation Centre continues to grow.

2.10 1995 World Food Day

This year's celebrations coincided with the 50th Anniversary of FAO. Both the LTR and *R/V Tanganyika Explorer* were prominently featured during the last day (=16.10.1995) of the festivities in Burundi. As stated earlier, *R/V Tanganyika Explorer* was officially inaugurated by H.E. the President of Burundi who also visited, accompanied by several Ministers, the LTR HQ.

2.11 Second phase of LTR

Following on one of the recommendations of the Third Joint Meeting of LTR Committees the follow-up phase for LTR was prepared thanks to effective cooperation among FAO HQ (Ms. Blessich, Dr. Kapetsky and Mr. Everett), University of Kuopio (Prof O. Lindqvist and Mölsä) and LTR field staff. The draft document will be presented tomorrow (see LTR/95/6).

2.12 Training activities

* **Training course in primary production studies:** in Kigoma (Tanzania), 1—9.12.1994. Course leader: Prof. J. Sarvala, 6 participants.

* **Training course in the use of hydrodynamics software:** in Bujumbura (Burundi), 3-6.12.1995 and in Kigoma (Tanzania), 8-10.12.1995. Courses leader: Ms. A. Peltonen, 8 participants from Burundi, Tanzania, Zaïre and Zambia.

* **First Fisheries Statistics Coordinators Meeting for Lake Tanganyika:** in Bujumbura (Burundi), 12-13.12.1994. Meeting leader: Mr. E.J. Coenen, 8 participants from Burundi, Tanzania, Zaïre and Zambia.

* **Training of *R/V Tanganyika Explorer's* officers and crew:** in Bujumbura and onboard research vessel, 22.4—20.5.1995 and 11.6-5.7.1995. Course leader: Mr. G. Pajot, 4 officers and 4 crew.

* **Workshop on the Planning and Management of Lake Tanganyika Pelagic Stocks:** in Bujumbura (Burundi), 1-3.6.1995. Workshop leaders: Prof. Lindqvist and Messrs. Everett and Hanek, 10 participants from Burundi, Tanzania, Zaïre and Zambia.

* **Practical training in hydrodynamics, acoustics, limnology, zooplankton and primary production studies:** aboard *R/V Tanganyika Explorer* during first four scientific cruises, 28.4—8.5.95, 15—30.6.95, 28.8—6.9.95 and 23.10—3.11.1995. Courses leaders: all cruise's leaders, 18 participants from Burundi, Tanzania, Zaïre and Zambia.

* **Ongoing computer training of counterparts** in WordPerfect, Lotus, Excel, ProCite and other specialized software at all LTR stations.

2.13 LTR Personnel LTR Committees

Dr. Raphael Mubamba, member of LTR International Scientific Committee, died on 6.8.1995. Upon learning this sad and unfortunate news, LTR informed all members and sent immediately its regrets and condolences both to his colleagues in Zambia's Fisheries Department and to his family. I now wish to record Dr. Mubamba's exemplary contribution to LTR and call for one minute of silence in his honour. We now welcome Mr. Arnold M. Katundu, Zambia's Fisheries Department Chief Fisheries Research Officer, who was appointed by his Director to represent Zambia on LTR's International Scientific Committee.

We also welcome Mr. Tshibangu Kalala, researcher from CRH/Uvira, who was named by CRH/Uvira Director-General to replace Dr. Gashagaza Masta on LTR International Scientific Committee.

LTR staff

There were numerous changes during the last year. A number of national counterparts joined LTR, some replacing those transferred elsewhere or simply strengthening the existing staff in order to cope with the demanding SSP. The number of Finnish scientists who are associated with LTR has again increased.

Four officers and four crew were hired for the operation of *R/V Tanganyika Explorer* in April 1995. Mr. E.J. Coenen left LTR in May 1995; he was replaced by Dr. J.F. Craig who joined LTR in June 1995. There will soon be also further changes as two Finnish APO's will be leaving LTR and the four Dutch APO's will have to be transferred by the end of the year.

The continuous and effective cooperation of all the four participating States is now recorded and gratefully acknowledged. All of them assigned a large number of competent researchers and technicians to the LTR stations around the lake. It goes without saying that without our national colleagues it would not be possible to execute SSP. The dedication and hard work of LTR's national counterparts is hereby recorded and acknowledged.

It is also important to record the dedication and hard work of all LTR's 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 operation and technical services of FAO Fisheries Department.

2.14 LTR Publications

The following LTR publications were produced since the Third Joint Meeting of LTR Committees:

A. Technical Documents

Hanek, G., Management of Lake Tanganyika Fisheries. FAO/FINNIDA
1994 Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN—TD/25 (En): 21p.

Hanek, G., Aménagement des Pêches au lac Tanganyika. FAO-FINNIDA
1994 Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/25 (Fr): 22p.

Salonen, K. and J. Sarvala, Sources of energy for secondary
1994 production in Lake Tanganyika: Objectives, approaches and initial experiences. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN—TD/26 (En): 30p

Salonen, K. and J. Sarvala, Sources d'énergie pour la production
1994 secondaire au lac Tanganyika: Objectifs, approches et experiences initiales. FAO/FINNIDA Recherche pour 1'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/26 (Fr): 31p.

Hanek. G. and E.J. Coenen (eds.), Report of the Third Joint
1994 Meeting of LTR's Coordination and International Scientific Committees. FAO/FINNIDA. Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN—TD/27 (En): 181p.

Coenen, E.J., Report on the First Fisheries Statistical
1994 Coordinators Meeting for Lake Tanganyika, 12-13.12.1994, Bujumbura (Burundi). FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/28(En): 28p.

Coenen, E.J., Rapport sur la Première Réunion des Coordonnateurs
1995 des Statistiques des Pêches pour le lac Tanganyika, 12-13.12.1994, Bujumbura (Burundi). FAO/FINNIDA Recherche pour 1'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/28 (Fr): 30p.

Podsetchine, V. and T. Huttula, Hydrological modelling.
1995 FAO-FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
/RAF/271/FIN-TD/29 (En): 27p.

Podsetchine, V. et T. Huttula., Modè1e hydrologique. FAO/FINNIDA
1995 Recherche pour l'Aménagement des Pêches au lac Tanganyika
GCP/RAF/271/FIN-TD/29 (Fr) :22p.

Hanek, G. (ed.), Reports of Travel 46-60 of project
1995 GCP/RAF/271/FIN. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN—TD/30 (En): 95p.

Coenen, E.J.(ed.), Historical Data Report on the Fisheries
1995 Statistics, Limnology, Bromatology, Zooplankton, Fish Biology and Scientific Publications review of Lake Tanganyika (Zaïre). FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/31 (En): 153p.

Coenen, E.J. (ed.), LTR's Fisheries Statistics Subcomponent:
1995 March 1995 update of results for Lake Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/32 (En): 45p.

Hanek, G. (ed.), 1995 Lake Tanganyika Fisheries Directory/
1995 Répertoire des pêches du lac Tanganyika 1995. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/33 (En & Fr): 87p.

Kurki, H. and I. Vuorinen, Zooplankton Ecology of Lake
1995 Tanganyika report on the results of LTR's Scientific Sampling Programme. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN—TD/34 (En): 29p.

Kurki, H. and I. Vuorinen, Ecologie du Zooplancton au lac
1995 Tanganyika: rapport sur les résultats du Programme Scientifique d'Echantillonnage de RLT. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/34 (Fr): 32p.

Pakkasmaa, S. and J. Sarvala, Preliminary study and growth of
1995 the pelagic clupeids in Lake Tanganyika estimated from daily otolith increments. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN—TD/35 (En): 29p.

Pakkasmaa, S. and J. Sarvala, Etude préliminaire et croissance
1995 des Clupéidés pélagiques du lac Tanganyika estimée sur base des accroissements journaliers des otolithes. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/35 (Fr): 32p.

Sarvala, J. and K. Salonen, Preliminary Experiments on
1995 phytoplankton production ecology in Lake Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN—TD/36 (En): 38p.

Hanek, G. and George V. Everett, (eds)., Report on the Workshop
1995 on the Management and Planning of Lake Tanganyika Pelagic Stocks. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/37 (En): 79p.

Hanek, G. et George V. Everett, (eds.), Rapport de l'Atelier sur
1995 l'Aménagement et la Planification des stocks de poisons pélagiques au lac Tanganyika. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/37 (Fr): 78p.

Aro, E. and P. Mannini, Results of Fish Population Biology
1995 Studies on Lake Tanganyika during July 1993-June 1994. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN—TD/38 (En): 113p.

Aro, E. and P. Mannini, Résultats des Etudes sur le Biologie
1995 des populations de poissons au lac Tanganyika pendant la période de juillet 1993 — juin 1994. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN—TD/38 (Fr): lisp.

Bambara, S., Rapport sur l'Enquete Cadre Simultanée pour le
1995 lac Tanganyika, Burundi. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/39 (Fr): 36p.

Craig, J.F., Report on LTR's Third Scientific Sampling
1995 Programme Assessment Meeting, Kigoma, 17-19 July 1995. FAO/FINNIDA Research for The Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-TD/40 (En): 24p.

Craig, J. F., Rapport de la Troisième Réunion d'Evaluation du
1995 Programme Scientifique d'Echantillonnage de RLT, Kigoma, 17-19 juillet 1995. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN-TD/40 (Fr): 24p.

Plisnier P.—D., Catch Assessment Survey in Zambian Waters of
1995 Lake Tanganyika in 1994. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN—TD/41(En): 33p.

Plisnier, P.-D., Enquête d'Evaluation des Captures effectuée
1995 en 1994 dans les eaux zambiennes du lac Tanganyika. FAO/FINNIDA Recherche pour l'Aménagement des Pêches au lac Tanganyika.
GCP/RAF/271/FIN–TD/41(Fr): 36p.

Kotilainen, P., T. Huttula and A. Peltonen, Results of the
1995 period of March 1993 - December 1994 in hydrodynamics on Lake Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN–TD/42 (En): 106p.

B. Field Guides and Manuals

Plisnier, P.-D., Field Manual for the Second Year of
1994 Limnological Sampling on Lake Tanganyika. FAO/FINNIDA Research for The Management of The Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-FM/13 (En): 53p.

Peltonen, A. Operation manual for Aanderaa software.
1994 FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-FM/14 (En): 20p.

Hanek, G. (ed.) *R/V Tanganyika Explorer:* Guidelines and
1995 Procedures FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-FM/15 (En): 72p.

Ndahigeze, S. Updated catalogue of Regional Documentation
1995 Centre for Lake for Lake Tanganyika/Catalogue mis à jour du Centre Régional de Documentation pour la Recherche des Pêches au lac Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-FM/16 (En & Fr): 194p.

Hanek, G. and G. Pajot (eds.), *R/V Tanganyika Explorer:*
1995 Guidelines and Procedures (Revision 1). FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN–FM/17 (En): Sip.

Salonen, K. and J. Sarvala, Field manual for the determination
1995 of chlorophyll and primary production in Lake Tanganyika Research. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika.
GCP/RAF/271/FIN–FM/18 (En): 24p.

C. Travel Reports

No. 57: Lusaka, Chilanga and Mpulungu, Zambia and Kigoma, Tanzania: **G. Hanek** (7–20.2.1995), 3p.

No. 58: Bujumbura, Burundi and Kigoma, Tanzania: **A. Peltonen** (02–09.12.1994), 3p.

No. 59: Kigoma, Tanzania and Bujumbura, Burundi: **P. Verburg** and **E. Bosma** (14.01 – 24.02.1995), 4p.

No. 60: Kalya and Sibwesa, Tanzania: **A.D. Kihakwi and N.A. Chale** (18–22.02.1995), 3p.

No. 61: Kigoma, Tanzania: **P. Paffen** (07–14.03.1995), 4p.

No. 62: Bujumbura, Burundi, Kigoma, Tanzania, Mpulungu, Zambia and Lake Tanganyika: **T. Huttula and J. Nieminen** (02–19.06.1995), Sp.

No. 63: Kigoma, Tanzania**: E. Bosma** (02–19.06.1995), 3p.

No. 64: Second scientific cruise: **E. Aro, P. Mannini**, **I.M. Kimosa, E.R. Makere and A. Chale** (15.30.06.1995): 61p.

No. 65: Rome, Italy: **G. Hanek** (25-30.06.1995), 3p.

No. 66: Dar es Salaam and Kunduchi, Tanzania: **G. Hanek** (13–17.08.1995)

No. 67: Third scientific cruise: **V. Langenberg** (28.08–06.09.95), 31p.

D. Progress Reports

No. 6: Progress Report for July - December 1994, **G. Hanek,** 7p.

No. 7: Progress Report for January – June 1995, **G. Hanek,** 6p.

E. Other publications

LTR Newsletter No. 11 (December, 1994)

LTR Newsletter No. 12 (March, 1995)

LTR Newsletter No. 14 (June, 1995)

LTR Newsletter No. 15 (September, 1995)

ANNEX 4

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES
Bujumbura (Burundi), 15-17.11.1995

LTR SCIENTIFIC COORDINATORS' REPORT: SUMMARY OF SSP RESULTS

1. INTRODUCTION

This report gives the results of the LTR Project's Scientific Sampling Programme (SSP) mainly for the year 1994-1995 but including a synopsis on the findings of the two full years of research 1993-1995. The results were derived from published LTR technical documents, those in preparation and abstracts of papers presented at the Symposium on Lake Tanganyika Research September 11 – 15, 1995 Kuopio, Finland (Mölsä 1995).

The main objectives of LTR's scientific research are to develop a model of biological productivity and incorporate this into a management plan for the lake.

The principal methodologies used by LTR to achieve the objectives have been data collection, processing and analysis at fixed stations and using *R/V Tanganyika Explorer* for lake wide surveys. Sampling at fixed stations started in 1993 but the first scientific cruise did not commence until April 1995. In the first phase of LTR, two years of intensive sampling were carried out in hydrodynamics, limnology, zooplankton and fish biology. The present phase involves the development of the predictive, biological model, fish stock assessment from lake wide hydroacoustic surveys combined with mid–water trawling, continuous basic monitoring and the development of management techniques. A long term programme of monitoring is now in place to provide continuous assessment of the fish stocks so that progressive adjustment can be made to the fisheries management plan.

The pelagic zone of Lake Tanganyika has a unique fish fauna of clupeids and their predators, four *Lates* species. Production from these pelagic fish has shown wide natural fluctuations.

from these pelagic fish has shown wide natural fluctuations. Understanding the mechanism behind these cycles is complicated by the increasing fishing pressure applied to the stocks from the artisanal fisheries and shifts in areas fished by the industrial fleet. The fishing has influenced the species composition as in recent years the catches have been reduced to the two clupeids, *Limnothrissa miodon* and *Stolothrissa tanganicae,* and one predator, *Lates stappersii.* The fishing effort varies on a lake wide basis from heavy exploitation in Burundian waters and the Mpulungu area of Zambia, to very light exploitation in the main parts of the lake, especially the central and open parts, belonging to Tanzania, Zambia and Zaïre.

The long term cycles in fish production of Lake Tanganyika are dependent on complex relationships between abiotic and biotic factors as well as the effects of fishing pressure on various parts of the stocks. Although the predictive model still needs to be derived, the links in the Lake Tanganyika's production system have been partly elucidated (see below). The basis of production is dependent on upwelling events, mixing of the productive surface waters and probably high levels of turbulence. There is an enormous reservoir of reduced substances in the hypolimnion. These substances could be made available by short periodical upwellings caused by episodic strong winds especially during the dry season. They may induce abundant primary production in the epilimnion, near the thermocline. The baroclinic model which has been developed provides a numerical tool to forecast the occurrence of the upwellings in space and time. The exchange of water between the epilimnion and hypolimnion can be activated by the upwellings. Another simpler method to predict upwellings uses Wedderburn numbers. These indicate the stability of the thermocline and thus the extent of mixing and might be used for prediction of primary production and thus potential fish yields. The NRI study of Lake Malawi compared, over a two year period, Wedderburn numbers derived from temperatures collected by remote sensing and wind data. One period of low Wedderburn numbers was reported to be a period of high primary productivity and high pelagic fish yields. The fish production in the pelagic zone of both these lakes is, however, a result of highly dynamic interactions between the nutrients, primary producers and consumers. Consumers show remarkable adaptation to predation and competition in the food web.

The results of LTR's activities will provide unique information about long term changes in the pelagic fish stocks and the capabilities to predict these fluctuations.

2. ACTIVITIES IN EACH RESEARCH COMPONENT

2.1 Hydrodynamics

The hydrological component combines field measurements with computer modelling. The main aims of the latter are to estimate the role of the major factors affecting water currents in Lake Tanganyika and to understand the peculiarities of spatial and

temporal variations of horizontal and vertical components of velocities, free—surface and water temperature. The model is three—dimensional. Numerical experiments with barotropic and baroclinic versions of the model revealed extremely high spatial irregularity (patchy structure) of upwelling zones on a lake—wide scale. Special attention was given to more accurate descriptions of wind—induced shear stresses, the main driving force of the lake dynamics. Recent experiments showed the significant role of the land-lake breeze system, which is intensified during the dry season, when south—easterly trade winds supply most of the energy to the lake. In the northern and southern parts the wind is thermal in origin, and during the dry season when the air temperature differences on land and on the lake are the highest, the winds are the strongest. Daytime winds are then onshore and night time winds are offshore. In the open and middle part of the lake the wind pattern, as recorded at Kigoma and Kipili, is not clear.

Currents around the lake are very variable following local and seasonal wind patterns and having a possible, but not always, clockwise circulation in the southern part of the lake. Water currents, measured in the field off Mpulungu during the dry season, were related to main upwelling events. Their presence was associated with the general homogeneity of water temperature and increased concentrations of nutrients (see Section 2.3). Internal waves have been recorded for the first time with automatic devices in this part of the lake. They are spread in all water layers. Spectral analysis revealed periods of 23.4 days in temperature fluctuations in the dry season at depths of 50, 150, 200 and 300 in and also at 70, 90 and 110 in but less significantly. These temperature fluctuations were not found near the surface due to the ‘noise’ of shorter term fluctuations. The small density gradient in the upper layers and intensive vertical mixing make it possible for noisy fluctuations to penetrate downwards. The thermocline prevents their penetration. Thus below the thermocline this outer, noisy component decreases and internal waves are more clearly found. The period of internal waves is 23.4 days in the dry season and 34.8 days in the wet season. The shorter period in the dry season is due to periodic forcing by the winds. The frequency of the waves support the theory that they are Kelvin internal waves. These waves may occur, but more weakly, in the Kigoma area with a periodicity of 26.3 days.

Water level changes seem to be mainly related to evaporation and rainfall. The importance of afferent and efferent rivers in the water budget is still under debate.

Destratification during the dry season in the southern part of the lake has been observed. Destratification is probably induced by the strong southerly winds and by surface cooling through evaporation.

2.2 Remote Sensing

In the early stages of the study, two thematic maps were calculated from the original images, a vegetation map and a temperature map. The vegetation map was not found to be useful but the temperature map could be related to the dynamic model of the lake. Later nine images of fourteen qualified data files were analysed against simultaneous ground station measurements and a regression equation derived to predict temperature. Routine procedures were established at the University of Kuopio, at no cost to the LTR project, to obtain Meteostat images and to analyse Eurimage pictures including geometric rectification. No atmospheric correction has yet been made. A PC programme for estimating the exact passing time of the NOAA satellite was made available.

Due to the long delivery time of satisfactory satellite images, the collection of simultaneous ground—truth temperature data has been less successful. Therefore the calibration of the satellite imagery was based on automatic temperature measurements taken by one meteo—station buoy. From 1994 data from two stations have been utilised.

2.3 Limnology and Carbon/Energy Budget

The limnology component has gathered information on the variability, in time and space, of some of the main physical and chemical water parameters in order to better understand how these might affect the abundance of zooplankton and fish. In turn, the information on fluctuations of limnological parameters in the water column on several time scales can be linked to the hydrodynamics of the lake.

Water temperature and dissolved oxygen are particularly significant in the lake’s limnological system. Annual variations in water temperature are probably caused by winds (force and direction). A strong southerly wind dominates the dry season (June to August) and loss of heat is caused mainly by evaporation. Upwelling of cooler water in the south reinforces the horizontal temperature gradient and movement of surface water towards the north under wind stress. During the dry season stratification breaks down at the south end and becomes very weak throughout the south basin (see Section 2.1). In the north basin a thermocline persists. About the upper 50 m are isothermal throughout the lake. At the beginning of the wet warming season (September to November) the southerly winds become less strong and change from south to north. Heat uptake by the lake is greatest in the south. At the north end isotherms rise 30 to 40 m in early September and the thermocline becomes less sharp. In October the heat content of the epilimnion is unevenly distributed along the lake, being much warmer as well as deeper in the south. By the beginning of December, (the season of maximum stability occurs from December to May) the thermocline reaches a depth of about 50 m. The thermocline deepens in January and is deepest during April to July.

When the thermocline starts to descend, ammonia, nitrite and nitrate are hardly detectable in the epilimnion. Concentrations of nitrate and nitrite peak within the thermocline. The oxicanoxic boundary acts as a sink for fixed nitrogen. In the deeper anoxic layers ammonia is the dominant form of inorganic nitrogen. The nitrogen cycle is restricted to the upper water layers. Normal diffusion flows of the nutrients through the thermocline are unlikely to determine the nitrogen balances in the epilimnion. Other sources of nutrients are thus very important including – 1) short periodical upwelling of nutrient rich hypolimnion water (phosphates, ammonia which rapidly oxidises and silicates) -internal wave oscillations have been observed of periodicity 23–42 days (see Section 2.1) and amplitude 15–20 m, 2) *in–situ* biological nitrogen fixation 3) precipitation (rainwater can contain considerable amounts of phosphates and inorganic nitrogen), 4) air borne dust (most probably aerosols), 5) terrestrial run–off, and 6) nutrient release by biotic activity. Nitrogen can be replenished during thunder storms.

Particulate nutrient ratios are closer to marine than lacustrine values. Nitrogen and possibly phosphorus may be limiting. Preliminary experiments with a field incubator on board *R/V Tanganyika Explorer* in April and May 1995 indicated that the production of phytoplankton was limited by these nutrients.

The occurrence of upwelling during the dry season in the south was related to nutrient increase and higher catches of clupeids. A tilting of the thermocline by wind forces was followed by a period of prominent movements of water between the south and north. This was reflected in a periodic fluctuation of several factors. Conductivity and pH were particularly good indicators of the oscillation of water masses. The occurrence of relatively strong wave action in the south during a no wind period has been observed at the end of the dry season off Mpulungu and appeared to occur along the whole southern shore. These periods were reported by fishermen to be associated with fish kills and sometimes with planktonic blooms. The displacement of warmer epilimnion water towards an equilibrium appeared to be the main cause of the internal waves. Off Bujumbura, Kigoma and Mpulungu these internal waves resulted in fluctuations of temperature, pH, turbidity and nutrient concentrations.

Weather conditions may have a profound effect on phytoplankton production, negative on clear sunny days and positive on moderately cloudy days after rain. The water from heavy rainfall is colder and thus denser and moves deeper mixing the epilimnion. At the end of the windy, dry season in September the photic zone is deep (maximum 30 m). During the rainy season the surface inhibition is less pronounced. In December chlorophyll a and primary production are possibly closer to the surface than in April. The zooplankton is below 20 m during the day which reduces grazing on the algae.

There is an enormous reservoir of reduced substances in the hypolimnion, intense denitrification at the oxic–anoxic

boundary, a secondary maximum of zooplankton just above the anoxic layers, clupeids in the oxic layer, high chlorophyll concentrations throughout the epilimnion and living phototrophic organisms at 60 m. Mixing caused by internal waves may induce the abundant growth of bacteria and/or algae near the thermocline. The danger of being swept into unfavourable zones is minimal but stirring provides fresh supplies of nutrients from the hypolimnion.

The yearly cycle of limnological factors may show significant correlations with the abundance of protozoa, zooplankton and fish. The loading of nutrients into the upper water layers by internal waves and associated vortices during turbulent processes could play a major role in lake production.

2.4 Fish and Zooplankton Biology

The zooplankton is dominated by *Tropodiaptomus simplex* (calanoid) and Cyclopidae. Minor constituents are medusae *(Limnocnida tanganyicae),* shrimps (Caridea), fish larvae and *Vorticella* spp. In the northern end cyclopoids dominant (68% Bujumbura and 73% Kigoma) and in the south, Mpulungu, cyclopoids and *T. simplex are* found in equal numbers. Zooplankton densities are highest in the northern part of the lake and lowest in Mpulungu waters when data are pooled. There are possible annual fluctuation patterns with two or three abundance maxima within one year depending on the Copepoda group and the sampling site. High numbers of egg carrying females of *T. simplex* were collected in September and October 1993 off Bujumbura and off Mpulungu. A clear reproduction peak was observed in April 1994 off Kigoma. In the Kigoma area diel vertical migrations of *T. simplex* copepodids and adults were noted. *T. simplex* probably seeks refuge in deeper water layers from visual predators (clupeids). At dusk it ascends to the surface and grazes on phytoplankton. Vertical distribution may also be related to photo-inhibition. The vertical distribution of Copepoda is restricted to the top 60 m off Bujumbura while off Mpulungu they are found down to 220 m, probably due to the availability of dissolved oxygen.

Dry weight biomass of zooplankton was determined using the dry weight values from the literature. Zooplankton samples were collected in December 1994 for carbon content analysis but the analysis has not yet been completed. Mean dry weight biomass of Copepoda for the first sampling year was off Bujumbura 3478 mgm^{-2} off Kigoma 2275 mgm^{-2} and off Mpulungu 1479 mgm^{-2} . The values for the second sampling year, which were similar to the first year, were 3021, 2108 and 1650 mgm^{-2} for each area respectively. It is of interest to note that Burgis (1984) gave a mean dry weight biomass of 4820 mgm^{-2} for the whole lake.

Pelagic shrimps appear to play an important part in sustaining *L. stappersii* stocks in the south. In this region, where the zooplankton density is lowest and the shrimps most abundant, the only remaining industrial fishery of the lake is for *L. stappersii.* In the north of the lake the fisheries are based on clupeids where the zooplankton abundance is highest and the number of shrimps lowest.

The size of clupeid stocks is closely related with zooplankton density in different parts of the lake although this has to be quantified. This may be done when suitable data are collected from the cruises. Reproduction and condition of clupeids appear to be linked to zooplankton production and food availability.

Until the commissioning of *R/V Tanganyika Explorer,* the study of the fish biology component was based on the catches of fishermen. All main fishing gears used to capture pelagic species (liftnet, purse seine and beach seine) have been regularly sampled. In order to reduce bias due to the possible schooling behaviour by size of some of the species, sampling has been carried out with a relatively high frequency, once a week, and has included 9 to 13 fishing units per month. Ancillary catch information has also been collected to enable information on relative abundance (CPUE) to be derived. Such derived statistics should be used with caution since the small, shoaling, pelagic fish are artificially attracted by light. The limitations of commercial catch data are known. Within LTR's study, the use of such data is primarily to provide information on exploitation patterns of the target species in the different areas of the lake. Furthermore, taking into account the characteristics of the fishing gears, the available data have and will be used to investigate the population biology and life cycles of the three main species, *L. miodon, S. tanganicae* and *L. stappersii.*

L. miodon is well represented in all sampling areas. The largest fish are found offshore and caught by purse seines. Juveniles occur in shallow, inshore waters where they can be caught in large numbers. Total number of specimens and catch per unit effort (CPUE) are highest in the southern part of the lake and lowest in the north. Full recruitment to the liftnet fishery is at 65 mm. The fisheries in the south exploit a wider size range than in the north. Young fish are more vulnerable in the south due to the use of beach seines and seines covered with mosquito netting which catch fish from 15 mm. Females grow larger than males. The overall sex ratio of male:female is 1:1.8. Males and females reach mean length of maturity (L_m) at 97 and 102 mm in the north and 90 and 86 mm in the south. The reproductive cycle is not very clear especially in males.

S. tanganicae is caught in all the sampling areas although very few are caught in the Mpulungu area. Largest catches and highest CPUEs are in areas where the open pelagic zone is closest to the shore line. The species is more abundant than *L. miodon* in most parts of the lake. The fish are fully recruited to the liftnet fishery at about 55 mm. The size distribution of the catch is dependent on the gear employed. As for *L. miodon* a wider range of length groups are exploited in the south than in the north but the catch is much smaller in the former. The sex ratio of male:female is overall 1:1.8. Males and females reach L_m at 77 and 79 mm respectively in the north, 79 mm for both sexes off Kigoma and 75 and 77 mm respectively in the south.

L. stappersii is not abundant in the north part of the lake, usually only immature specimens are observed in the

catches near Uvira and Bujumbura. Fishing pressure is thus only exerted on the juveniles in this region. The main distribution of this predator appears to be in the central and southern parts. Exploitation is highest off Mpulungu. The sex ratio of male:female is 1:1.2 overall. In the south the largest number of spawners are found in March (many females are ripe from November to April off Mpulungu and about half of the males are ready to spawn all the year round). Off Kigoma the main spawning period is August, the largest number of ripe males are found in this month. The proportion of ripe males then declines until March and then increases from April to June. L_m values for females are 277 mm off Kigoma and 230 mm in the south compared to males of 273 mm (Kigoma) and 222 mm (in the south).

Von Bertalanffy growth curves, length-weight relationships and mortality rates have been estimated for the three main, commercial, pelagic species. All species display relative fast growth which is similar throughout the lake. *S. tanganicae* has the shortest lifespan, 1.5 yr, compared to *L. miodon,* 2.5 yr, and *L. stappersii,* 7 to 8 yr. *L. stappersii* has a higher total mortality rate (Z) in the south compared to the Kigoma area and it would appear that this is caused by a higher fishing mortality (F).

Fish aging using otoliths has been undertaken. Increments should be regular due to diel movements of zooplankton, and thus the regular feeding of clupeids, and to the stable light and dark photoperiod. However the method as yet does not appear to be very useful in larger (older) fish as the otoliths are not easy to read and need careful preparation. Daily growth increments from the whole otolith could only be counted for small *L. miodon* and *S. tanganicae.* Results have indicated that 60 mm *L. miodon* were 120-160 days old compared to 150-160 days for *S. tanganicae* of the same size. *L. miodon* of 100 mm were aged between 250 and 350 days old.

Results obtained from length-based methods and otolith readings have been in good agreement and can be used to describe fish growth over most of the size ranges encountered. As mentioned above, uncertainty exists when aging larger fish. Otolith readings are expected to be particularly useful in describing juvenile growth. Backward projection of the growth curve, calculated by length-based methods, is inappropriate in explaining this growth.

2.5 Fish Genetics of Pelagic Fish

No clear picture about stock segregation of the pelagic fish species has been made. Genetic differences between *S. tanganicae, L. miodon, Lates mariae* and *L. stappersii* collected from five to six localities were examined using Random Amplified Polymorphic DNA (RAPD-PCR). Preliminary results indicated the possible presence of geographically local populations but there was no evidence of total reproductive isolation. Further studies are required before any definite conclusions can be made about population discreteness and its implications for fisheries management. No further analysis has been carried out since the

end of 1994 due to lack of funds.

2.6 Fisheries Statistics

Considerable support has been provided in the collection of historical data of fish catches in the four riparian countries. Catch assessment surveys (CAS) and frame surveys (both aerial and ground) have been carried out. Catches appear to be increasing on a lakewide scale due to the introduction of more efficient artisanal fishing gears.

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ANNEX 5

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

SUMMARY OF THE LTR PROJECT EVALUATION MISSION REPORT

Project		
Symbol	:	**GCP/RAF/271/FIN**
Title	:	**RESEARCH FOR THE MANAGEMENT OF FISHERIES ON LAKE TANGANYIKA**
Donor		**FINNIDA**
Budget	:	**US$ 5,728,874**
Duration	:	**January 1992 to June 1996**

Evaluation: In accordance with the provisions contained in the project document, and line with the decisions reached at the Third Joint Meeting of the LTR's Coordination Committee meeting, the evaluation mission took place from 25 April through 26 May 1995.
Prof. Jukka Salo of the Biology Department of the University of Turku in Finland represented FINLAND, and Dr. Fritz Roest of the Wageningen Agriculture Research Institute of the Netherlands represented FAO and acted as Team Leader. The mission was assisted by a designated representative in each participating country (Burundi, Tanzania, Zaïre, Zambia).

Main Findings: The project was found to fill an important need, since lack of research on pelagic fish stocks and the biological basis for fish production have been major obstacles to fisheries planning, development and management on Lake Tanganyika. The scientific programme of the project was felt to provide the basis for regional lake–wide management. Although there were sociopolitical problems in some of the participating countries, the activities of the project were largely being carried out on schedule, except for the limited level of the operations and inputs in Zaïre. Only the lake-wide survey programme was behind schedule, due to difficulties in acquiring a suitable vessel. Of the various options explored, the eventual solution of leasing the *R/V Tanganyika Explorer* was considered by the mission the

only feasible alternative. The vessel has been delivered to the project at the end of April 1995 and the survey programme started the same April 1995. While nationals of the participating countries had been fully involved in project implementation, there were constraints which made it unlikely that the countries could take over research and planning in the near future.

The Mission assessed all aspects of implementation and examined the progress of each component of ongoing research both at field level and at the University of Kuopio, who provide their professional experience towards the scientific coordination to the project.

The mission expressed its appreciation for the level of project implementation, the intensive sampling programme, the LTR documentation and for the sound management under often difficult conditions.

The mission members considered that the research effort should have been matched much more explicitly, and already at the time of formulation, by support to the four riparian countries towards a mechanism for an effective collaborative management practice. The "Workshop on Management" of June 1995 was considered a first important step to build upon. Continuity in provision of a solid scientific background to the overall management of Lake Tanganyika's resources could ultimately come forward only from the countries' own research institutes, which implies a stronger awareness at all levels of the need for continued monitoring of the resources. LTR had been instrumental in fostering such awareness.

Major Recommendations: Based on the above findings, the mission recommended that the **project be extended for two and half additional years as of January 1997 to**:

- integrate the data available after two full years of collection and formulate conclusions of various research subcomponents to define or adapt interdisciplinary working hypotheses to be tested in the field. Such information should be complemented with economic data to form the basis for the formulation of a draft management plan that can be refined as and when more detailed data become available;

- identify minimum data requirements for national monitoring of fish stocks, of commercial catch statistics including economic data, and of impact on environment;

- contribute to enhance the capacity of the participating institutes through their closer and more systematic participation in the scientific coordination and through a more active involvement in the conceptual development of the research programme;

- make every effort to establish a research base also in Kalemie, Zaïre.

The advice was to use this period to test working hypotheses through continued lake–wide research cruises, and to primarily provide initial management support to assist riparian countries in the building up of a management practice at the national and regional level. The regional approach would contribute to the integration of the various regional Lake Tanganyika projects.
FAO had already been for some time in the process of negotiating full collaboration between LTR and the GEF project "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika". The eventual establishment of a regional single body would place participating countries in a better position to implement their management plan and to also qualify for longer–term external support.

The evaluation mission pointed out clearly project achievements and the importance of the project contribution to biodiversity and environment protection of L. Tanganyika, particularly if LTR's achievements could mesh into the GEF project work, which is mainly addressed to inshore and artisanal fisheries with no priority to commercial fisheries, to contribute to GEF's efforts on maintaining biodiversity of inshore fisheries.

The mission identified the need for long–term engagement as even more essential in view of the complementarity of many LTR activities with the GEF project which was about to be approved. They recommended LTR should, during a second phase, exert the maximum attention to foster close interaction with the GEF programme to attain the common intent of contributing to the maintenance of biodiversity and environment safeguard of L. Tanganyika.

N.B. Findings and Recommendations represent the views of Mission members and do not necessarily reflect those of FAO, **Government of Finland or participating countries.**

ANNEX 6

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

SUMMARY OF THE LTR WORKSHOP ON PLANNING AND MANAGEMENT OF LAKE TANGANYIKA PELAGIC STOCKS

1. Following up on one of the recommendations of the Third Joint Meting of the LTR Committees, held in Kigoma, Tanzania from 28 to 30 November 1994, the project 'Research for the Management of the Fisheries on Lake Tanganyika' (LTR) organized the first Workshop on the Planning and Management of Lake Tanganyika Pelagic Stocks in Bujumbura, Burundi, from 1 to 3 June 1995.

2. Taking part were the following: Messrs. R. Kanyaru and B. Nyakageni (Burundi), Ms. E. Lyimo (Tanzania), Messrs. B. Makombo, W.B. Muyenga and W.B. Mambona (Zaïre), Dr. R. Mubamba and Messrs. C. Muziya and D. Chileshe (Zambia), Prof. O.V. Lindqvist (Finland) and Messrs. G.V. Everett and G. Hanek (FAO).

3. All the country statements *(i.e.* by Mr. Nyakageni for Burundi, by Ms. Lyimo for Tanzania, by Mr. Makombo for Zaïre and by Dr. Mubamba for Zambia) as well as presentations of Prof. Lindqvist and Messrs. Everett and Hanek provided the basis for a very effective and productive discussions. All participants, including those representing the fishing communities in all riparian States, took part in the discussion.

4. The country delegations were given the time to formulate and prepare a number of specific and general recommendations regarding the establishment of an appropriate management of Lake Tanganyika pelagic stocks.

5. The Workshop conclusions and recommendations were adopted aboard *R/V Tanganyika Explorer* on 3.6.1995 and are now presented herein.

CONCLUSIONS AND RECOMMENDATIONS

6. Participants noted that the important pelagic stocks of Lake Tanganyika are shared by all four riparian States. It was agreed that the level of their exploitation varies greatly. It was further agreed that this Lake's stocks and fisheries are interdependent and therefore concluded that these stocks should be managed as one entity.

7. Participants noted that although the legislation relating to the management of fisheries in Lake Tanganyika exists in each of the four riparian States it differs with regard to measures such as licensing of vessels, closed seasons, closed areas and minimum mesh size of nets. It was agreed that cooperation was required in establishing the legal framework for the management and development of fisheries in particular for Lake Tanganyika where there is a high incidence of shared stocks and for the formulation of harmonized legislation and corresponding regulations to be adopted by each country within that framework.

8. It was recommended that a draft text of harmonized fisheries regulations be drawn up for consideration at a workshop composed of lawyers and fisheries administrators from each riparian State.

Participants in the workshop recognized the great importance of Lake Tanganyika fisheries in:

(i) the supply of fish to the subregion and within the overall strategy of food security (as emphasized by the Director General of the Food and Agriculture Organization of the United Nations) ;

(ii) its place in the economy particularly in the field of employment and incomes.

9. Participants agreed that the overall objective of a fishery management plan for the Lake was conservation of the fishery resources for the economic benefit of the citizens of the four riparian States.

10. In view of the ratification, in 1994, of the United Nations Convention on the Law of the Sea (and the worldwide acceptance of terms as stated in articles 61 and 62 for allocation of excess resources) it was recommended that each riparian State ensure the optimal utilization of fish resources in its area of jurisdiction, and give neighbouring States access to the surplus of the allowable catch, once determined (where one State does not have the capacity to harvest the entire allowable catch).

11. Lakeside communities and fishers should be brought into the process of fishery management along with government authorities. Fishing activity should be monitored through surveillance of the fishing effort and national authorities should take appropriate measures to control fishing activity in cooperation with the lakeside communities and fishers in the interest of resource conservation throughout the lake.

12. The workshop agreed on the need to monitor economic information, so as to assess social and economic benefits and contribute to optimal management of the resources as a complement to the hydro-biological work undertaken in the framework of activities of the FINNIDA/FAO Project for Research for the Management of the Fisheries of Lake Tanganyika. The participants (as official representatives of their respective governments) requested donors to provide funds, in addition to funds to be made available, if possible, from governments of riparian States, to allow the social and economic data collection and analyses to be intensified, and, for urgent and immediate initiation of activities, requested the Director General of FAO to make available funds from the Technical Cooperation Programme (TCP).

13. Participants also requested that TCP funds be made available so as to prepare for and organize a workshop on requirements for establishing the Lake Tanganyika Fisheries Commission and associated harmonization of fishery laws and regulations, and necessary training for management of the Lake's fisheries.

14. In order to improve the safety and working conditions of the fishermen and other users of the Lake the participants requested that efforts be made to find the required funding in order to prepare navigation charts for Lake Tanganyika.

ANNEX 7

FOURTH JOINT MEETING
OF THE LTR'S
COORDINATION AND INTERNATIONAL SCIENTIFIC COMMITTEES

Bujumbura (Burundi), 15-17.11.1995

PROPOSAL FOR THE 1995/96 SSP

1. INTRODUCTION

Plans for sampling in 1995/96 are given below as discussed at the SSP Assessment Meeting held in Kigoma during 17-19 July 1995 (Craig 1995). The next period must be mainly used for data analysis and interpretation.

Important areas for consideration are as follows:

a) Segregation of stocks - to complete the analysis of the population and stock discreteness, alternative approaches to the RAPD-DNA method, which has not been cost-beneficial, have to be considered. For example complete the genetic analysis with mDNA studies and undertake morphometric and fish biology investigations (breeding grounds, nursery areas, migrations). Continuation of RAPD-DNA methods may be possible with further allocation of resources through joint efforts with OPS/NRI.

b) Fluctuations in abundance and biomass of pelagic fish stocks — correlations with biotic and abiotic factors/ reproduction and recruitment, predator prey relationships, fishing pressures on various parts of the stocks.

c) Recruitment and life history tactics of pelagic fish stocks (factors controlling recruitment, spawning period, parental stock size, stock fecundity, juvenile survival).

d) Remote sensing will be related to hydrodynamics and limnology by providing results of horizontal patterns of water characteristics (mainly temperature). Temperature observations will be included in hydrodynamic and circulation modelling developed by the LTR and OPS/NRI projects, respectively.

e) Can a model for primary production be derived based on weather conditions, solar radiation, epilimnetic mixing and zooplankton biomass?

f) What is the role of bacteria and protozoa in the primary production?

2. SSP3

The third year of investigations, 55P3, will place the main emphasis on basic monitoring, scientific cruises and specific investigations.

(a) Basic Monitoring

Regardless of the length of time that LTR continues, basic monitoring should be continued by national staff. The statistics gathered from this monitoring will be used in the management of the pelagic fish stocks. The basic monitoring programme will be as follows:

1) Hydrodynamics - Data collection by the automatic stations.

2) Limnology - The A/H and A/CE (carbon/energy) sampling. Each every two weeks alternating with each other.

3) Zooplankton - Three hauls with 100 µm net during limnology sampling at site A every week.

4) Fish - Total catches and effort from weekly landings. Length frequency, maturity, and gonad weight measurements twice a month during fishing periods.

5) Fish statistics - continue to collect by country. This should be a regular programme.

(b) Scientific cruises

Two types of cruise are planned, a) combined hydrodynamics and limnology (including primary production and collection of phytoplankton, bacteria and protozoa) and b) fish. Each type will be carried out bimonthly i.e. they will alternate with each other.

Specific hydrodynamics studies should be combined with limnology sampling and the use of Gulf nets to collect fish larvae and shrimps. Two types limnology sampling are proposed, deep (D) and surface (epilimnion) (E), 0 to 40 m. Only a few deep (D) investigations should be made since sampling will be intensive while surface (E) sampling should have a relatively high frequency, El every 30 km and E2 every 60 or 90 km. Samples taken for D and E2 should be analysed for SD, temperature, DO, conductivity, pH, turbidity, chlorophyll a, fluorescence, TP, TDP, SRP, TN, NH4+, N03-, N02-, alkalinity and silicates. Those taken for El should be analysed for SD, temperature, conductivity, chlorophyll a and fluorescence. Experiments on primary production should be performed using the on board incubator.

Ideally fish cruises should be carried out every month to accurately measure the dynamics of the pelagic fish populations. In practice they should be spaced by no more than two months. Priority will be given to investigations of fish temporal and

spatial biomass distributions and predator/prey relationships. Limited abiotic measurements including secchi depth (during daytime sampling) and, in particular, using the CTD, should be taken at the same time. The first combined acoustic and mid—water trawl cruise in June 1995 indicated the importance of lake-wide surveys in providing information on pelagic fish life histories which, at present, LTR lacks.

(c) Specific investigations

Hydrodynamics

The hydrodynamics component will study Huttula's new proposal concerning current measurements in deep water. If funding allows (through GEF) new automatic current devices should be ordered.

Limnology

The limnology component will put more emphasis on the A/H (traditional sampling extended with one horizontal sampling at the surface and chlorophyll *a* analyses) and A/CE sampling (traditional sampling extended with primary production measurements). Phytoplankton should be collected and identified every two weeks if possible but at least every month, throughout the year.

Zooplankton

Detailed investigations will be carried out on the shrimps and fish larvae collected during the cruises. The carbon content of the zooplankton species of Lake Tanganyika will be determined. Growth rates, turnover rates and P/B ratios of *T. simplex* and cyclopoids will be estimated. Copepoda will be reared in the laboratory at Kigoma from November 1995.

Fish biology

Detailed studies will be made on the fecundity and reproductive patterns of the clupeids and *L. stappersii.* The importance of shrimps in the pelagic food web will be investigated.

Remote sensing

By analysing the 'quick-look' of AVHRR Meteosat pictures of ESA or Internet sources (Edinburgh), the appropriate seasonal window (clear sky) can be obtained for closer viewing. The analysis, at no charge to the LTR project budget, will be performed at the University of Kuopio. It will concentrate on lake—wide observations of surface temperature patterns, on integration with hydrodynamic modelling (with special reference to upwelling and horizontal currents) and on seasonal patterns of lake limnology.

To verify the satellite data, three types of ground-truthing will be undertaken: a) temperature measurements from the surface sensors of the two thermistor buoys (Mpulungu and

Kigoma); b) CTD measurements taken during cruises with *R/V Tanganyika Explorer* and in the vicinity of the stations; and c) specific measurements of surface temperature and chlorophyll a on defined dates. The last scheme includes sequential measuring points at 500 m distances and the collection of water samples at 0330 and 1530 h (Burundi time). The dates of such calibration work will be selected to correspond with the delivery of NOAA AVHRR images from South Africa. In addition the exact passing time of the NOAA satellite over the lake can be estimated with a PC programme made available to LTR. Alternative sources of satellite images will be investigated.

Fish genetics

Through joint efforts with OPS/NRI, the ongoing RAPD-DNA analyses of pelagic clupeids and *Lates* species will be completed. Samples will be collected during cruises. Results from the fish biology component will be used to identify the breeding and migratory patterns of the major species. Complementary studies of mDNA will be made in collaboration with other international groups.

3. FUTURE OUTLOOK

If the project continues into Phase II, compilation of the scientific data will follow the following format. Station reports should be ready by December each year when a staff meeting will be held. Component draft reports will be available by January and final reports by March. A meeting to present and discuss progress will be held in June. Apart from basic monitoring, data collection will cease in December 1997 and final synthesis of the data will occur from February to June 1998. A final science report will be produced in June 1998.

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