1 Lake Monitoring

1.1 Objectives

The objectives of the Lake Victoria monitoring programme are to obtain data for:

- Determination of the present state of the lake water quality and ecosystem.
- Analysis of the relative importance of the biological processes and limiting factors in the eutrophication of the lake.
- Calibration of the Lake Victoria Framework Model.
- In the long term, monitoring the changes in the lake.

To achieve these objectives a programme for monthly and quarterly sampling on the lake was agreed on by the participating countries. The lake model consists some 8000 (20 vertical x 400 horizontal) grid cells with 38 state variables and bearing in mind that a proper model calibration requires about 1000 data per state variable a sampling programme would need careful planning. Thus the Consultant's tasks in the monitoring were to provide advice and assistance in:

- In planning of monitoring cruises for the three countries.
- In preparing on-board procedures and field forms for recording of field observations.
- Providing hands-on training by participation in sampling cruises.

1.2 Methods

1.2.1 Cruise planning

During the kick-off seminar a monitoring programme consisting of monthly and quarterly sampling cruises was agreed upon by the three countries. The monitoring stations are shown in Figure 1.1 and a summary of the number of cruises in Table 1.1.

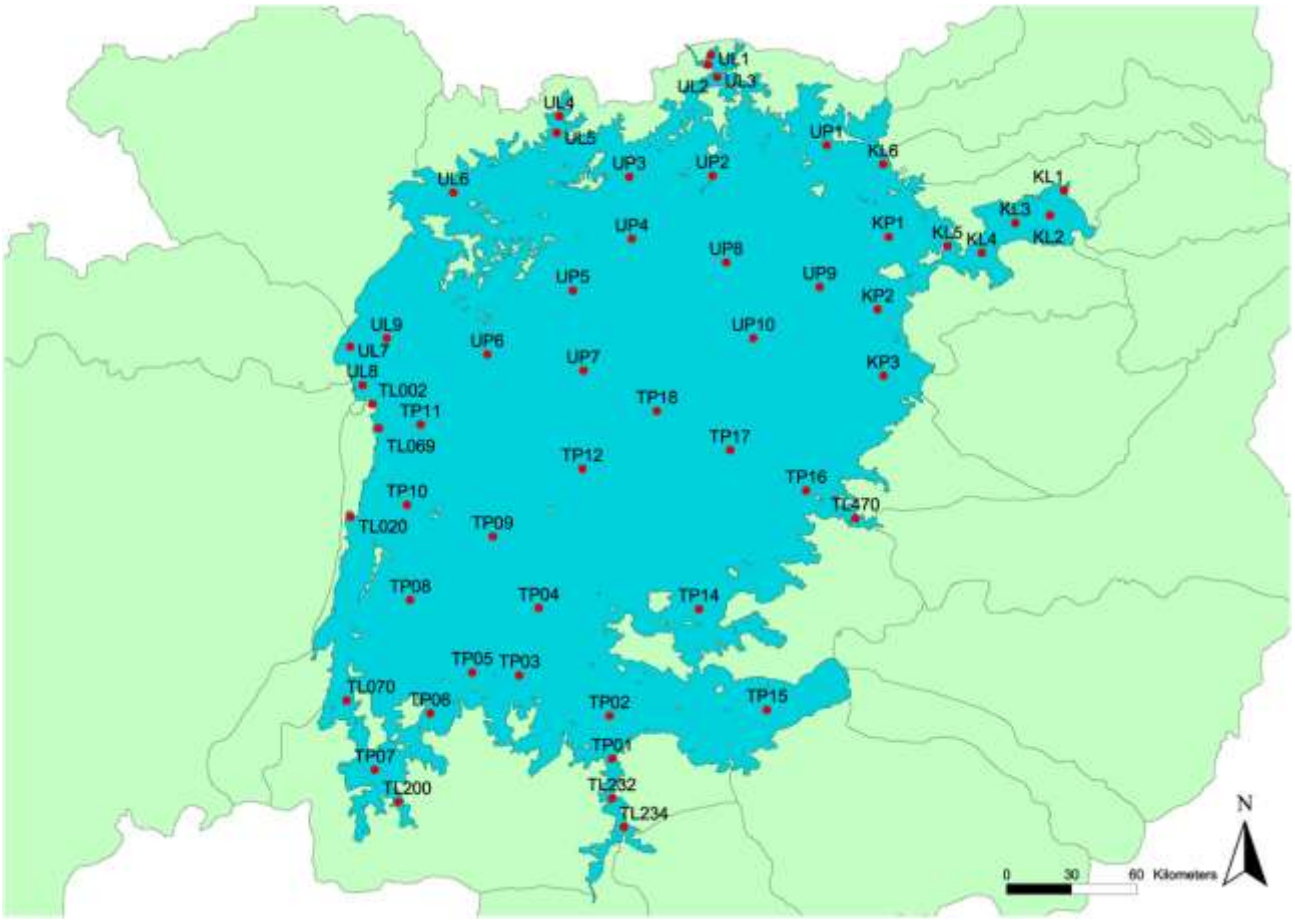

Figure 1.1 Monitoring Stations in Lake Victoria

The naming convention for the stations is as follows:

First letter : Country. K = Kenya, T = Tanzania, U = Uganda.
Second letter: L = Littoral (inshore). P = Pelagic (offshore).

The locations of the stations were chosen so that, as near as possible, they lie on transects along and across the lake.

The survey vessels used by the WQ Components were made available by the fisheries institutes in each country:

- RV Utafiti (KEMFRI)
- RV Tafiri II (TAFIRI)
- MV Mputa / RV Ibis (FIRRI)

The vessels are shown in Figure 1.2 to Figure 1.4.

Table 1.1 Summary of the planned cruises.

Stations	***Kenya***	***Tanzania***	***Uganda***	***Total***
Near shore monthly	6	8	9	23
Near shore quarterly	6	8	9	23
Offshore monthly	3	5	6	14
Offshore quarterly	3	18?	4	31
Total annual profiles	108	208	196	512

It was planned that a relatively limited number of key stations should be visited on the monthly cruises, and all stations on the quarterly cruises.

In Kenya all stations could be sampled by one cruise. It was necessary to obtain night accommodation on land because of the limited size and facilities on the survey vessel.

In Tanzania the monitoring of the offshore stations was interrupted by the need to return to Mwanza for refuelling and to seek overnight accommodation on islands and near-shore towns.

In Uganda offshore and some nearshore stations could be sampled in one continuous cruise because on-board night accommodation was possible.

The total of 500 annual profiles each consisting 5 - 10 samples depending on depth and the measurement of 15 - 20 nutrient and biota parameters provided a balanced monitoring programme according to the project objectives and the field and laboratory capacity of the WQ Components.

1.2.2 Field equipment

The field equipment used for the monitoring is:

- Hydrolabs
- ADCPs
- Secchi disks
- Automatic Weather Station
- Sediment traps
- Water Samplers
- Ekman dredge samplers
- Core Samplers
- Computers
- Deep freezers
- Sampling bottles

Figure 1.2 RV Utafiti, KEMFRI, Kenya.

Figure 1.3 RV Tafiri II, TAFIRI, Tanzania.

Figure 1.4 RV Ibis, FIRRI, Uganda.

Figure 1.5 Deployment of Hydrolab.

1.2.3 On-board procedures and field forms

The on-board procedure consists a number of tasks starting with recording of position, depth, wind speed, wind direction, air temperature, wave height, wave direction and wave period followed by measurement of secchi depth and recording of profiles of temperature, dissolved oxygen, conductivity, pH, light and current speeds and directions by means of suitable instruments. The depth and the temperature, DO and light profiles determined the depths for water samples and samples for phytoplankton and zooplankton:

1 0.5 m below surface
2 secchi depth or 10% surface light
3 2.3 x secchi depth or 1% surface light
4 start of DO- or temperature gradient
5 1 m below start of gradient
6 1 m above bottom
7 0.5 m above bottom
8 every 5 - 20 m between 3) and 4)

Finally Ekman dredge samples should be taken for benthos quantification and sediment traps deployed and retrieved according to procedures described in Chapter 9.

Water samples should be filtered through glass fibre filters (1μm) for determination of TPN, TPP, TPC and chlorophyll and through membrane filters (0.45 μm) for TBSi. Filters and filtrate should be stored by freezing or kept below 4^0C. Phytoplankton samples should be preserved with Lugol, zooplankton filtered through 50 um net should be preserved in 4% formalin and benthos sieved through 500 um screen should be preserved also with 4% formalin.

Field forms covering both profiles of physical parameters and for water samples were provided for all field personnel.

1.2.4 On-board training

Initially, the Consultant participated in one-day cruises from Mwanza, Kisumu and Jinja to be orientated about capacities and instrumentation of the vessels, sampling equipment and procedures for sampling and facilities for storage of samples. These demonstrations were important background for the further planning and the adjustment of procedures later agreed on. Further consultancy consisted in participation in one sampling cruise from Kisumu and Mwanza and two sampling cruises from Jinja.

Figure 1.6 On-board training.

1.3 Programme

In the period 20 November 2000 - 9 October 2001 (approx 10 months) the three countries accomplished the following cruises (Table 1.2):

Table 1.2 Summary of monitoring cruises carried out.

Month	***Kenya***		***Uganda***		***Tanzania***	
	Near shore	**Offshore**	**Near shore**	**Offshore**	**Near shore**	**Offshore**
Nov. 00			X	X		
Dec. 00	X	X	X		X	X
Jan. 01	X	X	X	X	X	X
Febr. 01			X		X	X
March 01				X		
April 01	X	X				
May 01	X	X	X	X	X	X
June 01						
July 01			X			
Aug. 01	X	X	X	X	X	X
Sept. 01			X			
Oct. 01	X	X		X	X	X
Total	**6**	**6**	**8**	**6**	**6**	**6**

On the above cruises the following number of stations were sampled and the following number of profiles and samples were taken (Table 1.3):

Table 1.3 Summary of stations sampled in monitoring programme.

	Kenya	***Uganda***	***Tanzania***	***Total***
Number of near shore stations	6	9	14	31
Number of offshore stations	3	10	17	30
Total number of stations	9	19	31	61
Number of near shore profiles	36	48	50	122
Number of offshore profiles	18	33	59	110
Total number of profiles	**54**	**81**	**109**	**244**
Total number of samples	**155**	**650**	**711**	**1516**

1.4 Conclusions and recommendations

1.4.1 Number of monitoring stations

The total number of stations visited during the period was increased from 54 to 61 mainly because some extra near shore stations were added in the Tanzanian programme. However, the original 54 are still considered to be sufficient and it is recommended to concentrate on these. In the following chapters it is shown that the lake is spatially inhomogeneous with regard to both the hydraulic conditions and eutrophication levels, and it is therefore recommended to retain all 54 stations until a more complete picture of this variability is obtained (at least 2 years with a better compliance regarding frequency and water quality analysis).

1.4.2 Frequency of cruises

During the 10 months from end November 2000 to start October 2001 244 profiles of water quality samples were taken out of the 512 profiles planned for a 12 month period. 40% of the planned cruises were not carried out due to, among other things, the unavailability of vessels. The main problems were technical, financial and lack of co-ordination with the fisheries research use of the vessels.

The time spent on the cruises varied from 2-3 days in Uganda and Kenya to up to 15 days in Tanzania. It should be noted that the cruising time is a factor limiting the total capacity of the monitoring programme. Thus, staff from the laboratories participating in the cruises is blocked from doing laboratory work during the cruise time and, moreover, some determinations such as ammonium cannot be made if the samples arrive late to the laboratory.

It is recommended that the original plan of one cruise per month be retained. The observed temporal variations in the state of the lake show that monthly cruises are required to resolve the changes that occur. It was also shown during the project that, when the Consultant's laboratory specialists were present, the laboratories were capable of analysing all the samples without being overloaded. However, it was also clear that the laboratory staff in Kisumu and Mwanza are still in need of long term training.

1.4.3 Planning

For cruises in the immediate future, it is recommended that planning and co-ordination with FIRI, KEMFRI and TAFIRI should be improved to accomplish more frequent cruises.

The flow of funds for consumables and staff allowances delayed and even prevented some of the cruises. Arrangements to avoid such occurrences in the future should put in place. Monitoring is expensive, but without it there is no project and no possibilities for rational management.

For the next phase of LVEMP, it is recommended that fast survey vessels be purchased for each country so that the cruises can be completed in much shorter time. This would give the survey and laboratory staff more time for other activities.

1.4.4 Facilities and equipment

The possibility of on-board accommodation and almost continuous steaming saved considerable time for the Uganda team. It is recommended that similar facilities be arranged for the other countries, particularly Tanzania which has such a large proportion of the lake to cover.

The time spent on sampling was reduced in all countries by improved co-ordination between the field staff including crew. The number of on-board field staff could be reduced even further by a more flexible use of personnel.

With regard to field equipment, the following recommendations are made:

- Water sampling equipment (bigger water samplers and winches) should be improved.

- Acoustic Doppler Current Profilers (ADCPs) and bed sediment coring equipment should be purchased for Kenya and Tanzania as soon as possible.

- More reliable communication (satellite telephones) and navigation equipment should be installed on all survey vessels.

It is repeated that, in the next phase of LVEMP, fast survey vessels should be purchased for each country.

1.4.5 Contingency plans

The monitoring teams experienced a number of technical problems with the survey vessels during the cruises as well as accidents. For example, an engine failure left the RV Ibis helpless on the lake for several days. It was extremely fortunate that they were finally able to contact Kisumu by mobile telephone to get help.

To ensure rapid response in the event of an accident or breakdown on the lake, more reliable communication (satellite telephones) and navigation equipment should be installed in all survey vessels. Equally important, contingency plans for rescue operations should be put in place.