Pollution control and other measures to protect biodiversity in Lake Tanganyika

WORK PLAN (with special reference to 1997) FOR THE LAKE TANGANYIKA BIODIVERSITY PROTECTION PROJECT (RAF/92/G32) SPECIAL STUDY ON 'POLLUTION IN INTERNATIONAL WATERS AND ITS EFFECTS ON BIODIVERSITY'

by

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Contents

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1. INTRODUCTION

1.1 Scope and aims

The 'Pollution' Special Study is a prominent component of the Lake Tanganyika Biodiversity Project (LTBP). This Plan describes the activities that the Special Study will carry out with the ultimate aim of:

'assessing the temporal and spatial influence of pollution on biodiversity'

The tasks are as follows:

to identify and measure pollution impinging on, and in, the lake

relate the findings to the biota associated with a variety of polluted and unpolluted sites from the littoral to open water and at a representative range of in-shore habitats and substrates from fine muds to submerged rock[1]

procure and install the necessary equipment

through a substantial training programme, establish cadres of field operatives, laboratory technicians and scientists to maintain the appropriate range of studies

obtain data in a repeatable manner to ensure that pollution-induced changes in biodiversity can be monitored and identified in the future and beyond the 'life' of the GEF project

develop a sustainable programme of research and its application to lake protection

in the long term, influence policy for the protection of the lake and the creation of special reserves/conservation areas

The Pollution Special Study will thus contribute substantially to the goals of the LTBP as a whole (Payne *et al*, 1997a), by:

influencing the nature and wording of pollution assessment and control policies to be developed by an eventual Lake Basin Management Committee

identifying, where necessary, the appropriate and feasible techniques/strategies for managing pollution threats to biodiversity

contributing to the debates on biodiversity conservation and on the sustainable use of the lake basin's resources.

The main work components envisaged are as follows:

identifying the *raison d'être* and aims of each research/applied research activity

- planning sampling programmes
- marshalling the equipment and human resources to carry out the various tasks
- sampling and recording of associated environmental conditions
- treating samples in the field as necessary (e.g. storing, fixing, filtering)
- analysing samples in the laboratory

logging and analysing data, and

interpreting the findings according to the 'end-user' (fellow scientist, school pupil, supporting administrator, policy-maker or interested bystander) - 'science-to-policy strategy'.

In order to assess the links between a pollutant/pollutant 'cocktail' and biodiversity, pairs of sampling sites, ideally with one being polluted and the other 'pristine', will be sought.

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[1]The Pollution Study Co-ordinator agrees with Biodiversity Special Study's plan to use the 'Rapid' method for assessing biodiversity (RBA) rather than the 'All Taxa Inventory Method' (ATBI); however, the Pollution group intends to test at key sampling sites at least, a simple, formalised and repeatable procedure developed in IFE for indicating the biodiversity of the lower, microscopic fauna and flora associated with the materials and substrata which it will analyse for pollutants.

In practice, however, as long as a reasonable number of sites representative of a particular habitat (substrate type, water depth) is targeted, a sufficiently wide spectrum of pollution levels should be encountered for the effects of pollution on the biota to be established.

The multi-faceted plan reflects the wide variety of field sampling, laboratory analytical work (and training in these aspects) critical to the successful assessment of elements and compounds that constitute 'pollution' (see below). In this connection it is stressed that even in Africa, capacity-building and resourcing in pure and applied aspects of fish and fisheries are no where near as rudimentary *compared with* the situation prevailing in pollution assessment.

1.2 Definitions

This section summarises issues of relevance to the Work Plan that are discussed in the Baseline Review (Bailey-Watts, Foxall and Wiltshire 1996), and this Study's contributions to the Inception Report (1996) and the recent report of the institutional resource assessment mission (Allison *et al* 1996).

1.2.1 'Pollution'

In this study, 'pollution' is viewed primarily as the anthropogenically accelerated inputs of the
following classes of substances to the lake - *via* the catchment or directly onto the lake surface in wet or dry deposition, including spillage from ships and boats:

- nutrients, especially phosphorus and nitrogen species in catchment runoff and in sewage effluent; these are the main agents of eutrophication *per se* and, more significantly, the cause of the enhanced production and biomass accumulation of nuisance plants, e.g. floating hydrophytes such as *Pistia stratiotes,* and potentially toxic, planktonic bloom-forming cyanobacteria, and mat-forming algae.
- organic (oxygen-demanding) compounds in sewage, and effluent from e.g. sugar-cane plantations.
- heavy metals from mining and leather tanning industries etc; these are often of concern because a number of them accumulate in sediment, fish food organisms and thus, fish themselves
- pesticides including chloro-hydrocarbons stemming from agricultural land including coffee and cotton-growing areas: residues of many of these compounds also accumulate progressively more acutely in sediments, in sediment-dwelling biota (especially molluscs) and the organisms including fish and birds at the top of the food chains.
- materials including drilling muds from oil exploration; and from accidental spills from e.g. electricity-generating plants, garages (author's observations).
- miscellaneous materials from e.g. salt factories, and 'litter' (especially plastic products).

At the Inception Workshop, regional scientists and administrators identified few gaps in the Baseline Review on pollution and its effects on biodiversity; indeed, their overall response was very positive. However, the following issues were highlighted as worthy of greater attention than the Review suggested. (i) *pollution sources:* the 'oozing' of oil likely to be associated with oil exploration; the combined effects of effluents, discharges and inflows containing a multiplicity of pollutants; cobalt and nickel; cattle 'ranching' effects on river margins; tourism as a pollutant!; fertiliser and pesticide runoff - Rukwa area; de-forestation in the Mpulungu area; fishing practices that use poisons. (ii) *concerns over aquatic weeds: Eichhornia* (although the Baseline Review did draw attention to the burgeoning of this plant in Lake Victoria, and the potential problems of *Pistia* which is in Lake Tanganyika); and *Salvinia* infestations (Zambia). (iii) *the pollution uptake potential of floating vegetation:* e.g. copper uptake by *Pistia*. There were concerns too, that the monitoring programmes should include *E. coli,* and on a broader front, a number of delegates were interested in the likelihood of the Study establishing whether reduced fish catches in Kigoma are due to over-fishing or pollution.

While not meriting immediate attention, the following issues will be borne in mind considering the desire to protect Lake Tanganyika over decades, even centuries into the future:

population increase and industrialisation increased pollution of the lake
deforestation and/or drainage of wetlands increase in particulate runoff and deposition of air-borne dusts
climate change changes in thermal stratification-vertical mixing cycles.

This Pollution Special Study is *not* considering as 'pollution' the essentially seasonal enrichment of the upper water mass of the lake due to wind-induced upwelling and other hydrodynamic changes, except where these appear to be due to 'climate change'. Similarly, no original work under this project is envisaged on the emission of sulphurous compounds, hydrocarbons and metals from hydrothermal 'vents', but they will be taken into account where they impinge on sampling and the interpretation of findings relevant to an understanding of pollution effects on biodiversity. This particular Special Study is also not dealing with sediment pollution, because this forms the basis of another Special Study; however, the sampling strategies of these two Studies and that of the main Biodiversity Study will be harmonised in order that the impacts on biodiversity of the different forms of pollution can be each can be identified. In this connection, it may prove difficult in some areas to distinguish between the 'natural' and the 'polluted' states as far as eutrophication is concerned. A good example, relates to the Rusizi River; the geology of the upper regions of its catchment ensures that nutrients including phosphate are in plenty long before the river reaches the more heavily populated areas near the lake.

1.2.2 'Biodiversity

As indicated above, the involvements of the Pollution Special Study in 'Biodiversity' will be restricted to a few sampling sites where we will examine all phylogenetic groups encountered i.e. from sub-micron pico-cyanobacteria to rooted vegetation; otherwise, this Study concentrates on the pollution status of the different zones and habitats, and the pollutant content of organisms in 'key' groups such as molluscs and fish on which the main biodiversity programme is primarily focused (Payne *et al*, 1997b).

1.2.3 ' Lake'

In principle, depending on progress, no zone of the lake (or its catchment) will be positively excluded from the study. Nevertheless, the profundal zones are not a priority here, although a lake-wide cruise on the MV '*Explorer*' (which is underway at the time of writing) is to yield deep sediment, water and plankton material, on which this Special Study will eventually carry out a range of test analyses. The main focus is thus on the uppermost ~200 m and furthermore, a selection of river and stream 'estuaries', along the lake edge, and open water within, say, 200 m of the shore[2].

[2] Particularly with the view to developing pollution control strategies, this Study will analyse outfalls etc., well up-river into the catchment.

2. GENERAL APPROACHES

2.1 Overall philosophies

2.2.1 Basic framework

A simple framework on which the pollution studies on Lake Tanganyika biodiversity can be designed, is as follows:

pressures + sensitivity = responses

The *pressures* are determined by catchment characteristics (land use, topography, climate), and developments that have the potential to 'adversely' affect species numbers and composition; examples are urbanisation, and land degradation due to agricultural practices and deforestation. This aspect of the work will be synchronised with that of the Sediment Study - with that programme providing the river samples for the pollution group to analyse. Factors determining the *sensitivity* of the system include a wide variety of physical features (e.g. lake depth, stratification patterns, water residence time), chemical constituents (major ion content), as well as the nature of 'fulcrum' biota (fish and zooplankton). The *responses* which represent the outcome of the interplay between the pressure and sensitivity factors are the physical, chemical and biotic features observed.

2.2.2 Some hypotheses regarding pollution-biodiversity relationships

The main tenor of the UNDP Project Document suggests that pollution threatens biodiversity by reducing the number of species. However, the Pollution Special Study suggests that this may not be the whole story. It is by no means certain that localised eutrophication and other forms of pollution or perturbation should not extend chemical and physical ranges, and thus, the potential for increased biodiversity; the congregation of birds around a worm-dominated sewage outfall might be a case in point.

2.2.3 Reliance on small boats

The main spatial limits prescribed above for the Pollution Special Study, can be achieved using small e.g. inflatable craft. This Study intends to rely as little as possible on the larger vessels - and especially during the first 12-18 months of the practical programme which will focus very much on training. We have identified three main reasons for this. First, the Special Study can design simple protocols on sampling, sub-sampling and immediate treatment of samples, for crews on the large vessels to occasionally secure material from the pelagic and deep zones[3]. Second, the Pollution Special Study cannot afford to rely on the availability of the large vessels to collect materials and/or carry out environmental recording as frequently as weekly or monthly - as envisaged for some key reference sampling stations. Even the limited experience of Dr Bailey-Watts in Burundi, Tanzania and Zaïre suggests that one would often fail to secure the use of either the '*Echo*' or the '*Explorer*' - with plans going astray due to breakdowns, competition for use, and political reasons (ownership etc.) Third, and perhaps most importantly, this Special Study does not view activities that would depend heavily on the large vessels and thus large 'tackle' and sampling gear, as 'sustainable'; as such, these methods and

[3] In this connection the Pollution Special Study will 'reciprocate' by analysing fish and mollusc tissues, and sediment materials produced by the other Special Studies.

practices contrast with the simpler, albeit wide-ranging approaches which characterise much of the Pollution Special Study[4].

2.2.4 Distinguishing between species paucity due to pollution and that resulting from other factor

In its endeavour to establish the links between pollution and the biota in Lake Tanganyika, this Pollution Special Study will adopt an approach that parallels the IFE's River Invertebrate Prediction and Classification Scheme ('RIVPACS'). It draws on knowledge on the relative importance of physical factors such as substratum availability on the one hand and pollution *per se* on the other, on benthic biodiversity. Most of the research has focused on indicator organisms in running waters, but 'discrepancies' between the observed biotic composition and that expected from (surveyed) physical and chemical features of the environment will also enable pollution stresses on lake littoral communities to be assessed.

2.2.5 Biodiversity assessment

As indicated above, Payne *et al* (1997b) are - in the initial stages at least - restricting their Biodiversity Study to key organisms such as fish and bottom-living invertebrates. Heavy costs necessary for training people in sampling and identifying organisms are an important consideration here. Nevertheless, the Pollution Study still aspires to assess the biodiversity of as broad a spectrum of organisms as possible at a few 'key' sampling sites. This Special Study Co-ordinator has trained with no mean success many pupils at undergraduate, Masters and Doctorate levels, to generate preliminary, but still repeatable, indices of biodiversity and species richness etc. In the first instance, 'proper' names of the biota encountered are hardly mentioned - even attempted; arrays of data are then of the following type 'A, J, A, B, A, C, M, Aa .....' where 'A', for example, is something that plainly differs from 'B' etc., and 'Aa' also differs from 'A' but not sufficiently enough to merit assignment to e.g. 'B'. The success of such an approach rests largely on positively *not* subjecting the early observer to Generic and Specific epithets and taxonomic texts. Rather, the focus is on 'pictures'. Experience shows that keen, and above all observant, students can soon distinguish between, and thus 'identify' many tens of different organisms. It is this very basic approach that the Pollution Special Study will adopt in assessing in a quantitative manner the nature of assemblages of 'lower' biota at some of the sites from which material will be collected for chemical analysis. In this connection this Special Study has yet to be convinced that, 'as an example of the algae, the phytoplankton (of Lake Tanganyika) is not high in number of species, and that there are no endemics' (*cf* Payne *et al*., 1997a).

2.2.6 Variation in range of activities envisaged as the project develops

Over the first 12-18 months - during which the emphasis will be on training - the Study will build up its expertise to the point at which all, or the vast majority of, the pollution-related determinands can be analysed by the regional trainees effectively and routinely. This strategy will also establish the priority monitoring activities that need to be maintained in the long term; this is especially important, since funding will almost certainly decrease once the UNDP project comes to an end. In this connection, the need for all observations and measurements to be made in a formalised, repeatable manner cannot be over-emphasised. Every attempt has also to be made to present qualitative information (on e.g. water-colour, wind-force and species lists) in quantitative terms (e.g. the concentrations of pollutants and the numbers of species per unit 'sampling effort'). If these rules are not followed, we will have lost unique opportunities to establish

[4] This does not mean that no sophisticated instrumentation will feature in the Pollution Study: state-of-the-art instrumentation will certainly be required for the analyses of e.g. pesticides, heavy metals and hydrocarbons.

'bench-marks' of pollution/biodiversity status, against which future measurements/records can be compared, and also the ability to identify change or lack of change.

2.2 The placing of two UK graduates as trainers in the region - a major requirement for success

The *range* of field and laboratory techniques to be demonstrated in training workshops and practised routinely for the Pollution Special Study, is considerably greater than that indicated for the other 'ecological' Special Studies. Moreover, the Pollution Special Study is responsible for analyses of materials collected by all three Study teams. The attainment of ideal sample sites and sampling frequencies will depend on many factors: the abilities and qualities of the staff appointed to the Project; the weather; social issues including the frequency of uprisings and unforeseen movements of refugees, for example. *We thus view as absolutely crucial* the appointing of, and placing in, the region two persons of MSc/PhD level trained by Drs Bailey-Watts and Foxall. Ideally, these would constitute a permanent trainer 'presence' in the area, although a 6-month probationary period would be advisable. In addition to training the African personnel, these two appointees would do the following:

- at the behest ultimately, of the Pollution Special Study Co-ordinator, guide and oversee all aspects of the Pollution Special Study, in liaison with the national consultants and researchers in the lake countries, and the Scientific Liaison Officer
- hasten and smooth the receipt of the field and laboratory equipment
- assist the Pollution Study Co-ordinator and his main Consultant in the installation of the equipment
- help with training workshops
- submit a 1- to 2-page report every month to the Pollution Special Study Co-ordinator and the Project Scientific Liaison Officer on all aspects of the Pollution Special Study's work and especially the progress with field and laboratory schedules including data logging, analysis and interpretation.

Without this, we are certain that the Pollution Special Study will not meet the goals identified in the original Project Document and re-iterated and developed in response to discussions with the other Special Study teams and the National Co-ordinators, and scientists and administrators in the lake countries. In this connection it should be noted that the Project Document identified only Drs Bailey-Watts and Foxall and Professors Hammerton and Hilton as international consultants/advisers to this Study. The roles set out above for the new persons envisaged, are of quite a different nature in being more or less permanent and focusing on day-to-day practices.

3. SAMPLING AND SAMPLE ANALYSIS

Bailey-Watts, Foxall and Wiltshire (1996) suggested that the Lake Tanganyika pollution-biodiversity investigations should be based on a sampling strategy characterised by comparing pairs of sites, each to all intents and purposes the 'same' in terms of substrate type, aspect, slope etc., but with one of the pair being polluted while the other is 'pristine'. Indeed, the Biodiversity Special Study (Payne *et al.*, 1997) is aiming as far as possible to achieve this. Subsequent deliberations by the present authors however, suggest that as long as an observable variety of e.g. cobble beaches, sandy bays and open water areas is selected, an association/lack of association between the biota and the chemical environment, will be established - that is, even where the ideal situation of a pristine site *sensu stricto* cannot be found. The main requirement is to choose from the outset groups of sites as similar as possible in terms of features such as substratum and aspect.

3.1 Dispersion of sampling sites

The Pollution Special Study will concentrate its work as far as possible, in the sampling areas first considered during the preparation of the Baseline Review (Bailey-Watts, Foxall and Wiltshire 1996), subsequently developed with the national counterparts at the Inception Workshop (Bailey-Watts and Foxall, 1996) and considerably enhanced as a result of the institutional resource assessment mission (Allison *et al* 1996). The latter was especially significant in identifying sampling areas which will be investigated by the pollution, sediment pollution, and the biodiversity teams. **Table 1** lists the presently selected sites. The Pollution Study will concentrate in the first year, on the sampling area nearest the main laboratory in each country (listed first in Table). As expertise increases, and tasks are achieved in an acceptable time, sampling will be extended to the areas listed second. Depending on overall progress and the initial results, any of these areas may be dropped or replaced in favour of the sampling areas listed third. In any event, a good deal of the areas relevant to the Pollution Special Study, are also to be assessed by the Biodiversity Study and/or the Sediment Special Study.

3.2 Temporal and spatial sampling frequency

Early sampling reconnaissances should establish the actual situations prevailing as regards where and when to sample most effectively. Frequency of sampling will depend on the type of substrate-biota associations. Encrustations and bottom sediments for example, *may* vary spatially more than say, the phytoplankton; contrastingly, planktonic assemblages could differ more temporally. The first year will thus see the Pollution Special Study *build-up* to a sampling programme in each country, that concentrates on two (see below) main sampling areas ('locations' à la Payne *et al.*, 1997). Each area will encompass open/offshore water and at least three of the following substrate types or 'habitats': underwater cliff-faces, boulders, cobbles, pebbles, sands, silts and muds; two sites apparently contrasting, or likely to contrast in pollution pressure/status (synoptic tests will establish the prevailing situation), will be sampled in each habitat (i.e. open water, cobble beach etc.) for the purposes of chemical (pollutant) analysis[5] and biodiversity characteristics. The total number of samples to be handled on each sampling occasion in each country is thus:

[5] Albeit depending on the physical nature of any sample, a wide spectrum of analyses is envisaged, and they will be practiced on a regional basis. Exceptions concern the determination of pesticides, hydrocarbons and heavy metals; requiring very expensive analytical instrumentation these samples will be analysed at one or two selected laboratories in the region.

2 sampling areas x 4 habitats (including open/offshore water) x 2 sites (contrasting in pollution status) x 2 samples (each to be analysed in the laboratory[6]) = 32

[6] Two separate field samples (e.g. bottles of water, or cores of sediment) must be collected, and each analysed; the apparent alternative where duplicate analyses are carried out on a single field sample, is unacceptable.

Table 1: Sampling areas for assessing pollution in international waters, and its effects on biodiversity.

Country/area	eutrophication - point-source domestic	eutrophication : point-source industrial	eutrophication : diffuse-source domestic	eutrophication: diffuse-source industrial/agric'l	organic waste excl. h'carbons	pesticides	heavy metals	h'carbons		rainfall (nutrients)
BURUNDI										
Bujumbura	U	U	U	U	U	U	U	U		
Rumonge	U		U			U				
Rusizi				U		U				
TANZANIA										
Kigoma/Ujiji	U	U	U	U	U	U	U	U		
Mahale										U
Malagarasi				U		U	U			
ZAIRE										
Uvira/Pemba			U		U					
Kalemie	U	U	U	U		U				
Moba	U		U					U		U
ZAMBIA										
Mpulungu	U	U	U					U		
Sumbu Nat. Pk.										U
Lufubu						U				
Sumbu Town			U					U		

While it is a guide to the extent of the chemical analytical programme required to meet the objectives of the Pollution Special Study, the number of samples indicated above is somewhat misleading. This is because, on average, 10 analyses per sample is envisaged (see Section 3.3). Thus, a programme dealing with some 300 analyses per sampling 'occasion' is planned for each country. This is not an inconsiderable target, but firstly, man-power is likely to be more or less unlimited in this project; this is why the main emphasis is on the use of manual e.g. pipette-burette titrations and colorimetry, rather than sophisticated (power failure-prone) photometry, although ion, conductivity, temperature and dissolved oxygen probes will feature prominently in the laboratories. Secondly, it has to be remembered that a sampling 'occasion' could span days - even weeks - collecting material from polluted and comparatively unpolluted sites, within the different habitats and areas. Then, even assuming that sampling *per se* takes 25% of the total time spent on the work, rather few analyses would need to be completed each day. This is very important since ideally, the physical, chemical and biological analyses of samples generated by a series of short forays alternating with laboratory work, should be completed, computer-logged, reasonably well analysed and interpreted, BEFORE the team embarks on the next sampling session. Until the first series of field and laboratory activities are completed, final decisions on sampling intensity cannot be made. Present indications are, however, that the schedule outlined above would allow time for occasional transect and depth profile studies. Such a schedule would also permit attention to 'special' sites such as Gombe (the nearest unimpacted area to Kigoma (Tanzania), and of importance in relation to the Jane Goodall Foundation); the relatively untouched Kipili and Kirando region; and the Tembwa area in Zaïre (opposite the Mahale Mountains in Tanzania).

3.3 Field/laboratory analyses

We see the following as the 'core' physical and chemical analyses/measurements:

indicators of environmental conditions: water temperature, transparency, wind force and direction
basic chemical descriptors: conductivity/salinity (and major ion contributions and alkalinity where possible), dissolved oxygen, pH, and total suspended matter content
pollutant indicators (i): fluoride
pollutant indicators (ii): oils (fuel, bilge etc.) in water, sediments, and the tissues of selected molluscs, crustaceans and fish
pollutant indicators (iii): pesticides and PCBs in fish tissues and molluscs (possibly also PAHs)
pollutant indicators (iv): trace elements and heavy metals (e.g. Cu, Zn, Pb, Cd and Hg (in mollusc and fish tissues)
eutrophication indicators and other nutrients: inorganic and organic, dissolved and/or particulate fractions of nitrogen, phosphorus and silica
a measure of phytoplankton and phytobenthos biomass: chlorophyll$_a$

The results of these determinations would be arrayed alongside various measures/indicators of biodiversity as generated by the main Biodiversity Special Study and from occasional investigations by the Pollution Study focusing on the lower, microscopic fauna and flora at a small selection of sites but covering the major lake habitats.

4. INSTITUTIONS AND PERSONNEL ENVISAGED FOR THE EXECUTION OF THE POLLUTION SPECIAL STUDY

This section concerns primarily, the African institutions that Drs Bailey-Watts and Foxall wish to appoint to the Pollution Special Study. Organisations and the numbers of personnel with the potential to be appointed to the project were indicated in our Baseline Review (Bailey-Watts, Foxall and Wiltshire 1996), and further modified as a result of the discussions with regional scientists at the Inception Workshop (Bailey-Watts and Foxall 1996). However, it was not until the institutional resource assessment mission was completed in September (Allison *et al* 1996) that the more or less full array of (i) organisations (ii) the numbers of people, and (iii) the most likely persons that we view as appropriate became more evident. **Table 2** indicates the 'core' posts and the numbers of people in each of these, that are required full-time for the Pollution Special Study.

Table 2. Regional posts required at each of four main towns* for the pollution-biodiversity study.

post	number required per country
driver/mechanic	2
handler for small e.g. inflatable craft and field recorder/sampler	2
laboratory cleaner	1
technicians/laboratory assistant	5
research scientist	2
station scientific coordinator	1
secretary/office assistant/typist	2

* Bujumbura, Burundi; Kigoma, Tanzania; Uvira, Zaïre; and Mpulungu, Zambia.

We suggest that these people be drawn primarily from the teams hitherto associated with LTR's 'Programme for basic monitoring' (**Table 3**). They would thus, come primarily from the Tanzanian Fisheries Research Institute (TAFIRI) in Kigoma; the Centre Recherche d'Hydrobiologique (CRH), Uvira in Zaïre; the Department of Fisheries at Mbala, Mpulungu in Zambia; and the complex comprising the LTR team, the Centre Hydrobiologique de la Cooperation Belgo (CRRHA) and associated University personnel in Bujumbura, Burundi.

This Special Study Co-ordinator wishes to leave the assignment of the person/s to the posts, to the Directors and Senior Officers of the organisations involved - although Drs Bailey-Watts and Foxall would be happy to discuss this; Table 3 lists a number of personnel who we met in the region.

The first 12 months is to be viewed as a training exercise. Appointees will being trained in all aspects of the work - although it is accepted that some of the personnel would already be experienced in a number of fields. In this respect, it is hoped that reliable data will be generated from the outset. The Study is seeking teams with as much experience as possible in areas of freshwater ecology/limnology relating primarily to water chemistry i.e. sampling ∫ field recording ∫laboratory analysis ∫ data handling/logging ∫ data analysis ∫ data interpretation. However, in view of the Study's intention to establish the biological constituents of the water, various substrata and surfaces, it is essential that each country supplies a technician/researcher with interests in microscopy and the lower aquatic organisms. In any event, appointees at technical and research, levels must be prepared to help with each other's work, and field operatives especially will have to be prepared to learn a broad range of sampling techniques and practices.

Note that the total number of personnel i.e. 14 per country is considerably less than the 23 estimated in our Baseline Review. This is because this 'core' group does not include a considerable corpus of other

Table 3: National scientific staff contributing to pollution and pollution-related biodiversity (excl. fish) aspects of the 'Programme for basic monitoring' at LTR Stations. Names in italics denotes those persons responsible for the activity at a station.

BUJUMBURA	
Hydrodynamics	*Mr Kakogozo* and Mr Nikomeze
Limnology	*Mr Tumba*, Mr Nyamushahu, Mr Tshibangu, Mr Butoyi, Mr Ndimunzigo, Mr Nikomeze and Mr Gahungu
Zooplankton	*Mr Bwebwa* and Mr Nyamushahu
KALEMIE	
Hydrodynamics	*Mr Detsimas*
UVIRA	
Zooplankton	*Mr Bwembwa*
Chemistry	*Mr Tshibangu* and *Mr Kimbadi*
Sedimentation	*Mr Kahindo* and *Mr Mwenyemali*
	also Mr M Kamalebo (algologist - mainly epilithon).
KIGOMA	
Hydrodynamics	*Mr Kihakwi*
Limnology	*Mr Chitamwebwa (Director)*, Mr Lyoba and Mrs Lyoba
Zooplankton	*Mr Kalangali (Deputy Director)*, Mr Muhoza and Mr Kadula
	also Mr U Kisisiwe (Field operative and Boatman).
MPULUNGU	
Hydrodynamics	*Mr Makassa*, Mr Kaoma and Mr Sichivu
Limnology	*Mr Mwape*, Mr Lukwessa, Mr Ngandu and Mr Shapola
Zooplankton	*Mr Zulu*, Mr Sichivu and Mr Kaoma

people who will be taken on for specific, shorter-term tasks. The organisations identified for these are indicated along with a host of people with whom we held discussions during our visits to the region, in **Table 4 (next page)**.

Table 4: Organisations/institutions and main personnel to be considered for *ad hoc* and collaborative assignments on the Pollution Special Study.

Kigoma: Regional Water Department (Tanzania): Mr Michael Baragwiha (Regional Water Engineer), Mr C E L Rubabwa (Geologist) Mr Theodore Mpyalimi (Hydrologist In Charge) and Mr Kiliho (Chemist).
LTR (FAO FINNIDA) (Tanzania): Mr P Mannini (Head of Station and fisheries biologist), Mr A Kalangali (Zooplankton researcher), Mr Muhoza (Zooplankton technician), Ms Els Bosma (Zooplankton, nekton and fish), Mr P Verburg (Hydrologist and fisheries biologist).
Kigoma High School (Tanzania): Mrs Fatima Mashaka (Deputy Head Mistress, Mr Kunga (Head, Department of Biology).
Mpulungu: LTR (FAO FINNIDA) (Zambia): Mr V Landenberg and Ms P Pfaffer (Researchers).
Mbala, Mpulungu: Motomoto Museum (Zambia): Mr E Nkole Sosala (Keeper of Pre-History Department).
Sumbu: Lufubu River, Sumbu National Park, and Department of Fisheries (Zambia): Mr Mwape (as above), Mr T Miti (Head Wildlife Service, Sumbu).
Mahale: Mountains National Park (Tanzania): Mr J Wakibara (Park Ecologist), Mr A H Seki (Senior Park Warden)., Mr W Daniel (Park Warden, Law Enforcement) and Mr F I Malisi (Park Warden, Tourism and Community Conservation Service).
Mpulungu: Water Engineer's Department (Zambia): Mr B J Kasonde (District Water Engineer).
Kasama: Provincial Water Department (Zambia): Mr S C Ngambi (Water Engineer) and Mr C Chizango (Deputy Co-ordinator, Irish Aid Development Programme).
Lusaka, National Council for Scientific Research (Zambia): Mr C Mwambe (Acting Secretary General) and Dr M Nomai (NCSR, Radio-isotope Unit).
Kigoma, Tanzania: visit from Selanyika Datomax (Warden, Gombe National Park).
Lusaka, University of Zambia: Professor D D Theo (Dean, School of Natural Sciences), Dr S M Mgwira (Head, Department of Physics), Professor J Cernak (Department of Physics), Professor P C R Jain (Manager, Environmental Resource Centre in the Physics Department), Dr F Kamona (Head, Department of Geology, School of Mines).
Lusaka, University of Zambia: Dr Jere (Dean, School of Mines) and Dr S Simukanga (Head, Department of Metallurgy and Mineral Processing).
Lusaka, Zambia: Bernadette Crawford (Senior Projects Officer, Irish Aid Development Programme).
Lusaka, National Council for Scientific Research (Zambia): Mr Kaposhe (Head, Livestock and Pest Centre at Chilanga).
Dar es Salaam, British High Commmission (Tanzania)
Gombe national Park, Tanzania: Dr Jane Goodall (Director, National Park and Research Institute).
Dar es Salaam: Ministry of Water - Subdivision of Water Resources' (Tanzania): Mr. Msuya (Meraji. O.Y.) Acting Director of Water Resources) and Mr. Mihayo (Hydrologist).
Dar es Salaam: University, Department of Chemistry (Tanzania): Professor Mulozoki (Acting Head of Department).
Dar es Salaam: University, Department of Zoology (Tanzania): Mr Betterweg (Biodiversity database incl. GIS).
Dar es Salaam: Wildlife Conservation Society of Tanzania: Mrs Alice S Bhukali (WCST Co-ordinator).
Dar es Salaam: Lake Victoria Environmental Management Plan (Tanzania): Mr Mbwana (LVEMP Co-ordinator).

Arusha: Tropical Pesticide Research Institute (Tanzania): Mr C J Muangirwa (Chief Research Officer); Mr J Ak'habuhaya (Head, Physical and Chemical Division).

5. EQUIPMENT

The complete list of equipment identified and collated primarily by Drs Bailey-Watts and Foxall (Bailey-Watts, Foxall and Wiltshire 1996) and Mr Kirika (IFE), is available, and has been submitted to a number of suppliers for Tender. **The gear includes that needed for the execution of field and laboratory activities planned for the 'ecological' Special Studies and primarily that concerned with pollution, but excluding the equipment needed for the fish stock and fish biodiversity aspects.**

The following types of equipment are thus, included:

- the gear needed to reach sampling sites;
- the materials and instrumentation for recording e.g. environmental conditions and site details
- the devices for collecting e.g. water, plankton, sediment and biota associated with various deposits and surfaces: wherever possible and appropriate, however, the performance/efficiency of simpler techniques (such as the use of Lund sampling tubes and counting chambers for of the smaller elements in the plankton) will be compared with these sophisticated instruments with the view to using the simpler, cheaper and more easily replaceable items in the long-term.
- sample containers and facilities for 'fixing' samples and, as appropriate, avoiding excess sunlight, heating etc. during return to the laboratory
- equipment for the chemical analysis and biological investigation of the samples.

Computing power (with associated electronic communication, and equipment protection facilities) and stationery for logging, analysing, interpreting, and presenting (in written and spoken form) the field measurements and analytical results, will also be supplied under the LTBP. The recent mission (Allison *et al* 1996) also points to the need for resourcing by way of literature availability - including Freshwater Biological Association library photocopies. In this connection, the Pollution study is producing manuals of field and laboratory practice.

6. TRAINING

As indicated in foregoing sections, training - along the provision of equipment and laboratory facilities - is viewed by this Special Study as one of the most important methods of resource strengthening in the Lake Tanganyika region. The first major training activity planned for the coming year, is a Workshop on limnological methods relevant to the assessment and management of pollution, sediment pollution and biodiversity. This is scheduled to be run at Kigoma in August 1997. The principal objective of the workshop is to develop and agree on sampling, analysis and data handling strategies and procedures. These harmonised procedures will then be adopted for the subsequent fieldwork by the research teams in all four countries. This particular training forum will also provide important opportunities to debate the *raison d'etre* for each study activity. Training elements relevant to the Pollution Special Study particular will include:

- field sampling techniques including environmental and sample recording, physical and chemical measurements, and the preservation of biological and other samples/materials.
- on-boat and laboratory-based analytical techniques for biological and chemical parameters, and quality control procedures.
- data recording and analysis.
- data interpretation, report writing and presentation of results.

Other short courses/regional workshops are envisaged, to train riparian country personnel in the following areas:

- pesticide and heavy metal analyses of biological materials(including fish, bivalves, shrimps) and sediments.
- monitoring of oil pollution in water and sediments
- determination of nutrients and other pollutants in rainwater.

These could involve University and Research Institute staff, and be held overseas or in-country, but they are unlikely to take precedence in first year following the August 1997 Workshop. This is because we expect the 'training' in the plethora of more regular routine activities will essentially continue for as much as one year after the first Workshop. Nevertheless, As already indicated, simple measurements such as the recording of weather conditions, water temperature and clarity; lake level measurands derived from probes, and even the simple biodiversity arrays referred to above, will feature in the data bases from the outset. The contrast between the initial training 'year' and the subsequent phases will be in the dispersion of sampling sites. This Special Study intends to simplify matters in the first instance by concentrating on sampling sites that take the minimal amount of time to reach. Only once the trainees are familiar with the planning preparation, execution and completion (including the writing of the results) of these sampling expeditions, will forays further abroad and involving more travel and the need for more extensive planning be attempted. Lake monitoring schemes world-wide illustrate the enormous advantages enjoyed by institutes, research stations etc., situated on the side of their study waters and near their major monitoring sites. With these views in mind sites close to Kigoma, Uvira, Mpulungu and Bujumbura will receive attention first. Fortunately, our initial reconnaissances have identified a spectrum of open water, inshore and offshore sites featuring the majority of substratum types in which this Special Study - and all of the other Special Studies - are interested.

The Pollution Study intends to provide as many opportunities as possible for researchers/technicians to visit Europe - for periods of 3-6 months[7] - as part of their studies towards MSc or PhD degrees. However, such developments are also not likely to materialise until the Project is well-established and its practices and activities are routine.

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[7]Experience shows that this strategy is much more effective than that based on 2- to 3-year sojourns away from the realities of Africa.

One of the main concerns of the Pollution Special Study is possible under-estimation of the need for diving skills in order to secure material associated with submerged, hard surfaces such as fringing rock faces and boulder-down-to-pebble size substrates. These cannot be sampled by grabs, pipes, corers etc., in the manner of the finer sands, muds and silts -and the water itself. What is more, divers will need to be trained in techniques that are almost certainly more exacting and 'delicate' than those employed for catching fish. In this connection, an alternative that is being considered is for the fore gut contents of freshly caught fish species to be extracted, suitably stored and submitted for chemical and microscopical analysis.

7. THE WORK PLAN

The timing of the multifarious activities as envisaged at the time of writing (March 1997) are shown in the following Table. In the main, the schedule is that proposed by Bailey-Watts, Foxall and Wiltshire (1995) but for re-timing consequent on delays occasioned not least by civil wars in both Burundi and Zaïre.

activity - all 1997 unless otherwise stated	start date	end date
identifying equipment needs	mid jan	mid feb
submit equipment list to NRI for onward Tender	mid feb	-
submission of Pollution Study Work Plan to NRI	1 apr	-
procure equipment	mid apr	-
submission of cv's for 2 'permanent' UK graduates to UNOPS *via* NRI	end apr	
deliver equipment to Lake Tanganyika region	1 may	-
transfer equipment to Kigoma	1 jun	
establish Kigoma laboratory (install and check equipment)	mid jun	end jun
transfer 2 'permanent' UK graduate trainers to Kigoma for 6-month probationary period	mid jun	mid dec
limnological methods w'shop	1 aug	end aug
on-going training and strengthening of routine sampling programme	end aug	end aug '98
TBW visit	25 jul	10 sep
additional TBW visit*	1 dec	21 dec
first CF visit	25 jul	10 sep
additional CF visit*	25 nov	15 dec

* these and subsequent visits by TBW and CF would be considerably reduced if the negotiations for appointing the 2 UK graduates are successful - and these persons perform satisfactorily throughout their probationary periods.

8. OUTPUTS

Subject to (i) the safe and timely delivery of equipment to the lake countries and (ii) the appointment of the UK consultants/trainers/supervisors and the National scientists, technicians, field operatives and administrative support identified above, the Pollution Special Study aims to deliver the following outputs - in addition to influencing issues relating to the Project as a whole (see section 1):

- a pollution assessment and monitoring programme for Lake Tanganyika
- a corpus of knowledge and basic equipment, together with the appropriately trained scientists, administrators and policy-makers capable of maintaining an effective pollution assessment and management programme.
- maps of pollution sources and their temporal occurrence and approximate magnitude (loadings and concentrations), and - in selected site cases - corresponding biodiversity arrays.
- an inventory of the least impacted/polluted sites and habitats.

If the project can develop the rigorous, formalised and repeatable protocols envisaged for sampling through to data analysis, it will generate new knowledge on the associations between biota and their environment. This is important in at least two respects. It will increase the region's awareness of the value of organisms as indicators of pollution pressures/stress. This is especially significant in the African situation where funding for water quality monitoring is likely to be restricted, since pollution assessments based on biota are cheaper than many chemical methods.

9. REFERENCES

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