Biodiversity Special Study (BIOSS)

**Aquatic Habitats
and Associated Biodiversity
of the Kigoma Area, Tanzania**

Final Consultant Report

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Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika (RAF/92/G32)

Lutte contre la pollution et autres mesures visant à protéger la biodiversité du Lac Tanganyika (RAF/92/G32)

Le Projet sur la diversité biologique du lac Tanganyika a été formulé pour aider les quatre Etats riverains (Burundi, Congo, Tanzanie et Zambie) à élaborer un système efficace et durable pour gérer et conserver la diversité biologique du lac Tanganyika dans un avenir prévisible. Il est financé par le GEF (Fonds pour l'environnement mondial) par le biais du Programme des Nations Unies pour le développement (PNUD)"

The Lake Tanganyika Biodiversity Project has been formulated to help the four riparian states (Burundi, Congo, Tanzania and Zambia) produce an effective and sustainable system for managing and conserving the biodiversity of Lake Tanganyika into the foreseeable future. It is funded by the Global Environmental Facility through the United Nations Development Programme.

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Preface note

This report was prepared by the international consultants as part of their contract to provide dive and survey training for BIOSS regional teams. As it is intended that all future BIOSS technical reports will be produced by the regional teams; this document may provide a template for such reporting.

1. INTRODUCTION

1.1 Kigoma

Kigoma is the largest centre of population on the Tanzanian coast of Lake Tanganyika, Fig 1.1. Approximately 60,000 people live in the town itself with another 400,000 in it's hinterlands (pers. comm. Dr K. West). Kigoma is also the only significant port located on the Tanzanian coastline, such that when the railway link between Kigoma and Dar-es-Salaam was washed out recently after the rains, the port of Mpulungu could not cope with the upsurge in lake traffic(pers. obs). The scale of human and commercial activity, makes Kigoma unique on the eastern shore of the lake.

Combined with this potential for pollution and environmental degradation, the area of the coast is of interest in itself due to its being the most easterly point of the eastern shore north of Mahale Mountains, and also because it is a an area of transition between rocky habitats to the north, and sandy habitats to the south as far as Mahale (Coulter & Lowe-McConnell, 1995). Whether as a consequence of the above or not, the coast adjacent to Kigoma is far more complex than that either to the north or south (Gombe Report ; April 1998), with a greater variation in habitats with respect to exposure, water depth and substratum. There are a succession of bays, headlands, beaches and peninsulas on this section of coastline, which guarantee habitat diversity.

The above features would ensure that the Kigoma area warranted investigation on it's own merits. However Kigoma is also the station where the Biodiversity Special Study is based, and where the underwater biodiversity survey training course was held during September and October 1997 (Training Course Report; Frontier Environmental / MRAG; January 1998), at the Tanzanian Fisheries Research Institute's base (TAFIRI). Therefore the area was used extensively to train divers in the techniques of underwater habitat mapping and fish census. This report outlines the findings of these exercises, which though not comprehensive, illustrate the importance of this stretch of coast.

1.2 Survey Aims

The survey training conducted adjacent to Kigoma was directed at fulfilling the long term goals of the Lake Tanganyika Biodiversity Project (UNDP/GEF/RAF/192/G32): Biodiversity Special Study (BIOSS). These objectives are to :

- Identify the Distribution of Major Habitat Types with Particular Focus on Existing and Suggested Protected Areas;
- Review Current Levels of Biodiversity in Lake Tanganyika;
- Suggest Priority Areas for Conservation Based on Existing Knowledge and Recommendation from Other Special Studies Supplemented by Additional Survey Work where necessary; and
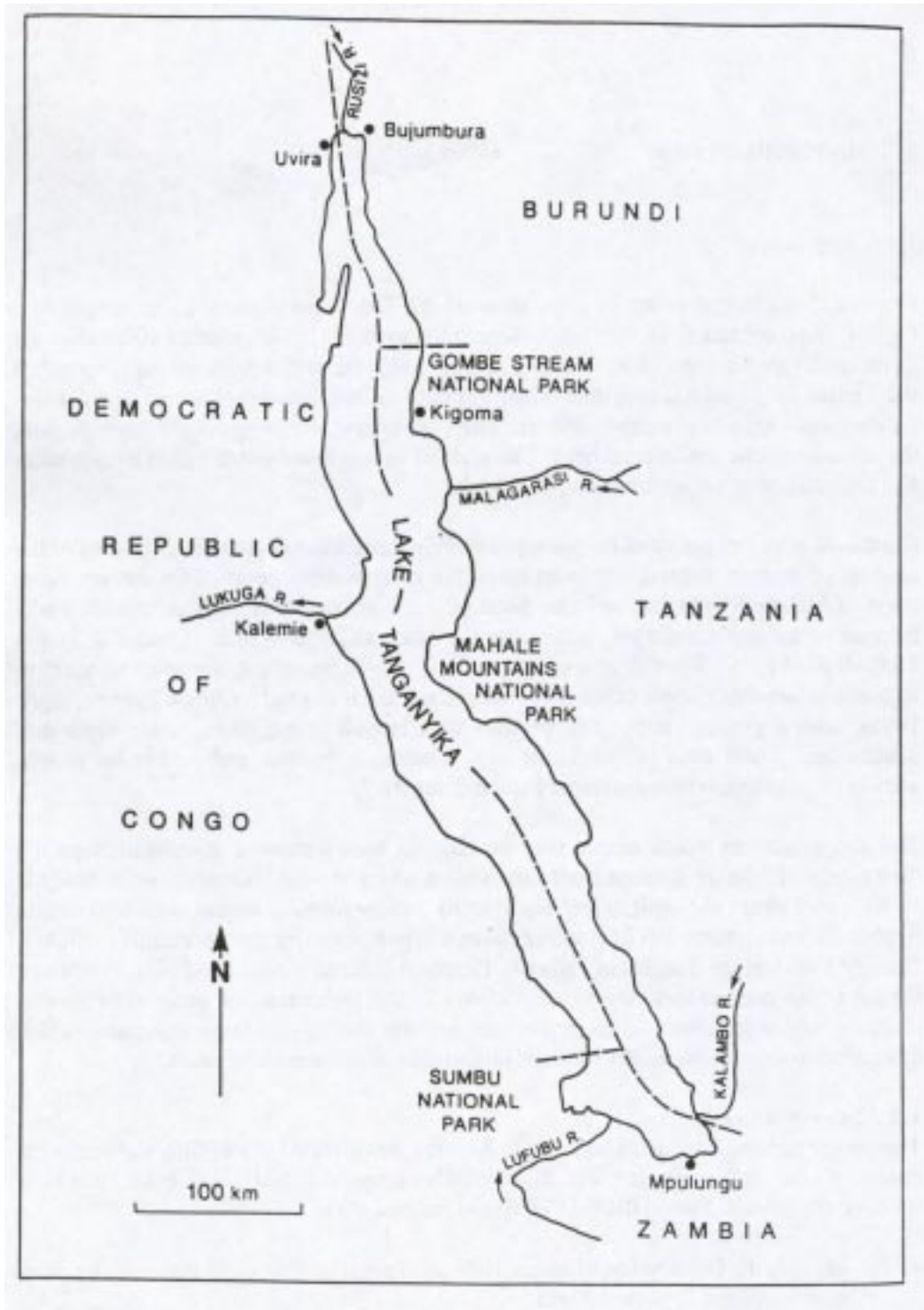- Develop a Sustainable Biodiversity Monitoring Programme.

Figure 1.1   General map of Lake Tanganyika with major population centres, rivers and national parks.

Objectives one, three and four are best addressed by teams going into the field to conduct surveys of areas which are protected, or significant in terms of biodiversity. The latter include sites which may be threatened with habitat degradation, which could be used to monitor change. Protected areas bordering the lake such as Parc Nationale de Ruzizi, Burundi, Gombe Stream and Mahale Mountains National Parks, Tanzania, and Nsumbu National Park, Zambia fall within the first category. Survey of the coast of the Democratic Republic of Congo will also take place in order to investigate biodiversity where no parks currently exist, although protective orders might follow.

The surveys of national parks and other areas may also involve components of the other four special studies to varying degrees. These are the Sedimentation Special Study, the Pollution Special Study, the Fishing Practices Special Study and the Socio-economic Special Study. For the Kigoma area only the BIOSS was involved due to the training nature of the exercises.

The results of these surveys would be used in the formulation of a Strategic Action Plan for the lake which would plan to preserve and best utilise the biodiversity of the lake, including the fisheries so important for local communities. This would in turn be incorporated by the Lake Basin Management Committee into a programme to monitor the health of the lake and it's resources.

The Kigoma area is a natural monitoring site for reasons outlined in 1.1, and sites were also conveniently close for training purposes, with all stretches of the coast accessible within an hours motoring from TAFIRI. Therefore survey of the Bangwe Point to Katabi Village was commenced on 25/09/97 and ended on 10/10/97 (Fig 3.2. 1). The adjoining coastline from Luansa Point in Kigoma Bay to Bangwe Point was surveyed from 10/10/97 to 15/10/97. As part of a training programme, the above surveys were not complete, as both the personnel and the methods used were untried, and evaluation of survey methods proceeded throughout these surveys with many modifications being made. In addition, training in fish census methods was limited to two locations, constrained by accessibility and availability of transport. As all data collected during these training surveys needs confirmation, a more comprehensive survey of this section of coastline will be needed at some future date.

1.3   Previous Work in Kigoma Region

Apart from surveys conducted in association with the aquarium trade, such as that reported in Brichard (1989), no ecological surveys have been completed in the Kigoma region.

1.4   Specific Objectives

These surveys of the Kigoma area followed training courses where fourteen nationals from Burundi, Congo, Tanzania and Zambia, were taught to swim and to dive before commencing survey training. These fourteen students comprised four each from Burundi, Congo and Zambia, with two from Tanzania. Survey training aimed to teach each national team to evaluate biodiversity at both coarse and intermediate level, through habitat mapping and census of various taxa, most notable of which are fish, but which will eventually include molluscs, insects, annelids, crustaceans and ostracods. These skills will then, hopefully, be transferable to their respective national coastlines, and the inventory of lakewide biodiversity will continue to grow.

The Tanzanians and Zambians were often occupied at the Field and Laboratory Methods Training Workshop, which was held at TAFIRI from 22/9/97 to 4/10/97 and therefore overlapping the BIOSS training course, hence the survey skills of these teams were less advanced at the end of the contracted period.

2.   METHODS

The requirements for field surveys where little prior information is available are, on one level, methods where large sections of coastline can be mapped for habitat with relative speed, backed up by methods which allow ground-truthing of the coarse data produced by mapping techniques.   Individual census methods can then be utilised for different taxa, to flesh out habitat data with detail on communities.   Different techniques will be needed for surveying various types of terrain, even within the same taxon, and protocols chosen must reflect this.   A number of field survey techniques were identified as potentially useful for the habitat mapping and fish census surveys. Census methods for other taxa were not available at the start of survey training and must follow piecemeal.   The data presented stems from information collected during these trial surveys.

2.1   General Habitats

Normally the first activity of any survey is a desktop search for all available maps, charts and aerial photographs of the target area.   At this stage all published work on the location is consulted, in addition to any publications relevant to the survey, in terms of proximity of location or similarity of target taxa.   A reference collection is built up, to gather as much information as possible on all aspects, prior to the field phase of the survey.   Using this information and the charts/maps, segments of coastline can be assigned a habitat type, to aid in deciding where survey effort is likely to produce maximum return.   Maps of the coarse distribution of terrestrial shoreline habitats are also useful in biodiversity surveys as terrestrial impacts on littoral habitats will influence the levels of biodiversity found.

In this study no time was allocated toward a literature review, and only a small number of privately held papers were available.   No charts, maps or aerial photographs suitable for the survey were found, and only 1:50,000 O.S. maps were accessible.   These were used to describe shoreline habitat categories as: (i) rocky shore, (ii) sandy shore, (iii) reedbed, (iv) gravel beach and (v) cliff.   Each class was qualified in terms of exposure, water depth, currents and proximity to estuaries.   Human impacts on littoral habitats were categorised as 1) farmland, 2) settlement, 3) scrub, 4) forested catchments and 5) fishing.

In view of the limited accessible information, the Manta Board Survey method was chosen as a coarse habitat mapping technique(UNEP/AIMS 1993). To supplement this, direct observation (Hiscock 1996), of habitats and communities in deeper water using SCUBA was chosen to verify, (i) whether the littoral habitats identified continued sublittorally, and (ii) to document the associated biodiversity of these habitats.   To achieve this techniques in habitat profiling and fish census were adopted.

2.2   Manta Tow

The manta tow is a technique used to map the distribution of shallow water habitats using a surface snorkeller towed behind a small boat. The technique was originally developed to assess broad changes in the benthic communities of coral reefs where the unit of interest was often the entire reef, or a large part of it.   Although the technique is far slower than aerial survey, it is a fraction of the cost and can identify underwater habitat types in depths of five to ten meters, depending on water visibility.   On a linear coastline, 20 km can be mapped in a single day. The technique is, however, unsuitable for areas of low water visibility and for parts of the lake where the snorkeller may be at risk from crocodiles, hippopotami, and water borne diseases such as bilharzia. This technique is not recommended for survey of deeper water using SCUBA due to the potential for uncontrolled ascents.

The full protocol is described elsewhere (Standing Orders Report) but basically involves towing an observer behind an inflatable using a rope and a manta board. The manta board itself is merely a rectangular piece of wood, which serves as a hydroplane, with handholds and an attached underwater slate on which observations are recorded.   The surveyor is towed along the surface, in snorkeling gear, noting the type of habitat as it passes below. The boat is stopped every three minutes to allow the surveyor to summarise the composition of the

substratum, passed over during the preceding three minutes, on the underwater slate. The data recorded included, bottom topography, inclination, features of rock and sand and biological communities which themselves are habitat forming. The latter would include large aggregations of shells (gastropod or bivalve), or extensive macrophyte fields of such species as *Valisineria* or *Potamogeton.*   The latter are associated with distinct communities and are known to be favored by certain species of cichlid. A second team member in the boat recorded the position of each stop, using a Global Positioning System (GPS) unit, and marked these positions on a map of the coastal section. A third observer recorded terrestrial features such as coastal topography, land cover, land use and human impact, which might have a bearing on any changes observed in underwater biodiversity. A fourth member kept time and watched out for rocks. All observations were made during boat stops to synchronise data recorded. The fifth and final team member was the coxswain of the boat.

The results of the survey were transferred to a map of the area, usually an acetate overlaid on a photocopy, and the distribution of littoral habitats was marked in using simple symbols explained by a legend. In this way the coast was divided into sections according to substratum, thus giving a broad scale inventory of the distribution of major habitats. Substratum type can be further classified using physiographic criteria such as the level of exposure to currents and winds. Site selection for further, more detailed survey using habitat profiles, was based upon the information provided from the manta tow survey.

2.3   Habitat Profiles

The deeper water habitats and their associated biodiversity were surveyed using SCUBA. The time limitations of using SCUBA to survey, required that deeper water habitats were spot surveyed at selected sites. These sites were chosen on the basis of the inventory of shallow water habitats revealed by manta tow surveys, to try to include the full range of major habitats, wind exposures, water currents, and water depths.

The survey technique is described in full in the "Standing Orders Document" so will only be summarised here. A buoyed and weighted vertical reference line is dropped at the selected site in 25 to 30 m depth, and it's GPS position recorded. A pair of divers descend this line and swim on the lakebed, along a bearing approximately perpendicular to the shore up to 5-6 m depth recording the changes in habitat and communities at 10 m intervals, along a horizontal line laid for this purpose. This line aids coordination with fish censuses and other exercises.

On completion of the dive the details of substratum, flora, fauna and depth are recorded on specific forms. As knowledge of communities increases, profiles can be recorded as series of habitats, denoted by the species assemblages. Each habitat would be recorded on a separate form, numbered shallow to deep, with all habitat sheets being stored with the single site sheet for that dive. Each site sheet has a site description and hand-drawn diagram, with most of the physiographic data contained on this sheet. Species are not sufficiently known to be incorporated onto the forms as yet. Data from successive surveys are stored in chronological order, each survey identified by it's survey number. Maps with the locations of each dive on that survey will be stored with the completed forms, should adequate maps ever become available.

2.4   Fish Census

The following fish census techniques, all of which are described in detail in the "Standing Orders Document", were evaluated for use in the BIOSS surveys: (i) Stationary Visual Census (SVC); (ii) Rapid Visual Census (RVC) and; (iii) Gillnets. The results of the evaluations are presented in a separate report (Ref: An Evaluation of Fish Census Techniques for Lake Tanganyika). The additional information collected on fish communities during these trials is presented below as a preliminary survey of the training areas. Each technique used is described in brief below.

(a)   SVC technique. A pair of divers censuses the fish population within a cylinder of water above a circular census area of 5 m radius on the lakebed. The species present and

the number of individuals within each species are recorded. The census is repeated at 15 m, 10 m and 5 m depths at each site. This technique provides information on the species diversity and density within small point census areas. Dive time limitations restrict this technique to the census of three areas at 15 m, 10 m and 5 m, starting at the deepest area and finishing with the shallowest, within each dive.

(b)   RVC technique. A pair of divers swim along a depth contour recording, for four consecutive five minute time intervals, the time interval when each fish species is first observed. The number of individuals of each species is not recorded. This technique can cover greater areas than the SVC and, although no information is collected on the actual abundance of species, it can determine relative abundance of species and it provides a more comprehensive species list for an area.

(c)   Gill Nets. Gillnets were set to provide a second measure of species diversity sampling both nocturnal species and areas not suitable for diving visual census. The nets used were monofilament, 60 m long and 1 m deep, with multiple mesh sizes ranging from 8 mm to 50 mm (diagonal mesh). In these trials nets were set parallel to the shore at depths ranging from 3 m to 10 m. Fish captured were measured (total length), weighed (combined weight for all individuals of each species within each mesh size), and identified to species.

2.5   Calculation of Diversity Indices

The Shannon-Weiner information statistic was used to describe the diversity within fish communities at each site. This statistic combines information on both the number of species and their relative abundance to describe the community in terms of its diversity. The formula used for calculating this diversity was:

$$H_s = - \sum_{i=1}^{s} p_i \log_2 p_i$$

H_s = the symbol for the amount of diversity in a group of "s" species.
S = the number of species
p_i = the relative abundance of the ith species from 0.0 to 1.0 (for example if the species under consideration is the second on the list, we label it $i = 2$; and if 10 per cent of all individuals belong to that species, $p_i = 0.1$)
$\log_2 p_i$ = the logarithm (base 2) of p_i.

The negative sign is added to make H positive as all logarithms between 0 and 1.0 will be negative. A larger value of H means that if an individual is picked at random there is less certainty about which species it will be than if H had a lower value. For any given number of species, H_s will be greatest if the species are all equally abundant. In effect the diversity index measures two things: **species richness** (number of species present) and **species evenness** (a measure of the evenness of the distribution of individuals between species). Species evenness can be separated from the index by dividing the observed diversity value by the maximum possible if each individual belonged to a different species. Evenness (J) is thus defined as

$$J = H_s / H_{max}$$

where H_s is diversity and $H_{max} = \log_2 s$. Using both values we can tell whether any difference in diversity between sites results from a difference in the number of species present or from a more even distribution of individuals between species. For example, a site with 20 species, 90% of which belong to only one species, will have lower diversity index than another site, also with 20 species, but with an equal distribution of individuals between species.

The project has hitherto concerned itself with fish censuses only, and therefore cannot debate biodiversity *per se*. Care must be taken not to prioritise sites for conservation solely on the basis of their fish species diversity indices as sites with many "rare" and few "abundant" species may have a relatively low diversity index, despite their obvious conservation value. Those sites with the same number of fish species, all of which are the more common and

more evenly distributed species, may mistakenly be given conservation priority based on their higher diversity indices. It therefore follows that records of the locations of rarer species must also be reported.

2.6   Other Taxa

At this stage in the BIOSS field programme, protocols for surveying fish were most advanced while procedures for other taxa were still under development. Therefore, the survey work reported here, as part of the training programme, based on habitat description and fish census.   As BIOSS develops protocols for other taxa, it is anticipated that future surveys in the Kigoma region will complete the initial picture reported here.

2.7   Selection of Survey sites

Survey sites were selected on the basis of their suitability as training sites, requiring good access, preferably by both boat and car, and supporting a variety of habitat types and a high abundance of fish species. To the north of Kigoma the shoreline was highly linear with little variety, and there was no access by road, due to the presence of the military in the surrounding hills. The coast south of Kigoma consists of two bays and one peninsula, Kigoma and South Kigoma Bays and Bangwe Peninsula, before sweeping southeastwards in great arcs through Ujiji, Karago and Kungwe Bays, stopping at the Mahale Mountains some 130 km to the south (Fig 1.1). This area immediately south of Kigoma was close to ideal for training, containing variety in habitats, species richness and being accessible. Although the priority in selection of this area was for training rather than survey purposes, the choice may prove suitable for monitoring.

3.   RESULTS

3.1   Surveys Conducted

The surveys conducted are summarised below in Table 3.1. The full details of site locations including GPS coordinates will eventually be held on the LTBP database.

Table 3.1   Sites surveyed, gear types and dates of deployment.

Census Type	Sites surveyed	Dates
Manta Tow Survey 1 Manta Tow Survey 2	Bangwe Pt to Katabi Village Luansa Pt to Bangwe Pt	25/9/97 10/10/97
Habitat Profile (10 dives) Habitat Profile (6 dives)	Bangwe Pt to Katabi Village -6 sites Luansa Pt to Bangwe Pt - 6 sites	26/9/97-10/10/97 10/10/97-15/10/97
Stationary Visual fish Census (SVC)	Jakobsens Beach Area-36 censuses South Kigoma Bay - 6 censuses	23/9/97 – 1/10/97 7-9/10/97
Rapid Visual Fish Census	Jakobsens Beach Area -21 censuses South Kigoma Bay -2 censuses	23/9/97 – 1/10/97 7-9/10/97
Gill Net Census	Jakobsens Beach Area (2 castes)	10/10/97

3.2   Shallow Water Habitat Distributions

For the purposes of survey the coast was divided into two sectors, primarily so Manta Survey of each could be finished in one day. The first section ran from Luansa Point to Bangwe Point and the second from Bangwe Point to Katabi Village in Ujiji Bay. This division of the coastline proved fortuitous as the northern and southern sections were markedly different. Manta Board Survey results are shown in Figs 3.2.1 and 3.2.2. The southern sector from Bangwe Pt to Katabi was surveyed, and will be described, first. Shallow water substratum type is indicated by symbols, explained in the legend. Each division represents the three minute cruising time between recording stops.   Allocation of a single substratum type to a three minute traverse depended on it forming 70% or more of the substratum observed. Manta survey substrata summary for the two cruises is given in Table 3.2.

Table 3.2Manta Survey substratum summary results for both coastal areas surveyed

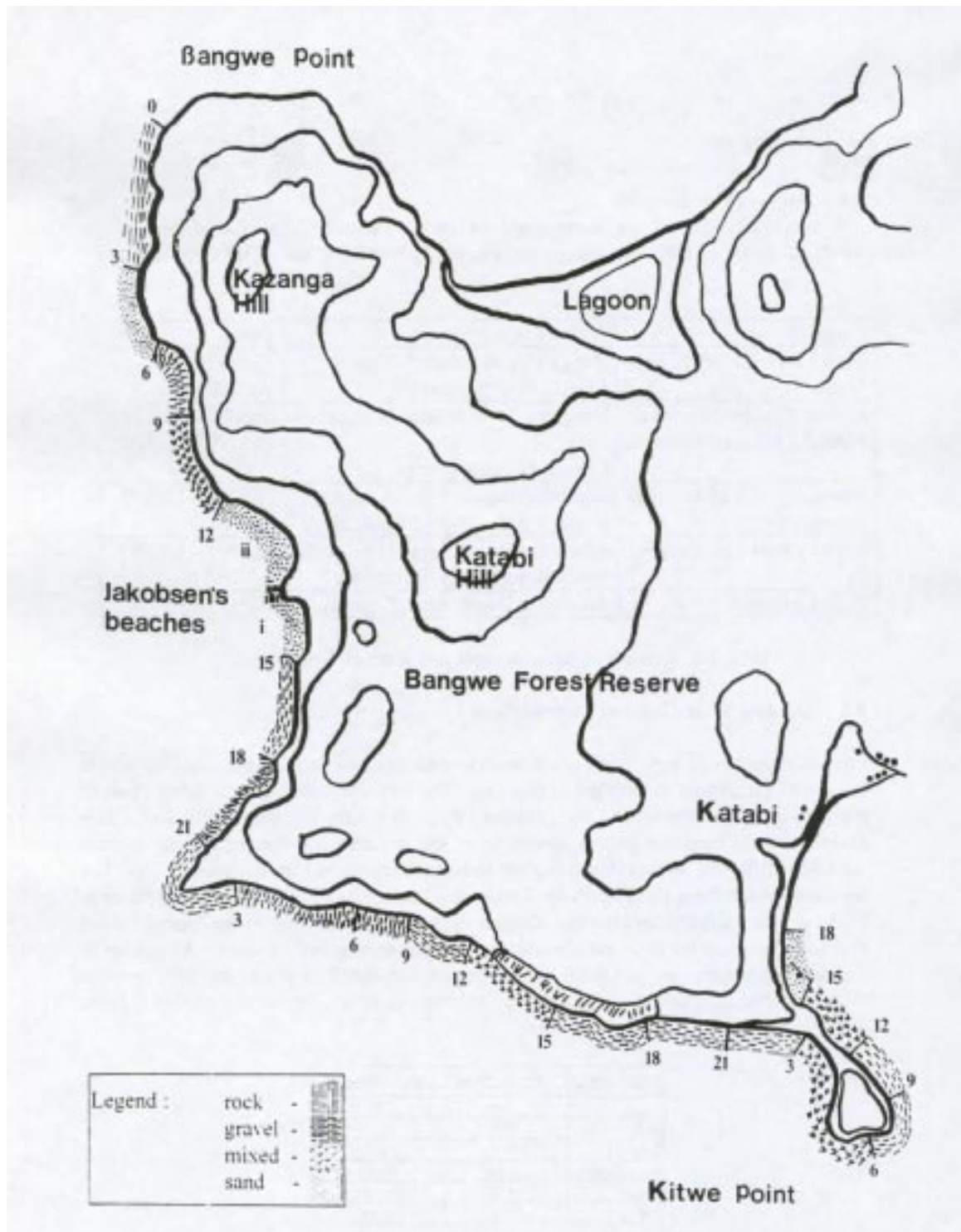| Substratum	Bangwe-Kitwe	Luansa-Bangwe
	%	%
Bedrock	11.2	12.27
Boulders	16.7	13.18
Rock-Cobble	25.65	17.95
Gravel	11.02	6.14
Sand	23.63	50.68

Figure 3.1   Substratum types mapped by the Manta Board Survey of the Bangwe Point to Katabi Village section.

3.2.1 Bangwe Point to Katabi Village

It can be seen that the Bangwe Pt to Katabi stretch is a primarily rocky peninsula with only two small sandy beaches apart from Katabi in Ujiji Bay. The other stretch of sand is just south of Bangwe, lies in 5-8 m of water, off a rocky shore. This paucity of sand is not surprising for an such an exposed peninsula. The 1: 50,000 O.S. maps mislead, in that the grid lines are not aligned north-south, and show Bangwe Pt in line with the coast north and south. In fact Bangwe Pt is the most westerly projection on the coast from the Burundian border to the Mahale Mountains (Belgian Exploration Series, 1946-47). This is significant in the context of proximity to deep water.

The peninsula in general comprises rocky habitats. Bangwe Point itself was rocky with some sand on its' eastern aspect facing into S. Kigoma Bay. From the point south to the next unnamed point the rock continued, broken by three sand patches, one due west of Kazanga Hill and the other two making up Jakobsen's Beaches i & ii (Fig 3.2.1). This rock comprised mainly of large boulders and bedrock, with small boulder fields seen occasionally at the limits of vision. Beyond the sharp point south of Jakobsens', is a stretch of classic storm beach pounded by surf, fully exposed to the southwesterly winds which dominated from May to October (Coulter, 1991). Shallow substrata of gravel and boulders lie off this beach, which continue around Kitwe Point before giving way to sand in the shallow waters of Ujiji Bay near Katabi Village. Sample manta survey forms can be seen in Appendix I.

3.2.2 Luansa Point to Bangwe Point

The Luansa Point to Bangwe Point sector by contrast, is composed of sandy bays interspersed with rocky headlands. Working from north to south, Kigoma Bay was shallow, sandy and relatively featureless, with rocky substratum associated with Luansa and Tembo Points. Kigoma Bay was the most heavily human impacted area surveyed. Luansa Point was fringed by small boulders and cobbles which gave way to sand at 5 m, and was shallow, being recessed in comparison to the other headlands. Tembo Point, whose main head was a sheer cliff of 40-50 m height, had accumulations of cobble at its' base in 6 m of water, in addition to stacks and very large boulders. Tembo Point also had a reef stretching into Kigoma Bay from its' smaller northern head. South Kigoma Bay had large sandy stretches associated with a dried out lagoon in its' southern corner, but boulder fields and gravel beds in it's northeastern corner, exposed to the southwesterly winds. This northern half also contained reefs of rock both parallel and oblique to the shore, to within 1m of the surface. The eastern aspect of Bangwe Point showed sand from the bay gradually mixing with bedrock and large boulders, which characterised the point itself.
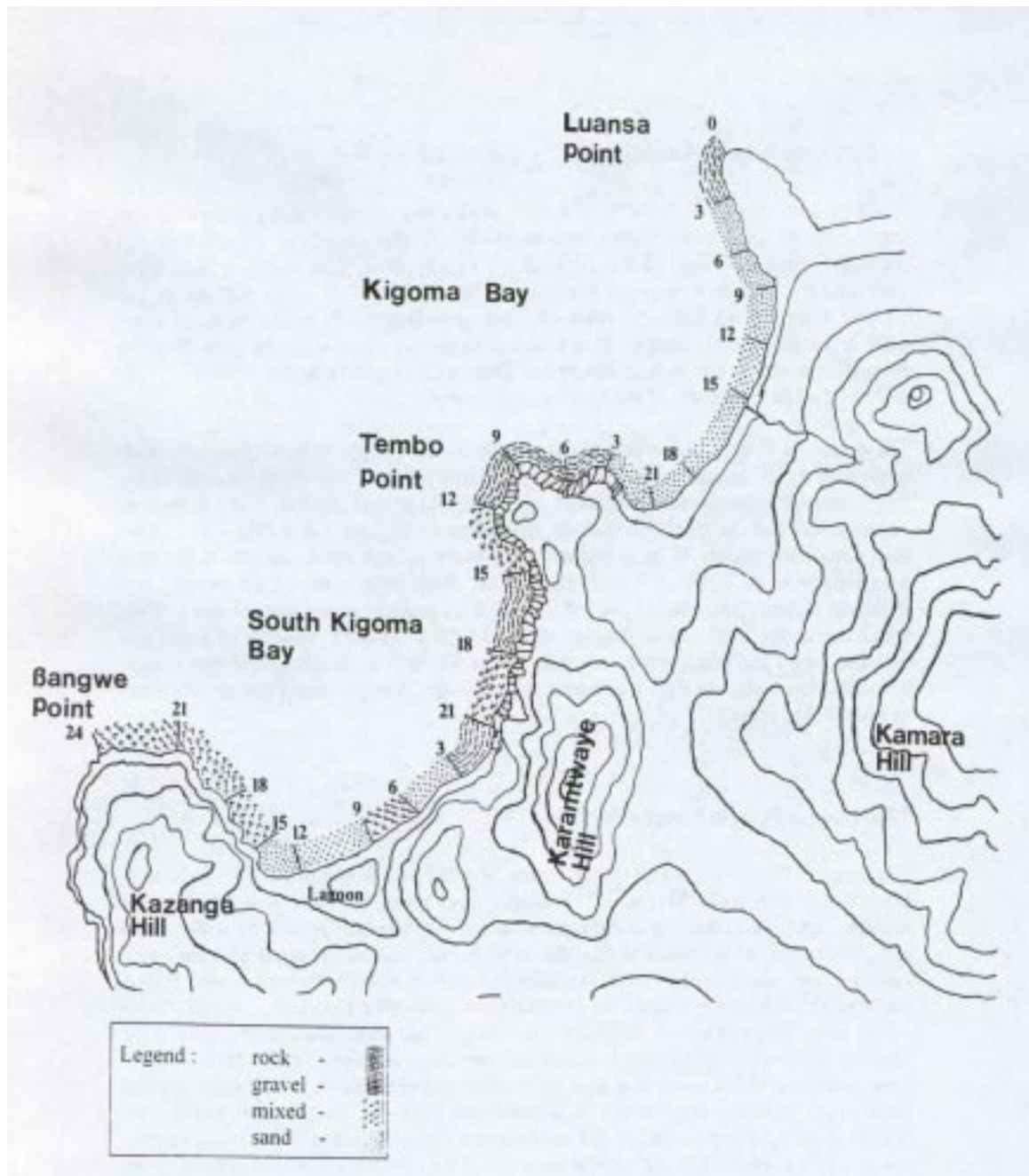
Figure 3.2   Substratum types mapped by the Manta Board Survey of the Luansa Point to Bangwe Point section.

3.3   Habitat Profiles

3.3.1 Bangwe Pt to Kitwe Pt

Initially, four sites were chosen to be profiled from Bangwe Point to Katabi, representing sheltered and exposed rock and sand. This was increased to six however to give a better appreciation of changing habitats (Fig 3.3.1).   This section of coast was profiled more thoroughly than the northern section, as the latter survey was disrupted by the trip to Gombe Stream National Park. In general, sand was the final substratum encountered replacing rock by 20-26 m at the deepest, and gradually shelving to the west before dropping steeply into the depths (Belgian Exploration Series, 1946-47). Sites topography was more variable above 20m, but as in temperate waters it proved difficult to predict sublittoral topography from that of the littoral (the terms littoral and sublittoral following Coulter 1991).   Some sample profile forms are given in Appendix II.

Site 1 : NW corner of Kitwe Point
This site consisted of a boulder slope from 23m upwards, at a gentle slope (30º). At depth sand was the dominant substratum, but boulders became more prevalent until they comprised 70% at 5m. Variable amounts of cobble and stone gravel were present throughout. The boulders were slightly flattened, with dense cover of calcite and filamentous algae, and eroded about their bases to provide major underboulder habitat. This site looked very exposed, but was remote from deep water.

Site 2 : Jakobsens' Beach No.2
This exposed beach proved interesting in that descent from the sandy beach, bedrock was encountered from 8m, which continued to 26m, at which point the dive was turned. Good numbers of fish were found off the rock, which was heavily coated in calcium carbonate. It was observed that the calcite took different forms at different depths. The gradient was moderate with rock faces providing vertical sections. This profile would not have been expected from the manta survey results. It is not known at what depth the rock gave way to sand, however, at sites just north and south, rock merged with sand at 30-35m. These latter sites were not formal survey sites.

Site 3 : SW corner of bay N of Kitwe Point
This site was in the partially protected corner of a bay, with a gently shelving bottom consisting of various mixtures of cobble and sand. At 25m cobble composed 80% of the substratum, but decreased to almost zero at 20 and 15m, before increasing to almost 100% at 10 and 5m. The shallower cobble was cemented together with calcite and where this had crumbled, due to erosion, left an overhanging 0.50m shelf much favored by the fish present. The shallow cobble was densely covered with filamentous algae, but fish numbers were modest. This bay lay off the storm beach and was very exposed to southwesterly swell, although the site itself was protected by Kitwe Point.
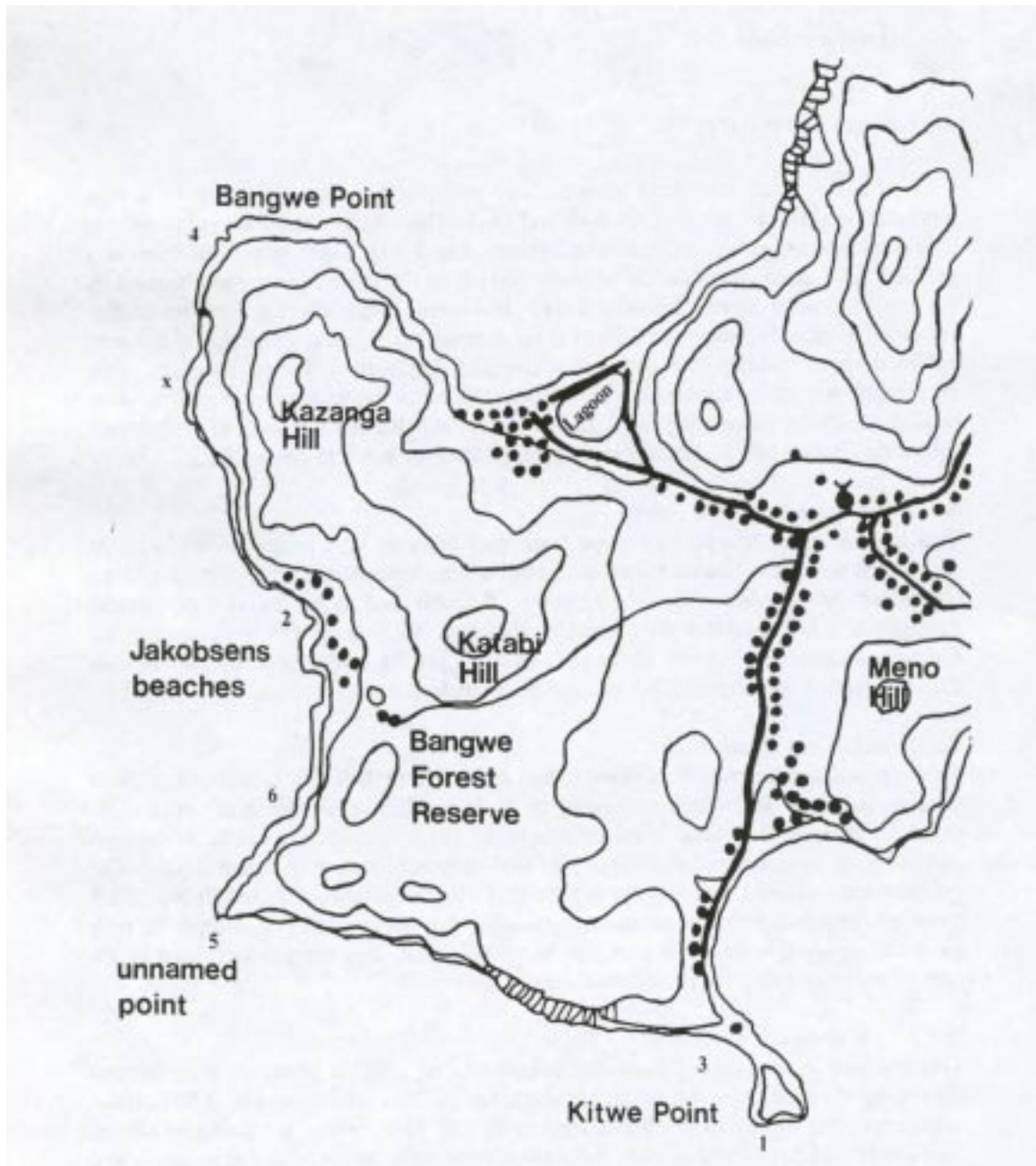
Figure 3.3   Sites of habitat profiles conducted on the Bangwe Point to Kitwe Point section of coast.

Site 4 : Bangwe Point
This site was characterised by shelves of bedrock and large boulders, with abundant overhangs, cliffs and crevasses, to depths of 25m where sand patches became more common. However, deeper than 25m was not surveyed due to the inexperience of the dive trainees. Dense communities of fish were associated with the rocky habitats, with good numbers of gastropods throughout. Westward around the point the gradient became steeper until reaching the steepest section at 'x'. Small sand shelves occurred at 4m in many areas.

Site 5 : Unnamed Point
This site was lying off a very prominent point, and showed a steep slope down to 26 m. At this depth the substratum consisted of boulders and sand with abundant dead *Mutela speksei* shells, calcite and filamentous algae. The boulders soon gave way to bedrock, with a change in calcite to 'cauliflower' type with the characteristic dark red cyanobacteria colonies. This form gave way to an open lattice on shallower rock, with small fish in each fenestration. At 5 m, a smooth calcite resembling flow-stone, coated the rock. The bedrock formed a tumbled slope with one vertical section leading on to a sand ledge at 5 m. A 0.5 kt southerly current was noticed on ascent from 5 m. The direction of the wind at the time was southwesterly. Fish numbers were good but not remarkable, possibly due to the relative absence of overhangs and crevices in the rock. This site suggested deeper water nearby, but on a separate dive was seen to bottom out on sand at 30 m, much like Kitwe Point. This illustrates the point that although both unnamed and Kitwe points look to be prominent westerly projections, they are considerably further east than Bangwe Point and hence well removed from deep water. They are in fact surrounded by aprons of sand, which may have a bearing on their lower diversity in fish than Bangwe Point.

Site 6 : Creek south of Jakobsens' Beach.
This was another site of steep profile down to 34 m, where a gentle sand gradient supervened. However bedrock composed the majority of the substratum, with a topography of rock ledges down to 27 m. Fish, gastropod and mussel shell were abundant, and the same changes in calcite type with depth, were found as at sites 2 and 5. A more mixed substratum occurred at 4 m.

Site west of Kazanga Hill ('x')
This site was unique, in that the gradient was steep down to 62 m, and at which depth the substratum consisted of sand with scattered boulders. There was no indication at this depth that the slope (45°) levelled off. Between 29 and 45 m a 70° cliff of bedrock was encountered, with high numbers of associated fish, although the rock showed only moderate fissuring and few crevices. This site was not one of the six chosen, but was profiled by Paul Tierney solo, and is included due to its' uniqueness. It is marked on Fig 3.3.1 by an 'x', due west from the summit of Kazanga Hill.

3.3.2 *Luansa Pt to Bangwe Pt*
The sublittoral of the two bays enclosed in this sector, was primarily sedimentary, with some exceptions, and exposed the survey to a distinct, though reduced, set of habitat types. In addition, Kigoma Bay is heavily impacted by local communities, through beach seining, boating, swimming and washing, and was familiar to the teams due to the training programme having been run in the bay off TAFIRI. Only two sites in Kigoma Bay were chosen for habitat profiling. South Kigoma Bay offered greater variety but was nevertheless a sandy bay, relieved by some reefs and rocky margins. A total of six sites were also chosen for this section (Fig 3.3.2). The omission of a coring/grabbing component to describe the sediment communities and granulometry, reduced survey ability to characterise habitats, for than on rocky substrata.

Site 1 : Luansa Point
This site consisted of a sandy plain from 4 m down, with most of the habitat being formed by discarded human artifacts. The gradient was gentle and observed diversity levels low. After diving the team were briefly arrested by the army as Luansa Point is military land. This might have been a useful monitoring site otherwise, due to its' proximity to Kigoma Port.

Site 2 : Lesser headland of Tembo Point
This site was more complex with a reef extending 50 m to the northwest from this point. The reef crest lay at 4 m and the western side dropped vertically to 12 m, where upon a cobble field at 25º dropped to 26 m, where the dive was turned. The cobbles were cemented together with calcite, and lay on a poorly sorted sandy shelly gravel, scattered with many dead *Mutela sp.* shells. The cobbles were undercut, forming abundant habitat for the numerous fish present. The reef was also well populated, and formed a series of low shelves on its' eastern side. The reef crest was covered with smooth 'flow-stone' calcite, with well grazed fields of filmentous algae. The calcite on the cobbles often formed an 'lip' on the stones. Large sponges were prominent on the underside of cobbles, shells, shoes etc. Turtle and *Lates mariae* specimens were also seen at this site.

Site 3 : Southern side of Tembo Point
This site again contained a reef, this time running southwest, starting some 15 m south of the southern aspect of the headland. This reef was calcite covered, forming small fissures occupied by insect larvae and sponges. The occasional crevice contained fish, including *Malapterus electricus*. The reef dropped vertically to 12 m, to a dense cobble field with abundant *N. brichardi*, and calcite. At 16 m this cobble field at a 15º slope, thinned out, the cobbles being sunk into shelly sand. Around most cobbles was excavated by small fish, forming territories which were guarded. This habitat extended to 24 m. A southerly 0.25 kt current was noticed while ascending from the reef top at 5 m.

Site 4 : South Kigoma Bay west of cliffs.
Substratum of coarse shelly sand dropping gradually (10º) to 25 m. Curiously flat-topped cobbles sunk into sand, with calcite formed around rock waist, as a lip. Most cobbles and small boulders were excavated underneath by fish, with each 'basement' divided into territories by shells and pebbles. This extended greatly the habitats available as demonstrated by the numerous fish, although of a limited number of species. Habitat seemed homogenous throughout.

Site 5 : South Kigoma Bay 400 m due north of lagoon
This site was very different from the last with sticky, well sorted and depauperate sand found throughout. Slope of 10º. Outcrops of bedrock and large boulders present at 5 m, and continued to 12 m. Sand only from 12 to 15 m where due to time constraints the dive was called. Fish were more plentiful on the rock, but not numerous. Shallow rock covered by smooth calcite and filamentous algae. Due to shallow gradient, this type of dive runs risk of incurring decompression.

Site 6 : Northern aspect of Bangwe Point
At this site large boulders and bedrock outcrops extended northwards from the shore in spines, of 1-2 m high. Not high enough to be called reefs. Down to 17 m between ridges, well sorted sand, accumulations of *Neothauma sp.* and *Mutela sp.* shells, plus deposits of small charcoal pieces, as if from a very large bush fire. Rock was smooth, calcite and algae covered. Many guarded fish nests on sand and rock.
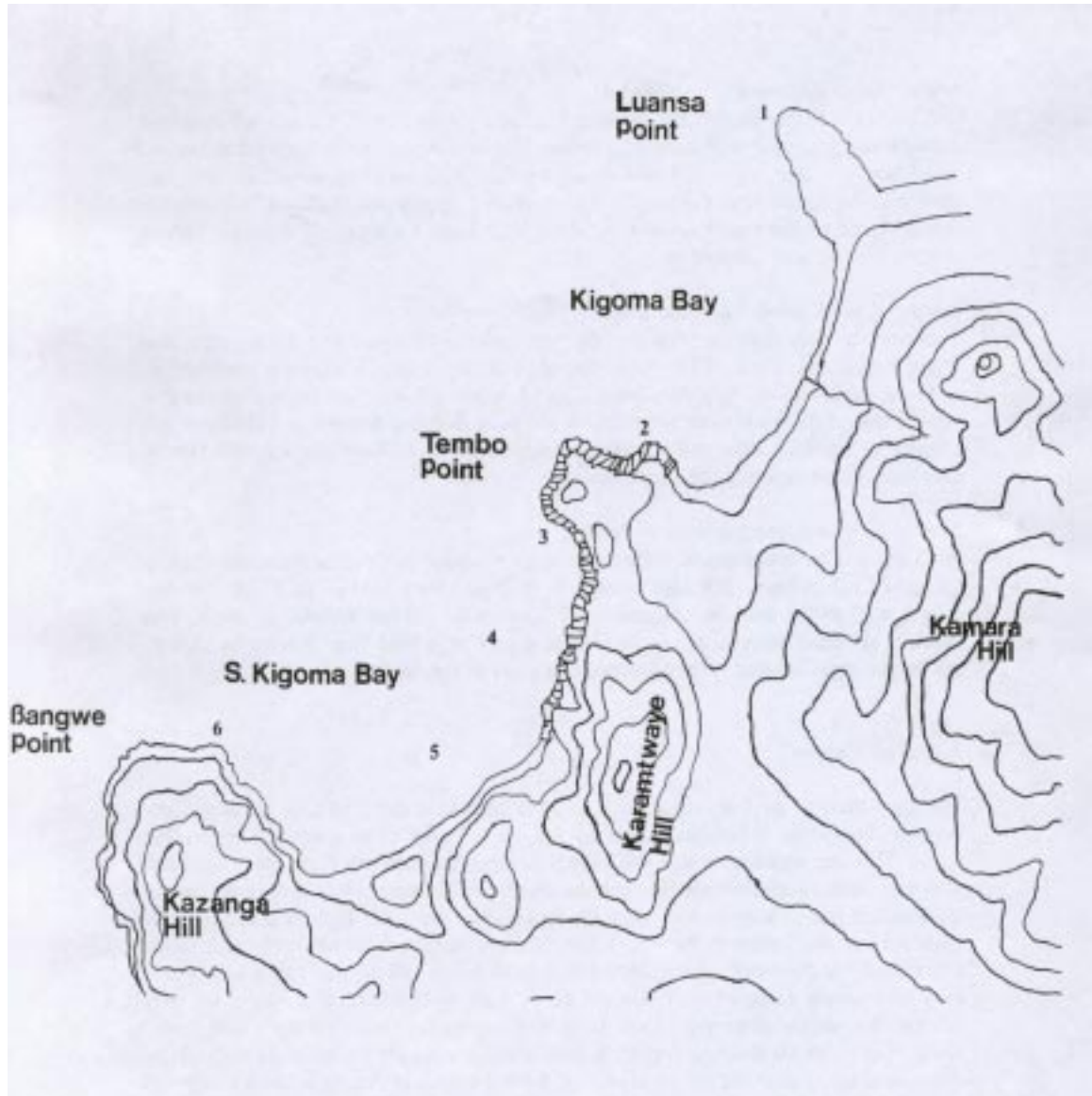
Figure 3.4   Sites of habitat profiles conducted on the Luansa Point to Bangwe Point section of coast.

3.4 Fish Census

The main trials of the fish census methods were conducted along an area of rocky shore between the two sandy beaches known as "Jakobsens" a few miles south of Kigoma (Fig 3.2.1). This area was chosen as a site known to support a relatively high diversity of fish with easy access both from the lake and the shore. Limited census was also carried out in the southern part of Kigoma Bay along the rocky shore and sandy bottom sites below the Hilltop Hotel on Tembo Point. The result of these surveys must be interpreted in the knowledge that the survey was restricted to only two sites and that the rocky habitat was more intensively censused than was the sandy habitat. In addition, all censuses were conducted at depths of between 5 and 10 m thus leaving the shallow water ("surf zone") and deeper water habitats unsurveyed. In conclusion, the results presented here should be considered incomplete and only preliminary for this stretch of coastline. As a number of the surveyors were inexperienced in fish identification at this time only data from those more experienced individuals has been used in compiling the results given below.

In overview the Jakobsen Beach area was found to support good examples of both rocky shore and sandy shore fish communities. The rocky shore communities were highly diverse with no obvious dominant species or genera. The sandy shore communities were typically less diverse and dominated by *Xenotilapia* and *Callochromis* species. Of note were the populations of *Enantiopus melanogenys* on the steep sand slopes below each of the beaches. The South Kigoma Bay fish communities differed from those at Jakobsens' in that they were more typical of a lightly sedimented rock / sand habitat supporting a lower overall diversity of species but significantly higher densities of selected species such as *Neolamprologus walteri*, *N. tetracanthus*, and *Xenotilapia ochrogenys.*

3.4.1 Species Richness

All censuses combined identified a total of 75 fish species of which 63 species were cichlids and 12 species non-cichlids. The list of species identified at each site is given in Appendix III.

Site 1: Jakobsen Beach Area
A total of 69 fish species were recorded at the Jakobsen Beach site of which 60 species were cichlids and 10 species were non-cichlids. The mean number of species recorded in each of the three areas, A B, and C censused most intensively during the trials (only 25 m apart) were 21, 23, and 15, respectively.

Site 2: South Kigoma Bay
A total of 38 fish species were identified in South Kigoma Bay of which 32 species were cichlids and six species were non-cichlids. Two additional species of non-cichlid, *Polypterus sp.* and *Auchenoglanis occidentalis* were observed during dive training raising the overall total to 40 species. The mean number of species recorded in each census area was 15 to 16.

Additional Species not recorded here:
Roger Bills (JLB Smith Inst.) collected a number of additional fish species during day and night-time gill netting in Kigoma Bay but his findings were not available to include in this report.

3.4.2 Species Diversity(H_s)

The overall diversity index for the combined sites of South Kigoma Bay and the Jakobsen Beach Area was 4.19.

Site 1: Jakobsen Beach Area
The overall site diversity calculated from the combined results of all censuses was 4.20.The mean point diversity for each 75 m^2 census area (3 areas censused a total of 21 times) was 3.03.

Site 2: South Kigoma Bay

The overall site diversity from the combined results of all censuses was 2.5.The mean point diversity for each census area (6 areas censused) was 2.32.

3.4.3 Fish Densities

The densities of fish within each 75 m^2 census area were compared. At the Jakobsen Beach area an average of 260 fish were recorded in each census area giving a mean density of 3.46 fish / m^2. In South Kigoma Bay the fish density was higher with an average of 631 fish in each census area giving a mean density of 8.42 fish / m^2. The high fish density in Kigoma Bay was, however, largely accounted for by the high abundance of a single cichlid species, *Neolamprologus walteri*.

3.4.4 Rare Species

The definition of "rare" species can not be determined on a lake-wide scale until the results of many more surveys are received from around the lake. However, on a more localised scale certain species may be classified as "rare" within the area or within a particular habitat type. Only one species *Polypterus sp.* was considered to be rare within the habitats surveyed with only two to three individuals recorded living in the soft sand / sediment areas below the north facing shore of Tembo Point.

3.4.5 Long-term Monitoring Sites

A number of sites throughout the lake are to be selected as long-term monitoring sites. Both South Kigoma Bay and the area between the two beaches at Jakobsens have been proposed as potential monitoring sites for this section of coastline. Communities near Luansa Point could also be monitored, being close but not in the port area, and likely to be affected by any pollution. No specific census areas have yet been identified in South Kigoma Bay but the three fish census areas at Jakobsens' have already been marked with submerged floats thus allowing repeated survey in the future. It would be safer however, to include non-fish taxa in censuses at monitoring sites. The data for fish census at these three areas is presented for future comparison in Appendix IV.

4. DISCUSSION

4.1 Overview of Findings

The results presented above provide a preliminary indication of the distribution of aquatic habitats and fish communities for the coastline stretching from Luansa Point to the Kitwe Peninsula. A full survey incorporating indicator taxa is recommended at some later date to quantify the biodiversity levels of this area. Although heavily impacted terrestrially in some areas, through clearance and human use, a wide variety of aquatic habitats and fish communities have been observed in an apparently healthy state. An exception to this would be the shallow shore below the TAFIRI research station where repeated overflows of oil from the TANESCO power station are expected to be having a negative impact on the resident fish populations. Although the northern part of Kigoma Bay was not surveyed, it is likely that shipping traffic and settlements pose a significant threat to biodiversity within that area.

4.2 Habitats

The prime determinant of habitat on this section of coast, in the absence information on community structure, was water depth. The effect of exposure was largely modified by the benthic gradient. The only area close to deep water, Bangwe Point, is significantly different from the other habitats, and the deeper rock communities (3.3.1: Site 'x') in particular warrant more dives. There were truly no deep rock habitats, as there are off the Congolese coast. Off Bangwe Point the adjacent deep water prevents accumulations of rubble and sand. Greater distance from depth allows prevailing winds to deposit sediment in the bays, but also around points such as Kitwe. The sand forms an 'apron' about this coast, which is contiguous with a narrow one off the coast north of Kigoma (Gombe Report). All sites, other than Bangwe west, bottomed out on sand at modest depth, and this does limit habitat available to the generally more diverse lithophilic communities. Given that the greatest concentrations of fish were found on rock, this is significant. Unfortunately, the diversity of the sediment habitats was not addressed due to the absence of established methods such as sampling for infauna and granulometry (Hiscock, 1996), from the protocol. Similarly, the absence of indicator taxa or species lists, for use on dives in all habitats, has heavily biased the survey toward fish diversity.

In the littoral, as would be expected, the more exposed headlands were associated with boulder/cobble mixtures, where gradient allowed. This was particularly obvious from the unnamed point to Kitwe Point where a storm beach showed three raised levels. Accumulations of sand in the shallowest water denoted some degree of protection from the prevailing southwesterlies, as in Kigoma and S. Kigoma Bays which are protected by the Bangwe Peninsula. The exposed littoral sand off at Jakobsens' beach No.2 was continuous with sublittoral sand at the southern end of the beach only, which was off the dive path. In terms of human impact, Kigoma Bay is heavily used, South Kigoma Bay is lightly used while the Bangwe Peninsula is not impacted, being part of the Bangwe Forest Reserve, running roughly from Bangwe Point to Kitwe Point. Several habitat features were observed often enough to deserve mention. Calcite deposition was found to be very prevalent, and was seen to contribute significantly to habitat creation and stabilisation. The form which this compound took, could vary with depth (or some other parameter), three distinct calcite forms were observed regularly on rock. The factors which govern calcite deposition, could provide important data on physico-chemical conditions at microhabitat level, which could clarify determinants of biodiversity. Calcite deposition needs further study.

Whereas the effect of exposure to wave surge readily observable, the influence of local water circulation was less obvious. Currents are a well recognised Lake Tanganyika phenomenon (Coulter, 1991; Fryer & Iles, 1972), and were recorded at Tembo Point and the unnamed point moving southerly, against the wind.   These could affect nutrient flow and larval dispersion locally, and further study of these currents armed with a more complete species list would be profitable.   Clearly this survey has not addressed biodiversity as such, merely habitat distribution and fish diversity. This area represents an ideal survey zone due to its' variety and proximity to Kigoma, with implications for training and pollution, and should be resurveyed.

However unless a more complete survey is undertaken, on all habitats, current conclusions will remain speculative.

4.3   Fish communities

The great variety of habitat types identified within this short section of coastline was, in turn found to support a wide variety of species rich fish communities even though only a small proportion was censused. The majority of cichlid communities were represented including those typical of deep and shallow water rock and sand habitats, pebble beaches, algal beds, shell deposits, underwater cave systems, and deep water sand / silt areas. The diversity recorded in this survey is high when we consider that only two sites were censused and no nocturnal gill netting results were included.

4.3.1 Modification of the SVC

Although the full evaluation of methods is reported elsewhere one important modification to the SVC for fish must be included here. It is recommended that juvenile fish be excluded from all future SVC counts. The counts of juveniles present in large, high density, single species shoals were not only hard to estimate accurately but their inclusion was found to significantly reduce the Diversity Indices computed for otherwise highly diverse sites. The inclusion of these counts in the calculations for diversity might indicate that the sites in question were largely dominated by a single species when in reality the majority of these juveniles would never survive to adulthood to take an established position in the fish community. It is therefore recommended that in future fish census juveniles are not included in the counts but their presence should still be noted down on a separate part of the form.

4.4   Recommendations for Future Work

*   Diver training must continue to establish a working survey team for this area.
*   Census of other taxa, such as crustaceans and molluscs, must be implemented.
*   A full survey of this coastal strip should be completed to include surf zone habitats, the algal beds in South Kigoma Bay, deep rock off Bangwe Point and benthic sediment habitats within the bays.
*   A reference collection for fish species should be compiled for the local area.
*   The monitoring programme must be implemented as soon as possible and a site selected for monitoring fish populations in South Kigoma Bay. A monitoring site closer to the port should be considered.
*   The potential impact of the translocation of fish species by the aquarium fish trade should be assessed as fish stocks are held in Kigoma Bay prior to shipment.
*   An evaluation of the potential for dive tourism should be instigated for this area, with recommendations to government or commercial interests.

4.5 Management Recommendations

(A) Reserve Status
Full management recommendations will have to wait until a more comprehensive survey is completed for this area. This preliminary survey does, however, find the area to support a sufficiently high diversity of habitats and associated fish communities to warrant recommendation that the coast from the Tembo Point to Kitwe Point be included within a reserve.

(B) Dive Tourism
The ease of access to the area combined with the high aesthetic value of these underwater habitats to cichlid enthusiasts suggests that the area may well have potential for the development of dive tourism. Although diver tourism is often seen as a negative influence through increased habitat destruction by divers, if properly managed it could bring significant benefits through:

- increased local income and employment opportunities from operating diving tours and renting out diving and snorkeling equipment;
- raised local perception of the area as an income generating resource worthy of preservation; and
- raising the international profile of the lake and its need for management and preservation.

The negative effects of dive tourism seen in other parts of the world are most often due to habitat destruction from anchors and careless divers. This problem is more applicable to the highly fragile coral reef ecosystems. The habitats of the lake are considerably more robust than those of coral reefs and would be unlikely to suffer from such damage. Although not available in the Kigoma area itself, the possibility of combining a diving tour with a wildlife safari in the surrounding areas such as Gombe Stream and the Mahale Mountains National Parks further strengthens the case for development of diver tourism in Lake Tanganyika. Although dive tourism is increasing rapidly world-wide, Lake Tanganyika could not compete with the Red Sea for example. However, there are undoubtedly divers, either cichlid enthusiasts or more wealthy divers, for whom a combined trip would appeal. Diving on Lake Malawi is well developed, primarily as a training operation, but there is little reason why Lake Tanganyika could not follow suit. These would be niche markets, and would probably be difficult to incorporate within the projects' remit. Commercial operations would be more likely to succeed.

5. REFERENCES

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6.   APPENDIX 1 – FISH CENSUS DATA – JACOBSON BEACH AND KIGOMA BAY

AREA	JACOBSONS					KIGOMA BAY		
SITE	J1	J1	J2	J1	ALL SITES	K1	K1	K1
CENSUS METHOD	SVC	RVC	RVC	GILL NET	COMBINED	SVC	RVC	COMBINED
DATA TYPE	Combnd count of 21 censuses	No. censuses when observed	No. censuses when observed	No. caught for 2 nettings	"*" = species was observed	Combned count of 6 censuses	No. censuses when observed	"*" = species was observed
TOTAL CICHLIDS	46	46	49	20	60	25	25	32
TOTAL NON-CICHLIDS	10	8	7	4	9	6	3	6
SPECIES								
Acapoeta tanganicae	1		3		*		1	*
Altolamprologus compressiceps	44	10	9	1	*	11	1	*
Asprotilapia leptosoma		3	5		*			
Barbus sp.		2	3		*			
Boulangerochromis microlepis		3	0		*	3	1	*
Callochromis sp.	30		0		*			
Chalinochromis brichardi	17	10	9		*			
Cyathopharynx furcifer	450	10	5		*			
Cyphotilapia frontosa	70	3	5		*			
Cyprichromis leptosoma	1459	8	6		*		1	*
Cyprichromis microlepis		1	4		*			
Enantopus melanogenys	6				*			
Gnathochromis pfefferi	19	5	8	3	*			
Grammatotria lemairii	2	1			*	6	1	*
Haplotaxodon microlepis	494	10	9	27	*		1	*
Julidochromis marlieri	30	7	7		*	2	1	*
Julidochromis regani		3	2		*			
Lamprichthys tanganicus	306		2	32	*	10		*
Lamprologus callipterus	529	11	10	9	*	344	1	*

AREA	JACOBSONS					KIGOMA BAY		
SITE	J1	J1	J2	J1	ALL SITES	K1	K1	K1
CENSUS METHOD	SVC	RVC	RVC	GILL NET	COMBINED	SVC	RVC	COMBINED
DATA TYPE	Combnd count of 21 censuses	No. censuses when observed	No. censuses when observed	No. caught for 2 nettings	"*" = species was observed	Combned count of 6 censuses	No. censuses when observed	"*" = species was observed
TOTAL CICHLIDS	46	46	49	20	60	25	25	32
TOTAL NON-CICHLIDS	10	8	7	4	9	6	3	6
SPECIES								
Lamprologus lemairii	18	6	8	1	*	14	1	*
Lamprologus sp.	5	2	1		*			
Lates sp.	25	9	3		*			
Lepidolamprologus attenuatus	44	5	4	2	*	45	1	*
Lepidolamprologus cunningtoni	6	1	2	2	*		1	*
Lepidolamprologus elongatus	171	11	8	12	*	120	1	*
Lepidolamprologus profundicola	6	5	5		*			
Lestradea perspicax	24				*			
Limnotilapia dardennii	113	10	7	3	*	22	1	*
Lobochilotes labiatus	99	11	10	1	*	19	1	*
Malapterus electricus						1		*
Mastacembelus sp.	13	4	6		*	3	1	*
Neolamprologus brichardi	1141	11	9	9	*	100	1	*
Neolamprologus furcifer	19	10	8		*		1	*
Neolamprologus mondabu	182	9	7	8	*	110	1	*
Neolamprologus niger	9	2	1		*	30		*
Neolamprologus savoryi			4		*			
Neolamprologus tetracanthus			2		*			
Neolamprologus toae	6		4		*			
Neolamprologus tretacephalus	57	11	6		*	7	1	*
Neolamprologus walteri	132	8	5		*	1980	1	*

AREA	JACOBSONS					KIGOMA BAY		
SITE	J1	J1	J2	J1	ALL SITES	K1	K1	K1
CENSUS METHOD	SVC	RVC	RVC	GILL NET	COMBINED	SVC	RVC	COMBINED
DATA TYPE	Combnd count of 21 censuses	No. censuses when observed	No. censuses when observed	No. caught for 2 nettings	"*" = species was observed	Combned count of 6 censuses	No. censuses when observed	"*" = species was observed
TOTAL CICHLIDS	46	46	49	20	60	25	25	32
TOTAL NON-CICHLIDS	10	8	7	4	9	6	3	6
SPECIES								
Opthalmotilapia ventralis	205	7	7	14	*			
Oreochromis tanganicae	14				*	4		*
Paracyprichromis breini		6	5		*		1	*
Perrisodus microlepis	140	10	7	10	*	9		*
Perrisodus straeleni						1	1	*
Perrisodus straeleni			3		*			
Petrochromis ephippium	7	7	6	4	*			
Petrochromis famula	6	7	3	1	*			
Petrochromis fasciolatus		1			*			
Petrochromis macrognathus		1	5		*			
Petrochromis orthognathus	4	7	4	3	*	34	1	*
Petrochromis polyodon	54	7	5		*			
Petrochromis trewaversae	5	1	1		*			
Plecodus elaviae						1	1	*
Plecodus paradoxus		2	1		*			
Plecodus paradoxus	4				*			
Simnochromis babaulti								
Simnochromis diagramma	20	2			*	11		*
Simnochromis marginatus	4	1			*			
Simnochromis sp	34	4	3	2	*	1		*
Synodontis eurystomus	1				*			

AREA	JACOBSONS					KIGOMA BAY		
SITE	J1	J1	J2	J1	ALL SITES	K1	K1	K1
CENSUS METHOD	SVC	RVC	RVC	GILL NET	COMBINED	SVC	RVC	COMBINED
DATA TYPE	Combnd count of 21 censuses	No. censuses when observed	No. censuses when observed	No. caught for 2 nettings	"*" = species was observed	Combned count of 6 censuses	No. censuses when observed	"*" = species was observed
TOTAL CICHLIDS	46	46	49	20	60	25	25	32
TOTAL NON-CICHLIDS	10	8	7	4	9	6	3	6
SPECIES								
Synodontis multipunctatus	19	2	1		*			
Synodontis petricola				2	*		1	*
Telmatochromis bifrenatus	82	7	6		*	75	1	*
Telmatochromis burgeoni	5	2			*			
Telmatochromis dhonti	6				*	1		*
Telmatochromis temporalis	48	6	6	3	*	655	1	*
Telmatochromis vittatus	9	2			*			
Tropheus duboisi	42	11	10	2	*	8		*
Trpheus moorii	10		1		*	2		*
Xenotilapia flavipinnis	1025	6	1	1	*	150	1	*
Xenotilapia sima	34	8	4		*			
Xenotilapia spilopterus	119	3	2	1	*			

7. APPENDIX 2 – SUMMARY OF CENSUS DATA FOR MONITORING SITES AT JACOBSON'S BEACH, KIGOMA

	SITE A	SITE B	SITE C	COMBINED SITES
DATE OF CENSUSES	23-25/9/97	23-25/9/97	23-25/9/97	23-25/9/97
NUMBER OF CENSUSES	9	6	6	21
MEAN DIVERSITY INDEX	2.64	3.62	3.01	3.03
MEAN No. SPECIES	20.5	22.8	15.2	19.5
MEAN No. FISH	499	211	69	260
MEAN DENSITY FISH / 75M2	6.65	2.82	0.91	3.46

	MEAN NUMBERS RECORDED PER CENSUS			
SPECIES	SITE A	SITE B	SITE C	COMBINED SITES
Acapoeta tanganicae	0.11	0	0	0.04
Altolamprologus compressiceps	0.56	1.17	0.43	0.72
Callochromis sp.	0	0	0	0
Challinochromis brichardi	1.44	0.17	0.43	0.68
Cyathopharynx furcifer	6.11	25.83	1.71	11.22
Cyprichromis leptosoma	138.89	0	0	46.3
Cyphotilapia frontosa	3.11	0	0.43	1.18
Enantiopus melanogenys	0.67	0	0	0.22
Gnathochromis pfefferi	1.33	1.17	0	0.83
Grammatotria lemairii	0.22	0	0	0.07
Haplotaxodon microlepis	43.11	16.67	0	19.93
Julidochromis marlieri	0.89	1.5	0.86	1.08
Lamprologus callipterus	26	20	12.57	19.52
Lamprologus lemairii	0.44	1.5	0.29	0.74
Lamprologus sp.	0	0	0.29	0.1
Lamprichthys tanganicus	0.67	16.67	0	5.78
Lates sp.	2.22	0	0	0.74
Lepidolamprologus attenuatus	2	1.17	1.86	1.67
Lepidolamprologus cunningtoni	0	0	0.86	0.29
Lepidolamprologus elongatus	7	7	4.14	6.05
Lepidolamprologus profundicola	0.22	0.5	0.14	0.29
Lestradea perspicax	1.67	1.5	0	1.06
Limnotilapia dardennii	3.44	9.17	2.71	5.11
Lobochilotes labiatus	2.67	2.83	0.71	2.07
Mastacembelus sp.	0.56	0.33	0.71	0.53
Neolamprologus brichardi	89.44	25.5	0.71	38.55
Neolamprologus furcifer	1.11	1.17	0.29	0.85

	SITE A	SITE B	SITE C	COMBINED SITES
DATE OF CENSUSES	23-25/9/97	23-25/9/97	23-25/9/97	23-25/9/97
NUMBER OF CENSUSES	9	6	6	21
MEAN DIVERSITY INDEX	2.64	3.62	3.01	3.03
MEAN No. SPECIES	20.5	22.8	15.2	19.5
MEAN No. FISH	499	211	69	260
MEAN DENSITY FISH / 75M2	6.65	2.82	0.91	3.46

	MEAN NUMBERS RECORDED PER CENSUS			
SPECIES	SITE A	SITE B	SITE C	COMBINED SITES
Neolamprologus mondabu	5	17.5	3.29	8.6
Neolamprologus niger	0	0.33	1	0.44
Neolamprologus toae	0	0	0	0
Neolamprologus tretacephalus	2.44	1.83	1.57	1.95
Neolamprologus walteri	5	7	6.43	6.14
Opthalmotilapia ventralis	6.56	16.83	5.86	9.75
Oreochromis tanganicae	0.11	0	0	0.04
No ID	0	0.83	0	0.28
Perissodus microlepis	7.33	9	1.86	6.06
Petrochromis ephippium	0.22	0.17	0.57	0.32
Petrochromis famula	0.11	0.33	0.43	0.29
Petrochromis orthognathus	0.11	0.17	0.29	0.19
Petrochromis polyodon	2.67	4.33	0.29	2.43
Petrochromis sp.	0	0	0.29	0.1
Petrochromis trewaversae	0	0	0	0
Plecodus paradoxus	0.33	0	0.14	0.16
Simochromis diagramma	0	0.33	0.71	0.35
Simochromis marginatus	0.22	0.33	0	0.19
Simochromis sp.	0	0.67	0.14	0.44
Synodontis eurystomus	0	0	0.14	0.05
Synodontis multipunctata	1.22	0.67	0.29	0.72
Telmatochromis bifrenatus	3.67	5	1.86	3.57
Telmatochromis burgeoni	0.56	0	0	0.19
Telmatochromis dhonti	0	0.17	0.29	0.15
Telmatochromis sp.	0	0	0	0
Telmatochromis temporalis	0.67	5.83	0.14	2.21
Telamatochromis vittatus	0.44	0.83	0	0.43
Tropheus duboisi	1.11	1.67	1.71	1.5
Tropheus morrii	0	0	0	0
Xenotilapia flavipinnis	113.33	0.83	0	38.06

	SITE A	SITE B	SITE C	COMBINED SITES
DATE OF CENSUSES	23-25/9/97	23-25/9/97	23-25/9/97	23-25/9/97
NUMBER OF CENSUSES	9	6	6	21
MEAN DIVERSITY INDEX	2.64	3.62	3.01	3.03
MEAN No. SPECIES	20.5	22.8	15.2	19.5
MEAN No. FISH	499	211	69	260
MEAN DENSITY FISH / 75M2	6.65	2.82	0.91	3.46

	MEAN NUMBERS RECORDED PER CENSUS			
SPECIES	**SITE A**	**SITE B**	**SITE C**	**COMBINED SITES**
Xenotilapia sima	0.22	1.34	2.29	1.34
Xenotilapia spilopterus	12.22	1.5	0	4.57
Xenotilapia sp.	1.11	0	0	0.37

8. APPENDIX 3 – SUMMARY FACT SHEET FOR THE KIGOMA AREA

Features /Description	
Location	Tanzania: south from Luansa Point in Kigoma Bay (04º 53.22' S 029º 37.42' E) to Katabi Village (04º 55.16' S 029º 36.64' E)
Length of Coastline	Approx. 7.3 km
Coastline characteristics	Diverse coastline of bays and headlands mostly shallow, one deep. Terrain cliff, rock, pebble, and sand shoreline.
Terrestrial Activities	Busy port and town, much shipping, fishing and oil transport, extensive deforestation throughout.
Percieved Threats to lake biodiversity	Oil pollution, and sedimentation due to land clearance. Possible translocation of fish by aquarium trade.
Habitat distributions	
Shallow water: 0-5m	Largely rocky with sandy areas, Kigoma, S.Kigoma, Jakobsens', Katabi. Rock, mix of bedrock, boulders and gravel.
Mid-water: 5-30m	Bedrock to boulders to sand with depth, dependent on exposure. Usually sand by 25-30 m. Some unusual habitats.
Deep water: > 30m	Dominated by sand in all areas except western aspect of Bangwe Point, where deep rock did occur.
Macrophytes	Extensive unsurveyed algal beds in the bay south of Tembo Point.
Shell Deposites	Low density shell deposits reported in south Kigoma Bay and in the bay south of Tembo Point.
Sites of interest:	(i) Stromatolite and cave formations at the base of north head of Tembo Point
	(ii) One area of deep rock at Bangwe Point (Site 'x' in Fig 3.3.1)
	(iii) Algal beds in the shallow water bay directly south of Tembo Point.
Fish Community	
General Description	Fish community typical of a mixed sand and rock habitat. Polypterus species observed in south Kigoma Bay.
Overall Diversity (shannon-weiner):	4.19 (no nocturnal species censused)
Total species cichlid	63 species
Total species non-cichlid	10 species
Sites of interest:	The steep rocky shores south of Bangwe Point supported highly diverse and dense fish communities.

Continued…

Features /Description	
Recommendations:	(1) Train a dive survey team for Kigoma
	(2) Initiate sampling programme for other fauna such as molluscs and invertebrates.
	(3) Compile fish reference collections
	(4) Set up and implement the monitoring programme with emphasis on the shallow water site below TAFIRI.
	(5) Conduct a more comprehensive survey to include the many areas not yet surveyed on this stretch of coastline
	(6) Consider development of diver tourism in South Kigoma Bay and along the steep rocky shores to the south.