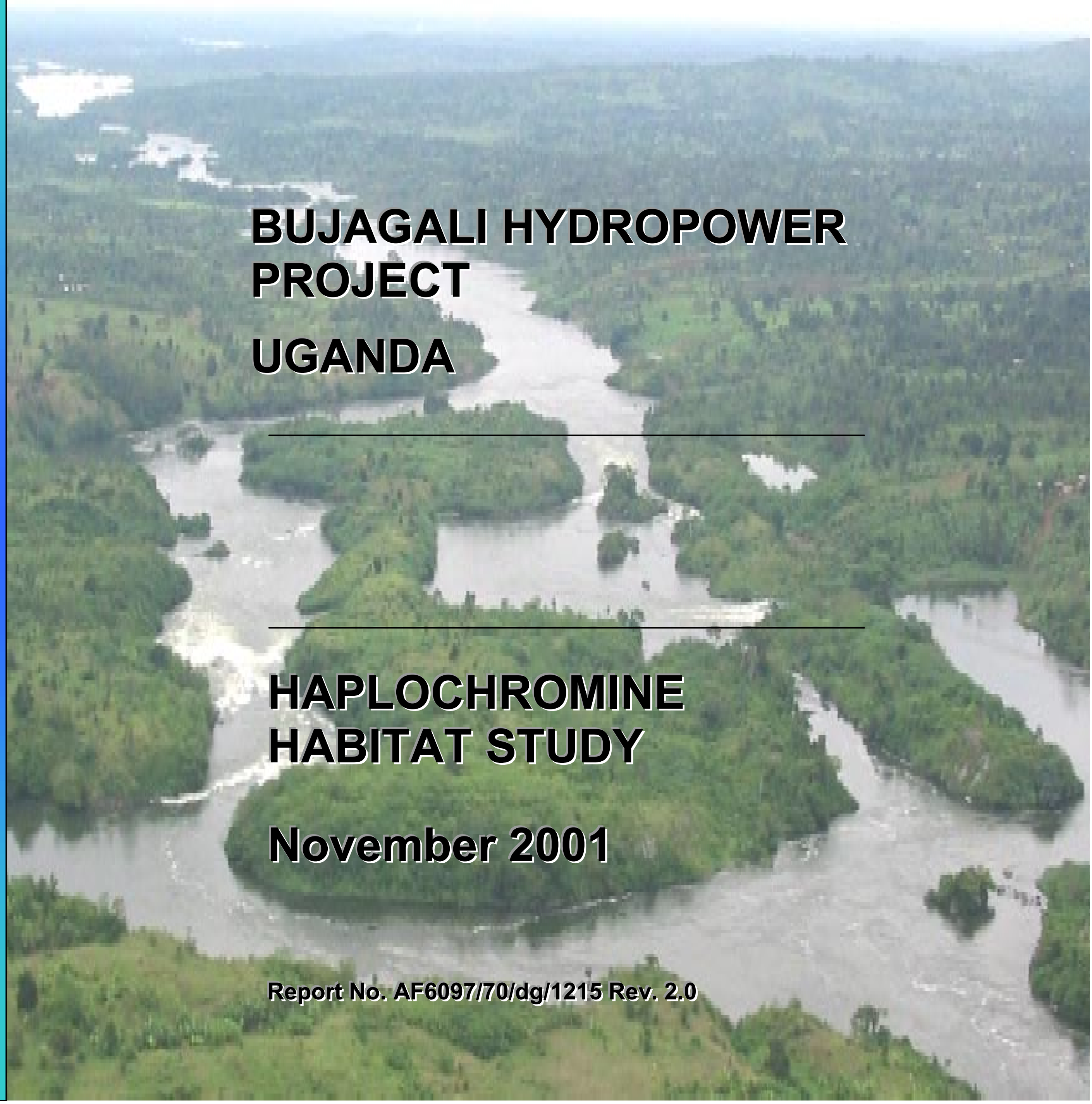
NILE POWER

WS/Atkins

NARO

FIRRI



# BUJAGALI HYDROPOWER PROJECT

# UGANDA

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# HAPLOCHROMINE HABITAT STUDY

## November 2001

Report No. AF6097/70/dg/1215 Rev. 2.0

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# EXECUTIVE SUMMARY

## INTRODUCTION

This report outlines the findings of an investigation into the rapids habitats of the Upper Victoria Nile in Uganda, and the potential impact of the proposed Bujagali Hydropower Project (BHP) on these habitats. The BHP will impound 8 km of the 117 km stretch of the Victoria Nile between Lakes Victoria and Kyoga (the 'Upper Victoria Nile'), which contains rapids areas that, it has been hypothesised, are important for a group of fish known as the haplochromine cichlids.

This report is an addendum to the previous study "A Survey of the Aquatic Ecosystem of the Upper Victoria Nile" carried out over a 12-month period in 2000 and submitted as an Appendix to the Bujagali Hydropower Project Environmental Impact Assessment. The 2000 report concluded that the proposed facility would not have a significant impact on the aquatic environment of the Upper Victoria Nile. The 2000 study identified *Neochromis simotes*, a species of haplochromine cichlid, which was previously thought to be extinct as it had not been reported since a catch at Kakindu (52 km downstream of the proposed BHP site) in 1911. In 2000, three specimens of this species were recovered at Kirindi, some 25 km downstream of the BHP site.

This investigation was commissioned in response to an hypothesis raised by a concerned stakeholder that the 2000 study did not adequately address the potential loss of rocky, fast-flowing areas and the importance that these may have as habitat for haplochromine fish species such as *Neochromis simotes*. The hypothesis also made a presumption that haplochromines of conservation importance may become threatened due to habitat disturbance resulting from the BHP.

The aspects of the investigation are as follows:

- Review of the conservation status of Ugandan haplochromine cichlids, and the historical importance of the Victoria Nile for these.
- Identification and characterisation of rapids habitats between Lake Victoria and Lake Kyoga, and assessment of changes that will take place as a result of the BHP.
- Field surveys of rapids habitats to assess the abundance and species composition of haplochromine cichlids.
- Assessment of the impact of potential changes in habitat in the Victoria Nile on haplochromine cichlids.

This investigation was carried out on behalf of AES Nile Power Ltd, the sponsor of the BHP, by WS Atkins International (Epsom, UK), in conjunction with the Fisheries Resources Research Institute (Jinja, Uganda).

## REVIEW OF CONSERVATION STATUS

Of the 29 Ugandan cichlid species that are classified as 'threatened' according to IUCN, only one (*Astatotilapia barbarae*) has a known distribution that includes the Victoria Nile. The distribution of this species includes Lake Victoria, which, with an area of 69,000 km$^2$, will offer about 20,000 times more potential habitat area than the area of the Nile that will be affected by the BHP.

Of the fish species that are protected by CITES, none have a geographic distribution that includes Uganda, East Africa or the rift lakes.

## IDENTIFICATION OF RAPIDS HABITATS

The BHP will have an impact on seven out of 30 sets of rapids that can be identified from 1:50,000 scale topographic mapping of the Victoria Nile between Lake Victoria and Lake Kyoga. Two GIS-based approaches were used to estimate the area of habitat that would be affected, based on satellite imagery, and to set it in the context of the total habitat area. The first approach identified areas of unbroken whitewater, and the second approach identified areas of 'rapidly flowing water' (i.e. areas containing a percentage of whitewater). Table ES1 below summarises the results of this analysis.

Table ES1. Rapids habitat areas in the upper Victoria Nile as calculated from satellite imagery

| Habitat identified | Habitat area upstream of Dumbbell Island (affected by BHP) | Total habitat area in upper Victoria Nile |
|---|---|---|
| 'Whitewater' | 25.3 ha | 73.5 ha |
| 'Rapidly flowing water' (including 'whitewater') | 50.4 ha | 335.1 ha |

The area of whitewater habitat potentially affected by the BHP is equivalent to 34% of that available in the upper Victoria Nile, while that area of rapidly-flowing habitat is equivalent to 15% of that available. Construction of the BHP will result in a reduction in flow velocity over a 4 km stretch of the river, immediately upstream of Dumbbell Island, as a result of increased channel cross-sectional area.

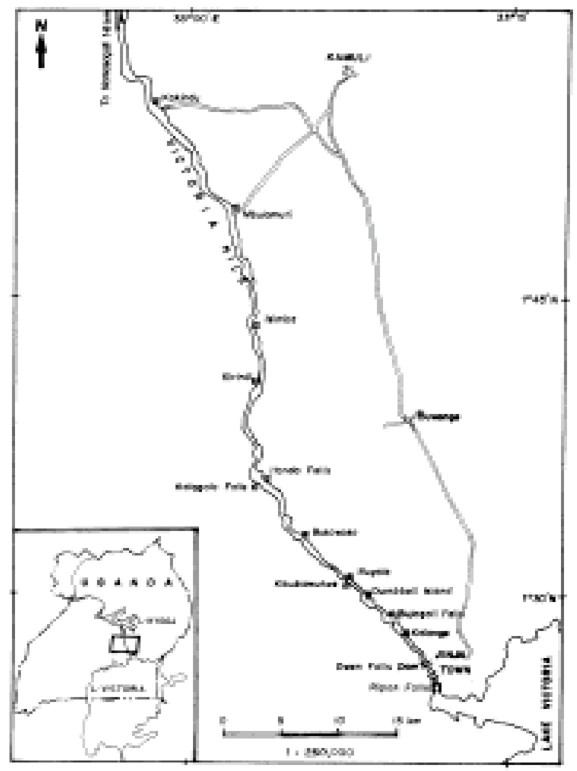
## SCOPE OF THE FIELD SURVEYS

Field work for the present study was carried out during July and August 2001. After a preliminary survey to identify potential sites, eleven sites were selected for sampling. These were intended to cover the range of fast-flowing and rocky habitats in the upper Victoria Nile, starting from Ripon Falls, 3 km upstream of the Owen Falls Hydropower facility, which is an existing barrier between Lake Victoria and the Victoria Nile. Two sites downstream of Owen Falls (Kalange and Bujagali Falls) were located in the 8-km reach to be impounded by the proposed BHP, while the remaining eight sites stretch downstream to the last area of rapids habitat at Kakindu, 63 km downstream of Ripon Falls (see Figure ES1 below).

Experimental fishing was carried out at each site, with equipment designed to target the haplochromine fishes, which are generally less than 100 mm in length. Angling was carried out by local fishermen with hooks and rods. In addition, fleets of gill-nets (ranging in mesh size from 25 mm to 203 mm) were set overnight.

More than 3000 haplochromines were recovered from the eleven sampling sites. All of these were identified to species level and enumerated. Where formal species descriptions were not available, existing or new working names ('cheironyms') were used. Haplochromines that were considered to be of potential nature conservation importance were tagged, photographed, and preserved in formalin. Prior to preservation, tail fin samples ('fin clips') were taken, and preserved in ethanol for possible DNA analysis in the future.

Figure ES1. Locations of sampling sites





WS/Atkins

Non-haplochromine species were identified to species level, weighed, measured and subjected to gut contents analysis to establish the importance of haplochromines as prey species.

## RESULTS OF FIELD SURVEYS

A total of 35 haplochromine cichlid species were recovered from the upper Victoria Nile by experimental fishing in rocky, rapidly-flowing habitats. Figure ES2 shows the species recovered at each site. All of the specimens recovered from sites upstream of Busowoko were previously known to science, and none are listed as threatened on the IUCN Red List for Uganda. The fact that they are relatively well-known is probably due to the species flock in the upper reaches of the Victoria Nile being closely related, if not a continuation of, the well-studied Lake Victoria flock.

Six previously-undescribed haplochromine species (and one which has been described but not formally named) were found at the Lake Kyoga (downstream) end of the Victoria Nile, from Busowoko downstream. The presence of previously-undescribed species in this section of the river is probably due to the close relationship of the haplochromines in this section with the Lake Kyoga species flock, which is less well-studied than the Lake Victoria flock.

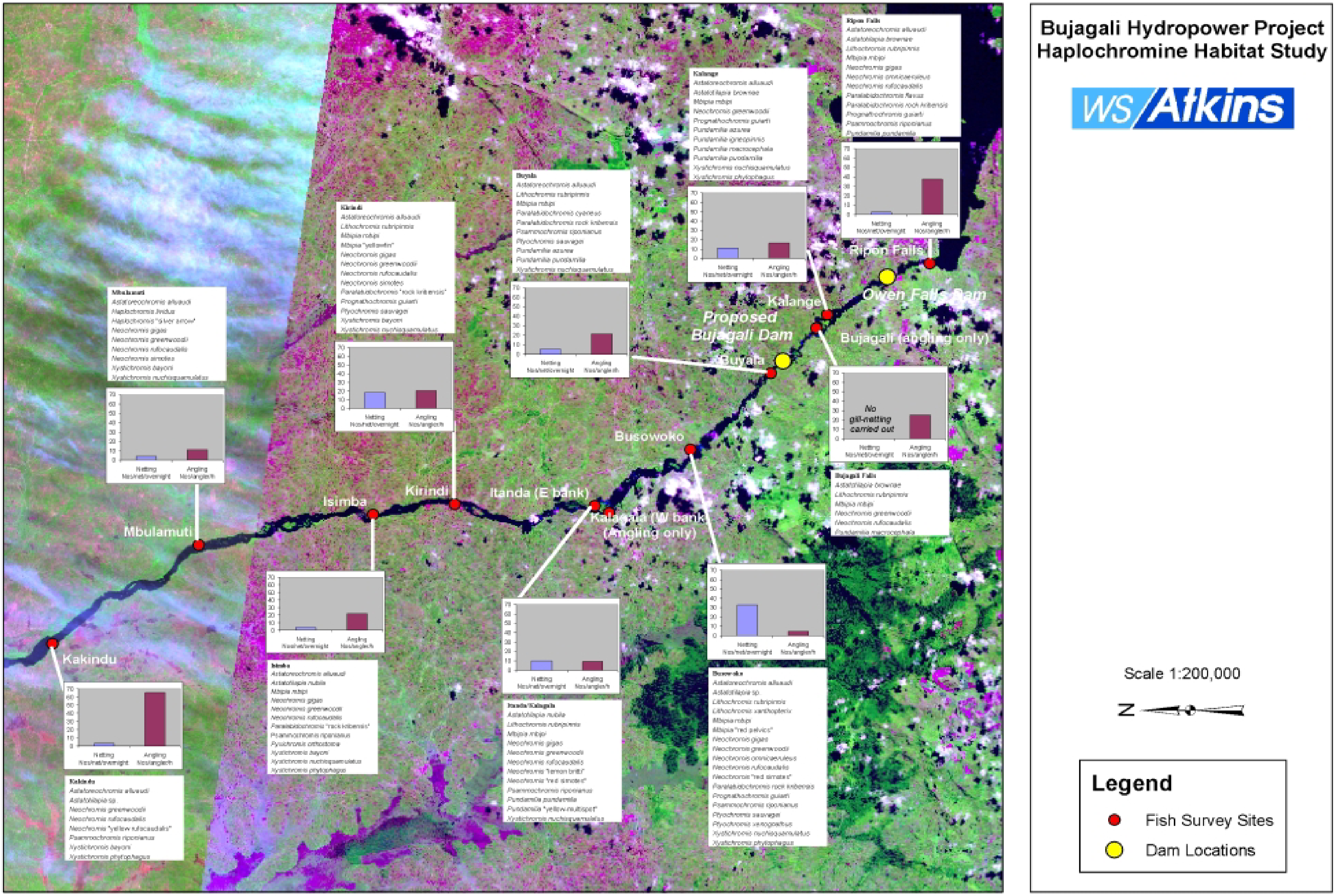
The highest haplochromine catch rates per unit effort (CPUE) were recorded at Ripon Falls and Kakindu (angling) and Busowoko and Kirindi (gill-netting). Although these sites contain considerable rocky habitat, they are the sites where flow velocities are lowest, which indicates that flow velocity alone is not a key determinant of habitat suitability for haplochromines. The high catch rate in the reach impounded by the existing Owen Falls dam (i.e. Ripon Falls sampling site) indicates that the presence of the Owen Falls dam has not had an adverse impact on haplochromine numbers upstream of the dam.

The highest species richness was recorded in the reach from Busowoko to Kirindi, which also includes the Itanda/Kalagala sites. This is likely to be due to a combination of lower Nile perch predation, the variety of habitats available in this reach, and the fact that this zone is where the Lake Victoria and Lake Kyoga haplochromine species flocks overlap. The high species richness in these reaches underlines the importance of the proposed 'Kalagala offset' in compensating any unforeseen reduction in haplochromine habitat availability as a result of the Bujagali Hydropower Project.

Only two haplochromine species (*Pundamilia igneopinnis* and *P. macrocephala*) were found solely in the reach to be impounded by the proposed BHP. These species are well-known from Lake Victoria and elsewhere, and are not considered to be of conservation importance.

The haplochromine *Neochromis simotes*, which was assumed to be extinct until being 're-discovered' during the 2000 surveys, was recovered in relatively large numbers at Kirindi and Mbulamuti. In addition, several individuals were observed in the catches of local fishermen at Busowoko. None were recovered in the reach to be impounded by the proposed BHP. These findings are contrary to the hypothesis put forward by some stakeholders, that this species is only found at Bujagali Falls.

Figure ES2. Haplochromine catch rates and species recovered at each sampling site



## CONCLUSIONS

The conclusions of the study are as follows:

The Bujagali Hydropower Project will not result in an adverse impact on any haplochromine species that are listed as threatened in the IUCN Red List, nor on any species that are included in CITES Appendices I, II or III.

The whole of the 117 km length of the upper Victoria Nile is dominated by rocky habitats. The BHP will affect 8 km of this length, but only the 4 km stretch between Bujagali Falls and Dumbbell Island will be subject to significant habitat change, due to increased water depth and resultant reduction in flow velocity. This represents, by area, 15% of the rapidly flowing water habitat in the upper Victoria Nile. For reasons discussed below, this is not expected to equate with a significant loss of habitat suitable for haplochromines.

The study has indicated that while rocky habitats are important for haplochromines, possibly due in part to the refuges they offer from Nile perch predation, flow velocity is not a prime determinant of habitat suitability. The relatively high haplochromine catch rates per unit effort at Ripon Falls (upstream of the existing Owen Falls dam), and the diversity of species at this site indicates that the slowing of flow velocities brought about by the construction of the Owen Falls dam has had no negative impact on haplochromine habitat, and may in fact have benefited haplochromine populations. This is supported by the observation that slower-flowing areas in the reaches downstream of Owen Falls also had higher haplochromine CPUE, as well as higher haplochromine species diversity. This indicates that reduction of flow velocities in the 4 km reach upstream of the proposed BHP will not have an adverse impact on haplochromine abundance or species diversity.

The finding of *Neochromis simotes* at two sites shows that this species is even more widespread than was previously understood to be the case. It is likely that further specimens would be found at other sites on the Victoria Nile (and possibly elsewhere, e.g. Lake Kyoga) should further sampling be carried out. The distance of these two sites from the BHP site (25 and 40 km downstream), means that the populations from which these specimens were sampled are unlikely to be adversely affected by the project.

The assertion by some parties, to the effect that *Neochromis simotes* is known only from Bujagali Falls is unsubstantiated, as the last three reported findings are from sites a considerable distance downstream. In fact, we can find no evidence (published or unpublished) that *N. simotes* has ever been found at Bujagali Falls.

Six previously-undescribed haplochromine species were discovered; all at sites several kilometres downstream of the area to be affected by the BHP. This is consistent with the belief of the scientific community that there is a great diversity of haplochromine fishes yet to be discovered in the Lake Victoria region.

Overall, it is concluded that the Bujagali Hydropower Project will have no significant impact on haplochromine populations in the upper Victoria Nile. The relatively high haplochromines species richness in the middle reaches, downstream of the BHP site, underlines the importance of the proposed 'Kalagala offset' in compensating any unforeseen reduction in habitat availability as a result of the Bujagali Hydropower Project.

# ABBREVIATIONS

| | |
|---|---|
| BHP | Bujagali Hydropower Project |
| CITES | Convention on International Trade in Endangered Species of Wild Flora and Fauna |
| cm | centimetre |
| CPUE | Catch per unit of effort |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| FIRI | Fisheries Research Institute |
| FIRRI | Fisheries Resources Research Institute |
| HEST | Haplochromis Ecology Survey Team |
| Ind. | Individuals |
| IUCN | International Union for the Conservation of Nature and Natural Resources |
| kg | kilogram |
| km | kilometre |
| m | metre |
| mASL | metres above sea level |
| mg | milligrams |
| MW | megawatts |
| NEMA | National Environmental Management Authority |
| Nos. | Numbers |
| Q | Quarter |
| sp. | species (singular) |
| spp. | species (plural) |
| ssp. | subspecies |
| UEB | Uganda Electricity Board |
| USh | Ugandan Shillings |
| UTM | Universal Transverse Mercator (Projection) |
| WBG | World Bank Group |

# INTRODUCTION

## GENERAL

This report presents the findings of a supplementary study to the Environmental Impact Assessment (EIA) for the proposed Bujagali Hydropower Project (BHP) in Uganda. The study is intended to supplement previous work on the fish populations and fisheries status of the upper Victoria Nile, where the proposed scheme will be situated. This study focuses on the changes in habitat for a group of fish known as the haplochromine cichlids that will arise from implementation of the BHP, and the resulting impacts on these fish.

The remainder of this Introduction outlines the background to the study, and the study's objectives. It is followed by sections on the conservation status of Ugandan haplochromines, an analysis of the habitat to be potentially affected by the BHP, an outline of field surveys, and conclusions of the study.

This study was carried out on behalf of AES Nile Power Ltd (the sponsor of the BHP), by WS Atkins International (Epsom, UK), and NARO/FIRRI (Jinja, Uganda). The principal staff involved in the study were:

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## BACKGROUND

### WS ATKINS EIA (1998-9)

Under the Terms of Reference for the original Environmental Impact Assessment study (WS Atkins, 1998), it was agreed that impacts of the Bujagali project on fish habitats and fisheries resources would be based upon existing secondary data, supplemented by primary data on catch assessments at fish landing sites.

Upon commencement of the main EIA study, it became apparent from consultation with NEMA, FIRI and other research organisations, that existing data on the fish resources of the upper Victoria Nile were scarce. Consequently, one of the recommendations of the EIA (WS Atkins, 1999) was that baseline aquatic ecology surveys should be carried out prior to construction. The recommended parameters for monitoring included water quality, macrophytes, invertebrates, fish species composition and the socio-economic importance of the riverine fishery. Surveys were to be designed so that they represented the range of habitats present in the river, and also covered a full annual cycle, so that any seasonal variation in these parameters could be detected. This view was reinforced in a statement issued by the World Bank Group in July 1999, to the effect that the EIA could not be approved until such primary data had been collected.

### FIRRI SURVEYS (2000)

Following a public hearing held in Jinja in August 1999, NEMA issued its environmental approval of the hydropower component of the Bujagali project in November 1999. One of the conditions of the approval was that the recommended baseline aquatic ecology and fisheries surveys be carried out prior to the commencement of construction.

In response to this condition, AESNP engaged WS Atkins to work with FIRI to develop a detailed methodology for carrying out these surveys. The resultant survey methodology was based on quarterly surveys of water quality, macrophytes and invertebrates, as well as experimental netting and angling, analysis of fisherfolk's catches at landing sites, and estimation of the number of livelihoods supported by fishing. Twenty sampling sites were specified; five sites at each of four transects across the river. One transect was located upstream of the proposed hydropower facility (Kalange), while the remaining three were located approximately 2 km, 25 km and 60 km downstream (Buyala, Kirindi and Namasagali, respectively). These sites were intended to cover the range of habitats present in the upper Victoria Nile, with the transects designed to cover the range present across a cross-section of the river (from slower-flowing, vegetated margins, to the faster-flowing 'thalweg'), while the longitudinal distribution of transects was intended to represent the range of habitats between Lakes Victoria and Kyoga (from the faster-flowing, deeply incised upstream end to the wider, slower-flowing habitats towards lake Kyoga).

FIRI (whose name changed to FIRRI [Fisheries Resources Research Institute] during 2000) was retained to carry out the field surveys, data analysis and reporting. The quarterly surveys were carried out in February, May, August and October/November 2000, with a report being produced after each survey (FIRRI, 2000*a* to 2000*d*). A final report summarising the findings of all four surveys (FIRRI, 2001) was produced in January 2001, and was included as an appendix to the EIA submission to the World Bank Group (AES Nile Power, 2001).

In these reports, it was pointed out that studies showed significant spatial differences in fish populations and fish densities among the investigated transects. The report also analysed keystone fish species ecology including distribution patterns according to macro-habitat zones and microhabitat features associated with the identified fishes as well as the trophic structure of the species. The most diverse, and also the most numerically-important, group of fishes were the haplochromine cichlids, and these were grouped into genera for the purpose of understanding the nature of fish diversity in relation to potential impacts of the AES Nile Power Bujagali hydroelectric power.

## BACKGROUND INFORMATION ON HAPLOCHROMINE CICHLIDS

This section is intended to provide an overview of the scientific importance and conservation status of the haplochromine cichlids. It is not intended to be an exhaustive review of all preceding research on these species.

The family Cichlidae (cichlids) falls within the order Perciformes (perch and related fish), which in turn falls within the class Actinopterygii ('ray-finned' or 'bony' fish). The cichlids comprise two sub-families, the tilapiines (tilapia and allied species) and the haplochromines. The species flock of haplochromine cichlids in Lake Victoria has been considered the most striking example of explosive evolution and adaptive radiation among vertebrates (Wilson, 1994, cited in Seehausen, 1996).

Haplochromines were until recently referred to under a single genus "*Haplochromis*". In taxonomic terms of relevance to this study, reappraisal of the *Haplochromis* generic concept has been undertaken in a series of studies (e.g. Greenwood, 1974; 1981; Strauss, 1984; Kaufman, 1997; Witte *et al.*, 1997; Seehausen *et al.*, 1998). The number of *Haplochromis*-like genera (e.g. *Astatoreochromis*) has increased to at least twenty. With these revisions, species names have either changed or "unidentified" species are being allotted "descriptor" labels. These *Haplochromis*-like genera (e.g. *Macropleurodus, Platytoeniodus, Haplotilapia, Lithochromis, Neochromis, Ptyochromis, Yssichromis* and *Pundamilia*) and those species that were retained under the genus *Haplochromis* are collectively referred to as haplochromine fishes.

> **Taxonomy: classification of organisms**
>
> The evolutionary relationship of organisms is know as *phylogeny* (from Greek *phylon*, race + *genesis*, descent), and this relationship provides a theoretical basis for the classification of organisms. The branch of biology concerned with classification is called *taxonomy*.
>
> The basic unit in classifying organisms is the **species**, which is a group of individuals capable of reproducing with each other and producing viable offspring, but reproductively isolated in nature from other groups.
>
> Species that resemble each other closely, and therefore are presumed to be closely related, are grouped together within a **genus** (plural: genera). Similar genera are grouped together within a **family**; similar families, within **orders**; orders within **classes**; and classes, within **phyla** (singular: phylum).
>
> The scientific name of a species is composed of words usually derived from Latin or Greek, of this the first is the **generic** name, and the second is the **species** name. All species in the same genus have the same generic name. As an illustration, the scientific names of the categories to which the Nile perch (*Lates niloticus*) belongs are listed below. Note that the family name always ends in *idea* and that the generic and species names are always italicised.
>
> Phylum Chordata
> - Subphylum Vertebrata
>   - Class Actinopterygii (ray-finned fishes)
>     - Order Perciformes (perch-like fishes)
>       - Family Centropomidae (Snooks)
>         - Genus *Lates*
>           - Species *niloticus*
>
> The collective name for these taxonomic divisions is **taxa** (singular: taxon)

Before Nile perch were introduced to the lake, there were more than 500 species of haplochromine cichlids that had adapted to fill a variety of ecological niches. Among them the different feeding (trophic) groups included insect eaters, mud biters, leaf choppers, snail crushers, shrimp eaters, baby eaters, fish eaters, scale scrapers and snail shellers. It is likely that this tremendous variety of fish had all evolved from one, or a few, ancestral generalist fish in the estimated 12,400 years since the filling of Lake Victoria (Johnson *et al.*, 1996). The question of whether the haplochromine cichlids of Lake Victoria form a monophyletic group (i.e. derived from one common ancestor) has long been debated. An ancestral species would likely be a riverine cichlid, similar to those haplochromines that inhabit the rivers of modern East Africa (Seehausen, 1996). Recent molecular evidence (from DNA analysis) indicates that the closest relatives of the Lake Victoria flock's ancestor are found in some of the smaller westward-flowing rivers.

Regardless of the ancestors of the flock, its striking feature is the amazing speed within which the founder population(s) evolved into an assemblage of hundreds of species that fill almost all of the major niches available to freshwater fishes. The various trophic groups have been mentioned, and there is also great diversity in the types of habitat utilised. They are known to inhabit almost every available lake and river habitat, from narrow crevices among rocks, water lily beds, and floating papyrus islands, to the entirely unsheltered pelagic zone of the open water body, and to the deepest parts of the lake that are not reached by daylight. Only 20 years ago, the catalogue of Lake Victoria haplochromines included only one lithophilic (rock-restricted) genus (*Neochromis*). However, during the 1980s and especially the 1990s, work carried out by Seehausen, Bouton and others has led to the identification of more than 100 previously-unknown strictly lithophilic cichlids (Seehausen, 1996; Seehausen *et al.*, 1998). Prior to the discovery of this rock-dwelling assemblage, the haplochromine flock of Lake Victoria was believed to be quite distinct from those of Lakes Malawi and Tanganyika, which contained significant numbers of lithophiles. However, due to the discoveries over the last 20 years, this notion has given way to the realisation that the assemblage of rock-dwelling cichlids in Lake Victoria closely resembles that in Lake Malawi. Given the small part of Lake Victoria that has been surveyed, and the restricted distribution of some species, the future discovery of a large number of additional species is expected (Seehausen *et al.*, 1988).

Apart from harbouring the large assemblage of rock-restricted cichlids, rocky shores and islands are the most important refugia for a number of cichlid species that were formerly not restricted to rocky substrates, but survived only there after the Nile perch upsurge ('rock refugees'). Nile perch (*Lates* sp.), a large predator, was introduced by man in the 1950s. When its number increased explosively in the early 1980s, the population of most open and deep water dwelling cichlid species collapsed. An estimated 150-200 cichlid species disappeared, many of which probably went extinct. The cichlids that inhabit rocky shores and other littoral habitats were less affected than others by these events. Consequently, rocky habitats are currently of major importance to the survival of at least some of the endangered species, and harbour the largest anatomical, ecological, and possibly genetic diversity in Lake Victoria (Seehausen, 1996). It may be construed that rocky habitats are similarly important in the Victoria Nile, where Nile perch is also a major predator.

## ISSUES RAISED ON PUBLICATION OF THE BUJAGALI EIA

Following publication of the final EIA documentation via the World Bank Group InfoShop in April 2001[1] queries were raised regarding the status of haplochromine cichlids in the Victoria Nile, and the importance of rocky and rapidly flowing habitats for these fish (L. Kaufman, Boston University, pers. comm. to P. O'Neill, AES Nile Power, and Kaufman (2001)). The issues raised can be summarised as follows:

- It is known that there are species of haplochromine cichlid fishes (*nkeje* or *nkejje*) in the Victoria Nile that have not been found in either Lake Victoria or Lake Kyoga.
- Most of these are rock-dwelling species, previously unknown to science.
- One species (*Neochromis simotes*) was previously thought to be extinct, but was re-discovered during the 2000 surveys.
- The study conducted by FIRRI as part of the EIA for the Bujagali project was lacking in two respects:
  - (i) Efforts to sample in quickwater and rapids habitats were minimal, and
  - (ii) The haplochromine species of the Nile were not worked up.
- Therefore the expectation that the Bujagali project would have minimal or no impact on native fishes or aquatic biodiversity is unsupported, in that the omission of careful work on haplochromine cichlids will provide a flashpoint for criticism of the project.

## STUDY OBJECTIVES

The Terms of Reference for the study reported in this document have been agreed with representatives of the World Bank Group's (WBG) Environmental Department, and are designed to provide the information needed to address these issues and to inform the WBG's decision on whether to provide financial backing for the BHP. The study has five objectives, as follows:

- To review the conservation status of Ugandan haplochromine cichlids in terms of international designations (IUCN and CITES).
- To identify and characterise the rapids habitats between Lake Victoria and Lake Kyoga, and assess changes that will take place as a result of the BHP.
- To collect data on the abundance and species composition of haplochromine cichlids inhabiting rapids habitats.
- To set the potential loss of haplochromine habitat arising from the Bujagali project in the context of the habitat available in the Victoria Nile between Lake Victoria and Lake Kyoga.
- To make a definitive statement on whether the Bujagali project will result in a significant loss of habitat for haplochromines.

It is not the aim of this study to carry out a full taxonomic 'working up' of the haplochromines of the Victoria Nile, however data and samples from this study will be made available to researchers should this be desired at a later date.

Note: The section of the River Nile known as the Victoria Nile extends from Lake Victoria at its upstream end, through Lake Kyoga and Murchison Falls, to the confluence with Lake Albert, in the north-west of Uganda. In this report, the term 'upper Victoria Nile' refers to the section of the Victoria Nile between Lake Victoria and Lake Kyoga.

# Review of the conservation status of Ugandan haplochromine cichlids

The conservation status of Ugandan haplochromine cichlids was reviewed by reference to literature published by the International Union for the Conservation of Nature (IUCN), and the Convention for International Trade in Endangered Species of Wild Fauna and Flora (CITES).

## IUCN Red List

The IUCN Red List of Threatened Species (Hilton-Taylor, 2000) identifies plant and animal species that are under threat of extinction in the wild. Each taxon (including taxa that are not yet formally described) can be placed into one of eight categories according to its threat status, as follows:

- Extinct (EX)
- Extinct in the wild (EW)
- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)
- Lower Risk (LR)
- Data Deficient (DD)
- Not Evaluated (NE)

Of the eight categories, CR, EN and VU are collectively known as 'threatened', and taxa within these categories are assigned further sub-codes based on the reasons for their being assigned threatened status (see Appendix 1).

There are currently 29 species of Ugandan cichlid that are classified as threatened according to the IUCN Red List. Their names, threat category, and distribution are provided in Table 1.

Other Ugandan species (e.g. *Xystichromis nuchisquamulatus*) are also listed as threatened, but as their distribution is known mainly from other countries, and therefore they are relatively widespread, they are not considered in detail here. Of the 29 Ugandan cichlid species that are classified as 'threatened', only one (*Astatotilapia barbarae*) has a known distribution that includes the Victoria Nile. *A. barbarae* is classified as Endangered A1ace, B1+2bcde. The suffixes to the 'Endangered' title have meanings as stated below:

Very high risk of extinction in the wild due in the near future, due to:

A) Population reduction in the form of:

1. An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on the following:
   (a) direct observation
   (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   (e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

B) Extent of occurrence estimated to be less than 5000 $km^2$ or area of occupancy estimated to be less than 50 $km^2$, an estimates indicating:

1. Severely fragmented or known to exist at no more than five locations
2. Continuing decline, inferred, observed or projected, in the following:
   (a) area of occupancy
   (b) area, extent and/or quality of habitat
   (c) number of locations or subpopulations
   (d) number of mature individuals

Table 1. Ugandan cichlid species listed as threatened by IUCN.

| Scientific name | Threat category | Distribution |
|---|---|---|
| *Allochromis welcommei* | CR A1acde, B1+2ce | LN |
| *Astatotilapia latifasciata* | CR A1acde, B1+2ce | LN |
| *Haplochromis* "ruby" | CR A1acde, B1+2ce | LN |
| *Harpagochromis worthingtoni* | CR A1acde, B1+2ce | LN |
| *Lipochromis* "backflash cryptodon" | CR A1acde, B1+2ce | LN |
| *Lipochromis* "parvidens-like" | CR A1acde, B1+2ce | LN |
| *Lipochromis* "small obesoid" | CR A1acde, B1+2ce | LN |
| *Prognathochromis worthingtoni* | CR A1acde, B1+2ce | LN |
| *Harpagochromis guiarti* ssp. complex | CR A1ace, B1+2acd | LV |
| *Harpagochromis plagiostoma* | CR A1ace, B1+2acd | LV |
| *Paralabidochromis beadlei* | CR A1ace, B1+2cd | LNab |
| *Haplochromis annectidens* | CR A1ace, B1+2cde | LNab |
| *Xystichromis* "Kyoga flameback" | CR A1ace, B1+2ce | LN |
| *Astatotilapia* "shovelmouth" | EN A1acde, B1+2ce | LK, LN |
| *Prognathochromis* "long snout" | EN A1acde, B1+2ce | LK, LN |
| *Haplochromis obliquidens* | EN A1ace, B1+2acd | LV, LBun |
| ***Astatotilapia barbarae*** | **EN A1ace, B1+2 bcde** | **LN, LV, VN** |
| *Gaurochromis simpsoni* | EN A1ace, B1+2cd | LNab |
| *Prognathochromis venator* | EN A1ace, B1+2cd | LNab |
| *Psammochromis aelocephalus* | VU A1ac, B1+2acd | LV |
| *Oreochromis esculentus* | VU A1acde, B1+2ce | East Africa |
| *Oreochromis variabilis* | VU A1acde, B1+2ce | LN, LV |
| *Paralabidochromis chilotes* ssp. complex | VU A1ace, B1+2acd | LV |
| *Paralabidochromis chromogynos* | VU A1ace, B1+2acd | LV |
| *Paralabidochromis crassilabris* | VU A1ace, B1+2acd | LV |
| *Psammochromis acidens* | VU A1ace, B1+2acd | LV |
| *Pyxichromis orthostoma* | VU A1ace, B1+2ce | LK, LN |
| *Harpagochromis* "frogmouth" | VU A1ae, B1+2acd | LV |
| *Astatotilapia velifer* | VU A1ae, B1+2c | LN |

Key: LN=Lake Nawampasa, LV=Lake Victoria, LNab=Lake Nabugabo, LK=Lake Kyoga, VN=Victoria Nile, LBun=Lake Bunyonyi.

## CITES Appendices

CITES works by subjecting international trade in specimens of selected species to certain controls. These require that all import, export, re-export and introduction of species covered by the Convention has to be authorised through a licensing system. ('Re-export' means export of a specimen that was imported.)

The species covered by CITES are listed in three appendices, according to the degree of protection they are deemed to need, as follows:

- Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.
- Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.
- Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Of the approximately 30,000 species of plants and animals that are afforded protection by CITES, only twelve are fish species that are listed explicitly. In addition, the entire Order Acipenseriformes is listed under Appendix II, and contains two families (Polyodontidae and Acipenseridae), with a total of more than 100 species. The species listed in CITES Appendix II are listed in Table 2 overleaf. Of the fish species that are protected by CITES, none have a geographic distribution that includes Uganda, East Africa or the rift lakes (Froese & Pauly, 2001).

Table 2.  Fish species afforded protection by the Convention for International Trade in Endangered Species of Wild Fauna and Flora

| Order | Family | Appendix I species | Appendix II species | Appendix III species | Distribution |
|---|---|---|---|---|---|
| CERATODONTIFORMES | Ceratodontidae | | *Neoceratodus forsteri* | | Freshwater – Australia |
| COELACANTHIFORMES | Latimeriidae | *Latimeria* spp. | | | Marine – Indo-West Pacific |
| ACIPENSERIFORMES | Acipenseridae | *Acipenser brevirostrum* | | | Marine – east coast of North America |
| | | *Acipenser sturio* | | | Marine – eastern Atlantic |
| | | | ACIPENSERIFORMES spp. | | Marine/freshwater – China to USA, plus other cold to temperate waters of Northern Hemisphere |
| OSTEOGLOSSIFORMES | Osteoglossidae | *Scleropages formosus* | | | Freshwater – Mekong basin |
| | | | *Arapaima gigas* | | Freshwater – Amazon basin |
| CYPRINIFORMES | Cyprinidae | *Probarbus jullieni* | | | Freshwater – south east Asia |
| | | | *Caecobarbus geertsi* | | Freshwater – lower Congo River system |
| | Catostomidae | *Chasmistes cujus* | | | Freshwater – North America |
| SILURIFORMES | Pangasiidae | *Pangasianodon gigas* | | | Freshwater – Mekong basin |
| PERCIFORMES | Sciaenidae | *Cynoscion macdonaldi* | | | Marine – Eastern Central Pacific |
| LAMNIFORMES | Cetorhinidae | | | *Cetorhinus maximus*# | Marine – widespread but endangere overfishing and low productivity |

*excluding those in Appendix I
#submitted by United Kingdom for inclusion in the appendix

## RIVERINE HABITATS IN THE UPPER VICTORIA NILE

The aim of this component of the study was to categorise the types of riverine habitat present in the upper Victoria Nile, and in particular to identify and categorise rapids habitats. This will allow the modifications to habitat (e.g. increase in water depth and reduction in flow velocity in rapids areas) as a result of the BHP to be quantified more accurately than has been possible in previous assessments, and will provide a platform for assessment of the effects on the habitat of haplochromines. It also provides the basis for 'ground-truthing' of the findings of the field surveys, in terms of identifying those habitat areas that are important for particular haplochromine taxa.

The rapids habitats available in the upper Victoria Nile were categorised by analysis of 1:50,000 topographic maps, and Landsat™ satellite imagery.

### 1:50,000 TOPOGRAPHIC MAPPING

Published 1:50,000 scale topographic maps for the upper Victoria Nile were examined to identify locations on the river where rapids are marked. The upper Victoria Nile is shown on six of the 1:50,000 scale sheets, as shown by the shaded cells in Figure 1 below.

Figure 1. Layout of 1:50,000 map sheets used to identify location of rapids.

**North (downstream)**

| | |
|---|---|
| Kidera 51/2 | Malima 52/1 |
| Bale 51/4 | Balawoli 52/3 |
| Kayonza 61/2 | Kamuli 62/1 |
| Kayunga 61/4 | Kagoma 62/3 |
| Lugazi 71/2 | Jinja 72/1 |

**South (upstream)**

Dates of aerial photography which provides the basis for construction of each sheet is outlined in Table 3 below.

Rapids identified from these map sheets are listed in Table 4 overleaf, along with the name of the nearest marked geographic feature, and UTM 36 co-ordinates. Also included is an assessment of the 'grade' of rapids, based on apparent magnitude from the 1:50,000 scale mapping. A grade of 1 represents the smallest rapids as shown on the mapping, while 4 represented the largest rapids as shown on the mapping. This is not intended to reflect the international gradings used by kayak and white-water rafting operators, and is merely to allow comparison of the magnitude shown on the mapping. It should also be borne in mind that the different sheets were published at different times, and therefore the magnitude of rapids may not necessarily be directly compared between sheets.

The locations of rapids thus identified are also shown on Figure 3.

Table 3. 1:50,000 topographic map sheets for the upper Victoria Nile.

| **Sheet Name** | **Sheet No.** | **Series** | **Date of aerial photography** |
|---|---|---|---|
| Jinja | 72/1 | Y732 Edition 3-U.S.D | January 1995 |
| Kagoma | 62/3 | Y732 Edition 3-U.S.D | January 1995 |
| Kamuli | 62/1 | Y732 Edition unknown | June-July 1955 |
| Kayonza | 61/2 | Y732 Edition 3-U.S.D | January 1995 |
| Bale | 51/4 | Y732 Edition 1-U.S.D | January-February 1960 |
| Kidera | 51/2 | Y732 Edition 1-D.O.S | December 1959- January 1960 |

Table 4. Rapids identified from 1:50,000 scale mapping

| Number | Nearest marked feature (name on 1:50,000 map) | Bank (where label located) | Eastings (UTM 36) | Northings (UTM 36) | "Grade" (from 1:50,000 map) |
|---|---|---|---|---|---|
| *Rapids upstream of Dumbbell Island* | | | | | |
| 1 | UEB station | W | 519300 | 49600 | 1 |
| 2 | Kimaka FR | E | 519200 | 51250 | 1 |
| 3 | Bujagali Falls | C | 517500 | 53600 | 1 |
| 4 | Kyabirwa | E | 517100 | 53600 | 1 |
| 5 | Kyabirwa Falls | C | 516600 | 54500 | 1 |
| 6 | Malindi | W | 515800 | 55200 | 2 |
| 7 | Kikubamutwe | W | 515500 | 55500 | 2 |
| *Rapids downstream of Dumbbell Island* | | | | | |
| 8 | Buyala | E | 514400 | 56700 | 2 |
| 9 | Buyala | E | 514100 | 57200 | 3 |
| 10 | Wakisi-Wakikoola | W | 512900 | 58000 | 3 |
| 11 | Wakisi-Wakikoola | W | 512300 | 58300 | 2 |
| 12 | Busowoko | E | 509900 | 60800 | 3 |
| 13 | Kalangala Falls FR | W | 508000 | 64700 | 3 |
| 14 | Itanda Falls | C | 506400 | 66300 | 3 |
| 15 | Bumegere | E | 505900 | 74300 | 2 |
| 16 | Namulumba | E | 505900 | 74800 | 3 |
| 17 | Nabukedi | E | 506300 | 77600 | 4 |
| 18 | Bupiina | E | 505700 | 79200 | 4 |
| 19 | Bupiina | E | 506000 | 79200 | 4 |
| 20 | Bugumira | E | 505300 | 84600 | 3 |
| 21 | Bugumira | E | 505200 | 85200 | 3 |
| 22 | Bugumira | E | 505300 | 86300 | 3 |
| 23 | Gobero | W | 504600 | 86800 | 3 |
| 24 | Gobero | W | 504900 | 87100 | 3 |
| 25 | Nekoyedde | W | 503500 | 90000 | 4 |
| 26 | Nekoyedde | W | 503400 | 90300 | 4 |
| 27 | Nabugenyi | W | 503400 | 90300 | 4 |
| 28 | Namatala Island | C | 500500 | 95600 | 4 |
| 29 | Namatala Island | C | 500600 | 95900 | 4 |
| 30 | Namatala Island | C | 500300 | 96000 | 4 |

Key: W=West bank, E=East bank, C=centre of river. Grading of rapids is semi-subjective, and based on the size indicated on 1:50,000 topographic mapping.

From the information presented above, it can be concluded that the BHP will result in modification of the habitat in 30 sets of rapids that are identified on 1:50,000 topographic mapping of the upper Victoria Nile. The following section calculates the area of habitat that this represents.

## Satellite Imagery Interpretation for the Delineation of River Rapids

### Methods

Two Landsat™ 5 Images were purchased from GeoCover for the purpose of identifying rapids in the upper Victoria Nile. Image 171/60, covering the southern extent of the study area, was acquired on 28 December 1986 and image 171/59, covering the northern extent of the study area, was acquired on 10 January 1986. Both images were geo-corrected prior to purchase and were based on the Universal Transverse Mercator (UTM) projection with WGS84 datum. The images had been resampled with the Nearest Neighbour resampling algorithm and have a pixel size (ground resolution) of 28.5 m.

An initial visual inspection of the imagery was made using Bands 3, 2, and 1 displayed through the Red, Green and Blue channels. With Landsat™ imagery this gives a natural colour image. It was apparent that some areas of rapids were indeed visible on the imagery. However, with a natural colour image these areas displayed with a white colour which was indistinguishable from cloud, and could therefore lead to confusion. Landsat 5 imagery has 7 bands which are collected in different wavelengths so different combinations of bands were tested in an attempt to find a combination which allowed cloud and river rapids to be identified separately. It was found that the combination of bands 7, 4 and 3 displayed cloud in white, while the rapids were displayed in blue.

To verify the identification of the rapids from the satellite imagery a section of aerial photography of Dumbbell Island was compared with the satellite imagery (Figure 2). Areas of 'unbroken' whitewater have been circled in red and it is clear that there is a strong correspondence between the aerial photograph and the satellite imagery. There are further areas of rapidly flowing water immediately downstream of the unbroken whitewater areas which are visible in the aerial photograph. These do not show clearly on the satellite image in Figure 2 but are more clear when the imagery is analysed on screen.

Areas of rapids were digitised in ArcView GIS using two different approaches (Figure 2), and the areas of the resulting polygons were calculated. The first approach was conservative, in that only unbroken areas of whitewater exceeding the pixel size of 28.5 x 28.5 m were digitised. Areas identified by this method are referred to as 'whitewater' in the following analysis.

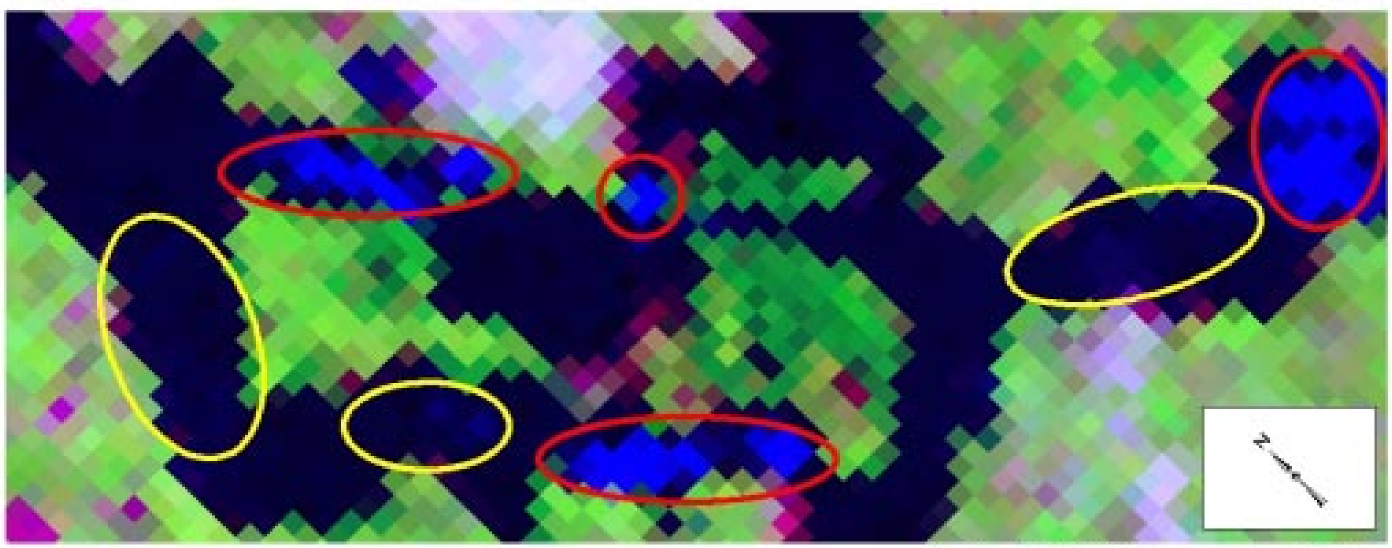
The second approach was used to identify areas which do not contain unbroken whitewater, but which contain a proportion of whitewater within each 28.5 x 28.5 m pixel, and therefore are obviously rapidly-flowing. Under this approach, a threshold between digital numbers 9 and 28 was applied to band 7 of the imagery, such that all pixels with a value between 9 and 28 were set to display red. Pixels with these values were ground-truthed against aerial photographs to check that they actually contained a proportion of whitewater. The red areas were then digitised to remain consistent with the previous approaches. Areas identified using the second approach are referred to as 'rapidly-flowing water' in the following analysis.

### Results of analysis of satellite imagery

Areas of rapidly flowing water identified by the second approach are shown on Figure 3, along with locations of rapids as identified from 1:50,000 topographic mapping. Areas of whitewater and rapidly flowing water identified by each of the two GIS-based approaches are outlined in Table 5.

Figure 2.  Identification of rapids habitat from Landsat™ imagery.

**Aerial Photograph**




**Landsat TM Satellite Imagery (Bands 7,4,3)**

## A Large Scale View of the River Rapids Around Dumbbell Island

A comparison of aerial photography and satellite imagery is shown.

Areas of "whitewater" (circled in red) are apparent in both sets of imagery. In the natural colour aerial photography the "whitewater" areas show up as white whereas in the false colour satellite imagery they show up as blue.

Areas of rapidly flowing water (ie areas downstream of "whitewater") are circled in yellow.

Figure 3. Rapidly-flowing water areas identified from Landsat™ imagery, and rapids identified from 1:50,000 mapping.

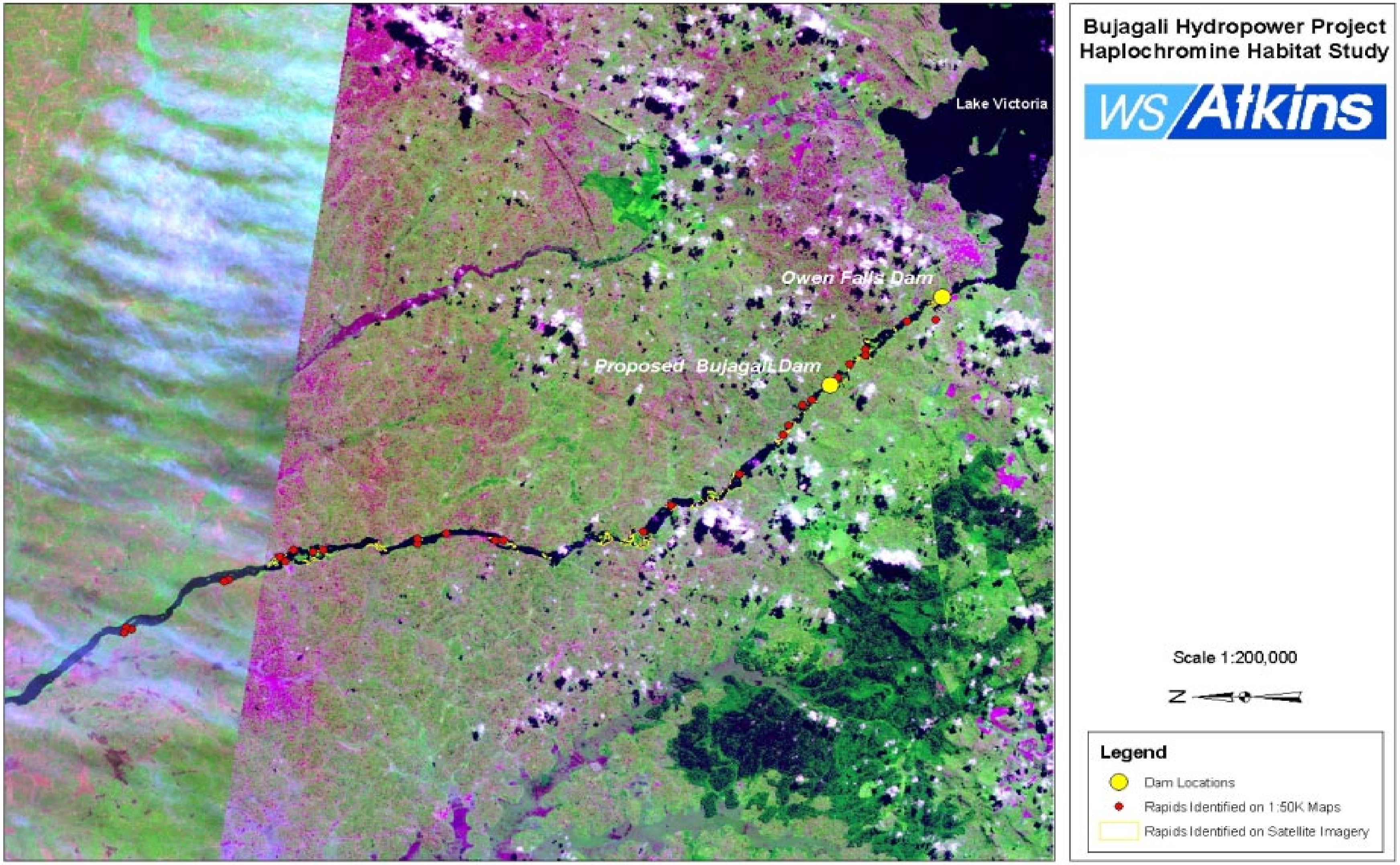


Table 5. Rapids habitat areas in the upper Victoria Nile as calculated from satellite imagery

| Analysis method | Habitat identified | Habitat area upstream of Dumbbell Island (affected by BHP) | Total habitat area in upper Victoria Nile |
|---|---|---|---|
| Conservative measurement | 'Whitewater' | 25.3 ha | 73.5 ha |
| Application of threshold filter | 'Rapidly flowing water' (including 'whitewater') | 50.4 ha | 335.1 ha |

From the analysis outlined above, it is concluded that construction of the BHP will result in a conversion of some 34% of the 'whitewater' habitat area in the upper Victoria Nile, or 15% of the 'rapidly flowing water' habitat area. The nature of this habitat conversion will be an increase in water depth and a reduction in flow velocities. The potential impacts of this habitat conversion on the haplochromine cichlids of the upper Victoria Nile are discussed further below.

## CHANGES IN FLOW VELOCITY UPSTREAM OF DUMBBELL ISLAND

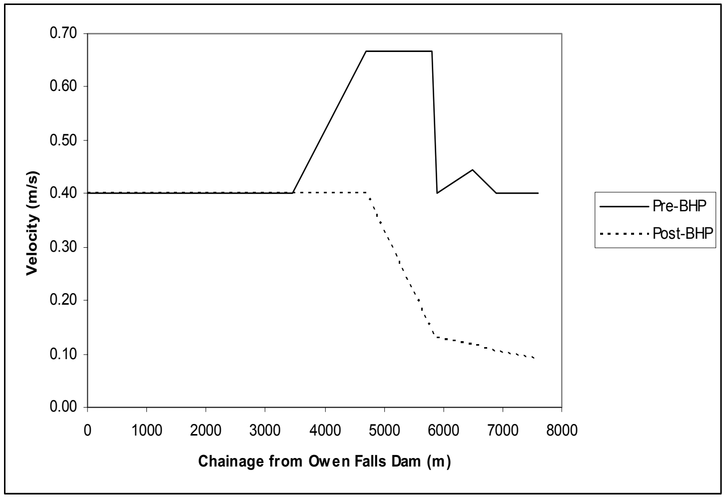
Upon completion of the BHP, the resultant reservoir will have an extremely short retention time (12-15 hours), and thus there will still be considerable exchange of water in the reservoir, and it is likely that flow velocities will remain moderate. In order to characterise the flow regime in the reach of the Nile upstream of Dumbbell Island pre- and post-construction of the BHP, velocities were estimated using known water depths in the upper part of the reach (based on Knight Piesold/Merz & McLellan, 1998), and an assumed constant discharge from Owen Falls dam of 1000 $m^3/s$. Flow velocity (V), was estimated using the formula $V = Q/A$, where Q = discharge in $m^3/s$, and A = river cross-sectional area in $m^2$. A was calculated from river channel width (from 1:50,000 topographic mapping), and known and estimated water depths at each chainage downstream of the Owen Falls dam (Table 6). The resultant calculated flow velocities (average value across the river channel) in the Bujagali reservoir, pre- and post-construction of the BHP, are shown in Figure 4.

Table 6. Input parameters for calculation of flow velocity in Bujagali reservoir area.

| Chainage from OF dam (m) | River bed levation (mASL) | Assumed channel width (m) | Water depth (pre-BHP) (m) | Predicted water depth (post-BHP) (m) |
|---|---|---|---|---|
| 0 | 1115.3 | 500 | 5 | 5 |
| 800 | 1111.3 | 500 | 5 | 5 |
| 1700 | 1110.4 | 500 | 5 | 5 |
| 2500 | 1110.4 | 500 | 5 | 5 |
| 3450 | 1106.4 | 500 | 5 | 5 |
| 4700 | 1105.5 | 500 | 3 | 5 |
| 5800 | 1097.9 | 500 | 3 | 14 |
| 5900 | 1095.8 | 500 | 5 | 15.5 |
| 6500 | 1094.2 | 500 | 4.5 | 17 |
| 6900 | 1094.1 | 500 | 5 | 19 |
| 7600 | 1089.8 | 500 | 5 | 22 |

The calculated results indicate no significant change in flow velocity upstream of Bujagali Falls, due to the fact that there is not predicted to be any significant change in water depth as a result of the BHP. For approximately 4 km downstream of this point, water depth is expected to increase by up to 17 m, resulting in an inversely proportional decrease in average flow velocity. The greatest change in velocity is at Bujagali Falls itself, where velocity is predicted to fall to about 20% of its present value. In the 4 km section of the river between Bujagali Falls and Dumbbell Island, flow velocities will be lowest (c. 0.1 m/s), due to the greatest water depth in this reach.

Figure 4. Calculated flow velocities between Owen Falls and Dumbbell Island, pre- and post- BHP construction.




# FIELD SURVEYS

## BACKGROUND

In the final report for the aquatic and fishery surveys carried out in February–November 2000 (FIRRI, 2001) an overview of the haplochromine genera recorded (Table 7) may not have provided a full indication, to species level, of the biodiversity in rock-dominated rapids habitats. Most haplochromines caught during that study, especially at the three upstream transects, belonged to the rock dwelling species flock generally referred to as the "*Mbipi*". One of the fishes encountered, *Neochromis simotes*, which was recovered at Kirindi, had been assumed to be extinct as it had not been reported since a catch in 1911 at Kakindu.

Table 7. Overview of the haplochromine fishes recorded during the four surveys of the four sampling stations of the upper Victoria Nile (Feb-Nov 2000)

| Genus | Common English name | Local name |
|---|---|---|
| *Haplochromis* | Haplochromines | Nkejje |
| *Astatotilapia* | Haplochromines | Nkejje |
| *Astatoreochromis* | Haplochromines | Nkejje |
| *Macropleurodus* | Haplochromines | Nkejje |
| *Platyaeniodus* | Haplochromines | Nkejje |
| *Haplotilapia* | Haplochromines | Nkejje |
| *Lithochromis* | Haplochromines | Nkejje |
| *Neochromis* | Haplochromines | Nkejje |
| *Ptyochromis* | Haplochromines | Nkejje |
| *Yssichromis* | Haplochromines | Nkejje |
| *Pundamilia* | Haplochromines | Nkejje |
| *Paralabidochromis* | Haplochromines | Nkejje |
| *Psammochromis* | Haplochromines | Nkejje |

During the quarterly surveys during 2000, the haplochromines were the dominant group of all fish taxa recovered from all transects. The bulk of these haplochromines belong to the rock-dwelling species flock known as the '*Mbipi'*. A total of 26 haplochromine species belonging to eleven genera were identified from the four transects. Kalange (Transect 1) had the greatest haplochromine variety, eleven species in eight genera, while Kirindi (Transect 3) had the least variety: five species in two genera. Close similarity in species composition was observed at the three upstream transects. These transects are characterised by fast running waters and rocky shoreline habitats. The 'Mbipi' and 'ptyochromines' were the most abundant haplochromines at these sites, contributing 68.7% of the total haplochromine catch during the fourth quarter. Among these rock-associated haplochromines, *Ptyochromis* dominated the catches at Kalange and Buyala while *Lithochromis* and *Neochromis* were dominant at Kirindi. Other rock dwellers recovered were *Mbipia, Pundamilia* sp. and *P.* "rockkribensis". At Namasagali, where the rock habitat is less prevalent, 'Mbipi' were not recovered. The haplochromines consisted mainly of the Lake Kyoga flock that included: the paralabidochromines; *P.* "blackpara"*, P.* "bluepara" *and P.* 'earthquake'*; Psammochromis* "shovelmouth" and *Astatotilapia* "kyoga astato". These species are currently of interest to scientists who continue research on their taxonomy and habitats, which was started by Greenwood (1981).

## FIELD SURVEY METHODS

### Site selection

A preliminary survey for rapids and site identification of the upper Victoria Nile from the source of the Nile upstream of Owen Falls dam to the confluence of the Victoria Nile and Lake Kyoga was undertaken by three FIRRI Scientists over a 12 day period during July – August 2001. The search survey involved tracking by truck as many accessible approaches to the river from both the east and west banks. During the preliminary search, the following stretches (identified by major location names) were evaluated; Ripon Falls (Bukaya), Sunset (Jinja), Nytil (Njeru), Kalange, Buyala (as in the previous EIA study), Bujagali Falls, Busowoko, Itanda/Kalagala Falls, (though more popularly known as the Kalagala Falls, the name is used for the west bank but is referred to as Itanda on eastern bank) Kirindi (as in the previous EIA study), Isimba Falls, Mbulamuti and Kakindu. The search survey was followed with a final site evaluation and selection by FIRRI, AES Nile Power and WS Atkins scientists.

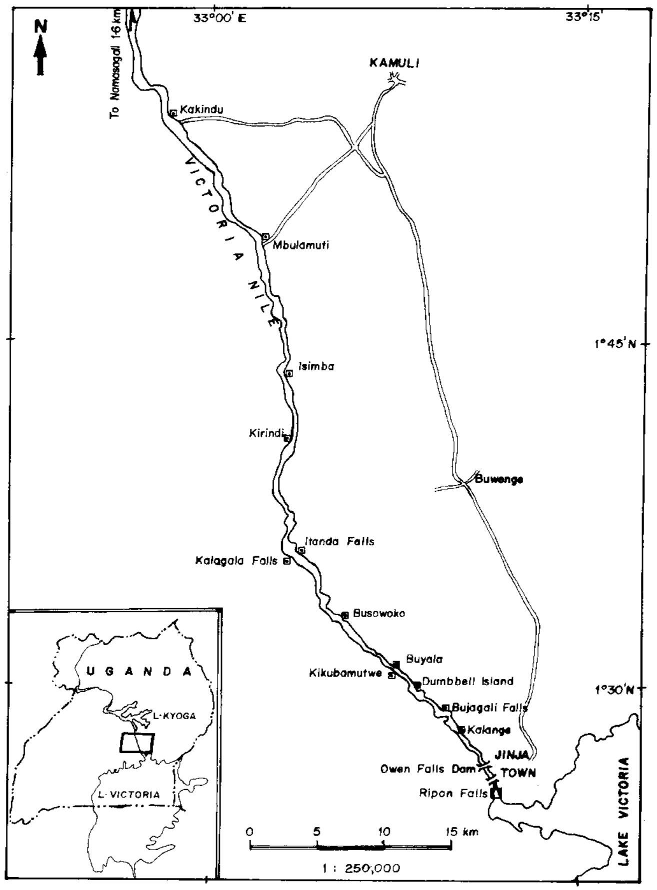
Selection of the sites to be sampled was based on the following criteria:

- Presence of rapids habitats;
- Presence of rocky outcrops in flowing water and similar stretches along the banks;
- Spread of rapids and rock-dominated habitats upstream and downstream of Dumbbell Island;
- Site above the present Owen Falls dam where habitat has already been modified (Ripon Falls);
- The site where Neochromis simotes were previously collected in 1911 (Kakindu)
- Sites which were sampled in the first survey and also provided haplochromine taxa that were not fully identified or reported on by species.

The 11 sites selected for sampling from upstream towards Lake Kyoga were: Ripon Falls, Kalange, Bujagali Falls, Buyala, Busowoko, Itanda Falls, Kalagala Falls, Kirindi, Isimba Falls, Mbulamuti and Kakindu (Figure 5). All sites were sampled by angling surveys, and nine of the eleven sites were sampled by gill-netting. Gill-netting was not carried out at Bujagali Falls and Kalagala Falls, as the flow velocities at these two sites are too high to allow this method to be used. Due to the proximity of these two sites, the data from Kalagala Falls have been combined with the data from Itanda Falls in the remainder of this report, and the sites are referred to as Itanda/Kalagala.

Field sampling was conducted over a three-week period between 11 and 31 August 2001.

Figure 5. Haplochromine sampling stations on the upper Victoria Nile




## Physical characterisation of the investigated sites

The eleven sampled sites were distributed over 63 km of river length, from Ripon Falls to Kakindu (Table 8). Three of the sites (Ripon Falls, Kalange and Bujagali) lie upstream of Dumbbell Island (the BHP site), and Ripon Falls lies upstream of the existing Owen Falls dam (Figure 5). The furthest downstream site sampled previously (i.e. Namasagali) lies 8 km downstream of Kakindu. The investigated stretch of upper Victoria Nile experiences periodic fluctuation in water level in response to water management at the Owen Falls dam. As a result, rapids and rocky outcrops are periodically exposed and submerged. This fluctuation in water level did not appear to influence fish yield. Indicative photographs of the sampled sites (Appendix 2) provide impressions of the habitats.

Table 8. Geographical positions of sampling sites

| Site Name | Eastings (UTM-36) | Northings (UTM-36) | Altitude (mASL) | Distance from Ripon Falls (km) |
|---|---|---|---|---|
| Ripon Falls | 521612 | 046348 | 1132 | 0 |
| *Owen Falls dam (existing)* | | | | *3* |
| Kalange | 518355 | 052624 | 1114 | 6 |
| Bujagali Falls | 517500 | 053300 | 1110 | 8 |
| *Dumbbell Island (site of proposed BHP)* | | | | *11* |
| Buyala | 514616 | 056086 | 1092 | 13 |
| Busowoko | 509741 | 061013 | 1081 | 19 |
| Kalagala | 505700 | 066500 | 1081 | 19 |
| Itanda | 506162 | 066874 | 1067 | 26 |
| Kirindi | 506260 | 075460 | 1048 | 36 |
| Isimba | 505600 | 080467 | 1046 | 41 |
| Mbulamuti | 503655 | 091147 | 1044 | 51 |
| Kakindu | 497353 | 100112 | 1041 | 63 |

## Fishing techniques

Two fishing techniques were used during the field surveys: gill-netting and angling.

*Gill netting:* At each site, four fleets of gill nets, each with mesh sizes from one inch to eight inches (25.4–203.2 mm) in half inch (12.7 mm) increments were deployed. At each site, four locations were selected for a 12 hour gill net sampling. The fleets were used to surround areas partly exposed to fast-flowing waters around rocky outcrops, banks and embayments. Whenever available, specimens of predators of haplochromines such as Nile perch and catfish were purchased from local fishers and used for gut content analysis.

*Angling:* Angling was carried out using hooks (size 20) baited with earthworms (*Alma* sp.) as used by local fishers targeting haplochromines. At each of the sampling sites, up to three pairs of local anglers were recruited, provided with bait and directed to defined locations. These locations were rocky outcrops in the vicinity of rapids (Plate 1) or in fast-flowing sections of the main river channel (Plate 2) where the anglers would be transported by boat, and left there angling for up to two hours. Each angler was required to collect fishes in separate containers.

In order to provide a comparable evaluation of all the sites, all sampling was conducted within a three week period during August 2001. It was assumed that within such a short time, there would have been no significant changes in fish stocks across the sites

.

Plate 1. Emptying gill-nets at Kirindi

Plate 2.  Angling rapids at Bujagali Falls

Plate 3.  Angling at Kirindi site (Nakweeya rocks)

## Taxonomic analysis

The identification of haplochromine species was primarily based on morphometric measurements, colour recognition and dentition (Plate 4). In the field, immediately on retrieval, haplochromine species were identified based on colour recognition and body habitus as in Greenwood (1981) and Seehausen *et al.* (1998). Fresh specimens were, with identification numbers attached, photographed in a perspex cuvette to record live colours. The same identification numbers were assigned to the specimens, and were recorded against the allotted species name. Representative specimens were fixed in 5% formalin for laboratory examinations and archival. Selected specimens were fin-clipped for DNA examination. The fin clips were preserved in 98% ethanol and have been stored for further analysis, should this be required in future.

In the laboratory, fish identities were further confirmed through morphometric measurements and counts as used by Greenwood and the Haplochromis Ecology Survey Team (HEST). The required morphometric measurements were taken with a mechanical calliper to the nearest 0.1 mm while dentition was assessed under a binocular microscope. Owing to the experience gained on previous routine studies undertaken by FIRRI scientists, the identification of these fishes and their confirmation according to literature and checklists was not considered problematic during this study.

Plate 4. Identifying haplochromines from Buyala

## Commercial haplochromine catch assessment survey

In the FIRRI (2000) study, significant differences in commercial fish species densities at the four transects studied were reported. On the basis of their trophic dominance (predator) and relative abundance, the commercial species were dominant amongst the recognised keystone species. However, the most diversified group, the haplochromines, were not considered from a socio-economic perspective in that survey. Therefore, this study paid attention to the importance of the group in the upper Victoria Nile fishery.

A simultaneous rapid fish catch survey and community perception of haplochromines was undertaken at the 11 survey sites. Three additional sites (Mutebi, Nganga and Njeru fish landings) upstream of Owen Falls dam were included in the study due to the observed intensive fishery in the area in comparison to the other sites. These sites were close to the Ripon Falls sampling site. The methodology for fish catch survey was as previously described in FIRRI (2001), and involved the use of a short questionnaire to assess community perception of haplochromines as a fisheries resource.

# RESULTS OF FIELD SURVEYS

## Major fish taxa encountered and their distribution

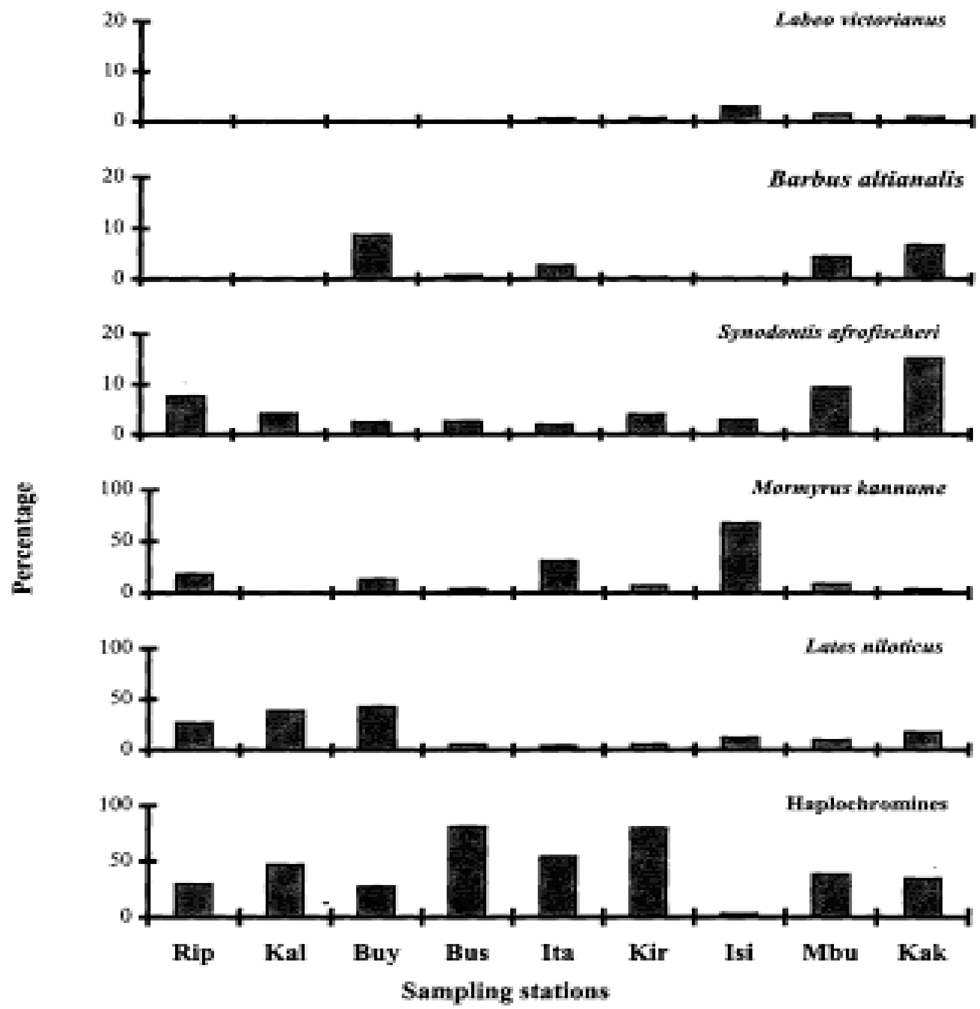
During this survey, at least 3000 fish specimens were caught from the investigated sites on the upper Victoria Nile. Twenty fish taxa were recorded from the study area (Table 9). In terms of numbers, haplochromines were the overall dominant fishes in the gillnet catches. Six major taxa (*Labeo victorianus, Barbus altianalis, Synodontis afrofischeri, Mormyrus kannume, Lates niloticus* and Haplochromines) were collected from the study area.

Comparing the longitudinal distribution of the species, *L. victorianus, B. altianalis* and *S. afrofischeri* were more common in downstream sites while *L. niloticus* occurred more frequently in upstream sites (Figure 6). Haplochromines were more common in the middle zone of the study area i.e. Busowoko, Itanda/Kalagala and Kirindi, possibly due to the lower numbers of Nile perch present here, and therefore reduced predation pressure (Musenero, 2000).

Table 9. Fish species percentage relative abundance by numbers at stations along the upper Victoria Nile

| Species | Rip | Kal | Buy | Bus | Ita | Kir | Isi | Mbu | Kak | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| *Brycinus jacksonii* | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| *Brycinus sadleri* | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Barbus altianalis* | 0.0 | 0.0 | 8.7 | 0.8 | 2.7 | 0.4 | 0.0 | 4.3 | 6.7 | 2.2 |
| *Bargrus docmac* | 1.0 | 0.0 | 5.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 |
| *Clarias gariepinus* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Gnathonemus longibarbis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 2.9 | 0.0 | 0.0 | 0.1 |
| Haplochromines | 29.5 | 47.1 | 27.3 | 81.1 | 54.4 | 79.9 | 2.9 | 38.4 | 34.3 | 55.6 |
| *Lates niloticus* | 26.7 | 38.6 | 42.6 | 5.3 | 4.0 | 5.1 | 11.8 | 9.4 | 17.1 | 18.1 |
| *Labeo victorianus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 2.9 | 1.4 | 1.0 | 0.4 |
| *Marcusenius grahami* | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.1 | 0.0 | 13.0 | 16.2 | 2.0 |
| *Mormyrus kannume* | 18.1 | 0.9 | 13.6 | 4.2 | 31.2 | 6.9 | 67.6 | 8.7 | 3.8 | 10.5 |
| *Mormyrus macrocephalus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.5 | 5.7 | 0.7 |
| *Oreochromis esculentus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.1 |
| *Oreochromis leucostictus* | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.7 | 0.0 | 0.7 | 0.0 | 0.2 |
| *Oreochromis niloticus* | 6.7 | 4.0 | 0.0 | 4.5 | 1.0 | 1.1 | 0.0 | 1.4 | 0.0 | 2.6 |
| *Oreochromis variabilis* | 0.0 | 0.9 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 3.6 | 0.0 | 0.5 |
| *Protopterus aethiopicus* | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| *Synodontis afrofischeri* | 7.6 | 4.2 | 2.5 | 2.6 | 2.0 | 4.0 | 2.9 | 9.4 | 15.2 | 4.3 |
| *Synodontis victorianus* | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 2.9 | 0.0 | 0.0 | 0.1 |
| *Tilapia zillii* | 8.6 | 2.0 | 0.0 | 0.8 | 1.3 | 0.0 | 5.9 | 1.4 | 0.0 | 1.4 |

Figure 6. Proportion of total gillnet catch represented by the six main fish taxa.




Rip = Ripon Falls
Bus = Busowoka
si = Isimba

Kal = Kalange
Ita = Itanda/Kalagala
Mbu = Mbulamuti

Buy = Buyala
Kir = Kirindi
Kak = Kakindu

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## The Haplochromines

### *Species Distribution*

The haplochromine species encountered in the upper Victoria Nile are species associated with rocky/sandy habitats. A total of 35 haplochromine species belonging to 14 genera were collected from the eleven sampled sites along the upper Victoria Nile (Table 10). Species occupancy of sites (other than Bujagali where only angling was done) ranged from eight at Kakindu to 18 at Busowoko (all downstream of Dumbbell Island). Figure 7 shows the geographical layout of the sampling sites, with information on the relative haplochromine catch rates and lists of the haplochromine species recovered at each site.

From Table 10, three haplochromine fish zones were recognised. These are:

(i) **The Victorian zone:** A 20 km stretch from the source of the Nile at Ripon Falls to just below the proposed dam site at Buyala. This zone is characterised by fast flowing waters over rapids such as the Bujagali Falls and Kyabirwa Falls. All the fish species found here have been reported to still exist in similar rocky/sandy habitats in the main body of Lake Victoria (Seehausen, 1996).

(ii) **The Transition "Yellow" zone:** An approximately 20 km stretch from Busowoko to Isimba. The water here is still relatively fast, and still flowing over rapids such as Itanda/Kalagala, Kirindi and Isimba Falls. The main difference is that the zone is relatively far from either of the lakes. Many of the fishes here also occur in the main body of Lake Victoria. However a number of undescribed and the two purely river species, *Xystichromis bayoni* and *Neochromis simotes*, occur in this zone. Most fish species from this zone are characterised by yellow/orange male nuptial colours especially on the unpaired fins, thus the nickname "yellow" zone. The zone has higher diversity (27 species) of haplochromine species compared with the Victorian zone (20 species).

(iii) **The Kyoga zone:** Below Mbulamuti, covering Kakindu and beyond. This is a stretch of navigable river without prominent rapids except at low water levels. The water flow here is relatively slow-flowing, the river is wider and is fringed by papyrus. Many haplochromine species here have been reported to occur in the two lakes and more so in Lake Kyoga (Greenwood, 1981), and for this reason the haplochromine assemblage of this zone is considered to be more representative of the Lake Kyoga flock. The Kyoga connection to this zone is underlined further by the presence of the mormyrid *Mormyrus macrocephalus* (Table 9), a species occurring in Lake Kyoga but not in Lake Victoria (Greenwood, 1966). Compared with upstream zones, this zone with fewer rock habitats was relatively poor in haplochromine diversity, with a total of only 13 species recovered from both Mbulamuti and Kakindu.

Species with the widest distribution/range (i.e. > 50% frequency of occurrence) were: *Astatoreochromis alluaudi, Mbipia mbipi, Neochromis greenwoodi, Neochromis rufocaudalis, Xystichromis nuchisquamulatus, Psammochromis riponianus, Neochromis gigas* and *Lithochromis rubripinnis*. Those species recovered from only one site are shown in Table 11.

*Astatotilapia brownae*, *Neochromis omnicaeruleus*, the rockpickers *Paralabidochromis cyaneus* and *P. flavus, Pundamilia igneopinnis* and *Pundamilia macrocephala* were restricted to the upper part of the river upstream of Busowoko. *Neochromis simotes*, *Pyxichromis orthostoma*, *Xystichromis bayoni* and the undescribed species (here given the cheironyms *Haplochromis* "silver arrow", *Mbipia* "yellow fin", *Neochromis* "lemon britti" and *Neochromis* "yellow rufocaudalis") were found only in the lower section of the river below the Itanda/Kalagala site (see Figure 7). As indicated by cheironyms, several *Neochromis* species were encountered, mostly from Busowoko towards Itanda/Kalagala, Kirindi and Isimba, to the most downstream site (Kakindu).

The transition "yellow" zone yielded the highest haplochromine catch rates. Of the four *mbipi* genera (Seehausen *et al*. 1998) the genus *Pundamilia* was restricted to the zone nearest Lake Victoria while only *Neochromis* extended into the last zone. While the genus *Mbipia* (especially the species *M. mbipi*) was very abundant in the upper zone, its numbers dwindled downstream.

| Species | Rip | Kal | Buj | Buy | Bus | Ita | Kir | Isi | Mbu | Kak |
|---|---|---|---|---|---|---|---|---|---|---|
| *Astatoreochromis alluaudi* | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ | ■ |
| *Astatotilapia brownae* | ■ | ■ | ■ | | | | | | | |
| *Astatotilapia nubila* | | | | | | ■ | | ■ | | |
| *Astatotilapia sp.* | | | | | ■ | | | | | ■ |
| *Haplochromis lividus* | | | | | | | | | ■ | |
| *Haplochromis* “silver arrow" | | | | | | | | | ■ | |
| *Lithochromis rubripinnis* | ■ | | ■ | ■ | ■ | ■ | ■ | | | |
| *Lithochromis xanthopterix* | | | | | ■ | | | | | |
| *Mbipia mbipi* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| *Mbipia* "red pelvics" | | | | | ■ | | | | | |
| *Mbipia* "yellowfin" | | | | | | | ■ | | | |
| *Neochromis gigas* | ■ | | | | ■ | ■ | ■ | ■ | ■ | |
| *Neochromis greenwoodi* | | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ |
| *Neochromis omnicaeruleus* | ■ | | | | ■ | | | | | |
| *Neochromis rufocaudalis* | ■ | | ■ | | ■ | ■ | ■ | ■ | ■ | ■ |
| *Neochromis simotes* | | | | | | | ■ | | ■ | |
| *Neochromis* "lemon britti" | | | | | | ■ | | | | |
| *Neochromis* "red simotes" | | | | | ■ | ■ | | | | |
| *Neochromis* "yellow rufocaudalis" | | | | | | | | | | ■ |
| *Paralabidochromis cyaneus* | | | | ■ | | | | | | |
| *Paralabidochromis flavus* | ■ | | | | | | | | | |
| *Paralabidochromis* “rockkribensis” | ■ | | | ■ | ■ | | ■ | ■ | | |
| *Prognathochromis guiarti* | ■ | ■ | | | ■ | | ■ | | | |
| *Psammochromis riponianus* | ■ | | | ■ | ■ | ■ | | ■ | | ■ |
| *Ptyochromis sauvagei* | | | | ■ | ■ | | ■ | | | |
| *Ptyochromis xenognathus* | | | | | ■ | | | | | |
| *Pundamilia azurea* | | ■ | | ■ | | | | | | |
| *Pundamilia igneopinnis* | | ■ | | | | | | | | |
| *Pundamilia macrocephala* | | ■ | ■ | | | | | | | |
| *Pundamilia pundamilia* | ■ | ■ | | ■ | | ■ | | | | |
| *Pundamilia* "yellow-multispot" | | | | | | ■ | | | | |
| *Pyxichromis orthostoma* | | | | | | | | ■ | | |
| *Xystichromis bayoni* | | | | | | | ■ | ■ | ■ | ■ |
| *Xystichromis nuchisquamulatus* | | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | |
| *Xystichromis phytophagus* | | ■ | | | ■ | | | ■ | | ■ |
| **Total no. of species** | **12** | **11** | **6** | **10** | **18** | **12** | **14** | **12** | **9** | **8** |

Table 10. Haplochromine species encountered at the sampling stations along the upper Victoria Nile – August 2001.

Rip = Ripon Falls
Kal = Kalange
Buj = Bujagali
Buy = Buyala
Bus = Busowoko
Ita = Itanda/Kalagala
Kir = Kirindi
Isi = Isimba
Mbu = Mbulamuti
Kak = Kakindu

Figure 7.  Haplochromine yields during experimental fishing, and species recovered, August 2001

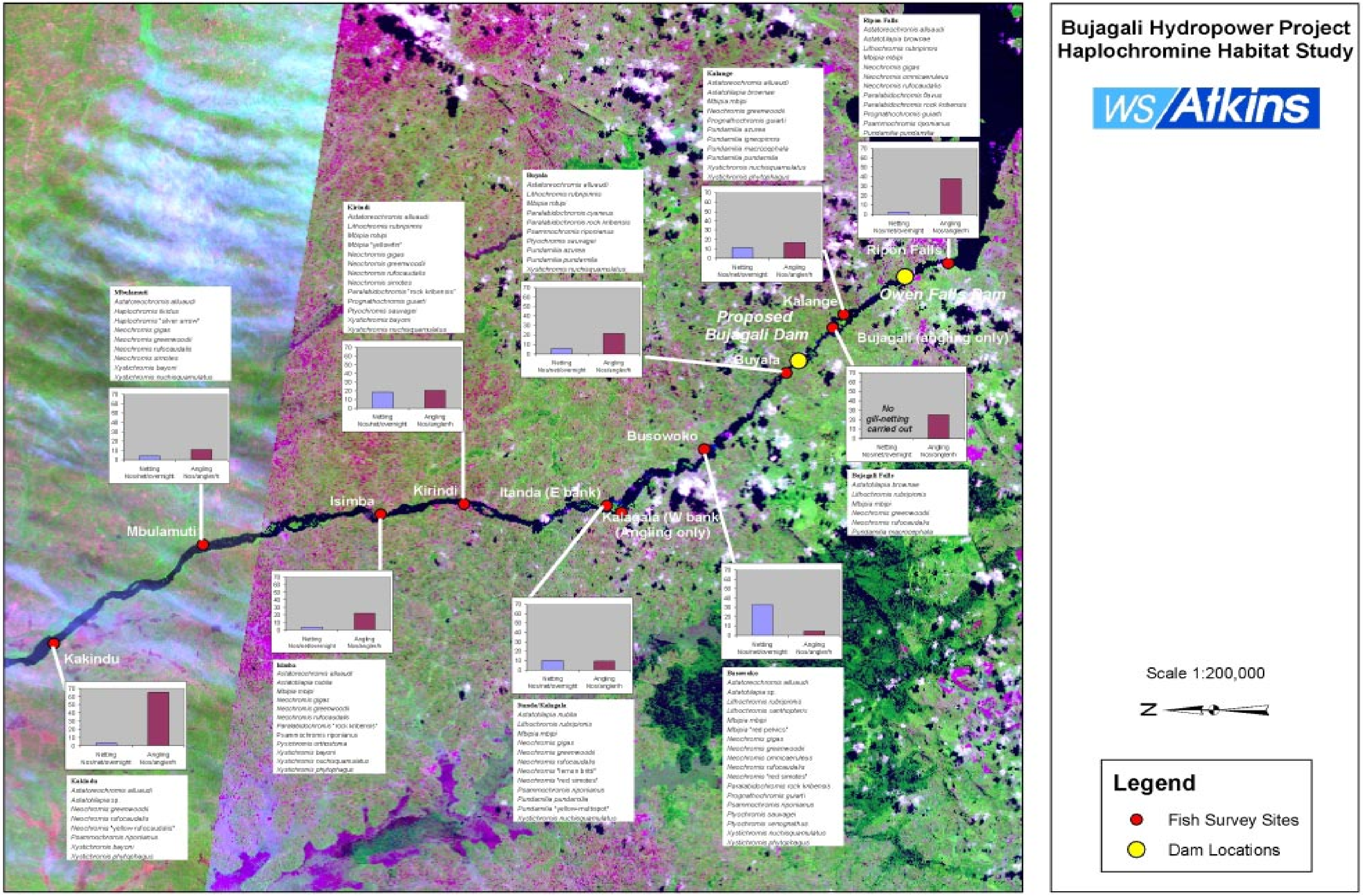




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Table 11. Haplochromine species recovered from a single site during sampling – Aug. 2001

| Site of capture | Fish species |
|---|---|
| Ripon Falls | *Paralabidochromis flavus* |
| | *Neochromis omnicaeruleus* |
| Kalange | *Pundamilia igneopinnis* |
| Buyala | *Paralabidochromis cyaneus* |
| Busowoko | *Lithochromis xanthopterix* |
| | *Ptyochromis xenognathus* |
| Itanda | *Neochromis* “lemon britti” |
| | *Neochromis* “yellow-multispot” |
| Kirindi | *Mbipia* “yellowfin” |
| Isimba | *Pyxichromis orthostoma* |
| Mbulamuti | *Haplochromis lividus* |
| | *Haplochromis* “silver arrow” |
| Kakindu | *Neochromis* “yellow rufocaudalis” |

## RELATIVE ABUNDANCE OF HAPLOCHROMINE SPECIES

### Gillnet catches

A total of 32 haplochromine species belonging to fourteen genera were recovered in gillnets (Table 12). These were dominated by *Xystichromis nuchisquamulatus*, (37.0% of gillnet catch by number), *Lithochromis rubripinnis* (13.5%) and *Xystichromis bayoni* (13.0%). Other species of numerical importance were *Psammochromis riponianus,* (8.2%), *Mbipia mbipi* (5.8%), *Neochromis gigas* (5.2%), *Astatoreochromis alluaudi* (3.8%) and *Neochromis rufocaudalis* (3.1%). Busowoko recorded the highest gillnet catch rates at 32.9 fish per net (Figure 8). Other stations recording high rates included Kirindi, Kalange and Itanda/Kalagala respectively at 18.3, 11.5 and 9.9 fish per net. Ripon Falls showed the lowest catch rates (2.6 fish per net). Kakindu, Isimba, and Mbulamuti also recorded low catches at 3.0, 3.6 and 4.4 fish per net, respectively. A further evaluation of Table 10 brings out clearly the haplochromine taxa zonation of the upper Victoria Nile into three sections; Upper, Middle and Lower sections. However, the relatively low haplochromine catch rates at the Isimba Falls sampling site was most probably due to logistical problems encountered in the field (loss of nets due to high flow velocities at some locations within the site). Therefore, some of the species not encountered at this site but found at the Kirindi and Mbulamuti sites were probably missed due to these problems.

### Angling catches

Twenty six cichlid species belonging to eleven genera were caught by anglers (Table 13). Two of the genera, covering three species, were tilapiines, while the rest were haplochromines. *Mbipia mbipi* (at 41.8% of total catch by number) was the dominant haplochromine species caught by angling. Other species, in descending order of numerical importance, were *Neochromis rufocaudalis* (20.6%), X*ystichromis bayoni* (8.6%), *Neochromis greenwoodi* (7.5%) and *Astatotilapia brownae* (7.3%).

Kakindu, with 65 fish/angler/hour, had the highest angling catch rates (Figures 7 & 8). Other stations with high catch rates were Ripon Falls (37), Bujagali Falls (25.25), Isimba (22.0) and Buyala (21.5). Lowest rates were encountered at Busowoko (4.8), Itanda/Kalagala (9.3) and Mbulamuti (11.3). The genus *Mbipia* dominated the Upper section of the river while *Neochromis* dominated the lower reaches. As indicated by cheironyms (e.g. “yellowfin”), several previously-undescribed *Neochromi*s species were collected from the sites downstream of Busowoko.

Table 12. Catch rates (Average Nos./net/overnight) of haplochromine species recovered from gillnets, August 2001

| Species | Rip | Kal | Buy | Bus | Ita | Kir | Isi | Mbu | Kak | Overall |
|---|---|---|---|---|---|---|---|---|---|---|
| *Astatoreochromis alluaudi* | 0.08 | 1.25 | 0.08 | 0.08 | 0.00 | 1.08 | 0.17 | 0.08 | 0.67 | 0.2 |
| *Astatotilapia brownae* | 0.08 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Astatotilapia nubila* | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.08 | 0.00 | 0.00 | 0.0 |
| *Astatotilapia* sp. | 0.00 | 0.00 | 0.00 | 1.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.1 |
| *Haplochromis lividus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.0 |
| *Lithochromis rubripinnis* | 0.08 | 0.00 | 0.67 | 2.75 | 6.58 | 2.25 | 0.00 | 0.00 | 0.00 | 0.8 |
| *Lithochromis xanthopterix* | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Mbipia* "yellowfin" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Mbipia mbipi* | 0.92 | 2.17 | 1.75 | 0.08 | 0.33 | 0.00 | 0.08 | 0.00 | 0.00 | 0.4 |
| *Neochromis gigas* | 0.08 | 0.00 | 0.00 | 0.33 | 0.17 | 4.17 | 0.00 | 0.00 | 0.00 | 0.3 |
| *Neochromis greenwoodi* | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.0 |
| *Neochromis rufocaudalis* | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 2.08 | 0.33 | 0.00 | 0.00 | 0.2 |
| *Neochromis simotes* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.0 |
| *Paralabidochromis cyaneus* | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Paralabidochromis flavus* | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Prognathochromis guiarti* | 0.08 | 0.17 | 0.00 | 0.08 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Psammochromis riponianus* | 0.33 | 0.00 | 1.83 | 0.50 | 1.83 | 0.00 | 2.42 | 0.00 | 0.58 | 0.5 |
| *Ptyochromis sauvagei* | 0.00 | 0.00 | 0.17 | 0.08 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Ptyochromis xenognathus* | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Pundamilia azurea* | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Pundamilia macrocephala* | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Pundamilia pundamilia* | 0.00 | 0.17 | 0.42 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Pyxichromis orthostoma* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.0 |
| *Xystichromis bayoni* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.83 | 0.00 | 3.75 | 1.33 | 0.8 |
| *Xystichromis nuchisquamulatus* | 0.00 | 7.25 | 0.17 | 24.67 | 0.67 | 1.17 | 0.00 | 0.00 | 0.00 | 2.3 |
| *Xystichromis phytophagus* | 0.00 | 0.08 | 0.00 | 0.42 | 0.00 | 0.00 | 0.42 | 0.00 | 0.08 | 0.1 |
| *Neochromis omnicaeruleus* | 0.42 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Paralabidochromis* "rockkribensis" | 0.00 | 0.00 | 0.08 | 0.08 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Neochromis* "red simotes" | 0.00 | 0.00 | 0.00 | 1.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.1 |
| *Pundamilia igneopinnis* | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| *Neochromis* "yellow rufocaudalis" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.0 |
| **Total** | 2.6 | 11.5 | 5.4 | 32.9 | 9.9 | 18.3 | 3.6 | 4.4 | 3.0 | 6.1 |

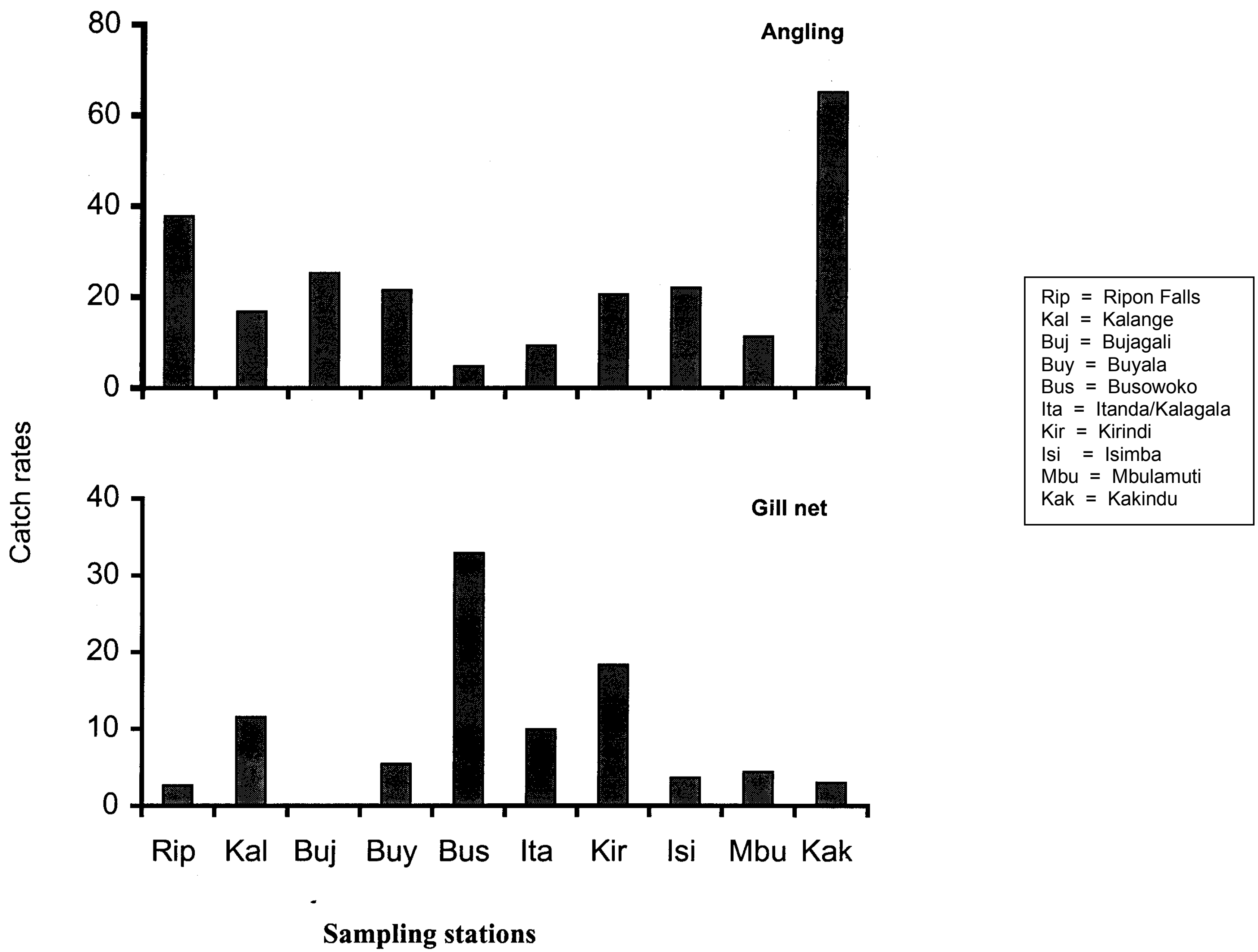
Rip = Ripon Falls
Kal = Kalange
Buy = Buyala
Bus = Busowoko
Ita = Itanda
Kir = Kirindi
Isi = Isimba
Mbu = Mbulamuti
Kak = Kakindu

Table13. Catch rates (Nos./hr) of cichlids recovered by angling at sampling sites along the upper Victoria Nile – August 2001

| Species | Rip | Kal | Buj | Buy | Bus | Ita | Kir | Isi | Mbu | Kak | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Astatoreochromis alluaudi* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.03 |
| *Astatotilapia brownae* | 0.00 | 9.75 | 7.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.68 |
| *Haplochromis* "silver arrow" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.03 |
| *Lithochromis rubripinnis* | 0.38 | 0.00 | 2.50 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 |
| *Mbipia mbipi* | 35.38 | 2.50 | 8.25 | 21.00 | 0.00 | 2.50 | 1.00 | 0.00 | 0.00 | 0.00 | 7.06 |
| *Mbipia* "red pelvics" | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| *Neochromis gigas* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 1.00 | 0.00 | 0.15 |
| *Neochromis greenwoodi* | 0.00 | 1.50 | 2.50 | 0.00 | 1.75 | 2.50 | 0.75 | 4.00 | 4.00 | 0.25 | 1.73 |
| *Neochromis omnicaeruleus* | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| *Neochromis rufocaudalis* | 0.00 | 0.00 | 3.50 | 0.00 | 0.75 | 2.25 | 16.75 | 16.00 | 4.25 | 3.50 | 4.70 |
| *Neochromis simotes* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 1.00 | 0.00 | 0.30 |
| *Neochromis* "lemon britti" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| *Neochromis* "red simotes" | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |
| *Neochromis* "yellow rufocaudalis" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.00 | 0.90 |
| *Paralabidochromis flavus* | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| *Paralabidochromis* “rockkribensis” | 0.75 | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.15 |
| *Pundamilia* "yellow-multispot" | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| *Pundamilia azurea* | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| *Pundamilia igneopinnis* | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| *Pundamilia macrocephala* | 0.00 | 0.00 | 1.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |
| *Pundamilia pundamilia* | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| *Xystichromis bayoni* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 19.25 | 1.98 |
| *Xystichromis nuchisquamulatus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.75 | 0.50 | 0.00 | 0.15 |
| *Oreochromis niloticus* | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 |
| *Oreochromis variabilis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.03 |
| *Tilapia zillii* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.03 |
| **Total** | 37.75 | 16.75 | 25.25 | 21.50 | 4.75 | 9.25 | 20.50 | 22.00 | 11.25 | 65.00 | 20.15 |

Rip = Ripon Falls
Kal = Kalange
Buy = Buyala
Buj = Bujagali
Bus = Busowoko
Ita = Itanda/Kalagala
Kir = Kirindi
Isi = Isimba
Mbu = Mbulamuti
Kak = Kakindu

Figure 8. Catch rates of haplochromines encountered by anglers (Nos./person/hr) and gill nets (Nos./net/overnight) at stations along the upper Victoria Nile – August 2001. Note: gill netting was not carried out at Bujagali Falls.

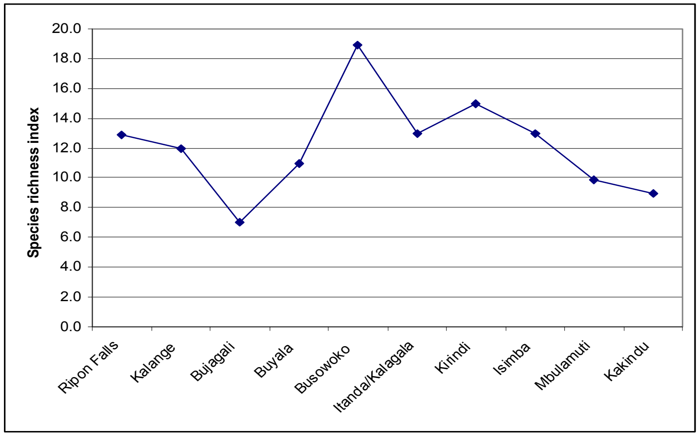


## Estimates of species richness

The jackknife method (Burnham & Overton, 1979) was used to estimate haplochromine species richness or diversity index (Ŝ) at each of the sampled sites. The jackknife method calculates Ŝ, based on the total number of observed species, the total sampling effort, and the number of unique species at each site.

Figure 9 below shows the calculated species richness index at each of the sites. It can be seen that the middle section of this river reach (from Busowoko to Kirindi) has the highest haplochromine species richness. Lowest species richness was found at Bujagali, and the two furthest downstream sites (Mbulamuti and Kirindi).

Figure 9. Haplochromine species richness in the upper Victoria Nile, estimated using the jackknife method.




## Threatened Species

Of the cichlid fish species recovered in experimental fishing, a total of three are listed as threatened in the IUCN Red List, and only one is a haplochromine species. The tilapiine *Oreochromis esculentus* was recovered at two sites downstream of Dumbbell Island, while *O. variabilis* was recovered at a total of four sites, one upstream and three downstream of Dumbbell Island, and were also recovered in the Victoria Nile during the surveys carried out in 2000.

The only threatened haplochromine recovered during these surveys was *Pyxichromis orthostoma* (Appendix 4; Plate 2), which is classified as 'Vulnerable' (Threat Category VU A1ace, B1+2ce; see Appendix 1), which was found at Isimba. According to the IUCN Red List, this species has only previously been recorded in Lakes Kyoga and Nawampasa, so the finding in the Victoria Nile extends the previously-assumed distribution. The BHP is unlikely to have an adverse impact on this species, as Isimba is a considerable distance (30 km) downstream of the proposed development.

## Commercial Fisheries

The commercial fishery of the surveyed sites (by fresh weight, Appendix 3) consisted of 75.5% Nile tilapia *Oreochromis niloticus*, (valued at about 15 million shillings per month, Appendix 3C), 5.1% Nile perch *Lates niloticus*, 12.9% minnows *Rastrineobola argentea*, 2.6% barbel *Barbus altianalis*, 0.9% *Mormyrus kannume*, 2.1% *Bagrus docmac* and 0.2% *Tilapia zillii*. The three sites upstream of Owen Falls dam (Mutebi, Nganga and Njeru) were most important for *O. niloticus*, contributing 74.2% of the total catch at all sampled sites. Most sites downstream of Dumbbell Island were used mainly used for transport canoes: most part-time fishers were absent preparing land for crop growing, a usual rainy season activity.

The most commonly used fishing gear was hooks. Angling (38.9%) of the sampled canoes downstream of Owen Falls dam was followed by longline 33.3%, passive gillnets 16.7%, active gillnets and traps 5.6% each. When the three sites upstream of Owen Falls dam were included, angling canoes contributed 67.1%, longline 11.4% active fishing and scoopnets 6.3% each, passive gillnets 5.1% castnets 2.5% and traps 1.2%.

Angling was more popular upstream of the Owen Falls dam where, of the 61 canoes, 87% were anglers targeting Nile tilapia at the entrance to the Owen Falls Extension headrace canal. The catch per unit of effort (kg per canoe per day) recorded was 13.5 kg at Njeru, 6.8 kg at Nganga and 9.4 kg at Mutebi landing sites.

Downstream of Owen Falls dam, at Kalange, catch per unit effort (CPUE:

kg/canoe/day) was 7.2; at Buyala (downstream of Dumbbell Island) CPUE was 4.1; at Busowoko was 3.8, and at Kakindu, was 9.5. At Itanda, Kirindi, Isimba and Mbulamuti, there were no commercial catches noted. Most of these sites had transport canoes, or a few small canoes used for subsistence fishing.

Full time jobs on sites visited (Appendix 3A) included food vendors, fishers, fish traders, boat making/repair, net repair, chairpersons of landing site, fisheries extension workers, kiosks owners, bait traders, guard, ornamental and fish trade. In total 466 people were involved in fishing, of whom 21.9% were women. The jobs involved more people (especially the fishers) at the three sites upstream of Owen Falls dam, making up 67.4% of the people in all the sites visited. This made the reach upstream of the Owen Falls dam a good fishing area as an estimated 60 or so canoes concentrated at the entrance to the headrace channel, where there are large numbers of Nile tilapia. These are generally caught using hook size 15 and earth worms as bait.

## Estimated catch and value per month

The estimation was based on sites where commercial catches were available for analysis. The three fish landing sites upstream of Owen Falls dam had the highest fish catch (24858 kg/month) and value (USh 14.9 million/month) compared to downstream transects (a total of 3668 kg valued at USh 3.3 million).

## Perception of communities towards the haplochromine fishery of the upper Victoria Nile

The questionnaire was administered to a total of 40 respondents (35% of whom were fishers using rented gear, 53% fishers and gear owner, 15% renters of boats, 1.5% students, 8% farmers) along the upper Victoria Nile. All the respondents were aware of the presence of the haplochromine fishery on the river and 90% participated in fishing for haplochromines or saw fishing activities for the species going on daily. The catches were rated as good (65%), fair (30%) and poor (5%).

Fifty five percent of the respondents eat haplochromines and some use them as a cure for measles in children, while 80% used the fish as bait for the Nile perch and *Bagrus docmac.* 23% sold the fish in local markets. The weekly income from the sale of haplochromine was in the range of 200 – 35,000 USh per fisher per week with a mean of 14,700: 95% of the respondents agreed that the fish was available in the river anytime it was needed. The fish was mainly caught using hook size of 20 (95%) of responses and earthworms as bait, while 13% of respondents used the small gillnet mesh sizes of 25.4mm and 38.1mm. 35% of the respondents had no problems in harvesting the haplochromines. The main problems associated with the haplochromine fishery of the river were ranked as:

- Bait collection in swamps
- Disturbance to the fishers by tsetse flies, leaches and crocodiles during fishing
- Getting hurt by slippery stones during fishing
- Excessive loss of hooks during angling thus constant replacement.
- Not easy to get haplochromines with hooks as they hide in rocks
- A lot of bait is needed and it is tiring to catch one small fish at a time
- The fish may not easily take the bait
- The haplochromines are seasonal and when the river is flooded it is not easy to catch them as they hide in submerged rocks.

The respondents were of the view that the haplochromine fishery will continue to flourish because:

- Little fishing effort is exerted on them – there is not much targeted fishing except when needed as bait for Nile perch or local cure for measles.
- Haplochromines have a high reproduction rate and good environment for reproduction and growth
- Haplochromines hide in rocks to avoid predation and are not easy to catch.

The general view is that "haplochromines are very numerous and have always been fished. They were around long ago and would still stay".

## Discussion of Field Survey Results

The haplochromine cichlids have been investigated in more detail than ever before during the present study, and this is considered to be the most comprehensive haplochromine study of the upper Victoria Nile to date.

The upper Victoria Nile connects Lake Victoria (upstream) and Lake Kyoga (downstream) (Figure 3). This stretch of the River Nile is an out-flowing river with respect to Lake Victoria, and becomes an inflowing river with respect to Lake Kyoga. In its course towards Lake Kyoga, the upper Victoria Nile cascades over numerous rapids and several falls, the most prominent of which include Ripon Falls, Bujagali Falls, Itanda-Kalagala and Isimba Falls, which lie over a c.60 km stretch of the river. These sites have considerable hydropower potential and the Owen Falls power station, which was commissioned in the 1950s, does not meet current demand for electricity. On the other hand, for the most part, the two lacustrine systems (Victoria and Kyoga) and the upper Victoria Nile as well as satellite lakes, rivers and streams in their catchments are ecologically similar in view of their past geological history and their faunal evolutionary trends (Beadle, 1972). Therefore, prior to species introductions (Nile perch and tilapia) in the two lakes and the upper Victoria Nile in the 1950s/60s, the lakes were known to contain species flocks of endemic cichlids (about 500 taxa, mostly haplochromines and two tilapiines (*Oreochromis esculentus* and *O. variabilis*). With respect to the hydrological and faunal links between the two lakes, the upper Victoria Nile behaves in three functional respects:

- In its upper reaches as it emerges at the “source” and behaves as an extension of the Lake Victoria fauna, it is an out-flowing river,
- In its lower reaches closer to Lake Kyoga, the Victoria Nile behaves as an inflowing river.
- The mid-sections comprising Busowoko, Itanda/Kalagala, Kirindi and Isimba sampling sites, occupy a transition zone especially from an ecological viewpoint as depicted in species distribution patterns.

It is possible that Kalagala/Itanda Falls represent the physical barrier that has led to the development of two separate haplochromine populations. If so, this makes the long-term conservation of Kalagala more important, as it represents the downstream limit of one population and the upstream limit of the other, i.e. the area in which the two species flocks overlap.

Results from the present study clearly indicate that haplochromine fishes are the most diverse group in the river, and the most dominant in terms of numbers. However, from both the distribution patterns of the fish and the other ecological attributes of the river elaborated in the EIA reports (FIRRI, 2001; AES Nile Power, 2001), the river fauna shows a zonation pattern with respect to cichlids. The most important sites for haplochromines are Ripon Falls, and a continuous stretch covering Busowoko, Itanda-Kalagala and Kirindi.

It has been shown in previous studies (e.g. Ogari, 1985; Ogutu-Ohwayo, 1985; Witte *et al*. 1992*a*; 1992*b*) that Nile perch predation had a major impact on haplochromine populations in both Lake Victoria and Lake Kyoga. The major threat to the haplochromines in the river might therefore be assumed to be Nile perch. In the previous fisheries studies on the Victoria Nile (FIRRI, 2000*a* to 2000*d*), it was found that dragonflies, shrimps and minnows were the main food items for the keystone predator species (Nile perch and *Bagrus docmac*), rather than haplochromines. It seems that the widespread rock dominated habitats offer protection from Nile perch predation to the haplochromine fishes living there. Similar conclusions have been reached in several studies conducted in Lake Victoria by Seehausen (1996; 1999) who found several species that could not be caught elsewhere other than rocky habitats. In view of the more widespread rocky habitats in the upper Victoria Nile, the riverine environment affords more protection to the remnant haplochromine species flock of a rock-dwelling type, and also to so-called ‘rock refugees’.

During the present study, two species were only recovered at a single site above Dumbbell Island (*Pundamilia igneopinnis* and *P. macrocephala* at Kalange and Bujagali Falls respectively), and a third species (*Astatotilapia brownae*) was only found from Ripon Falls to Bujagali. While this finding might imply that these three species are confined to the uppermost sections of the river, and therefore are most likely to be affected by the BHP, they are known to occur elsewhere in Lake Victoria e.g. Mwanza Gulf, Tanzania, (Seehausen, 1996; Seehausen *et al.*, 1998) and have frequently been caught in the Napoleon Gulf by FIRRI. They are not considered to be threatened, nor of particular importance from a conservation perspective. The reduction in flow velocity where rock habitats occurs may in fact improve habitat for these and other species, as it will be more similar to the Lake Victoria/Napoleon Gulf habitats.

Did the submergence of Ripon Falls eliminate rock-dwelling haplochromine species? Results from the present study indicate that despite being submerged and blocked off by the Owen Falls dam from the adjacent downstream sections of the river, there was a higher density (measured by CPUE) of rock-dwelling haplochromine fishes at Ripon Falls than the two adjacent sites (Kalange and Bujagali). This finding suggests that even submerged rapids can still support significant rock-dwelling haplochromine fish populations. The sampling sites at Ripon Falls, Kirindi, Mbulamuti and Kakindu in particular (see indicative photographs in Appendix 2) attest to this pattern of habitat occupancy. At these sites there is significant rocky habitat, but flow velocities are lower than at other sites such as Bujagali Falls and Kalagala Falls.

One genus of particular note in this study was *Neochromis.* After publication of FIRRI's previous report, it was observed that this rock-dwelling genus (in particular *N. simotes*) could be at risk of habitat changes especially as there were only three specimens collected in 1911 from which descriptions had been made of the British Museum. During the present study, eight species of *Neochromis* including *N. simotes* were found in the study area mostly downstream of Buyala. *N. simotes* was found at Kirindi, and had its highest density at the Mbulamuti site, where the river grades into less rapids-dominated habitats. It was also observed in large numbers in the catch of local fishermen at Busowoko, although not recovered at this site using either of the experimental fishing techniques. It may therefore be concluded that this species is not as rare as previously believed, and is highly unlikely to be affected by developments further upstream. It would also seem that should there be *N. simotes* present but not caught in the upstream sites during this survey, a more gently flowing regime, such as in the proposed quarry habitat enhancement site, would promote the establishment of this species in those habitats since other *Neochromis* spp. *(N. gigas, N. greenwoodi*, *N. omnicaeruleus* and *N. rufocaudalis*) have been found in this study to occur at those sites (e.g. Ripon Falls, Kalange and Bujagali Falls).

In the previous EIA study (FIRRI, 2001; AES Nile Power, 2001), it was found that the upper Victoria Nile can be categorised into two main zones: from Kirindi upstream to Kalange (the first transect during that study), and the river below Namasagali (the last transect). However, several sites between Kirindi and Namasagali were not sampled in that study. The present study recognises a transition zone from Busowoko to Isimba Falls. For biodiversity conservation purposes, in particular for *Neochromis simotes*, this study concludes that the haplochromine species that have raised concern would not be threatened by the BHP provided this zone is conserved.

# CONCLUSIONS OF THE HAPLOCHROMINE STUDY

This study has examined the availability of rapids habitats in the upper Victoria Nile between Lakes Victoria and Kyoga, along with the fish species that inhabit these areas, with particular emphasis on the haplochromine cichlids. In summary, the findings of the study are as follows:

- Examination of IUCN Red Data List and CITES Appendices indicated that only one cichlid species identified as threatened (*Astatotilapia barbarae*) has a known distribution that includes the Victoria Nile. As the distribution of this species also includes Lake Victoria, it is concluded that a development on the Victoria Nile is unlikely to be critical to the long-term survival of this species, regardless of whether the development affects habitat availability in the river.

- The whole stretch of the river sampled is associated with extensive rock-dominated habitats. Some of the rocks are submerged, while others emerge above the water surface. The habitats downstream of Owen Falls dam are subjected to daily fluctuations in water level due to variations in turbined flow at the dam.

- Construction of the Bujagali Hydropower Project will result in a reduction in flow velocities at a total of seven of the 30 sets of rapids identified on this stretch of river from 1:50,000 mapping. This is equivalent to 34% of whitewater habitat in this stretch of river, or 15% of 'rapidly flowing water', as identified by analysis of satellite imagery.

- Due to Nile perch predation, there are very few surviving rock-dwelling haplochromine fishes in the open waters of the main lakes (Victoria and Kyoga), but high densities (as shown by the current study) occur in the upper Victoria Nile. Of the available rocky habitats, those with slower flowing water, e.g. Ripon Falls, Busowoko and Kakindu are more important habitat for haplochromines than 'whitewater' areas such as Bujagali Falls.

- A total of 35 haplochromine cichlid species were recovered from the upper Victoria Nile by experimental fishing in rocky, rapidly-flowing habitats. All of the specimens recovered from sites upstream of Busowoko were previously known to science, and none are listed as threatened on the IUCN Red List for Uganda. The fact that they are relatively well-known is probably due to the species flock in the upper reaches of the Victoria Nile being closely related, if not a continuation of, the well-studied Lake Victoria flock. All of the species recovered from the area between Owen Falls and Dumbbell Island are well known from sites in Lake Victoria, including the Mwanza Gulf (Tanzania), and the Napoleon Gulf (Uganda). These findings are similar to the findings of the FIRRI (2001) study.

- All of the previously-undescribed species were found at the Lake Kyoga (downstream) end of the Victoria Nile, from Busowoko downstream. This is probably due to the close relationship of the haplochromines in these reaches with the Lake Kyoga species flock, which is less well-studied than the Lake Victoria flock.

- The relatively high haplochromine catch rates per unit effort at Ripon Falls (upstream of the existing Owen Falls dam), and the diversity of species at this site indicates that the slowing of flow velocities brought about by the construction of the Owen Falls dam has had no negative impact on haplochromine habitat. This is supported by the observation that slower-flowing areas in the reaches downstream of Owen Falls had higher haplochromine CPUE, and higher haplochromine species diversity.

- The highest species richness was recorded in the reach from Busowoko to Kirindi, which also includes the Itanda/Kalagala sites. This is possibly due to a combination of lower Nile perch predation, and the variety of habitats available in this reach. It may also be due to this being the stretch of river within which the Lake Victoria and Lake Kyoga species flocks overlap. The high species richness in these reaches underlines the importance of the proposed 'Kalagala offset' in compensating any unforeseen reduction in habitat availability as a result of the Bujagali Hydropower Project.

- Six previously-undescribed haplochromine species were discovered; all at sites several kilometres downstream of the area to be affected by the BHP. The discovery of several new species with relatively little effort is consistent with the belief of the scientific community that there is a great diversity of haplochromine fishes yet to be discovered in the Lake Victoria region (e.g. Seehausen *et al.,* 1998).

- The haplochromine *Neochromis simotes*, which was believed to be extinct until re-discovered during the 2000 surveys, was also recovered at Kirindi and Mbulamuti during the present study, and thus is even more widespread than previously believed. These sites are 25 and 40 km, respectively, downstream of Dumbbell Island, and will not be affected by the BHP.

- The assertion by some parties, to the effect that *Neochromis simotes* is known only from Bujagali Falls is unsubstantiated, as the last three reported findings are from sites a considerable distance downstream of Bujagali. In fact, we can find no evidence (published or unpublished) that *N. simotes* has ever been found at Bujagali Falls.

On the basis of the above findings, it is concluded that fast-flowing, rocky areas are not the principal habitat for haplochromine fishes in the upper Victoria Nile. Although the Bujagali Hydropower Project will result in a reduction in flow velocity in a 4 km stretch of the river, this area is not considered to be an important site for haplochromines. Reduction in flow velocities may in fact result in increased haplochromine abundance. Therefore it is concluded that the Bujagali Hydropower Project will not have a significant negative impact on haplochromine cichlids in the Victoria Nile.

The relatively high haplochromine species richness in the middle reaches, downstream of the BHP site, underlines the importance of the proposed ‘Kalagala offset’ in compensating any unforeseen reduction in habitat availability as a result of the Bujagali Hydropower Project.

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## APPENDIX 1. IUCN THREAT CATEGORIES

The following pages are taken from the IUCN website (www.redlist.org).

The 2000 IUCN Red List of **Threatened Species™**

**1994 Categories & Criteria**



## I) Introduction

1. The threatened species categories now used in Red Data Books and Red Lists have been in place, with som modification, for almost 30 years. Since their introduction these categories have become widely recognised internationally, and they are now used in a whole range of publications and listings, produced by IUCN as well by numerous governmental and non-governmental organisations. The Red Data Book categories provide an e and widely understood method for highlighting those species under higher extinction risk, so as to focus attent on conservation measures designed to protect them.

2. The need to revise the categories has been recognised for some time. In 1984, the SSC held a symposium, Road to Extinction' (Fitter and Fitter 1987), which examined the issues in some detail, and at which a number o options were considered for the revised system. However, no single proposal resulted. The current phase of development began in 1989 with a request from the SSC Steering Committee to develop a new approach that would provide the conservation community with useful information for action planning.

In this document, proposals for new definitions for Red List categories are presented. The general aim of the n system is to provide an explicit, objective framework for the classification of species according to their extinctio risk.

The revision has several specific aims:

- to provide a system that can be applied consistently by different people;
- to improve the objectivity by providing those using the criteria with clear guidance on how to evaluate different factors which affect risk of extinction;
- to provide a system which will facilitate comparisons across widely different taxa;
- to give people using threatened species lists a better understanding of how individual species were classified.

3. The proposals presented in this document result from a continuing process of drafting, consultation and validation. It was clear that the production of a large number of draft proposals led to some confusion, especial each draft has been used for classifying some set of species for conservation purposes. To clarify matters, and open the way for modifications as and when they became necessary, a system for version numbering was app as follows:

**Version 1.0: Mace and Lande (1991)** - The first paper discussing a new basis for the categories, and present numerical criteria especially relevant for large vertebrates.

**Version 2.0: Mace *et al.* (1992)** - A major revision of Version 1.0, including numerical criteria appropriate to al organisms and introducing the non-threatened categories.

**Version 2.1: IUCN (1993)** - Following an extensive consultation process within SSC, a number of changes we made to the details of the criteria, and fuller explanation of basic principles was included. A more explicit struct clarified the significance of the non-threatened categories.

**Version 2.2: Mace and Stuart (1994)** - Following further comments received and additional validation exercis some minor changes to the criteria were made. In addition, the Susceptible category present in Versions 2.0 an 2.1 was subsumed into the Vulnerable category. A precautionary application of the system was emphasised.



**Final Version** - This final document, which incorporates changes as a result of comments from IUCN member was adopted by the IUCN Council in December 1994.

All future taxon lists including categorisations should be based on this version, and not the previous ones.

4. In the rest of this document the proposed system is outlined in several sections. The Preamble presents som basic information about the context and structure of the proposal, and the procedures that are to be followed in applying the definitions to species. This is followed by a section giving definitions of terms used. Finally the definitions are presented, followed by the quantitative criteria used for classification within the threatened categories. It is important for the effective functioning of the new system that all sections are read and understo and the guidelines followed.

**References:**

Fitter, R. and Fitter, M. (eds) 1987. *The Road to Extinction*. IUCN, Gland, Switzerland.

IUCN. 1993. *Draft IUCN Red List Categories*. IUCN, Gland, Switzerland.

Mace, G. M. *et al.* 1992. The development of new criteria for listing species on the IUCN Red List. *Species* 19: 22.

Mace, G. M. and Lande, R. 1991. Assessing extinction threats: toward a re-evaluation of IUCN threatened spe categories. *Conservation Biology* 5(2):148-157.

Mace, G. M. and Stuart, S. N. 1994. Draft IUCN Red List Categories, Version 2.2. *Species* 21-22:13-24.

## II) Preamble

The following points present important information on the use and interpretation of the categories (= Critically Endangered, Endangered, etc.), criteria (= A to E), and sub-criteria (= a,b etc., i,ii etc.):

### 1. Taxonomic level and scope of the categorisation process

The criteria can be applied to any taxonomic unit at or below the species level. The term 'taxon' in the following notes, definitions and criteria is used for convenience, and may represent species or lower taxonomic levels, including forms that are not yet formally described. There is a sufficient range among the different criteria to en the appropriate listing of taxa from the complete taxonomic spectrum, with the exception of micro-organisms. T criteria may also be applied within any specified geographical or political area although in such cases special notice should be taken of point 11 below. In presenting the results of applying the criteria, the taxonomic unit a area under consideration should be made explicit. The categorisation process should only be applied to wild populations inside their natural range, and to populations resulting from benign introductions (defined in the dra IUCN Guidelines for Re-introductions as "...an attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area").

### 2. Nature of the categories

All taxa listed as Critically Endangered qualify for Vulnerable and Endangered, and all listed as Endangered qu for Vulnerable. Together these categories are described as 'threatened'. The threatened species categories for part of the overall scheme. It will be possible to place all taxa into one of the categories (see Figure 1).

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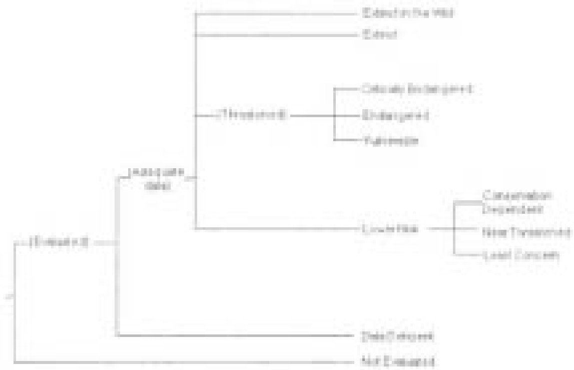


### 3.Role of the different criteria

For listing as Critically Endangered, Endangered or Vulnerable there is a range of quantitative criteria; meeting one of these criteria qualifies a taxon for listing at that level of threat. Each species should be evaluated agains the criteria. The different criteria (A-E) are derived from a wide review aimed at detecting risk factors across the broad range of organisms and the diverse life histories they exhibit. Even though some criteria will be inapprop for certain taxa (some taxa will never qualify under these however close to extinction they come), there should criteria appropriate for assessing threat levels for any taxon (other than micro-organisms). The relevant factor whether any one criterion is met, not whether all are appropriate or all are met. Because it will never be clear w criteria are appropriate for a particular species in advance, each species should be evaluated against all the criteria, and any criterion met should be listed.

### 4.Derivation of quantitative criteria

The quantitative values presented in the various criteria associated with threatened categories were developed through wide consultation and they are set at what are generally judged to be appropriate levels, even if no for justification for these values exists. The levels for different criteria within categories were set independently but against a common standard. Some broad consistency between them was sought. However, a given taxon sho not be expected to meet all criteria (A-E) in a category; meeting any one criterion is sufficient for listing.

### 5.Implications of listing

Listing in the categories of Not Evaluated and Data Deficient indicates that no assessment of extinction risk ha been made, though for different reasons. Until such time as an assessment is made, species listed in these categories should not be treated as if they were non-threatened, and it may be appropriate (especially for Data Deficient forms) to give them the same degree of protection as threatened taxa, at least until their status can b evaluated.

Extinction is assumed here to be a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified more taxa listed in a higher category are expected to go extinct than in a lower one (without effective conservation action). However, the persistence of some taxa in high risk categories does not necessarily mean their initial assessment was inaccurate.

### 6.Data quality and the importance of inference and projection

The criteria are clearly quantitative in nature. However, the absence of high quality data should not deter attem at applying the criteria, as methods involving estimation, inference and projection are emphasised to be accept throughout. Inference and projection may be based on extrapolation of current or potential threats into the futur (including their rate of change), or of factors related to population abundance or distribution (including depende



on other taxa), so long as these can reasonably be supported. Suspected or inferred patterns in either the rece past, present or near future can be based on any of a series of related factors, and these factors should be specified.

Taxa at risk from threats posed by future events of low probability but with severe consequences (catastrophes should be identified by the criteria (e.g. small distributions, few locations). Some threats need to be identified particularly early, and appropriate actions taken, because their effects are irreversible, or nearly so (pathogens invasive organisms, hybridization).

### 7.Uncertainty

The criteria should be applied on the basis of the available evidence on taxon numbers, trend and distribution, making due allowance for statistical and other uncertainties. Given that data are rarely available for the whole range or population of a taxon, it may often be appropriate to use the information that is available to make intelligent inferences about the overall status of the taxon in question. In cases where a wide variation in estima is found, it is legitimate to apply the precautionary principle and use the estimate (providing it is credible) that le to listing in the category of highest risk.

Where data are insufficient to assign a category (including Lower Risk), the category of 'Data Deficient' may be assigned. However, it is important to recognise that this category indicates that data are inadequate to determi the degree of threat faced by a taxon, not necessarily that the taxon is poorly known. In cases where there are evident threats to a taxon through, for example, deterioration of its only known habitat, it is important to attemp threatened listing, even though there may be little direct information on the biological status of the taxon itself. category 'Data Deficient' is not a threatened category, although it indicates a need to obtain more information o taxon to determine the appropriate listing.

### 8.Conservation actions in the listing process

The criteria for the threatened categories are to be applied to a taxon whatever the level of conservation action affecting it. In cases where it is only conservation action that prevents the taxon from meeting the threatened criteria, the designation of 'Conservation Dependent' is appropriate. It is important to emphasise here that a tax require conservation action even if it is not listed as threatened.

### 9.Documentation

All taxon lists including categorisation resulting from these criteria should state the criteria and sub-criteria that were met. No listing can be accepted as valid unless at least one criterion is given. If more than one criterion o sub-criterion was met, then each should be listed. However, failure to mention a criterion should not necessari imply that it was not met. Therefore, if a re-evaluation indicates that the documented criterion is no longer met, should not result in automatic down-listing. Instead, the taxon should be re-evaluated with respect to all criteria indicate its status. The factors responsible for triggering the criteria, especially where inference and projection used, should at least be logged by the evaluator, even if they cannot be included in published lists.

### 10.Threats and priorities

The category of threat is not necessarily sufficient to determine priorities for conservation action. The category threat simply provides an assessment of the likelihood of extinction under current circumstances, whereas a system for assessing priorities for action will include numerous other factors concerning conservation action su as costs, logistics, chances of success, and even perhaps the taxonomic distinctiveness of the subject.

### 11.Use at regional level

The criteria are most appropriately applied to whole taxa at a global scale, rather than to those units defined by regional or national boundaries. Regionally or nationally based threat categories, which are aimed at including that are threatened at regional or national levels (but not necessarily throughout their global ranges), are best u with two key pieces of information: the global status category for the taxon, and the proportion of the global population or range that occurs within the region or nation. However, if applied at regional or national level it m be recognised that a global category of threat may not be the same as a regional or national category for a particular taxon. For example, taxa classified as Vulnerable on the basis of their global declines in numbers or range might be Lower Risk within a particular region where their populations are stable. Conversely, taxa class as Lower Risk globally might be Critically Endangered within a particular region where numbers are very small declining, perhaps only because they are at the margins of their global range. IUCN is still in the process of developing guidelines for the use of national red list categories.

### 12.Re-evaluation

Evaluation of taxa against the criteria should be carried out at appropriate intervals. This is especially importan taxa listed under Near Threatened, or Conservation Dependent, and for threatened species whose status is kn or suspected to be deteriorating.

### 13.Transfer between categories

There are rules to govern the movement of taxa between categories. These are as follows: (A) A taxon may be moved from a category of higher threat to a category of lower threat if none of the criteria of the higher categor has been met for five years or more. (B) If the original classification is found to have been erroneous, the taxon may be transferred to the appropriate category or removed from the threatened categories altogether, without delay (but see Section 9). (C) Transfer from categories of lower to higher risk should be made without delay.

### 14.Problems of scale

Classification based on the sizes of geographic ranges or the patterns of habitat occupancy is complicated by problems of spatial scale. The finer the scale at which the distributions or habitats of taxa are mapped, the sma the area will be that they are found to occupy. Mapping at finer scales reveals more areas in which the taxon is unrecorded. It is impossible to provide any strict but general rules for mapping taxa or habitats; the most appropriate scale will depend on the taxa in question, and the origin and comprehensiveness of the distribution data. However, the thresholds for some criteria (e.g. Critically Endangered) necessitate mapping at a fine scale

## III) Definitions

### 1.Population

Population is defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life-forms, population numbers are expressed as numbers of mature individuals only. In th case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values the host taxon should be used.

### 2.Subpopulations

Subpopulations are defined as geographically or otherwise distinct groups in the population between which the little exchange (typically one successful migrant individual or gamete per year or less).

### 3.Mature individuals

The number of mature individuals is defined as the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity the following points should be borne in mind:

- Where the population is characterised by natural fluctuations the minimum number should be used.
- This measure is intended to count individuals capable of reproduction and should therefore exclude individuals that are environmentally, behaviourally or otherwise reproductively suppressed in the wild.
- In the case of populations with biased adult or breeding sex ratios it is appropriate to use lower estimate the number of mature individuals which take this into account (e.g. the estimated effective population siz
- Reproducing units within a clone should be counted as individuals, except where such units are unable survive alone (e.g. corals).
- In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle estimate should be made at the appropriate time, when mature individuals are available for breeding.

### 4.Generation



Generation may be measured as the average age of parents in the population. This is greater than the age at f breeding, except in taxa where individuals breed only once.

### 5.Continuing decline

A continuing decline is a recent, current or projected future decline whose causes are not known or not adequa controlled and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normall count as a continuing decline, but an observed decline should not be considered to be part of a natural fluctual unless there is evidence for this.

### 6. Reduction

A reduction (criterion A) is a decline in the number of mature individuals of at least the amount (%) stated over time period (years) specified, although the decline need not still be continuing. A reduction should not be interpreted as part of a natural fluctuation unless there is good evidence for this. Downward trends that are par natural fluctuations will not normally count as a reduction.

### 7.Extreme fluctuations

Extreme fluctuations occur in a number of taxa where population size or distribution area varies widely, rapidly frequently, typically with a variation greater than one order of magnitude (i.e., a tenfold increase or decrease).

### 8.Severely fragmented

Severely fragmented refers to the situation where increased extinction risks to the taxon result from the fact tha most individuals within a taxon are found in small and relatively isolated subpopulations. These small subpopulations may go extinct, with a reduced probability of recolonisation.

### 9.Extent of occurrence

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding of vagrancy. This measure may exclude discontinuities or disjunctions within the overall distributions of taxa (e large areas of obviously unsuitable habitat) (but see 'area of occupancy'). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degree and which contains all the sites of occurrence).

### 10.Area of occupancy

Area of occupancy is defined as the area within its 'extent of occurrence' (see definition) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughou area of its extent of occurrence, which may, for example, contain unsuitable habitats. The area of occupancy is smallest area essential at any stage to the survival of existing populations of a taxon (e.g. colonial nesting sites feeding sites for migratory taxa). The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon. The criteria include values in $km^2$, and thus to avoid errors in classification, the area of occupancy should be measured on grid squares (or equivalents) which are sufficiently small (see Figure 2).

### 11.Location

Location defines a geographically or ecologically distinct area in which a single event (e.g. pollution) will soon affect all individuals of the taxon present. A location usually, but not always, contains all or part of a subpopula of the taxon, and is typically a small proportion of the taxon's total distribution.

### 12.Quantitative analysis

A quantitative analysis is defined here as the technique of population viability analysis (PVA), or any other quantitative form of analysis, which estimates the extinction probability of a taxon or population based on the known life history and specified management or non-management options. In presenting the results of quantita analyses the structural equations and the data should be explicit.

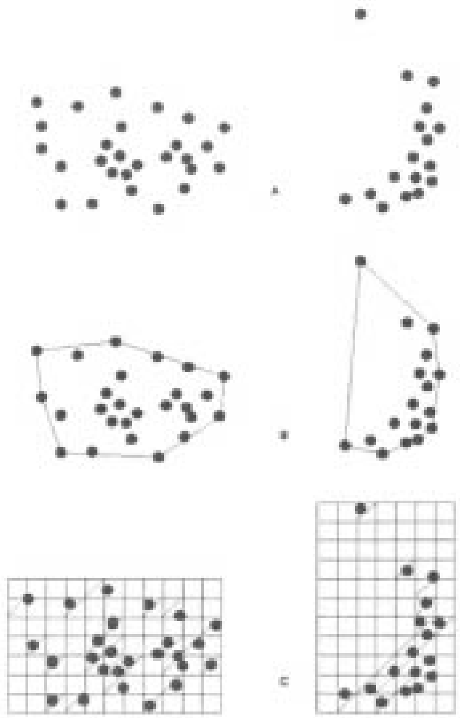


Figure 2:

Two examples of the distinction between extent of occurrence and area of occupancy. (a) is the spatial distribu of known, inferred or projected sites of occurrence. (b) shows one possible boundary to the extent of occurrenc which is the measured area within this boundary. (c) shows one measure of area of occupancy which can be measured by the sum of the occupied grid squares.

## IV) The categories

**EXTINCT (EX)** - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

**EXTINCT IN THE WILD (EW)** - A taxon is Extinct in the wild when it is known only to survive in cultivatio captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinc the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame



appropriate to the taxon's life cycle and life form.

**CRITICALLY ENDANGERED (CR)** - A taxon is Critically Endangered when it is facing an extremely hig risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below

**ENDANGERED (EN)** - A taxon is Endangered when it is not Critically Endangered but is facing a very hig risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.

**VULNERABLE (VU)** - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is faci high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as describ below.

**LOWER RISK (LR)** - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for an the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can separated into three subcategories:

1. **Conservation Dependent (cd).** Taxa which are the focus of a continuing taxon-specific or habitat-spec conservation programme targeted towards the taxon in question, the cessation of which would result in taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

**DATA DEFICIENT (DD)** A taxon is Data Deficient when there is inadequate information to make a direct, indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distributio lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indica that more information is required and acknowledges the possibility that future research will show that threatene classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

**NOT EVALUATED (NE)** A taxon is Not Evaluated when it is has not yet been assessed against the criteri

## V) The criteria for Critically Endangered, Endangered and Vulnerable

**CRITICALLY ENDANGERED (CR)**

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immedia future, as defined by any of the following criteria (A to E):

**A)** Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate for the taxon
   c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d) actual or potential levels of exploitation
   e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.
2) A reduction of at least 80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

**B)** Extent of occurrence estimated to be less than 100 $km^2$ or area of occupancy estimated to be less than 10 k and estimates indicating any two of the following:

1) Severely fragmented or known to exist at only a single location.
2) Continuing decline, observed, inferred or projected, in any of the following:
   a) extent of occurrence

b) area of occupancy
c) area, extent and/or quality of habitat
d) number of locations or subpopulations
e) number of mature individuals

3) Extreme fluctuations in any of the following:

a) extent of occurrence
b) area of occupancy
c) number of locations or subpopulations
d) number of mature individuals

**C)** Population estimated to number less than 250 mature individuals and either:

1) An estimated continuing decline of at least 25% within three years or one generation, whichever is longer or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:

a) severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals)
b) all individuals are in a single subpopulation

**D)** Population estimated to number less than 50 mature individuals.

**E)** Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer.

## ENDANGERED (EN)

A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild the near future, as defined by any of the following criteria (A to E):

**A)** Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:

a) direct observation
b) an index of abundance appropriate for the taxon
c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
d) actual or potential levels of exploitation
e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2) A reduction of at least 50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d), or (e) above.

**B)** Extent of occurrence estimated to be less than 5000 $km^2$ or area of occupancy estimated to be less than 50 $km^2$, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at no more than five locations.

2) Continuing decline, inferred, observed or projected, in any of the following:

a) extent of occurrence
b) area of occupancy
c) area, extent and/or quality of habitat
d) number of locations or subpopulations
e) number of mature individuals

3) Extreme fluctuations in any of the following:

a) extent of occurrence
b) area of occupancy
c) number of locations or subpopulations
d) number of mature individuals

**C)** Population estimated to number less than 2500 mature individuals and either:

1) An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:



**D)** Population estimated to number less than 250 mature individuals.

**E)** Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer.

## VULNERABLE (VU)

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction i the wild in the medium-term future, as defined by any of the following criteria (A to E):

**A)** Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:

a) direct observation
b) an index of abundance appropriate for the taxon
c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
d) actual or potential levels of exploitation
e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2) A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

**B)** Extent of occurrence estimated to be less than 20,000 $km^2$ or area of occupancy estimated to be less than 2 $km^2$, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at no more than ten locations.

2) Continuing decline, inferred, observed or projected, in any of the following:

a) extent of occurrence
b) area of occupancy
c) area, extent and/or quality of habitaty
d) number of locations or subpopulations
e) number of mature individuals

3) Extreme fluctuations in any of the following:

a) extent of occurrence
b) area of occupancy
c) number of locations or subpopulations
d) number of mature individuals

**C)** Population estimated to number less than 10,000 mature individuals and either:

1) An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:

a) severely fragmented (i.e. no subpopulation estimated to contain more than 1000 mature individuals)
b) all individuals are in a single subpopulation

**D)** Population very small or restricted in the form of either of the following:

1) Population estimated to number less than 1000 mature individuals.

2) Population is characterised by an acute restriction in its area of occupancy (typically less than 100 $km^2$) or in the number of locations (typically less than five). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period.

**E)** Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

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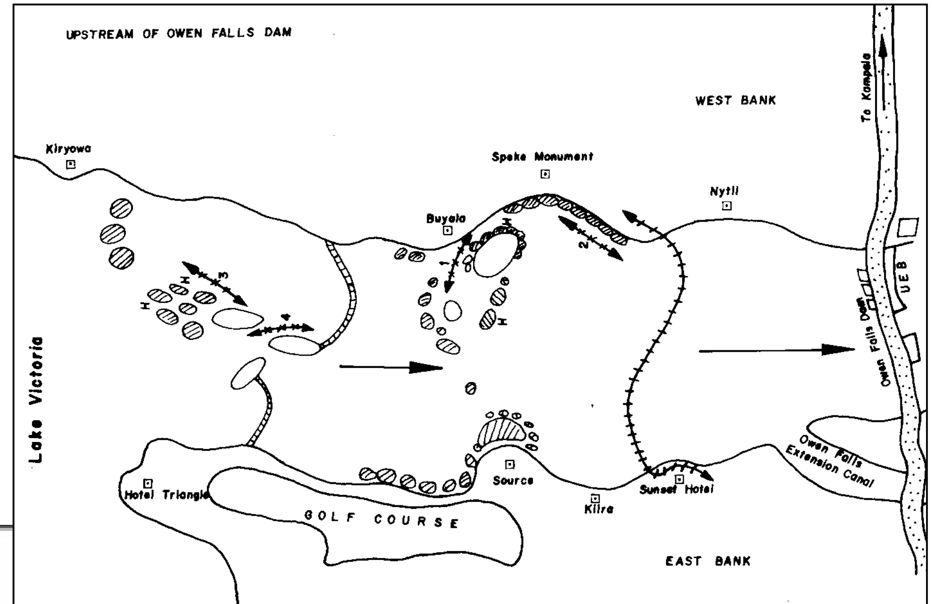
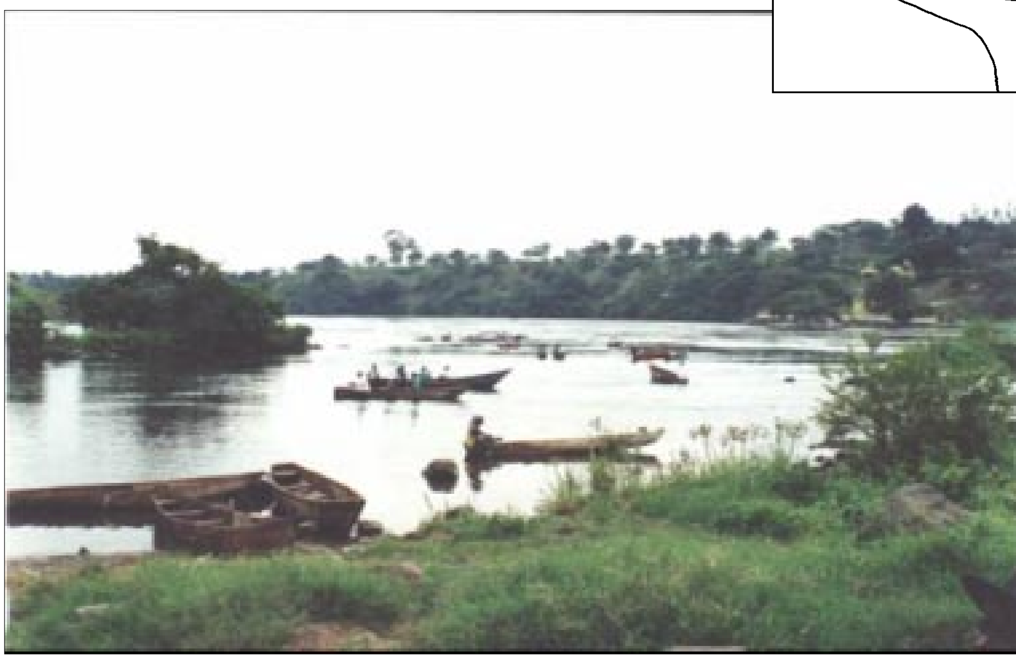
# APPENDIX 2. SAMPLING SITES

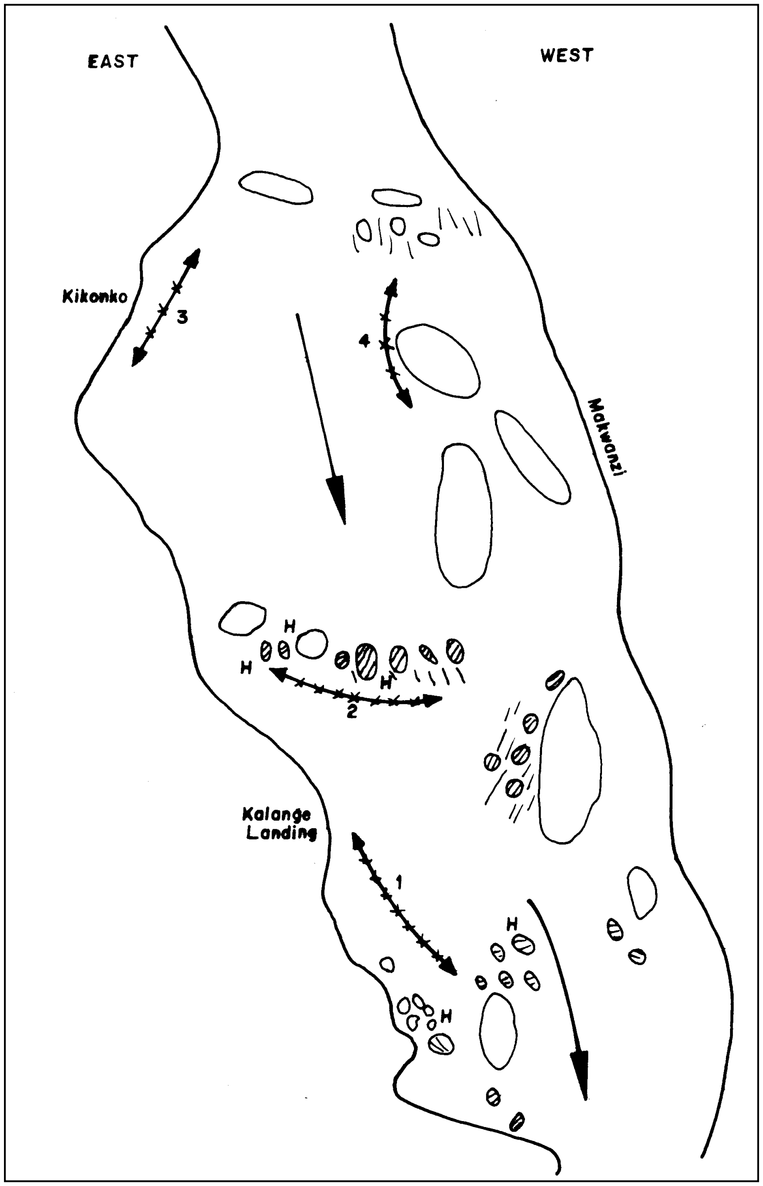
**Ripon Falls site:** This site was sampled from the western bank at the Bukaya landing site. With the construction of the Owen Falls dam, the Ripon Falls were submerged in the early 1950s. However, the site still contains rapid and rocky islands, two of which are thought to have been created out of material excavated in order to provide additional flow out of Lake Victoria to Owen Falls. The banks along the river are also rocky. Two water hyacinth booms have been constructed in the area. There is also an over-river rail and road bridge in addition to a by-pass canal which feeds into the Owen Falls Power Extension Project (Kiira Dam).

◄┼┼► = gill netting locations; H = Angling locations;

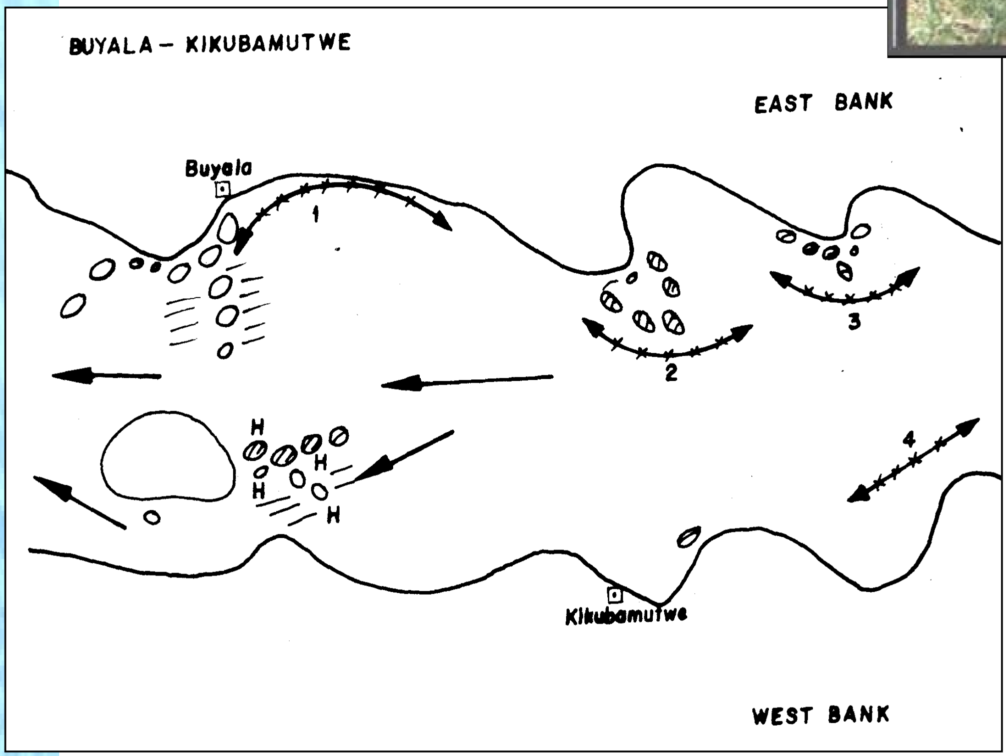


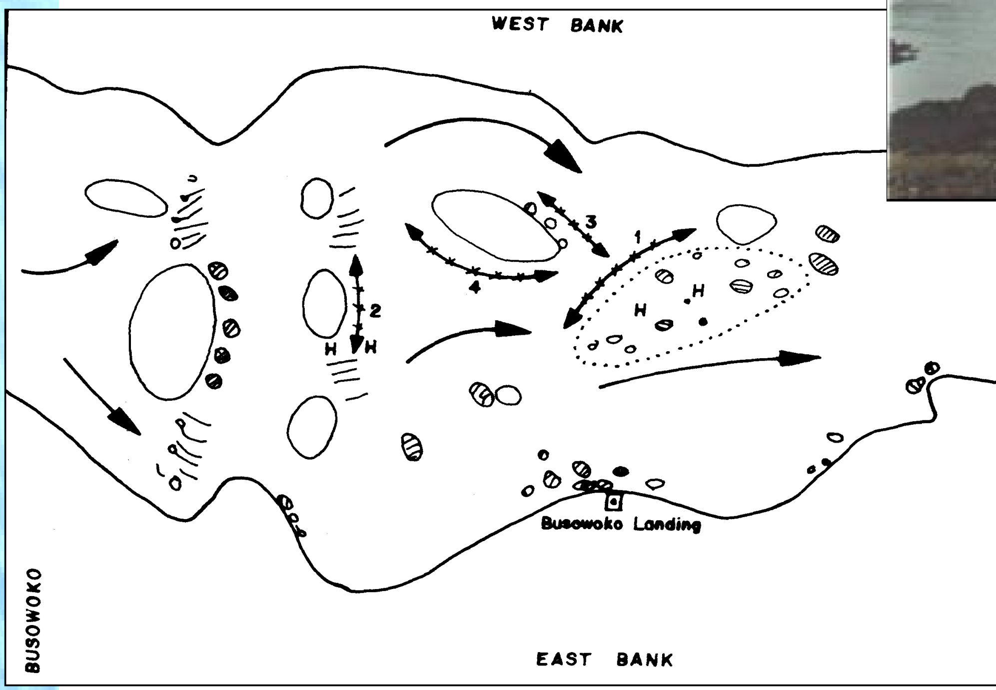
**Kalange site**: This site was sampled during the previous survey and lies about 2km upstream of Bujagali Falls. Several islands and numerous rapids characterize the sampled section. In the vicinity of the landing, there are strings of rocky outcrop periodically vary in prominence from totally submerged rocks to emergent rapids-like conditions in response to water discharge management at the Owen Falls dam.
◄┼┼► = gill netting locations; **H** = Angling locations;



**Buyala site**: This site represented the previously investigated Buyala transect. Most of the rapid habitats occur along the eastern bank.
←+—+→ = gill netting locations; **H** = Angling locations;



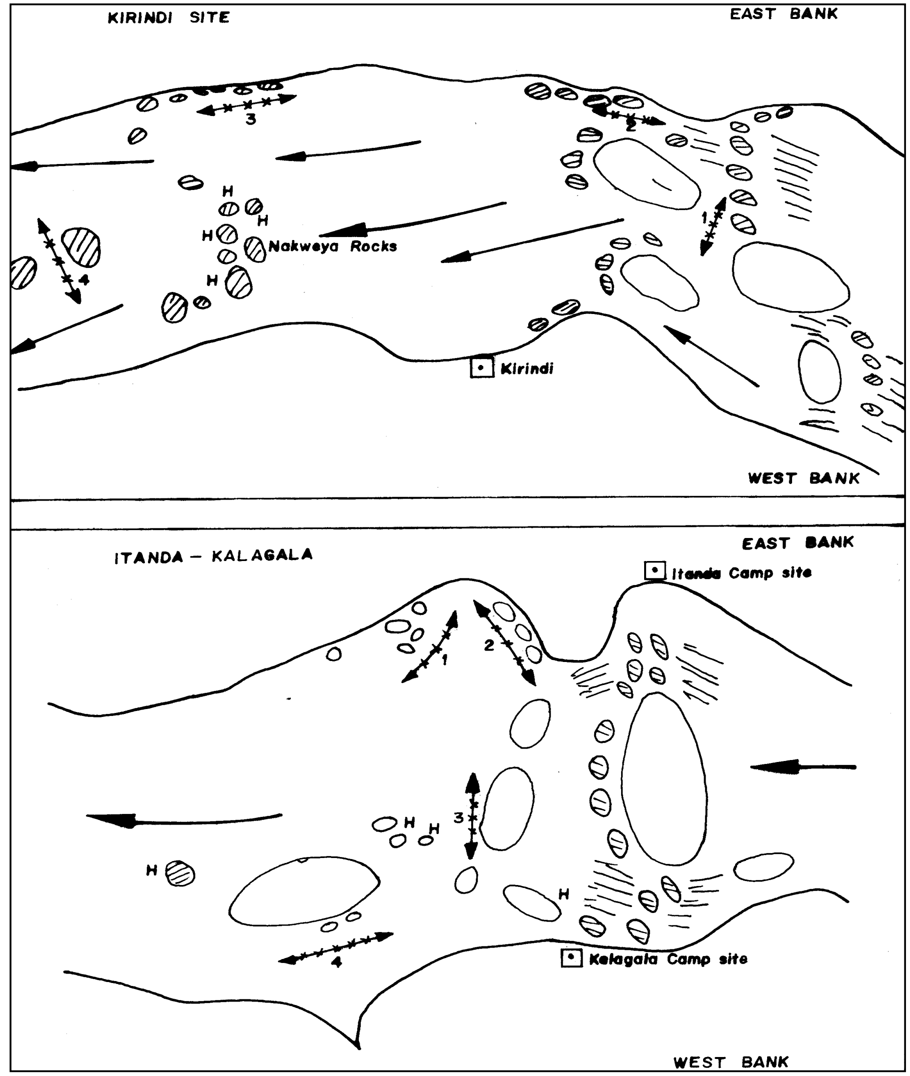
**Busowoko site:** Several islands in this site are associated with rocky interfaces and rocky outcrops at low water levels characterised this site.
◄┼┼► = gill netting locations; **H** = Angling locations;



**Upper frame: Kirindi site:** In the previous study (FIRRI, 2001), this site was referred to as Kirindi/Matumu. Upstream of the Kirindi landing site, the river channel is characterised by islands and extensive stretches of rapids.

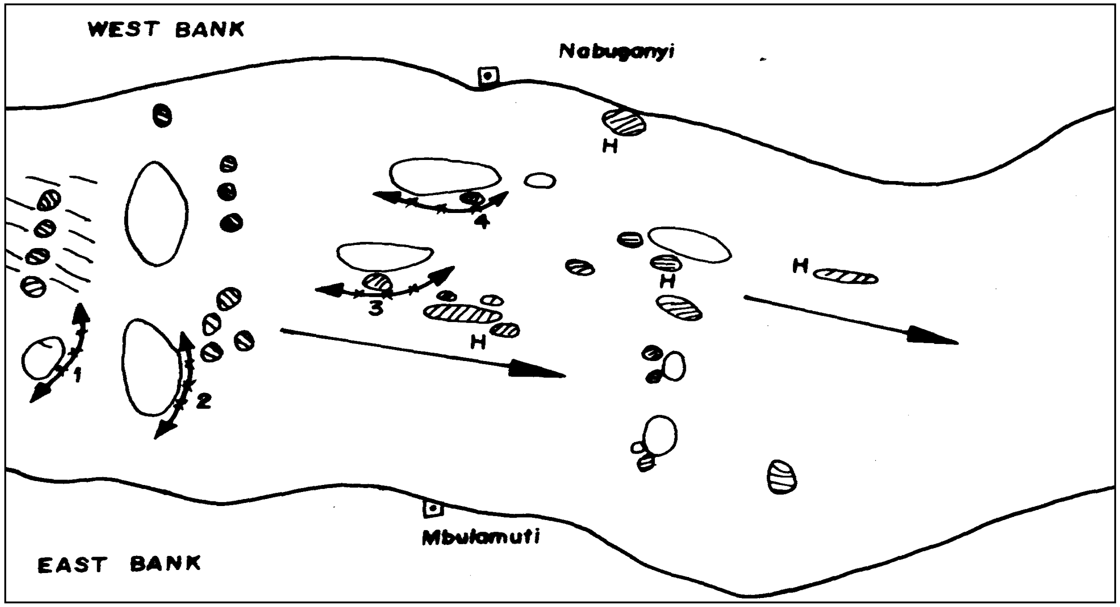
**Lower frame: Itanda Falls site:** This site corresponds to a cross section between Itanda Falls on the eastern bank and Kalagala of which there is a series of islands associated with rapids.

↔ = gill netting locations; H = Angling locations;



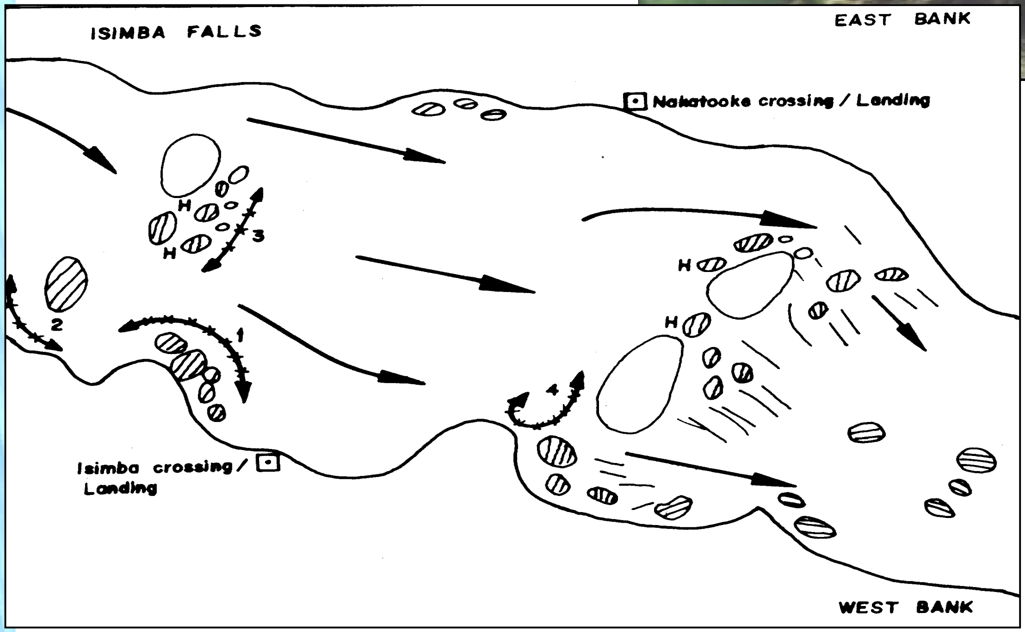

Rocks at Itanda/Kalagala, where gillnet fleet No. 4 was deployed

**Mbulamuti site:** From the landing point at Bugondha, upstream sections in this c.600m wide channel have a diffuse pattern of rocky islands.
(gill-net symbol) = gill netting locations; H = Angling locations.



**Isimba site:** From the landing site which is also a boat crossing point, extensive rapids occur both upstream and downstream.

◄+—+—► = gill netting locations; H = Angling locations.

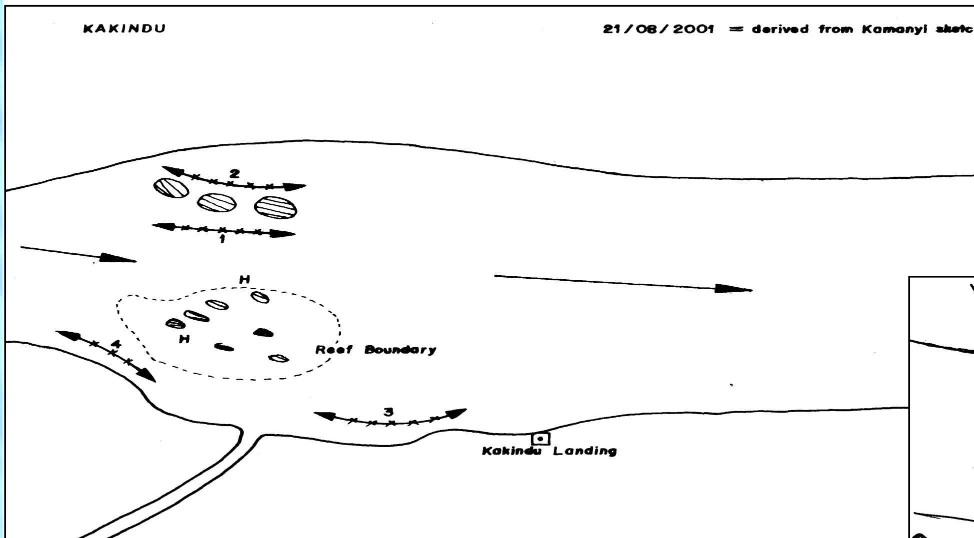


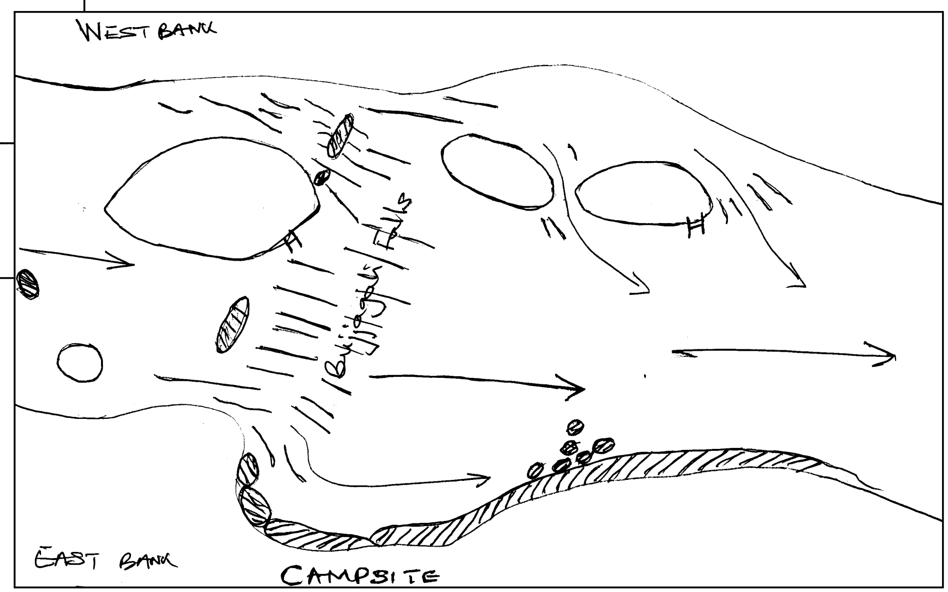



WS Atkins

**Kakindu site**: In comparison to all the other sites the Kakindu site is contained in a wider channel associated with a more defined flood plain. The eastern bank is sandy and apart from isolated patches of rock along the western bank, the channel has fewer observations.
◄—|—|—► = gill netting locations; H = Angling locations;

**Bujagali Falls.** H=angling sites



# APPENDIX 3.
# COMMERCIAL FISHERY DATA

**Appendix 3A: Full time jobs supported by the fishery on the upper Victoria Nile at the sites sampled upstream and downstream of Owen Falls dam (August 2001): m = Men; w = Women**

| **Site** | **Full time jobs supported by the fishery** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Food vendors | Fishers | Fish mongers | Boat repair / builder | Net repair | Orna-mental fish trader | C/person of landing | Exten-sion work | Bait tenderer | Kiosks | Guard | Market trader | Total |
| *Upstream Owen Falls dam* | | | | | | | | | | | | | |
| Nganga | 6w: | 62m: | 20m: 20w | 2m: | 3m: | | 2m: | 1m: | 2m: | 2m: | | | 94m: 26w |
| Njeru | 5w: | 78m | 2m:26w | 2m: | 3m: | | 1m: | 1m: | | 2m: | 1m: | 1m: | 91m: 31w |
| Mutebi | 4w: | 46m | 12m:18w | | | | 1m: | 1m: | | | | | 50m: 22w |
| *Down stream Owen Falls dam* | | | | | | | | | | | | | |
| Kalange | 10w | 30m | 12m: 8w | 2m: | 2m: | | 1m: | | | | | | 48m: 18w |
| Buyala | | 10m | | | | | | | | | | | 10m |
| Busowoko | 1w: | 33m | 1m:3w | 1m: | 3m: | | 1m | 1m: | | | | | 39m:4w |
| Itanda | | | | | | | | | | | | | |
| Kirindi | | | | | | | | | | | | | |
| Isimba | 1w 1m | 20m | | | | | 2m: | | | | | | 23m:1w |
| Mbulamuti | | | | | | | | | | | | | |
| Kakindu | | 5m | 2m: | | | 1m: | | | | | | | 8m |
| **Total** | **27w:1m** | **284m** | **39m: 75w** | **7m:** | **11m:** | **1m:** | **9m:** | **4m:** | **2m:** | **4m:** | **1m:** | **1m:** | **363m: 102w** |

**Appendix 3B: Yield estimates (kg per month) at different sampled sites on upper Victoria Nile (August 2001)**

| Site | No. active canoes | Mean catch per canoe per day (kg) | Average number of days fished per week | Estimated monthly catch (kg) |
|---|---|---|---|---|
| *Upstream Owen Falls dam* | | | | |
| Nganga | 29 | 6.8 | 6.6 | 5206.1 |
| Njeru | 40 | 13.5 | 6.4 | 13,824.0 |
| Mutebi | 25 | 9.4 | 6.2 | 5828.0 |
| Total | 94 | 11.0 | 6.4 | 24858.1 |
| *Downstream Owen Falls dam* | | | | |
| Kalange | 15 | 7.4 | 2.8 | 1243.2 |
| Buyala | 5 | 4.1 | 7.0 | 574.0 |
| Busowoko | 11 | 3.8 | 7.0 | 1170.4 |
| Kakindu | 4 | 8.5 | 5.0 | 680.0 |
| Total | 35 | 6.2 | 5.7 | 3667.6 |

**Appendix 3C: Estimates of monthly value (millions Uganda shillings) of fish catch at different sites on upper Victoria Nile (August 2001)**

| Parameter (Species) | Sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Upstream Owen Falls dam | | | Downstream Owen Falls dam | | | | |
| | Nganga | Njeru | Mutebi | Kalange | Buyala | Busowoko | Kakindu | Total |
| *O. niloticus* | 3.9 | 6.50 | 3.7 | 0.33 | 0.09 | | 0.04 | 14.56 |
| *L. niloticus* | | 0.30 | | 0.60 | 0.04 | | | 0.94 |
| *R. argentea* | | 0.40 | | | | | | 0.40 |
| *M. kannume* | | 0.02 | | 0.10 | | | | 0.12 |
| *B. altianails* | | | | | | 0.77 | 0.24 | 1.01 |
| *B. docmac* | | 0.06 | | | 0.58 | 0.52 | | 1.16 |
| *T. zillii* | | 0.02 | | | | | | 0.02 |
| **Total** | **3.90** | **7.30** | **3.70** | **1.01** | **0.71** | **1.29** | **0.28** | **18.21** |

## APPENDIX 4.

## PHOTOGRAPHS OF HAPLOCHROMINE FISHES RECOVERED FROM THE UPPER VICTORIA NILE

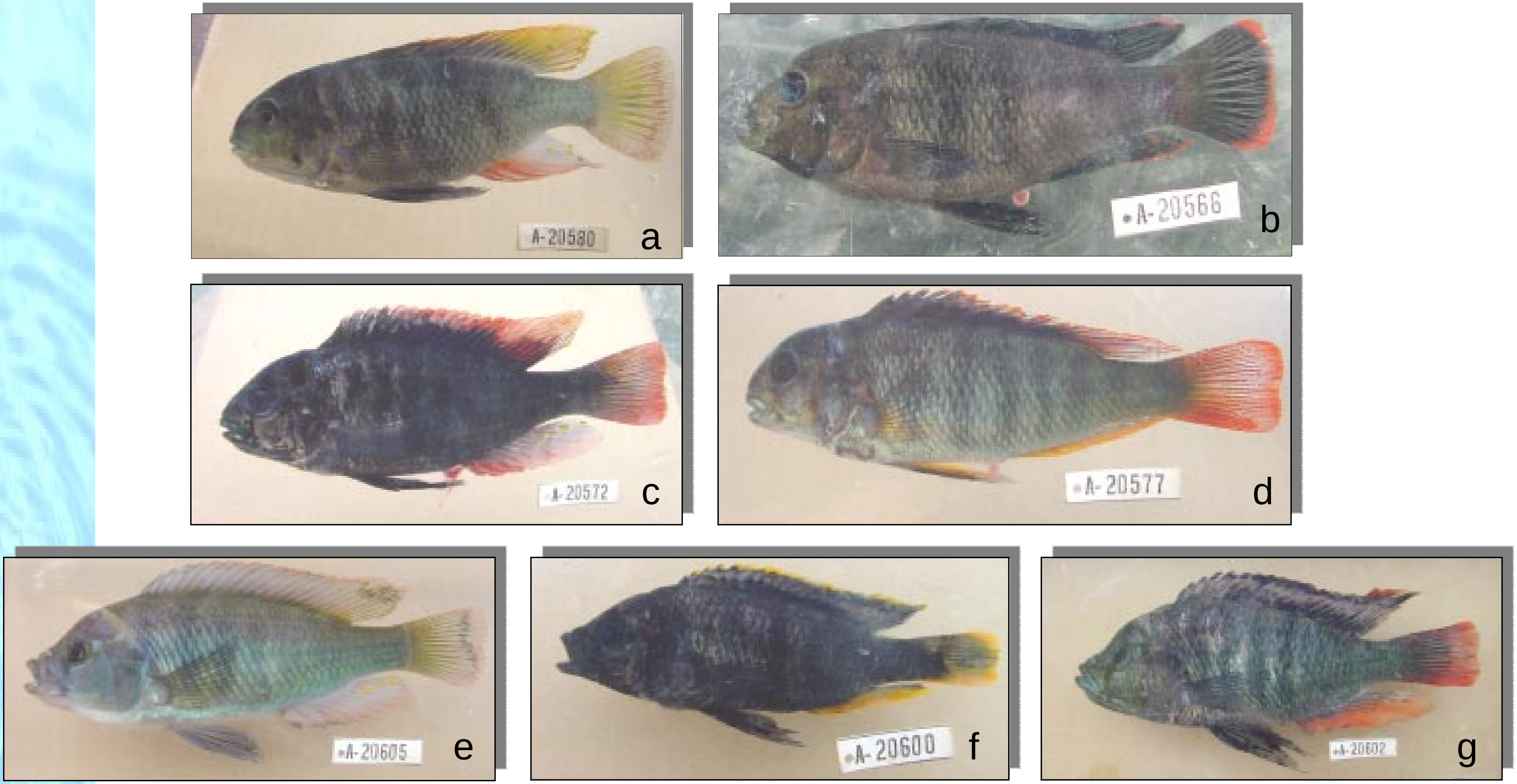



**Plate 1.** **a**, *Neochromis gigas* **b**; *N. greenwoodi*; **c**, *N. rufocaudalis*; **d**, *N. simotes*; **e**, *Pundamilia azurea*; **f**, *P. igneopinnis* and **g**, *P. pundamilia*. Scale: number tag = 22 mm long

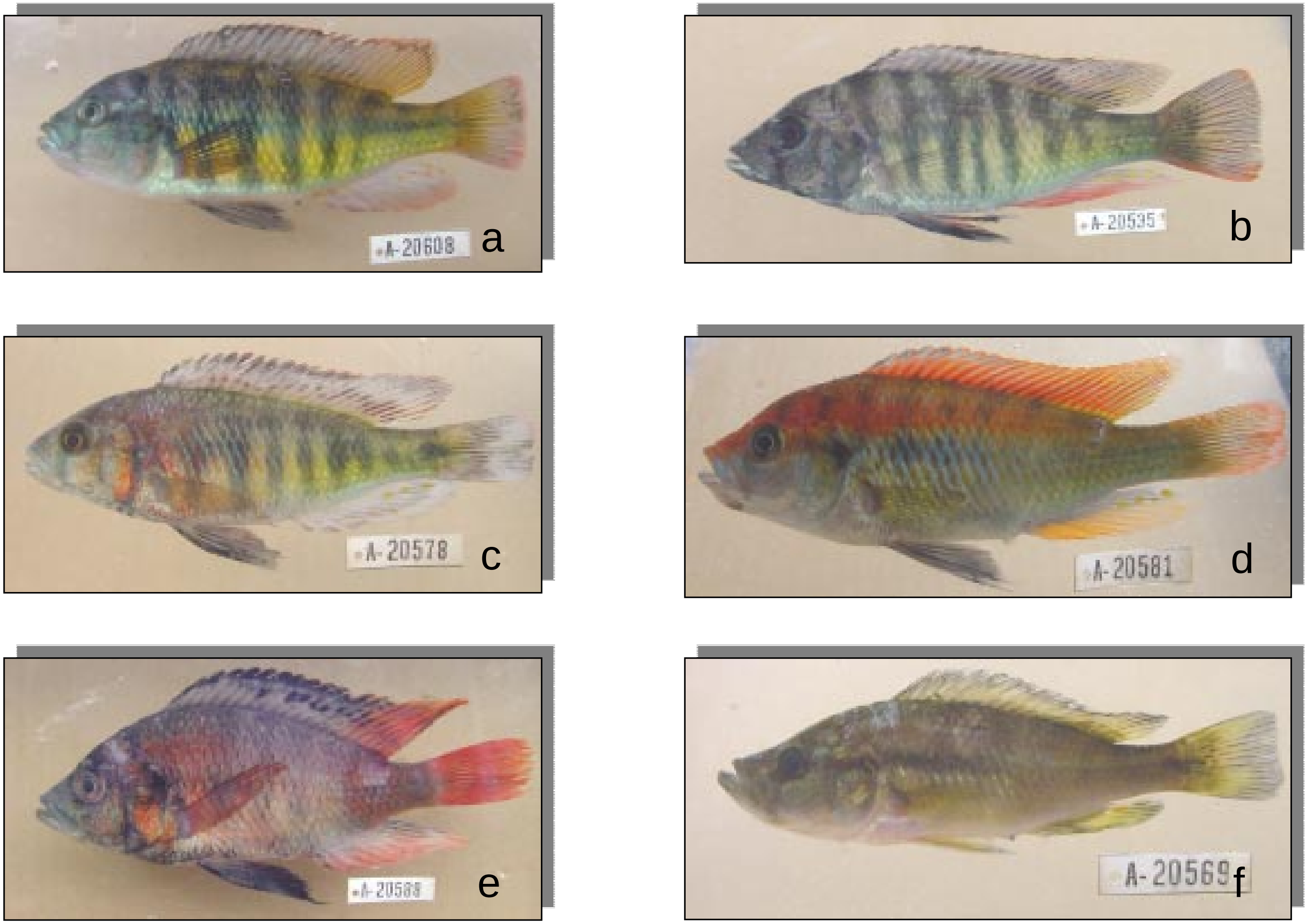



**Plate 2**. **a**, *Astatotilapia brownae*; **b,** *Psammochromis riponianus*; **c,** *Xystichromis bayoni*; **d**, *X. nuschisquamulatus;* **e**, *X***.** *phytophagus*; **f**, *Pyxichromis orthostoma.* Scale: number tag = 22 mm long.








**Plate 3**. Undescribed species: **a**, *Haplochromis* "silver arrow" **b**; *Mbipia* "red pelvics"; **c**, *M.* "yellow fin"; **d**, *Neochromis* "lemon britti" **e**, *N.* "red simotes"; **f**, *N.* "yellow rufocaudalis" **g**, *Pundamilia* "yellow multispot". **Scale**: number tag = 22 mm long.