

Fishes and fisheries of the Bangweulu Wetlands and Lavushi Manda National Park



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Foreword

The Bangweulu Fisheries Research Project has been vital in Bangweulu Wetlands management's quest to better understand the dynamics of this important fishery. Importantly, this research has probed the ecological and life history aspects of the fishery with a keen eye on the social dimension. This has allowed us to begin to develop a much improved and more holistic view of the fishery and the potential future management interventions. We are looking forward to the final results and are certain that whilst answering some aspects it will also highlight other important lines of enquiry worth pursuing.

Craig Reid
Park Manager
Bangweulu Wetlands



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Introduction

The Bangweulu swamps are an extensive wetland system on the Congo River drainage in northern Zambia. They are fed primarily by the Chambeshi River, and the swamps and Lake Bangweulu are drained by the Luapula River. The area is of immense conservation importance as it contains a significant population of the threatened shoebill stork (*Balaeniceps rex*) and a dense population of the endemic black lechwe antelope (*Kobus leche smithemani*). A large human population relies on the swamps and surrounding areas for their livelihoods, and the fish populations support one of the largest fisheries in the country.

The Bangweulu Wetlands conservation area, managed by African Parks, extends over the south-eastern portion of the swamp and its adjacent woodlands. The wildlife-rich Lukulu delta and its adjacent floodplains form the heart of this protected area. The upper reaches of the Lukulu river are protected inside Lavushi Manda National Park, and the fish fauna sampled there have been included in this report.

The main driving force behind the Bangweulu ecology is the annual flooding, during which this flat area is almost entirely inundated. The animals, birds, plants, fish and people are all adapted to the cycles of flooding and drought: this process is still completely intact and ensures the health of the ecosystem.

The main objective of the present study was to gain a better understanding of the fishery resource in the area. Bangweulu Wetlands is a conservation area that allows resource harvesting, and it is in everyone's interests to ensure that this continues sustainably into the future. In order to effectively manage the area a detailed understanding of the interactions between the fish, humans and the ecosystem was needed.

The fish research project was based at Chikuni Island, between the floodplains and the Lukulu Delta. Fishing activities were monitored as they changed through the different seasons, and local knowledge was consulted extensively. Fishes were collected from all the major aquatic habitats in the area, except from the deep Chambeshi channels in the far north of the project area.

This report has been designed to be an accessible reference guide to the fishes and fishing activities. In it, observations made during 14 months of field work have been summarised into a description of the area from an ichthyological perspective, a description of the fishery, and an annotated checklist of fish species occurring in the conservation areas. It is hoped that anybody with an interest in fish and fishing in Zambia, and the Bangweulu ecosystem in general, will find this report useful.

Live fast, die young: a fish's life in Bangweulu...

All of the fishes found on this floodplain belong to groups that are well-adapted to floodplain environments. The floodplain habitat is one of great disturbance: the sway from terrestrial to aquatic and back each season poses many challenges for aquatic organisms (and terrestrial ones too). Therefore, there are only a limited set of organisms that can survive these fluctuations.

The floodplain fishes can be likened to a crop growing in a field: every year the population is just about wiped out after harvesting, and yet the only a small number of seeds are required to ensure another crop can be grown the following year. The fish, like crops, are short-lived, grow quickly, and yield a good harvest. By the end of the dry season the few remaining adult fish are able to breed when the floods arrive. The offspring they produce are born into an ideal environment: the newly flooded plains provide warm, oxygenated and nutrient-rich water. With the abundance of food, growth is rapid, and with so much habitat and predators few and far between, survival is very high.

With all this growth, the fish biomass grows tremendously. While at the beginning of the floods it seemed there were no fish, with adults being few and dispersed, and juveniles tiny, the end of the floods see the plains teeming with masses of young fish. Just as with a crop growing in a field, not much of it can be seen shortly after germination. Before harvest, the plants are large and the field full. However in Bangweulu the fish crop is usually harvested before it has reached its full potential. With this in mind, one would ask: why not let the crop ripen? Surely the biomass of fish would be greatest if they were allowed to grow to their full size? Why then is there so much fishing on the juvenile fish at the end of the rains in Bangweulu?

The key lies in mortality. When the waters of the plains begin to recede, the ideal conditions for the young fish are over. The fishermen may as well harvest the great majority of what comes off the plain, for when this water is gone, the fish will find themselves in crowded conditions in deep water. Here challenges of predation (primarily larger fish and birds in the natural state), competition, parasites and stranding in drying pools become a reality.

All through the dry season, lowering water levels increase the pressure on the fish population. This is the bottleneck that a few adults will have to survive in order to breed the following year. The pressure stimulates the fish of the Bangweulu to mature earlier than their counterparts living in more stable lakes and rivers. Those fish have to invest in growth, so that they can ultimately produce more eggs: all because their juveniles won't have as ideal nursery circumstances as the fish on the floodplains. A fish on a floodplain can't afford to become old or large: it has to breed as early as possible. As a result, most of the fish in Bangweulu are small, and the majority are not likely to survive two dry seasons.

Deeper water refuges are critical for the fish population. Fish that can take shelter under vegetation are able to escape some human dangers. A fish may not find such a dry-season refuge: many become stranded in the vast expanse of the swamps that has few channels and pools.

Breeding also poses its dangers: fish must enter shallow water, and this exposes them to predation. Catfish, for example, have to deposit their eggs in the very shallowest, newly flooding water. The dangers posed by predators, heat, desiccation and exhaustion have led them to have a very short

breeding season: this way, they attempt to control the effect of predators simply by overwhelming them with their numbers. This even works for humans...there is a limit to how many catfish a man can spear, and before he knows it, the spawning event is over.

From the species found here, and the biology they show, we can conclude that the fish here were already adapted to high mortality and disturbance, even before humans started. Questions we need to ask is how great is the human impact relative to deaths caused by all the other factors? Would any intervention make any difference to an individual fish's chances of survival?

There is no doubt that increasing fishing pressure will lead (and maybe already has led) to a decrease in certain species. The first to show the effects of this pressure would be fish that reach a larger size or older age before breeding, and those unable to take advantage of the thick vegetation refuges. It seems that, for now, the fishes of Bangweulu Wetlands can withstand current fishing pressures. They are adapted to this extremely seasonal environment where factors like rainfall and degree of flooding are the strongest determinants of fish numbers.

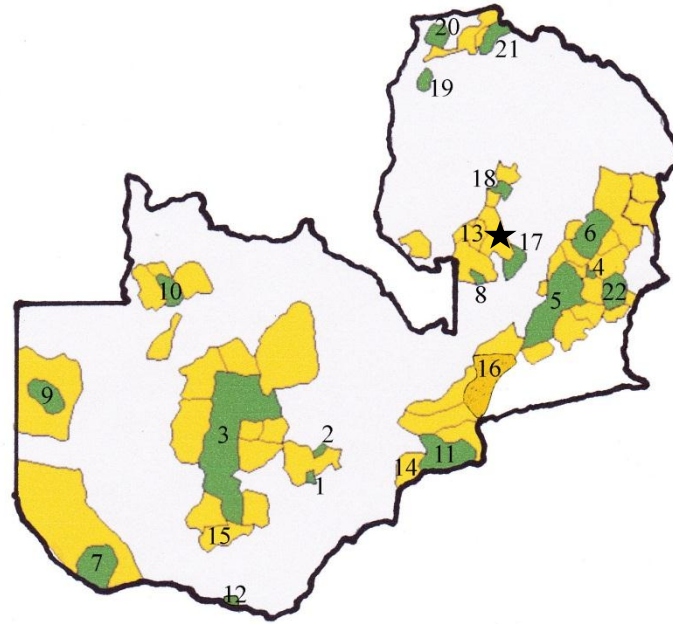
As an example, In the 2011/2012 rainy season the first rainfall peak was very low. As a result, flooding came late. The spawning event of the catfishes (uChilambo) seems to have peaked during mid-January, but there was little follow-up flooding for the juveniles. Fishermen predicted poor recruitment of fish for that year, as fish were forced to spawn 'near the deep water', where predation is naturally higher. Very high rainfall in March partially relieved the situation by giving fish juveniles a good chance to disperse and grow, and there was evidence of a second early March spawning for some species.



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'What's not caught by the fishermen...' - birds 'cleaning up' on the drying Chimbwe Plain

Zambia's Protected Areas

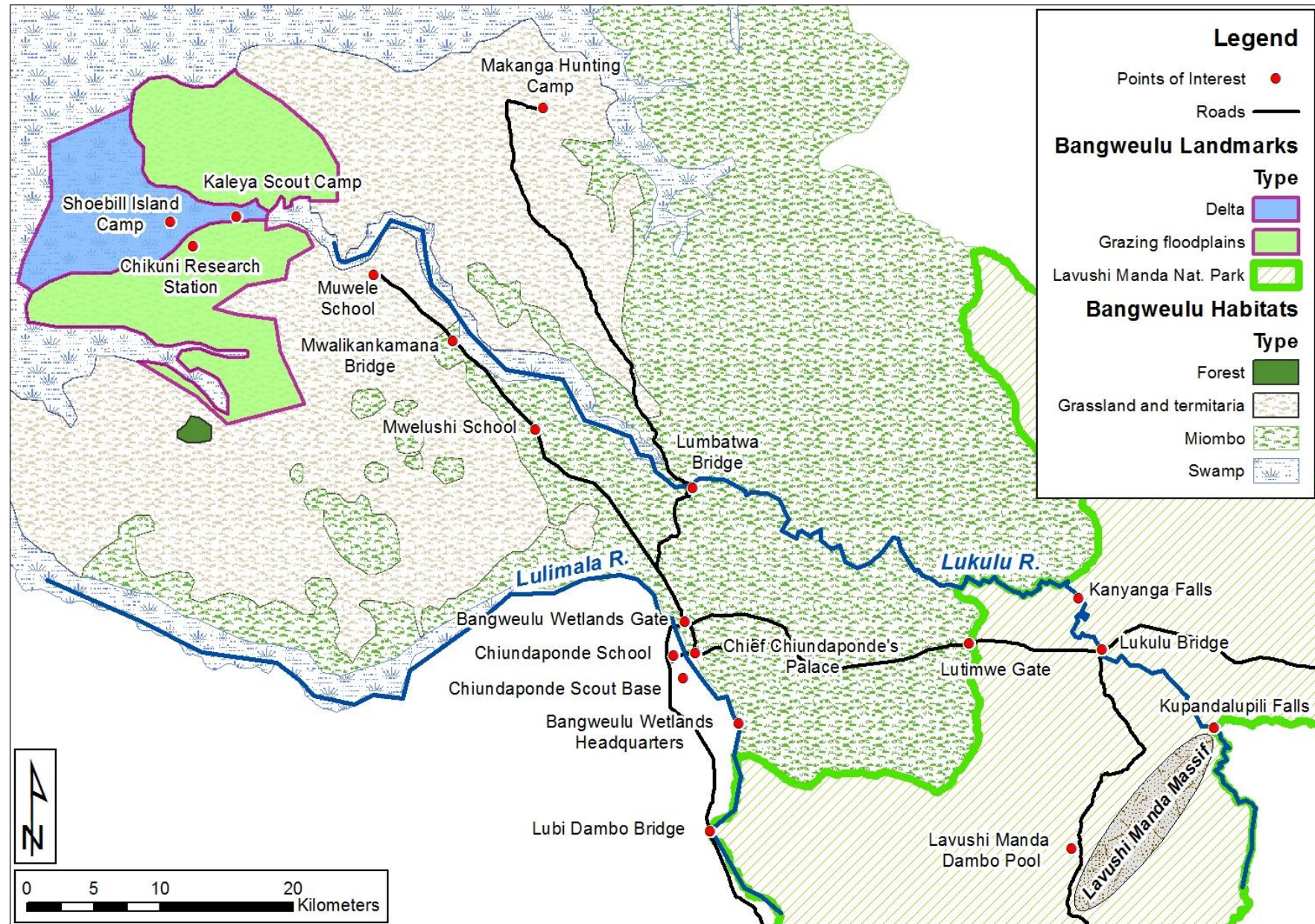


- 1 - Lochinvar NP
- 2 - Blue Lagoon NP
- 3 - Kafue NP
- 4 - Luambe NP
- 5 - South Luangwa NP
- 5 - North Luangwa NP
- 7 - Sioma Ngwezi NP
- 8 - Kasanka NP
- 9 - Liuwa Plain NP
- 10 - West Lunga NP
- 11 - Lower Zambezi NP

- 12 - Mosi oa Tunya NP
- 13 - Chikuni CPP
- 14 - Chiawa CPP
- 15 - Sichifula GMA
- 16 - West Petauke GMA
- 17 - Lavushi Manda NP
- 18 - Isangano NP
- 19 - Lusenga Plain NP
- 20 - Mweru Wantipa NP
- 21 - Sumba NP
- 22 - Lukusuzi NP

- NP National Park
- GMA Game Management Area
- CPP Community Partnership Park
- ★ Study site

Map of the study area in Bangweulu Wetlands and Lavushi Manda National Park



Chapter 1: The Area

Aquatic Habitats

Aquatic habitats inside the conservation area follow a shallow altitudinal gradient, from catchment streams through their delta and floodplains to deep floodplains or true swamp. Landmarks appearing on the map are in **bold**.

#1: **Lukulu River- rocky upper reaches**



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*Kupandalupili Falls in flood in March 2012, near where the Lukulu River enters Lavushi
Manda National Park*

The upper Lukulu inside the Lavushi Manda National Park is rocky, with alternating pools and rapids. The banks are heavily vegetated with trees, with a narrow grassy floodplain on either side. Rocks in the rapids are thickly covered with a fern-like aquatic plant (*Hydrostachys polymorpha*), and the water is generally clear, with a milky colour after rain. It has a very high volume late in the rainy season, but it quickly returns to its base level flows for the dry season. The water is nutrient-poor, and exogenous nutrient input (from outside, e.g. dead leaves) is very important. There is a low density of crabs, freshwater shrimp and aquatic insects. There are two low waterfalls, Kupandalupili Falls and lower down the river, Kanyanga Falls. Both falls are unlikely to be a serious obstacle to fish movements. A typical section of the river can be seen at **Lukulu Bridge** (1275m elevation).



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Rapids on the upper Lukulu River, inside Lavushi Manda National Park

#2: Lukulu River- middle reaches

The middle reaches of the Lukulu are typified by a deep river channel, with a sandy base and dense tree lines with many roots hanging in the water. The typical tree here is *Syzigium guineense* (waterberry), which has a willow-like growth habit. A typical section is in the northern sector of Lavushi Manda National Park and near the new **Lumbatwa Bridge** across the Lukulu in Bangweulu Wetlands (1193m elevation). This section of the river is quite short compared to the rocky upper reaches and the lower reaches.

#3: Lukulu River- lower reaches

The lower reaches of the Lukulu before reaching the delta consist of dense papyrus and floating grass mats covering the meandering main channel. Only in some areas is the channel uncovered, and these areas change. It is not known what causes the papyrus mats to break up or move, but it could be a cyclical event involving flooding and vegetation density thresholds. The main channel is very deep (>3m), and the 'river' with its adjacent floating papyrus-covered 'floodplains' is 300-700m across. A typical section lies adjacent to the road between **Mwelushi School** and **Muwele School**, at around 1179m elevation.



©C. Huchzermeyer/SAIAB

The papyrus-covered main channel of the Lukulu River where it enters the delta

#4: Lukulu Delta

The Lukulu delta starts with a narrow neck at Muwele Village and fans out widely in the Chikuni area, although a central, meandering main channel can still be discerned throughout the delta. The delta is typified by dense stands of vegetation; floating mats over deeper water, and rooted *Phragmites* reedbeds and sedges in shallower water. There are open pools and lagoons covered with water lilies, and other aquatic plants grow on the bottom of channels with flowing water. The thick vegetation of the delta probably helps floodwaters from the Lukulu break its banks and flood the plains instead of draining rapidly into the deeper swamps. This would explain how water levels on the plains can rise rapidly after heavy rains, and then only gradually drain off. The edges of the delta have a lot of fish weirs

constructed on them. The islands in the delta are low and flooded annually, with the uninhabited islands being favoured by buffalo, elephant and other wildlife.



©M. Trimble/African Parks

A pool on a delta channel with Nymphaea water lilies and Phragmites reed beds

The dense reedbeds and papyrus of the channels are burned from October to December, and the effects of this activity are not known. There are no particular reasons given for burning, and only the reeds rapidly regenerate. The dense vegetation and deeper channels of this delta provide good refuge for most fish species.

Shoebill Island Camp is in the delta.

#5: Floodplains- woodland pools

The last section of the river before it forms a delta is surrounded by wide wooded and grassland termitaria plains that are inundated (mostly by rainwater) for a few weeks at the end of the wet season. Fish migrate into this shallow water, where they are caught in weirs. The shallow floodwaters seed woodland pools with fish, most of which dry out during the dry season. Many of these pools contained the annual killifish *Nothobranchius rosenstocki*. All of the pools contain thick mats of grass and other plants, which provide a dense humus layer for the killifish's eggs to survive in during dry periods. The eggs will hatch when the pool fills with water again, and in this way populations of this interesting fish can survive in the most remote pools. These pools can be found near **Mwalikankamana Bridge** and **Lumatwa Hunting Camp**.



©Roger Bills/SAIAB

*A typical woodland pool inhabited by the annual killifish *Nothobranchius rosenstockii**

#6: Floodplains- swamp margins

During the peak time of the floods in late February and March the 'shallow' floodplains and lechwe grazing lawns become flooded. The area of water that is inundated is considerable due to the flat topography of the plains. This water is flowing, well oxygenated and is warm due to its shallow depth (<60cm deep). The vegetation on the floodplains is mostly emergent semi-aquatic, with some aquatics that will lie dormant once the plains dry out and become grassed-over. The large amounts of black lechwe antelope dung that build up during the dry season provide a rich suspended organic medium that no doubt contributes hugely to the aquatic food chain. **Chikuni Research Station** is situated on the margins of Chimbwe Plain, a shallow floodplain and grazing lawn.



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The flat Chimbwe Plain at Chikuni beginning to flood in February 2011, with the Lukulu delta on the horizon

The areas away from the riverine-influenced parts of the delta can be classed as ‘deep’ floodplain. These areas remain flooded for a longer time, and are dominated by various sedges and coarse grasses. The nutrient status appears to be lower, with less dense vegetation and lower ungulate utilisation. Higher fish weirs are made here due to higher water levels, and this appears to be the main form of fishing here. These areas can be extensive, and little fishing may occur in places where there is insufficient high ground for fishing huts. The fish fauna here is likely to be migratory, as there are few deeper water refuges for them later in the season. It is also in this kind of area where fish can become stranded in shallow, vegetation covered depressions and the occasional pool.

#7: Swamp

‘True swamp’ is hard to define but in this area refers to areas permanently inundated that are beyond the influence of perennial rivers. Some of these areas can be considered deep floodplain as they dry out during low-water years, and consist of long grasses and sedges rather than the reeds and papyrus of the riverine channel areas. This habitat is very hard to

access from Chikuni. At the northern boundary of Bangweulu Wetlands there are again deep water habitats around the islands in the small chiefdoms of Bwalya Mponda and Nsamba. These islands, channels and deep pools are part of the large Chambeshi river system that enters the Bangweulu swamps from the east. The top left part of the map shows areas of deep floodplain and swamp.

#8: Lulimala Stream

The Lulimala stream flows through part of the project area, and also forms a swamp delta nearer where the swamp waters begin to consolidate into the Luapula River. It is a relatively small stream, and only two sections were sampled. The stream at the **Bangweulu Wetlands Headquarters** at Nkondo is deeply incised, shallow and with a soft silty bed and well-wooded banks. The base flow during the dry season is low, and there are only a few small fish species present. During the rainy season the stream increases its flow considerably, even flooding grassy pools and dambos over its banks.



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A large disused fish weir on the Lulimala stream at Nkondo. The low flow of the stream during the dry season is evident, but during the rains it floods over the far bank visible in the picture

#9: Dambos and dambo pools

Dambos are grassy drainage lines in woodland areas. Fish can sometimes be found in these wetlands, especially nearer to streams. Some dambos have small lakes or pools in them, as can be found near the **Lavushi Manda Mountain** and at Lake Waka-waka east of Lavushi Manda National Park. The dambo environment is usually very nutrient poor: surrounding soils are shallow and leached, and the water has is acidic with few dissolved minerals. As a result only a few fish species are found here in very small numbers.



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A grassy dambo lake in the woodlands of Lavushi Manda National Park

Seasonality, flooding cycle and the effects on fish

The Bangweulu is one of the highest rainfall areas in Zambia, and with the flat topography of the Bangweulu Basin, the extent of flooding is considerable. The rainfall characteristically has an early peak in late December/early January, followed by a comparatively dry spell, after which very heavy rainfalls occur again in March. The rainfall in December must first saturate the soils, which are very dry after the long dry season. Once there is runoff into the streams and rivers the level rises, flooding the delta and floodplain margins. This first peak in rainfall is critical to trigger fish to spawn, and the amount of flooding that results

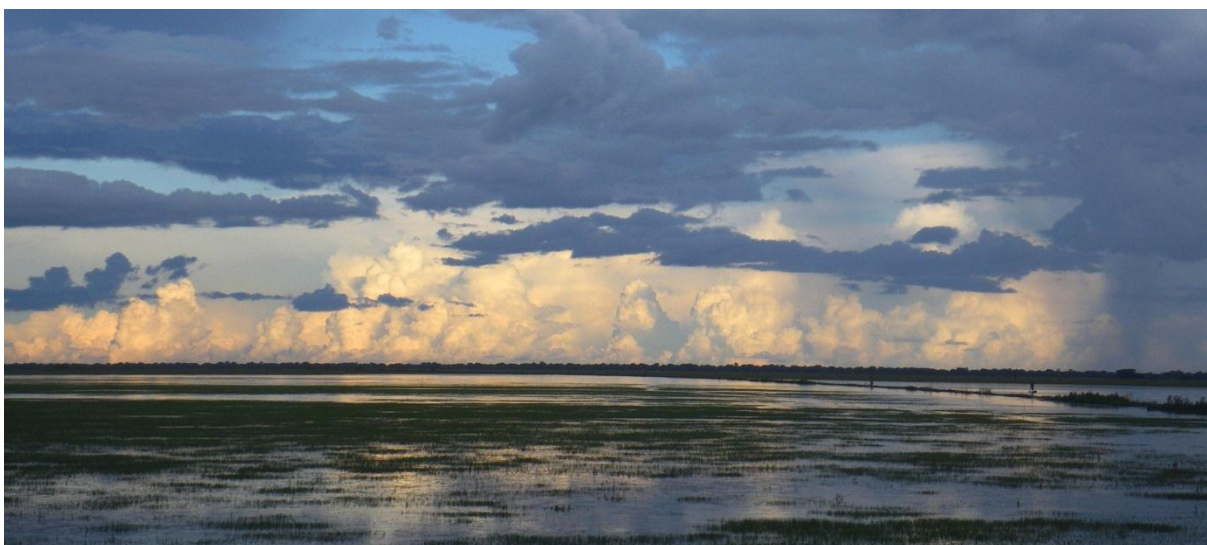
determines how much habitat is available, affecting the success and survival of the juveniles. The heavy March rainfall contributes most to the extent of flooding, and surface accumulation of rain water opens up vast areas of flooded grassland to fishes. It is this water that then takes a few months to recede from many areas.



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Wildlife along a new fish weir between Chikuni and Shoebill Island in July 2012. Note the water level marks on the dense reed bed in the background, from four months earlier

In April the rainfall comes to an abrupt stop, and by May the sky clears of clouds and the strong wind from the south-east begins. The shallow grassland plains are the first to lose their water, and by May the lechwe grazing plains begin to dry. Over winter (June to August) the drying slows down due to lower temperatures. The bulk of the water appears to be lost by evaporation rather than by drainage. By September most of the floodplains are dry, and the months of October into December see the delta and lagoons lose a lot of water. The hot temperatures and dry air greatly increase evaporative rates. By this time the volume of water in the inflowing streams is only a fraction of their wet-season discharge.



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The Chimbwe Plain in front of Chikuni Station during March 2012

The role of wildlife

The two main effects of wildlife on the ecology are their effects on the nutrient levels and on the physical structure of the ecosystem.

The nutrient cycling is driven by herbivores. The estimated 70,000 black lechwe antelopes graze the grasses growing on the floodplains, releasing nutrients back into the water and soil through their dung. The dung ensures a rich layer of humus, and allows nutrients to enter other pathways such as the aquatic food chain, instead of remaining locked up in plants. More research is needed to investigate the role that the herbivores play in keeping the area rich and productive. The effects of the lechwe grazing no doubt extend well beyond the lechwe range, into the swamp.



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Large herds of black lechwe grazing the dry Chimbwe Plain in front of Chikuni Station during July 2012. This part of the plain can be considered a 'grazing lawn' and sustains heavy herbivory for much of the year

The grazing also has a structural effect on the ecosystem: the lechwe maintain highly productive short-grass 'grazing lawns'. The grasses occurring on these lawns are highly nutritious, and can withstand further heavy grazing. In the absence of grazing, the plains would likely be invaded by unpalatable plants and long grasses, and the elevated nutrient status would be removed by the resultant annual burning that would take place.

Hippos also have a huge effect on their environment. Hippos release nutrients directly back into the water and help keep channels through thick vegetation open. Historically, there were many more hippos in the Bangweulu swamps, but they were heavily hunted in past decades. The hippo population around Chikuni appears to be healthy and growing. They

frequently use the same paths through channels and across islands, and due to their great bulk they keep paths through the densest vegetation open. These paths help fish move and access new areas, and the hippo's wading helps prevent the delta from becoming a uniform mat of floating grasses. At the edges of islands, hippos create long, deep paths ('slipways') where they come out onto land. These small bays add complexity to the fish habitat. The hippos around Chikuni are shy, and spend their days resting deep inside reed beds. It appears that hippo activity even may help control the dominance of reeds in the areas they favour.



©Chris Meyer

A pod of sixteen Bangweulu hippos in the Lukulu Delta. Note the dislodged vegetation

Elephants, which were still common on the floodplains a few decades ago, have been reduced to a resident population of five animals. Their potential effect on the ecosystem is huge: both through their browsing of a wide-range of shrubs and grasses, and their paths would greatly aid fish dispersal and migration. When the five elephants swim across a channel and through a dense papyrus bed, it was clear to see how the vegetation gets broken up by these large animals. Much larger numbers of elephants would likely have a very positive effect on the delta, both from a nutrient and structural point of view.

Other herbivores such as buffalo, zebra, sitatunga and tsessebe have similar effects on the ecosystem as the lechwe, but their numbers are much lower. Buffalo, which favour grazing

islands and flooded zones, in addition to consuming tall, unpalatable grasses, would also have a great effect, but their numbers are still well below the carrying capacity.



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A camera trap picture of a hippo using a 'slipway' path into a channel

Often overlooked is the termite: this small insect takes huge amounts of plant matter into the ground, enriching the soils. The mounds they produce probably make them the single-most important ecological component: their mounds raise land above the level of flooding, steadily accumulating into sizeable islands. These are hugely important for plant and animal diversity. Termite mounds are also critical to fishermen: often the only dry land to build a hut upon. The fishermen also say that young fish find rich feeding around termite mounds during the floods. It is unclear whether the fish feed directly on the termites, but the termite hills and their associated vegetation nevertheless would provide a variety of rich food sources.



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Termite mounds are a characteristic structural feature in the Bangweulu ecosystem

Fish refuges

The only official refuges for fish are inside the Lavushi Manda National Park, where fishing is illegal, but had been taking place for many years while the park was not formally managed. Within Bangweulu Wetlands a 4km section of stream at the Nkondo headquarters is also protected. The pool and canal at Chikuni Island are a small no-fishing area.

Many natural refuges exist for fish, mostly in the form of dense aquatic vegetation and floating papyrus beds. These become important at the end of the dry season, when every bit of open water is being fished. Fishermen also keep their distance from hippos, and therefore these animals can be considered 'moving no-fishing zones'!

While natural refuges and the adaptations of the fishes themselves seem currently to give them adequate protection from overharvesting, a closed area would be a useful indication of what an unharvested fish stock may look like. There are currently no such sites in Bangweulu. Large animals such as elephant, hippo and buffalo should be very strictly protected, mostly for their huge beneficial effect on the ecosystem, but also because fishing activities are reduced in the areas that they favour.



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The pool in front of Chikuni Research Station

Chapter 2: The Fishery

The fishing life

The study area centred at Chikuni falls within the Bisa chiefdom of Chiunda Ponde. The chiefdom is divided into two rough geographical and occupational components: a higher lying woodland region dominated by farming activities, and the lower lying floodplain area dominated by fishing¹. There is much intergradation between the two activities, with most of the inhabitants of the fishing region of Chiunda Ponde engaging in both fishing and farming. Some are full-time fishermen for the whole year, though this is not common as is the case in the Unga and Batwa tribes deeper in the swamp.

The people engaging in fishing, even if only for part of the year, can be considered to be migratory. This naturally causes disruption in the delivery of services such as education and health. Though formal school attendance is low, there is nothing lacking in the children's education in all aspects of the fishing life and their natural environment in the swamps.

Fishing camps in the swamp floodplains around Chikuni are generally clustered around slightly higher-lying areas of land that remain dry at the peak of the floods. The number of dwellings in a 'camp' usually varies from four to twenty, and they can be either densely or loosely clustered. The camps inside the Lukulu delta are densely clustered on high-points of sediment islands. Wet-season weir fishing camps are more dispersed over the termite woodland islands adjacent to the plains and delta. Here each hut is built on a levelled-off termite mound, which gives it sufficient elevation above the high water mark. Dry season camps used by seine net fishermen are temporary and can be constructed anywhere. They are usually clustered around pools suitable for seine netting.

Fishing huts are constructed from a wide variety of materials. There is a marked difference between the shelters used during the rainy season and those used during the dry season. The amount of rainfall is the strongest determinant of building style, materials and quality of construction. The best huts are seen in the grassy termitaria plains where the fishing season is short and early. These fishing areas rely on flooding due to rainfall, and hence are fished at the peak of the rains from January until early March. Here, huts are constructed with a rigid wooden frame covered by densely thatched grass walls and a thatched roof. Material is also easily available in this area.

The huts constructed in the slightly deeper weir fishing areas adjacent to the delta are also utilised while there is still rain. Huts here vary from temporary reed shelters to some more permanent structures built from unbaked bricks with thatch. There is less long grass in this area as thatching material, and the majority of huts are now covered with trucking

¹ Lusenga, W. G. 2012. *The united chiefdom of Chiundaponde*. Unpublished.

tarpaulins or plastic sheeting while in use. The tarpaulins are removed as soon as the fishing huts are vacated as the water dries, and hence make the huts far less visible during the main dry-period tourist season.



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A vacant fishing hut in the dry season. Note the termite mound around which the hut is built, giving the camp elevation during the floods

Dry season camps, mainly used for seine netting, can consist of anything from an established hut on higher ground to a mere propped up reed-mat covered with cloth. Some seine net fishers fish for only a short time, while others move to new areas frequently. The immigrant seine net fishers who had come from deeper inside the swamp in early 2012 were excellent hut-builders. The Unga people from deeper inside the swamps are renowned for building fishing huts even where there is no dry land, by using cut vegetation to build up a floating platform.

A fishing hut generally has a floor space of 3x7 metres. The roof is low, being 1.5-2m high at the gable. There is usually only a single entrance, which is low. A cooking fire covered by an iron smoking grid is usually positioned in the middle of the floor, with sleeping areas against the sides. Belongings taken out to the camps are basic, but luxuries include radios and their associated power source (photovoltaic solar panel and batteries). Outside the hut there is always a raised grass-mat fish drying rack, a flat sitting and working area, and a wood pile.

The fire and smoking rack are crucial parts of the hut. Almost all fish larger than 15cm are smoke-dried. The key equipment needed for this is the sun-drying rack, the indoor fire, a metal grid above the fire (either in a drum or as a grid over the fire), and a reed mat hung a metre above the fire where hot-smoked fish are stored. This storage rack is important and takes up a considerable amount of space inside the hut.



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The interior of a fishing hut, showing the smoking fire and rack for storing dried fish. The fish here are exclusively smoked catfish (muta)

The wooden dugout canoe (*ubwato*) is another crucial tool for swamp life and fishing. Every fisherman owns at least one dugout. These are usually made by the fishermen themselves. The dugouts are made from a variety of tree species, most commonly *Pterocarpus angolensis* (Mukwa), *Parinari curateifolia*, *Syzigium caudatum* (Waterberry), *Diospyros mespilliformis*, *Vitex cf. doniana* and a few others. Different woods require different carving and care, with harder woods often having very thin sides and softer woods thicker sides.

Others are more prone to cracking and are covered with turfs when not in use for some months. Dugouts are mostly made in tall forest-woodland away from the swamps, and are made in time to retrieve them at the rainfall peak. Dugouts made later need to be transported between four to six bicycles. Older canoes develop bad cracks and rot through in some parts. These are repaired with wooden planks or pieces of plastic bucket nailed over them. Smaller cracks are usually blocked with fibrous root masses and mud. In any case, a bailing scoop is an important part of a dugout canoe's accessories. In the past these were ornately carved wooden scoops with a handle (*ulwipo*), though these are now rarely seen. Old tin plates and pieces of plastic are more widely used now, and are apparently not as effective as the traditional scoop.



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The Bangweulu fisher's most crucial piece of equipment

Paddles for dugout canoes most commonly consist of a pole for pushing the dugout through shallow water. The favoured pole is taken from the last third of a *Raffia farnifera* palm frond, the longest leaf in the world. These palms are common on the escarpment streams approximately 100km from the swamp. Bamboo poles, planted in the villages, are becoming increasingly popular too though. In deeper water, a long-bladed wooden paddle is used. These are always carved from the wood of *Pterocarpus angolensis* (Mukwa) and a *Faurea* species (Saninga).

Large trees have been scarce in the Bangweulu swamp and its margins for much of the past century already². This is largely due to the demand for dugouts, and also for fuel. The study site around Chikuni still has comparatively many trees, though trunks large enough for dugouts are rare. The only surviving wetland *Mushitu* forest in Bangweulu Wetlands is under increasing pressure, with a small area of approximately 3km². A short 200m walk along the edge of this forest revealed seven trees felled for canoes from that year. The small size of many dugouts also bears testimony to the shortage of suitable trees.



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A large tree felled in the forest to carve a dugout canoe

Most dugouts are 3-5m long, and 30-60cm wide at the widest point on the base. Very large, stable dugouts employed for seining from a boat are very rare and often very old. These are reportedly acquired from sellers bringing canoes from forests higher up the Chambeshi River. These fetch a price of ZMK 1 million (USD 193). The shortfall of trees for making large dugout canoes has been slightly lightened by the purchase of fibreglass 'banana boats'.

² Brelsford, W.V. 1946. *Fishermen of the Bangweulu Swamps: a study of the fishing activities of the Unga tribe*. The Rhodes-Livingstone Papers: Number 12. Manchester University Press.

Banana boats are expensive (8 million ZMK, USD 1544) and are more commonly used for businesses such as hiring out to fish traders or transport services to the swamp islands. They are not as manoeuvrable as dugout canoes, and are therefore rarely used to deploy fishing gear except for seine nets. The shortfall of wood and trees means that there is good potential for fibreglass boats moulded on dugout canoes, such as those promoted by tourist operations in the Okavango swamps.

A hard-working fisherman has a full day. Around dawn he'll begin checking his gillnets and longlines. This can take two to three hours depending on how much gear he has set and what the catch is like. If he is fishing with *mono* baskets and *sola* nets, he can add another two hours onto his morning rounds. Late morning and early afternoons are spent mending fishing gear, resting and attending to business. In the late afternoon he goes out again to check and set his gears. If he is part of a seining team, they will pull their nets at dawn, over midday when it is hot, and again in the evening. If many pulls are made throughout the night, the day is reserved for resting.

Women live mostly in the weir-fishing camps: seine netting companies are usually comprised of men, especially if they are immigrant fishers. Women play an important role in fishing too: their job is to gut and scale fish, tend to fish that is smoking, and maintain the fishing household. Men living in the swamps without their wives process the fish themselves, but women are never seen mending or setting fishing gear. The children in the camp assist with all of the chores. Almost everybody knows how to paddle a canoe.



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The whole family helps with chores in the fishing camp. Here fish are being scaled and gutted

Note on fish processing and trade

The bulk of the fish caught in Bangweulu are preserved for storage and trade. Fish are processed differently according to size and species. Generally larger, oily species are smoked, and small fish are sundried.

Fish that require smoking are gutted, scaled (if necessary) and then placed in the sun for 1-4 hours. This firms up the flesh, after which fish are packed onto the smoking rack. At first a hot fire is used, almost cooking the fish, after which the fire is allowed to cool. The entire smoking process can take between five and 12 hours, after which the fish are placed onto the rack hanging higher above the fire. Freshly smoked fish are still a little soft if squeezed, termed *motomoya*. Once they have been in the dry air above the fire for a further two days they are completely dry, and will keep for a few months. Fish that are sundried are catfish, mormyrids and cichlids that are larger than 15cm in length. The smoked products are called *muta* (large catfish), *popa* (small catfish), *mintesa* (bulldog mormyrid) and *ilikota* (smoked cichlids).

Most fish smaller than 15cm are sundried. Some are scaled and gutted first, and fish under 8cm in length are usually dried whole. On sunny days it takes approximately a day and a half for small fish to become dry. Small dried fish are separated into three products for the trade: *baby lila* (a mixture of very small fish <40mm long), *kasepa* (mixed fish 40-80mm long) and *uluya* (a mixture containing a high proportion of mormyrids).



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A trade unit (pail) of kasepa. This unit is frequently used when buying fish, and contains about 2.5kgs of dry fish

Salting fish is becoming more common as there is good demand for this product from traders. Most fishermen prefer the wood-smoking process, but one trader from DRC bought fresh fish and salted them himself. Fish are split open and packed into a plastic drum, alternating layers of fish and coarse salt. After 24 hours of curing they are laid on drying mats in the sun.

Dried fish are brittle, and the market demands that fish be whole. Great care is taken to minimise losses, and this determines how fish are packaged for transport. Small, sundried fishes can be packed into 90-kg grain bags, with an average weight of 70kg. Both large and small catfish can also be transported in bags like these, with approximately the same weight. The dried mormyrids (*mintesa*) are very brittle, and these are packed in 'bundles'. The wood hoops and netting of the bundles act as frames, and offer more support to the fish being transported. Most other fish can also be packaged in bundles, and bundles made with grass lining were already in use before bags became common.



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A 'bundle' being made up before transport to market. Each bundle contains twice the amount of fish that can be packed into a regular 90kg grain bag

Most fishermen sell their fish to traders. These come by banana boat from 'Tuta Bridge' on the Luapula, from March until May. From May until December most come by road, and are based at Muwele Village. Traders, usually women, come from towns, buy fish, and sell it again in urban markets. They have access to capital, usually in the form of a spouse's salary. The greatest costs are transport: a boat with paddler/guide during the wet season and bicycle and vehicle transport in the dry season. Traders coming by boat usually bring goods into the swamps, and these 'floating shops' sell everything from mattresses and bicycles to medicine and clothes. Transactions are usually in cash, with limited bartering also taking place. Traders buy whatever fish is for sale, and if these aren't completely dry yet the traders will continue the curing process themselves. Some fishers wait until they have a full bag before selling as the price is more standard, while others sell fish as they have available, negotiating prices for varying amounts of fish. Hence the actual price per kilogram of fish fluctuates widely.

The local trade in fish is also very important. Farmers from the mainland have always traded meal with fishers from the swamps. In the Chikuni area, farmers from Chiundaponde come by bicycle to Muwele village and the fishing camps to sell maize meal. They then use this to buy fish. Bartering used to be common, but now cash is preferred. The price for cassava and maize meal is higher than on the mainland, especially at the end of the dry season when reserves begin to run low. Many bicycles on the road from Chikuni to Chiundaponde can be seen carrying a bag of meal and a small 4 litre bucket used for measuring.



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Maize or cassava meal being traded sold in a fishing camp

A very rough estimate of the fish production from around Chikuni is given below:

- A typical fishing group (father, family and 1-2 male relatives) operating a weir and its adjacent deeper waters fishes a 7 month season
- A group produces 7 x 70kg bags = 490 kg of dry fish for sale in the season
- Dry fish have usually lost 70% their fresh weight
- Seven bags of dry fish correspond to $490 \text{ kg} \times 3.3333 = 1.6$ tons of fresh fish
- Average daily catch in 7 months is $1600/210 \text{ days} = \mathbf{7.6\text{kg/day}}$
- There are 500 fishing groups in the delta and adjacent plains
- They produce $490 \text{ kg} \times 500 = 245$ tons of dry fish, which corresponds to a harvest of $1.6 \text{ tons} \times 500 = \mathbf{800 \text{ tons}}$ of fresh fish from the **area** in a season
- The 500 groups use an area that is approximately 15kmx15km (22 500 ha), most of which is only flooded for 5 months
- Therefore the production of the area is $800\,000 \text{ kg}/22\,500 \text{ ha} = \mathbf{35.5 \text{ kg/ha}}$
- One 70kg bag of dry fish is worth ZMK1 million (US\$ 221) when sold locally to traders
- The same bag is worth double that on the urban markets (ZMK 2 million/US\$ 442)
- The average local price per kilo dry is ZMK14 285/US\$ 3.16 and ZMK1428/US\$ 0.96 fresh
- This is an average price, larger species are worth more
- Thus a fishing group's seasonal **income** from seven bags is: ZMK 7 million/US\$ 1547
- The market value of one fisher's seven bags is ZMK 14 million (US\$ 3094)
- The **market value** of the 245 tons of dry fish produced in the Chikuni area is therefore **ZMK 7000 million/US\$ 1.547 million**
- Half of this (**ZMK 4500 million/US\$ 773 500**) goes to the fishers directly if they sell to traders, and a portion of the remainder goes to local transport services and boat hire
- There were approx. 40 groups of **immigrant fishers** around Chikuni in early 2012
- They took their fish to sell outside the area
- Therefore if they each produced 10 bags of dry fish, they removed 400 bags (28 tons) of dry fish

- This represents a **loss** of ZMK 400 million/US\$ 77 205 from the local economy, approximately **10%**

This sketch is very approximate. There is a lot of variability in prices and trading methods, and values used are broad averages. Once more of my data has been analysed a more accurate picture should emerge. However, this ballpark figure highlights the importance of fish to the local community, and also the threats posed by external fishers.

A resource economist would be able to calculate the details of the financial flow through the area resulting from fish. The 'economic ladder' surrounding the fish trade has many local components, each of whom also derives benefit from the fishery. These include shop owners, boat owners, vehicle and bicycle transport service providers and guides. These stakeholders, especially shop and vehicle owners, should be engaged with in discussion around the fishing as they have a large stake in the local economy.

The money coming into the area through the fish trade must 'leak' out rapidly, as the greatest portion of the money is spent on items manufactured elsewhere. Examples of such products are fishing gear, bicycles, radios, medicines, cosmetics and clothing. The only locally produced product of importance is the staple starch meal, and the trade in this commodity with the fishermen represents an important source of income for the farming communities.



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Discussing trade units with fish buyers

The traditional fishing authority

The areas that are important for fishing are divided up into tracts of land each under the control of a traditional fishing leader, or fishing chief, known as a *Chipupila*. They are servile to the area chief, Chiunda Ponde, though due to distance from the chief's court and the chief's old age, they now operate largely autonomously. The *Chipupilas* are descended from notable people who had performed miracles or other notable deeds, and were rewarded with fishing areas (and historically also hunting areas) to be under their control. Inheritance of this position is matrilineal, though various members of the same family can sometimes share this role. There are a few woman *Chipupilas*. A central responsibility of the *Chipupilas* is tribute collection on behalf of the chief, though this role appears to have become somewhat diminished. Most of the tribute collected from fishers, in fish or money, is retained by the *Chipupila*.

The responsibilities of the *Chipupila* are to allocate the fish resource in his area fairly among those who use it, and to resolve conflicts. Traditionally the *Chipupila*, like the village headman, would have to know his or her people intimately: their names and clan affiliation, their ancestry and their relations to one another, in order to keep the peace. A person wishing to fish in a certain area needs to approach the *Chipupila* controlling the area, and pay a fee. The *Chipupila* decides where the applicant may fish, and the size of the area (and hence density of fishers) is determined by the productivity and yield. A fisher failing to utilise his area effectively stands the risk of having it allocated to someone else. Hence people who have left the swamps to seek employment or those engaging in other economic activities will often appoint extended family members to fish in their area too.

The *Chipupila* is supposed to also play a spiritual role in the area, and they are referred to by some Zambians (in English) as 'spiritual leaders'. During the study, it was no longer practice to perform a ceremony and make an offering to appease the spirits of ancestors residing in the area, at the start of fishing, and whenever a new area was opened. The process of blessing new fields is still practiced in the agricultural areas, but appears to have diminished in the swamp fishery. Brelsford³ described the process, and also referred to the *Chipupilas* as 'fishing priests'.

During the study, only one case of a *Chipupila* attending to the spiritual health of the area was witnessed. This took the form of a large meeting of traditional healers and affected families in an attempt to cleanse the area from bad spirits after a fisherman had been drowned by a bewitched crocodile the previous year.

³ Brelsford, W.V. 1946. *Fishermen of the Bangweulu Swamps: a study of the fishing activities of the Unga tribe*. The Rhodes-Livingstone Papers: Number 12. Manchester University Press.

A discarded piece of paper with a list containing instructions for blessing a new seine net (or seine netting area) was found quite by accident near a fishing camp. Whether the instructions were received from a *Chipupila* or another fisherman is not known, but it mentioned needing the *Chipupila* to speak some words and bless the net. The list consisted mostly of the parts of many local trees that would be needed for the blessing.

The *Chipupila* is required to stay in the fishing areas almost year-round, and there are relatively few demands on their time. This and their easy access to tribute have led to heavy alcohol use by some of them. Some *Chipupilas* are more enterprising in their investments, with one of them owning his own fishing outfit and selling his fish directly to the Copperbelt and DRC border markets.

Problems with the *Chipupilas* include corruption, with them allocating areas to, and protecting the interests of, the highest bidder. This became a problem during 2012, when immigrant fishers were rented fishing areas without consultation with the area chief or local fishers. There are also boundary disputes between groups of *Chipupilas*. These are complex disputes, but are possibly motivated by attempts by one group to gain control over the tribute of another's area. The root of one conflict in particular was that many decades ago one group was given temporary access to another group's area after lions had been causing problems in the first group's area. The group that had moved never went back, and were now trying to formalise the boundary of their 'claim'. A 70 year old fisherman interviewed (from a *Chipupila* family) stated that he hoped to see the conflict resolved before he died: this highlights the seriousness of the dispute to the affected groups.



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A heated dispute over landmarks demarcating the boundary between fishing areas controlled by two rival Chipupila families. Representatives of the chief were present to mediate

Fishing methods and gears used in Bangweulu Wetlands

Fish weirs (*amaamba*)

Fish weirs are the iconic fishing method of the Bangweulu swamps. An aerial view of the floodplains reveals the extent of these structures, which have a complex traditional ownership system. Fishing is done as floodwaters reach their peak and as they recede, and for some groups of fishermen this is the only type of fishing they engage in.



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Fish weirs criss-crossing the floodplain near Chikuni

Areas used:

Fish weirs are used almost throughout the Bangweulu system. The most important areas where fish weirs are used are on the seasonal floodplains. There is a gradient of low fish weirs constructed in the termitaria woodlands and plains where the water levels are shallow, temporary and rain-fed, through higher weirs built on the floodplains, to weirs built from vegetation deeper in the swamps.

Fish weirs are also used in the greater Bangweulu catchment, being constructed across streams and dambos (drainage lines with grassy wetlands in the woodlands), though these are not used commercially.

Ownership:

In the Chikuni area of the Bangweulu swamps, there is still a strong traditional leadership system governing the ownership of fishing weirs and the allocation of fishing rights in the areas of water that drain through a fish weir. The *Cipupilas* are responsible for weir allocation: they determine where new fish weirs can be constructed, and also allocate portions of fish weirs to different fishers.

The long fish weirs around Chikuni have multiple owners. Every owner assists with the construction and maintenance of a fish weir, and the gaps left in a fish weir for trap placement are individually owned. A particular fisher can own gaps anywhere along a weir, and they are rarely all next to one another. When a new weir is constructed, ownership of each gap is indicated by branches of different types of bushes, palm fronds, or combinations of reeds; such that each owner can recognise his gaps according to the marking code he has chosen. Once a weir has been used for a season, there is little risk of anyone confusing where they may place their traps.

The ownership and allocation of fishing areas is derived from the practice of allocating land for agriculture. Much of the seasonal floodplain is viewed as a terrestrial environment, and in the deeper areas of the swamps, there is less emphasis on area ownership. In fact, in the deeper swamp areas inhabited by the *Unga* tribe, tribute is collected directly by the chiefs, although the island Chiefdoms of Nsamba and Bwalya Mponda are considerably smaller in size than that of the *Bisa* chief Chiunda Ponde, who controls part of the floodplains (BW Social Survey, unpublished data).

Construction, Maintenance and lifespan:

The typical fish weir is a low levee made of turfs cut from the surrounding grassy topsoil. The turf is used because the grass roots hold it together, and because the soil below 20cm depth has an increasing clay fraction that makes construction harder. Also, grass and vegetation regrows rapidly over the turfs, which allows a weir to withstand considerable flow going through the weir. The turfs are gathered from 1 to 2 metres on either side of the weir, and are packed up to a height of 0.7 to 1.5 metres depending on the water depth. The base of the weir is usually about 1 metre wide. Once the weir has been used for a season, it reduces considerably as the turfs compact, and maintenance in subsequent years mostly involves patching areas that have subsided below the water level. Weirs are constructed and maintained as soon as water levels have receded enough for the surrounding ground to become firm but not hard, usually from July to October.

The only cause of wear and tear on fish weirs apart from gradual rain and water erosion is trampling by animals, primarily the numerous herds of black lechwe antelopes. The animals move on narrow paths, and thus damage is easily repaired by re- blocking the gaps when

fishing commences. Sometimes tall reeds with flowering heads will be pushed into a new weir to ward off animals, though this is uncommon and probably largely ineffective.



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A new fish weir under construction. The weir is made very high, but it quickly compacts during the floods. The bird in the foreground is a vagrant spurwing lapwing

The remains of old disused fish weirs are commonly found; sometimes adjacent to newer functional ones. Some of these weirs belonged to families who for various reasons stopped using the area or that section of weir, and others may be abandoned when a new, better located fish weir is built nearby.

The main source of transport around the floodplains during the peak of the floods is by dugout canoe. Fish weirs naturally impede this transport, and thus it is common courtesy for there to be a boating gap in each fish weir. Various innovations such as reed mat and grain bag barriers have been observed which block fish from passing, but allow boats to pass over.

When water levels are reduced, some of the channels running through thicker vegetation become shallow enough to be blocked off with weirs constructed of vegetation, usually muddy peat, roots and grasses supported by reed stakes. Fish taking refuge in these thickly vegetated channels are then captured. Reports of more extensive reed fish weirs from deeper in the swamps have been received, though I had no chance to visit these.

Season:

Fish weirs are left open for water and fish to pass through when the flood plains begin to fill at the start of the rains from December to February. It is recognised by fishers that this is an

important time for fish spawning, and that juvenile fish need access to the shallow flooded areas to feed and grow. Also, the fish weirs cannot yet be 'closed' at peak flows at the end of the rains, from February to the beginning of March, or they would risk their weirs breaching. However, as soon as the first indications of reduced flows are detected, the fish weirs are 'closed' and fishing commences. Catches can be very low in the first few weeks after the floodwaters begin to recede, yet fishers must still painstakingly maintain their weirs to prevent escapes. Once the correct weather factors have signalled the true end of the rains, fish begin to move *en masse*. These environmental triggers consist of a steady, strong wind from the south-east, low cloud cover and an accelerated drop in water levels, and is called *apumbwe*. The fish weirs are fished for as long as there is still water for fish to move through, though catches diminish strongly as soon as water begins to become stagnant as it dries. Once the fish weirs really 'get going', very little effort is put into other fishing methods.

Notes:

An interesting note regarding fishing in fish weirs is revealed by the favourable attitude fishers show towards pelicans. The hunting activities of packs of pelicans often drive fish towards the weirs, where very high catches of fleeing fish can then be removed from the traps and nets.

Recent changes in fishing methods with the new mosquito netting *sola* nets have changed the utilisation and seasonal patterns in fish weirs, as well as possibly the hydrological effects of the weirs, and are discussed further under that gear.

At first glance the fish weirs appear to be complete barriers to fish movement. While it is likely that a great majority of the fish inhabiting an area of water surrounded by weirs are captured as they attempt to move through the weirs, a portion of fish do manage to escape. One species of fish, the 'amphibious' *Ctenopoma multispine* is capable of climbing over the weirs, and few are seen in basket and net traps despite being an abundant species. The cichlid *Tilapia rendalli* is capable of leaping over fish weirs, especially around *sola* 'sock nets' where they detect the barrier. Occasionally netting or reed mats are used to deter these fish from leaping across. The catfishes in the genus *Clarias* are capable of burrowing through weirs, especially where they can enlarge holes that leak water through the turfs used for their construction. These holes, if undetected and not blocked by the fisher, can lead to other species also escaping.

Basket traps (*umono*)

This widespread gear is a conical grass or reed basket with a valve at the front, and is set into fish weirs as floodwaters recede. The *mono* basket is a very effective gear for harvesting a wide-range of fish species and sizes.

Construction, Maintenance and lifespan:

Most fishers weave their own baskets, and are capable of constructing up to three basket traps in a full day. More usually, only a few hours each day are spent weaving. Materials used are the side shoots off the abundant *Phragmites* reeds, or straws of the thick *Hyparrhenia*-type grasses on the areas of the floodplain furthest from the delta. The straws are bound together in a mat with bark fibre, which is traded from the woodland areas where suitable trees grow. Sometimes a very strong sedge (*Lutindi/Insubwa*) from certain swamp areas is also used to bind baskets. This mat is then placed around two hoops made from pliable braches, and the end of the cone is bound with fibre. A valve woven from the same materials is inserted at the open end of the cone. Sizes of baskets are determined by water depth, and the hoop diameter varies from 70cm at the largest to 30cm in a very small basket. The most common hoop diameter is 40-60cm, corresponding to a total basket length of 100-120cm.



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A mono trap basket being woven. The valve will be added last

At an early age children in fishing camps begin to construct their own miniature baskets, and these are also occasionally set into miniature fish weirs around the fishing huts.

Most fish baskets are discarded at the end of the weir fishing season, and some baskets even need replacing or repairs during the fishing season if the area fished has deeper water and hence a longer fishing (and hence soaking) period. Old and new baskets that need to be stored (or transported) have the inside rings and valves removed, allowing them to be folded flat.

While fishing, damage by animals such as otters is surprisingly low. Another type of basket, no longer used in the Bangweulu swamps, was a coarse reed funnel without a valve, used in a similar way to *sola* nets and discussed under that gear.

Setting and fishing:

The *mono* basket traps are set into gaps in the fish weirs. The basket is set at a depth that part of the opening of the basket always remains above water, and care is taken to close any gaps below the basket with mud and turf. The basket is frequently covered with grass and aquatic vegetation to darken the interior of the basket, and thereby encourage fish to enter. This may also play a role in disguising the baskets from scavengers.

The baskets are most commonly set with the opening facing down the current. Fishers state that the baskets are more effective at catching fish migrating up the current, and that as water levels recede, fish instinctively move towards the source of the flowing water in the hopes of reaching a larger channel. Fishers do however also observe which way fish are moving, and baskets set in current earlier in the season can also be set with the opening facing into the current.

Fishing baskets are checked early every morning. The basket is lifted out of the weir and the binding is removed from the narrow end of the cone. The contents of the trap are then shaken into a bucket or canoe. The trap is replaced, and secured firmly ensuring that there are no gaps around the edges where fish can pass.

Catch:

The basket traps catch a large size range of various fish species. The effective 'mesh size' is between 0.4 and 0.7mm, but even tiny species such as *Aplocheilichthys* can be caught in small numbers. From my measurements, the baskets retained fish larger than 40mm for *Pseudocrenilabrus philander* and *Pollimyrus*, which is a marginally larger starting size than for mosquito nets.

The fish in the traps are usually alive and there is little soiling of the catch with debris. Trapped live *Clarias* catfish can consume the rest of the catch, especially if the baskets are not checked daily. Bycatch consists of low numbers of large aquatic insects, aquatic snails and large leaches that may also be preying on the trapped fish.

Mosquito net 'sock nets' (*sola*)

This is a new gear that has become established during the last decade. They are set in fish weirs and 'sift' out anything from the water moving through the weir. They are most effective when there is considerable water current, and have effectively brought forward the date at which weir fishing commences.

Construction, Maintenance and lifespan:

The primary material used for producing these nets is mosquito bed-nets. A long, narrow tube not unlike a windsock used at airports is made from the net. The opening is held open by a hoop made from a pliable branch, and the end of the net is closed with an overhand knot and this is placed in a gap in the fish weir.

The typical dimensions of a *sola* net are an entrance hoop diameter of 50-150 cm and a length of up to six metres. The netting quickly becomes blocked with fine debris, and the long length of netting allows enough free mesh for water to pass through. The 'cod end' of the net can become swollen with fish and debris until bursting point.



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A sola net being checked. Note the distance between the entrance hoop and the 'cod end'

The nets require frequent cleaning due to the debris and because fish die inside the net. Fish pressed against the sides of the netting by the water pressure tumble against the debris, causing them to die, lose scales and rapidly decompose. Pressure from fish traders

for a less-damaged fish product has resulted in some fishermen using innovations such as making enlarged, bulbous cod-ends or having the main tube of the *sola* net feed into a separate, box-like 'fish pen'. Apart from regular cleaning of debris, frequent stitching of torn holes in the nets is also required. By the end of the fishing season most of the nets are discarded, and the sun rapidly causes the netting to degrade.

Some attempts to create an entrance valve have been observed, but only when water flows were already low and most fishers had already switched to using *mono* trap baskets. When flow rates are high there are few fish powerful enough to escape the strong current flowing through the net, and most fish avoid passing through them until they are forced to by the environmental triggers.

Scavenging from *sola* nets by birds seems to be more common than in *mono* baskets. Protective barriers of reeds or gillnetting are sometimes placed around the cod end of a net, though this also helps prevent trampling of the nets by lechwe antelopes at night. Nets bursting due to debris accumulation likely result in larger losses of the catch, and the occasional leaking of dead or incapacitated fish from holes in the netting are most likely the reason why birds are attracted to the nets.

The netting used for constructing *sola* nets is almost exclusively sourced from antimalarial bed netting. Mosquito nets are either purchased or acquired free of charge from anti-malaria campaigns. Free mosquito nets were regularly handed out at the health posts in the villages, though apparently the supply diminished once health officials learned what they were being used for. This supply of nets does not meet the demand in any case, and additional netting needs to be purchased by the fishers. All the shops in the villages selling fishing gear also sell mosquito bed-nets. It is possible that these nets have been subsidised by aid organisations, reducing their price. Despite the popularity of using the netting for fishing (seine nets are also constructed from this netting), most of the fishers and villagers also use mosquito nets inside their abodes for their intended purpose.

Setting and fishing:

The *sola* net has had a large impact on the weir fishing season. Fishing can commence while the flow rate through the fish weirs is still very high, from early March until April. Normally the gaps in the fish weirs would be left open until water levels were reduced enough that *mono* baskets could be deployed without them washing away. With *sola* net fishing, gaps are closed far earlier, and the resistance caused by the nets themselves can lead to substantial differences in water levels between different fish weirs. The damming up of water behind these weirs results in high energy water passing through the *sola* nets. This often results in deep holes and channels being scoured out where naturally flows would have been rather even across a large area of the plain. The effects of this upon the hydrology of the floodplains are unknown, though it can be argued that this creates slightly more habitat complexity for fishes.

In the past reed funnels were used in a similar way to *sola* nets. The effective mesh size of these funnels had to be large in order for them to resist the water current, and mostly larger fish were caught. A similar funnel without a valve has been seen in a large fish weir in a dambo near Kasanka National Park. Here the reed funnel (which had large gaps) ended in a long, finely woven grass tube, protected by a tube of tree bark. Fish washed down the strong current would end up in the fine grass tube, which (like a *sola* net) has a long distance along which to lose water. Losses through the coarse entrance funnel would naturally occur. The bark tube no doubt protects against scavenging animals. The weir had been made of poles and branches, similar to those found on the Lulimala Stream near Nkondo headquarters. It is quite possible that the reason a mosquito netting *sola* net was not used was purely financial: the inhabitants around Kasanka National Park have considerably less income than the swamp inhabitants.



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A basket being used in fast current flowing through a fish weir near Kasanka National Park. Something similar to this type of basket was used in Bangweulu in the past, now replaced by mosquito net solas

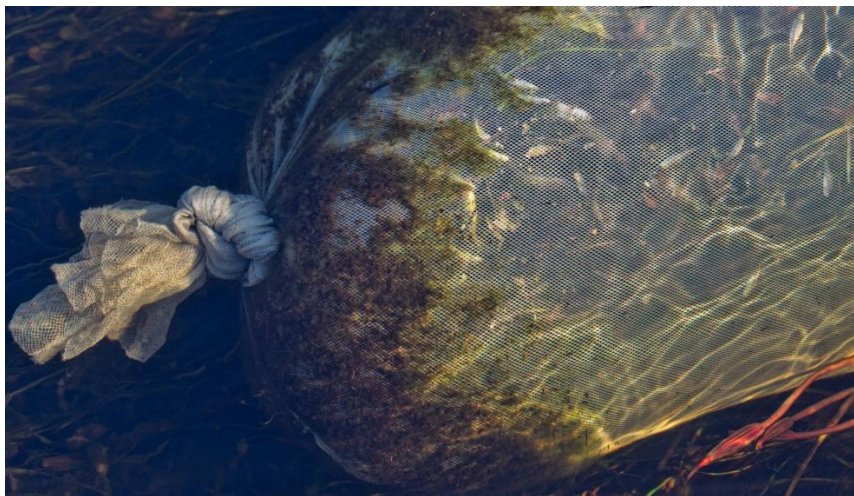
The *sola* net is very commonly used on the shallow floodplains around Chikuni, as well as on the extensive rain-fed termitaria plain nearer the villages. Here the water depth is shallow (20-50cm deep) and the *sola* nets set in the low fish weirs here have a smaller entrance diameter of 40-80cm, as opposed to 60-120cm where the water is deeper around Chikuni. On the deeper floodplain their importance appears to lower because by the time the water has receded enough for fishing to commence, the water current is already slow enough to allow the use of trap baskets. In some small channels through vegetation single *sola* nets were still observed in use by September, though catches appeared to be very low as the channels are not easily blocked off.

The nets are checked twice daily when flows and catches are high. This frequency of checking varies with the amount of catch and debris present in the nets, and later in the season the nets are often only checked each morning. During first weeks of weir fishing, catches in the *solas* are low: the nets are checked and cleaned daily, and their main function at this time is to allow water to pass through without fish escaping. It is only once the fish have been triggered to migrate that catches are made.

Catch:

The *sola* nets are capable of catching the full size and species range of fishes that occur on the floodplain. The portion of the catch consisting of very small fishes, mostly small *Barbus* species is very high, though by weight the catch is still made up of the two larger *Barbus* species, *B. paludionosus* and *B. trimaculatus*, mormyrids, cichlid fingerlings and *Clarias* fingerlings. The *Clarias* fingerlings, known as *Popa*, are the most valuable part of the catch, and in shallow areas far from the deeper waters (such as the termitaria floodplain) this fish is reportedly the main catch.

The fish that are caught are generally dead by the time they are retrieved from the net. This is largely due to the gradual exhaustion caused by the fish being unable to escape the water current. Even hardy species such as *Clarias* quickly perish. Many of the fish begin to spoil due to the warm water temperatures (>25° C) at that time of the year, and coupled with the debris, the catch is not an appetizing sight. Laborious sorting and cleaning is required so separate debris from fish. Spoiled fish are mostly sundried together with the rest of the catch. The state of putrefaction does not result in any discarded fish, though once sun dried, very bad batches will fetch a lower price. The very smallest fishes, impossible to thoroughly separate from the debris, are kept apart and dried as a product called 'baby *lila*', which fetches a low price and is frequently used as chicken food. Therefore the use of the very fine mosquito mesh is more due to its availability than for its catch of tiny fish.



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Fish and debris tumbling around in the 'cod end' of a sola net

It has been falsely assumed that in Bangweulu the increased use of mosquito net *solas* was due to diminishing catches and a reduced size in fishes due to fishing pressure. However, as the fish stocks appear healthy, the primary reason for their adoption seems to be that the weir fishing season has been extended because these nets allow an earlier start, and because of their ease of construction. Another factor making this gear popular is the occasional bumper harvest of young *Marcusenius*. Thousands of these fish, with catches weighing up to 25kg per night, can be caught in just a few *solas*, whereas baskets cannot hold that much fish. These catches are mostly infrequent, and are enjoyed by only a few fishermen in good areas. They are nevertheless widely admired, and reinforce the popularity of this fishing method. A reduction in the availability of mosquito nets could easily result in a reduction in their use, though substitute materials such as shade cloth could rapidly be brought in as more costly substitutes by traders.



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Part of a night's bumper catch of fish from a sola net

This gear likely results in the greatest portion of bycatch of all the gears used in the system. Any organism passing by the weir can get trapped in the nets. Species observed killed in the nets include frogs and toads, aquatic beetles and large numbers of aquatic snails. However, snakes (especially pythons), monitor lizards and smaller mammals may also become trapped. Netting discarded at the end of the fishing season is mostly aesthetically detracting, but poses only a minor hazard to wildlife as it deteriorates rapidly.

Gill nets (*umsumbu*)

This gear, easily the most important freshwater fishing gear in Africa, is widely used in the Bangweulu swamps. Small mesh sizes are used, and this reflects the small size classes and species of fish that make up the bulk of the fish fauna of this system.



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Gillnets are folded and hung up when not in use. Note the sandal foam floats and clay ball weights

Construction, maintenance and lifespan:

The type of gillnets used are almost exclusively multifilament nylon gillnets. Monofilament nylon gillnets ('grass/glass nets' in Bangweulu), increasingly common in other African systems, were very rarely encountered during 2011, but in 2012 they became very popular, with most fishers owning at least one of these nets.

Gillnets are readily available at shops in the villages, and are very inexpensive (ZMK6000 - 10000, USD 1.10 -1.90). Small mesh sizes are most popular, going from a minimum of 1 inch stretched mesh, through 1 ¼ inch, 1 ½ inch, 2 inch and 2 ½ inch, to a maximum of 3 inch, and very rarely 3 ½ inch stretched mesh.

Monofilament nets are more expensive (ZMK 120 000 -150 000, USD 23.20 – 28.95 for 200m 3-inch), and are brought in by traders from the border with Tanzania. These are only available in larger mesh sizes (2 ½, 3, 3 ½ and 4 inches). Four inches and above is too large a

mesh size to catch the cichlids, and catfish that large are also too rare to justify the use this size netting.

The nets are hung from a nylon cord and attached with nylon gillnet twine. An even hanging ratio is used, and the hanging ratio is not changed in order to catch different fish species. The nets are made up with the fisher in a seated position, with the feet being used to stretch the mesh to the correct spacing. Twine jigs are made from two bicycle spokes. Only every fourth or fifth netting square is attached to the float and bottom lines, and this is done to make the net feel 'softer' to any fish encountering it.

Floats are traditionally made from the large cork thorns of a local tree (*Kalunguti*). Plastic sandal foam is a more common material now, and traditional floats are rarely seen. The sandal foam is brought in by traders in the form of factory off-cuts from Tanzania.

Sinkers for the bottom line are made from balls of baked clay. Clay is gathered from the numerous anthills in the area, and rolled into a round or conical form around a stick. After drying they are laid in the coals of a cooking fire to bake. The stick burns away and allows the bottom cord to be passed through. Smaller mesh-sized nets used in shallow water often have no weights.

Very occasionally the nets are dyed with natural plant dyes to make them darker and less visible, though mostly the debris in the water rapidly discolours new nets enough for fishing to be effective.

The nets have to be cleaned daily by shaking off debris, and are regularly removed from the water to dry in the sun. Holes in the nets are not regularly repaired due to the ease of replacing a net. A net's average lifespan is two seasons, depending on how heavily used it is. Some abandoned nets are found lying on the plains at the end of each season, many still set in the water seeming to indicate that they had been forgotten. There is little gear damage to the nets apart from wear from repeated removal of fish. Lechwe antelopes, and very occasionally hippos can accidentally drag nets away if they walk through them.

Theft of a gillnet, or even removal of a fish from a net, is considered a very serious offence. Many fishermen use charms, and it is generally assumed that a net set in the water will bewitch anyone who may tamper with it. Thus nets are sometimes left in the water even if the owner departs to the village for some time. That way he is guaranteed some fish to eat when he returns, though a large portion of the catch will already be very spoiled.

Setting and fishing:

The most important season for gillnets is between February and May. During this time water levels and flows are good, and fish are very active. Through June to September, water temperatures are lower, leading to reduced fish movement and lower catches. Some gillnet fishing takes place again from October to December, though the very low water levels then

prevent extensive fish movements, and seine nets are the preferred gear. Gillnets are set to fish both during the day and during the night. They are usually checked only once a day, early in the morning. If there has been warm weather during the flooded season, indicating a greater diurnal cichlid catch, then nets can be checked twice a day.



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Checking a gillnet in the morning

The nets are usually set from a dugout canoe, but also by foot in shallow areas. Popular setting sites include along fish weirs (where fish move in the slightly deeper water created by the removal of turfs during construction), lechwe paths, among water lilies and on the edges of channels against vegetation.

The nets are set both parallel and perpendicular to the current. During the flooded season, gillnets are often set across the current if it is not too fast. If weights are not used, then the netting is often supported by submerged vegetation. The current is used to keep it vertical in the water.

In some areas fish are chased out of thick channel vegetation into gillnets (*kutumpula/kusakila*). This is done by mounting a large cup-shaped piece of wood onto the end of the paddling pole, which makes a deeply resonant splash when thrust into the water. I have observed this only once, deeper in the swamp near the swamp island of Bwalya Mponda. It is mainly done at night, and reportedly was a common noise heard by guests from Shoebill Island camp. This labour intensive practice of driving fish into nets appears to

have become less important in the Chikuni area, possibly due to a switch to more effective seine nets and monofilament gillnets.

Some older, more experienced fishermen are reportedly able to set their nets under papyrus mats. This apparently requires a laborious process of pushing the net along via a series of holes chopped into the papyrus. This is done when water levels are low, but the method was not used in the main study area.

Catch:

The multifilament gillnets harvest a wide- range of fish species and sizes. Most common in small mesh sizes (1 and 1 ¼ inch) are the two larger *Barbus* species and *Tilapia sparrmanii*. Medium mesh sizes (1 ½ - 2 inches) catch the 12- 18cm size-class of the larger cichlids, young *Clarias* and adult *Marcusenius*. Large mesh sizes (2 ½ -3inches) catch mostly *Clarias* and large cichlids, with a few larger *Marcusenius*. Interestingly, adult *Marcusenius* make up an important part of the gillnet catch, but catchability for juveniles seems very low for this gear.

The new monofilament gillnets on the other hand are not very selective and remove only large fish: catches are comprised mostly of large cichlids longer than 200mm and catfishes above 300mm.

Ctenopoma is a common wet- season catch, but due to their obligatory air- breathing needs, they always drown and often spoil in the nets. Other species are also prone to dying, and those caught shortly after the net has been set can be spoiled by the time the net is retrieved the next morning. These spoiled fish are not discarded, though they are rarely, if ever, eaten by the fishermen themselves. Fishers always pick the prime species and sizes for their own consumption.

The catch in a gillnet can be robbed by otters. Most commonly the heads of *Marcusenius* are chewed off, sometimes also blamed on large catfish scavenging. Crocodiles and hippos drag nets away in some areas, and scarecrows are sometimes put up to discourage these animals from moving through the fishing area.

Bycatch appears to be far lower than is usual for this gear. This could be due to the predominance of small mesh sizes and the rare use (in the past) of monofilament gillnets. I have only heard reports of pythons and water monitors becoming entangled. The small mesh sizes appear to never catch birds, even the cormorants that hunt and dive amongst nets. However, a jacana was caught in a monofilament net, and as these nets are largely invisible, one would expect a greater bycatch in this type of net. Juvenile crocodiles would be at risk, but are very rare in the system.

Hooks and longlines (*iindobane*)

The widespread availability of cheap hooks and nylon cord has propelled this very old gear to become one of the most important used on the floodplains today.

Construction, maintenance and lifespan:

The most common deployment of fishing hooks is in the form of longlines. These typically consist of 40- 50m lengths of nylon cord, with hook snoods at intervals of 1.2- 1.5m. This line is stretched between reed stems pegged into the plain at 10m intervals. The line is kept above the water level, with the snoods hanging down into the water. The snoods consist of a 40- 60cm length of nylon cord knotted to the main line on one end and to the hook on the other. The hook knot is tied onto the hook shank below the eye, enabling the hooked fish to twist without winding up the line. The hooks are bought in boxes of 100, in various sizes (standard j-hook shape with a single barb, shank lengths 1-5cm).

There are many variations to this form of setting hooks. Longlines are sometimes attached directly to vegetation, and shorter lines can be set inside very dense vegetation thickets. Sometimes a snood or two will be attached to a thick section of papyrus stem, and a couple of these will be deployed across a pool with minimal flow, where they drift untethered but are frequently checked by the fisher. In the dry season, catfish use 'breathing holes' (30- 70cm diameter gaps in the floating *imitafu* grass mats), and hooks are used here too.

The hooks and lines need daily cleaning, especially where a current in the water washes debris onto them. The hooks become blunt and rust through only after more than a year's use. The nylon cords also suffer sun damage, and thus a whole line will be discarded when it has reached the end of its lifespan. When not in use, longlines are neatly bunched together and stored.



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A bundle of folded longlines

Setting and fishing

The length and make-up of the longline depends on the type of area being fished (floodplain, water-lily pond, reed bed fringe etc.). Once this has been selected the lines are fastened to the vegetation or to reed stakes pushed into the ground. These are mostly green reeds. The main line is most commonly set above the water level. The long lines of hooks used on the open floodplain are set with the hooks outside of the water for baiting.

The hooks can be baited with a variety of baits, most importantly earthworms, but other popular baits include the large water snail, washing soap bar, pieces of fish and scarab beetle larvae. All baits except earthworms are cut into small blocks approximately 7x7x7mm. These are put onto the tip of the hook. Two different earthworm species are used: a large black earthworm found in damp topsoil, and a thinner, semi-aquatic earthworm found in floating mats of vegetation. The latter is interesting in being square in cross-section.



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Children collecting earthworms early in the morning. During April the worms migrate across the surface of the islands

Once all of the hooks are baited, the line is lowered into the water (in the case of the standard longline). This is done late in the evening, and prevents small diurnal species from removing the bait. The longlines are often set across the current moving over the plains at the peak of the floods, and in these conditions the bait is usually held in the top few centimetres of water, rather than allowing the snoods to be pulled by the current. Catfish take the bait near the surface, and are hooked as they turn around to return to the bottom.

The lines are checked at dawn. The fish are almost always speared before they are lifted into the boat to unhook. The spear usually severs the spine, and immobilizes the fish.

Occasionally fish are caught during the day when they take bait remaining from the previous night.



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A catfish hooked on a longline suspended above the surface

Catch:

The catch on longlines consists almost exclusively of catfishes. The majority of the catch is made up of *Clarias gariepinus* and *Clarias ngamensis*, with occasional catches of *Clarias stappersii* in the swamp channels, and rarely large specimens of *Clarias theodora*. The only non-clariid occasionally caught is *Serranochromis* sp. 'nsuku'.

Sizes of the catfish caught vary, but generally the catch does not contain any young-of-the-year until late in the season (October to December). If one quarter of the hooks set have caught fish, it is considered a very good catch.

The only bycatch reported is of terrapins in the main Lukulu channel at the neck of the delta near the village. A juvenile crocodile is also known to have been caught albeit "a long time in the past". The nylon lines spanned across the surface of the water presumably pose a hazard to low-flying birds, and are thought to play a role in discouraging African Skimmer (*Rynchops flavirostris*) birds from utilising the area. Occasionally lechwe antelopes and hippos will drag a longline until the hook or snood breaks, though serious entanglement is uncommon.

Notes

The practice of using green reed stems to secure longlines has undoubtedly led to the propagation and extension of *Phragmites* reed beds around Chikuni. Once the plains have drained these stakes can be seen sprouting, and many establish into small reed beds. Some fishers have expressed concern for this, but it is unlikely that a change to using the less accessible dry reeds will occur. Encouraging the removal of stakes after fishing is a possible management option.

Seine nets (*mukwawo*)

The seine net, as used by the Chikuni locals, is a very important dry- season gear, most commonly made from mosquito netting. It is used almost to the exclusion of other gears from June to November, and supplies fish to the limited fresh fish trade around Chikuni and in the village. During 2012 there was a huge increase in wet-season seine netting by immigrant fishermen.

Construction, maintenance and lifespan:

The seine nets used in the study are large and need a team of fishers to operate. They vary in length from 35 to 50m, and rarely exceed this.

The most common netting material used by local fishers is mosquito nets stitched together. Occasionally pieces of shade cloth or sardine netting from Lake Tanganyika are also incorporated. The nets are sewn together in the village, where an old man can sometimes be seen using a foot-powered sewing machine near the road. A 1-inch multifilament seine-netting material ('six ply' or 'nine ply') is sometimes purchased at great cost from netting originating in Tanzania, and is used by some of the more successful groups of fishermen, but especially by immigrant fishers from deeper in the swamps. This netting is strong. Rarely, a seine net will be constructed from small-mesh gillnets stitched together. This is labour intensive and few fishers make the effort. They are also not as durable.



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A thick mesh seine net being hauled in

The nets have a shallow 'cod-end', and in the case of mosquito nets contain many folds where the netting has been bunched together. This is called *indumba* and the explanation given by the fishers is that the fish swim against the folds of this 'pocket' and thus remain inside the cod end trying to push their way out. The centre of the net is marked with a large buoy.

The two 'wings' are made from the same netting panels, and are attached to a pole on each end. Each end of the pole is attached to the main drag line made from strong rope. The dimensions of the net are approximately 35-50 metres in length, with a depth at the cod end of 5-7m and a depth at the wing ends of 1-2m. The drag ropes are also 20- 30m long. Nets made from '6/9-ply' seine net material can be larger, depending on how much material can be bought, as they have less drag in the water. The drag produced by the fine mosquito netting limits their size. The net sizes currently used can be bundled transported on the back of a bicycle or in a narrow dugout canoe.

Large floats are used to keep the net on the surface. These consist of large pieces of sandal foam, plastic bottles and sometimes pieces of papyrus leaf stem. They are placed at intervals of about one metre. Weights consist of large baked clay balls or pieces of brick or concrete rubble held to the bottom line by a cloth bag. Comparatively few weights are used, or else the net would be too difficult to haul in and the material would come under strain. The spacing of weights is 2-3m apart for mosquito nets, and possibly contributes to some fish escapes.

Seine nets need constant repairs, especially those made from mosquito netting. Holes develop easily, and these tears are stitched shut or have patches sewn over them. The risk of tearing is one of the reasons why pools are carefully cleared before the nets are used. During 2010 there were two reports of a hippo breaking through a seine net while it was being retrieved. Another interesting note is the malicious destruction of a seine net by elephants in September 2010. The net had been left outside a fishing hut while the owner was on an errand in the village. During his absence the net was completely shredded and destroyed. Malicious damage to property is common in the region, where elephants are harassed for their crop-raiding habits.

Setting and fishing:

The use of seine nets is largely dependent on the availability of shallow (1-2.5m deep) pools, also referred to as lagoons. Once a pool has been identified, much of the aquatic vegetation, especially water lilies, is cleared from the pool. This is done using sickles tied to paddling poles, and the immigrant groups use a large home-made scythe. Later in the season, when water depth is less than 60cm much of the lagoon vegetation is cleared by feeding and trampling lechwe antelopes.

Dry season seine netting is done most commonly during the night, though daytime seining is also common. Lunar conditions are important determinants of fishing catches and effort, with catches of mormyrids being highest on dark nights. A seine net is usually hauled between four and six times a night, at intervals of one to four hours. Daytime hauls can vary between two to eight hauls, and usually take place from late morning through the afternoon. Cool air temperatures at night can discourage fishing at night, and then little effort is made during the daytime when cold conditions are prevailing. If a group has fished hard during the night, they will also rarely fish during the daytime as they rest. During early 2012 (end of wet season) the immigrant groups fishing with seine nets hauled their nets exclusively during the daytime.

Typically a seine net is set along one edge of a lagoon and left there for a period of time. This allows fish to resume their natural movements through and around the lagoon. The net can be left set out for periods varying from 20 minutes to two hours, before it is hauled in. Occasionally a second haul is made immediately following from the last. Allowing a pool to 'rest' before hauling the net appears to be particularly important when water levels are high, when fish easily find refuge in surrounding vegetation or leave the pool. Mormyrids are very sensitive to disturbance, and absolute silence is apparently essential in ensuring a good haul of 'bottle fish/*mbubu*' (*Mormyrus sp.*) when they come out of hiding in thick vegetation. This fish hasn't been recorded from the Chikuni area, but their habits are well known from the Luapula and Chambeshi areas.

The seine net can be hauled either from dugout canoes or from the bank. Large, stable dugouts with wide bottoms are popular for early season seining (May to July), when water levels don't permit easy seining from the bank. The shortfall of such canoes is filled by fibreglass banana boats, especially by immigrant fishers. The number of seine nets in use by locals increases drastically once seine hauling from the bank becomes possible.

The larger mesh size seine nets have a more rapid haul rate. As a result, most of the nets seen in use during the early part of the seining season (May to June 2011, and March to May 2012) were of this type, with mosquito net seines becoming increasingly common as the season progressed. As the water volume decreases, fish become more concentrated, which increases the effectiveness of the mosquito net seines.

An interesting note on seine netting is that during August and early September 2011, the *Chipupila* of Fibili fishing camp near Chikuni put a ban on daytime seining. At this time there were many people in the camp, and more than five seine nets in use in the same pools. The reasoning for the ban was that daytime seining was disturbing the night-time muntesa (*Marcusenius*) catch. Evidently the returns on daytime cichlid catches were not as good as on an undisturbed nocturnal haul of muntesa. This highlights the sensitivity of mormyrids to disturbance, as well as their economic importance.

Catch:

There are major differences in catch composition between 'large' mesh and mosquito mesh seine nets. The '6/9-ply' seine nets catch fish generally larger than 120mm, with the smallest species that makes up a good portion of the catch being the threespot barb, *Barbus trimaculatus*. Large numbers of the medium and larger size classes of cichlids form the bulk of the daytime catch, while at night adult *Marcusenius* dominate the catch.

The mosquito mesh seine nets catch a broader range of sizes and species, with comparatively few large adult cichlids by day, and a wider range of sizes of *Marcusenius* at night. Theoretically the mosquito seine nets should contain a large proportion of very small and juvenile fishes. This doesn't appear to be the case, and is most likely due to the clearing of vegetation where seine nets are used. From a boat, it is possible to see the difference in numbers of small fish (mostly *Aplocheilichthys* and small *Barbus*) between intact stands of water lilies, and those cleared for seining. The catches also show that the small fish caught are mostly 'open water' species such as *Barbus paludinosus* and the universally abundant *Pseudocrenilabrus* dwarf cichlid. Small fishes known to inhabit dense vegetation such as *Pollimyrus* are virtually absent from seine net catches when compared to the catch of a *mono* basket or *sola* net from a vegetated area.

The catch of *Clarias* is highly variable in seine nets; with there even being variation in whether they are caught at night or during the day. As the water warms up towards December, the 'young-of-the-year' size class (by now approx. 30cm long) are well represented in the catch. Larger *Clarias* appear to be able to escape from underneath seine nets.

Cichlids, especially *Tilapia rendalli*, are good jumpers, and considerable numbers can leap over the floatline of the net. For this reason hauling team members will enter the water and lift the net up at the surface and disturb the water to prevent these losses.



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Holding up the sides of a mosquito mesh seine net to prevent fish jumping

Spearing (*uChilambo* and *ukusopa*)

Spears become important for fishing at two times of the year: when water levels are very low in November and December, and during the catfish spawning run (*uChilambo*) in late December or early January.

Every fisherman keeps a spear throughout the season, mostly for removing catfish from longlines. However, when he intends to target catfish by spearing, he will usually prepare additional spears. These are constructed from varying sizes of metal rod or wire, sharpened to a point and often with serrations cut into the metal shaft to serve as barbs. This is pushed into a reed or thin piece of bamboo, and held in place with melted plastic and tightly bound with nylon cord.

There are a few pools on the floodplain that are well known for retaining large numbers of catfish as the water recedes. These pools are surrounded by thick floating grass mats. When water levels are low enough in these pools for fishing to commence (mostly in November), then a combination of seining and spearing the margins is used (*ukusopa*). Many people gather around these pools to fish, and are only encamped there temporarily. The spearing is done by thrusting spears blindly through the floating mud until contact is made with a fish. A second is then thrust down in case the first spear did not secure the fish well. Fishing is done until the pool is depleted of fish.

The fishing around these pools with spears appears to be quite a social event, with women, children and men all enthusiastically taking part. Many people come from the village just for the day to get themselves some fish. The whole event is overseen by the *Cipupila* of that area.

The Chikuni area is renowned for its *uChilambo* catfish spawning runs. When the rising water levels in the Lukulu delta first break the banks onto the floodplains, anywhere between late December and early January, huge numbers of adult *Clarias* (and also *Marcusenius*) swim onto the newly flooded grass to spawn. Though this event falls within the middle of the countrywide fishing ban, it remains a very important date on the fishing calendar. Huge numbers of fish are very easily speared in the shallow water, and some of the specimens are very large (2-6 kg).



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Crowds gathered to seine and spear a drying pool

Poison (Piscicide)

The use of poison to stun fish is an ancient form of fishing, and a great variety of plants containing alkaloids known to stun fish are known. In Bangweulu a large number of trees and shrubs are known to have these properties, and though only one or two are regularly used, the knowledge of the others is nevertheless passed on. In recent times, the most popular fish poison is a cultivated plant: *Tephrosia vogelii*. It is common in fields, where it is grown primarily as a fish poison but also because of its pesticide and nitrogen-fixing properties.



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Tephrosia vogelii- a popular fish poison grown throughout the area

Fish poison is prepared by pounding leafy parts of the plant into a fibrous mass. This is put into baskets, which are washed around in the water, releasing the toxic compounds. Fish poisoning is done where fish have limited space to escape the contaminated water. Such sites include river and stream sections with grass and wood barriers placed into them, isolated woodland pools and swamp channels cut off from the main water bodies. Therefore, fish poisoning is primarily an activity of the late dry season, when fish are concentrated in the least amount of water.

The method appears to be widely practiced, but at a low intensity. It seems to have decreased in importance in the swamp areas, at least around Chikuni. Here only two or three poisoning parties were organised, and catches were low. In Lavushi Manda National Park there is a lot of evidence that this method is widely used along the upper Lukulu River in the dry season.

Drag baskets (*ulwanga*)

Another gear that has in use is the lift-basket, *ulwanga*. This large, rigid basket is used exclusively by women and children, and is still popular in some areas. It was rarely seen in use around Chikuni, but it would definitely be an effective method of fishing the shallow, densely vegetated pools deeper in the swamps at the end of the dry season. This basket is shoved into densely vegetated water, with the opening towards the fisher. She stamps her feet, frightening fish out into the basket, which is lifted about ten seconds after it was put down. The catch is varied, but near Chikuni it consisted of small *Ctenopoma* and mormyrids.



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A woman fishing the marginal vegetation of a drying pool with an ulwanga basket

Digging

During years when water levels become very low (not in 2011), fish become stranded in large areas of grassy floodplain north of Chikuni. I have not visited these areas, and they are poorly served by accessible channels. These areas can be considered 'true swamp', typical of the Bangweulu Swamps: vast, flat, and lacking in channels, drainage lines, islands and other topographical features. When these areas dry out, fish are trapped under dense vegetation mats in shallow depressions. People find these refuges by watching bird activity, and if the vegetation is hauled out fish can be caught in great numbers. Fish are caught by hand and spear, and people are said to 'dig for fish'. Common fish are catfish and cichlids, indicating that these refuges are not entirely stagnant and deoxygenated.

Changes in the fishery in the period 1940's- 2000's.

There is no doubt that in the past, fishermen were not able to exploit the full potential of the fish stock available. Their main limitation was in their fishing gears, which were limited in availability and laborious to make. According to Lusenga⁴, gillnets used to be woven from root bark fibres of the Ng'ansa tree, *Brachystegia boehmii* (Lusenga, 2012). It took considerable skill to knot these nets, and being made of a natural fibre, they were less durable than modern nets. Hooks were made by village blacksmiths. An old fisherman interviewed stated that seine nets, already adopted at an early date by the Unga in the main swamp, had to be woven from fibres taken from old tyres.

Interviews with fishermen have revealed that there has been a shift from subsistence fishing to commercial fishing within the last two to three decades. Young fishermen in their mid-twenties recall their fathers fishing largely for home consumption and local trade, and the elderly *Chipupilas* interviewed confirmed that the fishing was 'not for business' and that 'there are many new things in fishing'. Elderly fishermen noting these changes did not express any views on how the resource would respond. Fishing 'companies' largely consisted of a father and one or two of his older sons or nephews as his apprentices. Fishing was done with less gear, and fishing trips were shorter in duration. Once the amount of fish needed had been caught, they would return to their villages to continue their farming activities.

This contrasts with the fishing that occurs deeper in the swamps, where Brelsford⁵ described the shift from subsistence to commercial fishing occurring on a considerable scale already in the 1940's. Possible factors that contributed to the late development of fishing for trade in the Chikuni area include the remoteness of the delta and floodplains and their situation on the very margin of the swamp. This represented a challenge to access: both by land and by water. Prior to 2008/2009 the road to the villages at the swamp edge (Muwele/Ng'ungwa/Mwelushi) was rarely open during the wet months, and water access to the main swamp and the Luapula River trading posts is only feasible at the peak of the floods. This likely kept the trade in fish from the floodplains and delta relatively localised, as access to the main roads and the main swamp channels was limited. The roads have improved in recent years, but the waterways, if anything, have become only more challenging to negotiate with the artificial channels dug in the past no longer being maintained. Access to the market is one of the most important factors influencing the fishery.

Fishermen have stated that there has been an increase in the number of fish weirs around Chikuni, due to the change to more commercial fishing, demand for fishing areas and

⁴ Lusenga, W. G. 2012. *The united chiefdom of Chiundaponde*. Unpublished.

⁵ Brelsford, W.V. 1946. *Fishermen of the Bangweulu Swamps: a study of the fishing activities of the Unga tribe*. The Rhodes-Livingstone Papers: Number 12. Manchester University Press.

population growth. While in the past a marginal area could have yielded sufficient fish for subsistence, there will be an increasingly greater focus on the quality of a fishing area for business prospects.

New fishing gears and trends (2012 season)

The fishing in the area changed considerably between 2011 and 2012. This is both as a result of changes in gear, as well as changes in the people using these methods. The greatest change in gear was the widespread adoption of monofilament gillnets, or 'grass nets'. In 2011 there were only two or three fishers using a total of 5-7 of these nets, while in 2012 almost every fishing group had at least one of these nets, raising the number in use to easily more than 100. While seine nets are not a 'new' gear, there was a huge increase in their use during early 2012, mostly by 'immigrant' fishers.

Fishermen 'from Luapula'

The flooded season during 2012 saw a strong influx of fishermen from Luapula Province of Zambia. These were mostly full-time fishermen of the Unga tribe, and originated from areas such as Nsalushi Island (Chief Nsamba) near the Chambeshi delta, all the way across to the Lake Bangweulu at Samfya. The majority of groups had come from the chiefdom of Kasoma Lunga, well outside of the Bangweulu Wetlands boundary.

These groups used seine nets, often of the large, strong '6-ply' and '9-ply' type, and the now popular monofilament gillnets, or 'grass nets'. For some of the people from the lake, these are not the gears they are accustomed to using, with one group only recently having changed from fishing on the lake for the kapenta-like '*chisense*' using tilly-lamps at night.

The immigrant fishermen customarily move about during the flooded season, seeking areas of shallow enough water to fish. Nobody was completely clear as to why so many of them had come during 2012: was it because of high water levels pushing them further to the swamp margins? Was it because there is more fish around Chikuni? Answers given to queries in this regard confirmed that it was a combination of factors. There had indeed been heavy rainfall and flooding in the Lunga area of the swamp, rendering most of their fishing areas unsuitable for seine netting. However, the large majority of fishers had never been to the Chikuni area previously. These stated that they had heard from traders and two or three groups who had come to fish the year before, that there were still good numbers of large breams to be caught in the channels.

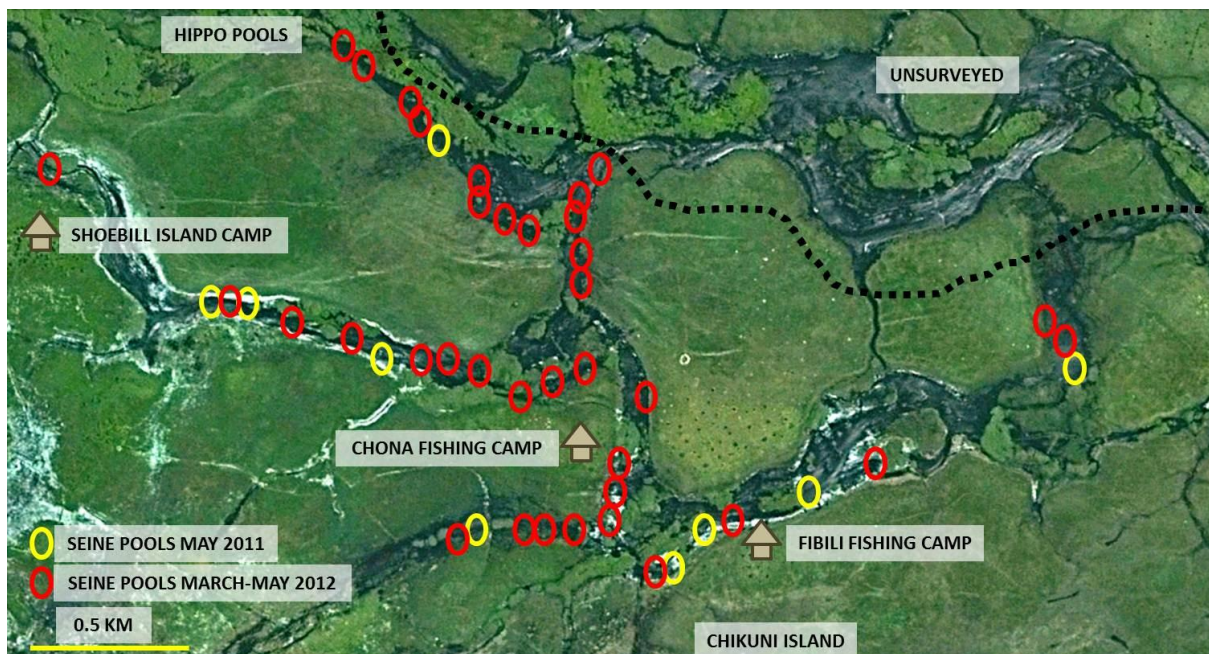
The immigrant fishermen tend to be generous, friendly and inquisitive. Being new in the area, many came to Chikuni just to see the infrastructure there. Others commented on the animals, and took a closer look at elephants and buffalo. Their friendly attitude was no

doubt because they were fishing in another's area, and they had no reason not to cooperate with the fish research activities.

The locals are very concerned. They have seen the amounts of fish being caught by the immigrant fishermen, and there are now very real concerns that there will not be enough fish left for many of the local fishermen who only arrive for fishing during the dry season. During March to May, the local resident fishermen were all using their fish weirs, and resent other groups having a 'head start' on the seine net fishing.

It appears that until recently, the channels of the Lukulu delta were a comparatively unexploited refuge for fish. Seine nets have only come into use over the last decade (in the study area at least), with great intensification of effort during early 2012. The recent exploitation of the deeper channel habitats using seine nets and the targeting of large fishes using monofilament gillnets, are probably the last major change in the fishery around Chikuni, with no major component of the fish community remaining unexploited.

By June the immigrant fishers had mostly left back to their home areas, and apparently fish numbers were not great in the period of May to June. Attempts to remove these immigrant fishers were made after reports were taken to the chief. However, nothing came of these actions, and it seems that the immigrants left of their own accord in the end. It will be interesting to see whether they return every year, and what effect they have had on the cichlid stock that becomes important to the locals later in the season.



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Map of the delta edge near Chikuni, highlighting the proliferation of seine netting between 2011 and 2012. Each pool represents a group of fishermen, as most seining companies must pay for each pool they use. Shallower rather than deeper areas are preferred.

Gears used in the context of fish sustainability

Through many decades of fishing, the fishers of Bangweulu have adapted all their methods to most efficiently catch the available fish at different times of the year. While this high yield ensures maximal economic output, the question is whether this output can be sustained into the future.

While the adaptations of the fishes seem to make the stock quite resilient (see note on fish biology in the introduction to this document), some fishing gears may have a more destructive effect than others.

The Zambian fisheries regulations state that for the Bangweulu area gillnets below 2-inch mesh size and seine netting are prohibited. If these laws were enforced, the small benefit certain fishes would enjoy would be far outweighed by the economic loss to the fishers. In addition, it could result in more targeting of larger fishes, while the current harvest of small fishes is ecologically less damaging. Therefore a review of the regulations where they apply to floodplains is long overdue.

The annual fish ban (December to February), though unpopular in Bangweulu, falls over a good time. The majority of fishers attend to their farms, fishing mostly for home consumption. Vulnerable breeding fish should be protected at this time, but the ban is rarely enforced in the vast fishing grounds. The limit on fish trade during this time definitely reduces effort in the fishery.

Some fishers have noted a decline in catches. This is not necessarily a sign of a reduction in the fish stock, but rather that the same stock of harvestable fish is being shared between more people, who all perceive a decline in their portion of the catch.

Wherever possible, it should be ensured that the large adult portion of the stock is protected. These are critical to the supply of new juveniles. The ecology of the floodplain fishes allows heavy fishing of small fish and juveniles, but with limited deep water refuges, survival of adults shouldn't be compromised. This is particularly a problem with the spearing of large adult catfishes during the *uChilambo* spawning run.

In the past, catfish running onto the plains could be encountered during the daytime. The greater level of human disturbance pushes fishes to move predominantly at night, and even then fishers have complained of reduced catches during this time. They correctly attributed this to the available fish being shared between so many more people, and the change from subsistence to commercial harvest. The widespread availability of cheap LED torches and batteries has no doubt facilitated the harvest.

Fishers operating weirs very far from the delta and rivers are dependent on healthy stocks of juvenile catfishes. They have perceived declines in catches, which can be attributed to

less flooding and poor recruitment during 2012, but also due to high levels of spearing of spawning fishes. If the sentiments of these fishers could be harnessed to discourage others from persecuting large spawning adults, then it would go a long way towards preventing this practice.

Other gears that target a disproportionate amount of large adults are monofilament gillnets and '6/9-ply' seine nets. These gears selectively catch adult cichlids, and if the use of these gears continues to increase we should see a great reduction in the population of *mpende* (redbreast bream) and *nsuku* (largemouth bream). This is where the mosquito net seine 'paradox' lies: the catch from this gear closely matches the true size and species compositions of the fish community present in the area, and is therefore less likely to be harmful to any particular component of the community than a more selective gear. The larger mesh seine focusses too much on large broodstock and leaves certain abundant species unharvested.

Fishers have recognised the potential threat to the large bream stocks, and it remains to be seen whether any actions can be taken to discourage the use of the 'new' monofilament gillnets and halt the proliferation of seine nets, especially by fishers from outside of this area.

In terms of habitat effects, most of the fishing methods used have little effect. The fish weirs may interrupt the very flat topography of the grazing lawns, but the main potential effect they pose is discouraging grazing and altering the flow of water over the plain. The inadvertent propagation of reed beds through longline fishing stakes is also a potential concern. The only gear that causes habitat destruction is seine netting. The clearing of pools definitely has a negative effect on fishes by removing the plants that fish require for food and shelter. Ecologically however, the seine netters are only doing what huge pods of hippos would have done historically, and the vegetation recovers rapidly.

The largest factor to influence any future changes in the fishery, and its sustainability, will be access. The exact effects of improved transport systems and roads into this area will have to be carefully assessed. Road access into the area is rapidly improving, and there will be both positive and negative effects on the conservation area. While the local economic growth linked to road infrastructure may put more pressure on the fish resource, it will also present greater opportunities for the rapidly growing population of Chiundaponde chiefdom, many of whom may find alternatives to fishing.

Fishing and tourism

The potential clash between tourism development ideals and the local fishing activities was one of the primary motivating factors to understand the fishery. Despite its truly impressive nature spectacle, the Bangweulu floodplains will never be able to be marketed as an 'exclusive wilderness destination'. However, being able to see so much wildlife in close association with humans is something truly unique that can be promoted when marketing the area to tourists.

Visitors are quick to draw conclusions of overfishing when they see the gears in use, and the large numbers of people. Well-trained guides could go a long way towards enlightening visitors. What is usually a negative experience for visitors, could be turned into something very positive as they learn how this interesting fishery works. Visitors given a brief on the fishing life of the local inhabitants will also have a richer experience of their time in Bangweulu. This report ought to be useful in the training of tourism operators and guides.



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A well-presented tour and participatory tour of the fishing activities would undoubtedly enrich most visitors' experience of Bangweulu Wetlands

Table 1: The fishing calendar

	Weather	Water levels	Local Fishing methods	Intensity	Immigrant fishing	Fish biology
January*	warm, heavy rain	major rise	<i>chilambo</i> - fish breeding	low- farming and rain	?	spawning, disperse
February*	warm, light rain	stable to slight rise	gillnets and hooks	low- mostly subsistence, hook catch good	seining begins	juvenile disperse
March	cool, heavy rain	rise, rain water floods higher areas	gillnets and hooks	low- weir maintenance, subsistence catch	seining intense, gillnets	juvenile growth
April	warm, rain ends	stable, rain water dries	weirs- <i>sola</i> , gillnets	low- awaiting fish movement	seining, gillnets	juvenile growth
May	warm, wind begins	receding, shallow floodplains dry	weirs- <i>sola</i> and <i>mono</i> baskets	high- fish moving, focus on weirs	left area	migration, high mortality
June	cool, windy	recedes slowly	weirs- <i>mono</i> baskets, seining	high- weirs drying	?	migration, slow growth
July	cold, windy	recedes slowly	seining	low- water cold	?	slow growth, little movement
August	cool, windy	recedes slowly, deeper plains dry	seining	medium- water cold	?	slow growth, little movement
September	warm, wind begins	recedes faster, channels deep	seining	high- water warm	?	growth, gonads start developing
October	hot, calm	recedes faster, channels shallow	seining, gillnets, poison, spearing	high- water warm, fish concentrated	?	gonads ripening, movements
November	hot, cloudy	recedes faster, channels low	seining, gillnets, poison, spearing	medium- little water	?	gonads ripening, movements
December*	hot, rain begins	lowest levels, slight rise at end	seining, gillnets, poison, spearing	low- little water, farming starts	?	gonads ripe, some spawning
* Government fish-ban period						

Chapter 3: Fishes

The fish communities of the Bangweulu region consist of typical floodplain groups, with many having wide distributions across floodplains in central and southern Africa. The fish are diverse, but the challenging floodplain environment is a constraint. A total of 44 species were recorded, from 12 families. Upon closer examination in the laboratory, some of the small fishes may consist of multiple species that were difficult to distinguish in the field. Fish collected, seen or otherwise recorded during the course of the project in Bangweulu Wetlands are listed below following the groupings of Skelton (2001).



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Young Marcusenius mormyrids, called uluya locally. These interesting fishes feed on invertebrates living in the bottom sediments. The rich layer of organic sediment resulting from the lechwe grazing no doubt contributes hugely to these and many other fishes' food sources

Family Mormyridae (Mormyrids/Elephant-snout fishes)

Mormyrus sp.- 'mbubu', Western Bottlenose/Bottle Fish

This large mormyrid (400mm and longer) is known from the Bangweulu region, where it inhabits deep channels near the Luapula and Chambeshi rivers. No evidence of this fish species was found anywhere near Chikuni, but a 70-year-old fisherman distinctly remembers them occurring in the Lukulu Delta during exceptionally high-flood years. It likely still persists in the area, but not reported from catches during the study period.



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*A view onto Nsalushi Island (Chief Nsamba) from a deep-water channel forming part of the Chambeshi Delta, on the northern boundary of Bangweulu Wetlands. Some species occurring in these deeper waters, such as the mbubu (*Mormyrus* sp.), are uncommon or absent in the core study area as the shallow habitat is less suitable.*

***Cyphomyrus discorhynchus*- 'Icimpumwe', Zambezi parrotfish**



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Distribution and habitat: This fish species occurs throughout the Lukulu delta and swamp, where it inhabits vegetated channels.

Size and biology: Shoals of adults caught in June contained fish measuring 80- 150mm, while juveniles (<80mm FL) were seen in catches in November and in the later part of the flooded season (March to May).

Importance: The species appears only sporadically in fishermen's catches, and appears to move in shoals, often together with adult *mintesa* (*Marcusenius macrolepidotus*). Mostly recorded from seine net catches where it is occasionally a significant part of the catch. Also caught in *mono* trap baskets and in mosquito net *solas*. It is mostly marketed as the more abundant *mintesa* (*Marcusenius macrolepidotus*), either smoked or sun-dried if small.

Notes: Mwape (2003) interpreted the Bemba name of this fish as '*Chipuma*'-'*mabwe*', 'hitting'-'stones'. Most local fishers could not explain the origin of the name, until one senior fisherman stated that the word '*cipuma*' refers to the hump on its head and speculated that the fish could use this hump to push its way through the thickest vegetation, or perhaps even rocks. The English name of related small mormyrids (*Pollimyrus*) is 'stonebasher', and this is likely a translation of the Zambian vernacular name for the group.

***Marcusenius macrolepidotus*- 'Mintesa', Bulldog**

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Female Marcusenius macrolepidotus (note straight base of the anal fin)

©R. Bills/SAIAB

Male Marcusenius macrolepidotus with indented anal fin base

Distribution and habitat: This nocturnal species, possibly the most important fish in the Bangweulu floodplain fishery is widespread in swamp and floodplain habitats in the Bangweulu Wetlands. It favours shallow water where there is aquatic and emergent vegetation for it to hide amongst during the daytime. During the flooded season it forages and spawns widely on plains at night, returning to hiding areas in thick vegetation during the day. Larger fish retreat to channels in the delta, but can still be found in shallow (<50cm deep) water.

Size and biology: This medium sized species (typically 80-200mm in length, with weights up to 150g) appears to have an extended spawning season and rapid growth rate, with a definite flood season peak in spawning. Small groups of large adults can apparently be observed in very shallow water at night, spawning during the *uChilambo* period, noted for its catfish runs. Sexual dimorphism is shown in the anal fin, where male fish have got a distinct indentation at the base of the fin. The indentation becomes apparent at maturity, already at a small size (120mm). Male fish attain a larger size than females (fish over 200mm are considered large).

This fish clearly shows the single gonad typical of many mormyrids, where the testis or ovary forms only on the right-hand side of the fish's visceral cavity. Fish sampled from October to November were found to be maturing, and none of the gonads were ripe yet. Fish sampled in March had finished spawning, though some showed freshly spent gonads. A large size range of juveniles were observed in April, from fish that had already reached 100mm to some tiny 20mm long fish that could only have been spawned a few weeks earlier, perhaps after late rains in March. The species grows very fast.

Importance: As one of the keystone species in the fishery around Chikuni, they are caught by almost all methods throughout the year. During the flooded season they are caught in gillnets (mostly adults in mesh sizes 2-2.5 inches), mosquito net *solas* and in *mono* trap baskets. Juveniles are seldom caught in gill nets. Juvenile and medium-sized fish are very important in the fish weir catch, and in the low-water season from July to November the fish becomes the most important part of the nocturnal seine net catch.

Adult fish (120- 250mm) are gutted, scaled and smoke-dried after firming in the sun. Smaller juveniles are simply sundried, sometimes after scaling, and together with scaled *Barbus trimaculatus* form the bulk of the higher-quality *kasepa* dried fish product. A greater proportion of *mintesa* in the mix has a favourable effect on the price. This fish is predominantly marketed and consumed on the Zambian Copperbelt.

Notes: The *mintesa* can die off in large numbers if there is a heavy first flood pulse coming down the Lukulu River into the head of the delta. The fish come to the surface and breathe rapidly at the surface, occasionally with large mortalities. A possible explanation is oxygen-depletion in the water due to large amounts of organic sediments being stirred up by the floods and the resultant greater aerobic bacterial activity. Local fishermen claim that large amounts of ash from burnt reed beds acts as an irritant to the fish, and can also cause mortality. The lifting of papyrus beds by flood waters no doubt also contributes to the release of organic matter and anaerobic water. The onset of the rains at the end of 2011 was very gradual, and floods were not abrupt enough to cause any die-off.

The viscerae of this species have large fat deposits. When large catches are made, the viscerae are boiled and the oil at the surface is collected and bottled as cooking oil for home use. It is not traded. The juveniles are called *uluya*.

***Petrocephalus* sp.- 'Icele', Churchill**



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Distribution and habitat: This striking small fish is found in the Lukulu delta in vegetated, shallow channels.

Size and biology: Rarely exceeding 100mm in length, the tiny mouth on the underside of the head and bright silver and gold colours when fresh make this fish easily distinguishable from the other mormyrids found in the area.

Importance: It is rare in catches, and is captured mostly in fish weirs and mosquito seine nets.



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Measuring a catch of Pollimyrus (next species). The knife was used to keep the plate steady in the wind

***Pollimyrus cf. isidori/castelnaui*- 'Ishimba' Dwarf Stonebasher**



©R. Bills/SAIAB

Distribution and habitat: This common fish is very widespread in the Lukulu delta, and in streams and rivers. Its habitat comprises vegetation around swamp channels, and in forested streams such as the Lulimala at Nkondo headquarters, it lives in thick tangles of tree roots hanging into the water. It has been collected from roots in very fast waters in the Lulimala stream, indicating that.

Biology and size: This is the smallest mormyrid in the area, never exceeding 80mm in length. Like most of the species in the area, this fish likely breeds during summer. Breeding fish were caught in baited experimental fish traps in the pool in front of Chikuni in January 2011, and fish with ripe eggs were also seen at the end of the rainy season at Chikuni in late March 2012. This, and the large size range caught throughout the year, indicates that the breeding season may be extended over many months in summer. It seems to have strong swimming abilities, as it was collected from fast-flowing sections around fallen logs in the Lulimala stream.

Importance: Numerically this fish is very important in catches, but its very small size makes it contribute little to the overall weight of catches. Large numbers are caught in fish weirs in mosquito *solas* and *mono* trap baskets, and also in mosquito seine nets at night. Together with *Pseudocrenilabrus philander*, this fish makes up a large portion of the lower-quality *kasepa* sundried fish product.



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Family Cyprinidae (Cyprinids)

Genus **Barbus**: This is a very diverse group in the region, and most species are shared with the Okavango/upper Zambezi systems. The collective term used for barbs is *misenga*, with *Barbus trimaculatus* being the only common species with its own vernacular name, *mushipa*. *Barbus trimaculatus* and *Barbus paludinosus* are very abundant, relatively large barbs (80mm and 130mm respectively), which makes them important to the fishery. The other smaller and rare species are far less important, and most catches are made in mosquito net seines and mosquito *solas*. Traditionally they would only have been caught in dipping baskets or with poison.

Barbus neefi- Sidespot barb



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Distribution and habitat: This barb was collected from the Lukulu rapids and in the Lulimala stream at Nkondo. It was not found in swamp habitats.

Size and biology: This is a small to medium sized species (40-60mm), and is uncommon.



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***Barbus bifrenatus*- Hyphen barb**

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Distribution and habitat: Collected from both floodplain and stream environments. On the plain it appears to prefer vegetated water adjacent to channels with flow.

Size and biology: A small, robust species attaining a length of 60mm, it is an important prey species, found inside the stomachs of predatory cichlids and catfishes during the summer.

Importance: Caught in gears that use mosquito netting as mesh. This is the second most-common small barb caught in *sola* nets around Chikuni.

***Barbus brevidorsalis*- Dwarf barb**

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Distribution and habitat: A species from stream and woodland pool environments, also encountered in the delta around Chikuni.

Size and biology: A very small species, the dwarf barb is mostly less than 30mm, though larger individuals up to 40mm have been collected.

Importance: This species forms a large part of the catch in *sola* nets that are used in fish weirs very far from the rivers. One bag of small dried fish brought from the woodland fish weirs contained almost exclusively this species (small catfishes were in a separate bag). These areas, which are flooded for only 3-5 weeks, are 6-15 km distant from the nearest permanent water. This wide dispersal ability also accounts for its presence in remote woodland pools where only the *Nothobranchius* killifish populations survive the pools drying out.

***Barbus fasciolatus*- Red barb**

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Distribution and habitat: This colourful barb occurs on the margins of streams and rivers, but not on the floodplain. Elsewhere it is known to inhabit swampy habitats (Skelton 2001).

Size and biology: A small delicate barb, up to 70mm in length, it appears to swim close to the bottom and against the sides of streams, not in open water.

Importance: Was seen caught in baited bottle traps set by children at the Lulimala Bridge. Otherwise likely to also be caught when streams are poisoned and in stream fish weirs that use mosquito netting.

***Barbus radiatus*- Beira barb**

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Distribution and habitat: An uncommon barb occasionally encountered near swamp channels in the Lukulu delta.

Size and biology: A fairly large barb, individuals up to 100mm in length have been seen, though the majority are probably young fish around 60mm long.

Importance: Only two adults were seen from seine nets, and smaller fish were seen in *sola* net catches when flows through the fish weirs were still high.

Notes: Fishermen from deeper in the swamps recognized the fish and said it occurred in greater numbers there. The name they used for it was *Inchunga*. One local fisherman also mentioned the name *Chitulu*.

***Barbus haasianus*-Sickle-fin barb**



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Distribution and habitat: This widespread barb is found in grassy shallows in streams (Lulimala), dambos, woodland pools and in the swamps around Chikuni.

Size and biology: The smallest barb in the area, with individuals rarely exceeding 30mm in length. Males have elongated pelvic and anal fins, and over summer are tinged with a bright pink-orange. At other times of the year the fish are brown in colour.

Importance: Seen in *sola* net catches, but easily overlooked. Definitely part of the catch when woodland pools are poisoned, though collecting such small fish from amongst the thick grass must be a challenge.



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Sorting a catch for measuring the different species separately

***Barbus trimaculatus*- 'Mushipa', Threespot barb**



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Distribution and habitat: This species occurs throughout the area in swamp and floodplain habitats. It was not collected from the Lulimala stream and Lukulu River, though it likely occurs in slower-moving sections. It favours channels and deeper pools, depressions and channels on floodplains, usually where there is some water movement.

Size and biology: Attains 130mm, and males are distinctly smaller than females (fish greater than 100 mm are all female). Gonads begin to ripen in November, and by March the gonads are completely resorbed, indicating that spawning occurred well before then. No small or immature fish were observed from August- December, indicating a limited summer breeding period and rapid growth. Typical sizes are 70-90mm for males and 100- 120mm for females.

Importance: This is a very important small species, caught in small-mesh gillnets (see *Tilapia sparrmanii*). It is also caught in basket traps, *sola* and seine nets. The high oil content of this fish makes it a popular eating fish in its dried form. The fish are carefully sundried because of their high oil content, and are a popular addition to higher grades of dried *kasepa* product. Fishers noted a marked reduction in the population of this species in early 2012. The fact that these fish appear to have only a very short spawning period makes them more sensitive to fluctuations in flooding conditions, which were certainly not ideal in the 2011/2012 rainy season.



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***Barbus eutaenia*- Orangefin barb**



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Distribution and habitat: This barb occurs exclusively in streams and rivers, and is common in both the Lukulu and Lulimala rivers, where it favours shady, deep water near trees and rocks.

Size and biology: This is a large barb that reaches sizes of 120-130mm. It has a large mouth, and may be more predatory. The thick black line down its side is even darker in life, and may serve as camouflage in the dark, forested streams it occurs in. Many of the other fish species in these streams have similar colouration.

Importance: Likely only a catch when stream sections are fished with poison and traps.



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A typical section along the upper Lukulu River, inside Lavushi Manda National Park. The midrib of the fronds of the Raffia palm on the right are popular paddling poles in the swamps

***Barbus multilineatus*- Copperstripe barb**



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Distribution and habitat: This ubiquitous barb lives in a wide variety of habitats, from swamps to isolated pools and in dambos.

Size and biology: A very small fish, most are between 25mm and 40mm in length. It is very abundant wherever there are grassy shallows. Young fish have bright red fins, which pale to orange in adults. Some individuals (possibly a different form or even species) have a broad orange band running from the eye right through the fork of the tail, and less pronounced black stripes.

Importance: Very common in catches from mosquito mesh *so/a* nets, and it probably makes up the greatest proportion of small barbs caught. It is not very valuable though, and goes into the '*baby lila*' mix of dried fish, which fetches the lowest price.

***Barbus afrovernayi*- Spottail barb**



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Distribution and habitat: Found in streams and in the delta.

Size and biology: Small, rarely exceeding 40mm. During the flooded season some individuals have a purple iridescent colour on their sides.

Importance: The fish is caught only in mosquito net *so/a* and seine nets.

***Barbus paludinosus*- 'Misenga', Straightfin barb**



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Distribution and habitat: This fish occurs throughout the area in all inflowing streams, swampy streams, the Lukulu delta and swamp. It prefers shallow areas of open water, often outside of currents and near grassy cover.

Size and biology: The usual size ranges from 40 to 70mm, and a large size range of fish is found throughout the year, possibly indicating an extended breeding season. A few individuals reach large sizes (120mm), although these are rare.

Importance: This fish is caught in small-meshed gillnets and in seine nets, especially in shallow waters at night. It is also important in basket traps and *solas*. Interestingly, if a catch contains large numbers of barbs they are usually either almost exclusively *B. paludinosus* or *B. trimaculatus* and rarely a mixture between the two species. The two species may therefore be incompatible or not shoal together, despite inhabiting similar habitats. This fish has a lower fat content than *B. trimaculatus* but is still a significant addition to the better quality *Kasepa* product.



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Little egret with Barbus paludinosus catch

***Barbus kerstenii*- Redspot barb**



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Distribution and habitat: This species lives in both streams and swamp channels. Adults prefer deeper channels, and only juveniles are seen in catches from fish weirs.

Size and biology: A medium- sized barb (up to 80mm). The red spot on the gill cover is distinctive and lends the fish its common name.

Importance: A very minor part of the catch, with adults occasionally being caught in seine nets, and smaller fish (<50mm) are also found in catches from mosquito net *solas* (usually from weirs adjacent to channels).



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Chikuni Research Station- on Chikuni Island

***Labeobarbus* sp.- Yellowfish (South African name for the genus)**



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Distribution and habitat: This is the most common large fish in the upper Lukulu River inside Lavushi Manda NP. Juveniles were collected at the lower Kanyanga Falls on the Lukulu River, in a rock crevasse just above the falls. Adults were only observed when water levels were very low in November, above and below the upper Kupandalupili Falls, where they moved in small shoals patrolling areas of the large pools there. When the river was in flood in March 2012 this species was caught against the banks of large pools.

Size and biology: The largest fish collected was 550mm in length, and fish of 250-350mm are common. Fish in the genus *Labeobarbus* are known to be very slow growing and late maturing, which puts them at risk in areas where they experience fishing pressure.

Importance: Possibly caught illegally inside the park with poison and traps, although they would be most vulnerable to gillnet fishing. Members of this genus are popular angling fishes, renowned for their fighting strength. They are likely to be an important recreational catch-and-release angling species inside Lavushi Manda National Park. This fish needs a more appropriate English name.



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The fish are darker when the water is low and clear in the dry season.

***Labeo cf. cylindricus*- Redeye Labeo**



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Distribution and habitat: This fish was collected in strong rapids amongst water fern below the Kanyanga falls in the Lukulu River inside Lavushi Manda National Park. They prefer fast-flowing water with a rocky substrate.

Size and biology: This is a small to medium-sized, robust *Labeo*. The single specimen collected was approximately 150mm long. The photograph was taken after preservation in formaldehyde, and does not show its live colours, which were dark brown. These fish have a mouth adapted to rasping algae off rocks, and feeding tracks were seen on rocks in the waterfall plunge pools. A live *Labeo* was also observed amongst a mixed shoal of juvenile *Labeobarbus* swimming at the edge of a large rock in a pool below the Kupandalupili Falls on the Lukulu River inside Lavushi Manda NP. It was elongate in shape with clear lateral stripes.

Importance: Possibly caught illegally inside the park with poison and traps.

Notes: Related to the famous 'Luapula salmon' (*Labeo altivelis*), which was renowned for its huge spawning run up the Luapula river out of Lake Mweru. This Luapula/Mweru stock of this widespread species was fished to complete collapse, and is only very occasionally still found in tributaries.



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Family Distichodontidae (Citharines)

Hemigramocharax multifasciatus- Multibar citharine



©R. Bills/SAIAB

Distribution and habitat: Collected from the Lulimala stream at Nkondo in shallow areas of the stream shaded by forest.

Size and biology: A small species attaining a length of 80mm.

Importance: It is not abundant, and is likely only part of the catch when sections of the stream are poisoned and the fish drift up against grass barriers during the dry season (July-November).



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A barrier weir across the Lulimala Stream in the dry season. This would be used in conjunction with poison to catch multibar citharines and other small resident species

Family Characidae (Characids)

Brycinus peringueyi- Dwarf tigerfish



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Distribution and habitat: This striking fish was found in the upper reaches of the Lukulu, below Kupandalupili Falls, during the high water period in March 2012. None were seen when the water was low and clear in November 2011, though they could have taken refuge in deeper sections of the river. They appear to inhabit the main stream and deeper pools of the river. They are not found in the Lukulu Delta or in the main swamps, although they do inhabit the swampy Kasanka River inside Kasanka National Park.

Size and biology: A medium-sized characin, most are 150-180mm long, and one very large fish over 200mm was also caught. The species is a fast, active fish with sharp, triangular cutting teeth and strong jaws. The black line on the side of the body is very dark in life.

Importance: Possibly caught by illegal fishers inside the national park. The local name wasn't established during sampling.



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Children preparing an herbal piscicide from Tephrosia vogelii

***Micralestes sardina*- Redeye robber**

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Distribution and habitat: This fish was collected from rapids on the upper Lukulu, below Kupandalupili Falls, during the very high flows of March 2012. It appeared to favour fast-flowing water.

Size and biology: This robust characin reaches 80mm, and is an aggressive scavenger, investigating large fishing lures, baited hooks and anything that falls into the water. In life the upper half of the eye is red, the fins are tinged with orange, and iridescence blue line goes down the body. These features are less visible in the photograph. Large numbers of juveniles were found in the shallows amongst grass, indicating that this species had spawned earlier in the summer.

Importance: Likely an important prey species for predatory birds and fishes.

***Rhabdalestes rhodesiensis*- 'Itala', Slender robber**

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Distribution and habitat: This slender, silvery fish is widespread in flowing waters of the Lukulu delta (Chikuni) and its floodplains, and is also abundant in the Lulimala River. It was not seen in the upper sections of the Lukulu River. It inhabits open water where there is some current, and is only found on the floodplain during the high-water period.

Size and biology: The fish reaches 50- 60mm in length, and is found near the surface. At night it can easily be seen in torch light, as a long slender fish swimming very close to the surface.

Importance: This species is rarely a large component of the catch, caught in mosquito mesh *sola* nets and in mosquito seine nets. Favoured for being similar to Kapenta (a freshwater sardine from lakes that is very popular) by some fishermen, though catches are rarely large enough even for home consumption.

Hydrocynus vittatus- 'Manda', Tigerfish

This aggressive predator has historically been recorded from the Lukulu channel at the head of the delta, where it is listed in Pitman's 1936 faunal survey of Zambia⁶. Ian Manning, an early conservationist who lived in the area in the 1970's confirmed their presence, as well as elsewhere in the swamp. Older fishermen remember the fish occurring in the delta though during exceptionally high-water years, many decades ago. The lack of maintenance on artificial swamp channels in the past half-century may have limited the dispersal range of the tigerfish, which could have used these deep channels to penetrate the area from the Chambeshi River delta, where it occurs in good numbers. Another verbal record has been obtained from a labourer inside Lavushi Manda NP that they occur in that section of the Lukulu River, though none were observed in its clear waters at the end of November. The only good habitat is on the middle Lukulu near the bridge to Lumbatwa, where the river is deep and with a sandy bottom. Here reports were received of a fish called *Akalondo*, which is uncommon but approximately matched the description of a tigerfish. It can attain large sizes (600mm), but fish here would rarely reach that size, if they occur at all.



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Interviewing a 70-year-old fisherman who remembered tigerfish occurring in the Lukulu

⁶ Pitman, C.R.S. 1934. *A report on a faunal survey of Northern Rhodesia with especial reference to game, elephant control and national parks*. Northern Rhodesia Government Printer.

Suborder Siluroidei (Catfishes)

Family Amphiliidae (Mountain catfishes)

Zaireichthys sp.- Sand catlet



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Distribution and habitat: This interesting species was found in the Lulimala River. It was not collected in the Lukulu River, but likely occurs there.

Size and biology: This tiny (<40mm long) catfish lives among sand and fine gravel in currents in the stream. It often buries itself, which makes it hard to find, and it is best collected with a drag net pulled through the bottom sediment. Most people around the Lulimala Stream are not as familiar with the fishes there as people from the swamps, and nobody appeared to know of this small fish.



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Emptying a mono basket

Family Shilbeidae (Butter catfishes)

Shilbe intermedius- 'Lupata', Silver catfish



©C. Huchzermeyer/SAIAB

Distribution and habitat: This catfish is widespread in swamp and the Lukulu delta. This fish prefers flowing water in both shallow and deeper channels near vegetation. In the dry season it appears to be limited to the main, deeper Lukulu Channel in the delta. Fishermen say that this fish migrates widely during the flooded season.

Size and biology: In the Bangweulu area it only reaches a small size for its species (<180mm in length).

Importance: The silver catfish is caught mostly in *mono* trap baskets and small-mesh gillnets. It is also part of the *sola* catch and only small numbers are caught in seine nets. After capture, the venomous spines are removed, and the fish usually sundried. This fish is very abundant in some areas of the swamp nearer the Luapula River, and made up a significant proportion of the dried fish in a bag of fish brought from that area. In the Lukulu delta its abundance decreases during the dry season, which may explain it not forming a large part of the seine net catch.



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Salted fish drying

Family Clariidae (Air-breathing catfishes)

Clarias gariepinus- 'Inyenda', Sharptooth catfish



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Distribution and habitat: This species, the most widespread on the African continent, is very successful in the Bangweulu swamps and floodplains. It is found in great numbers in the Lukulu delta and its adjacent floodplains, dispersing widely during the rains. It was not seen or collected in the upper reaches of the Lukulu River or the Lulimala Stream.

The adult fish requires cover during the daytime in the form of thick vegetation or water deeper than 1m, but it forages in very shallow water at night. Large numbers shelter under floating vegetation and under papyrus mats. Juvenile catfish penetrate very far inland during the flood season, often being found many kilometres away from any channel among shallowly flooded grass. Large adults live in the deeper channels of the Lukulu delta, and are only really ever seen during the big spawning runs onto the plains in late December and January. Many catfish are left in isolated pools of water in the woodlands once floodwaters recede, many of which they share with the *Nothobranchius* killifish.

Size and biology: The sharptooth catfish is a very fast growing species, with fish below 20cm rare in catches late in the season (October- November). This may indicate that all fish recruited in the season have already attained a larger size after 8-10 months. Growth rates appear to be variable because there was a large size range among presumed 'young-of-the-year' juveniles. The majority of the fish examined during November were mature and ready to breed. Large catfish inhabit the deeper water of the Lukulu delta, with the largest individual observed measuring 110cm in length and 8.5kg in weight. Fish above two kilograms are rare. A nocturnal breeding (and no doubt feeding) migration occurs when the flood waters first inundate the floodplains, called *uCilambo*, and large fish can be seen at this time. During the 2011/2012 summer, this event reportedly occurred around the second to third week of January. The juveniles disperse widely, and when the water on the floodplains begins to recede huge numbers of these juveniles accumulate against fish weirs, attempting to return to deeper channels. At the end of April 2012, huge numbers of these small catfishes tried to get back into the pool and canal at Chikuni.

The fish is dependent on gulping air from the atmosphere, and they can be heard 'gulping' in deep inside thick vegetation such as papyrus beds. Fish sheltering under floating grass mats sometimes form 'breathing holes'. The flagship species for the Bangweulu tourism and conservation effort, the threatened shoebill stork (*Balaeniceps rex*), capitalises on this behaviour, and selects its foraging sites according to where a high density of catfish must force their way through the floating vegetation to breathe.

Importance: In the Bangweulu floodplain fishery, this is the most important fish species by weight. There is an excellent market for smoke dried catfish in southern DRC (mostly in the city of Lubumbashi). This is a fairly recent trend and may have resulted in a greater level of targeting this species in recent years. The majority of adults are caught on longlines, and large numbers of juveniles are caught in basket traps, mosquito net *solas* and mosquito net seines.

During the *uCilambo* in late December to early January, large numbers of fish are killed at night with the aid of torches and spears. The annual fishing ban has so far not protected these vulnerable spawning fish from this activity. However, the species does not seem to be in any serious danger and is still extremely abundant. As the large catfishes are the most important food source for shoebill storks, the numbers of catfish in the area should not be compromised too greatly.

During the dry-season catfish can be caught in considerable numbers from isolated pools. The first pools to be fished (from May to August) are the grassy woodland pools. These are usually fished with poison, baskets and spears, and a variety of smaller fish are caught in addition to the catfish. Later in the dry season (October to December), pools in the swamp become shallow and the method of catching *C. gariepinus* (and *C. ngamensis*) is through *ukusopa*. Here, people gather around an isolated pool and begin thrusting spears blindly into the mud and through floating marginal vegetation. A struck fish can be felt, and more spears can be thrust in to secure it. Spears are light, and the metal tip is usually smaller than 7mm round-bar. This is a very social form of fishing, and enjoyed by all participants. Up to six fish can be speared in a session lasting a few hours. Seine nets are often also employed in these pools, but due to the thick mud and tangled vegetation fish escape. Some pools sustain intense fishing for two to three weeks before becoming depleted, and can yield a considerable amount of fish while neighbouring pools hold few fish. A similar method is employed by the Lozi tribe on the Barotse Floodplains around Liuwa Plain National Park.

During 2012 reports were received that fishers operating fish weirs in the vast termitaria plains 10-15km from the Lukulu delta complained of very low catches of juvenile catfishes. Poor spawning conditions during the initial floods, low and late flooding, and high harvesting pressure during *uChilambo* can all have contributed to this reduction in yield.

Notes: In the local *Bisa-Lala* and *Unga* dialects, there is a generic common name for larger Clariids- *Muta* for fish above 30cm and *Popa* for juveniles.

***Clarias ngamensis*- 'Inkose', Blunt- tooth catfish**



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Distribution and habitat: This species is found alongside the sharp-tooth catfish, from which it is hard to distinguish. It is widespread in the Lukulu delta, where it inhabits both shallow and deeper vegetated waters, possibly not extending as far away from channels as *C. gariepinus*. They appear to utilise deeper water than the other species.

Size and biology: This species is generally smaller than *C. gariepinus*, with large fish typically measuring 350mm, with 400mm being the maximum observed thus far. This species appears to be slower growing than *C. gariepinus*. Small fish below 20cm are found throughout the year, and young-of-the-year juveniles are always much smaller than the same age class of *C. gariepinus*. The growth rates seem more uniform, as juvenile cohorts are all of similar size. This could also be due to a shorter spawning period.

According to local fishers, this species also moves onto the plain adjacent to channels together with *C. gariepinus* during *uCilambo*. Several larger (350mm size class) females dissected in March 2012 had retained eggs. It is possible that spawning conditions had not been favourable with the late and gradual onset of floods. Nevertheless, large numbers of juveniles were observed returning from the plain to the channels in early May.

The bite of *C. ngamensis* is considerably more forceful than *C. gariepinus*, and this corresponds with the difference in dentition, with *C. ngamensis* having a grinding plate of rounded teeth. No difference in diet could however be detected between the two species, both usually having consumed small fish. Additional distinguishing characteristics between the two species are that the blunt-tooth catfish has a smaller mouth, thicker barbels and a more compact body.

Importance: It is overall not as abundant as *C. gariepinus*, and only in dry season seine catches can it occasionally be caught in equal numbers to that species. It is caught using all the same methods as for *C. gariepinus*. This fish is not distinguished from *C. gariepinus* in the trade, with larger fish also being called *Muta* and smaller fish *Popa*.

Notes: The flesh of *C. ngamensis* has a darker colour, and remains pink when cooked as opposed to the yellowish flesh of *C. gariepinus*. It has a better taste, and is preferred by some when cooked fresh.

***Clarias stappersii*- 'Bomba', Blotched catfish**



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Distribution and habitat: The blotched catfish is widespread in the area. It prefers riverine habitats, occurring in channels with moving water in the Lukulu delta, and is common higher up in the Lukulu River in rapids and among rocks. It was the only clariid collected in the Lukulu inside the Lavushi Manda National Park, and it was also present in the Lulimala stream among tree roots on the bank. The fish in the photograph was collected inside Kasanka National Park.

Size and biology: Little is known about this fish. Juveniles were seen in May- August (<100mm) and adults reach a size of 400mm.

Importance: This fish is occasionally caught on hooks or in *mono* basket traps, mostly close to channels. It is rare in catches in the Lukulu Delta, making up a small portion of the longline catch where these are set near channels. The fish has short, venomous spines and when caught it is usually immobilised by a gash through the spine.



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Chikuni Island at the peak of the floods- March 2012

***Clarias theodora*- 'Mulonfi/Mulonge', Snake catfish**



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Distribution and habitat: This aptly named species is abundant and widespread in swamp and in the Lukulu delta. It favours thickly vegetated waters, living among the roots and stems of floating vegetation and flooded reeds, and also in pools covered by water lilies. This species is very abundant in certain parts of the swamps where there are large expanses of floating vegetation covering shallow water, and the fish may have a competitive advantage in this habitat.

Size and biology: This species either has a protracted spawning season, or, less likely, a slow growth rate, as very small fish were found over a long period after the summer. Small fish (<50mm long) were found in D-net sampling among vegetation in June, and *mono* basket trap catches in May still contained many very small fish in the <70mm size- class. The largest fish (280mm- in photo) was collected by the author in a baited trap in the pool in front of Chikuni house.

Importance: The snake catfish is very important in the fishery. Though small, they are dried whole and then smoked. They fetch the highest price on the Congo- border fish markets of all the clariid products. The fish are caught mostly in *mono* basket traps, but can also be caught in large numbers in mosquito net *solas* set near vegetation. It is rarely caught on hooks.

Interesting notes: The pectoral spines of this fish are short but venomous. Even small specimens are beaten with a stick once they are placed on the drying mat. When certain parts of the swamps dry out, this is apparently one of the very abundant species caught by 'digging' open floating vegetation mats.

***Heterobranchus longifilis*- 'Sampa', Vundu**

This very large catfish species was not observed or collected in the area. Older fishermen have seen the fish as a rare catch on hooks from the deeper Lukulu channel at the head of the delta near the village. It likely still occurs in this area.

Family Mochokidae (Squeakers)

Synodontis nigromaculatus- 'Cingongongo/Cinyimba' Spotted squeaker



©C. Huchzermeyer/SAIAB

Adult (150mm)



©C. Huchzermeyer/SAIAB

Juvenile (80mm)

Distribution and habitat: This fish has a limited distribution in the Lukulu Delta, where it inhabits vegetated water adjacent to deeper channel. It was only very occasionally observed at Fibili fishing camp, near Chikuni. Reportedly occurs higher up in the Lukulu river delta at Muwele village, where it is more common. It is also likely to occur in the deep middle reaches of the Lukulu, near the Lumbatwa Bridge.

Size and biology: Mostly adults of various sizes have been observed (130-170mm), though one juvenile of 80mm was also collected. Very few fish (< 3) were seen during the flooded season, until November when five fish were caught in a week in the same locality. This was after the first proper rain shower, and the movement of the fish could have been related to breeding.

Importance: They are caught in gillnets set in moving water adjacent to vegetation mats, and one observation was made from a seine net catch. The juvenile specimen was caught in a *mono* trap basket. It is not economically important and not favoured for eating by the local fishers.

Notes: This fish appears to be nowhere abundant in the Chikuni area, unlike in other river systems such as the Zambezi. The venomous spines are usually removed with a knife as soon as a fish is landed inside a canoe. The name *Cingnongongo* is onomatopoeic, referring to the sound made by the fish when captured; the squeaker produces this rapid grinding sound by moving its pectoral spines, which have a toothed socket joint not unlike a gear cog.

Family Aplocheilidae (Annual killifishes)

Nothobranchius rosenstockii- 'Lombwe-sweta', Bangweulu killifish



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Nothobranchius rosenstockii- male



©R. Bills/SAIAB

Nothobranchius rosenstockii- female

Distribution and habitat: This 'annual fish' species is restricted to temporary environments, such as shallow woodland pools. Within the Bangweulu Wetlands area, it is probably widespread in the correct habitat. It has been collected from Kasanka National Park, woodland pools on the western bank of the Lukulu near Muwele village, a tributary stream near Muwele and also likely occurs on the opposite bank of the river (Lumbatwa plains) where similar pools occur. The habitats the fish are found in are vegetated marshy pools and stream banks.

Size and biology: These small, robust fish don't exceed 40mm in length. They are interesting in that members of this colourful genus have the unique ability to produce eggs that can survive in dry pools where the adults no longer survive, hatching with the next season's rains. They appear to prefer dense mats of drowned grass, and they live near the bottom; when collecting, deeper net pulls are required than for catching their surface-water relatives, the topminnows. In these habitats they coexist with other species (*Clarias*, small *Barbus*, *Tilapia sparrmanii*, *Aplocheilichthys*, *Ctenopoma* and *Marcusenius*).

Importance: The killifish is only a very minor component of the catch when pools are fished using seine nets and baskets, often in combination with fish poison. The small size of these pools means that fishing is done by nearby residents purely for home consumption. This small, colourful fish (30-40mm) is only known to people living near the pools who see them in their catches. There was one verbal record received of them being an occasional weir basket catch near Chikuni.

Notes: An interpretation of the vernacular name is that it means 'red sweater', referring to the colours of the male. The species became known to science only in 2005 (Valdesalici and Wildekamp, 2005). It has already become popular in the European aquarium hobby, where aquarists have been breeding the species in captivity and distributing their eggs to other killifish keeper around the world.



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Weaving the valve for a mono trap basket: the part below the fisherman's right hand is left open so that fish can push their way into the basket

Family Poeciliidae (Topminnows)

Aplocheilichthys spp. 'Bwelele', Topminnows- various species



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This group of small fish species are difficult to identify in the field. There are at least three different species in the area, probably more. DNA barcoding will highlight species-level differences between specimens, and aid greatly with the identification of species in this group. They have been grouped together for the purposes of this document.

Distribution and habitat: This group of fishes is very widespread, with various species in the Lukulu delta (Chikuni), the Lukulu River inside Lavushi Manda NP, the dambo sampled inside Lavushi Manda NP, the Lulimala River and pools in the woodland. The fish are found near the surface in water among vegetation such as waterlilies, riverine margins with branches and roots, and flooded grasses. The reliance of these fish on cover is evidenced by absence of these fish where lechwe or seine net fishermen have cleared waterlilies; adjacent intact patches have a high density of these fish. This species must disperse widely during the rains as it is found in non-permanent pools in the woodlands, and unlike the killifish its eggs are not known to become dormant in damp vegetation of dry pools.

Size and biology: Small, slender fishes, they vary in size from 20mm to 60mm in length. They likely breed throughout the summer, as females were observed with eggs in March/April, near the end of the rains.



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Importance: These small fish are very abundant in the swamp, but never appear in numbers in catches. There are always a few in catches from mosquito net *solas*, and catches are also made in mosquito-net seines. They are not common in seines probably due to the clearing of vegetation in seining areas. The fish is sun-dried and sold as '*baby lila*', a low value product that is often fed to chickens.



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A very large sola net designed to go into a deeper fish weir with strong current

Family Cichlidae (Cichlids)

Pseudocrenilabrus philander- 'Cikundu', Southern mouthbrooder



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Distribution and habitat: This dwarf cichlid is very widespread, found throughout the Lukulu delta. It also occurs in the Lulimala River. It favours shallow, muddy waters, and is extremely abundant in shallow areas of the floodplain, occurring in water only a few centimetres deep.

Size and biology: This small fish varies in size from 20- 70mm, with males getting their breeding colours already at 40mm. The southern mouthbrooder breeds throughout the year, with different size classes and juveniles present throughout the year.

Importance: The species is an important catch in mosquito net *sola*, *mono* trap baskets and mosquito seine nets. It has an extended occurrence in the catch due to its shallow water habitat, and it is usually one of the last species to move through fish weirs that are becoming dry. It is a lower quality ingredient of the sundried *Kasepa* product.



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***Sargochromis mellandi*- 'Mbilya', Brown bream**



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Distribution and habitat: This fish is widespread in the Lake Bangweulu and the Luapula River, but in the Bangweulu Wetlands it is limited to channels of the Lukulu delta, where fishers say it may migrate up from the Luapula River. It inhabits open water pools, and is mostly seen during the flooded season. It was not seen at all during early 2012.

Size and biology: The largest fish seen was 150mm long, which they apparently rarely exceed. They are mouthbrooders.

Importance: Individual fish of this species are occasionally present in a seine net catch, but only when water levels are high. Only two young fish (70mm) were seen as part of the catch in mosquito *solas* in fish weirs adjacent to flooded channels.



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Traffic on Chikuni Canal

***Serranochromis* sp. 'nsuku' - 'Nsuku', Largemouth bream**



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An adult nsuku (above) and juvenile nsuku (below)



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Distribution and habitat: This is a very widespread fish, found throughout the Lukulu River, its delta and the swamps, ranging in habitat from rocky rapids and pools to quiet lagoons and channels with water lilies.

Size and biology: This species is similar in appearance to *Serranochromis robustus*, a well-known angling fish from the Zambezi drainage, though it doesn't appear to reach the same size. Large adults measure 350mm and weigh 800g. In Bangweulu it appears to have an extended breeding season with a summer peak, as small specimens are found until late in the year (September). Its mouthbrooding reproductive method probably makes it less dependent on flooding for successful breeding, though juvenile survival and growth would be highest when the plains are flooded. Breeding adults seem to remain in deeper water. Young fish on the floodplain hunt near currents, and stomachs contained almost exclusively small *Barbus* species during the flooded season.

Importance: This species is a very important component of the fish weir fishery (juveniles), and gillnet and seine net catches (juveniles and adults). Smaller fish can leap out of seine nets to escape. It is also occasional hooked on longlines. It is prepared for sale mostly by smoke-drying after sun-firming, and is also split and salted. The fish is sold fresh around the wildlife scout camp at Chikuni.

Note: Young specimens of the Nsuku (<200mm) are known as *Matongo*.

***Serranochromis angusticeps*- 'Polwe', Thinface largemouth**

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Distribution and habitat: This cichlid is widespread in the Lukulu delta, and also inhabits more expansive areas of swamp. It is an ambush predator that inhabits shallow, heavily vegetated areas such as waterlily pools, grassy backwaters and channels around fish weirs with submerged aquatic vegetation. The presence of dense submerged aquatic vegetation appears to be critical for this species.

Size and biology: This is the largest cichlid occurring in the Bangweulu Wetlands (attains over 40cm and 1kg in weight). The fish matures at a relatively small size (at 200mm all fish were mature), a size probably reached within a year. In November the fish displayed bright breeding colours and had ripe gonads. It is also a mouth brooder, but uniform size in the juveniles points to a limited breeding period in early summer (December to January). The fish is laterally compressed, which reduced its profile when seen from above or from the front. This makes it harder for its small fish prey to detect its approach, and the mouth folds out to a considerable size, enabling it to suck in prey from a distance. Juveniles have orange speckles on the face.

Importance: This fish is relatively important to the fishery, though not as abundant in catches as other large cichlids. Small and medium sized fishes (90- 200mm) are caught in fish basket traps and gillnets. Large individuals are scarce, but are caught in seine nets. The fish is probably far more abundant than catches show: its cautious, slow ambush movements protect it from gillnets, and their dependence on thick vegetation makes them avoid area used by seine net fishers. The fish spoils easily, and is usually smoked.

***Tilapia sparrmanii*- 'Matuku', Banded tilapia**



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Distribution and habitat: This is a common species, distributed throughout the Bangweulu Wetlands area, in the Lukulu delta, swamp, floodplains and rivers. It prefers shallow habitats with little flow, where there is some cover in the form of grass or other vegetation.

Size and breeding: Fish larger than 150mm are very rare, and most measure less than 120mm in length. During summer some fish have a dark black ventral surface and pelvic fins, presumably their breeding dress. This is clearly shown in the fish in the photograph, which was taken inside Kasanka National Park. In Bangweulu, these intensely coloured individuals were observed from October to April. Fish in clearer water show more yellow. It has an extended breeding season, with multiple size classes available throughout the year. The occasional fish has a hump on the head, possibly related to age.

Importance: This species is an important catch in small-meshed gillnets, especially during the high-water season. It is the predominant catch together with *Barbus trimaculatus* in the small mesh-gillnets. The fish is also caught in seine nets, basket traps and mosquito net solas. It is prepared mostly by sundrying after scaling and gutting. Small fishes left ungutted taste bitter, lending the nickname 'Chloroquin' (a bitter antimalaria medication) to the lower-quality *kasepa* mix.

***Tilapia ruweti*- 'Cifinsa', Okavango tilapia**



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Distribution and habitat: This dwarf tilapia is widespread around the Lukulu delta and its floodplains. It likes shallow, flowing water, sometimes in thick vegetation.

Size and biology: Adults are small, 60-80mm in length. The males of this species have a colourful breeding dress, and intense colours were still observed into March with receding waters.

Importance: It is a minor catch, usually too small to be caught in basket traps. It has been seen in catches of mosquito *so/as* and the pull/dip baskets. It is rarely abundant. In early March 2012, children were catching adults in small-mesh gillnets on a grassy flooded plain adjacent to the Lukulu River near Muwele Village. When sundried it changes to a black colour allowing it to be distinguished from other small sundried cichlids.



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Tending drying fishes

***Tilapia rendalli*- 'Mpende', Redbreast tilapia**



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Distribution and habitat: This vegetarian cichlid species is widespread in the Lukulu Delta, vegetated parts of the river near the delta and also in the upper reaches inside Lavushi Manda National Park. It also occurs throughout the vast shallow parts of the swamps elsewhere. It is always associated with vegetated waters. It favours the verges of channels with quite strong currents during the rains and lives in waterlily pools during the dry season. Fishers say they apparently don't like areas under floating mats of vegetation where there is little current, due to a lack of leaves for food and/or low oxygen.

Size and biology: A medium-sized cichlid that grows to 300mm in length and 600g in weight. The species guards its eggs and fry in a nest consisting of a cleared arena 80-150cm in diameter, into which a number of cup-shaped holes are dug. Nesting begins in November, in the very shallow parts of the same pools that have experienced repeated seining for months. Fish had ripe gonads in November, and nesting continues through the summer until March. Later in the floods (January to March) the nests are found on the shallow plains away from the channels, where juvenile survival is likely higher. By October and November no small (<150mm) fish were found in catches in 2011. Therefore the growth rates are likely to be fast, with fish maturing within a year. Large fish can be seen taking flight to the bottom of clear fast flowing channels during the wet season, at a time when the pools they inhabit are still too deep to be fished.

Importance: The *mpende* is a key species in the Bangweulu fishery. Small fish (<100mm) are caught in small-mesh gillnets and in mosquito sola nets, while all sizes are caught in basket traps, though very large fish (>250mm) remain in deeper water. Larger fish are caught almost exclusively in seine nets from May to December in 2011, and in 2012 already in February. Monofilament gillnets, increasingly used in the area also catch large specimens.

This species is the most popular fish for eating fresh, and is sold in bunches of three to five fish, depending on the price and size of fish. It is also smoked or salted, and the fresh fish keeps well, allowing it to be transported to the villages for sale, where it fetches a premium price.

Fishers say that the numbers have apparently increased in recent years, possibly due to high flood levels in 2007-2009 that would have allowed better recruitment and survival. More likely there has been a perceived increase as fishers began using gears more effective at catching these fish (monofilament gillnets and large-mesh seine nets). Traders attest to never having been able to buy numbers of this species in the past. The massive increase in pressure on this species witnessed during 2012 may well lead to a reduction in numbers of this species, which is long lived. Fishermen will always select the largest specimens of this species for their own consumption, before considering the remaining catch for sale.

Notes: This fish is adept at jumping, and can easily clear both fish weirs and seine nets. It is one of the species that benefits most directly from the heavy grazing of the area by lechwe antelopes: juveniles find rich forage on the flooded grazing lechwe lawns, and the nutrient spike in the water that occurs when the lechwe dung gets flooded leads to excellent algal growth. These fibrous algae are favoured by adult redbreast tilapia, and a diet of these algae lends the fish their high oil content rich in polyunsaturated fatty acids. These oils make the fish tasty, and are also an important nutrient for human health.



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A nest of Tilapia rendalli (Mpende) showing chambers dug for the eggs and fry

***Oreochromis macrochir*- 'Nkamba', Greenhead tilapia**

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Distribution and habitat: This large cichlid is rare, and seems to have a limited distribution in the Chikuni area, being found in deeper channels of the Lukulu delta. Open water deeper than 2m appears to be the limiting habitat factor, and it was absent from almost all of the seine netting pools in use during early 2012, from Kaleya to Shoebill camp. It is said to be more abundant in seine net catches higher up on the Lukulu delta, adjacent to the first villages (Ng'ungwa/Muwele village).

Size and biology: This fish has been seen up to sizes of 300mm in Bangweulu. Juveniles of 100mm were seen in April in catches from deeper fish weirs, but they were rare. The fish is a mouth-brooder, with males building display nests on the bottom (Skelton 2001).

Importance: Adults are occasionally caught in seine nets and juveniles have been seen in mosquito net *solas* and seine nets. In Lake Mweru this fish is a very important fishery species, and the shallow, heavily vegetated habitat of the Bangweulu Wetlands appear to be largely unsuitable for this species.

Family Anabantidae (Labyrinth fishes)

Microctenopoma intermedium- 'Nkandiya', 'Kashilukafunte', 'Nkandakatopolyo',
Blackspot climbing perch



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Distribution and habitat: This tiny fish is widespread in the Lukulu delta (Chikuni), and was also found at a tributary near Muwele village. The fish lives in dense vegetation, especially floating grasses.

Size and biology: It rarely exceeds 40-50mm in length. This fish does not appear to be as amphibious as its larger relative.

Importance: The fish is not abundant and is of minor importance to the fishery, caught in lift baskets and mosquito seine nets.

Notes: One of its vernacular names, *Kashilukafunte*, means 'mad thing', referring to the way it twists/summersaults when caught.

***Ctenopoma multispine*- 'Nkomo', Manyspined climbing perch**



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Distribution and habitat: This interesting fish is very widespread, seen throughout the swamp and collected from the Lukulu delta, Lavushi Dambo, pools in plain and woodland and a tributary stream of the lower Lukulu River near Muwele village. This fish inhabits surface water in dense vegetation. The preferred vegetation is mostly coarse, such as the fringes of papyrus and the submerged stems of larger grasses.

Size and biology: A medium-sized fish reaching lengths of 200mm, with the typical size range being 80-140mm. The species is well-known for its amphibious habits, as it can breathe air into a 'labyrinth organ' inside the head and crawl over land using its extended, serrated gill covers for traction. As a result, this species can move extensively during the rainy season, often being the first fish to move through accumulated rain water on the plains. It forms part of the catch of the higher lying fishing camps, being caught in weirs in the higher ground inside the Mandamata woodlands. It can cross large areas of open water/ground, but will always seek shelter.

Importance: It is an important feature of the basket and gillnet fishery, but the soft flesh disintegrates upon drying. It is often eaten fresh after roasting over coals. Its fragility when dry affects its marketability. It is often separated from the sun-dried mixed fish *kasepa* product.

Importance: Among the local fishers, this charismatic fish is frequently a source of mirth due to its tenacity and terrestrial animal-like appearance. The connection between this fish's movement behaviour and the onset of the rains is well-appreciated.

Table 2: Distribution of species between different habitats:

Occurrence of a species in a particular habitat is marked in black. Question marks denote expected occurrence based on verbal evidence collected from local fishermen.

Fish Species	River and Stream	Floodplain	Delta
Family Mormyridae (Mormyrids)			
<i>Mormyrus</i> sp.- 'mbubu', Western Bottlenose/Bottle Fish	?		?
<i>Cyphomyrus discorhynchus</i> - 'Icimpumwe', Zambezi parrotfish			
<i>Marcusenius macrolepidotus</i> - 'Mintesa', Bulldog			
<i>Petrocephalus</i> sp.- 'Icele', Churchill			
<i>Pollimyrus cf. isidori/castelnaui</i> - 'Ishimba' Dwarf Stonebasher			
Family Cyprinidae (Cyprinids)			
<i>Barbus neefi</i> - Sidespot barb			
<i>Barbus bifrenatus</i> - Hyphen barb			
<i>Barbus brevidorsalis</i> - Dwarf barb			
<i>Barbus fasciolatus</i> - Red barb			
<i>Barbus radiatus</i> - Beira barb			
<i>Barbus haasianus</i> -Sickle-fin barb			
<i>Barbus trimaculatus</i> - 'Mushipa', Threespot barb			
<i>Barbus eutaenia</i> - Orangefin barb			
<i>Barbus multilineatus</i> - Copperstripe barb			
<i>Barbus afrovernayi</i> - Spottail barb			
<i>Barbus paludinosus</i> - 'Misenga', Straightfin barb			
<i>Barbus kerstenii</i> - Redspot barb			
<i>Labeobarbus</i> sp.- Yellowfish (South African name for the genus)			
<i>Labeo cf. cylindricus</i> - Redeye Labeo			
Family Distichodontidae (Citharines)			
<i>Hemmigramocharax multifasciatus</i> - Multibar citharine			
Family Characidae (Characids)			
<i>Brycinus peringueyi</i> - Dwarf tigerfish			
<i>Micralestes sardina</i> - Redeye robber			
<i>Rhabdalestes rhodesiensis</i> - 'Itala', Slender robber			
<i>Hydrocynus vittatus</i> - 'Manda', Tigerfish	?		?
Suborder Siluroidei (Catfishes)			
Family Amphiliidae (Mountain catfishes)			
<i>Zaireichthys</i> sp.- Sand catlet			
Family Shilbeidae (Butter catfishes)			
<i>Shilbe intermedius</i> - 'Lupata', Silver catfish			
Family Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i> - 'Inyenda', Sharptooth catfish			
<i>Clarias ngamensis</i> - 'Inkose', Blunt-tooth catfish			
<i>Clarias stappersii</i> - 'Bomba', Blotched catfish			
<i>Clarias theodora</i> - 'Mulonfi/Mulonge', Snake catfish			
<i>Heterobranchus longifilis</i> - 'Sampa', Vundu	?		?

Family Mochokidae (Squeakers)			
<i>Synodontis nigromaculatus</i> - 'Cingongongo/Cinyimba' Spotted squeaker	?		
Family Aplocheilidae (Annual killifishes)			
<i>Nothobranchius rosenstockii</i> - 'Lombwe-sweta', Bangweulu killifish			
Family Poeciliidae (Topminnows)			
<i>Aplocheilichthys</i> spp. 'Bwelele', Topminnows- various species			
Family Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i> - 'Cikundu', Southern mouthbrooder			
<i>Sargochromis mellandi</i> - 'Mbilya', Brown bream			
<i>Serranochromis</i> sp. 'nsuku'- 'Nsuku', Largemouth bream			
<i>Serranochromis angusticeps</i> - 'Polwe', Thinface largemouth	?		
<i>Tilapia sarrmanii</i> - 'Matuku', Banded tilapia			
<i>Tilapia ruweti</i> - 'Cifinsa', Okavango tilapia	?		
<i>Tilapia rendalli</i> - 'Mpende', Redbreast tilapia			
<i>Oreochromis macrochir</i> - 'Nkamba', Greenhead tilapia			
Family Anabantidae (Labyrinth fishes)			
<i>Microctenopoma intermedium</i> - 'Nkandiya', 'Kashilukafunte', 'Nkandakatopolyo', Blackspot climbing perch			
<i>Ctenopoma multispine</i> - 'Nkomo', Manyspined climbing perch			
Total species per habitat:	30	25	34



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Dissecting fish at Chikuni Research Station. Elijah M. Mofya (left), Carl F. Huchzermeyer (centre) and Brighton M. Mofya (right)

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Useful websites:

The following websites contain information and photographs about Bangweulu Wetlands and Lavushi Manda National Parks:

www.bangweulufish.wordpress.com

www.morgantrimble.com

www.african-parks.org

www.kasanka.com