WWF

SUMMARY REPORT

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Conservation | Climate Change | Sustainability

Status of the Kafue Flats Fishery

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more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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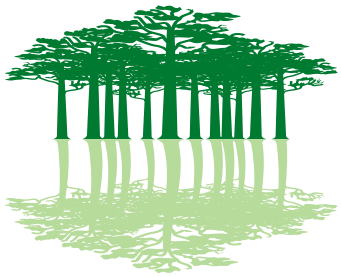
A fisherman holding fish/ *Photo by: WWF*



INTRODUCTION

World Wide Fund for Nature (WWF) Zambia commissioned a Situational Analysis of the Kafue Flats Fish and Fisheries in 2017 in order to consolidate and review existing data on the Kafue Flats. Based on this review, new fisheries dependent and independent surveys were designed and implemented to produce an update of the fish and fisheries activities of the Kafue Flats.

The fisheries independent component of the project aimed to:

- Review and synthesise existing data from the Department of Fisheries (DoF).
- Provide an update on the biodiversity and abundance of the fishes of the Kafue Flats.
- Provide an estimate of the occurrence and distribution of the invasive redclaw crayfish (*Cherax quadricarinatus).*
- Assess current trends in relation to historical data collected by the DoF.
- Provide suggestions for future monitoring using the findings of these studies.

The fisheries dependent component of the project aimed to:

- Review existing fisheries dependent data collected by the DoF.
- Provide updated information on fisher household demographics, employment and financial data.
- Outline patterns in seasonal targeting of species, fishing effort and gear.
- Assess the regulatory environment in the Kafue Flats and enforcement of fishing licences, closed seasons and closed areas.
- Provide updated data on livelihood activities of the residents of the Kafue Flats.
- Provide data on land ownership and means of accessing land in the Kafue Flats.
- Provide an up to date assessment of current fishery trends (Effort, Catch Per Unit Effort (CPUE), and harvest).
- Provide an up to date assessment of the catch composition.
- Provide an up to date estimate of harvest volumes and value from markets on the Kafue Flats.

The stakeholder mapping and governance component of the project aimed to:

- Identify and analyse major role players and stakeholders in the Kafue Flats fishery, from national stakeholders to local fisheries committees.
- Assess the status of the fishery.
- Discuss possible options for co-management.

OVERVIEW OF THE BIOPHYSICAL ENVIRONMENT

The Kafue Flats are located on the lower section of the Kafue River and comprise a low-lying floodplain system (Figure 1). The area is located in the sub-tropical region of Zambia and experiences two distinct seasons; a rainy season extending from November to April and a dry season from May to October. Due to the size of the Kafue Flats system (6,500km2), shallow gradient of the area (20m), and general complexity of the habitats, flood pulses are delayed and the floodplains generally become inundated between December and May. The soils of the Kafue Flats are classified as vertisols, consisting of black, margallitic clays which are impassable when wet and contract, creating fissures, when dry. This seasonal flooding drives the productivity of the Kafue Flats and supports the high productivity and biodiversity that historically existed here. The Kafue Flats are roughly 240km long and 50km wide and are bounded by man-made dams on the upper and lower ends. The Kafue Gorge dam was constructed in 1972 and is located at the lower end of the Kafue flats and regulates the release of water flowing from the Kafue Flats. The Itezhi Tezhi Dam was built in 1977 and regulates flow of water into the Kafue Flats wetland from the upper Kafue system. Both dams are hydroelectric power schemes and regulate the flow of water through the Flats by managing incoming and out-flowing releases. There are two national parks, Lochinvar National Park (428km2) and Blue Lagoon National Park (500km2), and several kilometers designated" as Game Management Areas (GMA) (totalling 6,000km2) on the Kafue Flats (Figure 1). The Kafue Flats were identified as an internationally important Ramsar wetland due to the important biodiversity that this complex habitat supports (Ramsar, 2007).

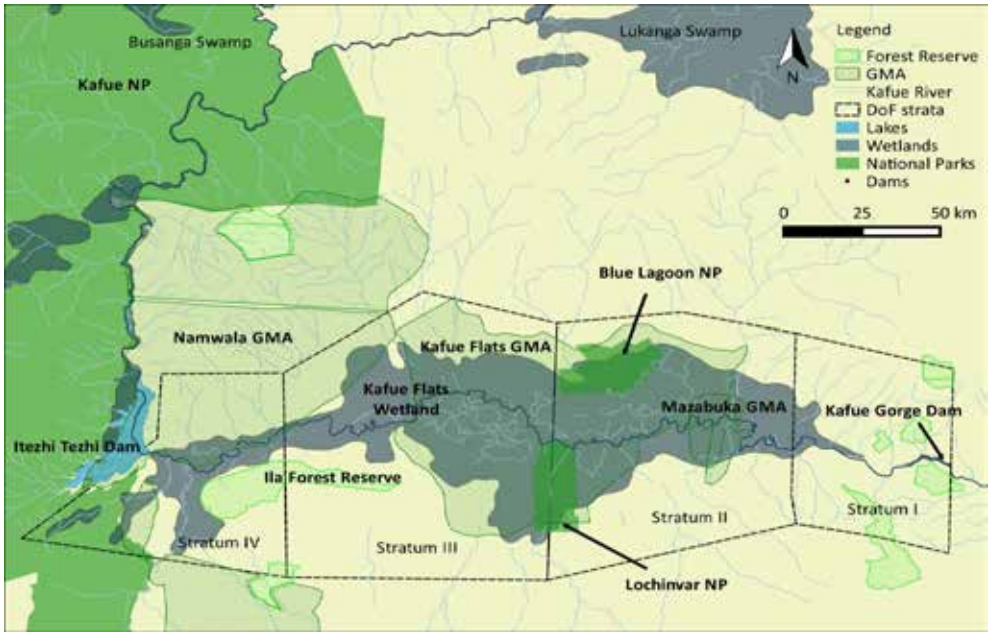


Figure 1: Overview of the study area illustrating national parks, game management areas (GMA), forest reserves, Department of Fisheries sampling strata, lakes, wetlands, rivers and dams.

Hydrology

The flooding of the Kafue Flats historically relied on high flows of the Kafue River upstream of the Kafue Flats. These high flows (in excess of 170m3s-1) exceeded the capacity of the channel in the Kafue Flats, resulting in inundation of the floodplain with the peak flood extent historically occurring in April or May and low water in October or November (Mumba and Thompson, 2005). However, presently flow in the Flats is managed through storage and controlled releases from the Itzehi Tezhi Dam (capacity of 4950 x 106m3 (Deines et al., 2013)) to ensure sufficient supply for the turbines at Kafue Gorge (White, 1973). The Kafue Flats have experienced a clear hydrological shift since the construction of the Itezhi Tezhi and Kafue Gorge dams: lower wet season peak flows have reduced the flood extent (Deines et al., 2013) whereas year-round releases from Itezhi Tezhi have resulted in permanent inundation of parts of the floodplain (Figure 2). This permanently flooded area includes parts of Chunga Lagoon and covers between 800 and 1,100km2 (Figure 2).

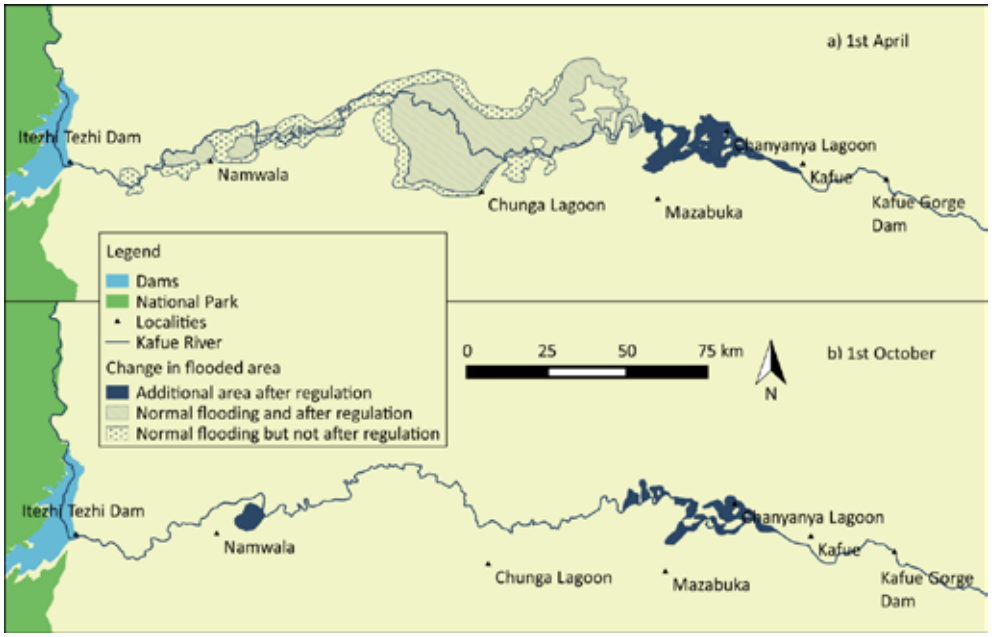


Figure 2: Flooded areas of the Kafue Flats in dry years (when regulation effects are most pronounced) before and after dam construction. Situation in: a) April; b) October (Source: Ellenbroek 1987).

Ecology

The Kafue Flats are home to a variety of terrestrial animals including birds, ungulates, carnivores, rodents and shrews which migrate annually on and off the floodplain as flood waters recede and rise again (Sheppe, 1972). The most notable resident mammal is the Kafue lechwe, an endemic to the Kafue Flats and a wetland specialist. Zebra are also plentiful with lower numbers of wildebeest, buffalo, roan, kudu, sitatunga and hippo also present. Today, Lochinvar and Blue Lagoon National Parks provide a temporary sanctuary for the remnants of vast herds of Kafue lechwe now numbering approximately

28,000, the lowest population estimate ever recorded (a loss of over 81,000 animals) (Shanungu et al., 2015). Large concentrations of resident and migratory water birds (a number of these are species of conservation concern) are still found on the Kafue Flats, many of which rely on this area as a breeding ground. Thus the Kafue Flats were identified as an Important Bird and Biodiversity Area by BirdLife International (2017). The Kafue Flats is the most important wetland in Africa for wattled cranes with 25% (about 3,000 birds in 2015) of the total population of 8,000 utilising this area (Shanungu et al., 2015).

The main vegetation types of the Kafue Flats include woodland (miombo, mopane, Acacia and combretum), termitaria grassland, flooded grassland or plants growing in water meadows, permanent swamps, levees and lagoons (Ellenbroek, 1987). Many indigenous plants of the Kafue Flats rely on the natural flooding regime such as wild rice Oryza barthii which is abundant. Alien and indigenous plants may also become invasive on human-impacted floodplains (White, 1973; Mumba & Thompson, 2005). These effects have been documented, for example the extensive spread of the alien plant Mimosa pigra and the increased extents of indigenous plants such as Dichrostachys cinerea (Shanungu et al., 2015), Phragmites mauritanus and Typha domingensis (Mumba & Thompson, 2005) as a result of the human-induced hydrological changes. The rapid infestation of Mimosa pigra in particular, which began in the mid 1980s, has had knock-on implications for all grazers on the Kafue Flats, domestic and wild alike (Mumba & Thompson, 2005). This woody species has quickly replaced once widespread grassland species such as Echinochloa stagnina and Oryza longistaminata and is thriving in areas that have become permanently inundated as a result of the year-round releases from Itezhi Tezhi and the backwater effects from the Kafue Gorge Dam (Mumba & Thompson, 2005). These significant changes in vegetation are likely to have detrimental impacts on the floodplain ecosystem (Mumba & Thompson, 2005).

Ichthyofauna

The Kafue River fauna is largely of Upper Zambezian origin (Bell-Cross, 1972), isolated from the Middle Zambezi originally by the Chasunta Falls, now supplemented by two large dams. Of the 60-77 species recorded from the Kafue River system (Bell-Cross, 1972, Tweddle et al., 2004), 21-23 are considered commercially important (Cowx et al., 2011). The fishery is dominated by cichlids (Oreochromis macrochir, O. andersonii and recent introduction of O. niloticus; Tilapia rendalli, T. sparrmanii, Serranochromis angusticeps); Clariid catfishes (Clarias gariepinus, C. ngamensis); Schilbe mystus; Hepsetus odoe; Labeo molybdinus. Less important species include Serranochromis robustus, S. thumbergii, S. macrocephalus, Haplochromis carlottae, H.codringtonii, H. giardi, Synodontis macrostigma, Brycinus lateralis, Marcusenius macrolepidotus, Petrocephalus catostoma, and Mormyrus lacerda.

Four key fishery species were chosen as indicators of temporal change in size structure, three of those important contributors to overall biomass

(C. gariepinus, S. angusticeps and S. intermedius) and the fourth M. macrolepidotus, a less important but nevertheless significant contributor to the fishery. All four indicator species results show that there have been significant shifts in size structure between 1980 and 2005. The general trend was both a decrease in mean length of fish from the Kafue Flats as well as length range for all species, however, the latter was less pronounced.

Introduction and Spread of Non-Native Species

The introduction of Nile tilapia in the early 1980s is highly contentious as it has had both positive and negative impacts on the fish and fisheries of the Kafue Flats. Nile tilapia now forms a significant component of the Kafue Flats fishery, contributing approximately 3,000 tonnes.year-1 and comprising 50% of total catch (Cowx et al., 2011; Deines et al., 2013). In addition to wild harvest, the introduction of Nile tilapia precipitated the formation of a successful aquaculture industry (1,000 tonnes.year-1) and is a very popular table fish 3 distributed throughout Zambia. The introduction of Nile tilapia has potential to have catastrophic impacts on native species within the genus Oreochromis, including longfin tilapia O. macrochir and threespot tilapia O. andersonii. While the introduction of Nile tilapia has caused the loss of genetically pure versions of two native species (Deines et al., 2014), catchment level consequences of this introduction on native biodiversity are unknown.

The redclaw crayfish (*Cherax quadricarinatus)* was introduced into the Kafue Flats accidently from fish farm escapees in the vicinity of Kafue Town in the 1990s (Tyser & Douthwaite, 2014). Very little research on their distribution, abundance or ecological impacts on the Kafue Flats has been undertaken but by 2009 they were considered an established population (Phiri, 2009). Potential impacts include competition with other crustacea such as crabs that occupy a similar environmental niche; transfer of parasites and diseases; predation by crayfish on fish eggs and larvae; alteration of the physical habitat due to their burrowing habits and cropping of macrophytes. Currently, the only reported negative impacts of crayfish are on the fishers themselves, with crayfish causing considerable damage to fishers' nets (Cowx et al., 2011), increasing processing time and servicing costs. No mitigation or control measures have been implemented on the Kafue Flats to curb its spread or impact.

Water hyacinth is known to have been in the upper part of the Kafue gorge since 1966 and it is now well established both as a floating and as a terrestrial plant on the Kafue Flats (White, 1973). Water hyacinth has the potential to reduce areas open for fishing, interfere with fishing activities and cause problems with navigation of clogged waterways (Sinkala et al., 2002; Cowx et al., 2011). Various strategies of control have been investigated such as using hyacinth as growth media for mushroom growing or as a fertilizer; however, no large-scale control operations have been undertaken on the Kafue Flats (Sinkala et al., 2002).

Invasive Species Mimosa Pigra found on the Kafue Flats/ *Photo by:* Gareth Bentley

Overview of the Socio-Economic Environment

The Kafue Flats are densely populated and census data suggest that almost one million people reside in the area (CSO, 2003). Many people rely on the wetland for their livelihoods: the highest density of cattle (250,000 according to Shanungu et al. (2015)) in Zambia is grazed on the floodplain when the floods recede; numerous fishers rely on the fish resources for protein and income; and many subsistence and small-scale farmers cultivate the land surrounding the floodplain. Extensive (20,000ha) irrigated farmland (mainly commercial sugar plantations) around Mazabuka and the Mazabuka Town itself rely on water from the Kafue Flats.

The Central Statistical Office (CSO) in conjunction with the DoF undertook frame surveys in all villages within 1km of the shoreline (these villages were chosen as fishing is the primary activity) on the Kafue Flats based on three

structured questionnaires. The results from the two most recent surveys (2006 and 2015) were compared and the data indicate that the number of fishers has increased greatly, suggesting significant recruitment into the fishery has taken place since 2006.

The vast majority of fishers in 2015 reported fishing for nine months of the year (55 %), followed by fishers who reported fishing for twelve months of the year (25%), accounting for 80% of the fishers. Gillnets were reportedly used everywhere but predominantly in Stratum II, while traps were used almost exclusively in Stratum II. Baskets and seine nets follow the same trend.

A Catch Assessment Survey was undertaken by DoF in 2011 and this determined that Tilapia species were the most important component of the catch (25%) followed by Nile tilapia (16%). 93% of fishers reported selling their catch for cash, while only 3% reported fishing for home consumption. Most catch was reported to be sold fresh (53%), or smoked (40%), with limited salting (3%) and sun-drying (4%) taking place. Much of the value adding was reported to be practised by the traders rather than the fishers. The average number of traders in the area was 1,453 per month, 62% of which are women. Most of the trading was reported to take place at harbours and landing beaches.

Major crops found to be cultivated in the Kafue Flats included maize, sorghum, millet, pumpkins, beans and cassava. Other reported economic activities included livestock rearing (mainly cattle) (27%), non-timber forest product harvesting (24%), and charcoal production (49%).

Overview of the Fishery

The Kafue Flats fishery is a typical African floodplain fishery being diverse, characterised by multiple user groups applying a multi-method, multispecies approach that contributes significantly to the livelihoods of those that rely on the resource as either a source of protein, income or supplementary income (Haller and Merten, 2006).

The Kafue Flats fishery developed extremely rapidly in the 1950s due to the introduction of cheap nylon gillnets and an increase in market demand for fish (Williams, 1960). During this period the number of gillnets in the fishery increased by more than 400%. Associated with this was a large increase in annual harvests from the fishery, which rose from 2,000 tonnes in 1954 to >10,000 tonnes in 1958. This massive increase in total catch came at a significant cost to the fish stocks and fishers involved, and catch rates (catch per unit effort) for both the gillnet and seine-net fishery showed subsequent declines. The gillnet fishery catch rates dropped 50% from >40kg.net-1 in 1954

to 20kg.net-1 in 1958. For the next four decades, gillnet effort continued to rise and catch rates continued to decline until post-construction of the Kafue Gorge Dam. During this period fluctuations in total catch were related to the annual flood/drought cycle stabilising, around 6,000 tonnes.year-1, although there is some uncertainty around this figure due to limited monitoring.

Impoundment of the Kafue River through the construction of the upstream Itezhi Tezhi and downstream Kafue Gorge dams impacted on seasonal flow/flood regimes by changing the timing, duration and magnitude of flooding. The most profound impact is the general decrease in seasonally flooded areas of the Kafue Flats during the wet season and increased inundation of areas during the dry season. Although it is clear from the research that flooding magnitude and extent significantly impacts on relative abundance, reproductive success and biomass of fishes on the Kafue Flats, impacts related specifically to impoundment construction remained unclear. This was due to a lack of fish or fisheries specific impact studies on the downstream Kafue Flats subsequent to the construction of the Itezhi Tezhi impoundment.

Human population estimates, number of fishers, boats and nets utilised in the fishery have increased drastically, particularly in the period 1990-present (Figure 3). This coincides with the introduction of Nile tilapia (O. niloticus) in the 1980s and rapidly became an import component of the fishery.

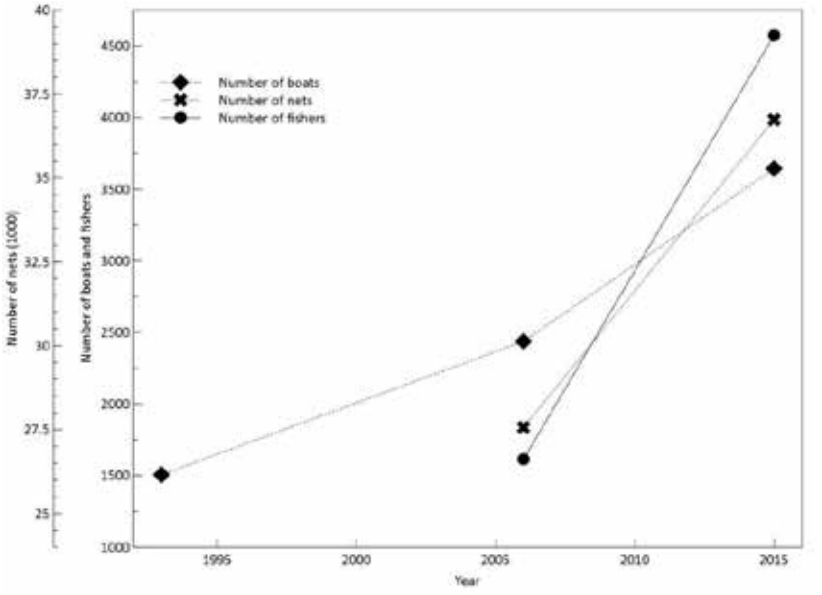
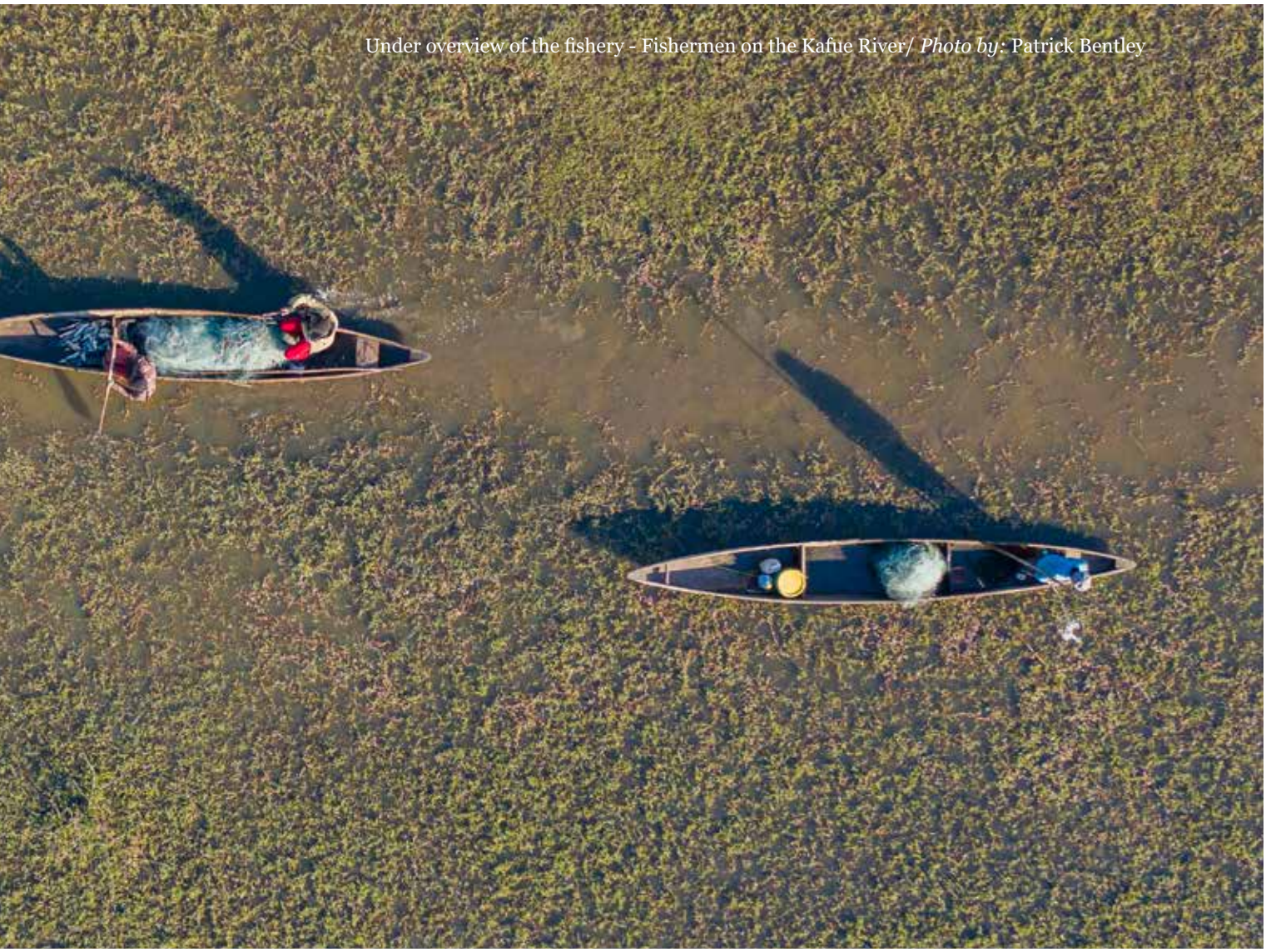


Figure 3: A comparison of three indices of effort for the Kafue Flats fishery from 1995-2015 (Data source: DoF 1993, 2006, 2015).



Under overview of the fishery - Fishermen on the Kafue River/ *Photo by:* Patrick Bentley

THE KAFUE FLATS FISHERY HAS PROVIDED BETWEEN 3,000 AND 11,000 TONNES/YEAR AND IS A SIGNIFICANT CONTRIBUTOR TO OVERALL FISH PRODUCTION IN ZAMBIA

In the absence of both traditional and contemporary management regimes, the Kafue Flats fishery exists as an open-access resource. Due to a lack of regulation, the fishery displays all the classic signs of overfishing. These include the use of smaller and smaller mesh sizes outside of legal sizes to maintain catch rates, an increase in the use of active gears or chasing fishes into nets, decrease in size of the major fishery species and decreasing catch rates over time.

While total catch estimates have remained relatively stable the catch rate continues to decline while fishing effort increases due to changes in techniques (e.g. passive to active). The multi-method, multispecies harvest approach employed by Kafue Flats fishers maximises the benefit they derive from the resource. If effort (the number of fishers/gears used, and manner in which the gears are used to harvest the Kafue Flats) is left unregulated and is poorly enforced, all the crucial life-stages of fishes are targeted resulting in a high probability of overfishing.

The Kafue Flats fishery has provided between 3,000 and 11,000 tonnes/year and is a significant contributor to overall fish production in Zambia (Tweddle, 2010; Tweddle et al., 2015). However, it is thought that this is a gross underestimate and that the Kafue Flats fishery could yield anywhere from 11,000 to 20,000 tonnes.year-1 (Cowx, 2011, Denies et al., 2013, 2016). Despite the significance of the fishery and the extensive fish and fisheries research that has been undertaken on the Kafue Flats, accurate estimates of total production are lacking.

IF MANAGEMENT PRACTICES WERE CHANGED, THE ECOSYSTEM SERVICES PROVIDED BY THE KAFUE FLATS COULD BE INCREASED.

In a study investigating the potential trade-offs between hydroelectricity generation and artisanal fish production on the Kafue Flats over a 54 year period, Deines et al. (2013) conclude that there is little evidence indicating that the construction of dams has had a significant impact on the fishery. Catch per unit effort, effort and harvest trends are more consistent with overfishing as a consequence of the open-access nature of the Kafue Flats fishery (Deines et al., 2013). Importantly, however, they conclude that if management practices were changed, the ecosystem services provided by the Kafue Flats could be increased. Cowx et al. (2018) reviewed various options for hydropower production on the Kafue Flats and concluded that the effects of flow manipulation has had important consequences for the ecosystem services provided by the Kafue Flats. This includes not only fish production, which the authors argue has been affected due to a change in the nature of the aquatic environment from a highly dynamic floodplain to a more stable lacustrine like environment (as evidenced by the change in species composition over time), but includes changes to terrestrial grazing lands, which are an important resource used by local communities, and a reduction in the flooded grasslands, which are important for local wildlife (especially the Kafue Lechwe). They argue that hydroelectricity generation is having a significant impact on the ecosystem services provided by the Kafue Flats, and any further generating capacity development should consider these to ensure they are not further compromised, thereby increasing resulting in further (economic) loses to the Kafue Flats.

Fisheries Governance

Fisheries in Zambia are managed through the Fisheries Act (Act No. 22 of 2011) which contains several regulations regarding permitted gears, declaration of closed areas and seasons and the management of fisheries. However, compliance is weak due to a lack of enforcement, and the use of illegal nets and methods is widespread (Cowx et al., 2011). The Chunga and Lwato lagoons are proclaimed closed areas which serve as refuges for breeding populations of fish, but there is little policing of these areas and therefore considerable illegal fishing (Cowx et al., 2011). Fishers are required to have a licence to fish, but there are no limits to the number of licences issued, and limited compliance monitoring, and therefore many fishers fish illegally without permits (Cowx et

al., 2011). Through the Act, a closed season is currently declared throughout Zambia over the wet season from 1 December to 28 February in order to protect vulnerable spawning stocks over this period (ACF/FSRP 2009). However, enforcement of this regulation is poor and the 2015 Frame Survey results suggest that more than 30% of fishers do not respect the fishing ban.

The Kafue Flats are mostly managed by the Department of Fisheries, which is based at Chilanga, and has regional offices in the Namwala, Monze, Mazabuka, and Kafue districts. Namwala and Mazabuka have no research mandate, while the Mansangu (Monze/Lochinvar) and Kafue offices both have extension and research mandates.

The portions of the fishery that fall in the National Parks (Lochinvar National Park and the Blue Lagoon National Park) and Game Management Areas (GMAs) are managed by the Department of National Parks and Wildlife (DNPW, formerly the Zambian Wildlife Authority (ZAWA)).

Communities in the Kafue Flats are governed by traditional rulers who are the custodians of customary land, and are responsible for allocation of land under their control but the extent to which this is applied to fishing areas is unclear.

A comprehensive Fisheries Management Plan for the Kafue Fishery was developed in 2011 for the Kafue Flats, but has yet to be implemented (Cowx et al. 2011).

Sampling Approach for the 2017 Surveys

In order to generate a recent dataset for WWF to use for future interventions in the Kafue Flats, a baseline fish and fisheries data collection programme was developed. This was divided into three components:

1. A fisheries independent sampling survey which aimed to characterise the biodiversity of the Kafue Flats.
2. A fisheries dependent sampling survey which aimed to characterise the fishery itself using questionnaires to obtain quantitative information on fishing activities from local fishers.
3. A stakeholder engagement survey which aimed to identify, engage, map and prioritise key stakeholders associated with the governance of the Kafue Flats fishery.

Fisheries Independent Data Collection

Fisheries independent data collection was aligned with previous surveys conducted by the DoF to ensure comparability of data. This was to ensure that there is a standard temporal dataset for assessment of the composition and relative abundance of key fishery resources in the Kafue Flats which is independent of the fishing methods used by the local fishers (i.e. fishing gear and effectiveness will not change over time). The key gear type used by the DoF is a gillnet fleet, and consists of one 585m long gillnet comprised of 13 panels of different mesh sizes. The mesh panels included meshes of 25, 37, 50, 63, 76, 89, 102, 114, 127, 140, 152, 165, 172mm stretched mesh size. Each panel is 45m long at a 0.5 hanging ratio and 2m deep with mesh panels positioned in the net from smallest to largest. The gillnet was set for three nights in each stratum during high flow (April 2017) and low flow (October 2017) surveys.

THE GILLNET WAS SET FOR THREE NIGHTS IN EACH STRATUM DURING HIGH FLOW (APRIL 2017) AND LOW FLOW (OCTOBER 2017) SURVEYS.

Gillnet surveys were supplemented through the use of fyke nets, electrofishing and crayfish traps. Two fyke nets were set per night and each area was sampled for three nights during the high and low flow surveys. Between 15 and 20 baited crayfish traps were set overnight in areas adjacent to the main sampling gears over three consecutive nights during the high and low flow surveys. Electrofishing was used in shallow waters in a range of habitat types, and effort ranged between 4 and 12 sites per strata during the high and low flow surveys.

Fisheries Dependent Data Collection

The fisheries dependent monitoring survey was designed to track the changes in fishery characteristics through obtaining information from fishers and fishing communities using structured interviews. Three types of surveys were run concurrently:

1. A detailed household level Socio-Economic/Livelihood Survey was undertaken with individual community members.
2. A Market Survey was undertaken opportunistically at landing sites and markets to obtain information on the value and distribution chains of the fishery.
3. A Catch Assessment Survey was undertaken based on a roving creel design with interviewers moving through the strata to identify fishers returning from fishing. This survey was aligned with previous surveys conducted by DoF to ensure comparability of data.

Ten field workers per survey (low and high flow) were appointed and trained to gather data over the course of 20 days per survey.

The Socio-Economic/Livelihood Survey was similar to a household survey and establishes the importance of fishing to the household relative to other livelihood activities such as farming and trading. The Catch Assessment Survey (CAS) was designed to capture information on key fishery indicators, market related data and information on the fisher's ethnic and residential status.

A separate Market Survey[1] was undertaken on an ad hoc basis to quantify the value of the fishery. The value of the different types of fish (or groups of fish) was ascertained, as well as any processing that has taken place. An estimate of annual turnover and volume was calculated based on the measurements undertaken at each market.

A governance stakeholder mapping exercise was undertaken and consisted of stakeholder identification (through consultation with DoF and WWF, through the information contained in the literature review, and through ongoing engagement with stakeholders), analysis (groups were assessed in terms of their expertise, willingness and value), mapping (linking stakeholders and objectives through the ranking used in the analysis) and prioritising (in relation to agreed-upon objectives by WWF).

Study Area

The Kafue Flats comprises four major sampling strata as delineated by the DoF (Figure 1), namely:

- Stratum I from Kafue Gorge Dam to upstream Chanyanya Lagoon.
- Stratum II from Chanyanya Lagoon to Chunga Lagoon (in Lochinvar National Park).
- Stratum III from Chunga Lagoon to Namwala.
- Stratum IV from Namwala to the Itezhi Tezhi Dam.

The sampling for the fisheries independent surveys followed the DoF sampling protocols as closely as possible to ensure comparability of data. The same fisheries independent sampling zones that are sampled by DoF were therefore chosen in each of the DoF strata. These zones included the Kafue area (Stratum I); Chunga Lagoon (within Lochinvar National Park) (Stratum II); and the Namwala Lagoon, a channel of the Kafue River that flows past Namwala Town (Stratum IV). An additional sampling zone was included in Mazabuka where the Zambia Sugar Estate borders the Kafue River main channel and some diversity sampling was conducted to the south west of Lochinvar National Park (Stratum II) (Figure 4).

[1]*Note that the market survey did not include visiting any other markets outside the Kafue Flats, therefore prices and destinations were determined based on interviews conducted with buyers at the landing sites only.*

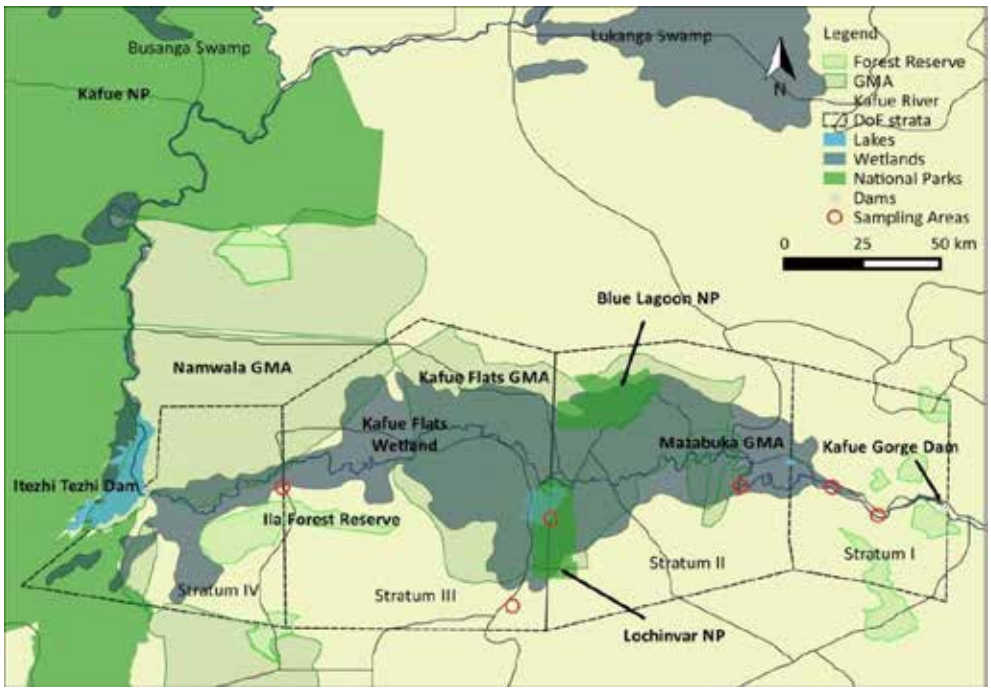


Figure 4: Overview of the sampling areas across the four strata (red circles) sampled during the fisheries independent sampling surveys.

Fisheries Independent Sampling Results

Overall 24 gillnet nights, 48 fyke net nights, 363 crayfish trap nights and 30 electrofishing sites were completed during seasonal surveys, with an equal split in effort between high and low flow periods.

In total 49 species of fish representing 13 families were captured during the bi-annual surveys on the Kafue Flats using the four main sampling methods. Of the 49 species of fish captured during the survey, two (Oreochromis niloticus and Limnothrissa miodon) are introduced and non-native to the Kafue system. The redclaw crayfish (Cherax quadricarinatus) is also an exotic, introduced species which was captured in the current survey.

Gillnet Survey Results

Overall 31 species from 8 families were captured during the gillnet surveys across all strata. Both biomass (CPUE kg) and relative abundance (CPUE n) were highest in the smaller mesh sizes in all strata and during both high and low flow surveys.

Species richness was highest in Stratum IV (13.3±2.5 species), followed by Stratum III (12.8±1.5 species), Stratum II (8.2±0.9 species) and the lowest number captured in Stratum I (3.4±1.1 species). Relative biomass decreased from 5.8±2.1 kg.net-night-1 to 0.2±0.1 kg.net-night-1, and relative abundance decreased from 189.8±63.5 fish.net-night-1 to 7.8±4.1 fish.net-night-1 from Stratum IV to Stratum I respectively (Figure 5).

With the exception of Stratum IV, species richness, relative biomass and relative abundance were all higher during the low flow survey in all strata. The discrepancy in Stratum IV was investigated in more detail and the cause for the low values during the low flow survey was due to poor catches on one of the three net-nights during the low flow period.

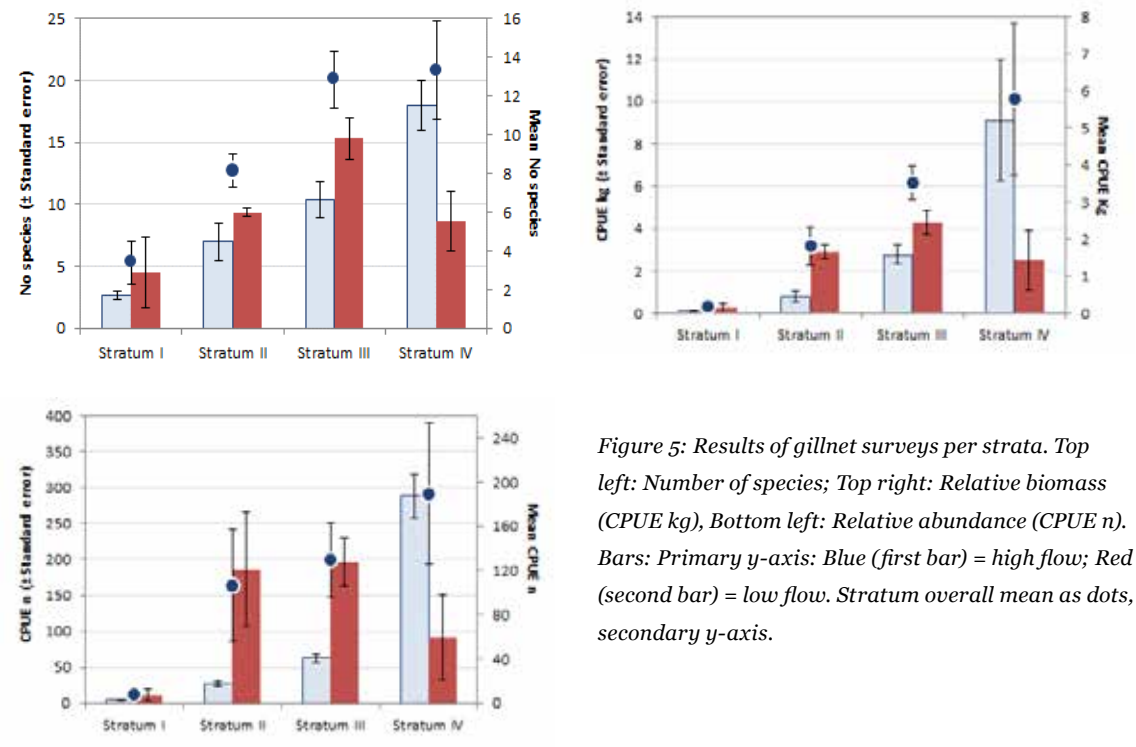


Figure 5: Results of gillnet surveys per strata. Top left: Number of species; Top right: Relative biomass (CPUE kg), Bottom left: Relative abundance (CPUE n). Bars: Primary y-axis: Blue (first bar) = high flow; Red (second bar) = low flow. Stratum overall mean as dots, secondary y-axis.

Fyke Net Survey Results

In total 22 ichthyofaunal species were captured in fyke nets with 19 and 16 species captured during the high and low flow surveys respectively. Two species, Enteromius multilineatus and Nannocharax machadoi were only captured in fyke nets and not in gillnets.

The average number of species.net-night-1 was highest in Stratum III with 4.3±0.6 species.net-night-1 and lowest in Stratum I with 2.8±0.4 fish.net-night-1. Seasonal differences were slight and neither season had clearly high diversity across the strata. The relative abundance of ichthyofauna was

highest in Stratum II during both high and low flow surveys while lowest relative abundance occurred in Stratum I during the low flow survey. No clear longitudinal or seasonal trends were apparent in the number of species or relative abundance of ichthyofauna across strata.

Crayfish Survey Results

The invasive redclaw crayfish C. quadricarinatus was captured in crayfish traps in all four strata during both high and low flow survey. The relative abundance differed significantly by stratum (Kruskal-Wallis Chi = 146.9, d.f. = 3, $p<0.05$) with Stratum IV having significantly higher numbers than all other strata (Figure 6). Carapace length differed significantly between strata with Stratum III having significantly larger C. quadricarinatus compared to all other areas, and Stratum IV being significantly larger than Stratum I. Carapace length did not differ significantly between seasons (Kruskal-Wallis Chi = 0.539; d.f. = 1, $p>0.05$) (Figure 6).

The sex ratio varied between zone and seasons with no clear spatial or temporal trend apparent. The proportion of females with eggs was higher during the low flow than high flow in Strata II and III, but similar in Strata I and IV (where abundance was higher).

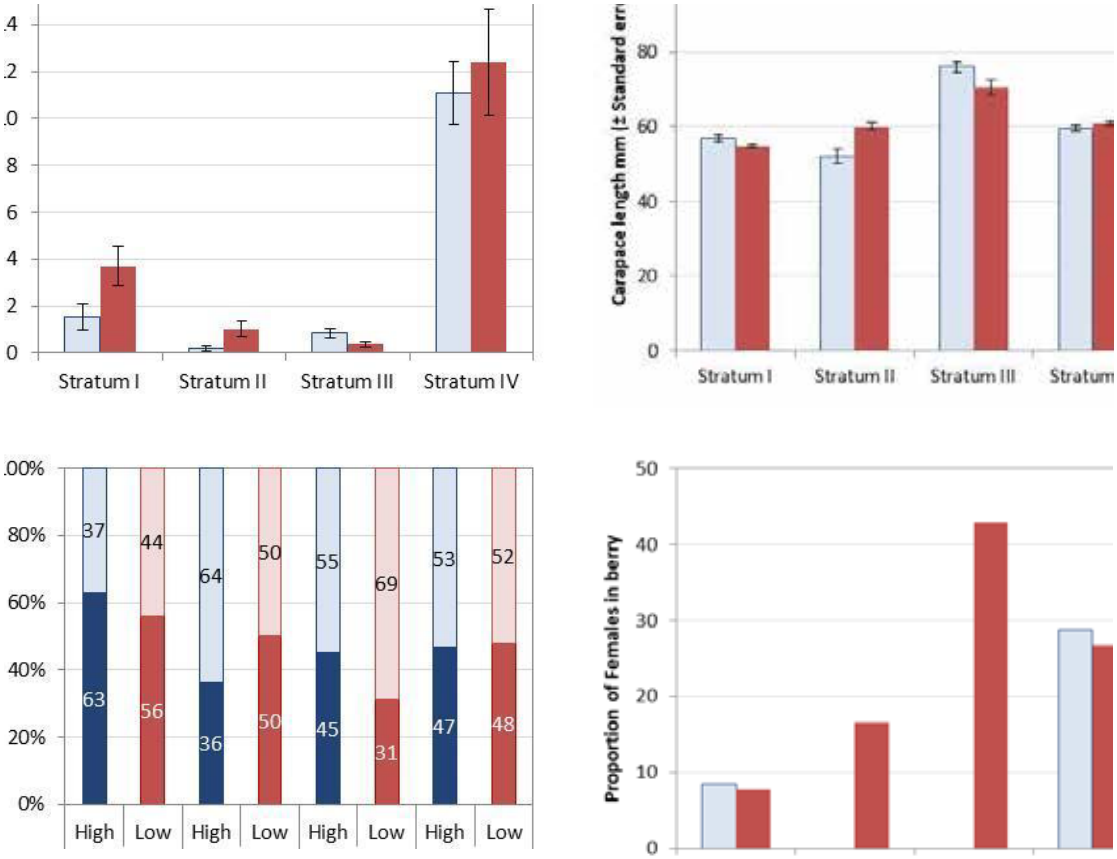


Figure 6: Relative abundance (top left), mean length (top right), sex ratio (bottom left) and proportion of females with eggs (bottom right) of C. quadricarinatus caught in the Kafue Flats in crayfish traps. Blue (first bar) = high flow; Red (second bar) = low flow. Sex ratio males above (light), females below (dark).

Electrofishing Survey Results

Electrofishing was conducted in fringing habitats and backwaters in order to contribute to a full survey of the ichthyofaunal biodiversity in the Kafue Flats. In total 32 species were captured, with 24 captured during high flow sampling and 22 captured during low flow surveys. Fourteen species captured electrofishing were not captured during gillnet or fyke net surveys. The majority of these were small species not susceptible to capture in other sample gears. In contrast 15 species captured during gillnet and fyke net surveys were not captured by electrofishing.

Comparison with Historical Data

A comparison of the data collected during the situational analysis with data collected by the DoF gillnet survey was undertaken. Time-series data on the fisheries statistics for the Kafue Flats fishery were obtained from DoF annual fisheries statistics reports. The data show that there has been a notable decline in the relative abundance, relative biomass and average size of fish in the Kafue Flats from the late 1980s to the current survey (Figure 7). Relative abundance peaked in 1988 at 283.7±20.3 fish.net-night-1 (mean±standard error) and decreased consistently during the 1990s. The current survey results are less than half (38%) of the peak value with a mean relative abundance of 108.5±49.3 fish.net-night-1. Relative biomass shows a similar trend with a peak in 1986 at 44.5±5.6 kg.net-night-1 with a progressive and dramatic decrease to 2.8±1.3 kg.net-night-1 in the most recent survey in 2017. A coarse indicator of the quality of fish is presented as the average biomass of individual fish (CPUE kg/ CPUE n). This indicator also demonstrates a significant decline in mean fish weight from 0.44kg in 1983 to 0.03kg in the current survey (Figure 7).

Indicator Species Size Structuring Results

Four key fishery species were chosen as indicators of temporal change in size structure in the broader Kafue Flats area, three of those important contributors to overall biomass (the sharptooth catfish (C. gariepinus), the thinface largemouth (S. angusticeps) and the silver catfish (S. intermedius)) and the fourth which is the bulldog (M. macrolepidotus), is a less significant contributor to the fishery in terms of biomass but is still caught in large numbers. These species were selected as indicators based on the catch composition of the most recent survey (2017) as they were present in sufficient numbers for comparative purposes. Historically other species such as the threespot tilapia (O. andersonii), the greenhead tilapia (O. macrochir), the redbreast tilapia (C. rendalli), the leaden labeo (L. molybdinus), and the African pike (H. cuvieri) were the most important species in the fishery. The mean number of individuals caught per net night for these species shows a dramatic decline, highlighting the collapse of the fishery during the 1990s. The absence of these species in recent surveys indicates a notable shift in the fishery as a direct result of overharvesting. These species, with the exception of S. angusticeps, are no longer present in the current day catches in sufficient quantities to allow for long-term comparison with historical data and hence have been excluded as

indicator species.

The data for the chosen indicator species show that there have been significant shifts in size structure, which is supported by the more recent data collected during the 2017 survey (Figure 8). There is a general trend of decreasing percentage of mature individuals, mean length, size range and maximum size for all indicator species on the Kafue Flats. These all indicate that the fishery is overfished.

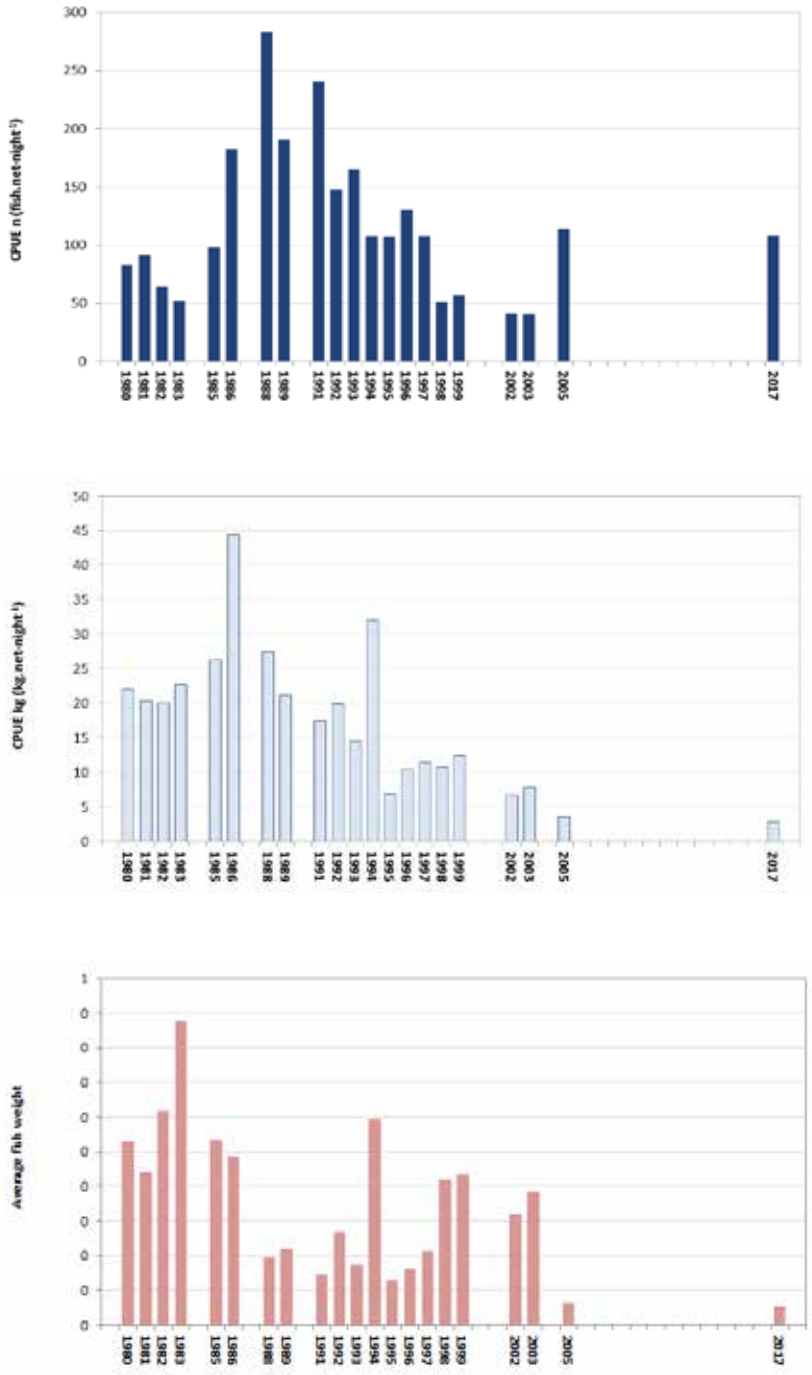
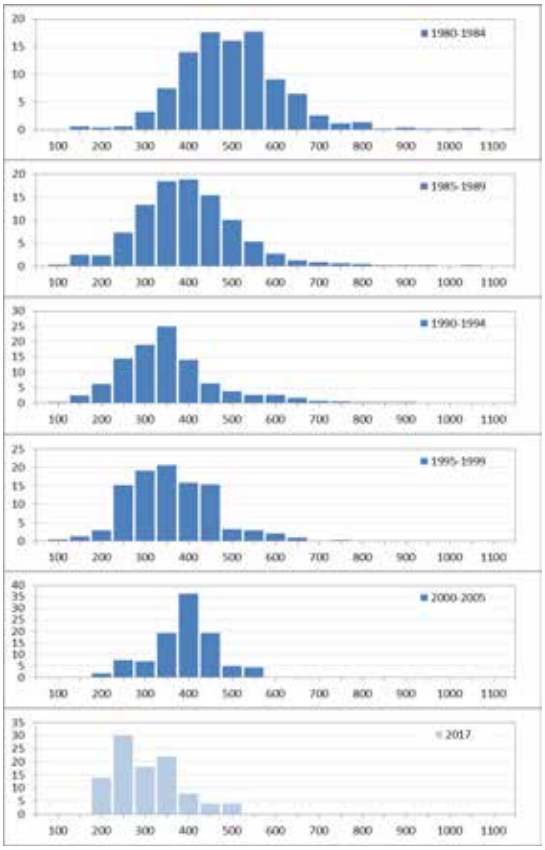
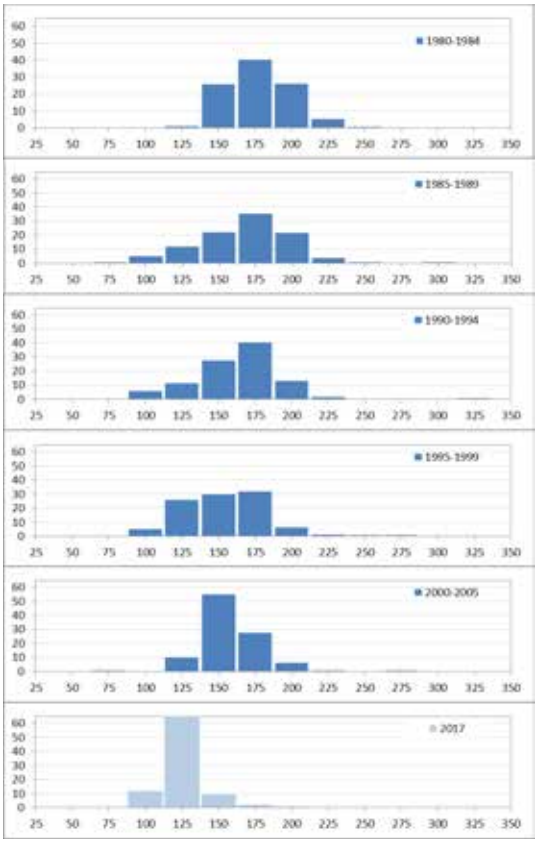


Figure 7: Temporal presentation of historical DoF and current survey data for the Kafue Flats (all sites pooled). Top: Relative abundance (fish. net-night-1); Middle: Relative biomass (kg.net-night-1); Bottom: Average size of fish (kg). The large gap in data collection is due to a lack of funds to undertake the DoF monitoring surveys.

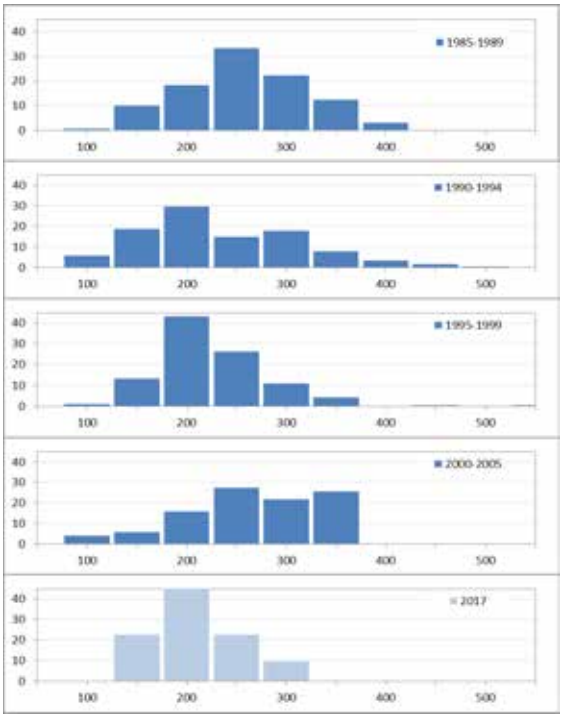
Sharptooth Catfish (C. gariepinus)



Bulldog (M. macrolepidotus)



Thinface Largemoth (S. angusticeps)



Silver catfish (S. intermedius)

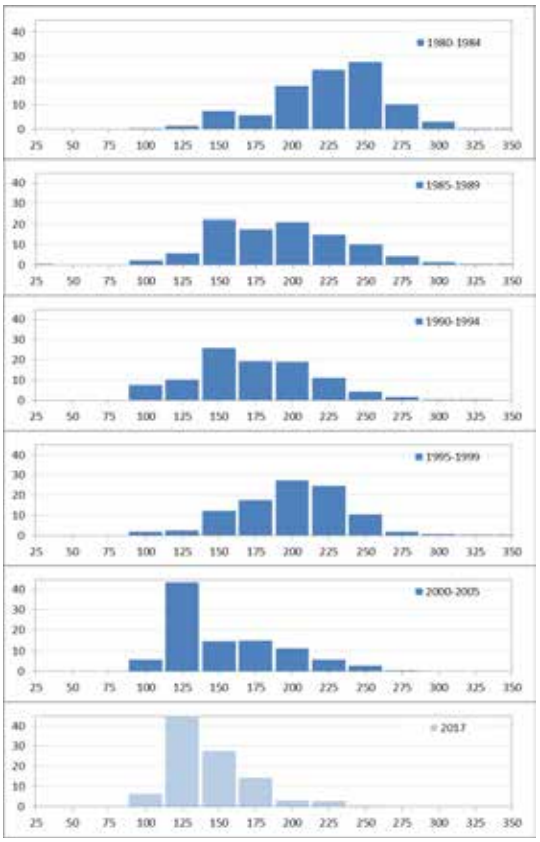


Figure 8: Sharptooth catfish (C. gariepinus) (top left), thinface largemouth (S. angusticeps) (top right), bulldog (M. macrolepidotus) (bottom left) and silver catfish (S. intermedius) (bottom right) length frequency time series distributions

A fisherman on the Kafue Flats/ *Photo by: Patrick Bentley*

Fisheries Dependent Sampling Results

Household Socio-Economic Survey Results

A total of 1,329 respondents were interviewed during the Socio-Economic Survey undertaken during the high and low flow periods across the four strata. The stakeholder engagement process revealed that the distinction between permanent and migrant residents no longer applies in a fisheries analysis context, and most fishers on the Kafue Flats are year-round residents. Although there are still differences between groups based on origin and historical connections to the Kafue Flats, the residents are not distinct in their level of involvement in all aspects of the fishery (fishing, processing, trading, and participatory management). The results from the surveys are therefore not divided into permanent and migrant results since these distinctions are no longer meaningful.

The main tribal groups interviewed were Bemba (39%), Lozi (19%), Tonga (19%), Nyanja (6%), and Ila (5%). The average age of men ranged from 36 (±15 years) in Stratum I to 45 (±16 years) in Stratum IV. This was slightly older than the average age of women on the Kafue Flats, which ranged from 37 (±16 years) in

Stratum I to 43 (±13 years) in Stratum IV.

SIX MAIN GEAR TYPES WERE REPORTED. GILLNETS ARE BY FAR THE MOST DOMINANT GEAR TYPE ACROSS ALL STRATA

The mean household size was very similar across the strata varying from 5.6±3 people in Stratum III to 5.9±3.1 people in Stratum I. The number of dependants (<16yrs of age) was lowest in Stratum III (average of 2.4±1.2 dependents per household) and highest in Stratum I (2.9±2.4 dependants per household).

The average number of household members employed was low across all strata but particularly in Stratum IV. Stratum III had a higher average number of people who also fish in the household compared to other strata. The average number of household members who farmed was higher in Stratum I, followed by strata IV and II and was lowest in Stratum III. The average importance of fish protein to household diets was lower in Stratum I compared with the other strata.

Fishing Activities

Six main gear types were reported. Gillnets are by far the most dominant gear type across all strata. Other popular gears and fishing methods include draw nets, basket traps, kutumpula (actively chasing fish into a gill net by beating the water), longlines and hook and line fishing, but their use varies across strata.

In order to obtain an estimate of seasonal fishing effort, fishers were asked to provide information on the number of days on which they fished per week/ month for each month of the year. Reported fishing effort was highly variable across all strata, but was reported to decline in all strata between December and February (during the fishing ban).

Fisheries Governance Results

More than half of the fishers in Stratum IV had fishing licences (66%) but, in all other strata, the majority of fishers did not have fishing licences, particularly in Stratum III. Fishers from all strata reported being prevented from fishing in certain areas at some point, but the number of cases reported in Stratum I was very low compared to the other strata. The highest occurrence of fishers being prevented from entering closed areas was reported in Stratum III (42%) followed by Stratum IV (38%) and Stratum II (24%). The main agents enforcing the closed areas was reported to be the DNPW in strata II, III and IV, with DoF representatives also reported to be enforcing closed areas in Stratum II.

The highest proportion of fishers reporting being prevented from fishing during certain times of the year was in Stratum I (57% of respondents). The majority of respondents reported being prevented from fishing by DoF representatives in all strata. Other enforcement agents included DNPW agents in strata II and III.

Livelihood Activities

Strata I (56%) and IV (26%) have the highest proportions of people whose livelihoods are based exclusively on farming, and Stratum III has the highest proportion of people whose livelihoods depend exclusively on fishing (92%). Between 5-46% of the respondents interviewed reported practising both farming and fishing as part of their livelihood strategies across all strata. Overall, 54% of the people interviewed across all strata are dependent on fishing only as a livelihood, 18% on farming only and 21% on both (Figure 9).

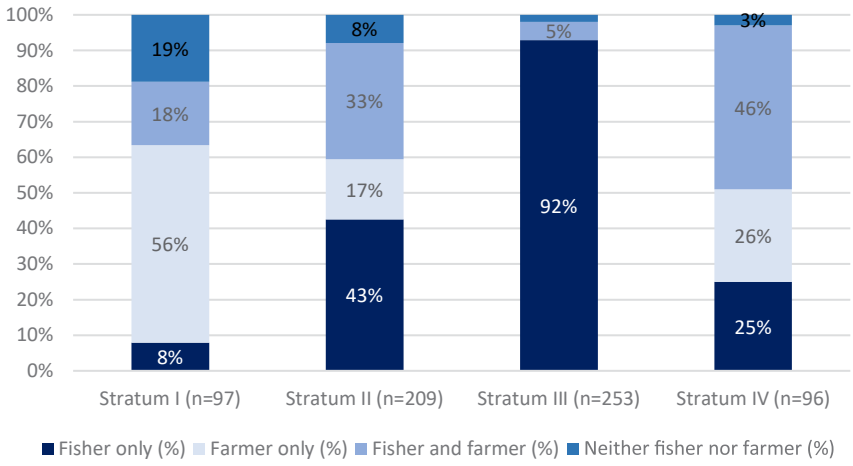


Figure 9: Livelihood activities reported by Kafue Flats residents per stratum

Farming livelihoods can be divided into three broad categories: crop farming, livestock rearing and other livelihood activities. The most common crop in the Kafue Flats is maize. Poultry (chickens and ducks) are the most common type of livestock kept on the Kafue Flats across all strata although they are proportionally slightly less important in Stratum IV than the other strata. Cattle are the second most important livestock type in Strata IV and III, whereas goats are more important in strata I and II.

Alternative livelihoods are most common in Stratum I and include activities such as running a bakery, working in a shop, selling air time, alternative employment and working in a market. Fish processing is the major alternative livelihood activity reported in strata II and III, followed by fish trading. Fish trading is the most important alternative livelihood to farming and fishing in Stratum IV.

Catch Assessment Survey Results

In total 1,208 Catch Assessment Survey interviews with local fishers were conducted during the low and high flow surveys. Mixed small fish, small cyprinids, catfish, silver catfish and banded tilapia are the main components of the fish catches. Fibre boats were most common in Stratum I, while canoes

were most common in Stratum II and Stratum IV, and plank boats were most common in Stratum III. Gillnets were the most popular gear.

Catch per unit effort (CPUE) ranged from 3.2±0.7 kg.fisher-1.day-1 to 60.0±17.1 kg.fisher-1.day-1 in Stratum IV and Stratum II respectively (Figure 10). Fishing effort ranged from 3.2±0.2 to 4.0±0.1 days per week across both seasons and all strata, with no seasonal or spatial patterns in fishing effort evident (Figure 10).

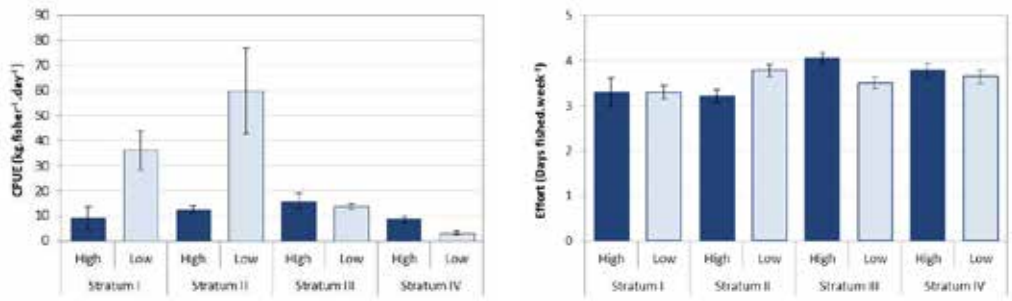


Figure 10: Seasonal CPUE, effort (fish days and number of fishers) and harvest per stratum based on Catch Assessment Survey data.

Using these CPUE and effort values, seasonal and annual harvest per fisher for each stratum was calculated[2] using three different methods. Data based on CPUE per fisher provides an estimate of 15,956 tonnes.year-1. Calculation of total harvest using number of boat days (including shore based angling days) result in an estimated annual harvest of 13,360 tonnes.year-1. Estimating harvest using the estimated fisher number from the 2015 DoF frame Survey and increasing the population size by 3.03% per annum produces an estimated annual harvest of 18,365 tonnes.year-1. These values fall within the expected range for a moderately to heavily exploited floodplain fishery.

The estimates of annual harvest on the Kafue Flats translate into a spatial yield of 20 to 28kg.ha-1.year-1. This is considerably lower than the theoretical estimated annual yield for floodplain rivers based on the morphoedaphic index which ranges from 72-200kg.ha-1.year-1 (Henderson and Welcomme, 1974; Welcomme 1976). Actual values for moderately to heavily exploited floodplain fisheries range from 28 to 134 kg.ha- 1.year-1 (Welcomme 1975). The estimated harvest and corresponding annual spatial yield for the Kafue Flats, which is heavily exploited, is therefore within this observed range. The large range in calculated annual harvest highlights the difficulties in estimating the scale of the fishery and the need for accurate estimates of total effort (fisher and boat numbers) which are critical for calculating estimates of annual harvest.

Market Survey Results

The Market Surveys undertaken at Chunga, Nakambala, Kalukulu and Namwala revealed an estimated annual volume of 1,177 tonnes (dry and wet weight) with a total value of approximately ZMK 26,000,000 per annum from these four markets (Table 1).

[2] This calculation assumes 6month high flow and 6 month low flow periods and takes into account the 3 month fishing ban.

Parameter	Chunga Harbour		Kalukulu Market, Kafue		Nakambala Market, Mazabuka		Namwala Market	
	High flow	Low flow	High flow	Low flow	High flow	Low flow	High flow	Low flow
Total Weight (kg)	8,505	6,055 ± 1,344	263	324	950	764 ±378	193	206 ± 29
Wet weight (kg)	2,788	1,237 ± 349	184	19	427	78 ± 34	33	64 ± 15
Dry weight (kg)	5,717	4,818 ± 1,682	79	305	523	685 ± 373	161	143 ± 13
Total value (ZMK)	208,376	148,343 ± 32,946	4,021	6,300	12,688	18,348 ± 7,856	3,545	4,375 ± 573
Market days.week^{-1}	2		7		7		7	
Estimated Seasonal Volume (tonnes)	417	297	45	56	163	131	33	35
Estimated Seasonal Turnover (ZMK)	10,210,424	7,268,807	689,602	1,080,450	2,175,992	3,146,682	607,968	750,313
Estimated Annual Volume (Tonnes)	**713**		**101**		**294**		**69**	
Estimated Annual Turnover (ZMK)	**ZMK 17,479,231**		**ZMK 1,770,052**		**ZMK 5,322,674**		**ZMK 1,358,280**	
Estimated Annual Turnover (US$)	**US$ 1,747,923**		**U$ 177,005**		**US$ 532,267**		**US$ 135,828**	

Table 1: Summary of estimated fish harvest and value from four markets visited on the Kafue Flats.

Economic Value

THE ENTIRE KAFUE FLATS FISHERY IS ESTIMATED TO BE IN THE REGION OF US$30 MILLION PER ANNUM

In order to estimate the economic value of the fishery the first method of estimating annual yield (CAS CPUE x DoF Number of fishers) was used as it was based on the number of fishers in each stratum which was required to account for the proportion of catch used for home consumption. This method estimates the annual yield at 15,956 tonnes. The proportions of catch used for home consumption and proportion sold were used to calculate the annual yield sold based on the number of fishers per stratum and taking into account seasonal CPUE and the 3month fishing ban. Based on these calculations and an estimated wet weight sale price of ZMK18.80/kg from the market surveys, the estimated value of the sale component of the fishery is in the region of US$22.6 million. The economic value of the retained fish for home consumption is estimated at US$7.3 million and hence the value of the entire Kafue Flats fishery is estimated to be in the region of US$30 million per annum.

Although this seems extraordinarily high for an artisanal/subsistence fishery Seyman et al. (2001) estimated the value of the Kafue Flats fishery to be around US$13.3 million in 2001 and Cowx et al. (2011) suggested the value of the fishery could be in the region of U$30 million (2011) taking into account home consumption. The economic value of the fishery determined in this study is in line with these estimates.

Stakeholder Engagement and Governance Survey

The engagement process involved meeting with the following key role players:

- National stakeholders: DoF Chilanga, DNPW Chilanga, Worldfish.
- Regional stakeholders: District administrators, DoF and DNPW regional and field offices.
- Traditional leadership: Chiefs, senior headmen and headmen.
- Community organisations: Fishers organisations, Fishing Village Management Committees, Fish

Trader organisations

Semi-structured interviews were undertaken with each stakeholder to understand the structure of the current fisheries management regime, and to obtain a history of the stakeholder's activities in relation to fisheries management. Based on the findings of these interviews a stakeholder analysis was prepared.

The discussions revealed that the DoF face severe funding and capacity challenges. These can to some extent be addressed through establishing partnerships, and identifying means to generate additional running income. Capacity limitations can be addressed through training programmes. The existing partnership with the DNPW is working well and should be fostered into the future. The DNPW and DoF share common concerns regarding the effects of flow manipulation for electricity generation on the biological productivity of the Kafue Flats. The discussions held with the district leaders revealed that there is potential for good collaboration and assistance from district administrations to enable the DoF to undertake their mandate. However, further clarity on the devolution of powers from central government to the district level is required. It was determined that chiefs are not directly involved in the day to day fisheries activities and are therefore less salient to a potential management plan, but they have an important role to play in terms of mobilising community activities. Headmen face legitimacy issues in respect of fishers who have settled on the Flats from elsewhere in Zambia. The headmen hold an important position in terms of initiation of management interventions, but require support from senior headmen, chiefs and DoF to enhance their perceived legitimacy. Meetings with the VFMC and Fishers Association were positive, with both organisations showing strong signs that their involvement in co-management initiatives are likely to be viable. Traders do not appear to be in need of management interventions since they are working efficiently at present.

All key stakeholder groups with an interest and potential for co-operative management of the Kafue Flats fishery were engaged during this study. The

stakeholder engagement process did not uncover any additional organisations that were omitted during the initial screening stages, and those engaged with during this process are the main players that will need to be partnered with in future management intervention planning.

Discussion

Overall Assessment

15 & 22% OF THIS TOTAL HARVEST

Persistent and unregulated high levels of fishing effort have contributed to the decline and collapse of the fishery on the Kafue Flats. This has been demonstrated through the decline in the relative abundance, relative biomass and average size of fish in the Kafue Flats from the late 1980s to the current survey. Significant long- term changes in gear use have occurred which have enabled fishers to maintain catch rates despite declining stocks, which coupled with increasing participation have contributed to the stock collapse. Changes in gear use from passive gears (gillnets) to active fishing (dragnetting) are seen throughout the Kafue Flats and are an indication of the increasingly more demanding means required to maintain catches. Species which were previously targeted and abundant in the Kafue Flats are no longer present in catches, or are only occasionally caught which is indicative that serial overfishing has occurred. Examples of such species include the threespot tilapia (O. andersonii), the greenhead tilapia (O. macrochir), the redbreast tilapia (C. rendalli), the leaden labeo (L. molybdinus), and the African pike (H. cuvieri). The absence of these species in recent surveys indicates a notable shift in the fishery as a direct result of overharvesting. A significant reduction in fishing effort through regulating the number of participants and gears used is required to improve the health of the fishery in the long term.

The total estimated value of US$30 million.annum-1 for the entire Kafue Flat fishery demonstrates the status of this fishery at a national level. The total fish production for Zambia in 2017 is reported at 85,762 tonnes (Zambia Agricultural Status Report 2017), meaning that the Kafue Flats accounted for between 15 and 22% of this total harvest (depending on the method of total harvest calculation used). The contribution of the fishery to food security has previously been acknowledged, but its importance as a major source of income generation to many actors in the Kafue Flats and further afield has been underestimated. This is a fishery of national relevance and requires management intervention to ensure its durability in the long term.

Co-management of the Kafue fisheries is feasible but will be difficult to implement. Project funding to initiate activities, followed by long-term commitment to support by the government authorities (DoF, DNPW, Local Government) is essential. The initial structure for community involvement, notably the VFMCs, is in place but needs major inputs of education, training and funding to become effective. Short-term goals should be to stabilise the

fisheries by removing the most destructive gears, i.e. all monofilament netting and shade cloth dragnets. Restoration of a more valuable fishery for large cichlids is a long-term goal and cannot be achieved unless effort is controlled at levels well below the current unsustainable levels. The goals for management need to be established through a consultative process involving the fishers as well as the stakeholder organisations.

Fisheries Independent Situational Analysis

The main objectives of the fisheries independent situational analysis were met, but several challenges were encountered during the project. One of the primary aims of this project was to collect data that could be compared to DoF historical data records to provide an assessment of change over time in the fishery. For this reason, the same gear type and sampling locations as those used by the DoF gillnetting surveys were selected for the purposes of this sampling programme. The overall survey design can be improved relatively easily to facilitate the field work and increase the statistical power by using a larger number of shorter gillnets which account for the same (or very similar) overall effort, and include the same range of mesh sizes.

THE OVERALL SURVEY DESIGN CAN BE IMPROVED RELATIVELY EASILY TO FACILITATE THE FIELD WORK

Ongoing monitoring should continue to utilise gillnet surveys as the primary means to assess long-term trends in key indicators in all strata, taking into account the above recommendations. Gillnet surveys can be supplemented periodically by other methods to assess small species not captured in gillnets which comprise a significant proportion of the ichthyofaunal biodiversity. The programme should also include the regular use of standardised (type, size and bait) crayfish traps to monitor the spread and distribution of the redclaw crayfish throughout the Kafue Flats.

The following indicators can be used as a basis to track changes in the resources over time:

- Frequency of Occurrence of species.
- Relative biomass by weight (CPUE kg).
- Relative abundance by number (CPUE n).
- Community composition (in kg and number).

In addition species which are targeted by the fishery should be used as key indicators to monitor change using the following metrics:

- Mean size (size distribution).
- Relative biomass (CPUE kg).
- % above size at first maturity.
- Maximum size.
- Size range.

Four species were used in this assessment as they comprised a significant

proportion of the catch and are targeted by the fishery, namely S. angusticeps, C. gariepinus, S. intermedius and M. macrolepidotus. Improved replication in the survey design will contribute to providing more data for calculation of species specific indicators.

Fisheries Dependent Situational Analysis

The results from the various components of the fisheries dependent survey were satisfactory and set down a useful framework for future monitoring. However, poor numeracy was a challenge encountered during implementation of the socio-economic and catch surveys. In order to improve future data collection from mini frame surveys, the enumerators should be trained to collect information directly themselves rather than relying on respondent recall. This will improve the reliability of data (provided monitors are well trained); however, it is time consuming and requires the willingness of the villagers to participate.

The AES field team highlighted that fishers were much more reluctant to provide information to the field workers during the low flow survey because of fears over a rumoured six month fishing ban. People were also reluctant to admit to fishing during the fishing ban between December and February. A good relationship needs to be established between the field workers and the communities and respondents with whom they are engaging.

The following indicators should be used to monitor socio-economic aspects of the fishery going forward:

- Relative proportion of fishing income to household income.
- Changes in fishing equipment ownership (people will not invest in new equipment unless it is
- necessary).
- Fishing effort and seasonality:
    - Number of months in which fishing is undertaken.
    - Important fishing months.
    - Days fished each month of the year.
- More detailed socio-economic and livelihoods data could be obtained periodically on a small sub-sample of the population using the full socio-economic/livelihoods survey as used in the current study.

The catch assessment questionnaire used in this situational analysis obtains information on catches as well as some basic socio-economic data, which change daily. This survey should be focussed on landing sites only, while the socio-economic interviews should be conducted in fishing villages. The following indicators for the catch assessment survey are recommended:

- Catch composition.
- Relative biomass (CPUE kg).
- Relative number (CPUE n).

- Mean length.
- Gear use.
- Daily sale value.
- Number of days fished in last 7 days.

Stakeholder Engagement and Governance

The stakeholder engagement and governance survey was well executed and ensured that most role players were interviewed. Co-management of the Kafue fisheries is feasible but will be difficult to implement and will require on-going support. Successful implementation of a co-management strategy will require a secure source of funding in the long term. Given the many needs of government funding in Zambia, this would likely be difficult to secure.

Baseline Data Collection

The primary objective of updating the baseline information on the current situation of the fish and fisheries of the Kafue Flats was successfully achieved. The surveys designed and developed during this study will be useful for future monitoring, and comparisons of data over time will enable a measurement of progress in management interventions.

Recommendations

Areas that require attention going forward are:

- Provide training to the DoF field staff in fish identification and fisheries management. Provide logistical and budget support to these offices to allow them to operate.
- The identification of sources of funding for continued support to fisheries management efforts in the Kafue Flats to decrease fishing effort and allow the fishery to recover from over-exploitation.
- Revise and update the current DoF monitoring protocol to improve the survey design and quality of data produced; this includes greater replication in the gillnet survey and the use of traps for monitoring redclaw crayfish.
- Engage with VFMC, Kafue Fishers Association, headmen and district councils to start piecing together a management framework that can serve as a basis for a co-management plan.

Concluding Remarks

The Kafue Flats floodplain system is subject to the following major pressures:

1. Regulation of the flood pulse.
2. Fishing effort.
3. Alien invasive species.

THE FLOOD PULSE IS THE MOST IMPORTANT DRIVER OF PRODUCTIVITY IN FLOODPLAIN ECOSYSTEMS AND FISHERIES IN PARTICULAR

The flood pulse is the most important driver of productivity in floodplain ecosystems and fisheries in particular (Jul-Larsen et al., 2003). The lack of seasonal flooding and nutrient inputs means lower primary and secondary productivity and hence less productive fisheries (Jul-Larsen et al., 2003). A review of the current water release plan and development of an Integrated Flow Management Plan may contribute towards improving the ecology within the Kafue Flats through optimisation of the volumes and periodicity of releases.

The current levels of fishing effort are resulting in an over-fished system, with fishers having to resort to using smaller and smaller mesh sizes and more active fishing methods to maintain catch rates. Fishers who were previously only part-time participants in the fishery (migrant fishers) are now permanently settled, which is indicative of a lack of alternative livelihoods elsewhere in Zambia for fishers. It also indicates an increase in dependency of local populations on the fishery, which increases their vulnerability to fluctuations in catch levels as a result of lower rainfall and a weaker flood pulse. Fishing activities need to be managed by an adequately funded DoF.

Crayfish were reported to be having a major negative impact on fisher catches during the stakeholder engagement process and during ad hoc interviews with fishers. The accidental introduction of Nile tilapia in the 1980s has resulted in the hybridisation with other species (Deines et al., 2014). Water hyacinth is well established both as a floating and as a terrestrial plant on the Kafue Flats.

These three distinct pressures are acting synergistically on the ecology of the Kafue Flats, resulting in changes in the ecology of the ichthyofauna of the Flats. The pressures can only be managed through an integrated management approach, which considers the requirements of all role players and involves consensus based decision making.

A fisherman on the Kafue Flats/ *Photo by: Patrick Bentley*

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A fisherman on the Kafue Flats/ Photocredit:Patrick Bentley

Water Resources Protection Areas

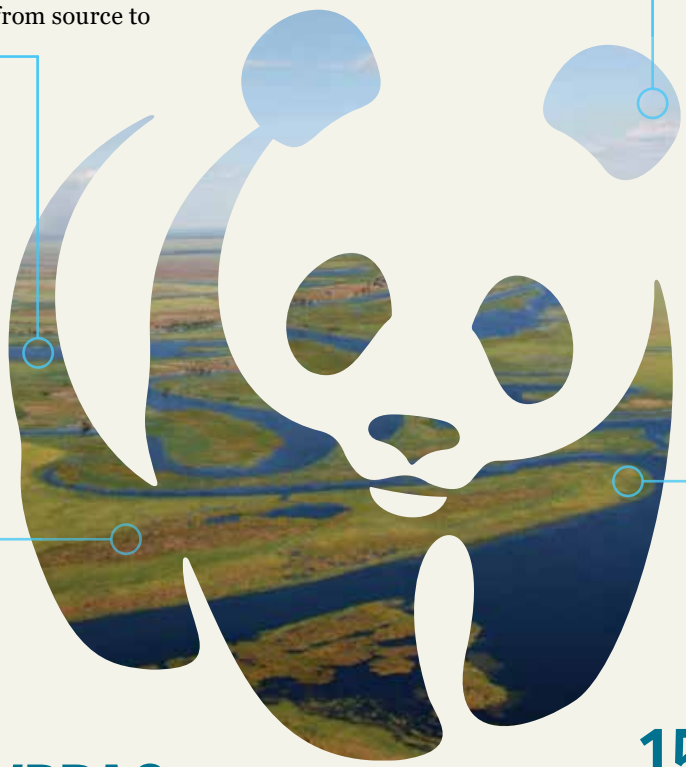
SUMMARY REPORT 2019

3 SPECIFIC CRITERIA LISTED

- High importance in providing water
- High aquatic ecological importance
- Sensitive to use and anthropogenic impact

1 LONGEST FFR IN ZAMBIA

Luangwa is the longest Free flowing river wholly in Zambia from source to sink



12 WRPAS TARGETED

Zambia's 7th NDP targets to protect 12 Water Resources Protection Areas by 2030

15: SDG GOAL

Life on Land : Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

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