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Baseline Fish Biodiversity Surveys – Experiences from the Zambezi River, Southern Africa

AWF Conservation in Practice Papers



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Cover photos clockwise: Surveys teams assessing fish catch on Zambezi River; survey team seining in shallow bay; sample of fish caught by survey team; fishing village on Zambezi: Photo credits AWF.

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Introduction

The Zambezi River and its tributaries are critical habitat for abundant freshwater fish resources ranging from socially and economically significant species such as tigerfish (*Hydrocynus vittatus*), lungfish (*Protopterus annectens brieni*), to rare or endemic cichlid (tilapias) and cyprinid species. Out of the 239 species recorded in the whole Zambezi Basin (excluding Lake Malawi), 122 species use the Zambezi River itself (Skelton, 2001). While there is a paucity of knowledge regarding species diversity in the Zambezi, anthropogenic activities, from fishing pressure to curtailed migration patterns due to dams, are known to impact fish resources along the river's entire length. It is therefore critical to assess species diversity in various habitats along the stretch of the Zambezi River in terms of endangered, rare, and endemic species and related threats from anthropogenic activities in order to guide planning of conservation interventions.

To fill this knowledge gap, the African Wildlife Foundation (AWF) implemented two sub-projects

centered on field investigations conducted by the Aquatic Resources Working Group (ARWG) in the Four Corners Transboundary Natural Resources Management (TBNRM) area (see Mwima and Mandima (2004) and Map 1).

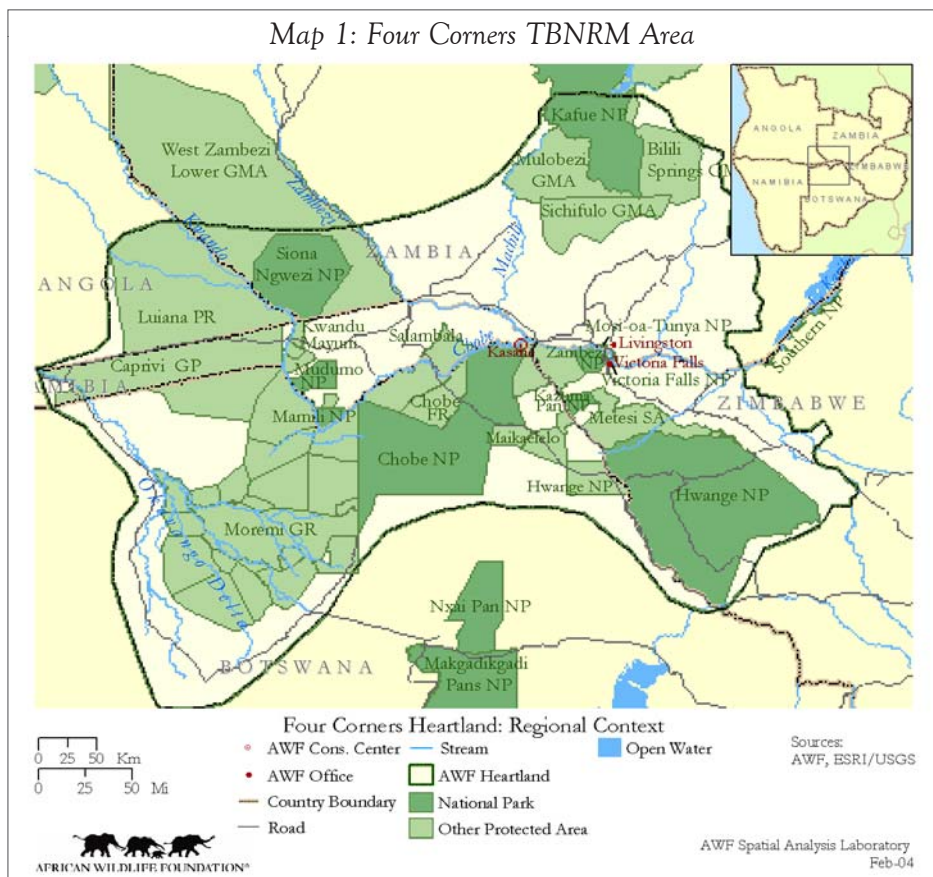
The investigations were designed to address two basic requirements for successful conservation intervention in fisheries resources management in Southern Africa – (i) objectively verifiable scientific information used to inform management decisions and strategies in the form of a fish biodiversity inventory, and (ii) standardization and harmonization of ecological monitoring methods by all parties involved in the management of shared fisheries resources. Fish biodiversity surveys were also undertaken by AWF and partners in the Middle Zambezi (Mwima and Mandima (2004) and map 2).

All fish biodiversity surveys were started first in order to inform both resource users and managers on the status of the resource. This database of fish from this inventory then forms a benchmark for conservation monitoring over time using standard methods developed and adopted as per requirement (ii).

Fish Biodiversity Surveys in Upper and Middle Zambezi

The main activities under this component were concentrated in the Four Corners TBNRM area, where, with leadership from the South Africa Institute for Aquatic Biodiversity (SAIAB), AWF conducted three long field investigations of fish biodiversity in Zambia's Upper Zambezi. In the Middle Zambezi, AWF used in-house expertise working with staff from partner institutions (Mwima and Mandima (2004) to carry out four short field investigations of fish biodiversity. The objective for the investigations in both sites was to produce baseline assessments of fish

Map 1: Four Corners TBNRM Area



species present, and a database that will be a valuable tool and reference to guide the management of shared fisheries resources.

Survey Locations and Timing

The Upper Zambezi surveys spanned a longitudinal transect from headwaters of major tributaries of the Zambezi River at its source downstream to the Victoria Falls region, with latitudinal transects from midstream to the outer extremity of the river at various key stations along the longitudinal profile of the river system. The surveys targeted the following sites:

- The headwaters of the Zambezi - West Lunga River and Kabompo River
- Pre-floodplain mainstream rivers: Kabompo River at Kabompo; Zambezi River at Zambezi
- Barotse floodplain in Mongu area
- Lower floodplain, Senanga area
- The Zambezi River above Victoria Falls (Kazungula to Livingstone/Victoria Falls)

Zambezi and Luangwa rivers where local people make extensive use of the fishery. Carried out during the declining and low water periods, surveys targeted both non-fishing and fishing sites in order to generate information that could demonstrate the conservation utility of restricted access areas in fisheries management. As the confluence site includes communities from three countries, it offers a laboratory to investigate the influence of different management regimes on transboundary, shared fishery resources. In addition to this site, surveys were conducted in Cahora Bassa Reservoir in Mozambique where an active inshore fishery exists in the Zumbo Basin of the lake.

Scientific Methods

Collecting methods included use of seine nets, gillnets, fyke nets, hand-held D-nets, electric fishing, and rod and line. Representative (voucher) specimens are preserved and lodged at the SAIAB and will also be lodged with

the respective country natural history museums. Tissues for biochemical and genetic analysis have been taken from as many species as possible, preserved in 100% ethanol and lodged in the SAIAB tissue bank. A digital database will be prepared through AWF and will be used with the Southern African freshwater fish atlas GIS to plot species distribution maps.

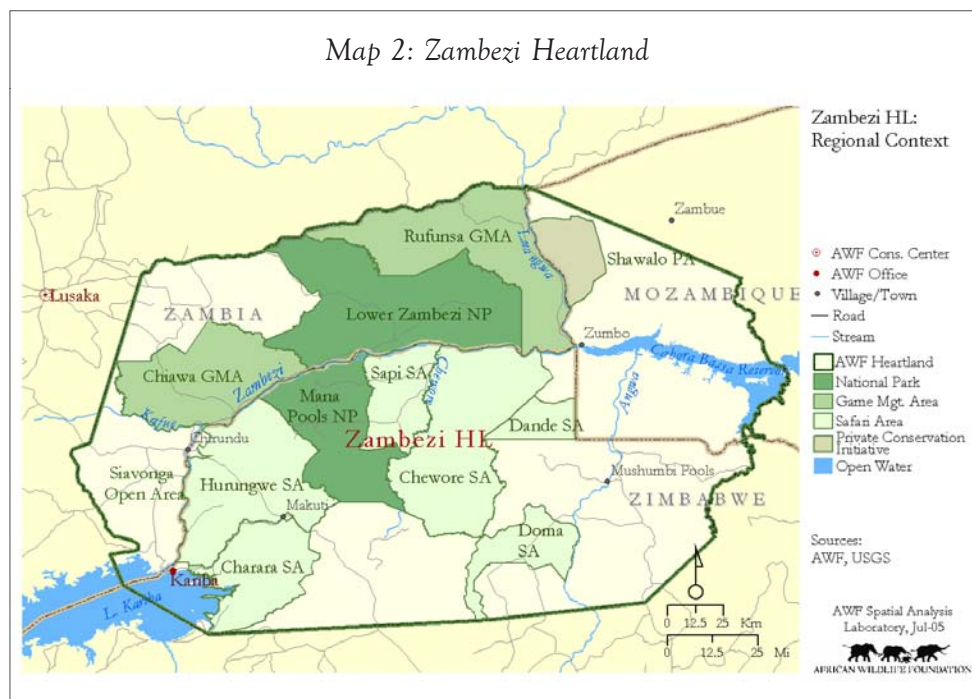
Highlights from Biodiversity Investigations

A total of 98 species were caught in all three surveys carried out to date in the Upper Zambezi River, a significant finding given that the

entire Zambezi River system has 122 species on record to date. These surveys suggest that there are possibly about 20 more species mainly from the headwaters in northwestern Zambia to be added (Denis Tweddle, pers. comm). Research on these species is ongoing. Additional highlights include:

- Conducted surveys for the majority of habitats in the river system.

Map 2: Zambezi Heartland



The surveys sought to cover the range of the natural biological cycle as reflected in the annual flood cycle of the river, with expeditions timed to coincide with the low water, rising flood, peak flood, and declining flood periods. The survey started from the low water period of 2002 (August-September) through to the low water period of 2003.

In the Middle Zambezi, researchers staged four field surveys in Zambezi Heartland at the confluence of the

- Improved understanding of the distribution, habitat preferences and responses to flooding cycle of the great majority of the species found in the Upper Zambezi River system.
- Acquired good samples of specimens for taxonomic description of new, undocumented species which will be published as part of the project.
- Identified taxonomic issues that need to be addressed with follow-up research.

In the Middle Zambezi River, the four surveys yielded a total of 30 species, which is approximately 50% of the total species composition recorded for the Middle Zambezi to date (Skelton, 2001). Key observations include the following:

- Catches from experimental gillnetting were dominated by five species from five different families
- Fish caught in non-fished breeding sites were significantly larger than those from fished areas providing evidence for the utility of closing some areas as a management strategy.
- The composition of species caught represented a rich faunal diversity dominated by juvenile stages, which is a good sign for a viable breeding species assemblage.

Standardization of Aquatic Resources Ecological Monitoring Methodologies

The project was initiated in order to establish a fisheries resource monitoring team for the Four Corners TBNRM area that would develop a suite of ecological monitoring methods and eventually become an integral component of a more broadly based ecological monitoring knowledge team for the Southern African Development Community (SADC). The specific objective was to formulate and test standardized methods for monitoring fisheries resources in the Four Corners TBNRM area, with the long-term aim of establishing a system of joint fisheries management among the four nations of the Four Corners TBNRM area.

In order to satisfy these aims and objectives, AWF, through the ARWG undertook the following activities.

a. Workshop to Design Standard Ecological Monitoring Methodology

The workshop agreed on several methods for fish sampling in shallow and backwater habitats with multi-mesh gillnets serving as the main method supplemented by electro-fishing, seine netting and trap-nets (fyke nets).

b. Field Testing of the Selected Standard Methods

Two field expeditions were carried out by the ARWG. Both field activities were based at Senanga, a site on the lower reaches of the Barotse Floodplain in the Upper Zambezi, Zambia where fishing is an important activity for local communities. The first expedition in April/May 2003 surveyed twelve sites, representing different floodplain microhabitats for species abundance and diversity, yielding a total catch of thirty fish species dominated by *Schilbe intermedius*, the butter catfish, followed by the tigerfish, *Hydrocynus vittatus*. At the time of the survey, the flood regime was at a record high for the decade restricting the survey to a limited range of habitats.

The biodiversity survey was complemented by Catch Assessment Surveys and Frame Surveys, during which forms designed at a planning workshop for collecting socio-economic data on the floodplain fishing industry and for recording catches from fisher folk were tested. A second species abundance and diversity survey was conducted during the low water flood regime in September/October 2003. An electrofisher and seine net were used as additional gears for fishing in shallow lagoons and backwaters. This survey recorded a total of 41 fish species but the species dominance pattern remained the same with *Schilbe intermedius* contributing 55% of the total catch.

To complement the field data collection and testing of monitoring methods, AWF also established a GIS sub-committee of the ARWG with the goal of building the capacity of the four countries to develop standardized data collection, documentation and analytical procedures for processing results from the field surveys. The sub-committee is developing a shared GIS database to archive survey data and analytical products.

Highlights from Standardization of Ecological Methods:

- Recorded more than 50 species of fish during the surveys.
- A suite of ecological monitoring methods was tested and will be adopted for use by the fisheries departments of the Four Corners countries.
- Established the utility of different monitoring methods during different seasons and relevant recommendations will be developed.
- An aquatic resources database is being developed. An interface with GIS software will be established to allow for presentation of species distributions and conservation threats.

General Fisheries Observations in Upper and Middle Zambezi Sites

In addition to the biological survey activities carried out while in the field, teams also made observations on general fishing activity, and noted perceptions of different local stakeholders about the conservation status of the fishery. This section briefly describes those socio-economic aspects of the fishery in the project sites that are relevant to conservation.

Upper Zambezi River

Fishing pressure was intense throughout the floodplains. All available fish stocks including the smallest species are exploited throughout the river system. On the floodplain in particular, teams observed exceptionally intensive fishing. Drifting gillnets and large open water seines were in widespread use leaving few sanctuaries for fish. The drifting gillnets were used close to the bank, with fish sheltering in riverbank vegetation being driven out of cover by beating the vegetation in advance of the floating net. These methods place considerable pressure on both adults and larger juveniles of the larger species. Without exception, people interviewed noted a decline in catch size in the last two decades attributed to increased use of small-meshed nets. This was reported in northern areas such as Zambezi and Mwinilunga in addition to the more recognized fishing areas such as the Barotse floodplains.

Meetings held with the traditional leadership – the ‘ngambela’ and the ‘kuta’ at Limulunga - discussed the

use of fishing with small meshed gears. The Royal Establishment has drawn up proposals for regulation of the fishery, and it is recommended that the Fisheries Department, local administrative authorities and the Royal Establishment get together to develop a management plan at the local level.

Middle Zambezi River

Most fishing activities take place along the Luangwa River upstream from the confluence with the Zambezi River. Fishers are mainly Mozambican and Zambian using drifting gillnets, mosquito netting, traps and poisons. Drifting gillnets are common and these are often used throughout the day with nets being checked continuously during peak fishing seasons. Local communities believe that the area is overfished; many speculate that drifting gillnets contribute significantly to excessive fishing pressure. Observations during our field surveys confirmed this notion, and it appears to pose a real threat to the sustainability of the fishery. Another interesting observation was the gender allocation of chores in fishing activities. In contrast to the Upper Zambezi River observations where women and children participate in the harvesting of fish in the shallow floodplain and lagoons using baskets (Figure 1), in Middle Zambezi only males participate in the active fishing. This is presumably because on average most of the fishing grounds are fast flowing main river channels and fishing involves following drifting nets in hand paddled dugout canoes (*mokoros*)—generally labor intensive work.



Figure 1: Women and children using baskets for fishing in shallow backwaters, Upper Zambezi (Source: W. Mhlanga, ARWG, Four Corners TBNRM area)

Females, however, are heavily involved with the fish processing at the landing sites, and in most cases, those processing were fish traders from as far away as Lusaka and the Copperbelt in Zambia. Consequently, most of the fish from the confluence area and the Zambezi River and Cahora Bassa reservoir in Mozambique are destined for markets in Zambia. Women from Zambia spend 2-4 months staying in fishing camps using sun and fire to dry the fish, and leave only after accumulating large quantities for sale in urban centers.

We also observed that there is a close business relationship between fishers who are mostly Mozambican nationals, and fish traders, who are mostly women from Zambia. The traders barter gillnets from Lusaka for the fishers for fish caught by the fishermen. Traders have to buy a license to buy fish from Mozambique but they are not allowed to fish directly. Nonetheless, cases of such traders employing Mozambican nationals to work as their fishers are rampant (Figure 2).



Figure 2: Pile of dried fish on the shores of Cahora Bassa, Mozambique ready for dispatch to the market in Zambia (Source: J. Mandima, AWF, Zambezi Heartland)

There is minimal fishing on the Zimbabwean side of Zambezi Heartland as most of the river stretch is under the Parks Authority and is thus protected. Limited fishing started recently close to the confluence where a local community group was granted a permit to fish using gillnets. Gillnets with meshes less than 3.5 inches are prohibited, but policing is poor and the catches are also very low, suggesting a likelihood of illegal fishing in waters under Parks estate, thereby threatening sites set aside for regeneration and breeding.

Other Field Activities Conducted

In addition to the testing of ecological monitoring methods in the field and the fish biodiversity surveys, AWF and its partners (reference other AWF freshwater essay) carried out a survey of aquatic plants and general limnology of the system. The plants survey provides baseline information for fish habitat characterization that will be useful in correlating fish species distribution, diversity and abundance to habitat type while the limnological assessments provide information on the health status of the aquatic habitat.

From the aquatic plants survey done in Upper Zambezi River, a total of 67 aquatic plants were collected and identified from the floodplain at Senanga.

Results from the limnological assessments in the Middle Zambezi are still anecdotal but it is noteworthy that the total phosphorous (TP) levels ranged between 18.1 $\mu\text{g/l}$ and 205 $\mu\text{g/l}$ in the Zambezi River below the confluence and in the Luangwa River respectively. In trophic terms, a TP level of 47 $\mu\text{g/l}$ suggests an oligotrophic system, between 47 $\mu\text{g/l}$ and 115 $\mu\text{g/l}$ is considered mesotrophic, while TP levels above this indicate eutrophy (Carin van Grinkel, 2002 in Magadza, 2003). Our Luangwa River measurement of TP level (205 $\mu\text{g/l}$) is within the eutrophic range suggesting potential problems related to nutrient loading. This indicates a need to investigate potential sources of nutrient enrichment such as the common human settlements and crop agriculture along the river.

Conservation Logic and Lessons Learned

The activities carried out by AWF in Southern Africa's largest freshwater system are aimed at contributing to the improvement of the management of shared water and aquatic resources in SADC. The Zambezi River is a major aquatic system that transcends borders and different landscapes from its source to the mouth. It traverses countries with variable water and fisheries resource policies and regulations. Yet the activities of an individual country has a direct or indirect impact on all others within the catchment. It is evident from fisheries observations made in Zambezi Heartland that fish are a 'common good' being utilized by citizens of the trans-boundary region regardless of nationality. It is also clear that current fishing practices cannot allow for the sustainable use of the resource, hence the need for intervention on the basis of baseline data gathered.

Such interventions span biological, socio-economic and legal issues.

The documentation of fish species distribution in various habitats along the longitudinal transect of the Zambezi will assist in resource allocation between different user communities who depend on fishing as a livelihood strategy. This baseline information allows for informed decision-making by both resource managers and users, and will cater to more equitable and sustainable use of fish resources. This approach captures the key tenets of the ecosystem approach, defined by IUCN as '*a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way*' (Smith & Maltby, 2003).

As an organization we note that our experience in Southern Africa clearly demonstrates that working with local partners with the requisite knowledge of the area, including local communities - who are often considered to be both threats to and beneficiaries from the resource - is a critical component of trans-boundary, landscape-level conservation. It also assists in building local and regional capacity that will aid the sustainability of such initiatives once an external organization leaves.

Identified Knowledge Gaps

The work done on the Zambezi River and the related findings point to the following information gaps that require further work in order to conserve and use aquatic resources in a sustainable manner in southern Africa.

- Improved understanding of fish stocks and fisheries interactions.
- Further study of rare and possibly threatened species is needed to determine if there are potential threats to their existence. More needs to be known of the conservation status of other species known only in upper reaches of tributaries.
- Intensify genetic studies to explore the differences in populations of fishes of both fisheries and conservation importance.
- More socio-economic data is required to complement biological data and involve local communities in the management and conservation of their '*own*' resources.

It is intended that lessons learned during the standardization of ecological monitoring methodologies will form a good basis for following up on the SADC agenda (under the Fisheries Protocol) to harmonize fisheries legislation in the region.

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