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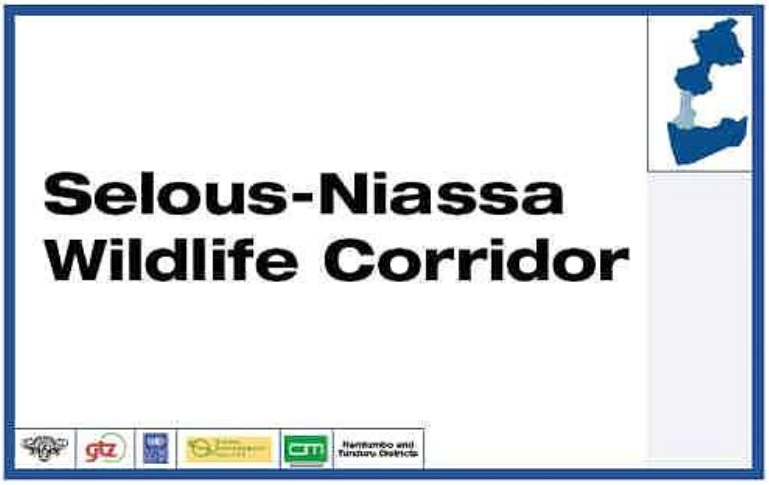

ECOLOGICAL AND SOCIO-ECOLOGICAL SURVEY OF THE RUVUMA RIVER CONTAINED WITHIN SELOUS NIASSA WILDLIFE CORRDIOR, TANZANIA AND NIASSA NATIONAL RESERVE, MOZAMBIQUE

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Ruvuma River Survey

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Plate 1: The survey team

All images were provided by R. Hahn, N. Madatta

Summary

The Selous Niassa Wildlife Corridor (SNWC; 8000 km^2) provides an important landscape linkage between the extensive protected areas of the Selous Game Reserve (SGR; 47 000 km^2), southern Tanzania and the Niassa National Reserve (NNR; 42 000km^2), northern Mozambique. The objective of this study was to complete an ecological and socio-ecological survey of the portion of the Ruvuma River forming the international boundary between SNWC and NNR. The aims were to provide baseline information for the future management of natural resources and the development of ecotourism along the Ruvuma River, an important interface for cross border cooperation between SNWC and SRN. A standardized surveying protocol was developed consisting of nine datasheets and the SNWC survey team (12 people) walked the entire length of the survey area (176km) over a period of 24 days in November 2006.

A total of 47 permanent fishing camps and two mining camps were identified, primarily on the Tanzanian north bank with only three camps routinely utilized by Mozambicans. The majority of fishermen come from the Tanzanian villages of Nchoteka and Nalasi (Tunduru District), Magazini, Lusewa, Msisima, Likusanguse and Matepwende (Namtumbo District). On average a fishermen takes 4.5 hrs (range 1-12 hours) to reach the fishing camps by bicycle and nine hours on foot (range 1-18 hours). Of the fishermen interviewed (n =39), 33% transport their smoked fish catch to markets in their own village, while just more than half (54 %) prefer to sell to traders that come directly to their fishing camps. Over 95% of the fishermen who have been fishing on the Ruvuma for more than 5 years reported that they were catching less fish than previously and suggested the reason for this to be an increase in the number of fishermen on the river, with an associated increase in competition for limited fish stocks. Yet more than 90 % of the fishermen stated that owning more fishing gear, not decreasing the number of fishermen would improve their lives. Four main pedestrian cross-border commuter routes were identified in the survey area.

The fishery is complex with 24 different fishing techniques utilised within the Ruvuma and Lugenda Rivers and their tributaries. During this survey 13 different fishing techniques were recorded including seven natural, plant based poisons. All the fishermen were utilising gill nets, 82 % also fished with hooks and lines and 44% had traps. Of the 604 fish caught from 16 net catches, species diversity was low representing only eight fish species with 98% of the catch made up of only four species. Initial results suggest that the low species diversity and small size of the larger fish species may indicate over-utilisation of the fishery. It is recommended that additional baseline data on the composition and size of fish catches be collected to assess this further and allow comparison with Lugenda River system (at least 100 catches over the main fishing season).

Data collected on river indicator species also raised some issues of concern. The hippo population appears to have declined dramatically with only 4 sightings totaling 23 individuals (0.1 hippo / km), with the largest group consisting of 12 individuals. Poaching is considered an ongoing threat. Obtaining an

accurate indication of crocodile numbers has proved difficult, however the survey results do show that crocodiles are breeding in the survey area. A crocodile management plan for the Ruvuma River is to be developed. From 14 spotlight transects covering 10.96 river kilometers an overall density of 2 crocodiles / km was calculated with 60% of these juveniles (< 1.8m in body length). At present conflict with crocodiles and hippos in the study area is relatively minor. Since 2000, there have been no fatalities from hippos but three people have been injured. Crocodiles have killed three people and injured five. All the crocodile incidents have occurred in two places, at regular crossing points.

Water bird density can provide a relatively simple visual indicator of river health. Three groups of globally threatened African Skimmers were observed in sandy channel habitat with an overall density of 0.17 birds / km. Eggs, chick and adults are harvested by the fishermen and it is likely that breeding sites on sand bars are disturbed by pedestrian traffic. It is of some concern that none of the larger resident fish eating birds (African Fish Eagle, Pels Fishing owl, Goliath Heron or Saddle-billed Stork) were sighted during the survey. The low density of these birds may suggest an absence of suitably large fish and over fishing. Further investigations into water quality and fish stocks are needed. Riverine habitats have been identified as biodiversity hotspots and conservation priorities in both SNWC (Bloesch & Mbago 2006) and NNR (Timberlake *et al*. 2004). Basic habitat mapping during the survey identified 11 stretches of riverine woodland along the north bank of the Ruvuma with the most significant stretches east of the Lusanyando River.

A combination of four approaches to manage the Ruvuma fishery are suggested. As is currently the case, it is recommended that the use of gill nets with a mesh size of smaller than 2.5 and fish poisons (artificial and plant-based) be illegal under all circumstances. Effective law enforcement is required. The use of fine mesh valve traps needs to be investigated further. All fishermen should continue to be required to have a license, but cooperation is needed between Tanzanian and Mozambican authorites to ensure licensing systems are compatible and complement management goals. Licenses should specify river zones in which fishing can occur and if possible limits should be set for the number of licenses issued for a particular stretch of river to prevent over utilization. The establishment of fish ponds / breeding programs close to villages will to some extent counter future restrictions on the number of fishermen allowed to fish on the Ruvuma River. The formation of fishing groups each responsible for fishing activities and fish stocks in a designated section of river is recommended, with user rights leased to each fishing group by respective villages. It is also proposed that six sections of the Ruvuma River within the survey area be set aside as fish breeding / conservation and ecotourism zones. In these zones no fishing, mining, or harvesting of resources should be allowed. At present the preliminary zones cover 42 river km (24% of the total area surveyed) and will affect 40% of the fishing camps. The zones are of necessity a compromise between human needs such as access to prime fishing areas, spritiual sites, and commuter routes, and ecological factors such as important breeding areas, migration routes and hippo pools. Regular surveying (every 3-5 years) following the same protocol is considered essential so that trends can be monitored and the

effectiveness of different management techniques assessed and adapted where necessary. Of particular importance will be further assessment of the sizes and diversity of fish catches, the monitoring of the densities and ditributions of hippo, crocodile and key indicator birds, (African Fish Eagle, Goliath Heron, Pels Fishing Owl, African Skimmer, and Saddle-billed Stork) and the monitoring of wildlife-human conflict.

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7.0 Introduction & Study Area

The Selous-Niassa ecosystem, which extends across southern Tanzania into northern Mozambique, is one of the largest trans-boundary ecosystems in Africa covering approximately 154 000 km^2 of primarily eastern miombo woodland interrupted by wetlands, open woodland and riparian forest (Hahn, 2003). The habitat is characterised by geological stability over a long time period, a long dry season, flat topography interrupted by monolithic granite inselbergs, sluggish drainage on the plateau, old nutrient poor, highly leached soils, frequent fires, and relatively low levels of large herbivores with episodic high levels of insect and small mammal herbivory (WWF, 2006). The region experiences a marked seasonal climate and can be divided into two main seasons, the hot-wet season from mid-November until the end of April and a prolonged dry season that may last up to six or seven months (May to November).

Within this ecosystem the Selous Niassa Wildlife Corridor (SNWC; 8000 km^2) provides an important landscape linkage between the extensive protected areas of the Selous Game Reserve (SGR; 47 000 km^2), southern Tanzania and the Niassa National Reserve (NNR; 42 000km^2), northern Mozambique (Fig 1). The SNWC is known to cover the traditional migratory routes for elephants and potentially provides a permanent link between two of the biggest intact elephant ranges in Africa (Mpanduji *et al.* 2002). In addition it also potentially links and allows gene flow between significant and globally important populations of the critically endangered African wild dog *Lycaon pictus* (Begg & Begg 2007), lion (IUCN 2006), leopard, sable, Lichtensteins hartebeest and Nyassa wildebeest (Hahn 2003).

The focus of this survey and this report is the Ruvuma River, which forms the northern border of the NNR (approximately 380 km in extent from west to east) and is the international border between Mozambique and Tanzania. This perennial river arises in the Matagoro Mountains in south eastern Tanzania and has an annual flow to the sea of about 28 km^3 of which 10 km^3 comes from Tanzania and 18 km^3 from the Lugenda River, a similarly sized perennial river that flows through NNR (350km) joining the Ruvuma at Negomano village in the north-eastern corner of NNR. Both the Lugenda and Ruvuma Rivers are sand bed rivers with strong perennial flow that feed numerous seasonal tributaries in the region. These rivers provide an important focus for wildlife especially during the end of the long dry season when standing water is scarce. In addition, they are an important resource for local communities through both fishing and mining activities.

To the east of the SNWC, dense human populations and agricultural activities on the North bank in Tunduru district, Tanzania combined with poaching pressure (R. Hahn pers com; Gibson & Craig, 2004) are likely to be preventing any significant migration of wildlife from NNR into Tanzania. However, within the SNWC animals can potentially cross, particularly in the late dry season when river levels are low. In addition, given that this is the only significant portion of the Ruvuma River afforded conservation protection on both banks, this section of river provides an important opportunity to protect key species

specifically associated with the river system (e.g. riverine forest, fish, terrapins, mollusks, waterfowl and other bird life, crocodiles and hippos).

However, even in this 176 km section of river there are concerns that concentrated fishing activities and snare lines might hinder animal movements. This would be especially prevalent in the dry season when animals are most dependent on the river for water and food (Hahn *et al*. 2003). In addition, unsustainable fishing activities and destructive fishing methods (use of fish poisons particularly pesticides) may be depleting fish stocks and disturbing aquatic fauna (Hahn 2003) and trans-boundary poaching for bush meat and trophies (ivory) continues to be a problem (Hahn *et al* 2003, R. Hahn, pers. com. 2006).

In 2004 a heavily utilised portion of the Lugenda River, was extensively surveyed (Begg *et al*. 2005). This survey revealed that an estimated 250 fishermen were utilising this section of braided channels during the peak fishing period between September –November and while these fishermen were primarily NNR residents some were from Tanzania and Mozambican villages outside of NNR. In addition a minimum of 50 traders were based at the fishing camps during the peak season purchasing dried fish and transporting the fish to markets in Tanzania and Mozambique for commercial sale. In conversation, several fishermen and traders suggested that fishing was no longer productive in the Ruvuma River and this was causing an influx of fishermen onto the Lugenda River. However, no data were available to validate these claims (Begg *et al* 2005). The survey highlighted concerns about the status of the Lugenda and Ruvuma Rivers and emphasized the need for the establishment of regular ecological and socio-ecological surveys to monitor river health, collect baseline information on river use and the densities of key river species and to provide information to inform trans-boundary collaboration in natural resource management.

With this in mind, an informal collaborative effort was initiated between SNWC and SRN in 2006 to develop a standardized, repeatable protocol for surveying of the Lugenda and Ruvuma Rivers. In August of 2006 this protocol was used to survey the entire length of the Lugenda River contained within the NNR (C & K Begg in collaboration with SRN; Begg *et al.* in prep) and in November this same protocol was used by the SNWC survey team to assess that portion of the Ruvuma River forming the boundary between the SNWC and NNR. It is the results of this Ruvuma river survey that are reported on here. This study provides baseline information for the future management of natural resources and development of ecotourism along the Ruvuma River, as an important interface for cross border cooperation between SNWC and SRN.

8.0 Objective and Aims

2.1 Objective

To complete an ecological and socio-ecological survey of the portion of the Ruvuma River (176 km) situated between the Lukimwa (11.4316S, 35.8681E) and Sasawara Rivers (11.5494S, 36.81355E) protected within the Selous-Niassa Wildlife Corridor (SNWC), Tanzania and Niassa National Reserve (NNR), Mozambique.

2.2: Goals

1. To provide baseline information on the current ecological "health" and utilization of the river against which future surveys can be compared and natural resource management decisions assessed.
2. To use the information provided to initiate resource management strategies that ensure sustainable utilization of this resource by local communities.
3. To provide information useful for the development of ecotourism along the Ruvuma River.
4. To provide an important interface for cross border cooperation between the Tanzanians and Mozambicans to manage this shared resource.

2.3. Specific Aims

- To collect ecological information on the densities and distributions of key river species that can be used as indicators to monitor "river health" over time.
- To census and monitor hippo and crocodile numbers.
- To collect quantitative social-ecological information on the densities and distribution of fishing and mining camps and the numbers and origins of fishermen and traders utilizing the Ruvuma River to allow monitoring of fishing and mining activities over time.
- To provide information for licensing and zoning activities useful for cross- border cooperation on natural resource management and security issues.
- To collect information on fish catches and fishing methods to better monitor fish stocks and ensure fisheries remain sustainable
- To monitor and provide baseline information on the level of human-wildlife conflict on the Ruvuma River, especially crocodile conflict.

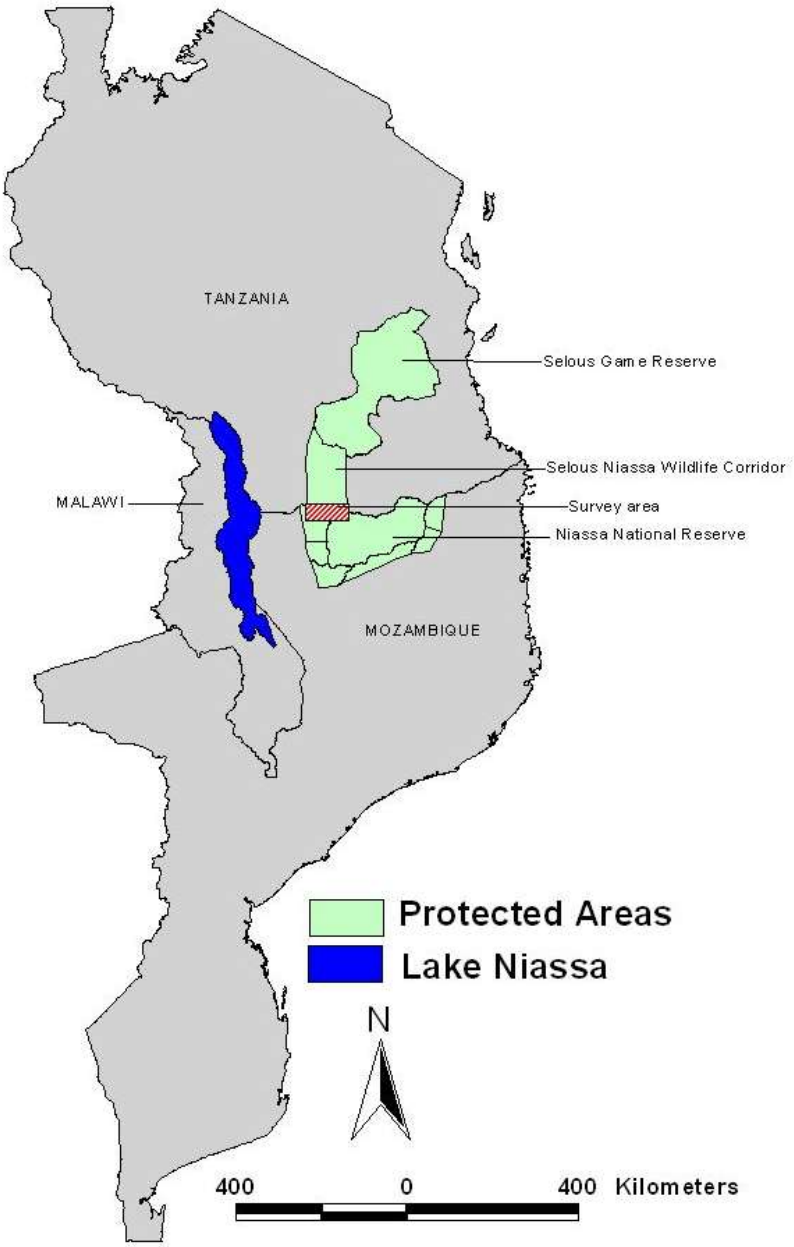

Fig 1: Regional map of the Selous-Niassa ecosystem in southern Tanzania and northern Mozambique, showing the location of the Selous Niassa Wildlife Corridor, southern Tanzania and Niassa National Reserve, northern Mozambique. The section of the Ruvuma River surveyed is highlighted in red and displayed in detail in Fig 2.

Fig 2: Detailed view of the section of the Ruvuma River forming the boundary between Selous Niassa Wildlife Corridor and Niassa National Reserve extending between the Lukimwa River in the west to the Sasawara River in the east (surveyed in November 2006; 176 km). Villages and settlements within 50km straight line of the Ruvuma River are shown in red.

3.0. General methods

3.1 Survey protocol

A protocol was developed to standardize surveying of the Ruvuma and Lugenda Rivers and provide baseline data for future analyses (C. Begg, 2006). This consisted of a set of nine datasheets with instructions for data collection (summarized in Table 1). On completion of the Lugenda River survey in August 2006 (Begg *et al*, in prep) modifications were made to the datasheets where necessary by C. Begg and these were provided to the SNWC team.

3.2 Data collection and analysis

The SNWC survey was completed over a period of 24 days during November 2006 in the late dry season. The survey team (12 people) walked the entire length (176 km) of the Ruvuma River forming the boundary between SNWC and NNR, along the northern riverbank or in the riverbed of the Ruvuma River depending on the situation. As the river was in most areas narrow and unbraided the opposite bank of Mozambique could be seen and surveyed at the same time. Where necessary canoes provided by local fishermen were used to survey islands. Conversations with local fishermen and village scouts provided invaluable information on the position of fishing camps, important sites, hippo pools etc. Logistical assistance was provided by a re-supply vehicle that waited for the survey team at designated points along the river wherever possible.

All data was entered onto the datasheets by the SNWC survey team, where necessary with additional detailed notes. These data were later digitally captured in Excel and Access databases and the geo-referenced information was mapped using Arcview and Mapinfo software. Where relevant, Landsat 7 satellite photos were used to analyse the data further. GIS background information for NNR was provided by SRN. Plant based poisons were identified from photographs by U. Bloesch and F. Mbago.

The survey area was divided into 4 sections to facilitate analysis and zoning (see Fig 3). These sections were:

- Section A: Survey start point on Lukimwa River to confluence of Ligunga River (46.3. river km)
- Section B: Confluence of Ligunga River to Confluence of Lucheringo River at Milepa Village (42.8 river km).
- Section C: Confluence of Lucheringo -Milepa Village to Confluence of Lusanyando River (30.8 river km).
- Section D: Lusanyando River to Survey End at Sasawara River Confluence (55 River km).

Table 1: Summary of the nine datasheets comprising the river survey protocol for SNWC and SRN/ NNR

Datasheet	Type of information
1. Register of fishing and mining camps	Location, size and density of fishing and mining camps and the numbers and origins of people utilizing these camps.
2. River indicator Species (excl. hippo)	Density, distribution and status of key river indicator species e.g. elephant, crocodile, African fish eagle, African skimmer, Pels fishing Owl, goliath heron and saddle-billed stork. Additional information collected on other waterbird species.
3. Hippo census	Density and distribution of hippo
4. General Information	Geo-referenced data on miscellaneous issues of interest for management and zoning i.e. location of spiritual sites, pedestrian paths, crocodile nesting sites, potential tourism areas, non navigable rapids.
5. Human-Crocodile Conflict	A survey of the number of deaths and injuries of fishermen due to crocodiles, providing the location, and name of the victims.
6. Crocodile Survey	1-2 km track and spotlight counts to survey the age distribution, density, and distribution of the crocodile population.
7. Register of fish catch weights, fishing methods	The total weight of fresh fish catches using different technique to allow comparison of different fishing methods and river systems and to track changes over time
8. General Habitat Mapping	Geo-referenced mapping of the general habitats of the river on a coarse level to highlight habitats of particular interest (riverine forest, wetlands) and inform management decisions i.e. establishment of no fishing zones.
9. Fishermen Interview	To assess opinions of fishermen through a simple questionnaire on the fishing activities, distances traveled, and possible ways to improve their lives and livelihoods and effectively zone the river

SECTION A: FISHING AND MINING ACTIVITIES

4.0 Fishing and mining camps

4.1. Number and distribution

- A fishing camp was defined as a base camp on the river (away from the villages) where fishermen process their fish on smoking ovens, sleep and keep their belongings and canoes.
- A total of 47 fishing camps and two mining camps (M1, M2; Fig.3) were identified along the 176 km of the Ruvuma that was surveyed (Fig 3).
- Masoko Camp (Fig 3, No 40) on the Mozambican (south) bank appears to be used for snaring as well as fishing activities
- Two camps were identified as prospecting (mining) camps (Mbumule 2-M2; Mkolesya-M1; Fig. 3; Plate 5, Plate 6) although fishing activities also took place from these camps. Tanzanians operated both of these camps.
- Of the fishing camps, only 47 % (n = 22) were active at the time of the survey. November is consider the month with the lowest level of fishing activities (see section 5.2). However, fishing activities resume with the first heavy rains expected in late November.
- In total, 100 people were counted in the fishing camps during the survey. Given the high proportion of inactive camps at this time of year this can only be considered a minimum count.
- The majority of the river users were men (89 men; 11 women). Of these men, 33 (37%) were fishermen, 53 were assistants or children, and three were traders/ fishmongers. The low number of traders on the river also reflects the low level of fishing activities on the river at this time.
- On the Lugenda River, the total number of fish smoking ovens in each camp have been shown to provide an indirect index of the number of professional fishermen utilizing a camp at any one time as ovens are generally individually utilized (Begg *et al.* 2005). A total of 72 smoking ovens were counted during this survey, suggesting that at least this many fishermen are active on this stretch of the river during the peak fishing period when all the camps are active.
- The number of ovens in each camp varied from 1- 4 (mean = 2 ovens). This is significantly less that the prime fishing area on the eastern Lugenda where fishing camps varied in size from 2-24 ovens (mean =8) with three camps supporting more than 16 ovens (Begg *et al,* 2005).
- Overall only 30% of the camps were situated on islands with the majority located on the Tanzanian mainland. This reflects the river habitat, which is characterized by long stretches where both banks are visible with relatively few braided channel areas.

- As this was the first ground survey of this section of the Ruvuma it is currently impossible to determine whether the number of people utilizing the river is actually increasing and if so at what rate. However, during the fishermen interviews (n =39), 56 % of the fishermen reported that they were catching less fish than previously and sighted the reason for this to be an increase in the number of fishermen on the river, with an associated increase in competition for limited fish stocks.
- The only historical data on the number of fishing camps in the survey area is provided by the helicopter aerial survey of Tello & Dutton (1979) from the Sasawara River confluence to the Ligunga River confluence. During this survey nine camps and 19 canoes were counted whereas 33 camps were counted over a similar distance on this ground survey.
- This suggests that fishing activity on the Ruvuma River might have increased significantly over the last 30 years, although it must be borne in mind that aerial surveys tend to undercount fishing camps (Begg *et al* 2005). In the more recent aerial survey completed by Bills (2004) in a fixed wing aircraft, 12 fishing camps were recorded between the SNWC border and the Lusanyando River (Milepa) whereas 22 camps were counted on this foot survey over the same distance.
- Unlike fishermen on the eastern stretches of the Lugenda River who are more nomadic, 79% of the fishermen surveyed on the Ruvuma (n = 39) stated that they always return to and utilize the same fishing camp.
- In all cases, the fishing camps appeared to be well established permanent camps, with recognized names and stable positions from one season to the next. Nearly all the fishing camps had thatch shelters and in some cases even had well-established banana trees planted around the camp (Plate 2, Plate 3). This contrasts sharply with the temporary camps that are common on the eastern stretches of the Lugenda River.

4.2. Origin of river users and movement patterns

- Given that the Ruvuma River is an international boundary, information on pedestrian entry points and cross-border commuter routes is essential for cross-border management of security issues and resource use.
- Four main pedestrian cross-border commuter routes were identified in the survey area (Hahn & Ngwatura 2007) with two additional secondary routes. These are described in detail in Table 3 and their positions are shown in Fig. 3. Activity at the secondary routes still needs to be verified.
- Data from Tello & Dutton (1979; Fig 4) show that there has been little change in the position of pedestrian routes over the last 30 years, with the majority of crossings east of Milepa Village between the Lucheringo and Lusanyando Rivers (current crossings coded as

C, D, E, F), all within easy walking distance of the Tanzanian Village of Magazini (14km straight line from Ruvuma River).

- The majority of fishermen using this stretch of the river are Tanzanians from the villages of Nchoteka and Nalasi (Tunduru District), and Magazini, Lusewa, Msisima, Likusanguse and Matepwende (Namtumbo District). All villages within 50 km of the Ruvuma are shown on Fig 2.
- For zoning purposes it is important to note that fishing camps 1 to 23 (Fig 3) are primarily utilised by people from Matepwende and Msisima villages, while camps west of Milepa (No 26 to 47) are primarily utilised by people from Magazini, Likusanguse and even further afield from Nchoteka.
- The average straight line distance traveled by fishermen to their camps from their home village is 38 km, ranging from 22 –120 km, although actual distances traveled are likely to be longer along pedestrian paths and roads. On average a fishermen takes 4.5 hrs (range 1-12 hours) to reach fishing camps by bicycle and nine hours on foot (range 1-18 hours).
- Of the fishermen interviewed, 33% transport their smoked fish catch to markets in their own village, while just more than half (54 %) prefer to sell to traders that come to their fishing camps and 10 % sell to both depending on the circumstances. Only one fishermen transported his fish to a village market that was not in his home village
- Only one active camp was exclusively utilised by Mozambicans ("Kwa Mzungu"; No 5; Fig 2.) with some additional Mozambican activity at Mtwalo Crossing Point (A; Fig 3) Milepa (no 26; Fig 3) and Masoko (no 40; Fig 3). However, given that the survey was conducted in November when many fishermen have already returned to their home villages to prepare their fields for the rain, this needs to be investigated further at another time of the year.
- The low level of use of this section of the Ruvuma by Mozambicans was somewhat surprising and the reasons for this remain unclear. It may simply reflect the relatively low density of people within 50 km of the Ruvuma River as only two Mozambican villages, Milepa and Mbunjo (Chamba) and one small settlement, Mtwalo are situated within this distance. However, we also know that fishermen and traders in NNR routinely walk or bicycle at least 80-100 km to access prime fishing areas on the Lugenda River (Begg & Begg, pers. obs), and to reach markets and the hospital in Tanzania.
- In western NNR, people from Matondevela village (51 km straight line), Lipembo village (75 km), and even the densely populated Mavago-Msawize village complex in NNR, which supports at least 9 000 people could conceivably utilise the Ruvuma River but this does not seem to be the case. It may simply be that for residents of these villages the Lugenda River is slightly closer, and more productive with less competition.

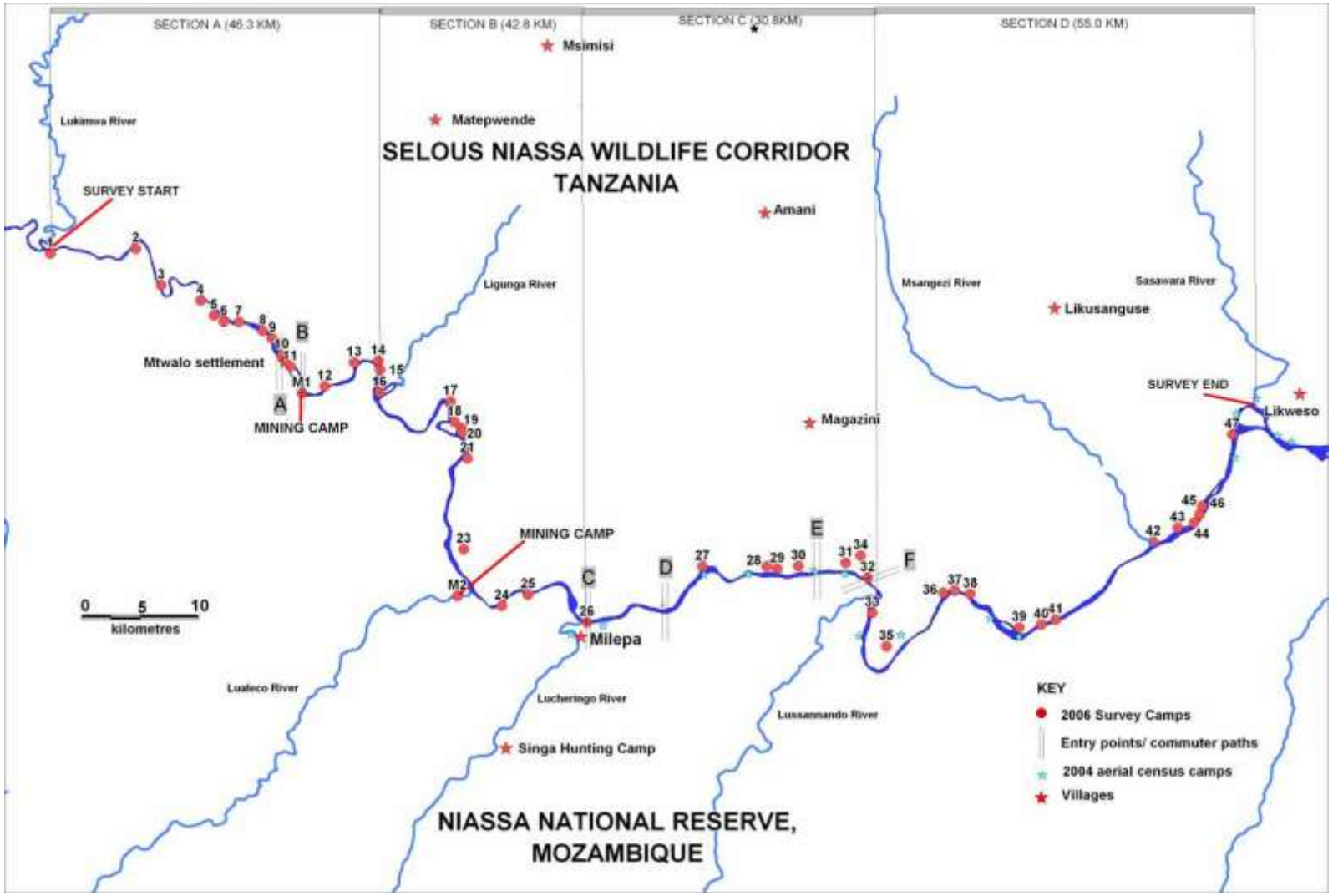

Fig 3: Distribution of fishing and mining camps along the Ruvuma River (176 km) on the boundary between the SNWC, Tanzania and NNR, Mozambique. Each camp is provided with a unique identification number, which is related to further information provided in Table 2. The letters A-F denote current pedestrian entry points and cross-border commuter paths and details are provided in Table 3. Note: Due to slight differences in the digitized and current river course some camps appear to be away from the river (23, 34, 35), however in reality all the camps are located on the actual Ruvuma River bank.

Table 2: Fishing and mining camps located during the survey showing the name of each camp, the origin of the majority of users and the number of fish smoking ovens. Fishing camps in bold were active during the survey. The identification numbers refer to Fig. 3

Id No	Camp Name	Origin of users	No. of ovens	GPS-South	GPS-East
1	Namboya	Unknown	1	-11.42907	35.87059
2	Ngoma Litako	Unknown	2	-11.42579	35.93758
3	**Misewe**	**Tanzanian**	**4**	-11.45458	35.95723
4	**Litivi**	**Tanzanian**	**3**	-11.46657	35.98806
5	**Kwa Mzungu**	**Mozambique**	**1**	-11.4787	35.99857
6	**Masta**	**Nchoteka Village, Tz**	**2**	-11.4834	36.00616
7	Matumbi	Unknown	2	-11.48372	36.01803
8	Maboti 1	Unknown	0	-11.49069	36.03645
9	Maboti 2	Unknown	1	-11.49663	36.04396
10	**Ahela Tatu**	**Msisma Village, Tz**	**1**	-11.50965	36.05129
11	Unknown	Unknown	1	-11.51871	36.05811
M1	**Mkolesya**	**Tanzanian**	**0**	-11.53948	36.06683
12	**Namakungwa**	**Msisima Village, Tz**	**1**	-11.53432	36.08498
13	**Kimamba**	**Matepwende, Tz**	**1**	-11.51603	36.10814
14	**Ndewe**	**Matepwende, Tz**	**4**	-11.51496	36.12716
15	Kayange 2	Unknown	1	-11.53971	36.12776
16	Kayange 1	Unknown	2	-11.52201	36.12847
17	**Halifa Hwaiti**	**Lusewa, Tz**	**1**	-11.54701	36.18348
18	**Kinyakanyaka**	**Msisima, Tz**	**1**	-11.56311	36.18644
19	Mbumule 1	Unknown	1	-11.69827	36.18749
M2	Mbumule 2	Unknown	2	-11.69827	36.18749
20	Angecha	Unknown	1	-11.56775	36.19165
21	Lujombo	Unknown	0	-11.57114	36.19233
22	Amimu	Unknown	2	-11.66203	36.19273
23	Chitungutungu	Lukala, Tunduru, Tz	1	-11.59145	36.19649
24	Unknown	Unknown	0	-11.70625	36.22223
25	**Omari Selemani**	**Magazini Village, Tz**	**1**	-11.6977	36.24284
26	Milepa	Mozambique & Tz-	0	-11.71959	36.2891
27	Kipembele	Unknown	1	-11.67708	36.38029
28	**Mtogoro**	**Magazini, Tz**	**1**	-11.67755	36.43079
29	Mwarabu	Unknown	0	-11.67943	36.43894
30	Mtigiti	Unknown	1	-11.67773	36.45558
31	Lutukila	Unknown	1	-11.67525	36.49297
32	**Kawile**	**Magazini Village, Tz**	**2**	-11.66985	36.50464
33	Lusanyandu	Unknown	1	-11.68713	36.51006
34	**Alunasi**	**Unknown**	**0**	-11.71428	36.51351
35	**Mikangaula**	**Nchoteka & Magazini, Tz**	**2**	-11.74065	36.52436
36	**Mkasha**	**Nchoteka & Nalasi, Tz**	**2**	-11.69903	36.56952
37	Misakala 1	Unknown	3	-11.6976	36.57869

Table cont. overleaf.

Id No	Camp Name	Origin of users	No. of ovens	GPS-South	GPS-East
38	Misakala 2	Unknown	1	-11.70036	36.59064
39	**Lipunga**	**Nchoteka, Tz**	**3**	-11.72689	36.62893
40	Masoko	Mkongo, Tz	3	-11.72465	36.6464
41	**Lukawanga**	**Magazini & Nchoteka, Tz**	**2**	-11.72096	36.65755
42	**Msangesi**	**Mkonga, Tz**	**2**	-11.66089	36.7349
43	**Magumuchila**	**Nalasi & Nchoteka, Tz**	**2**	-11.65026	36.75426
44	**Mahiwa**	**Nchoteka, Tz**	**3**	-11.64629	36.76694
45	**Kisumulo 1**	**Nchoteka, Tz**	**2**	-11.63995	36.77135
46	Kisumolo 2	Unknown	2	-11.63344	36.77358
47	Nnala	Unknown	1	-11.57799	36.79774

Plate 2: Namakungwa Fishing Camp (No 12; Fig 3) a typical permanent fishing camp with thatch shelter. This is the former camp of a German hunter named "Klose"" who hunted for hippo tusk, crocodile skins and ivory in this area during the 1960s.

Plate 3: Misewe Fishing camp; a permanent camp complete with banana trees

Table 3: Descriptions and GPS positions of pedestrian entry points and cross-border trading routes, where codes (A-F) refer to Fig. 3

Code	Name	GPS-South	GPS-East	Description
A	**Mtwalo**	-11.51479	36.05313	Cross border commuter route between Mtwalo village –Matepwende Village. On Mozambican side there is a small village of approximately 15 households, they grow cassava and maize. The settlement was established after the Civil War and was named after the traditional leader known as Mzee Mtwalo **(Plate 2)**
B	**Mkolesya**	-11.53948	36.06683	Cross-border crossing point from Mkolesya camp –Matepwende Village. Major commuter crossing point at this fishing camp, also prospecting activities. **(Plate 3; Plate 4)**
C	**Milepa**	-11.71959	36.2891	Major Cross-border Crossing and Trading point between Magazini Village, Tanzania and Milepa Village, Mozambique. A canoe ferry is used to cross the river (**Plate 5**, see **Plate 6** for ferry prices on Tanzanian side). Border control facilities are found on the Mozambican side and there is a camp on the Tanzanian side for ferrying people and goods across.
D	**Binti Hassani**	-11.70669	36.34882	Pedestrian and elephant traffic and entry point to Ruvuma
E	**Makaloye**	-11.67993	36.46671	Major Cross Border Trading route –Makaloye-Magazini Village. This is a former crossing point for refugees south of Magazini Village
F	**Lusanyando**	-11.68713	36.51006	Elephant and pedestrian traffic.

Plate 4: Mtwalo Crossing Point from the Tanzania (north bank). The Mtwalo settlement is on the Mozambican bank

Plate 5: Gemstone prospecting at Mkolesya crossing point

Plate 6: Signboard showing gemstone mining near Mkolesya Crossing Point

Plate 7: Milepa Crossing point at the confluence of the Lucheringo and Ruvuma Rivers

Plate 8: Tanzanian Ferry Prices at Milepa Crossing

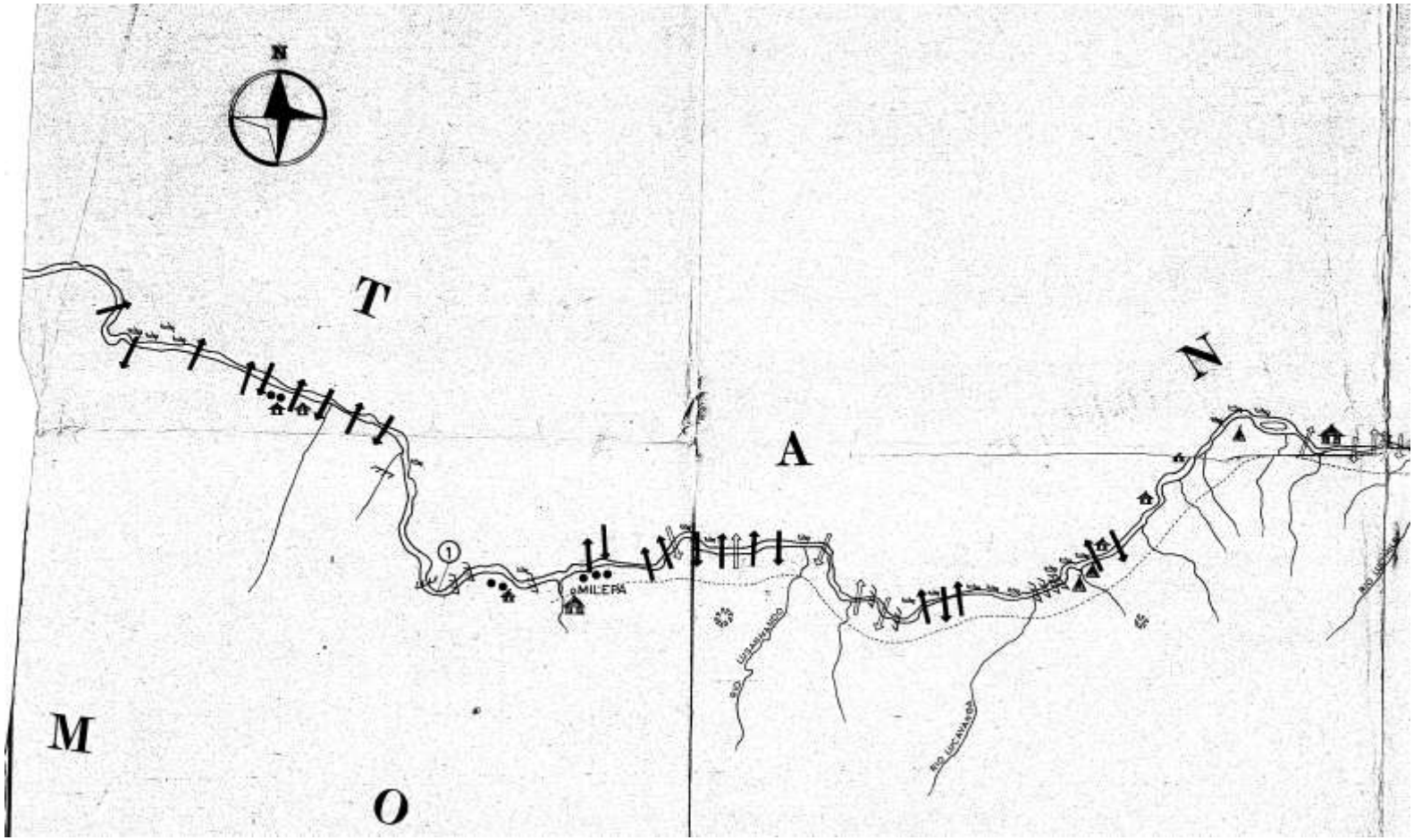

Fig 4: Hand drawn map of the Ruvuma extending from slightly east of the western boundary of SNWC to Chamba / Mbunjo Camp from a helicopter aerial survey conducted in 1977 (Tello & Dutton, 1979). This shows the position of elephant crossing points (solid arrows), pedestrian routes (open arrows), settlements and fishing camps (house and tent icons), mashambas (solid circles), fishing fences and canoes. Scale:1cm = 5 km

5.0. Dynamics of the Fishery

- In total 39 fishermen were interviewed from 22 fishing camps by four interviewees using the standardized interview datasheet. The fishermen interviewed provided a good cross section of fishermen of different ages (Fig. 5) and experience (Fig 6), and the answers are therefore likely to provide a representative sample. However, given that November is considered the time with the lowest fishing activities (see below) it would be useful to conduct further fishing interviews during the two peak fishing periods of August – September and December to investigate this further, particularly given that different fishing techniques are likely to be used during these periods.

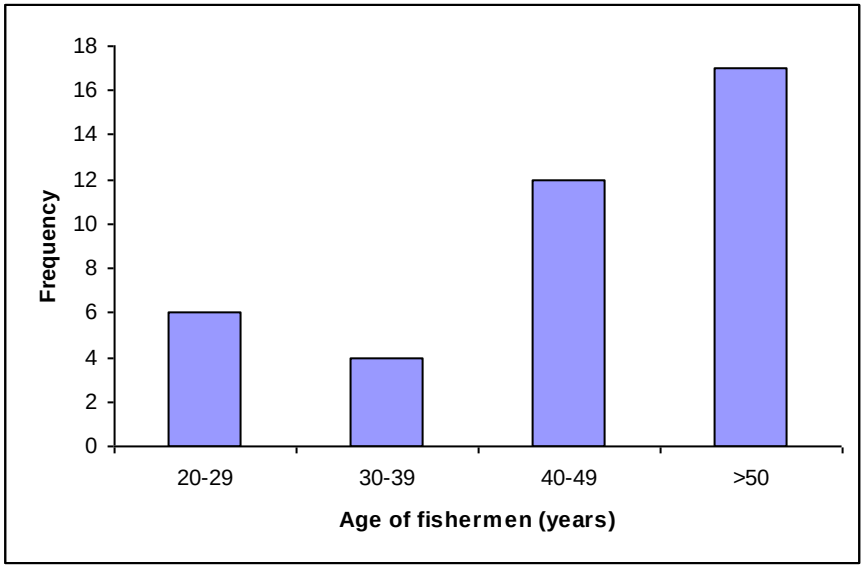

Fig 5: Age distribution of fishermen interviewed during the Ruvuma river survey (n =39)

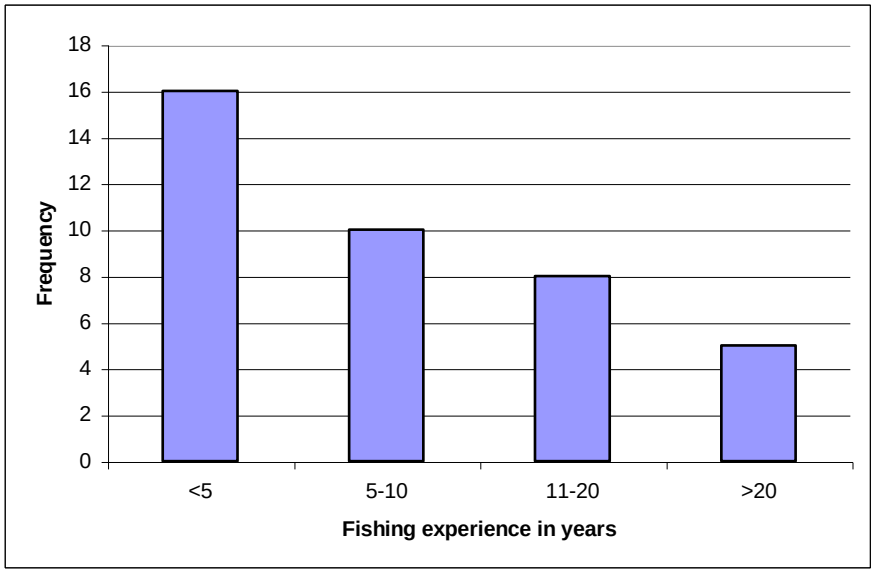

Fig 6: Years of fishing experience of fishermen interviewed during the Ruvuma River survey

5.1 Licensing

- Both Mozambique and Tanzania require fishermen to purchase a license for any fishing activities. However, given that the Ruvuma River is an international border, two different licensing systems are in operation and a variety of different license formats are legal. Management and enforcement of the licensing system will require effective and close coordination between the two countries.
- Details of the Mozambican licensing systems, problems and possible solutions are provided in detail in Begg *et al (*2005) and will not be repeated here.
- In Tanzania a license costs Tz Shillings 3000 –6000. The majority of fishermen interviewed had purchased a fishing license (Fig.7) with only 11% having no license. 17 fishermen purchase a license during the survey (08/11/2006 –22/11/2006) with a total revenue of Tz Sh 51 000.
- Two fishermen remarked that being able to buy a license more easily would improve their life. At present Tanzanian fishermen are purchasing licenses from five main locations (Fig 7). Mozambicans fishing on the Ruvuma are likely to be purchasing their licenses from Mavago Village, the district capital within western NNR, however this requires further investigation.
- While Mozambican law requires a fish trader/ fishmonger to purchase a license in order to transport smoked fish to market, this is currently not the case in Tanzania. It is therefore recommended that a levy be charged on fish traders to ferry fish from the fishing camps to the markets within or out of the district.

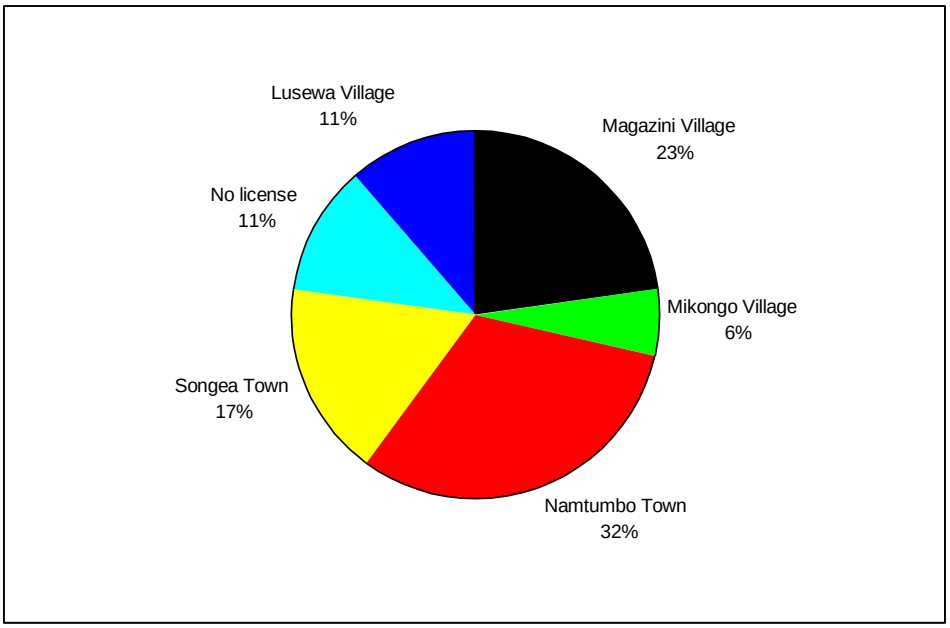

Fig 7: Pie chart indicating where the fishermen interviewed (n =39) had purchased their fishing licenses.

5.2 Timing of fishing activities

- Structured fishermen interviews and anecdotal observations suggest that fishing activities on the Ruvuma River can be divided into three main periods:
    a) **April- July**: The early dry season period when water levels are still reasonably high and temperatures are relatively low. With the receding water levels, many people arrive on the river pools to catch fish from the many drying up pools and shallow tributaries. Use of traps and barriers is common. Overall 50% of the fishermen interviewed in November arrive on the river to fish during this period (Fig. 8).
    b) **August-November**: This is the late dry season period and the peak fishing period for the serious fishermen on the Ruvuma. However, observations suggest that November, just before the first rains fall, may be the time of the lowest fishing activities as the majority of fishermen return to their home villages to prepare their fields for the rains (R. Hahn pers. com.). This is similar to the timing of fishing activities on the Lugenda River(C. Begg pers. com). Fishing is considered more difficult at this time of year, as water levels have dropped significantly. A wide variety of fishing techniques are used (gill nets, traps, chingombo, chigundenje, namatepa, chikukwele, luando, manga; Table 4). The survey team considered this to be the period when illegal fishing techniques are extensively used, particularly the use of poisons in the receding pools in the tributaries.
    c) **December –March**: This is the wet season fishing period. The majority of fishermen (84%) still on the river in November considered December the best month for fishing with the highest fish catches (Fig 8). Catches are considered good during this period due to increased water levels, warm water, more active fish and the initial flow of tributaries. The predominant fishing methods are lines with hooks, gill nets, nets and some traps. Many of the fish in the Ruvuma River are anadromous species (breeding when the river and its tributaries come down in flood). In preparation for the arrival of the floodwaters the gonads of anadromous fish ripen fast and breeding is likely to commence as soon as the river is in full spate (Begg *et al* 2005). This period is therefore the spawning period for many of the fish when they move upstream, which results in increased fish movement. It is therefore essential that fish breeding zones include tributaries to prevent over fishing of this breeding stock. In January-March many fishermen return to their villages as the river begins to flood (Fig 8).

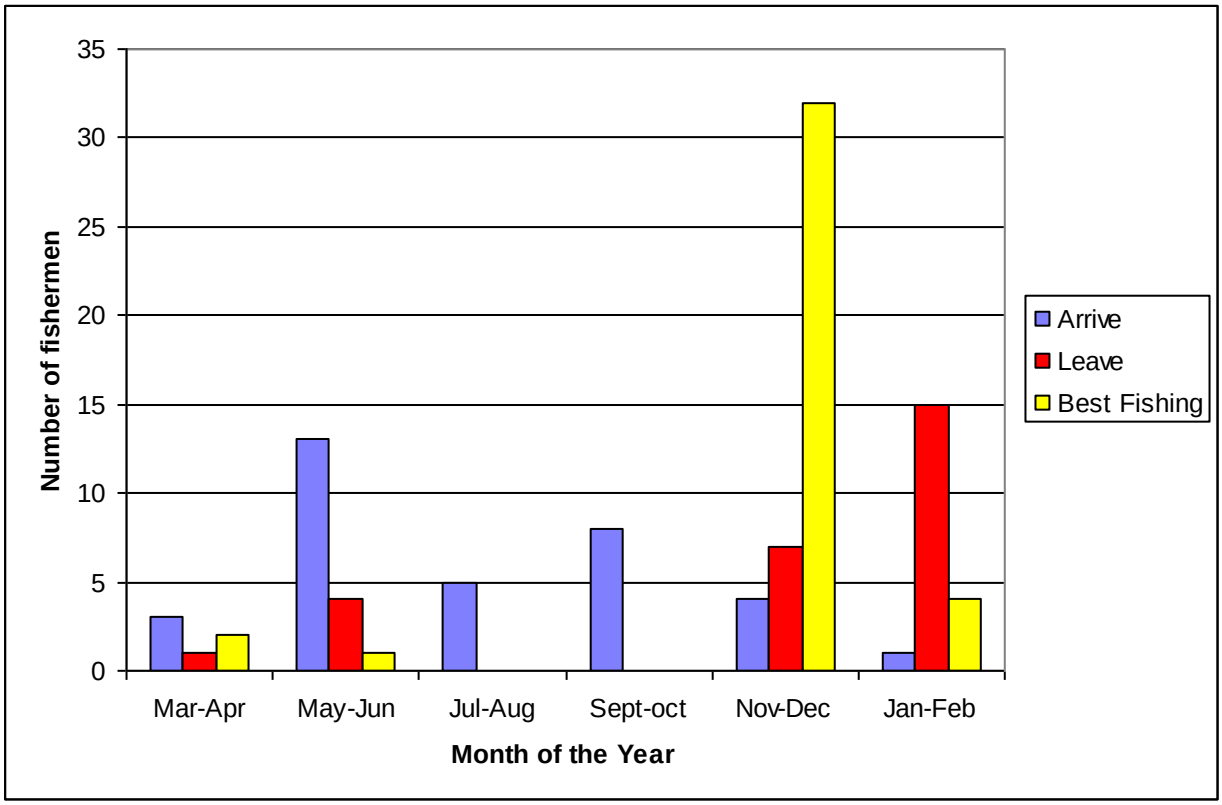

Fig 8: Timing of fishing activities from fishermen interviews (n = 39) showing the influx of fishermen throughout the dry season (May-November), with the best fishing perceived to occur in December. The majority of the fishermen interviewed leave the river and return to their villages during late December to February when the river reaches its highest levels.

5.3 Fishing techniques

- For all the fishermen interviewed during the survey, fishing provides their only source of income and a critical source of food.
- The Ruvuma and Lugenda fisheries are exceptionally complex systems. In total 24 different fishing techniques have been identified (Table 4), each designed to exploit a different niche and/or different spectrum of fish species at a different period of the year (Begg *et al*. 2005). During this particular survey, 13 different fishing techniques were recorded and these included seven different types of natural, plant based poisons (Plate 9).
- Of particular interest is the circular fence or "Rwando" with a single trap (Plate 10), which is not commonly used on the Lugenda River. Their use might be related to water turbidity (Bills 2004).
- Information on fishing gear and fish catches was obtained from 39 fishermen. Of these fishermen, 82% fished with lines & hooks, 100% had gill nets and 44% had traps. In total these fishermen utilised 444 lines, 198 gill nets and 98 traps. On average each fishermen owned 11 lines (range: 0-30), 5 nets (range: (0-11) and 3 traps (range 0-12).
- If these figures are indicative of all the fishermen utilizing this section of the Ruvuma it suggests that during peak fishing period when at least 72 fishermen are active (estimated from the number of fishing ovens) a minimum of 360 gill nets, 800 lines, and close to 200 traps may be in use.
- These data are similar to statistics from the Lugenda River where each gill net fishermen owned 4 nets (range: 1-12) and 3 traps (range 1-6) on average. However, the proportions of fishermen using the different techniques are different with only 50% of the Mozambican fishermen currently utilizing gill nets. This is largely an economic and logistical issue as gill nets are an expensive item for local Mozambican fishermen to buy and sometimes have to be purchased in Tanzania (Begg *et al*., 2005).
- In most cases, the nets are being brought from the local villages and traps are made from local bamboo. More than 90% of the fishermen said that being able to buy additional fishing gear, particularly nets and hooks would improve their lives. Three fishermen said that getting a license would make their lives easier, two stated that obtaining a canoe would be helpful and two fishermen suggested they would benefit from expert guidance from fisheries officers on how to improve their catch yield.
- Interestingly, none of the fishermen suggested that control of the numbers of fishermen on the river would be beneficial despite an increase in the number of fishermen being sited as the major reason fish catches have declined. Instead the solution was perceived to be the purchasing of more fishing gear.

5.4 Fish catches

- Of the 39 fishermen interviewed, 16 fishermen had catches weighing a total of 102.75 kg, with an average catch of 6.4 kg (15 catches from gill nets; 1 catch from Chikukwele net fishing), while 24 of the fishermen had no catch.
- Of the 604 fish caught, species diversity was low representing only eight fish species. Over 98% of the catch was made up of only four species (Fig. 9): one species of mudsucker (Nyingu: leaden mudsucker; *Labeo molybdinus*), two species of bream known collectively as Likwale (Bream, *Oreochromis* sp. & *Tilapia rendalli*) and juvenile Likambale (*Clarius sp.;* catfish). The remainder of the catch was made up Campango (*Bagrus orientalis*; 0.3%), Chikolokolo (*Synodotis sp.;* 0.82%); Libono (goby species; 0.5%), Ngunga (Eels; 0.1%) and Nyanda (*Mormyrus longirostris*; 0.3%).
- This is similar to data from the Lugenda River, where bream and mudsuckers (4 species) were the most common species caught comprising more than 90% of the fish catch (Begg *et al*. 2005), however species diversity was higher with 17 species were recorded over more than 200 fish catches.
- The lack of Nchali (red nosed mudsucker) in the Ruvuma fish catches, a common gill netting species in the Lugenda River, was surprising (27% of total catch on the Lugenda River). It is possible that these were simply lumped with the other similarly sized *Labeo sp.*, but this requires further investigation.
- In addition, R Bills (pers. com) suggests that it is the larger species (Vundu, Campango, Clarius) that will be the first affected by over fishing. At present sample sizes are too small to investigate fish catches in detail. However, it is interesting to note that only two campango (4kg, 10kg) were recorded in more than 600 fish measured and while 100 Clarius were caught in one catch, 50 were only 20 cm long, and 50 were 15 cm long, and these are considered juveniles.
- Given the low percentage and small size of the Clarius and Campango in the catch, the extensive use of rods and lines as a fishing technique (which targets the larger species) and the complete lack of sightings of the large fish eating birds (African Fish Eagles, Goliath Heron, Saddle-billed Stork, Pels Fishing Owl; see Section B) on the Ruvuma, this may be cause for alarm and a sign that the system is being over utilized.
- However, without data from other years it is currently impossible to assess objectively whether fish stocks are declining in the Ruvuma or whether current fishing levels are sustainable. Additional baseline data on the composition and size of fish catches will be useful from the Ruvuma (at least 100 catches spread over a number of different sites and fishing techniques) both to compare with the Lugenda River and also to provide a baseline against which the effectiveness of future management strategies can be assessed.

- Overall, 95% of the fishermen interviewed who had been fishing for more than 5 years (n=22) stated that they were catching less fish than previously. The majority of fishermen said the decrease in catch was due to an increase in the number of fishermen on the river. One fisherman blamed mining activities, three suggested changing weather conditions with a decrease in water levels was playing a role and one fisherman suggesting crocodiles were a major problem.

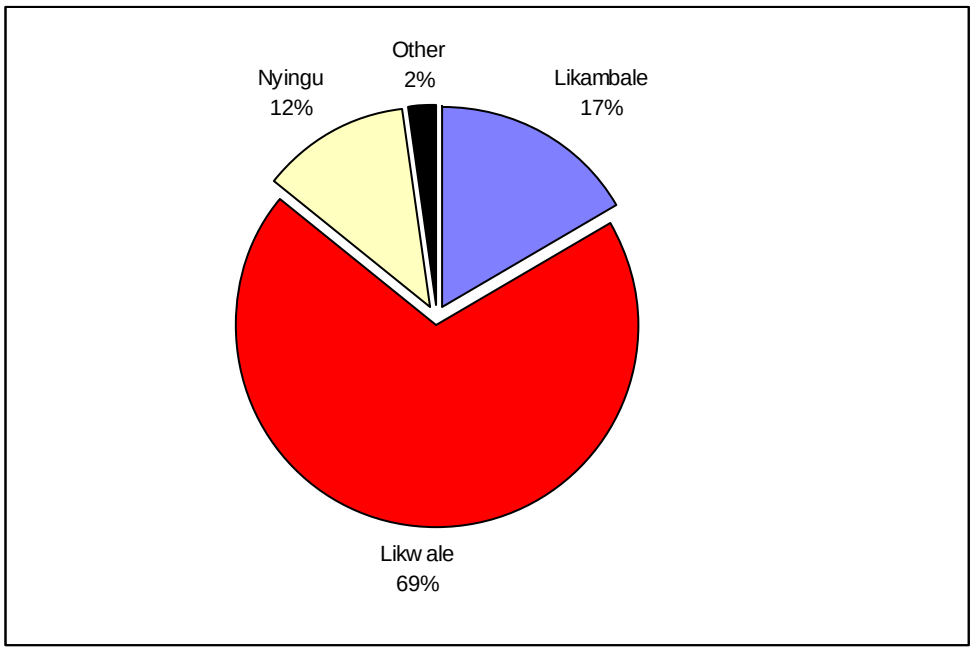

Fig 9: Relative proportion (%) of different fish species in measured catches on the Ruvuma (n = 604 fish; n = 16 fish catches).

Table 4: Descriptions of common fishing methods used on the Ruvuma and Lugenda Rivers with information provided from this survey as well as the NNR Lugenda surveys (Begg *et al.* 2005; Begg & Begg in prep). Techniques highlighted were specifically observed during this survey.

Fishing method		Description of method		
CYao	**Kiswahili**	**Type of Gear**	**Time of use**	**Description**
A: Traps				
Masyazya	Masiazia (mti na majani)	Traps and bait	Usually used in April-November	Large mesh valve traps are placed in sandy channels and pools when water is either running slowly or static. Traps are baited with leaves and twigs (possibly *Phyllanthus reticulatus* or *Xylotheca kraussiana*). These leaves have a strong smell, which attracts fish into traps. The bait plant is cut into pieces and laid in the sun for 2-4 days before use for the smell to develop.
Chilavika		Traps and bait	Throughout the year	Portions of termite mounds are placed in small mesh insevila traps in pools of large rivers. The termites attract juvenile Chilenge and Mbojojo fish. These fish are eaten and used for bait for rod and line fishing,
Insevila	Insevila	Traps	Throughout the year	A fine mesh valve trap placed is placed in a sandy, grass barrier, which is built across shallow sandy channel tributaries. This trap is designed to catch juvenile fish for which there is a specific market.
Nsangulo -lipata	Midema	Trap +straight line barrier	Throughout the year, but usually July – December	Unbaited, standard mesh valve trap traps made locally from bamboo are placed upstream of straight line barriers that are built across the river, usually in rocky channel habitat in rapids using rocks, bark, tree trunks, branches and palm leaves. Traps are placed in openings on the barriers (Plate 11)
Rwando	Uzio	Traps & round fence	July-December	Built of bamboo in a circle and shaped and covered by grass. Food is placed inside the circle, the fish enter the fence through the openings, and when they can be seen jumping the openings are quickly closed. A standard valve trap placed near the opening catches the fish as they try to escape. This technique is not commonly used on the Lugenda River (Plate 10).
Manga	Uzio	Traps & straight fence	July - December	Placed in small streams to catch fish moving from a pool to shallow water. Traps are placed along the fence with the trap entrance facing the pool as the fish move from major water to the shallow water

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Cyao Name	KiSwahili Name	Type of gear	Time of use	Description
B: Nets				
Chingombo	Chingombo (wavu)	Net	July-December when water levels have dropped, day	In Lugenda primarily used by children and teenagers, in Tanzania also utilised by adults. Used in rocky channel habitat during the day. A panel of discarded gill (various mesh sizes; approx. 45 cm x 60cm) is attached between two pieces of bamboo and staked in a channel downstream of a site such as a rock where fish are considered to be hiding. Fish are flushed into the net by swimming underwater. A small float attached to one side of the bamboo via a long string provides an indication of where the nets are and when a fish has been caught.
Jalife	Jalife (wavu)	Gill net	Dry season, June-December day and night	Used in rocky channel habitat and deep pools. A two-ply net is used with varying mesh sizes (4.9 cm –9.8 cm; 2-4 inches). Nets are 45 m long when new and vary in height from 1.5-2.5m. A head rope woven from twine/ bark/ palm leaves and floats made from *mawale* (cyao) or light buoyant timber or bamboo are attached to each net. A bottom line made from twine/bark/ palm is fixed to each nets and weighted with stones.
Chikukwele / Nkwanga	Chikukwele	Gill net	All season, primarily late dry season, day.	Used in medium depth (thigh high maximum) shallow sandy channels where conditions are suitable. Same net as Chingundenge fishing (monofilament, frequently nylon, 100m gill net, mesh size 2-3) Net dragged through shallow water by 1-3 people onto a sandbar
Chingundenje	Chingundenje	Gill net	All season, primarily dry season, throughout the day	In late dry season in deep channels and pools. Similar to seine netting and is done through the day. A 37mm monofilament deep (2.5m) drop gill net is fitted with a float line and a weighted bottom line. A group of 4-5 people flush fish from their hiding places by swimming and diving while gradually pulling the net closed.
Namatepa	Namatepa	Net	Wet season, primarily	Large net (100m, mesh size 1.5 - 2 cm is staked with bamboo stakes at regular intervals in sand across confluences of tributaries. Frequently used to catch fish swimming upstream to spawn
Ukoka –mosquito	Kukoka –mosquito	Mosquito net	Wet season; January-March	Primarily used by women when tributaries are running; shallow water. A mosquito net is dragged through the water to catch juvenile fish
Kupa	Kupa			Primarily used by women. A barrier of mud or sand is constructed across a shallow channel to block off both sides, water is thrown out with a bowl or plate and trapped fish are removed. Primarily juvenile fish are targeted.

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Cyao Name	KiSwahili Name	Type of gear	Time of use	Description
C: Rods and lines				
Kulopozia	Kutambeza	Rod & Line	All year	In all habitats, specifically for campango, barbel and vundu as well as other larger fish. A short length of heavy gauge nylon lone, seldom longer than 3m is fixed to a bamboo rod. Rods are hand held from the bank or rocky island.
Matavilia	Matavilia	Static line		Static lines are attached to stakes that are left permanently embedded in the floor of deep pools and with the aid of a canoe are checked every morning.
D: Poison				
Luchimbili	Sumu (mzizi wa mti)	Natural poison - leaves	July-December	The leaves are pounded in stone potholes in order to get husks, which are stirred into static water pools. Water bubbles or foams and fish die. Scientific name still to be identified.
Chiombola	Sumu (majami ya mti)	Natural poison-leaves	July-December	The leaves of *Strychnos spinosa* are pounded in stone pits in order to get husks, which are stirred into static water pools. Water bubbles or foams and fish die (Plate 9d)
Ngwesa	Sumu (mti laini) / Lipanagapanga	Natural poison – tree, *Agape spp*.	July-December	*Euphorbia candelabrum* are cut into portions and placed in shallow pools, water is stirred, and it bubbles or goes milky. Small euphorbias found on inselbergs are very poisonous, said to kill crocodiles (Plate 9c)
Ntutu	Sumu –mjamba (majami ya mti na shambami)	Poison-crop leaves	July-December	Leaves are taken and pounded in stone pot holes to get husks. This is then stirred into the water pools, it bubbles and fish die soon thereafter. This is used in large quantities.
Chingenge	Sumu (matunda ya mti)	Natural poison – tree fruits	July- December	Fruits of *Bobgunnia madagascariensis* (previously *Swartzia madagascariensis*) are pounded in stone pot holes and stirred into pools during the dry season. (Plate 9b).
Nsondoka -Chisondoka	Sumu matunda ya mti	Natural poison-tree fruits	July-December	The fruits of *Catunaregam spinosa* are pounded in stone pot holes and stirred into pools (Plate 9a).
Kanzimbile	Sumu –mzizi/ mhogo na magukulu	Natural poison-shrubs, roots		
Ngunga	?	Natural poison-roots	July-December	A root parasite *Hydnora sp* .Tubers are pounded into coarse pieces and placed in pools to kill fish. Fish can be eaten with no ill effect.
Ntofilo	Ntofilo	Pesticide		Crop pesticide bought from cotton farmers and placed in shallow pools. People get sick from eating fish killed in this way.

a) Chisondoka / Matunda ya mti (*Catunaregam spinosa*)

b) Chinyenge / Matunda ya mti (*Bobgunnia madagascariensis*)

c) Ngwesa / mti laini (*Euphorbia candelabrum*)

d) Chiombola / majami ya mti (*Strychnos spinosa*)

Plate 9: Four of the natural plant poisons used to kill fish in pools on the Ruvuma River. Descriptions of the poisons are provided in Table 4.

Plate 10: Circular fences / Rwando / Uzio

Plate 11: Fine mesh large valve traps / Nsangulo / Midema: Unbaited

SECTION B: RIVER INDICATOR SPECIES

6.0. Hippo

6.1. Status and importance

- The IUCN Hippo Specialist Group re-evaluated the status of the hippo in 2004. They found dramatic population declines in key countries, with widespread poaching and a rising number of human conflicts. The status of the hippo was therefore upgraded to Vulnerable on the International Red List of Threatened Species in 2006 (IUCN 2006).
- As large herbivores, hippos have significant effects on vegetation and are likely to be important for maintaining open plains areas (wooded grassland) close to the main rivers, which are in turn important for other ungulates such as impala. They are also critically important for nutrient cycling in rivers, particularly in the larger pools and lakes. In Lake Edward, in the DRC where hippo numbers have crashed from 29 000 more than 30 years ago to less than 400 today, the drop in the hippo population has been accompanied by a collapse in the lake's fishery. Hippo dung helps to sustain the lake's fish, and in recent years as hippo numbers have declined *Tilapia* catches have plummeted in size and number (Lewison, 2006).
- Hippo are therefore an important indicator of the wilderness status and ecological "health" of a large river. In addition hippo have significant benefits for both sport hunting and ecotourism ventures.

6.2.Distribution and density

- The hippo population in this section of the Ruvuma appears to have declined dramatically with only 4 sightings of 23 individuals in 176 km (0.1 hippo / km; Fig. 12), with the largest group consisting of 12 individuals.
- An additional 6 hippos have been seen in the lower Lucheringo River (Block E, NNR), with a further six hippo estimated to be present in the Upper Lucheringo (Block D1), a major tributary of the Ruvuma inside the NNR (Begg & Begg 2007). It is estimated that a maximum of 25 hippo are found in the whole Lucheringo River at present. The numbers of hippos in the Tanzanian tributaries are very low.
- In 1977, Tello & Dutton (1979) counted 73 animals in the Ruvuma during a helicopter survey, comprising 12 groups, ranging in size from 1-23 individuals with a mean group size of 6.3 individuals (range 1-23 individuals, mean group size 6.3). However, of these only 1 hippo was sighted in the actual survey area (Fig. 12). Yet, historical records (Sutherland 1912; Siggins 1931 in Tello & Dutton 1979) suggest that hippo were abundant in the

Ruvuma River up until around 1965 when they were dramatically reduced through meat and ivory poaching.

- Poaching of hippo on the Ruvuma appears to be an ongoing threat. A few years ago, Mahiwa Pool (Fig 12) had more than 50 hippos (R. Hahn, pers com) but during this survey not a single hippo was seen in this area.
- The south bank of the Ruvuma between the western boundary of SNWC and the Lusanyando River (approximately 126 km) is managed as a hunting concession in NNR (Block E; Niassa Hunters). In this concession, an annual hunting quota of three hippo has been provided by SRN since 2003. Given the populations known in the Ruvuma (8 hippo) and Lucheringo (33 hippos), we estimate that there are approx 41 hippos in this concession (Begg & Begg, 2007). Since 2003, one hippo has been utilised each year, but in all cases three trophies appear to have been taken from the Lucheringo River and not the Ruvuma River. Data suggest that while the off-take of one male is probably sustainable, the current quota of 3 males should be reassessed and hunting of all hippo in the Ruvuma should be discouraged until populations recover (Begg & Begg 2007). Based on these recommendations, the hippo quota for Block E has been decreased to one for 2007 (SRN 2007)
- Hippo numbers were also depleted in the Lugenda River due to hunting pressure in the past. However, the current density is 1.6 hippo / km of river (more than double the Ruvuma hippo density), but patchily distributed. The total Lugenda population (including its tributaries) comprises more than 600 individuals and it appears to be increasing (Begg & Begg, 2007).

7.0 Nile Crocodile

- Between 1997 and 1998, crocodiles killed 17 people on the Ruvuma River with 59 human-crocodile incidents since 1985. As a result, at least 123 crocodiles were killed between 1989-1999 in the Ruvuma region, and the majority of these were on the Ruvuma River (Games & Severre, 1999a).
- Subsequent surveys carried out on the Ruvuma River suggested that crocodile densities are now low (Games & Severre, 1999b). An aerial census of approximately 150 km of the Ruvuma upstream of Negomano (confluence of the Lugenda & Ruvuma) calculated a density of 0.05 adult crocs / km.

7.1 Survey results

- Obtaining an accurate indication of crocodile densities on either the Ruvuma or Lugenda Rivers has proved difficult. Adult crocodiles are secretive and are seldom seen sunbathing on sand bars as is the case in other areas, possibly due to high levels of pedestrian traffic and active persecution.
- However, sightings of crocodiles were collected opportunistically and where possible spotlight surveys were conducted to assess crocodile numbers more systematically.
- In total, 13 opportunistic sightings of crocodiles were made over the month long survey period. In addition, two crocodile nests were located, one with the remains of egg shells obviously active in 2006 (Plate 12).
- Crocodiles can be easily located with a spotlight at night due to their eye-shine. In an attempt to obtain a more systematic indication of crocodile density, spotlight counts were conducted wherever possible. Each crocodile sighted was placed in a general age category based on the width between the eyes: small (juvenile; <1.8m in body length), medium (sub adult; 1.8 - 2.3m) and large (adult; >2.3m).
- However, spotlight counts are hampered by the difficulties in moving around at night on the bank, particularly in rocky channel habitat with dense vegetation, and braided channels. During this survey, 14 spotlight transects ranging in length from 0.59 –1.1 km covering 10.96 river km were completed. Seven transects were in sandy channel habitats and seven in rocky channels habitats.
- In total 23 crocodiles were observed (2 crocs / km) with 14 juveniles (1.2 / km), two subadults (0.18 / km) and seven adults (0.64 / km).
- Sample sizes are small, but these data do at least confirm that crocodiles are breeding in the study area with 60% of the sightings being of juvenile crocodiles, similar to results from the Lugenda River. However, overall crocodile densities similarly calculated from spotlight counts in the Lugenda River were substantially higher with 13.4 crocodiles / km (Begg *et al* 2005). In addition, for both surveys the densities are significantly higher than the results of the aerial census completed by Games & Severre (1999b; 0.05 crocodiles /km) even if only adult crocodiles are taken into account.
- Details of Crocodile-human conflict on this stretch of the Ruvuma are provided in Section 10.1.

Plate 12: Recently hatched crocodile nest with eggshells located during the survey period

8.0. Elephant

- Data from Tello & Dutton's aerial survey (1979) 30 years ago show significant movement of elephants across the Ruvuma throughout the study area (Fig. 4; solid arrows). Of particular interest is the concentration of elephant movement near the Ligunga River, which is not mentioned in more recent studies.
- More recent studies of elephant migratory routes suggest two main crossing areas across the Ruvuma within the study area (Mpanduji *et al.* 2002; Fig 13). These are situated:
    - Just west of Milepa, 27 km east of Magazini Village between the Lualeco and Lucheringo Rivers (2 crossing points).
    - East of the Lusanyando River, about 14 km west of Magazini village, near Mikangaula Fishing Camp (3 crossing points).
- During the SNWC river survey, elephants were only visually observed on one occasion however fresh tracks and/or dung were recorded on a further 4 occasions (Fig 12).
- The NNR 2004 aerial census (Craig & Gibson 2004) shows a concentration of elephants near the Lusanyando River on the Mozambican side, which correlates with the migratory movements in this region (Fig. 10). However, of major concern are the high levels of snare lines that were seen in this same area during the 2004 aerial census (Fig. 11).

- The aerial census results also suggest that elephants are uncommon along the rest of the length of Ruvuma adjoining the SNWC, at least during October when the survey was completed (Fig 10). The 2006 aerial census results are not yet available.

Fig 10: Elephant distribution and density recorded during the 2004 aerial census, reproduced from Craig & Gibson (2004)

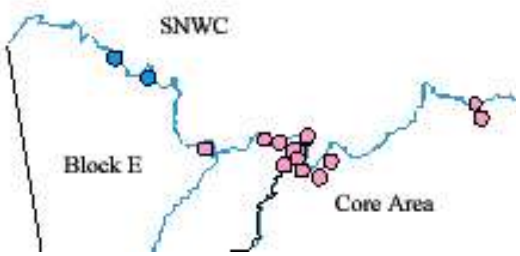

Fig 11: Position of snarelines (pink circles) recorded during the 2004 aerial census, reproduced from Craig & Gibson (2004)

9.0 River Indicator: birds

9.1 African Skimmer

- African Skimmers may be important indicators of the "health" of the sandy channel habitat and are important species for ecotourism i.e. bird watching and canoe safaris. However, this species has shown significant population declines across its range and is now considered Endangered in Southern Africa.
- Population declines in most areas are due to habitat loss through flooding and damming, harvesting as food and disturbance of breeding sites on sandbars by people (Hockey, Dean & Ryan, 2005).
- In NNR and SNWC, fishermen harvest eggs, adults and chicks as food (Begg pers. com) and nesting sites on sandbars are easily disturbed by fishermen and canoes, as is the case on the Zambezi River.
- During the survey, three groups of skimmers were observed (group sizes of 14, 4, and 12) representing 30 birds and an overall density of 0.17 birds per kilometers of river.
- It is recommended that at least some of these African skimmer colonies are included in fish breeding / conservation zones where human activity and harvesting is minimized to ensure their protection and allow their numbers to increase (see Section C).

9.2. Water-birds as indicators of river health

- Water-bird density can provide a relatively simple visual indicator of river health (water quality, nesting and refuge habitats, fish stocks and aquatic fauna). Of particular importance as indicators are the large resident fish eating birds such as African Fish Eagle, Pels Fishing Owl, Goliath Heron and Saddle-billed Stork (Plate 13).
- Results from this survey and the Lugenda River survey are presented as the number of individuals counted per kilometer of river surveyed (Table 5). For African Fish Eagles and the Pels Fishing Owl, calls as well as visual observations were noted whereas for the other species only visual observations were recorded.
- A number of relatively common bird species were not observed during the Ruvuma survey, but were seen on the Lugenda River (Table 5). Of particular concern is the lack of sightings of Goliath Heron, Saddle-billed Stork, and Pels Fishing Owl, all of which generally catch fish in the medium size range (2-3 kg), a similar size targeted by the fishermen.
- In addition, no sightings of African Fish Eagles were recorded during the survey although one old nest was located on Angecha Island. However, fish eagles have been seen on several occasions on the Ruvuma in recent past years (R. Hahn pers. com.)This is the most conspicuous and easily observed of the indicators due to its regular and easily identifiable call and habit of sitting in the open, on large waterside trees and it is unlikely that they were simply missed. This is markedly different from the Lugenda River where 51 Fish eagles were located over the 345 km surveyed.
- The lack of Fish Eagles on this section of the Ruvuma should be of significant concern as their absence can be related to an absence of large fish and overfishing. In Namibia, Fish Eagles were absent in 1989-1999 on the Kavango River but returned to breed within a few months after people moved away due to guerilla activity. Their return has been linked to an increase in the abundance of large fish that had previously been caught by the local community (Hockey *et al* 2005).
- Further investigation into water quality and fish stocks are urgently needed. It will be important to monitor whether future river surveys show a higher density of these species once the fish breeding zones are in place.
- Comorants, darters and the more migratory storks were fairly common on both the Ruvuma and Lugenda Rivers although their distributions were, as expected, very localised and dependent on specific river conditions.
- It is also of interest that no Palm-nut Vultures (*Gypohierax angolensis*) were recorded during this survey. While these are not primarily fish eaters (although fish and crabs do form a portion of their diet), they are habitat specific and are linked to the presence of *Raphia* palms with palm fruits providing their main food. (Hockey *et al*. 2005). It is not

known whether their absence is simply due to a natural lack of suitable habitat. On the Lugenda they are seen fairly regularly in localised well developed riparian habitats (Begg & Begg, in prep) and they may well be a good indicator of pristine riparian habitats.

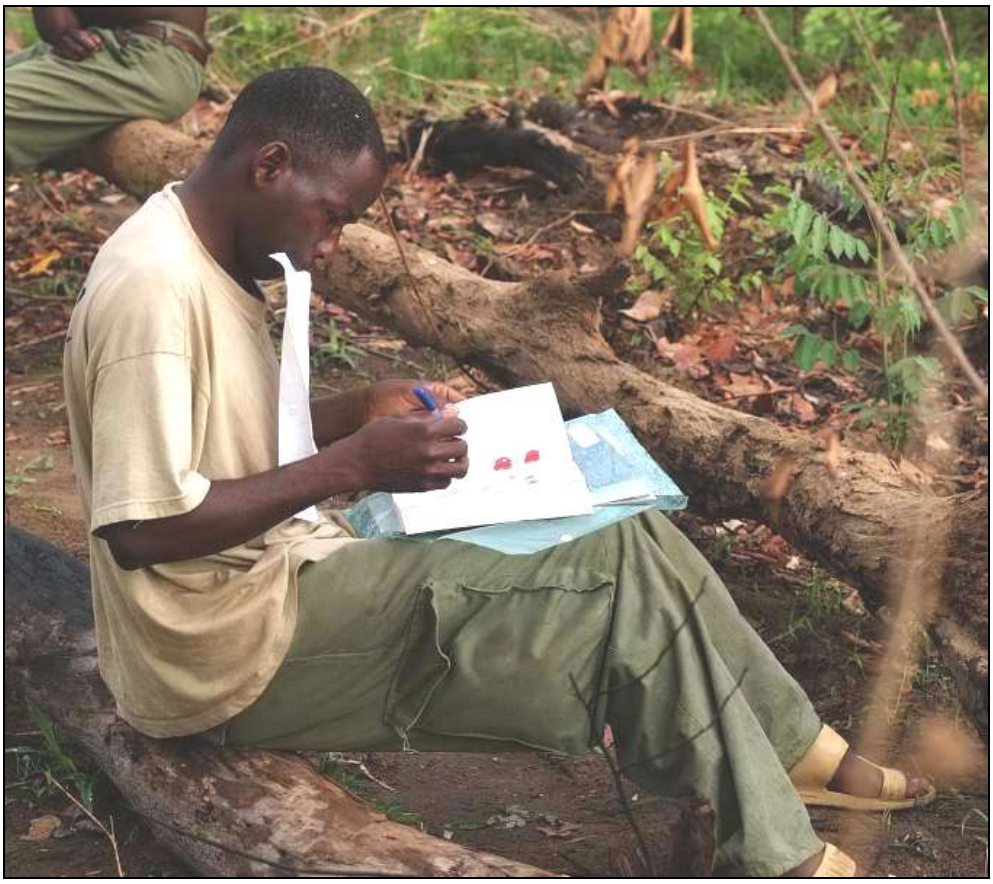

Plate 13: Survey team member noting indicator bird species

Table 5: Densities of key water-birds and indicator species observed during the surveys of the Ruvuma and Lugenda Rivers in 2006.

Species-Common name	Ruvuma River (176 km surveyed) (No. of individuals / river km)	Lugenda River (345 km surveyed) (No. of individuals / river km)
African Skimmer	0.17	0.63
Comorants & darters	0.65	0.57
African Finfoot	0.02	0.03
African Fish Eagle	0.01	0.2
Pels Fishing Owl	0	0.05
Palmnut Vulture	0	0.02
Goliath Heron	0	0.03
Grey Heron	0	0.04
Purple Heron	0	0.01
Great White Egret	0.09	0.03
Saddle-billed Stork	0	0.08
Yellowbilled Stork	0.03	0.08
White Stork	0.05	0
Black Stork	0.06	0
Woolly Necked Stork	0	0.11
Openbilled Stork	0.06	0.03
Spurwing Goose	0.01	0
Knob-billed Duck	0.01	0.02

10.0 Additional information collected

10.1. Conflict with other animals

- Fishermen do not like crocodiles as they regularly damage nets and are seen as competitors for fish. Anecdotal evidence suggests that large numbers of juvenile crocodiles are killed in nets by accident and are affected by fish poisons. A fisherman in the study area reported a 4m crocodile caught in a fishing net. Nests are also destroyed when they are found.
- The survey suggests crocodiles have killed at least three people and injured five in the last six years. An additional three people have been killed and one injured prior to this in the survey area. However, plotting of the conflict reports shows that they are occurring in only two areas: near Milepa Village at the major commuter crossing point (Crossing point C; Fig. 12) and near the Lusanyando River crossing point (Fig 12.). This is similar to the

Lugenda where the majority of attacks are happening in areas where the behaviour of humans is predictable, such as regular bathing, washing and crossing sites.

- While hippo are potentially a threat to fishermen in canoes, direct conflict is rare, even in the Lugenda where hippo densities are much higher. In the last 6 years (since 2000) three fishermen have been injured by hippos and hippos have capsized two fishermen's canoes in this stretch of the Ruvuma River. No fatalities have been recorded.
- Interestingly, unlike on the Lugenda River, no fishermen mentioned African Clawless Otter ("Kawusi") as a problem and otters were not seen during the survey. Since otters are generally only a problem for trap fishermen, this may be a reflection of the relatively low use of traps or alternatively otters may be scarce in the Ruvuma River due to the absence of appropriate food (crabs, fish) or adequate feeding and refuge conditions.

10.2 Riverine habitats

- Riverine woodland and forest is relatively poorly developed along both the Lugenda and Ruvuma Rivers and is generally limited to river bends and confluences, but this habitat is high in plant biodiversity and should be considered a major conservation priority (Timberlake *et al* 2004).
- People from the nearby villages travel specifically to the Ruvuma river valley to collect dum palm leaves for the making of rope and weaving of baskets and other household items.
- The single most important resource used by fishermen other than fish is firewood which is needed to feed the smoking ovens and for food preparation.
- In addition, two types of canoes, dugouts and bark canoes are constructed in the study area, both of which require large riparian trees to be cut down or debarked. At least five species of trees are used to make dugout canoes *in situ* in the region *(*Mukwa *Pterocarpus angolensis;* two *Sterculia sp;* Pod mahogany *Zanthocersis zambesiaca;* and Marula *Sclerocarya birrea*, Begg *et al*. 2005). In addition, during this survey a dug out canoe being made from a *Ficus sp.* was also recorded (Plate 15).
- Dug out canoes are the most common (n = 21) with only four bark canoes observed. Interestingly this is only slightly more than the number of canoes observed in the study area during the aerial survey conducted by Tello & Dutton (1979) thirty years ago.
- No data are currently available on the potential effect on the riparian vegetation of this harvesting of mature trees and this needs to be investigated.
- Basic habitat mapping during the survey identified 11 stretches of riverine woodland along the north bank of the Ruvuma (Fig 13; Plate 14) with the most significant stretches east of the Lusanyando River. Several of these stretches of riverine woodland have been included in the special conservation / fish breeding zones (Fig 13). It is recommended that harvesting

of forest resources including firewood, thatching, canoes, palms etc be limited in these areas.

- General observations of water quality showed that during the survey period the water was clear with relatively little red sediments characteristic of other months when gold mining activities are taking place in the tributaries upstream of the Ruvuma. Gold mining activities cease in November due to the lack of water for the washing process.

Plate 14: Riverine Forest in rocky channel habitat

Plate 15: Dugout canoe being made from a *Ficus* tree

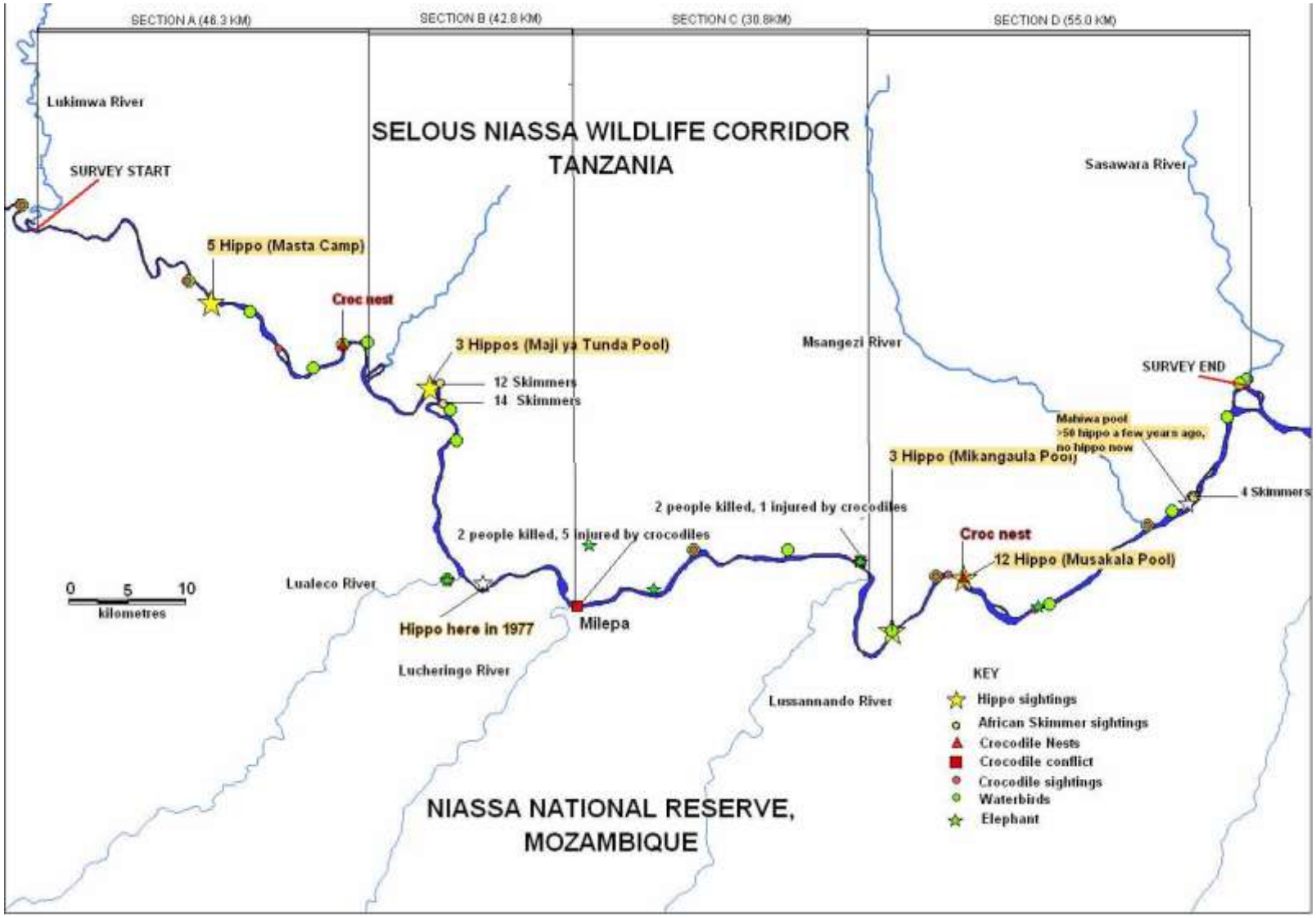

Fig 12: Distribution of river indicator species, particularly hippo, crocodile, African Skimmer, elephant and water birds (storks, egrets, cormorants, herons).

SECTION C: RECOMMENDATIONS

11.0 General Recommendations

- Regular surveying (every 3-5 years) of this section of the Ruvuma River following the same protocol) is recommended so that changes over time can be tracked and the effectiveness of different management techniques can be assessed and adapted where necessary. Of particular importance will be further measurement of the sizes and diversity of fish catches, the monitoring of the densities and distribution of hippos, crocodile and key indicator birds, particularly African Fish Eagle, Goliath Heron, Pels Fishing Owl, African Skimmer, and Saddle-billed Stork, and the monitoring of wildlife-human conflict.
- In consultation with the Wildlife Department of Tanzania, a crocodile management plan will be developed by R. Ferguson for the Ruvuma River (R. Hahn, pers. com).
- The data suggest that management of the fishery is essential to prevent over-utilisation of this important resource both for the sake of human needs and in the light of conservation goals.
- Of particular concern is the perception amongst fishermen that decreasing fish catches can be mitigated by increasing the amount of fishing gear used rather than by limiting the number of fishermen. Intensive extension work with fishing communities will be needed to resolve this issue.
- There are four main ways in which this Ruvuma fishery can be managed to ensure use of the fish resources is sustainable and fish stocks recover. A combination of these approaches is likely to be the most successful:
    - Banning of detrimental fishing technique (section 11.1)
    - Limiting the number of fishermen allowed to fish on this section of the river through effective licensing (section 11.2.)
    - Formation of fishing groups with each responsible for a certain section of river (11.3).
    - Zoning of the river to provide fish breeding/special conservation areas (Section 10).

11.1 Fishing techniques

- The majority of fishermen each use a combination of different fishing technique to take advantage of constantly changing river conditions. Monitoring and enforcement of complicated fishing rules is likely to be difficult and time consuming given that there are more than 20 different fishing tehcniques in operation on the river (see Table 4).
- It is therefore recommended that control of fishing methods be kept relatively simple and clear cut (Table 6).

- As is currently the case, it is recommended that the use of nets with a mesh size of less than 2.5 (gillnets, mosquito nets) and the use of fish poisons (pesticide and natural) continue to be illegal under all circumstances. Improved law enforcement is required.
- The use of fine mesh valve traps (insevila fishing) needs to be more carefully assesed as while this method of fishing targets juvenile fish in the sandy channels, it is very specific in where and when it is used. It may be sufficient and simpler to limit the number of fishermen utilising the river at any one time and provide fish breeeding zones on the Ruvuma and its tributaries where no fishing at all is allowed rather than to ban this technique.
- All other fishing techniques should be allowed and limited through the number of licenses issued.

Table 6: Summary of fishing techniques and recommended actions

Fishing technique	Action
Net fishing with mesh size smaller than 2.5 cm,	Illegal
Use of poisons	Illegal
Use of fine mesh valve trap (Insevila)	To be assessed further, perhaphs simply limited through zoning and licensing
Net fishing with mesh size larger than 2.5	Allowed
Hooks and lines	Allowed
Trap fishing with effective mesh size of larger than 2.5	Allowed

11.2 Licensing and limiting the number of fishermen

- As is currently the case, all fishermen should be required to have a license.
- Close cooperation between Tanzanian and Mozambican authorities will be needed to ensure licensing systems are compatible and complement management goals.
- Only one license per fishermen should be issued and if possible a limit for the number of fishermen allowed to fish on each stretch of the Ruvuma River at one time should be set. This limit should be practical based on the number of fishermen currently using the river and this will need to be coordinated between Tanzania and Mozambique.
- To counter the potential costs to communities of future restrictions on the number of fishermen allowed to fish on the river, it is proposed that fish ponds and fish breeding programs be established close to the villages to provide additional fish resources.

- Licenses should specify river zones in which fishing is allowed to occur. For Tanzanians it is suggested that Lusewa and Magazini are the proposed areas from which licenses can be purchased and set in the fishing license books (Revenue Books).

11.3. Formation of fishing groups

- Fishing groups can be formed where each group is responsible for a certain section of the river.
- Each group should consist of a maximum group size of five licensed fishermen.
- The respective villages will lease the user rights of each fishing section to the respective fishing group.
- The villages with the community scouts will supervise fishing activities and any fishing groups using illegal techniques will be banned from fishing.
- This will transfer responsibility of the fishing activities and the fish stock to the fishing groups and village communities and will resolve the present situation where any fisherman can carry out fishing activities wherever it pleases him, with no responsibility for the resource.
- The formation of fishing groups is already catered for in the new fisheries legislation of Tanzania.

12.0. River Zoning

- It is proposed that certain sections of the Ruvuma River be set aside as fish breeding/ conservation/ ecotourism zones. In these zones no fishing, mining or fishing camps will be allowed and, harvesting of resources (canoe building, harvesting of birds, eggs, terrapins) will be not be allowed.
- Given that the Ruvuma River is an international boundary, setting up of effective conservation/ fish breeding zones will require close cooperation and consultation between both Mozambican and Tanzanian fishermen, and the management authorities of SNWC & SRN (including the Block E hunting concession) as well as coordination of licensing, monitoring and security systems.
- Consultation with the resource users will be critical, both to minimize undue conflict and because local knowledge of the areas involved will be invaluable in setting up practical, pragmatic zones.
- The recommended zones outlined here can therefore only be considered a first step to focus further discussions.

12.1 Setting up of conservation / fish breeding zones

- A number of factors, both human and ecological, need to be taken into consideration when determining the zones. The reality is that areas of high habitat biodiversity (rocky channels, riparian vegetation, vegetated islands) are generally the best fishing areas as well as most important for wildlife. This is illustrated clearly by mapping of the data collected during this survey (Fig, 4: fishing camps, Fig 5: animal sightings) and has also been shown on the Lugenda River, where fishermen, fish breeding sites, crocodiles nesting sites and the large hippo pools are generally concentrated in rocky channel habitat in braided channels (Bills 2004, Begg *et al*, 2005, Begg, Begg & Muemedi, in prep). Therefore, it is not useful to simply designated areas with low fishing activity as the fish breeding zones, and conversely it is not fair to designate all rocky channel habitats as conservation zones when these are prime fishing areas. Instead effective zoning must take into account both the needs of human resource users and conservation goals and will at best be a compromise.
- It is essential that some conservation zones / no fishing zones include tributaries, as these are important fish spawning areas during the breeding season and the pools that remain during the dry season are important for re-stocking the Ruvuma River.
- It is counterproductive to designate areas in close proximity to villages, major spiritual sites and major trading/ commuter routes and crossing points as fish breeding zones/ conservation zones. These will be difficult to enforce and may cause undue conflict.
- Zoning therefore needs to take into account human elements such as:
    - Areas of spiritual significance
    - Traditional pedestrian routes
    - Snaring activities
    - Potential ecotourism benefit (campsites, pools, mountains)
    - Dangerous areas (non-navigable rapids, crocodile and hippo conflict areas)

  As well as ecological factors such as:
    - River and land habitat diversity (e.g. rocky channels, riparian vegetation)
    - Preferred breeding sites of key species such as crocodiles (rocky channels, vegetated sandy islands often with reeds), African Skimmer (broad sandy islands, little pedestrian traffic), water birds (vegetation cover, vegetated islands), Pels Fishing Owls (dense riparian vegetation with deep pools) and Fish Eagles (large trees, with suitable pools for fishing).
    - Inclusion of seasonally inundated wetlands and river tributaries as fish and water bird breeding sites.
    - Location of preferred sites for hippos with wooded grassland grazing areas.
    - Elephant migratory routes with suitable crossing points across the river.

- The survey team provided preliminary recommendations for six fish breeding zones based on their in-depth observations during the foot survey, which provided the basis for further analysis.
- This section of the Ruvuma was then divided into four sections (A-D) and relevant elements were mapped in detail onto each section and overlaid on a satellite photograph to provide information on habitats. The six proposed zones were then adapted based on further information provided from the mapping exercise and are shown in Fig 14, 15, 16, 17. The beginning and end points for each zone are in some cases estimates as for practical reasons they will need to be linked to obvious landmarks on the ground to minimize confusion amongst the fishermen.
- A broad schematic overview of the location of the six zones is provided in Fig. 13 while the extent of each zone is summarized in Table 7 and details are provided below.

12.2 Zone 1- Masta (Section A)

- The original zone suggested by the survey team extended from Masta Fishing Camp to Maboti Fishing Camp. It includes the five hippo at Masta fishing camp, rocky channel habitat with braided channels as well as a short stretch of riparian vegetation (Fig.14).
- This zone has been extended further upstream (west) to include the confluences of two small tributaries (one on the Mozambican side and one on the Tanzanian side), which are likely to be important fish spawning sites during the wet season and are important for water birds and crocodiles. In addition, the satellite photograph suggests that this extension will provide some protection for a section of sandy channel habitat and an important section of riparian and wetland habitat primarily on the Mozambican side around Camp 5 (Fig. 14) where one back channel of the Ruvuma makes a wide bend. This back channel probably only flows in the wet season but is likely to be a very important spawning area for fish.
- This westwards extension includes a further two fishing camps but is considered justified given the importance of including river tributaries and fish spawning areas in protection zones and the relatively low density of fishing camps in this section with no major commuter routes on this western side
- Downstream of this zone are two major commuter routes, a mining camp, as well as Mtwalo Settlement on the Mozambican bank comprising 15 households.

12.3 Zone 2-Angecha Island (Section B)

- This zone includes Angecha Island, Maji ya Tunda hippo pool (3), two African Skimmer sites, as well as extensive riparian and wetland habitats.
- A potential campsite is situated near the hippo pool, on an elevated point at a sharp bend in the river.

- Angecha Island is a well-known landmark in the area. It is about 2 km^2 in area with several fishing pools, riparian vegetation, an old Fish Eagle nest (the only sign of Fish Eagles recorded during the survey), 3 fishing camps, an old smelting site (probably of historical importance), as well as fresh animal signs of hippo, elephant, kudu, leopard and bushbuck and a variety of bird species (Turacos etc).
- The original fish breeding / conservation zone did not encompass the entire island (Fig 15), however given the concentration of animal activity and wetland and riparian habitats in this area, we recommend this zone is extended further east and south to encompass the entire island as well as an extra section of river downstream where there are currently no further fishing camps.
- The southern bank of the Ruvuma is within Block E Hunting Concession on the Mozambican side and will require their cooperation for effective management.

12.4 Zone 3- Lusanyando (Section C)

- The original zone recommended by the survey team began at Jame pool at Kawile Fishing Camp (No. 32) slightly west of the Lusanyando River but no end point was given. This camp has been the site of crocodile conflict in the past (two people killed, one injured) and is also a major crossing point for both people and elephants (Lusannnando F).
- Given the relatively high volume of people traffic through this camp we suggest that it would be pragmatic for this zone to start slightly downstream of the camp but still include the Lusanyando River confluence. This zone could possibly be extended to the Mikangaula hippo pool (3 hippo). This would encompass 11 km of river length and 2 fishing camps
- The close proximity of the Lusanyando River, extensive riparian habitat, concentration of elephant activity and elephant migration routes in this region suggest high levels of animal activity. However the concentration of snaring activities are likely to be preventing movement of animals across the Ruvuma highlighting the need for this to be a conservation / fish breeding area and receive special attention
- Management of this area will require close cooperation with SRN / NNR staff due to the snaring occurring in this area on the south bank.

12.5 Zone 4- Misakala –Deadly Cave (Section D)

- This zone extends from Misakala 1 fishing camps (no 37) to the "Deadly Cave" at Masoko Fishing camp (no 40; Plate 16).
- It includes the Misakala Pool, which supports the largest group of hippo in the survey area (12), as well as extensive wetland (birds & terrapins; Plate 17) and riverine forest habitats important for crocodile and fish breeding.

- It also includes an area of braided rocky channels where the river is very wide dividing into six tributaries with numerous islands and rocks. This is the only extensive area of braided channels in the survey area and is therefore of significant conservation importance.
- The river then becomes very deep and narrow (10-15 m wide) with a strong current and eventually reaches the " Deadly Cave". This cave (S11.72465; E 36.64640) is approximately 4-5m wide and faces upstream. It is easily visible during September – December when water levels are low. At least three fishermen have lost their lives here when they have become trapped in the cave after their canoes capsized during fishing activities (Kandula Selemani –1995; Hamisi Ausi- 1997; Jafari Mkwepu –2006).
- This is probably one of the most important zones due to the extensive braided channels in this area, which provide the complexity of habitats important for fish diversity.

Plate 16: Entrance to the "deadly cave" where at least three fishermen have died.

Plate 17: Misakala wetland, an important breeding and feeding area for water birds and terrapins.

12.6. Zone 5- Mahiwa (Section D)

- This is the smallest of the conservation / fish breeding zones and is centered around Mahiwa Pool where there used to be at least 50 hippos.
- It starts at Mahiwa Camp (no 44) and ends at Kisumola 2 Camp (no 44) and incorporates only 2 km of river.
- It includes sandy channel habitat with a small African Skimmer colony as well as a well-developed section of riverine forest but could possibly be extended downstream to include a portion of braided channels.

12.7. Zone 6- Kisungule Mtn (Section D)

- This zone on the eastern boundary of the SNWC has significant potential as an ecotourism area. The zone starts at Nala Fishing camp (no 47).
- It is scenically very beautiful with the Kisungule Mountain providing extensive views, deep pools, rocky channel habitat, and is a "hotspot" of bird life (Plates 18, 19, 20).
- The original zone ended at a potential campsite at the Kisungule Mountain however it is recommended that the zone be extended to include the confluence of the Sasawara River on the north bank as this will be an important fish spawning area. Rocky channel habitat starts at this point.

Plate 18: Kisungule Mountain in the east of the study area in Zone 6. This zone has been provisionally designated as a potential ecotourism area.

Table 7: Summary of Fish breeding / Conservation Zones

Name	GPS-Start	GPS-end	Approx. River length	No. fishing camps affected
1. Masta	S11.4572	S11.4947	8.5 km	5
	E35.9838	E36.0425		
2. Angecha	S11.5440	S11.5904	9.2 km	4
	E36.1690	E36.1976		
3. Lusanyando	S11.6970	S11.7407	8 km *	1-2
	E36.5185	E36.5343		
4. Misakala	S11.6976	S11.7251	10 km	4
	E36.5787	E36.6479		
5. Mahiwa	S11.6463	S11.6335	1.9 km *	3
	E36.7669	E36.7761		
6. Kisungule	S11.5779	S11.5432	4 km	1
	E36.7977	E36.8160		
Total			41.6 km	19 (40 %)

* Zone 3: Possible extension to Makangaula Hippo pool = 11.1 km; Zone 5: Possible extension to 3 km to include portion of rocky channel habitat.

Plate 19: Zone 6 showing a view of Sasawara River and Ruvuma River confluence from Kisungule Mountain. This is designated as a potential ecotourism area.

Plate 20: Further views in Zone 6, from Kisungule Mountain showing the scenic beauty of the area.

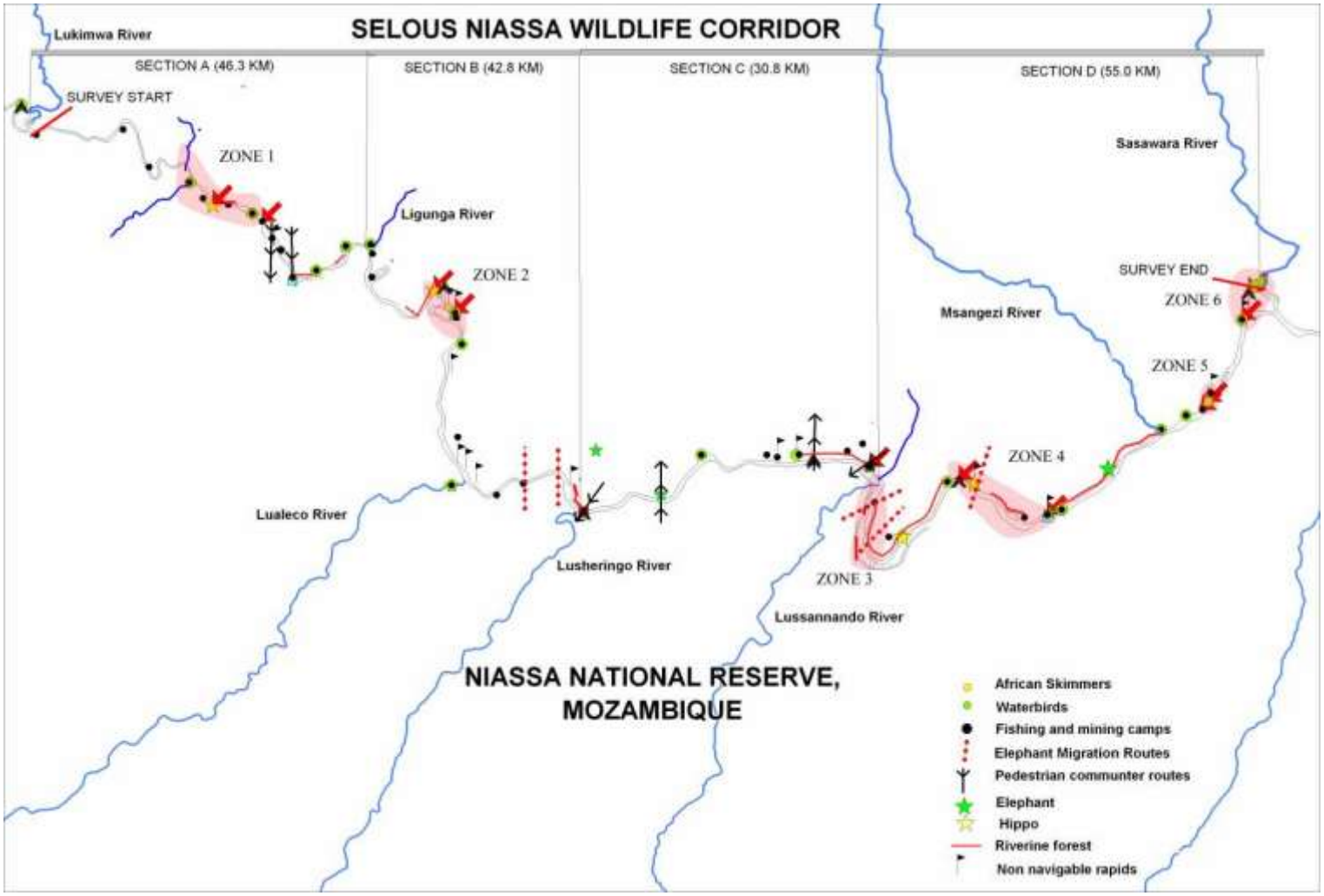

Fig 13: Schematic overview of survey area showing the general location of the six proposed fish breeding / conservation areas.

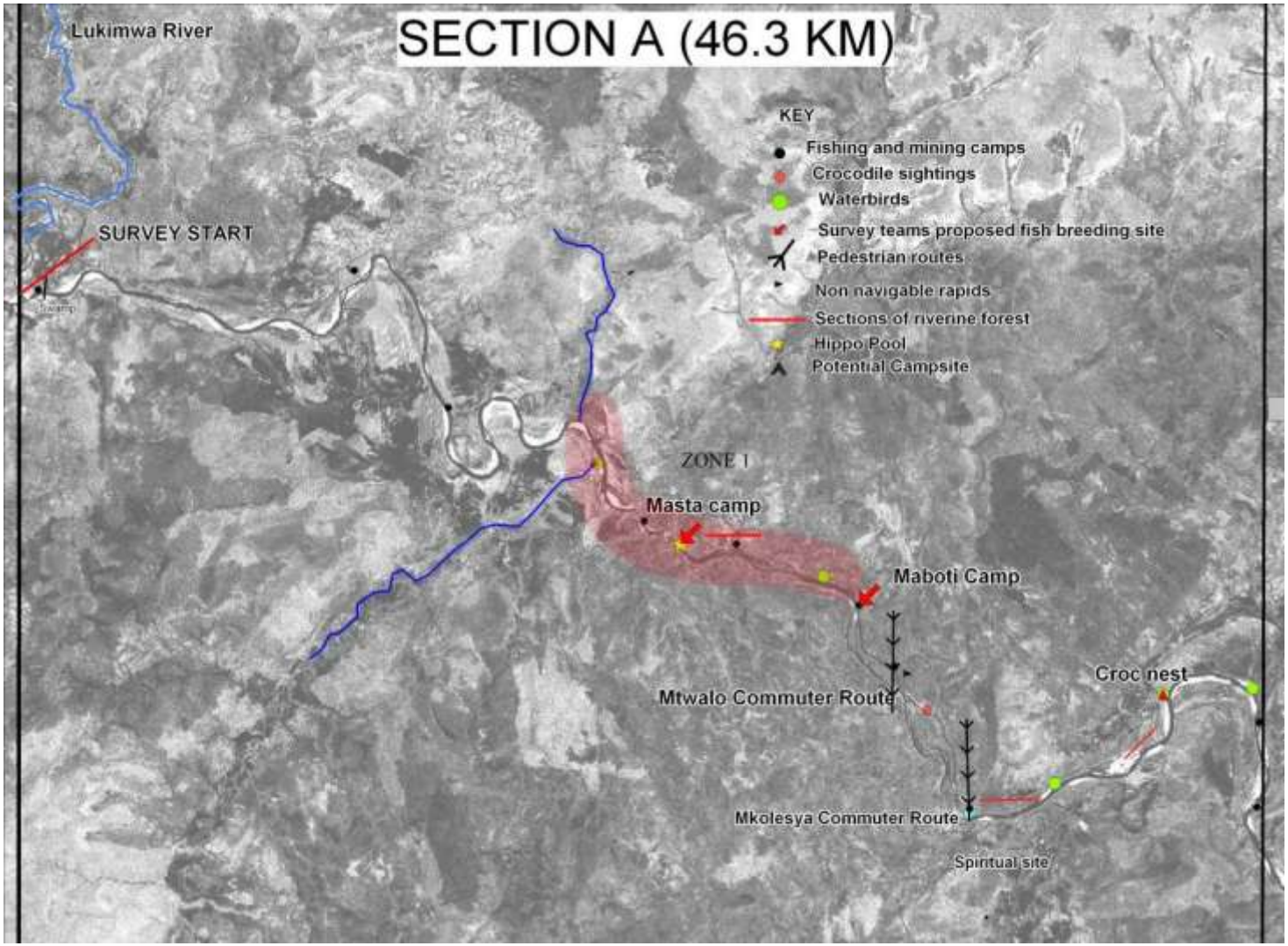

Fig 14: Detailed view of Section A of the Ruvuma River showing the proposed location of ZONE 1 -fish breeding / conservation area. Details of each zone are provided in Table 7.

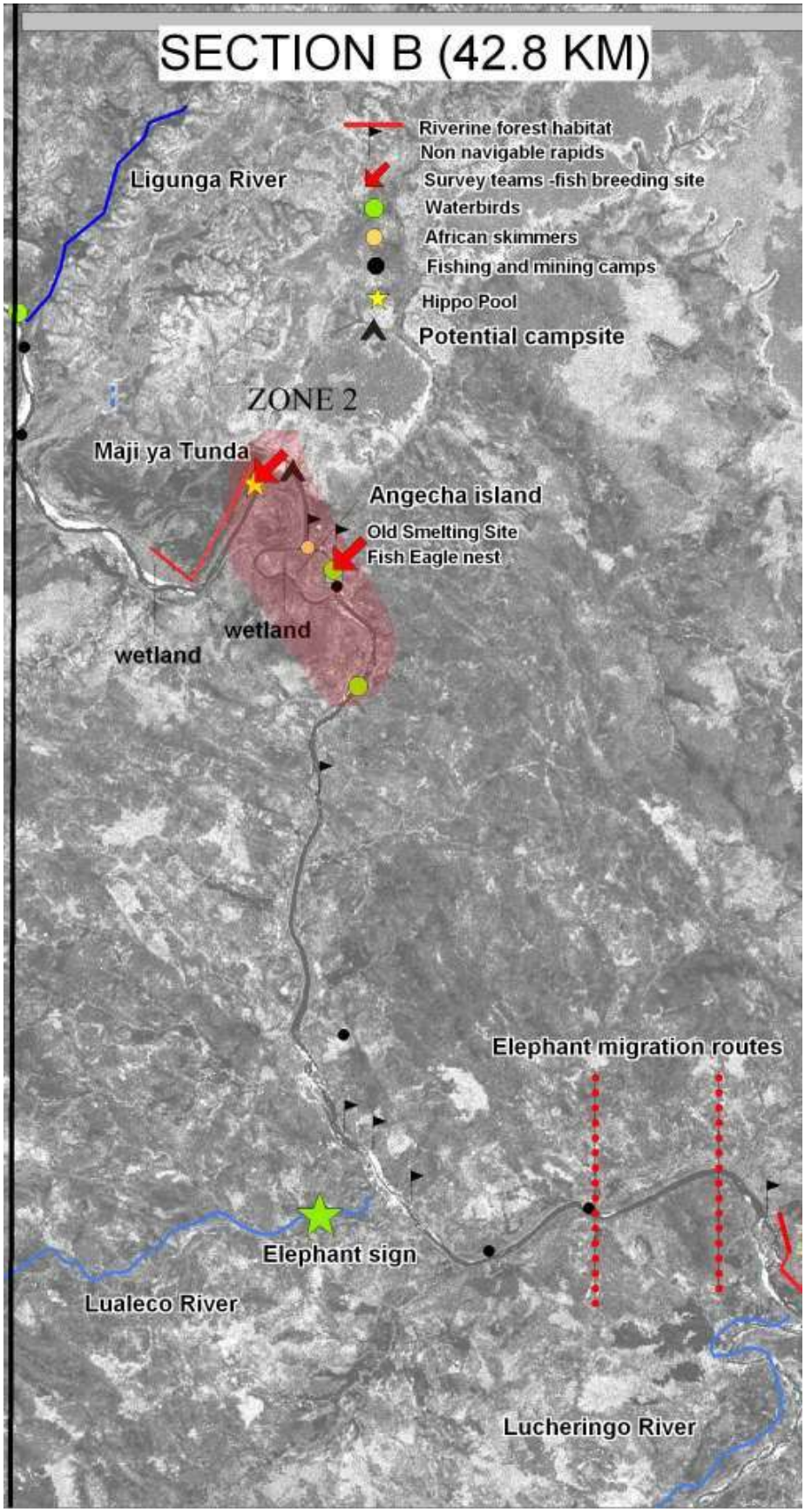

Fig 15: Detailed view of Section B of the Ruvuma River showing the proposed location of ZONE 2 - fish breeding / conservation area. Details of each Zone are provided in Table 7

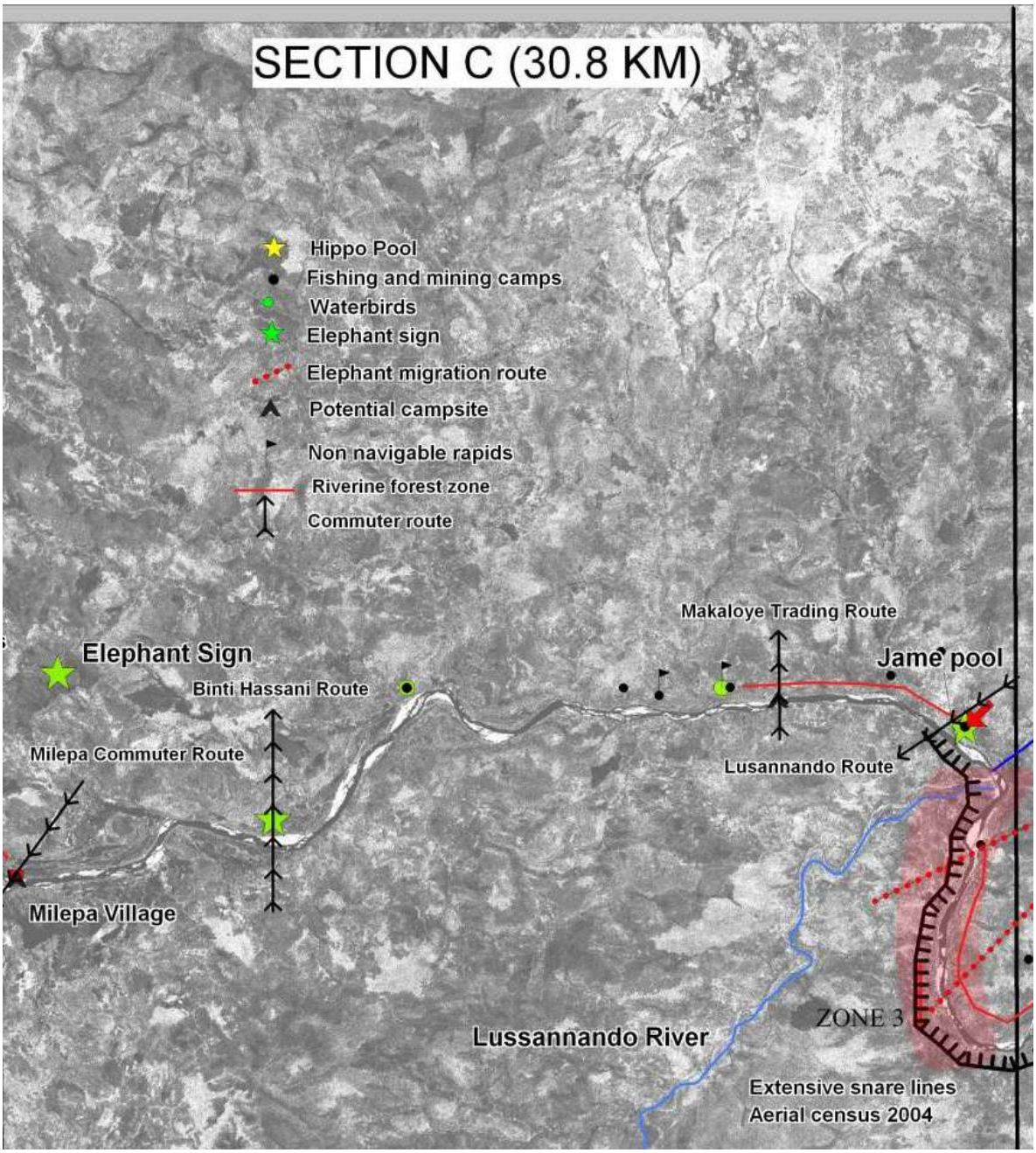

Fig 16: Detailed view of Section C of the Ruvuma River showing the proposed location of ZONE 3 - fish breeding / conservation area. Details of each zone are provided in Table 7.

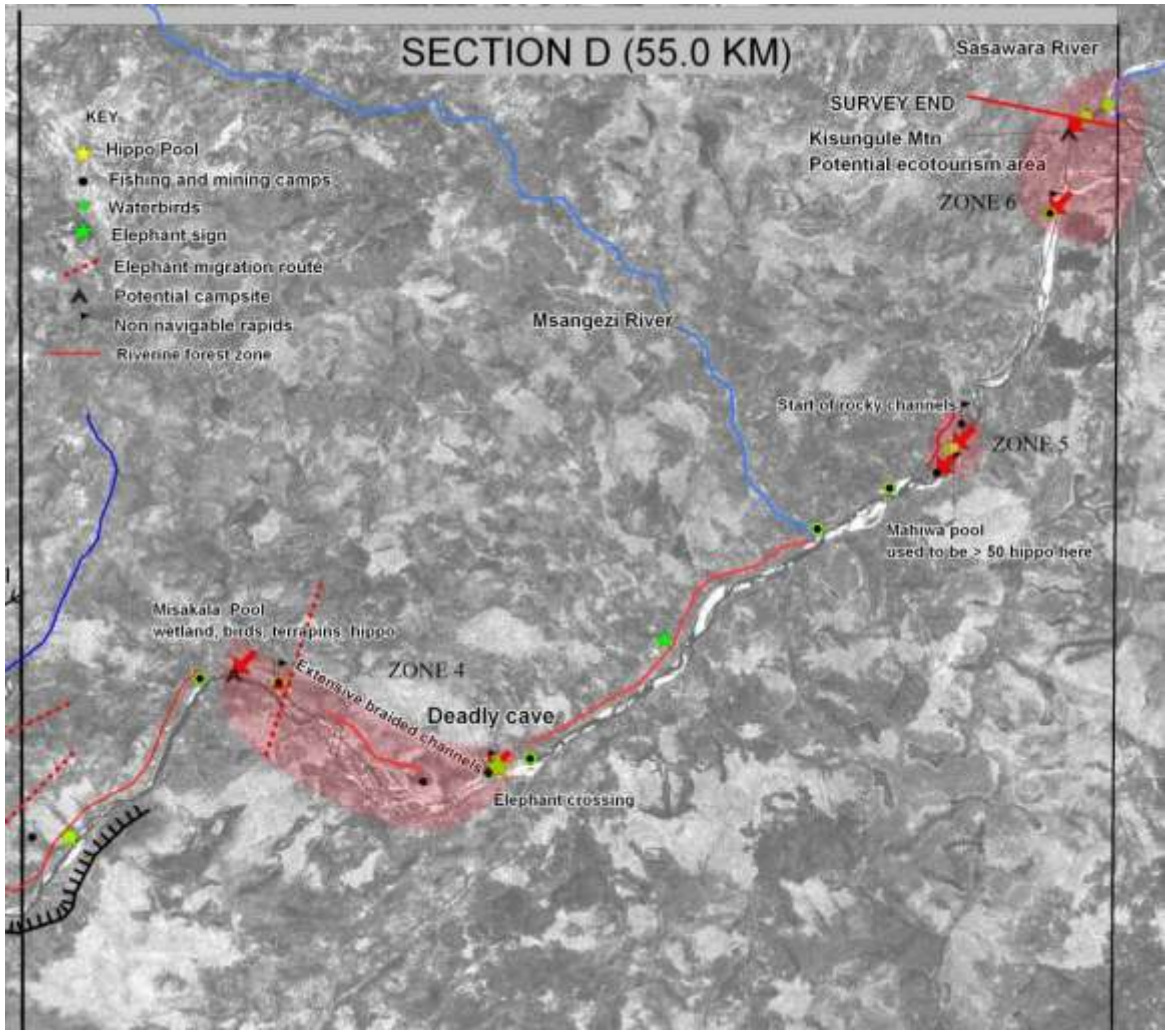

Fig 17: Detailed view of Section D of the Ruvuma River showing the proposed location of Zone 4, Zone 5 and Zone 6 fish breeding / conservation areas. Details of each Zone are provided in Table 7.

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