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Environmental & Ecological Assessment of the Sobat River Fisheries

Upper Nile and Jonglei States, South Sudan

South Sudan Transition and Conflict Mitigation Program (SSTCM)

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DISCLAIMER

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EXECUTIVE SUMMARY

In support of USAID South Sudan's programmatic objectives to explore an expansion of the USAID-funded South Sudan Transition and Conflict Mitigation (SSTCM) program's Youth Fisheries Project of 2011-2012, an ecological and environmental assessment was conducted. The study not only focuses on the aforementioned project itself but also on the wider environment of the Sobat River and associated bodies of water. Two visits were made to the area, one during the late dry season in March-April 2013 and the second at the start of the (late) rains in June 2013. This temporal spacing of visits enabled a better picture to be established of the overall situation, than had only one visit been made.

Fisheries are an integral part of the Nuer livelihoods systems. In recent decades, the role of fish in people's livelihoods has undergone very significant changes due to a progressive and almost total adoption of modern fishing gears. During the civil war this was mostly due to material inputs on a large scale from external agencies. More recently, since the Comprehensive Peace Agreement (CPA) in 2005, markets have become more accessible, bringing fishing gear in and allowing fresh and preserved fish to be traded. The result is that there is now a section of the Nuer community who are wholly dedicated to fishing for a living.

The physical, temporal, spatial and biological characteristics of the Sobat fishery are explained in detail in this report. A creel survey was undertaken as part of the assessment. This enabled preliminary length-frequency analysis and a basic figure for Catch Per Unit Effort (CPUE) to be determined.

The fishing gear inputs as part of the SSTCM Youth Fisheries Project are scientifically analysed and results presented and discussed in the context of the entire Sobat system. Further studies to gather data over a five- year period is recommended in order to determine the Maximum Sustainability Yield and the ecological impact of the SSTCM Youth Fisheries Project.

Recommendations are made both in the area of fisheries and non-fisheries programming, particularly from a strong conservation perspective, rather than just from an economic development perspective.

INTRODUCTION

USAID's South Sudan Transition & Conflict Mitigation program (SSTCM) seeks to support South Sudan to transition into a viable new nation. The program's purpose is to direct quick-impact conflict mitigation and stabilization programming to South Sudan's most volatile regions. The program continues to support activities intended to revitalize war-shattered communities, cultivate peaceful dialogue, and promote stability and democratic transformation in the region.

In the Sobat River Corridor, the conflict between the Lou Nuer of Akobo County in Jonglei State and the Eastern Jikany Nuer of Ulang and Nasir counties in Upper Nile State escalated in 2009, resulting in intense violent cattle raiding and numerous deaths. SSTCM sought to address this conflict with support to increase dialogue such as the Wanding Conference in 2010, extend the presence of Akobo, Ulang, and Nasir counties' local government and traditional authorities to manage such conflict, and engage at-risk youth. In addition, SSTCM has also focused its activities to address the destabilizing inter-ethnic conflict between the Lou Nuer in Greater Akobo (Akobo, Nyirol, and Uror counties) and the Murle in Pibor County, as well as the conflict related to the rebellion of David Yau Yau in Pibor County. The conflict

between the Lou Nuer and the Jikany Nuer has subsided significantly since 2009; however, insecurity prevails from the inter-ethnic conflict with the Murle and the David Yau Yau rebellion.

In 2011-2012, SSTCM carried out a number of activities – mainly the provision of fishing equipment, boats, training, and infrastructure – in support of youth-based fisher groups along the upper reaches of the Sobat River and tributaries, namely the Gilo, Baro & Sobat rivers between Akobo, Jonglei State and Nasir, Upper Nile State. The Youth Fisheries Project was funded by USAID and implemented by AECOM International South Sudan (AISS) through in-kind grants totalling approximately US $ 1,300,000.

This report presents the findings of a wide-ranging assessment of mainly environmental and ecological aspects of the region's bodies of water, focusing specifically on fisheries biology and a scientific analysis of the SSTCM Youth Fisheries Project to support potential fisheries interventions in the region by USAID and/or other donors to recovery and developmental programming in the future.

FISHERIES ECOLOGIST CONSULTANCY: SCOPE OF WORK, ACCESS AND METHODOLOGY

In support of USAID/South Sudan's Office of Transition and Conflict Mitigation (OTCM) programmatic objectives, a fisheries ecologist was engaged to conduct a broad-spectrum investigation of the ecology and environmental issues pertaining to past and potential future fisheries-related programming in the Sobat River Corridor. Additionally, the ecologist conducted an investigation of fisheries-linked household economic and livelihood security in rural communities along the Sobat Corridor. The original SOW is included as Appendix 1.

This report is concerned with the bodies of water of the Sobat River Corridor, namely the Sobat, Baro, Gilo and Pibor rivers, and associated seasonal wetlands between Nasir of Upper Nile State and just south of Akobo in Jonglei State (see map of survey area – Appendix 2). Communities that neighbor and depend upon these aforementioned bodies of water, predominately on the South Sudan side of the border with Ethiopia, were investigated. More specifically, this report focuses on two communities divided by ethnicity that are home to the Lou Nuer and the Eastern Jikany Nuer.

The survey area appears to be in a state of political flux. As a result, it is difficult to get definitive details regarding administrative boundaries. Nevertheless, seven areas (payams that benefitted directly from SSTCM's Youth Fisheries Project in 2012) adjoining the rivers are included in the survey – five in Upper Nile State, including four in Luakpiny/Nasir County (Nasir, Jikmir, Maker, and Wanding) and one in Ulang County (Makak); and two are in Akobo County of Jonglei State (Dengjok and Nyandit). Additionally, the Anyuak community of Old Akobo in Alali Payam, as well as Akobo and Nasir towns, were also investigated as part of the assessment.

Two visits were made to the area, one during the late dry season in March-April 2013 and the second at the start of the rains in June 2013. This temporal spacing of visits enabled a better picture to be established of the overall situation. Travel between payams and villages was provided by SSTCM speedboat, and by foot when visiting locations further from the river.

Information was collected through formal meetings with fishermen, traders, community leaders, villagers, elders, women and youths. A questionnaire was used to allow for some comparative analysis of findings. Twenty-seven questionnaires were completed in 18 locations. In addition to these meetings, informal visits to fishing camps, cattle camps, markets, homes and *luaks* (structures to shelter and keep livestock)

provided supplementary information. An interpreter was employed throughout the effort. Additional anecdotal information was collected through first-hand observation of fishing and farming methods.

To minimize errors during interviews and/or due to limited capacity of the translators, local names were used for seasons, months of the year, locations, species, etc., which were later professionally translated. The excellent drawings from Boulenger 1907 (Appendix 3) were also used to aid fish identification and recall.

A roving creel survey was undertaken to determine fishermen's daily catches (to species level) in representative landing sites and markets. Fish catches were weighed; fish lengths were measured for length-frequency analysis; and fishing gear in use was examined where possible. An attempt was made to determine fishing effort, during both visits, by river transect counts of canoes and fishing gear (gill-nets and hook-lines). In addition, an attempt was made to determine approximate number of households in proximity to the rivers in the survey area, however, this proved impossible within the available timeframe.

A transect survey of the number of representative species of wild mammals, birds, reptiles and habitats was also made. GPS, Google Earth Pro and GIS software were employed to map the rivers, centers of habitation and areas of fishery or other interest.

In 1996-1998, the ecologist was engaged as the ECHO/UNICEF Operation Lifeline Sudan (OLS) Fisheries Consultant. In such capacity, he had carried out a fisheries assessment in Akobo and Wanding, and wider-ranging baseline assessments of Anyuak and Lou Nuer fisheries-related activities. He also assessed the household economy in Pochalla and what was then known as Bieh State (present north-eastern Jonglei and southern Upper Nile States). The knowledge acquired during these previous assessments enabled valuable comparisons to be made with the current situation.

OVERVIEW OF THE SOBAT RIVER BASIN: NOMENCLATURE, PHYSICAL CHARACTERISTICS AND HYDROLOGY

The Sobat River's watershed covers an area of 224,000 km^2. Average rainfall is 1,090 mm, normally falling from April to September. It encompasses the extensive Pibor Plain in the west and the highlands of Ethiopia's Gambela Region in the east. Long but relatively minor streams, such as the Kengen, Lottilla, Geni, Agwei and Akobo, drain the Pibor Plains and collectively form the Pibor River and contribute significantly in times of high rainfall to the Sobat River watershed. The Pibor is joined by the larger Gilo River, draining the western foothills of Gambella. The Sobat River begins where the Pibor River flows into the Baro River. Of the two rivers, the Baro provides a much larger proportion of flow. West of Nasir, Fullus and Nyanding are seasonal KHORS, which add minor amounts to the Sobat River during the rains. The Sobat River finally joins the White Nile near Malakal, the capital of Upper Nile State, contributing 50% of the White Nile's flow in Malakal and 14.5% of the total flow in Khartoum. For the purposes of this report, the above rivers are all part of the Sobat system, corridor or basin.

The Sobat system shows extreme seasonal variation in flow regime. During the rains, the rivers flood and inundate large parts of the surrounding grassy plains, known as TOIC (pronounced toich – in spoken Nuer "ch" is written "c"). Between Wanding and the confluence of the Baro River and the Pibor River lie large TOIC areas. Besides the main river channels, there are numerous minor KHORS that feed seasonal and permanent pools, some of which are quite extensive and do not dry up in a normal dry season. The KHORS themselves generally dry up.

Due to the extreme flatness of the terrain and the seasonally-variable levels and volumes of water in the main river channels and surrounding KHORS, streams and pools, it is an unusual phenomenon that these smaller channels may flow in different directions at different times of year.

The following table gives some river distances measured by GPS during the survey:

River stretch	**Distance measured by GPS (km):**
Nyandit – Akobo	15.0 (estimate – not travelled)
Akobo – Dengjok	19.8
Dengjok – Wanding	30.0
Wanding – Gilo/Pibor conjunction	18.9
Gilo/Pibor conjunction– Makak	48.0
Makak – Baro/Gilo conjunction	6.7
Baro/Gilo conjunction – Maker	20.0 (estimate – measured from map)
Baro/Gilo conjunction – Jikmir	5.0
Jikmir – Nasir (Khor Wakou entrance)	36.5
Khor Wakou length	6.0 (estimate – fully length not travelled)

DEMOGRAPHICS OF THE SURVEY AREA

The survey area lies on the border between South Sudan and Ethiopia. Broadly speaking, four distinct ethnic groups live in or seasonally use the survey area: Lou Nuer, Eastern Jikany Nuer, Anyuak (Anywaa) and Lotillanya Murle. These are divided into sub-tribes and clans, each generally occupying their own area. It is important to recognise that these boundaries are not static in the context of historical and continuing ethnic and resource based animosities.

The communities in the South Sudanese territory north of Akobo Town on the west side of the Pibor River, and beyond Old Akobo on both sides of the river including in what is known as the Baro Salient, up to Wanding, are predominantly Lou. Historically, this was all part of the Anyuak Kingdom. A small number of Anyuak live in Alali Payam with its administrative center at Old Akobo on the confluence of the Akobo and Pibor rivers. The population in the area is increasing with the arrival of returnees. Southeast of Alali Payam live the bulk of the Anyuak community, now living a predominantly sedentary life mostly in Ethiopia, having moved eastwards and given up dependency on cattle over recent decades in the face of pressure from cattle raiding by their Lou and Murle neighbours.

The Wanding Conference in 2010 confirmed an earlier high level political decision that Wanding is part of Nasir County; however, most of its current residents are Lou Nuer and it is closer in proximity to Akobo Town than to Nasir Town.

North of Wanding, the Lou venture as far as the Gilo – Pibor confluence (sometimes known as Kier), and Lou fishermen use the Gilo River, but apparently they do not venture north beyond the confluence. At this point, Jikany territory starts and extends northwards to Nasir, Maker and beyond.

Despite the Pibor River north of Old Akobo being the border between South Sudan and Ethiopia, little notice is taken of the border and movement across it in either direction appears to be free flowing with some people registered as nationals of both countries. For dry-season grazing of cattle, each community treats portions of each country as accessible to them. The Murle, while not living in the survey area as they primarily live in Pibor County, historically extend their dry-season grazing as far north as the Gilo TOIC, mainly in Ethiopian territory.

While it is difficult to get definitive details regarding administrative boundaries and nomenclature, the following were found to be the areas currently recognised on the ground:

- Akobo County has been divided into two sub-counties, West Akobo and East Akobo. West Akobo, centred around Walgak, comprises Diror, Walgak and Buong payams. Due to their inland locations away from the river, these are not discussed further in this report. East Akobo is made up of Bilkei (containing Akobo Town), Nyandit, Dengjok and Alali payams. With the exception of Alali Payam, which belongs to the Anyuak, the rest of Akobo County is occupied by the Lou Nuer.

- Ulang County extends to the Pibor River.

- Luakpiny / Nasir County is shared by three Nuer groups: Eastern Jikany, Gaajok and Gagwang. In total there are 14 payams, including: Jikmir, Kuerenga, Kierwan, Dhuarading, Dinkar, Roam, Gaireng, Keih, Koat, Maker, Mading, Gurnyang, Wanding and Weinyot.

While their importance in analyzing past and determining future interventions is paramount, current population estimates for the survey area appear not to exist. The last national census was carried out in 2008 and the results of that are undoubtedly incorrect both in respect to administrative boundary delineation and names, and actual population estimates. Some areas continue to have a large influx of returnees. That said, the census nevertheless provides some indicative figures, as follows:

Statistics from the Statistical Yearbook for Southern Sudan 2010 (2008 census)

State	County	Payam	Total Pop	Households
Jonglei	Akobo	Alali	4,156	608
		Bilkey	35,797	5,169
		Dengjok	17,163	2,449
		Nyandit	25,499	3,926
Upper Nile	Ulang	Kurmuot	28,539	3,776

	Luakpiny/ Nasir	Jikmir	28,614	4,103
		Maker	11,183	1,602
		Nasir	43,733	5,532

Number of persons per household (counties):

- Luakpiny / Nasir: 7.2
- Ulang: 7.4
- Akobo: 7.7

LIVELIHOOD SECURITY AND FOOD ECONOMY; RECENT CHANGES THEREOF

Traditionally, both Lou Nuer and Jikany Nuer made use of a mixed economy incorporating cattle, crops and fishing as the major components. The Nuer year historically rotated around the location of their large cattle herds. Few people did not have any cattle, but a man might lose some or all of his herd on account of three factors. Firstly, if he married or re-married (Nuer will take an indefinite number of wives); secondly, due to a livestock epidemic; and thirdly, due to raiding. Only very rarely will the cattle be slaughtered, and milk is the main product derived from them. Milk production starts a few weeks into the rains once green grass has become available.

The ongoing insecurity has recently caused significant changes to take place in the Lou economy. Cattle numbers for many Lou Nuer were severely depleted when five cattle camps in the Rumyieri TOIC in Ethiopian territory, north of Wanding, were raided by Murle on March 9, 2012 of up to 25,000 cattle. (While reports of half a million cattle stolen that day are surely a gross exaggeration, the exact figure is unknown and the above is derived from the knowledge that 5,000 head constitutes a very large cattle camp). Fearing further Murle raids, the Lou then moved the bulk of their remaining cattle further north within Jikany territory and deep in Ethiopia (Mataar Gaguang). However, it has been impossible to get a figure for the number of remaining cattle, or indeed a accurate idea of the proportion of the whole that they represent.

With respect to the Eastern Jikany Nuer, the overall pattern of livestock ownership has also undergone some changes in the past few decades. Sections of the community, especially some people now permanently living along the main Sobat River, seem to a greater or lesser extent to have abandoned cattle. Insecurity during and since the civil war played a large part in the change, as did relief and development agencies, such as through the opportunities presented by fishing material interventions. While Jikany have only been at peace again with Lou since 2010, the relative stability has enabled trade to flourish, especially between Nasir and Gambela, and this has brought further changes in many peoples' lives.

During the assessment, the Consultant observed that the majority of Jikany still have large cattle herds and fewer but still significant numbers of goats and sheep; however, a significant portion of cattle was lost in inter-ethnic raids by and between the Murle and the Lou Nuer in prior years. Occasionally, livestock is sold in Nasir.

Dry season cattle camps are as much chosen for their opportunities for fishing as for the water and pasturage they provide. At the onset of the dry season, small camps can be found almost anywhere, for at this time surface water and fish are still widely available. Larger camps, which are formed later in the season, tend to be situated near permanent bodies of water, and in the survey area, are traditionally found on the TOICS near the Pibor River and, especially, the Gilo River, as well as further north between Jikmir and Nasir on both banks of the Sobat River. No cattle was visible in several of the places visited by the ecologist, such as Makak, as the cattle had been taken elsewhere for fear of raiding by the Murle.

In the past, when Nuer led a more nomadic life than they now do, DURA (sorghum) was grown inland during the wet season, during which the Nuer spent in extended villages. However, sorghum was almost entirely abandoned in the 1990s in deference to MANTAP (maize), which prior to this time had only been grown in negligible quantities in the survey area. Now maize is exclusively grown – no sorghum was found. Although maize has lower nutritional value, it has the benefits over sorghum of a quicker harvest and less susceptibility to the ravages of birds, particularly Quelea (MOR), which before the proliferation of maize were a widely-quoted problem in Nuerland. Maize does, however, need to be grown near the rivers

and this brings a different set of problems – that of high floods affecting the crop, and of riverbank erosion. Nevertheless, crop losses to flooding are now usually counter-balanced by a larger harvest of fish resulting from the same high floods.

Hunting of wild mammals was traditionally a dry-season activity of little importance to the Nuer, relative to other Nilotic ethnic groups, such as the Anyuak. That appears to have altered significantly. Hunting is carried out using dogs, and traditional spears have been replaced by firearms – the latter having allowed this resource to be utilised as never before, mainly for trade although some is eaten fresh. Near Akobo and Nasir, the meat is mostly sold fresh; while further out of town, it is generally sun-dried in thick strips for trade or future consumption. In addition to hunting, the shooting of wild mammals also occurs as opportunities present themselves. As the firearm of choice is the inaccurate AK47, presumably many are injured to die later to no-one's benefit.

Some claim that Nuer only consume cloven-hooved animals and, therefore, they do not target wild birds despite the large number of birds in the region. However, terrapins, both the smaller pond-frequenting species (KWEET) and the rare but larger riverine Nile Soft-shelled Terrapin (MIER) are speared or netted, respectively, and eaten. Nile Crocodiles (NYANG) are also shot or netted, and the meat is consumed, while the skin is marketed.

Historically within the Nuer economy, fishing was a recourse activity – to help quickly rebuild resources after the loss of cattle due to marriage, epidemic, or raiding. People resorting to fishing are referred to as BAR. BAR are generally in transition between a state of having no cattle and once again having cattle. A person within BAR, having lost his cattle, would undertake certain activities in order to recoup his wealth. One option was to go fishing in order to "make a fast buck". Being a profitable activity, a good fisherman could start restocking within a few months. It would then take about two years to recover enough cattle (about 10) to leave "recovery mode" and return to the more favoured cattle-dominated lifestyle.

In recent decades, the role of fish in people's livelihoods has undergone very significant changes due to a progressive and almost total adoption of modern fishing gear. During the civil war, this was mostly due to material inputs on a large scale from external aid agencies. More recently, since the Comprehensive Peace Agreement (CPA) in 2005, markets have become more accessible, bringing fishing gear in and allowing fresh and preserved fish to be exported through trade. The result is that there is now a section of the community who are wholly dedicated to fishing for a living. Some of the SSTCM-sponsored men are undoubtedly now in this group. Anybody who specialises in fishing, whether on a temporary or permanent basis, is known as BALANG REI (expert in fishing).

Another change associated with increased use of modern gear – nets and hooks – is evident in gender. Previously, men and women both fished using a variety of traditional means. Men exclusively have now adopted the modern methods. Fishing by women remains restricted to the use of traditional traps, gaffs and fishing spears, methods only viable during the later dry season. As a result of these changes men now bring in a much greater proportion of the total catch, and greater quantities, than they used to. However, women play a role in transporting the fish to market.

Trade of preserved (almost exclusively sun-dried) fish has traditionally been in Akobo and Nasir towns for transport into Ethiopia and to inland areas of the Lou and Jikany. These routes are functioning and trade appears to be increasing. One notable change in the trade is from a bartering mechanism of exchanging fish for grain, tobacco, livestock, clothes or other consumer goods) to a buoyant cash market mechanism in which those same items are bought using money earned from the sale of fish.

Trade with Gambella in Ethiopia, which is the main source of exports from the Sobat region, depends largely on the seasonal river levels. In March the Baro River was too low to be passable by the traders' ubiquitous 10 meter long sheet-metal transport boats. However, by June this situation had changed – the river was at high water levels and many boats arrived daily to Nasir and perhaps 4-5 per week to Akobo (smaller centers seem to get bypassed). The main commodity imported was sorghum in 100 kg sacks and to a lesser extent, maize, followed by crates of Ethiopian beer. Despite almost all commodities being significantly more expensive than the cost of comparable goods in Ethiopia or Juba, cash seems to be universally available, but it is suspected that in Akobo this might be from a reserve left over from when cattle were more plentiful.

Green vegetables barely feature in the Lou, Jikany and Anyuak diet. Whether the significant role of wild foods has changed much in the recent past is unknown, but that is unlikely. As elsewhere throughout the Sahelian Region, LALOP (aka *Balanites aegyptica*, desert date, and THOU) is the most important wild food. Other wild foods identified to be used during the assessment were WOR (*Portulaca quadrifida*), *thait*, *nyang kajang* (*Corchorus tridens*), and interestingly, baobab (*Adansonia digitata*), two specimens of which were presumably planted in Akobo during the British colonial era.

At the time of the Consultant's second visit (at the start of the rainy season), communities in this region would historically be entering their "hunger gap", when the previous year's grain stocks have run out and the current crop has just been planted. However, in comparison to the OLS period (1990s), there was little evidence of hunger or malnutrition in any of the locations visited. Children were extremely active, raucously playing late into the night. Presumably the traded sorghum, coupled with plentiful wild meat and fish, and in Jikany areas milk starting to be produced, are serving to lessen or perhaps even eliminate the hunger gap.

In terms of food security, the region is certainly self-sufficient in fish, considering the amounts of dried fish that are taken to market. It is improbable that the present high proportion of fish in people's diets is set to expand a great deal in any circumstances, especially in Lou areas where cattle have been lost.

FISHING MATERIALS AND METHODS

Before the creation of South Sudan as an independent state, the Sobat River was a direct trade link between the greater Upper Nile region and northern Sudan. Until recently, Malakal was the central market for the entire southern Sudanese fishery. It is anticipated that the significance of this centre for fish trade may now decline over time, in deference to Juba and Gambella.

As a direct result of this link and access to the northern Sudanese markets, non-traditional fishing methods have for several decades been known and used by the Lou and Eastern Jikany fishermen in the Sobat Corridor. As a result, a wide variety of traditional fishing methods have with time largely given way to nets (ABWOI) and hooks (RAMAI), a process that is now almost complete. Nevertheless, the traditional methods are described below, as they probably will still be found in some places.

Culturally, amongst the Nuer, anybody can fish with the exceptions of very young girls and very old men and women. A change in the respective roles of women and men with regard to fishing has already been mentioned.

With regards to fishing methods, women employ spears, GOR (gaffs), KOR (harpoons), THOI (basket traps), and drag hook-lines. Men will also use spears, GOR, hook-lines, set gill-nets, cast-nets and drag-nets. An impressive long curved harpoon called ROI, used by men for fishing in deeper waters, not seen at all by

the Consultant on the lower Sobat Corridor investigated in the 1990s, is surprisingly still in use in Jikmir and one other location on the Baro. It features on the cover of Evans-Pritchard's seminal work *The Nuer – A Description of the Modes of Livelihood and Political Institutions of a Nilotic People.* The examples seen in 2013, and their mode of use, seem unchanged in the 70 years since that photograph was taken.

All traditional methods in use in greater Upper Nile can be classified as active implements for fishing. In contrast, modern gear, such as stationary gillnets and un-baited longlines, is primarily passive, and therefore, intrinsically more efficient. Another important difference is that nets can work at all but the lowest water levels, where hook-lines take over; whereas, the traditional methods are most effective when water levels are low, restricting their use primarily to the latter half of the dry season.

The making and mending of nets and hook-lines is solely a male occupation. Only men and grown-up boys are involved, plus younger boys who are learning. Nets are constructed manually. Mesh size often varies considerably along the net. Rarely is twine saved for repairs.

Nets for use in the rivers are generally wider and have larger meshes than those for use in seasonal pools. For river use, it might take a man about one week to make a gill-net of 20 m by 2 m, using four spools of 21-ply twine. If a single individual does not have access to sufficient twine, then several people might combine their resources into one net and share the resulting catches. In most locations visited, mesh sizes of 100-160 mm stretched mesh (s.m.) were seen to be used. This range is best suited to river fishing for large fish. Neither floats nor weights are added, although head- and foot-ropes on which the net is suspended usually consist of 3-4 strands of the same twine braided together for thickness. The net is staked vertically in the water using a pole at either end. Plastic soda bottles are used as floating markers.

Nets made for use in pools and inland need not be and never are larger than that which is made with one or two 500 g spools. A standard net, made from a single 500 g spool of 21-ply twine and intended for use in a seasonal pool will be 10 m x 1 m, with an average 70-80 mm s.m. When only a single spool is obtained, the whole spool is used at once, maximising net size for a short-term increased catch.

A second kind of net is PATHOOT, which is used exclusively for large Nile perch (the literal translation of PATHOOT is "we shall pull each other" in reference to the size of fish caught for a Nile perch can attain 200 kg). This kind of net was originally introduced around the 1970s by West-African (*Fellata*) or Arab commercial fishermen running co-operatives, and is made of very thick twine (72-120-ply). Ideally, 50 spools or more are needed to construct a PATHOOT net.

For the methods described below, individual nets are often joined to make a longer one. When used in this way the nets are weighted with lead or locally-smithed iron sinkers if these are available, alternatively shaped rocks or bones if not; and effectively floated using 500 ml plastic soda bottles, which have replaced the gourds (*keer*) used before. In the past strong rope made from plant fibres (*thep*) was employed as effective head- and foot-ropes, however these too are now hardly in evidence as modern twine is used, if necessary several strands twisted together.

Firstly, drift netting is carried out in the main river channels during the dry season. Two canoes, with a net stretched between them, are allowed to be drifted downstream. Fish that find themselves in the path of the net, particularly those swimming upstream, are caught by the gills in the meshes of the net. Secondly, drag netting is employed when the water level drops to its lowest, and involves the same kind of net being dragged by two or more people walking or wading along opposite banks of the river. Using this method, large numbers of fish can be caught. The longest such net seen was 125 m long and had used 20 x 500 g

spools of 21-ply twine in its construction. A third method – seining – known in the lower Sobat Corridor but not encountered during the current assessment, probably takes place in some areas at times of low water. Seine nets are long nets which are spread, using boats or canoes, in a circle in open water or in a semicircle near the shore, and then progressively pulled onto shore or onto the canoes by means of long ropes tied to each end. The fish are initially enclosed and finally end up in the last piece of net to be hauled up, if not gilled before. Seining and drift- and drag netting are active fishing methods, as opposed to the placing and leaving of a stationary hook-line or set gill-net, which are passive methods.

Throwing- or cast-nets (*kieth*) have Arabic origins and have long been used along the Nile from Egypt southwards. A few cast-nets are made locally from multifilament twine and thrown from the bank or from a canoe. These have meshes of 40-50 mm s.m. and operate on a gilling principle, targeting mainly *Tilapia*.

Nets and hook-lines can be expected to last on average two years. Variables which will extend or reduce longevity around this figure are many and include the following: quality and ply-rating of twine, quality of hooks, regularity of usage, the species targeted, the physical characteristics of the body of water, availability of repair material and so on. Nets used in seasonal pools have a much longer lifespan than those used all year round in flowing waters.

The minimum legal[1] mesh size during the period of peace between the two civil wars in Sudan (approx. 1972 - 1983) was 3 inches (76 mm) bar length (equivalent to 152 mm s.m.) (Nyang & Gumaa 1981). It appears that no guidance is currently being given to fishermen and certainly no enforcement is undertaken. Only limited research has been carried out on the efficiency of gillnets in South Sudanese waters. Bailey (1989) states that nets with 39-48 mm s.m. sizes set in open water could yield good crops of little-exploited species such as *Alestes* sp. and *Eutropius* sp. without adversely affecting juvenile stocks of larger species. This, however, is only applicable in lakes in the Sudd, and not in the Sobat Corridor. In the absence of on-going full-time fisheries assessment and monitoring, such small mesh sizes would not be advocated by this Consultant at present.

The Nasir market and, to a lesser extent, the Akobo market have factory-ready nylon mesh nets for sale, known as Silka or Silkan. These vary between 40-55 mm s.m. Each costs in the range of SSP 130-150. For river use, several of the Silka nets are generally joined together, for an accumulated cost of SSP 800-1,000. They need to hang from head- and foot-lines, which doubles the initial cost. Their lifespan is short – as little as two months in some cases. However, they are highly efficient and the expense can be recouped in as few as four days. Usage of the Silka nets range from only a minor proportion of all nets used in Akobo County to the majority of the nets being used near Nasir Town.

Also seen in Nasir was a factory-built net with very small mesh – 70 mm s.m. This net was sourced in Renk and was planned to be used to catch mormyrid fish in the main river at night.

The hook-lines used are almost always un-baited longlines (*yieth*), with usually 100 hooks on 20 cm droppers suspended 10 cm apart along a 10 m length of 3-4 strand braided twine. The droppers themselves are usually 2 strands braided together. The line is then staked, by means of two poles, such that the main strand is parallel to the substrate and the hooks hang just above the bottom. The principle is then one of foul-hooking: any fish that happens to pass through the barrier of hooks might get snagged.

[1] Sudan Fisheries Dept. Nyang, B.B. & S.A. Gumaa (1981).
Development of the fisheries of the White Nile. CIFA Technical Paper 8: 96-104.

As such the method is dependent on factors such as sharpness of the point and the hooks' distance apart. Hook-lines are used in the river at times of low water and otherwise in pools and on the drying TOIC. Hook-lines, too, are sometimes lengthened by putting several together, for the purpose of dragging through the water.

Very occasionally hooks are baited. Young boys will occasionally fish for tiny *Tilapia* from the riverbank, using a short stick for a rod, tied with a fixed line and small baited hook. However, the method previously used in the lower Sobat region to target large catfish, whereby a large baited hook on a strong line is staked into the riverbank, left overnight and checked on in the morning, does not seem to be known here. Likewise, the method of baiting a very big hook with a small live fish to catch large Nile perch does not seem to be practiced here.

The problems fishermen encounter with their fishing gear are numerous and varied. The main enemies, real and perceived, are floating islands of vegetation, and crocodiles and hippos (both of which through indiscriminate hunting have become scarce in the area), which can cause the loss of set gillnets and might imperil fishermen. Various species of fish are said to cause damage to the twine while such fish try to feed on fish caught in the nets. Additionally, small spiny synodontid catfish reduce the efficiency of cast-nets when they continuously get tangled up in them. Lastly, poor quality is the leading complaint of hooks (mainly attributed to those from Sudanese traders), resulting in rusting, breaking or bending (opening).

Fish Preservation

Sun drying of fish without salt is carried on primarily during the dry season, and in some form during the rainy season. This is the most common method of fish preservation in the survey area and in most of the wetlands of South Sudan. The main species which are sun-dried are as follows: *Clarias, Tilapia*, *Lates*, *Distichodus*, *Citharinus*, *Heterotis* and *Gymnarchus*.

The fish is initially scaled, gutted and beheaded, then either cut into longitudinal strips which are still joined at the tail, or split dorso-ventrally and opened out into a 'sheet'. In either case the fish is then draped over horizontal poles in the sun, to dry for a period of about 3-5 days in the dry season and up to 2 weeks in the rainy season.

Sun-dried fish (SDF) is prone to infestation by flies, beetles and other insects. Spoilage in this way, though hard to quantify, is especially bad in the wet season and where fish is stored for long periods. The incidence of flies is directly related to the dampness of the fish, and this is a point that is generally recognised by fishermen. Fish that can dry quickly is therefore less prone to infestation.

TEMPORAL AND SPATIAL CHARACTERISTICS OF THE FISHERY

The location where fishing occurs at any given time depends on a number of factors, most importantly, the season, and related to this, the level of the water and the general whereabouts of the fish in the system.

The fishing year in Lou and Eastern Jikany areas can be divided up into spatial as well as seasonal elements, each directly related to the other. The fisheries in most parts of South Sudan show extreme seasonal variation, so it is incumbent to understand the characteristics of the year itself and the state of the bodies of water in each season in order to analyse the fisheries. The fishery seasonal calendar in Appendix 4 (still with the consultant, so missing from this report) illustrates the variation throughout the year in the survey area.

Annual variations in the fishery are proportional to the height of the rivers – years that start with a high flood are good fishing years, not only on the main rivers but especially in seasonal pools in which large fish get trapped when the waters recede again.

The dry season (normally starting in mid-September/October through mid-March/April) is when the bulk of fishing activities traditionally takes place in the survey area. Fishing takes place either inland or along the permanent stretches of water. The Pibor – Sobat system exhibits huge seasonal variation, with a difference between low-water and flood flow of up to 5 meters. In severe drought years, the Pibor and Baro rivers may actually stop flowing, though this is rare. Even in these cases, enough water remains for fishing to continue. As a consequence of this fairly continuous, though seasonally highly variable flow regime, the fisheries along the Sobat Corridor has a permanent element, though it is subject to wide seasonal fluctuations in numbers of fisher-people and fish catches.

In the dry season, throughout the survey area, the bulk of fishing takes place on the main river channels. In addition, from Wanding northwards (i.e., the far northern Lou part and all of the Jikany areas), fishing takes place all year round in the perennial pools in the TOIC away from the main river channel (such as Dong Dol and Koat pools near Jikmir), with increasing effort and harvest as the pools evaporate towards the end of the dry season. Unlike in the permanent rivers where small fish are normally never targeted, in the seasonal pools, everything that is caught is consumed. However, since many of these pools dry up completely anyway, this is of little consequence to sustainability.

The start of the wet season has a lull, though by no means a cessation, in fishing effort, as people concentrate their time on preparing, planting and weeding their farms. Limited wet season fishing continues inland when the KHORS and their associated tributaries flow during the latter half of the rains, and the TOICS become flooded and the pools fill up.

In the past, there used to be (and is likely to still occur though unconfirmed during this assessment) a short peak in fishing that would occur at the onset of the rains usually around May, when any fish remaining in pools would try to move out into the inflowing water. Dams and weirs were built at this time, which allowed the fish, when they encountered the barriers, to be speared. This time is known as BAK.

Another peak in fishing (NYOC) would follow in August/September, characterized by a spawning migration of numerous *Clarias* catfish, which could then be caught in large numbers, out of the flooding main river channels and into inflowing rainwater streams. The fish would then be easily speared at night by the light of burning grass torches and fires, as they approached and tried to pass the obstacles. Flood years were synonymous with a good NYOC, when daily catches of 10-20 large *Clarias* catfish at ca. 4 kg in one night were possible. Dry years usually had a smaller NYOC*,* with catches down to only 3-4 fish per day. In the past, as now, NYOC was an extremely important phenomenon, especially in anticipation of a low harvest, because it can considerably help reduce the 'hunger gap' between the depletion of grain stocks and the next harvest.

Fishing is predominantly an adult male occupation within the household. Children and, in rare circumstances, women check nets and lines near to their homes. Men and grown-up boys go out to fish in canoes, occasionally staying out for a number of nights on the bank or on islands of vegetation in so-called "fishing camps". From these semi-permanent camps, some fishermen carry out full-time commercial fishing whereby the catch is dried and moved to nearby towns to be exchanged or sold.

Fishing camps are widely distributed throughout the survey area, particularly along the banks of the main river and on the edge of pools. These cattle-less camps (KAL) are usually no more than small areas of

flattened vegetation on the riverbank, with mosquito nets and mats for sleeping. Only men occupy these camps and the sole purpose is to fish, and if the opportunity arises, to shoot wild animals. Simple horizontal poles are erected as fish and meat drying racks. Except for a little grain or LALOP and the occasional wild animal they killed, people live on fish alone for several days or weeks.

In more permanent camps, such as Koat near Jikmir, rough bamboo platforms are added, on which the dried fish are piled for storage. Here huts are built and whole families stay, including old people and children. Nets and'/or hooklines (depending on the water level) are left permanently in the river or pool. They are checked twice a day, morning and afternoon/evening. In deep parts of the rivers, a canoe is usually needed, but in more shallow parts of the river and in the pools, the fisherman will wade out to check the catch.

Using fishing equipment received from USAID's SSTCM Youth Fisheries program in 2012, people in these intensive fishing camps were catching very large quantities of fish. For example, in Koat fishing camp near Jikmir but on the Baro river, 30 people were fishing in March-April, catching approximately 8,000 *Clarias* in 1-2 weeks (equivalent to 20 fish or 40-80 kg per person per day). While this seems high, it is not improbable if all the gear given to them was in use at the time; however, it was found that in general, a good day would usually yield 30-40 fish (or 60-160 kg) per team of five fishers. One man stated he had caught 1,500 fish since October 2012 (equivalent to 10 fish or 20-40 kg per day). One team of five men stated they had taken 6,000 dried fish to Nasir for sale in the month of March. At SSP 5-10 per fish, the value of this quantity is SSP 30,000 - 60,000.

Similarly, in Makak, the SSTCM-sponsored fishermen were found in June to have stored 3,000 dried fish since January (wrapped in tarpaulins, exposed to the sun and rain). They were waiting for a boat to take the fish to Malakal, where each fish would fetch SSP 10. The total value was SSP 30,000, but they would incur taxes (SSP 2,400) and transport costs (SSP 2,400) on the way.

Three Lou fishermen fishing at the Gilo-Pibor confluence said that they could only transport dried fish harvested from up to five days' worth of fishing in their two canoes.

BIOLOGY OF THE FISHERY

When asked to comment on the variety of fish in the Nile, one of the fishermen gave a humorous explanation, in simple English: "there are those fish that are big, bigger and biggest, and those that are small, smaller and smallest!"

In fact, 127 fish species (in 27 families) can be found in the Nile system (compared to 787 and 2,000-3,000 species in the Zaïre and Amazon rivers, respectively). Of these, only around 20 species within about 10 families are of economic or nutritional significance to the Pibor - Sobat fishery. (See Appendix 3 for an identification guide and illustrations.) Nuer and Anyuak vernacular names of these important groups are listed in the table below:

Scientific name (Genus species)	**Common name**	**Lou / Jikany name**	**Anyuak name (Alali)**	**Length at first maturity (cm)**	**Common / (Maximum) length (cm)**	**Common / (Maximum) weight (kg)**
Clarias gariepinus	Catfish	PET, CIEK,	AGWILA	34	90 / (170)	5 / (60)

		REICAR				
Heterotis niloticus	Heterotis	LEK	OLWAK	?	? / (100)	? / (10)
Gymnarchus niloticus	Gymnarchus	RIAL	WITH	?	? / (167)	? / (18.5)
Lates niloticus	Nile Perch	CAL	GUR	74 (range 53 - 85)	? / (200)	? / (200)
Tilapia (*Oreochromis*) *niloticus*	Tilapia	RUETH	ORWËTHO	18 (range 6 - 28)	? / (60)	? / (4.3)
Polypterus bichir	Bichir	JUETH	ODWËLA	?	? / (72)	? / (2.7)
Distichodus niloticus	Distichodus	YAATH	APURO	?	? / (83)	? / (6.2)
Citharinus citharus	Citharinus / Moon Fish	PATPAT	OBÄL	?	? / (58)	? / (7.0)
Hydrocynus lineatus / brevis	Tiger Fish	JOKLEI	WEERI	40	? / (70 F / 105 M)	/ (28)
Synodontis schall plus other spp.	Squeaker	Yeow	Okok	21 (range 12-17)	/ (49)	/ (500g)
Heterobranchus longifilis / bidorsalis	Sampa catfish	Cuur	Ciou	?	? / (150)	5 / (55)
Mormyrids (about 4 spp.)	Elephant-snout fish & similar kin	Not, Kwoth	Dollo	?	?	?

Unfortunately the many **question-marks** in this table, most critically the data for the length at first maturity, are an indication of the paucity of knowledge about the biology of many species in this fishery. This deficiency will have direct implications on the designing of sound resource management planning.

The biology of the fish community in the Nile, as with that of other rivers with a marked seasonality, is largely geared to the flood regime. Patterns of breeding, growth and mortality are established on this seasonality. Simulations have shown that within African rivers having flood regimes, biomass (and numbers of individuals) increase rapidly to a maximum at bankfull on the falling flood. The degree to which the increase in biomass occurs may be linked to both the extent of flooding and the amount of water previously remaining in the system at low water. Thus, catches are generally better in years following good floods than in years following poor ones. Interviewees, without exception, stated that the best fishing follows a high flood, supporting that this theory applies in the present context.

Part of the questionnaire dealt with knowledge of fish biology. In Wanding, only one fisherman appeared to have any awareness about different species' reproductive habits. Apart from this interested individual, a high level of ignorance was observed beyond simple recognition of all but the less common species and knowledge of their local names. This may be an indication of the novelty of fishing to many people. In contrast, as might be expected, the Lou and Jikany display a high level of innate knowledge regarding cattle husbandry.

In the absence of year-round creel data, the questionnaire helped to elucidate some biological and economic aspects of the fishery. Fishermen were asked to rank, in order of importance, the five species that they consider the most significant. (So as not to introduce too many layers of complexity to the interview, it was not specifically asked why these are important, only in which season they are most common). The importance rankings appear in the table below.

Species	**Overall Ranking**	**Akobo to Wanding Ranking**	**Nasir/ Maker/ Makak Ranking**
Gymnarchus	**3**	5	**2**
Synodontis	11	8	No Score
Tilapia	5	**3**	8
Hydrocynus	6	9	5
Heterotis	**1**	**1**	**3**
Distichodus	13	10=	10=
Clarias	**2**	**2**	**1**
Citharinus	10	7	No Score
Lates	4	4	4
Polypterus	8	10=	6=
Bagrus / *Chrysitsthes*	9	No Score	6=
Mormyrids	12	No Score	9
Heterobranchus	7	6	10=

Each of 13 groups (species or related genera) received a score, which is a clear indication of the multi-species nature of this fishery. Overall, starting from the highest score, *Heterotis*, *Clarias*, *Gymnarchus*, *Lates* and *Oreochromis* (=*Tilapia*) were the top scoring groups. However, when the survey area is roughly divided into a southern and more northerly component, then some differences appear, which are worth examining. While *Heterotis* and *Clarias* in Akobo follow the overall ranking (no. 1 and 2 respectively), *Heterotis* falls to no. 3 in Nasir in deference to *Gymnarchus* at no. 2, while this species in turn only ranks 5 in Akobo. This may be a reflection on *Gymnarchus'* much higher market value compared to *Heterotis* in

Nasir, where the market is considerably more developed than around Akobo. *Gymnarchus* appears to be considered a tastier fish, consequently in Nasir, a large *Gynmnarchus* fetches SSP 50-60 while a similar weight *Heterotis* sells for SSP 15-20. In Akobo, prices are far lower and, surprisingly, a large *Heterotis* at SSP 6 is more expensive than a large *Gymnarchus* at SSP 5. These enormous differences are difficult to understand.

An analysis of the ranking of *Tilapia* and *Citharinus* together may lead to some indications of their levels of exploitation in Akobo and Nasir, respectively. *Citharinus* is the species most similar to *Tilapia* in morphology, a factor which may cause them both to be vulnerable to be caught by similar fishing practices. *Tilapia* in Akobo ranks no. 3, while in Nasir it ranks no. 8; *Citharinus* in Akobo ranks no. 7 while in Nasir it was unranked. This difference might be explained by a high level of exploitation of both these species in Nasir, which may have depleted both stocks to a degree at which they are no longer perceived as important.

Having derived such conclusions from this data, it should be stated that interviewees' answers did not necessarily match accurately with what was observed by the consultant team. For example in the Koat fishing camp, the following species were ranked by interviewees (with their months of prevalence), most important first: *Hydrocynus* (Nov - Jan), *Bagrus* (Jan – Mar), *Gymnarchus* (May – Jul), *Clarias* (May – Jul), *Polypterus* (Jun – Jul). During the Consultant's visit in March/April, the predominant species seen fresh and dried were *Clarias* and *Heterotis*, and *Clarias* again in June, but this time with the addition of *Polypterus,* while *Heterotis* was still prevalent. The reason for a discrepancy in what was reported and that actually seen is unclear, but probably relates to perceptions of certain species' value or importance with respect to their market value or edibility.

Based on all the available evidence, *Clarias* and *Heterotis* are the most commonly caught fish in the Sobat system throughout the year. *Clarias* is also the main component of the catch when seasonal pools are finally fished out. Other species have seasonal peaks such as *Lates* and *Polypterus*, which are mainly caught in the wet season, and *Hydrocynus*, which is predominantly caught in the main river channels during the early dry season. *Lates* and *Gymnarchus*, *Tilapia* and *Hydrocynus* are considered the best to eat, and when sold (at least at the fish market in Nasir), command the highest prices relative to similar-sized fish of other species. However, from a purely macro-economic point of view, the most important species are *Clarias* and *Heterotis*.

Biological synopses of families or species of importance to the fishery are presented in Appendix 5.

RESULTS AND DISCUSSION

Theory of Population Dynamics in Fisheries

A basic understanding of population dynamics is fundamental to responsible fisheries management. The following is an outline of such population dynamics, with references to the Sobat fishery, with particular focus on areas of SSTCM's Youth Fisheries Project. Any population of fish, or stock, can be regarded as a simple biological system. With any given species, the forces acting on the population and controlling its numbers are as follows: reproduction (of adult fish), recruitment (i.e., addition of young fish to the population), growth (of individual fish, resulting in an increase in overall biomass of the stock), natural mortality (usually due to predation) and, in exploited stocks, fishing mortality (i.e. fish caught by fishers).

In a species that is unexploited or fished at a low level, losses due to mortality are balanced, on average, by gains through recruitment, and stock abundance will fluctuate around a mean level. If, on the other hand, exploitation is high, the number of adult fish may be reduced to a level where reproduction is

unable to replace the numbers lost. Recruitment will be too small to maintain the stock size and the numbers of fish will decrease – at that point overfishing has begun. Once a species has been overfished, it might take many years of a cessation of fishing activities for the stock to fully recover. In severe cases of overfishing, a species may even become locally extinct.

To determine the status of any population it is necessary to estimate the following parameters: stock abundance, growth, recruitment and mortality. The system is dynamic, however, and values of these parameters may fluctuate widely, even in the absence of fishing. The population parameters of a fish stock may be estimated from different types of data, including the number of fish at different lengths (length-frequency data) and catch rates (catch per unit effort – CPUE). These data may be collected from fishers' landing sites, fish markets and processors (fishery-dependent data) and from the activities of fisheries researchers (fishery-independent data).

Length-frequency data is obtained by measuring the length of each fish in the sample using a graduated board with a block at one end against which the snout of the fish is placed. The number of fish in the sample is counted and the data can then be plotted on a length-frequency histogram. Length-frequency analysis is primarily useful in estimating age and growth rates, recruitment and mortality, the degree of exploitation, and an indication of how much more could be caught with a different fishing strategy. However, such analysis relies on the assumption that the size distribution of the population as a whole is previously known. This, in turn, can only be the result of many years of in-depth biological study of the stock. Sadly, in the case of the Sobat fishery, this is as yet lacking. Some representative length-frequency histograms are given in Appendix 6.

CPUE is used as an index of Relative Abundance (the number of individuals in one area in relation to the numbers present in another area, or in the same area at another time). It can be measured, and utilised, in different ways. For example, in the current context, it could be the number (or weight) of fish caught per day by a "standard" 21-ply gill net of 10 m x 1 m with 120 mm s.m. meshes. The basic principle of using CPUE data is that changes in CPUE accurately reflect changes in the abundance of fish in the stock. However, there are many problems in using CPUE data, most of which relate to the difference between the way effort is perceived and subsequently measured (apparent effort versus actual or effective effort – theory versus reality). CPUEs based on apparent effort can be poor indices of abundance.

Effort may be measured in units of increasing refinement. A gross measure of effort is the number of fishers using gill nets, in which case CPUE is recorded as kg per fisher (useful in food / economic analysis). If the number of days fished is also known, a more precise measure of CPUE would be kg per day (useful for seasonal comparison). Ideally, the length (and indeed condition) of the gill nets used would also be known, and CPUE could thus be recorded in units such as kg per 10 m x 1 m net (and thus by extension per 500 g spool of 21-ply twine) per day. Similarly, for hooks, it could be expressed as kg per hook-line of 100 hooks per day.

Knowledge of relative abundance, i.e. CPUE, can then be put to practical use as follows: if for example a fisher catches 10 fish per day in one area and 20 per day in another, the inference is that there are twice as many fish in the second area. However, assumptions abound, and how reasonable this inference is depends on the fisher using the same gear and same skills, and that the fish are randomly distributed, and equally susceptible to being caught in both areas, and that the stock is totally homogenous.

The above assumptions are numerous, especially when one is dealing with a spatially and temporally extremely variable system such as the Sobat. Further layers of complexity are added to the situation by virtue of the fact that we are dealing not only with a multi-gear fishery but a multi-species fishery too.

Thus, each species must be considered independently. In the case of the Sobat fishery, at least 20 species are regularly caught, of which about 10-12 form the bulk of the catch.

Maximum Sustainable Yield

The sustainable yield from a fish stock depends on complex interactions between many environmental and biological parameters, and any attempt at its estimation from just a few parameters, which may be variable in any case, is unreliable.

The above population parameters can be used to estimate the maximum weight of fish, or yield, which may be taken from a stock without adversely affecting future reproduction and recruitment. This quantity, termed the Maximum Sustainable Yield (MSY), and the level of fishing effort required to take it, forms the basis of all responsible fisheries management, with the ultimate twin aims of fully utilising the stock while ensuring it is not overexploited.

If the intensity of fishing effort on a species' stock is increased beyond a certain level, the biological system is thrown out of balance in two ways. Firstly, young recruits entering the fishery may be caught before they have reached breeding maturity (known as Growth Overfishing). Secondly, and more important, the adult stock may be reduced to the extent that insufficient offspring are produced to maintain the population (Recruitment Overfishing).

Unfortunately, despite much effort being expended worldwide in attempting to estimate the catch that can be taken without overexploitation, the only totally reliable way to know the sustainable catch level is by exceeding it. Symptoms to look out for include falling catch rates and unprofitability in economically-driven fisheries. Eighty percent of fisheries worldwide have reportedly been overfished. Once a fishery has reached that point, depending on how large it is to start off with, it can continue to be fished, even expanded, for a given period of time, after which it will rapidly crash. Some fisheries never recover after this point.

Yield Models Based on Basin Physical Characteristics

Several models have been promoted by FAO for estimating the sustainable yield of African rivers and floodplains, using catchment area, river length and floodplain area as variables (Crul 1992). The model using catchment area is as follows:

$$\text{Catch (t/y)} = 0.048 \text{ Catchment Area } 0.93$$

The model using river length (main channel length in km) is as follows:

$$\text{Catch (t/y)} = 0.01 \text{ Length}^{1.81}$$

Using the above formulas, however, produces two disparate results, thereby raising concerns that they may not be accurate. The results produced are presented below and because of the disparate results, these models will not further considered for purposes of this report.

Using the area of the entire Sobat catchment (224,000 km^2), the catch determined using the above formula is approximately 4,550 tonnes per year.

Using the river length model, the catch for the 354 km length of the Sobat's main channel to Malakal is calculated to be just 410 tonnes per year – the difference between the results derived from the two models are apart by a whole order of magnitude; therefore, not useable for this report.

A third model exists, based on floodplain area:

$$\text{Catch (t/y)} = 8.78 \text{ Floodplain Area}^{0.90}$$

Calculations based on this model cannot be determined, as it has not been possible to determine the exact area of the floodplain.

Estimating Yield in the Sobat System Based on Population Dynamics and Fishery Data – a Preliminary Creel Survey

As part of the current assessment, a creel survey was undertaken in Akobo, Wanding, Nasir and several intermediate sites over the course of four weeks. Landing sites and points of sale were surveyed, including the SSTCM-constructed fish market in Nasir. In total, 2,605 fish were measured for length and weight (occasionally averages had to be estimated where large numbers of similar-sized individuals of a species could not all be individually measured). Length-frequency raw data was shared with SSTCM and can be provided on request.

Where possible, fishermen were interviewed and the gear used to catch the measured fish was assessed for type, quantity, configuration, condition, positioning, period of time in use, etc. No standardised experimental fishing was undertaken due to a lack of resources and time in any one area. Nevertheless, a very rudimentary understanding of CPUE for hooks and gillnets as used on the Sobat Corridor, now exists. This can be approximated as:

- 100 No 7 hooks on a 10 meter un-baited hook-line, set in shallow pools and close to river-edges, generally in the dry season, catches 2-4 fish weighing in total 5-10 kg per day.

- 1 spool of 21-ply twine made into a net of 10 meter x 1 meter with 120 mm stretched mesh (s.m.), set within a river or deeper pool, likewise catches 2-4 fish weighing in total 5-10 kg per day.

Unfortunately, the basic biology of most species of Nile fishes is not well enough known at this time. Length-at-maturity data can be found for only five of the important species. The following table shows the under-size percentage for each important group. Of the five species for which length at maturity data exists, two – *Lates* (Nile Perch) and *Hydrocynus* (Tiger Fish) - show very high degrees of under-size catching during the creel survey – 85% and 65%, respectively. However, sample sizes in both cases are quite low, calling for a longer sampling period, as well as for more sampling during the different seasons.

JUNE 2013 CREEL SURVEY: % UNDER MIN. LENGTH, MIN. & AV. LENGTH, AV. WEIGHT & SAMPLE SIZE						
	Length at maturity (cm)	Minimum length measured (cm)	Average length measured (cm)	Percent at or under min length	Average weight (kg)	Sample size
Clarias	34	30	69	ca 1.0	4.18	792
Lates	74	31	44	85	n.a.	20
Oreochromis (Tilapia)	18	15	29	ca 5.0	ca 0.7	337
Hydrocynus	40	30	38	65	1.1	17
Synodontis	21	15	30.9	0.8	ca 0.5	365
Gymnarchus	Not known	43	81.9	?	2.4	78
Heterotis	Not known	25	56	?	ca 3.0	201
Polypterus	Not known	30	52	?	ca 1.3	1060

JUNE 2013 CREEL SURVEY: % UNDER MIN. LENGTH, MIN. & AV. LENGTH, AV. WEIGHT & SAMPLE SIZE						
Citharinus	Not known	16	26	?	0.5	98
Distichodus	Not known	16	38	?	1.2	68

A major constraint with the creel survey was that more advanced biological study, such as the sexing of fish and investigation of reproductive state, could not be carried out for cultural reasons. The Nuer see it as taboo to open up a fish, or indeed gut it, before sale. The explanation repeatedly given was that a potential consumer may suspect something is wrong with the fish if it has been tampered with. In any future assessments, scientifically-controlled experimental research fishing is advocated which would address this problem as well as allow more accurate CPUE data to be gained.

Basic Food Economy Analysis (FEA) techniques can provide one step towards determining the average quantity of fish caught by a household per day in each season, which in turn can give an indication of the nutritional benefits provided by fish. However, this kind of information has no bearing on the question of sustainability.

In conclusion, at the present time it is impossible to make any accurate assumptions of Maximum Sustainable Yield in the Sobat fishery based on our current knowledge. To determine this will require a long-term biological baseline study to be undertaken, during which creel data is collected in numerous locations over a period of time incorporating each season, and several representative sample sites are subjected to controlled and carefully monitored fishing effort, using representative quantities and types of fishing gear, throughout the fishing year. Length-frequency and CPUE data gathered in this way over a sufficiently long period of time is the only reliable way to determine Maximum Sustainable Yield in any fishery.

In addition, accurate demographic data will need to be collected to determine the number of fishers on a temporal and spatial basis.

The current creel survey and its related investigations should therefore be seen as the precursor of a much longer study. To have any true value, data will need to be collected for a period of at least five years.

The Effect of TOIC Fertilisation

Of great interest and direct relevance to this survey, are studies done in the Okavango Delta which compared the fish biomass found during the dry season in floodplain pools (comparable to those found in the Sobat TOICS) in un-enriched pools to be 100-200 kg / ha, whereas pools enriched by cattle dung around the edge of the swamp had the much higher biomass of 700 kg / ha, a difference of 3.5 – 7 times as much. The significance of such findings in the context of the Sobat system, where first the wild megafauna and now, in some locations cattle, have ceased to exist and fertilise the TOIC, is self-evident.

The Effect of the Nilotic Mind-set Regarding Natural Resources

There is an enormous, fundamental challenge to the future security of the fisheries and wildlife in South Sudan, and it is one of psychology. There seems to be a perception or firm conviction – amongst the Nilotics in general, including the Nuer – that the wild animals and fish that they have lived with for several centuries “can never be finished”. If a population appears to be reduced in number, whether it is fish or wildlife that has already been exterminated from many parts, it is simply thought that “they have run away to another place because they know they are being hunted”. Only a serious campaign of targeted

education to instil a sense of responsibility towards their valuable resources / natural heritage may be able to change this mentality.

PAST FISHERIES PROGRAMMING INTO THE UPPER SOBAT

For certain periods during the UNICEF / WFP Operation Lifeline Sudan (1989-2005), the community around Akobo received relief and interventions in the fishery sector on a very large scale, mainly on account of their proximity to, and control over, the airstrip in Akobo; and due to the operations of the NGO Pisces Aid (headed by the infamous Tom Murphy). A large general distribution of fishing gear (twine, hooks, mosquito nets, blankets, etc.) and canoes (some of which are still visible in the Sobat Corridor) was carried out by Pisces Aid in 1994 and followed up by further large quantities being traded out of the "bush-shop" which the same organisation set up. This operated on the principle that beneficiaries of previous inputs would catch fish and exchange it in the "bush-shop" for more fishing equipment and other commodities, in a self-perpetuating circular arrangement. The fish so procured was salt-dried and distributed by OLS to hospitals and feeding centers around the country. Unfortunately, no records of Pisces Aid's inputs could be found, even back in 1997.

After Pisces Aid discontinued in late 1995 / early 1996, other agencies (in particular UNICEF and SCF-UK) continued to supply fishing equipment to the community that had already received more than any other in southern Sudan. After this, there is a gap in knowledge regarding inputs made between the late 1990s and the present time. There have been reports that Catholic Relief Services (CRS) and Save the Children International (SCI) brought fishing equipment as part of their relief interventions for returnees and other vulnerable groups in the past few years, but actual figures have not been obtained despite the Consultant's requests for information. Minor amounts of gear seen was said to be from these relief distributions in inland locations (Walgak / Waat) over the past few years. Gear from these distributions was occasionally brought to Akobo and sold and re-sold in the market there; or alternatively distributed along kin lines to someone who will use it on the river in an arrangement whereby part of the catch in the form of dried fish is sent back in return.

Other players in the fisheries sector, which may have had programmes in the Sobat basin in recent years, include MARF, FAO, UNIDO (with Canadian Embassy support), Joint Aid Management (JAM) in Pochalla. No relevant statistics are available or could be sourced for this report.

The USAID – SSTCM Fisheries Youth Project 2011-12

Much of the fishing gear seen during the assessment in all locations with the exception of Nasir was provided by the USAID / SSTCM Youth Fisheries Project. A master distribution list prepared by AISS is included as Appendix 7. (This list does not exactly match the final distribution as an additional location was added (Maker) and an additional 10 beneficiaries were added in Wanding. Although interviews with recipients indicate considerable variation in the actual distributions made, differing from the plan on paper, this is largely immaterial as a broad analysis can still be achieved using the figures at hand.)

A rough estimate of the potential catch per annum – assuming all of the assets provided under the SSTCM Fisheries Youth Project were utilized at the same time – is shown in Appendix 8. The assumption that all the gear provided is put into use at once and remains in use provides a "worst-case scenario" from an ecological (conservation) perspective in order to assess what might be the worst consequences if such intense fishing is conducted. In practice, this assumption needs to take into consideration discount factors, including, amongst others: (1) any loss or destruction of fishing gear (to the extent such loss (if stolen) would not catch fish as effectively elsewhere); (2) the sharing of assets and division of labor among fishers such that they may not use all the fishing gear simultaneously, but may

alternate responsibilities to include processing of fish; (3) the market capacity to absorb such an increase in supply without infrastructure and consistent trade routes to facilitate trade as fishers find a balance between their supply and demand; (4) the engagement of fishers in cultivation or other activities towards the start of the rainy season (though calculating the potential catch for six months instead of a full 12 month per annum accounts for cultivation during the bulk of the rainy season); (5) the time required to construct nets out of twine; (6) management of.fishing rights that may prevent fishers with gear from fishing in certain areas; and (7) the natural cycle of areas with an abundance of fishing during certain time periods coupled with the need and ability to relocate to areas with more efficient fishing as time progresses during the fishing season.

Given the limitations of the consultancy, it was difficult to assess the actual level of usage of the assets; however, there is evidence that it is less – arguably, significantly less. For example, over 1,000 spools of twine were stolen from the Nasir storage unit in the spring of 2012 and never retrieved; such twine may have been used by others who may not have engaged in the same level of fishing as the SSTCM supported fishers or utilized all the stolen assets simultaneously. In addition, it might be expected that fishers would keep some materials in reserve, or stagger their use, either as unused spools of twine or made-up nets in storage. The Consultant did not observe such reserve of materials (other than nets which had been removed from the water due to ongoing cultivation); however, the SSTCM fisheries consultant who helped to train, manage, and guide the fisheries groups in 2011-2012 and returned in 2013 to evaluate the project has noted that the fishing gear are not in the water at the same time. Instead, it takes considerable time (a week as noted above) to build the nets and multiple fishers work together to fish using a single net.

The catch per annum shown in Appendix 8 – based on the assumption that all nets have been put into action at the same time, which as noted above, is arguable – seem remarkably high at 13,396 -24,026 Metric Tonnes (MT) per annum. By way of comparison, the total yield of the entire Sudd swamps, an area of 30,000 km^2, has been variously estimated at between 100,000 – 200,000 MT per annum.

To put the figures derived from this calculation in another context, the Banguelu Basin fishery in Zambia (a complex of six major lakes interlinked by channels, swamps and floodplains, with a total area 15,000 km^2) has a well-studied and managed fishery, which is based on gillnetting and which produced an annual yield average of 11,500 MT over a 20 year period through 1985. Maximum Sustainable Yield for the fishery is estimated at around 25,000 MT annually. Up to 11,750 fishermen are involved in that fishery. This means that each fisher produced 1 MT annually until 1985, and could produce just over 2 MT per year before the Maximum Sustainable Yield is reached.

Economically, the figures produced from the above analysis and assumptions are extraordinary. Firstly, they indicate that the size of the potential catch is such that in two to four days of fishing, the market value of the gear has been returned. Secondly, they indicate that a single fisherman can catch fish worth SSP 100,000 – 200,000 (US$ 25,000 – 40,000) in a year. To put this into context, in the market during the assessment period, a bull costs SSP 1,500 and a 2-step cow (a 2-year old cow) costs SSP 700. An interesting comparison can thus be made with the rate of re-stocking that was previously possible (as mentioned earlier) and now. Currently, the income reported from the SSTCM Youth Fisheries Project does not reflect that in Appendix 8, indicating that the actual catch per annum projected may exceed actual catch.

In theory, these catch figures can be attained and if fishing activity ever reach such a magnitude, it would be viewed with a high degree of concern from an ecological point of view. However, in practice, the level of fishing activity and thereby catch results may be depressed significantly by other external factors, some

of which are noted above. At this point in time, without the ability to calculate the Maximum Sustainability Yield with reasonable data and without the ability to fully determine a credible catch per annum, the ecological effects need to be addressed utilizing field work over longer periods of time, and with more substantive participation of data collectors. Future studies to build on this report are recommended.

The Consultant knows two case studies of similar large interventions within the survey area in the past two decades:

Case Study 1: Pochalla:

The Akobo River around Pochalla has twice in recent history experienced fisheries interventions by external agencies on a large scale. Widespread and intense fishing had previously been an unknown phenomenon in the Anyuak Kingdom. The first instance was in 1992 after the fall of Mengistu, when tens of thousands of Nuer refugees fled Ethiopian camps in which they had been staying and came to Pochalla. They reportedly put a heavy strain on the local community and on available resources. This strain was exacerbated when relief agencies supplied the refugees with large amounts of fishing equipment. How much the local Anyuak population benefitted from these inputs, if at all, is not known. In any case the equipment received allowed the refugees to severely deplete fish stocks in the Akobo River such that, on moving on to their destinations in Equatoria, Kenya and Uganda, they left little behind. The intervention, therefore, had two adverse effects: locally the river had been overfished and little remained for the resident Anyuak population around Pochalla; and secondly fish on their seasonal migration upstream where they would provide part of the livelihoods of other communities, are said never to have arrived[2] (Perner 1994).

Unfortunately records of the actual fishing inputs into Pochalla in 1992 were not found. Nevertheless, fish stocks in the Akobo River, a relatively small stream after all, were adversely affected by the intervention. By 1996, some degree of recovery had taken place[3] (Rottcher 1997).

But then in 1996, heavy rainfall in the Ethiopian Highlands and surrounding regions resulted in unusually high and prolonged flooding in parts of the Anyuak Kingdom, starting in May 1996. The flood was possibly the highest since previous highs of 1946 and 1956. Flooding was most severe to the south of Pochalla, and the situation was reported as a disaster, which led to a major relief intervention that started in June 1996 and continued into 1997. During this time at least 8,500 x 500 g spools of twine and 513,000 hooks were brought to Pochalla and distributed by relief agencies. The Consultant is not aware of any documentation on the effect that this large intervention had on the fishery. However, fishing is currently done in Pochalla, contributing to the diet of the Anyuak, and USAID through the Wildlife Conservation Society (WCS) currently has a fishing livelihood project in Pochalla.

Case Study 2: Akobo

The Pibor River was subject to similar massive inputs of fishing gear and a resulting over-exploitation of the fish stock as a result of the involvement of the NGO Pisces Aid in Akobo (as described above).

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[2] Perner, C. (1994). *Notes on the 'appropriateness' of the fishing project 'Pisces' in Upper Nile area.* Letter from Kwacokworo to Philip O'Brien, 04.04.94.

[3] Rottcher (1997). Fishery Assessment to Pochalla, Anyuak Kingdom. ECHO/OLS Fisheries Consultant

In 1995, a year after Pisces Aid started its program, fish catches in the river had reportedly decreased (Rottcher 1997). Fishermen were forced to travel further than they previously had needed to in order to reach fishing grounds. Unfortunately, no records exist of the quantities of gear that Pisces Aid distributed.

RECOMMENDATIONS FOR FUTURE FISHERIES INTERVENTIONS

1. On-going biological research. Creel surveys to add to length-frequency database and controlled experimental fishing to determine CPUE for different sites.
2. 5-year study recommended, during which time, ramp up the monitoring of length-frequency and CPUE data of the SSTCM Youth Fisheries Project.
3. In the meantime, use existing estimates of CPUE to design a program, i.e. hook-line of 100 size 7 hooks or 1 x 500 g spool 21-ply twine can be assumed to catch 2-4 fish weighing in total 5-10 kg per day.
4. Ensure appropriate inputs specific to local conditions are planned, taking lessons learned from the SSTCM Youth Fisheries Project. For the Pibor-Sobat fishery, these are: hooks of size no. 6 or 7 and 1 in the ratio 100:5. No. 1 hooks are specifically useful for Nile Perch and large catfish. Multifilament twine in the ply ratings 21, 36 and 72 or 120 in the ration 1:1:1. Good quality gear is essential for longevity. A net, if maintained properly, should have a useful service life of at least 2 years; hooks should last longer.
5. A cautious approach might be, per beneficiary and for a limited number of target group: a maximum of 200 size 70 hooks and 10 size 1 hooks; twine of a maximum of 5 rolls each 21, 36, 72/120-ply. 72/120-ply is specifically for PATHOOT nets targeting large Nile Perch. As 50 spools make an effective net, this will encourage sharing. Note that CPUE for No. 1 hooks and for PATHOOT and 36-ply nets do not yet exist. 72/120-ply also useful as head and foot-lines for nets and for hook-lines.
6. Avoid small-meshed factory-made nets and ENSURE that monofilament and “Silka” nets are avoided UNLESS they have a minimum 120 mm stretched mesh size.
7. Good recording / reporting of actual quantities and types of inputs of fishing gear (ply / hook size, etc.) reaching specified locations is critical to future CPUE analysis.
8. Correct timing of inputs is fairly important. Best coverage might be achieved during or at the end of the cultivation period, around September to October, as then people are sedentary and have time to prepare the gear (net making takes several weeks) for use by the beginning of the main dry season fishing period.
9. It is important to recognise any political differences that may exist between different communities, when designing development projects in this region, as their implementation should be carried out with the direct cooperation of the administration in the specific target area for which the project is intended.
10. Reporting of outputs – accurate landing-site creel logs (length-frequency and effort) and fish sale logs should be kept. This had been part of the previous project but no records other than scanty sale records were found by the Consultant.
11. Education of fishers in setting of nets will help to avoid conflict with motor-boat traffic. Nets should avoid going across the entire width of the river and be set lower than outboard propellers can reach.
12. Information must be shared with agencies providing fishery inputs into the same system in order that the total inputs might be known for use in planning. Types and quantities of fishing gear available in markets should feed into the knowledge-base.

13. Support should be directed towards fisheries policy creation and the enforcement thereof through the appropriate authorities. In the absence of national policy, regional and State policy development should be encouraged.
14. Further education of local fishers with respect to improvement in methods of preservation and storage of preserved fish. Sun- and salt-drying are deemed to be ways forward. Attempts have been made to introduce the concept of smoking fish. It is unknown to what degree, if at all, these have been accepted. An end-user acceptance survey should be carried out. Wet salting used to be done with Egypt. Again, the applicability of reintroducing this method, and potential markets, should be explored.
15. Education with respect to the cleaning of fresh fish for sale in the market (i.e. gutting and gilling). This requires a change in the culture and mind-set as it is currently a widely held Nuer taboo to do clean the fish prior to sale.
16. Education with regard to nets lost or left in water when cultivation starts, etc. – needless catching and loss of fish, problem exacerbated by rotting fish attracting predator fish or crocodiles / terrapins. Especially true of Silka nets.
17. Well-constructed fiberglass canoes represent the best fisheries inputs possible. There is a high demand and traditional dug-out canoes are hard to source and obviously destructive to the environment. A well-made fiberglass canoe can last for over 15 years, as attested to by the UNICEF canoes brought by the Consultant to Wanding and Akobo in 1997 that are still in operation.
18. The SSTCM fish market in Nasir has been very successful. Investigate replication in Akobo.
19. Minor additional inputs might include the following: small files for sharpening blunt hooks, pliers for restoring opened hooks, and sharpening stones for knives (there are few natural stones in the survey area).
20. Proceed with caution! It is imperative that further detailed analysis be done of the potential impact of fishing material interventions of the SSTCM Youth Fishery Project 2011-2012. Sustainability of the fish stocks is imperative and any short- or long-term economic benefits that massive intervention in the fishery sector might bring must be weighed against the possibility of causing long-term damage to the fishery. A full understanding of all the factors at play is critical.

NON-FISHERIES PROGRAMMING – CONSULTANT'S OBSERVATIONS

Human Population Growth

Almost every problem seen during this assessment, be it environmental, social or political, can be linked to a fundamental underlying issue – that of a human population undergoing rapid and uncontrolled growth. The survey area is experiencing a population explosion on two accounts: a flood of returnees since the signing of the Comprehensive Peace Agreement (CPA), and an apparent total lack of family planning.

Brief surveys in both Akobo and Nasir markets showed that no birth control methods, including condoms, are available. (It would appear, however, that since the assessment was completed, Plan International have started a program in Akobo. Further details are not known).

Education

Also fundamental to future social and environmental stability in the region, is good education. An almost total lack of basic primary education is very apparent in all areas visited during the assessment. The vast

majority of children are not in school. Few functioning schools exist in the region. It would appear that there has been a regression in provision of basic education facilities since the OLS period.

Girls are noticeably absent from public life due to the non-stop household chores that they are culturally obligated with; on the other hand boys and youths (especially in towns) are totally idle. An absolute lack of discipline can be observed from the smallest male child upwards.

Support to the education sector by the provision of schools, training of teachers and encouragement of school attendance are strongly advocated. It is not known to the Consultant whether any environmental education or family planning aspects feature in the school curriculum. However, these are areas in which support should be applied.

Adult education is equally applicable, to improve environmental awareness and promote family planning.

Wildlife Preservation

Land mammals

The part of South Sudan dealt with by this study, and the adjacent part of Ethiopia was, some 50 years ago, the richest in wildlife of any in South Sudan, and as prolific as the famous Serengeti National Park of Tanzania. The pastoralist inhabitants of the region, much like the Maasai of Kenya and Tanzania, freely coexisted with this abundance of game, hunting sustainably with dogs and spears for domestic consumption.

A proliferation of firearms, regional insecurity, lack of law enforcement, an increasing and food-insecure population, and hunting for profit, now severely threaten the survival of this important part of South Sudan's natural heritage.

The possession by a large proportion of the population of firearms has had a severe impact on the formerly abundant wildlife, for most species likely to a degree beyond sustainability of this valuable resource. Both SPLA and civilians are responsible.

Two national parks have been created, at least on paper, to help preserve what remains of this natural heritage. Gambella National Park (5,061 km^2) lies between the Baro and Gilo rivers in the so-called Baro Salient just to the east of the survey area in Ethiopia, and Boma National Park (22,800 km^2), established in 1986, of which the northernmost part lies just to the south-east of Akobo County. Unfortunately the existence of either park has not had much conservation impact on the ground. See map in Appendix 9.

Despite their seasonal movements being far more extensive than the areas included in the national parks, both parks were created in part to help preserve the migration routes of the White-Eared Kob *Kobus kob leucotis* (Nuer THIL), once estimated at one-million-strong, the Mongalla Gazelle *Eudorcas albonotata* and the Tiang *Damaliscus korrigum korrigum*. Two other threatened antelopes, the Nile Lechwe *Onotragus megaceros*, and the swamp-adapted Sitatunga *Limnotragus spekeii*, are sedentary and live in the flooded TOIC and swamps, respectively.

Other large species that occurred in the area, and may still, include the following: African Elephant, African Buffalo, Giraffe, Lion, Leopard, Cheetah, Serval, Reedbuck, Waterbuck, Eland, Plains Zebra, Oryx, Roan Antelope, Lelwel Hartebeest, Warthog, Grey Duiker, Spotted Hyena, African Wild Dog, Olive Baboon, and Guereza Monkey, among others. All these can be assumed, today, to be much reduced in number, and in some cases totally eliminated.

The White-eared Kob is the only species that is any longer much in evidence in the study area. In March 2013 a large herd (ca. 5000 individuals?) was seen north of Wanding, spread out on the dry TOIC. Hunters were regularly seen with dead Kob and a thriving trade of Kob meat into Akobo exists. At the beginning of June the migration had apparently reached Akobo and daily many tens, possibly hundreds, of animals were being killed in and around the town and north to Dengjok, with the meat being distributed for home consumption and drying, while a proportion was sold fresh in Akobo market by women and boys. Approx 1kg sells for SSP 5.

While no recent census or harvest data exists, it is assumed that the off-take at the current rate may be unsustainable and the White-eared Kob, despite its apparent numerousness, may go the way of most of the wildlife heritage of South Sudan.

Hippos and crocodiles

The importance of Hippopotamuses and Nile Crocodiles to the health of African riverine ecosystems and their benefit to the fish community, through enrichment of the water with nutrients, has been scientifically well established. Nevertheless, the decimation of these two species continues apace and their eventual extinction is likely unless a stop is put to the needless killing.

Both species were once distributed throughout the Nile system. The last hippos in the Nile Delta were killed at the beginning of the 17th Century. 1786 marks the last known record from Egypt. Since then, hippos and crocodiles - despite the prominence of both species in Ancient Egyptian mythology - have been progressively but inexorably wiped out. Today no hippos remain in Egypt or Sudan and in Egypt crocodiles are probably extinct from the river of their namesake.

The process continues unabated, and during the Consultant's transect survey along 190 km of river that in the recent past would have supported hundreds of both hippos and crocodiles, no sign of a single hippo was seen, and less than 10 crocodiles - of which only 2 were of breeding size. Both species are shot at on sight or, in the case of small crocodiles, killed if they get caught in fishing nets. It was stated by a number of interviewees that hippos persist in the Gilo TOIC in Ethiopia, but it is assumed that the number is now very low. A few weeks before the Consultant's second visit, two hippos were shot dead between Dengjok and Akobo. In Kuot Ker a small crocodile skin was seen. One can probably anticipate total decimation of both species in the Sobat system within only a few years from now.

Birds

The birdlife supported by the rivers and other water-bodies in the Sobat system, is remarkable not for the number of species when compared to many other African regions (nevertheless around 470 have been recorded) but for the sheer numbers of water birds present. Fortunately, these do not seem to be persecuted, as are the mammals. Crowned Cranes, White-faced Whistling Ducks, Open-billed and Abdim's Storks, Sacred Ibises, Pratincoles, Cattle Egrets and many other species can be seen in large congregations.

Most species are specialized in their feeding requirements: some need swamp margins, or open water, or flooded grassland, others come when the TOIC is burnt, and so on. As might be expected, there is a constant movement of birds as the distribution of each species' optimum habitat changes with seasonal changes in water level. While some species simply make local movements to reflect this variation, others migrate out of the area entirely, some making intra-African migrations, some to and fro from the Palearctic region.

During the dry season survey in March, thousands of Black Kites were found to be congregating in large flocks around the Pibor fishing camps, benefitting from scraps off the fish-drying racks. By June none remained, indicating that they had been the Palearctic migrant yellow-billed subspecies. Likewise, Crowned Cranes and Abdim's Storks were seen in March but only very few in June, while Marabou Stork numbers were reduced on the second visit. The remarkable Shoebill, *Balanites rex*, is of particular interest. A large proportion of the species' entire population is located in the swamps of South Sudan and it likely occurs in the Gilo swamps.

Hundreds of Great White Pelicans were seen in spectacular large rafts between Makak and Wanding during the dry season – a good indicator of the richness of the fish stocks - but less than 10 remained in June. African Darters, *Anhinga rufa*, a shy, seldom-seen species that dives for fish, occurred in good numbers on the same stretch (300 dry season, 141 wet). This species is very susceptible to being entangled and drowned by gill-nets: indeed, one Darter was seen dead, hanging from a tree by a piece of fishing net that had entangled it. In neighboring Kenya the species has been rapidly driven almost to extinction since gill-nets were first introduced in the 1960s.

African Fish Eagles showed a good population (77 were counted over 90 km: allowing for those missed this gives a likely density of one pair every 2 km of river). Fish Eagles (and Darters) are dependent on the presence of river-bank trees for perching and, in the case of the sedentary eagles, nesting. Several immature Fish Eagles were seen in June, indicating breeding is ongoing. Where trees have been eliminated, such as around Akobo and Nasir, so these species have disappeared.

It was noted that distributions of most bird species (apart from scavengers such as Black Kites, Marabou Storks, Hooded Vultures) are mutually exclusive with human habitation, indicating that there may be a competitive exclusion over the available fish resource in the case of pelicans and other piscivorous species, but much more likely, that the birds simply cannot tolerate the disturbance that human presence entails.

Boats

Any future proliferation of river traffic, particularly that of noisy, fast "speed boats", would be a matter for concern with respect to bird conservation. Pelicans and darters are particularly susceptible to disturbance from boats. They will fly off the water and then, unable to gain height in order to leave the river's narrow corridor of vegetation, will be forced to fly ahead of the boat, sometimes for several kilometers before they can turn back. Panicked birds are sometimes seen jettisoning their stomach contents to reduce their weight. Pelicans would normally spend the whole day on the water, and taking off each time requires a lot of energy for such a big bird. If this is repeated several times a day, each time a boat passes, then the birds' energy balance is likely to be severely disrupted, which can quickly lead to death. Several dead pelicans were seen during the river transect.

Another detrimental effect of passing boat traffic is the wake hitting the river-bank or washing over floating vegetation, and the consequent inundation of birds' nests. African Jacanas nest on lily pads and other floating vegetation; several plovers and Water Thick-knees do so on the bank directly next to the water.

Conclusions on Wildlife

The bird-life of the Pibor River, especially on the uninhabited stretches between Dengjok and Makak, combined with the White-eared Kob migration and the other mammal species that occur there, are indisputably a spectacular natural wonder. If at any time the political and security situations will allow it, then this region could rival the great game parks of Kenya and Tanzania and would doubtless draw tourists (in the dry season).

The challenge for the present moment is to allow the wildlife to survive in sufficient numbers until such time. This may require provision of support to local administrations / schools to increase the communities' awareness of the importance of wildlife; or to the Wildlife Department to build their capacity to manage the resource and police it.

Opportunities should be explored for combining preservation of this valuable natural resource with fisheries stock management. For instance, a no-fishing zone could be created along a stretch of river, protected on one or both sides from hunting. Sport fishing with its inherent benefits could be introduced, for tiger-fish and Nile perch, for example.

Both areas that have been designated national parks currently have an element of human habitation, possibly contrary to regulations. This aspect would need to be regularized in future. There is a case in point that insecurity, *per se*, can be of benefit to wildlife. In Kenyan and Tanzanian national parks no human habitation or livestock grazing are permitted – the land has been strictly set aside for wildlife. If this premise were to apply in South Sudan, then the strategic creation of further national parks in disputed grazing lands, could be a useful tool in keeping warring communities apart, as buffer zones, while conserving wildlife at the same time.

In the context of the current situation in which many people have lost their cattle and cattle-related insecurities persist, such a land-use change could go hand-in-hand with a cultural shift from predominantly cattle-keeping to predominantly fishing, while eventually the area could benefit from tourism.

Riverbank and Farmland Degradation

Wherever there are centers of habitation, especially around Akobo, Wanding and Nasir, the riverbank is perennially bare and suffering erosion at a much greater rate than if it were vegetated as it naturally is elsewhere. The reasons for the loss of ground cover are several, as follows:

- High, and increasing, human traffic: washing, collection of water, fishing, swimming, collection of building sand from river-bed.
- livestock grazing and trampling – for example where cattle camps on located on the river-bank (eg Jikmir - Nasir).
- crop (maize) cultivation right up to the edge of the river-bank.
- tobacco cultivation on the slope of the bank.
- direct cutting of trees growing on or above the bank.
- collection of aggregate by women for sale for concrete-making (Akobo only). The price paid by NGOs is currently SSP 10 per bucket-full. The method of collection involves scraping it out of the substrate, thereby destroying any ground-cover plants' roots.

A more rapid erosion of the river-bank than normal may not be a problem in itself; however the most significant consequence of this process is the loss of large trees from the river's edge, as they collapse into the river once their roots have been exposed and the retaining soil is undercut. While this could be perceived as a natural process, the difference in this case is the unnatural speed at which it is happening and, importantly, that very few young trees are coming up to replace the older ones. Particularly in the centers, browsing by goats and cattle, and human and livestock foot traffic are ensuring that there is virtually no regeneration. In a short time these areas could become largely tree-less. The trees seen being lost in this way during the survey were valuable species such as *Balanites aegyptiaca* (LALOP / Desert Date / THOU), *Tamarindus indica* (Tamarind / KOAT), *Crataeva adansonii* (KEC), *Ficus* spp. (KWEL), *Cordia* spp. (NYOAT), *Acacia sieberiana* (THEP) and *Kigelia africana* (LUAL).

Potential mitigation measures of the twin problems of erosion of the river-bank and the consequent loss of trees are as follows:

- Indigenous tree nurseries and tree planting programs (there seems to be some awareness & knowledge regarding tree care around Nasir).
- Planting up of eroded bank stretches using local vegetation types.
- Exclusion zones to promote natural regeneration.
- Limiting of closest distance from top of bank at which cultivation can take place.
- Awareness creation / education re erosion and importance of trees in soil conservation.
- Promotion of zero grazing for donkeys and cattle within towns (as seen in Nasir during the assessment) – this can bring in extra income to women and girls.

Note: the effects of tobacco cultivation, a widespread practice on the slope of the riverbank, are hard to assess – on one hand it stabilizes the bank and access to destructive livestock or human traffic is prevented, but on other hand weeding and eventual harvesting is bound to create erosion.

An apparent disregard or ignorance of the value of trees was observed throughout the survey. In numerous instances, trees would be seen being felled for potentially very short-term gain. For example, in Wanding and Akobo, *Balanites aegyptiaca* trees, probably over 50 years old, which annually provide a vital LALOP harvest, were felled simply to provide thorns for one season's worth of fence around a maize garden. The same trees could have been pruned or perhaps pollarded instead, and thereby continue to produce a regular harvest of fruit and branches.

Building materials - such as poles, thatching grass, reeds for fencing - are collected from woodlands and TOIC areas on the outskirts of villages, and where these have been depleted such as in the environs of Akobo and Nasir towns, they are brought from locations further afield. Kuot Ker is one such location, where large amounts of poles and thatching material are sourced and from there, taken to markets downstream by means of current-propelled rafts made from a large tarpaulin.

Water Hyacinth

Water hyacinth, *Eichhornia crassipes* (Nuer: TUITUI) is a floating water plant and pernicious invasive weed native to tropical South America, from where it has been spread by man throughout the world's fresh water-bodies. One of fastest-growing plants known, water hyacinth creates thick floating mats up to a meter high and can double its area in two weeks. It reproduces both sexually (flowers) and asexually (budding). Once established, it has proven impossible to eradicate. Seeds are viable for 20+ years. In lakes it is spread by wind, in rivers it is carried downstream by the current, and it can be equally spread upstream by boats and to virgin water-bodies by waterbirds. It was introduced into the Nile system in 1957/8 and is prevalent throughout the Sobat system.

Effects of water hyacinth can be broadly categorized into environmental and those directly affecting humans.

Environmental effects of water hyacinth infestations

The plant is known for displacing native species such as the Nile Cabbage *Pistia stratiotes* and changing the overall ecology of the water-body; when it completely covers areas of water it will starve the water of oxygen, thereby causing mass or individual die-offs of fish and invertebrates. It prevents sunlight reaching into the water, thereby killing native water plants. While being a prime habitat for mosquitos, and snails known to host the parasitic flatworm causing schistomiasis, it also hosts insects and their larvae, which

are important as the base of the fisheries food chain (though probably no more so than the indigenous vegetation is). It increases evaporation rate over that of bare water through a very high rate of transpiration through the leaves.

Human effects

Undoubtedly the most serious issue is that hyacinth can block waterbodies and become a major impediment to river traffic and movement. Affected are trade boats plying river routes and fishermen accessing their fishing grounds. The Pibor river can become clogged in this way at times of low water such as the end of the dry season around March-April. When the water level rises again the hyacinth dams break up and float away downstream.

Control methods

- Chemical – enzyme-based and chemical herbicides have been employed to control hyacinth, at great financial and environmental cost (other non-target plant species are killed too). 2,4-dichlorophenoxyacetic acid (2,4-D) was sprayed in the 1970-80s in the Sudd, with limited success. These methods are not applicable in the current context.
- Biological – various natural insect and microbial pests of hyacinth have been employed elsewhere, with varying degrees of success. In the Sudd, a weevil and a beetle were established in the early 1980s. Due to the technical complexity of initiating and monitoring biological control it is currently unlikely to be of relevance in this area.
- Physical - While mechanical extraction devices have been developed elsewhere in the Nile Basin such as on Lake Victoria, in context of the Pibor and Sobat Rivers situation, only manual extraction is likely to be of relevance. This can be achieved by raking up of plants from the water and the controlled desiccation thereof by spreading them out to dry in the sun above the bank for a period of weeks or months. However, subsequent inundation of the land will rehydrate and refloat any plants that have not yet died.

Possible environmental benefits

- Where the hyacinth has not covered 100% of the surface area, it may provide a refuge and nursery to juvenile fish.
- By preventing fishing in certain stretches, it effectively provides a no-take zone, creating a reservoir from which surrounding areas can be naturally re-stocked, thereby benefitting the fishery.
- May help mitigate river-bank erosion by reducing the impact of the wake wash created by passing motor boat traffic (currently estimated at 5-10 large transport boats per day Gambela – Nasir, 1-5 per day Gambela – Akobo). In addition, NGO / government “speedboats” operate daily in Akobo and Nasir environs and have a considerable impact on the river-bank.

Uses

Water hyacinth has been found to have myriad uses throughout the world. Those perceived by the Consultant as having potential relevance in the current context are as follows:

- Stems can be used as source of fibers, braided or woven into cord which can be made into footwear, bags, hats and decorative items.
- Can be used as raw material for paper.
- Can be used in biogas production.
- As dry fuel for cooking, reducing dependence on wild-harvested firewood and charcoal.

- As a base for compost; the other main ingredients, manure from livestock, fish and livestock bones (ideally ground down into bone meal, for calcium and phosphate) and ash (against termites and to add nutrients), being readily available.
- As mulching material for vegetable gardening.
- Livestock feed: hyacinth is 18% protein, 17% fiber, 36% carbohydrate. However the plants are 90-95% water by mass, so need to be partially dried before transport. Excessive use can be toxic. Hyacinth is known to assimilate toxins (allowing its further use in waste-water treatment plants, treatment of water contaminated by mine tailings etc) so for human and livestock consumption only that harvested from relatively clean, fresh water should be used.
- Human consumption: Leaves can be boiled or fried; young bulbous bases fried; flowers boiled. Can lead to itching in some people so should be tried cautiously.

RECOMMENDATIONS FOR FUTURE NON-FISHERIES RELATED PROGRAMMING

1. Introduction of family planning programs, or in the case of any existing programs, support thereto.
2. Support to the education sector by the provision of schools, training of teachers, development of environment curriculum and encouragement of school attendance and discipline.
3. Education of communities with regard to the importance of wildlife resource management / preservation.
4. Education of fisherfolk & river users with regard to importance of preserving hippos & crocodiles.
5. Education of boat drivers re deleterious effects of boats on birdlife (pelicans / darters etc.)
6. Education of fishers to minimise conflict between Darters and gill-nets.
7. The above education recommendations could be incorporated into a mobile environmental film show program, using existing wild-life and environmental films (possibly translated into local languages). Experience from Kenya and Tanzania shows this to be a highly efficient and effective medium for environmental education in rural areas.
8. Support to Wildlife Department and local administrations to increase capacity with respect to wild-life law enforcement on the ground. This includes recognition of and support to the existing Boma National Park.
9. Examine opportunities for combining wild-life preservation with fishery conservation measures. For example fishing no-take zones could be implemented in areas that currently are not being fished and support the main concentrations of mammal and bird-life.
10. Perennially insecure border areas between warring communities (e.g. Lou & Murle) could be declared no-go zones and thereby set-aside for the dual-purposes of keeping a buffer zone between these communities while providing security to wildlife & fish stocks they contain.
11. Soil conservation on and close to the river bank should be promoted (as detailed in the relevant chapter).
12. Education with respect to tree conservation (see relevant chapter for further details / explanation).
13. Creation of tree nurseries as a simple low-cost intervention: Both locally-indigenous species and carefully selected non-indigenous varieties (for fuelwood and fruit) should be promoted. The indigenous component must not be allowed to be over-shadowed by the others and only indigenous trees should be replaced and added where they have been lost.
14. Introduction of efficient wood-burning clay stoves of well-proven designs (e.g. from Kenya) to reduce firewood consumption. As these are made of fired clay, they should be locally produced, thereby providing local women with income. Their use with dry fuel from water hyacinth should be investigated.

15. Environmental education with respect to deleterious use of river: pollution, clothes washing using detergents, garbage disposal on bank, etc.
16. The potential for water hyacinth harvesting and use should be thoroughly investigated (as per the relevant chapter recommendations above), especially in areas where river blockages are a problem. Compost creation can be combined with tree nurseries.
17. Pending a stable future, development of tourism (bird-watching, wild-life safaris, sport-fishing). Safari camps could be established in various scenic river locations.

REFERENCES & SELECT BIBLIOGRAPHY

Bailey, R.G. (1989). An appraisal of the fisheries of the Sudd wetlands, River Nile, southern Sudan. Aquaculture and Fisheries Management 20: 79-89.

Bailey, R.G. (1994). Guide to the fishes of the River Nile in the Republic of the Sudan. Journal of Natural History 28: 937-970.

Beadle, L.C., 1974. The inland waters of tropical Africa: An introduction to tropical limnology. London, Longman. 365 p.

Bishai, H.M. The water characteristics of the Nile in the Sudan with a note on the effect of Eichhornia crassipes on the hydrobiology of the Nile. Hydrobiologia Vol. 19 No. 4, pp 357-382.

Bloss, J.F.E. (1945). The Sudanese angler. Sudan Notes and Records 26: 256-281.

Borhan, M.A., 1981. River Nile fish and fisheries 1980. Progr.Rep.Inst.Oceanogr.Fish. Inland Waters Fish Cult.Branch, Alexandria, (5):pag. var.

Boulenger, G.A. (1907). The fishes of the Nile. Hugh Rees, London.

Carey, T.G., 1967a. Kafue river and floodplain research. Fish populations in lagoon and riverine environments. Fish.Res.Bull., Zambia, (3):9–12

Carmouze, J.P., J-R. Durand and C. Leveque, 1983. Lake Chad, ecology and productivity of a shallow tropical ecosystem. The Hague, Junk, 575 p.

Cave & Macdonald. Birds of the Sudan

Charters, R. (undated). ICRC Fisheries Programme South Sudan.

Crul, R.C.M., 1992. DIFRA. Database on the inland fisheries resources of Africa. CIFA Occas. Pap., No. 17. Rome: FAO, 21 pp.

Dansoko, F.D., H. Breman and J. Daget, 1976. Influence de la secheresse sur les populations d'Hydrocynus dans le delta central du Niger. Cah.ORSTOM (Hydrobiol.), 10(2):71–6

Evans-Pritchard, E.E. (1940). The Nuer – a description of the modes of livelihood and political institutions of a Nilotic people. OUP, London.

Everett, G.V., 1974. An analysis of the 1970 commercial fish catch in three areas of the Kafue floodplain. Afr.J.Trop.Hydrobiol.Fish., 3(2):148–59

FAO/UN, 1970a. Report to the Government of Zambia on the fishery development of the Central Barotse floodplain. Based on the work of G.F. Weiss. Rep.FAO/UNDP (TA), (2816):19 p

Girgis, S. (1948). A list of common fish of the Upper Nile with their Shilluk, Dinka and Nuer names. Sudan Notes and Records 29: 120-125.

Hammerton, D., 1972. The Nile River - a case history. In River ecology and man, edited by T. Oglesby, C.A. Carlson and J.A. McCann. New York, Academic Press, pp. 171–213

Howell, P.P. & J.A. Allan (eds.). The Nile – sharing a scarce resource. 1st ed., reprint 1996 (1994)

Hurst, H.E. & P. Phillips. The Nile Basin. Vol. I (1931): General description of the basin, meteorology, topography of the White Nile Basin. Vol. II (1932): Measured discharges of the Nile and its tributaries. Vol. III (1933): Ten-day mean and monthly mean gauge

Hurst, H.E. The Nile – a general account of the river and the utilization of its waters. Revised ed. 1957 (1952)

Kapetsky, J.M., 1974a. The Kafue river floodplain: an example of preimpoundment potential for fish production. In Lake Kariba: a man-made tropical ecosystem in Central Africa, edited by E.K. Balon and A.G. Coche. The Hague, W. Junk, pp. 497–523

Loat, L. (1902). Report on the Nile fish survey, pp. xx-li in Boulenger, G.A. (1907) The fishes of the Nile. Hugh Rees, London.

Lowe-McConnell, R.H., 1975. Fish communities in tropical freshwaters. London, Longman, 337 p.

Lowe-McConnell, R.H., 1977. Ecology of fishes in tropical waters. Inst.Biol.Stud.Biol., (76):64 p.

Ludwig, E. The Nile – the life-story of a river. One volume edition 1950 (1936), cloth, dj.

Lyth, R.E. (1947). Correspondence. Sudan Notes and Records 28: 212-3.
Mefit-Babtie (1983). Development studies in the Jonglei Canal area: Swamp Ecology Survey: Volume 3: Invertebrate & fish studies & Volume 4: Final Report.
Nyang, B.B. & S.A. Gumaa (1981). Development of the fisheries of the White Nile. CIFA Technical Paper 8: 96-104.
Perner, C. (1994a). Notes on the 'appropriateness' of the fishing project 'Pisces' in Upper Nile area. Letter from Kwacokworo to Philip O'Brien, 04.04.94.
Perner, C. (1994b). The Anyuak – Living on Earth in the Sky. Volume 1: The sphere of spirituality. Helbing & Lichtenhahn.
Perner, C. (1997). The Anyuak – Living on Earth in the Sky. Volume I1: The human territory. Helbing & Lichtenhahn.
Rottcher, N. (1997a). Fishery Assessment to Pochalla, Anyuak Kingdom. ECHO/OLS Fisheries Consultant.
Rottcher, N. (1997b). Fishery Assessment of Bieh State, Central Upper Nile
Rottcher, N. (1997c). Preliminary assessment of fishery and fisheries needs in Akobo and Wanding, Upper Nile.
Rzoska, J., 1974. The Upper Nile swamps, a tropical wetland study. Freshwat.Biol., 4:1–30
Rzóska, Julian (ed.). The Nile – biology of an ancient river. 1976
Säfholm, P. (1973). The river-lake Nilotes. Uppsala.
Sandon, H. An illustrated guide to the freshwater fishes of the Sudan. SNR, 1st, 1950, card covers.
Sandon, H. and A. Tayib, 1953. The food of some common Nile fish. Sudan Notes Rec., (34):205–23
Sayer, J.A. and L.P. van Levieren, 1975. The ecology of the Kafue lechwe population of Zambia before the operation of hydro-electric dams on the Kafue River. E.Afr.Wildl.J., 13:9–37
Seligman, C.G. & B.Z. Seligman (1932). Pagan tribes of the Nilotic Sudan. George Routledge & Sons, London.
Sutcliffe JV & YP Parks (1999). The hydrology of the Nile – Chapter 7: The Sobat Basin & the Machar Marshes
Vanden Bossche, J.-P. and G. Bernacsek, 1990a, b, 1991. Source book on the inland fishery resources of Africa. Vol I. CIFA Tech. Pap., 18/1-3: 870 pp.
Welcome, R.L. and D. Hagborg, 1977. Towards a model of a floodplain fish population and its fishery. Environ.Biol.Fish., 2(1):7–22
Welcome, R.L., 1972. The inland waters of Africa. Les eaux interieures d'Afrique. CIFA Tech.Pap./Doc.Tech.CPCA, (1):117 p.
Welcome, R.L., 1975. The fisheries ecology of African floodplains. CIFA Tech.Pap., (3):51 p. Issued also in French
Welcome, R.L., 1976. Some general and theoretical considerations on the fish yield of African rivers. J.Fish Biol., 8:351–64
Welcome, R.L., 1979. The fisheries ecology of floodplain rivers. London, Longman, 317 p.
Welcomme, R.L., River fisheries. FAO Fish. 1985 Tech.Pap., (262): 330 p.
Williams, R., 1971. Fish ecology of the Kafue River and floodplain environment. Fish.Res.Bull., Zambia, (5):305–30

APPENDIX 1: SCOPE OF WORK

SSTCM Youth Fisheries Support and Economic Growth Engagement Opportunities Assessment
Nasir County, Upper Nile State, and Akobo County, Jonglei State
S3STTA011

A. INTRODUCTION AND OVERVIEW OF THE STTA

USAID's South Sudan Transition & Conflict Mitigation program (SSTCM) was initiated to support the understanding and implementation of the Comprehensive Peace Agreement (CPA). Following the establishment of an independent South Sudan, the program continues to support activities intended to revitalize war-shattered communities, cultivate peaceful dialogue, and promote stability and democratic transformation according to the political framework set forth in the peace protocols and in the transitional constitutions at RSS and state levels.

AECOM, operating in South Sudan as AECOM International South Sudan (AISS), implements the SSTCM program on behalf of USAID's Office of Transition and Conflict Mitigation (OTCM) by managing a comprehensive in-kind grants program, providing commodities and services to grantees for their implementation of mutually agreed upon activities.

SSTCM is seeking to provide appropriate technical assistance to USAID South Sudan Mission, other donors and the Government of South Sudan with respect to viable opportunities to enhance environmentally sensitive economic development in a conflict sensitive manner, among some of the most conflict affected rural communities in Jonglei and Upper Nile States. The STTA will assess the 2012 interventions in the Sobat River corridor to prepare a SWOT analysis with clear indications of successes, failures, opportunities and threats for ongoing support over the next three years by USAID and other donors.

BACKGROUND ON THE SSTCM SUPPORT TO YOUTH LIVELIHOODS THROUGH FISHERIES ACTIVITIES

In November and December, 2011, SSTCM undertook an early dry season assessment of the Sobat River fisheries between Nasir and Akobo. The purpose of the assessment was to develop an understanding of the existing markets and value-chains associated with fisheries and commerce in the area; to identify opportunities where infrastructure, material inputs or training could help increase safe productive river use in otherwise inaccessible areas. The assessment focused on activities which can improve harvesting methods, product quality, access to markets and innovations that enhance market opportunities.

Discussions were held with government officials, local community based organizations (CBO's), International non-governmental organizations (INGOs), youths (*bunam*), youth leaders, and village fishery focus groups. Key informants, industry middle-men in Nasir, Akobo, Malakal and Juba, transportation industry providers, trade unions, fish industry experts, processing equipment providers, engineering consultants, and fish consumers, were also consulted. The assessment resulted in these main findings:

- Fisheries equipment and training is necessary.
- Lack of financial capital prevents participants from accessing required equipment.

- Youth (*bunam*) and youth leaders are interested in fishing, especially after seeing the profits they can reap from it.
- All river systems have significant and valuable harvestable species.
- Lack of transportation options limits market access.
- Limited processing options constrain value-added interventions.
- Conflict over river access is an ongoing issue.

Commencing in January 2012 and continuing through July 2012, the SSTCM program launched a number of project activities (in kind grants) which sought to address some of the key findings in the initial assessment. These included 7 grants that directly engaged with and provided technical advisory assistance, training and equipment (motorboats, fiberglass canoes, nets, hooks, etc.) and small scale infrastructure built by the youth themselves (fishing storage buildings, fish dryers and smokers) to youth based fisher groups along the Sobat River, especially Akobo, Dengjok, Nyandit, Nasir, Wanding, Jikmir and Kurmout communities. One additional grant later provided resources for the construction of a new fish market building in Nasir town. Three local CBOs (UNSYAD, NCDA and AYA) were SSTCM's implementing partners for the project. These CBO's were responsible for interacting with the local community leaders and youth fishers groups. One of the important roles of the local NGO implementing partners was to engage with the community and payam administrations, and traditional authorities, to enhance awareness and commitment to conflict sensitive community-based fisheries management and territorial fishing use rights, The implementation of the activities also intended to look at how relationships along the value chain could be strengthened and expanded as ways of organizing the fishers/processors/ markets and reducing conflicts. SSTCM made an investment of just over $ 1 million USD in these 8 projects, over the course of about 10 months of implementation. directly engaging with more than 400 youth fishers and many more households, traders and river transporters as well as directly engaging with community, payam and county administrations. These initiatives were seen as having made a significant positive impact for conflict mitigation in these communities, engaging youth prone to cattle raiding during the dry season.

BACKGROUND ON THE STTAS - THREE SEPARATE BUT LINKED COMPONENTS

General Overview of the Situation: The Republic of South Sudan, independent since July 9, 2011, faces a host of stabilization challenges as it transitions to full and responsible statehood. The new state faces a complex web of challenges which fuel local tensions and undermine the government's capacity to extend authority over large swathes of its territory, raising fears of the creation of a failed state. A sprawling, sparsely populated landscape with little physical infrastructure makes it difficult for under-resourced and over-stretched local governments to provide services, including security. Cattle herders compete over scarce resources of water and grass during the dry season, while a culture of cattle raiding, fueled by easy access to arms after the civil war, leads to tit-for-tat raids which can quickly escalate into full-scale conflict between groups. Moreover, a meager local economy and limited access to education provides few alternatives to life in the cattle camps for youth, who, idle and unemployed, are ready recruits for cattle raids, intertribal conflict and rebel insurgencies. In view of this, the challenge for the immediate post-independence period is stabilizing the new state.

Spanning Upper Nile and northern Jonglei and spilling across the border with Ethiopia, the Sobat River Corridor is a remote and volatile area with a long history of destabilizing conflict. Stretching from Malakal to Pibor and encompassing Nyirol, Uror, Nasir, Ulang and Akobo, the Sobat Corridor has for decades been on the frontline of wars between north and south and within the south. The reverberations of these conflicts, in the form of proxy militia remnants and a profusion of small arms, layered on top of ethnically-based competition over scarce resources of water and grass, continue to destabilize the area. Nor have Sudan civil war-era patterns of divide and

rule entirely disappeared; the rebel forces of former SPLA Lieutenant General George Athor, before Athor's death in December, were accused of funneling small arms from the north to Lou Nuer youth allies. Over the past year, retaliatory attacks on a massive scale between the Lou Nuer of Uror, Nyirol and Akobo counties and Pibor County's Murle have killed thousands of people, captured hundreds of thousands of cattle, and threatened to send the center of Jonglei State into all-out war. By contrast, considerable involvement in the last year and a half by SSTCM in Nasir and Akobo, centered on the town of Wanding, has resulted in a markedly improved relationship between the Lou Nuer and Jikany Nuer. As learned from Nasir and Akobo, key to creating peace in the Sobat Corridor is addressing the region's extreme economic and physical isolation – including a dearth of accessible roads and trade routes – and providing alternatives to cattle raiding and gun-related livelihoods for local, uneducated and idle youth. Consolidating and expanding the gains of the two years in Nasir and Akobo is vital if the Sobat Corridor, one of South Sudan's most isolated and underdeveloped areas, is to find stability and recover.

The communities in Nasir, Ulang and Akobo counties face the daunting challenge of addressing a two decade-long inter-communal conflict between the Lou Nuer and Jikany Nuer ethnic groups. The junction of these counties along the bank of the Sobat River in southeastern Upper Nile State and northeastern Jonglei State are an isolated area, dependent on dry-season tracks and river transport. A split in the SPLA, expulsion of South Sudanese refugees from Ethiopia, and a ferocious drought in the early 1990s sparked the long conflict between Nasir and Ulang's Jikany Nuer and the Lou Nuer of Akobo in Jonglei State. Recent efforts supported by SSTCM to create peace in the contentious Wanding payam as well as to strengthen the local government and provide peace dividends to the population have significantly improved conditions in these three counties. However, the area has a large population of illiterate youth and demobilized SPLA soldiers possessing easy access to arms, and engaging and providing employment opportunities to these youth will be critical to creating an enabling environment for development and stability in this area in the long term.

Youth, who are often susceptible to political manipulation and cattle-raiding for profit or revenge, are a key component to lasting peace in the area. Violent confrontation between Lou and Jikany youth in can rapidly undermine achievements and agreements and has threatened to do so in recent months. Youth livelihoods are largely based on cattle, with few alternative opportunities available, providing a large pool of underemployed and unengaged youth available to involvement in cattle raiding and retaliatory attacks, if the relationship between Lou and Jikany should degenerate. In an effort to engage and provide livelihood alternatives to violent cattle-raiding, SSTCM has undertaken a number of direct activities with the region's youth which has given the opportunity for more than 400 youth to engage in a contextually appropriate livelihood alternative to cattle raiding.

Component 1: Impact assessment of the FY2012 SSTCM engagement in the Sobat River Basin youth fisheries projects: This component of the STTA would provide technical expertise to return to the 6 communities over a six - eight week period and assess the ongoing involvement of the youth in the river fisheries, with a focus on determining the extent to which the fisheries opportunities provided legitimate alternatives to cattle raiding, and with a special focus directed towards the sustainability of the local fisheries activities and the conflict impact and opportunities, whether successfully acted upon or not. The STTA would include a conflict sensitive approach, to determine how much the previous SSTCM program activities actually contributed towards positive community-based fisheries management, conflict sensitive territorial fishing use rights, and if any interventions that helped build the value chain was done in a conflict sensitive manner.

This study would look deeper at the opportunity and impact and intended sustainability (SWOT analysis) of the previous market related support interventions by SSTCM, from the actual production / catching / fishing activity, through the provision of motorboats for transport of equipment and fish product, preservation (drying and

smoking) initiatives and any other important aspects of the nascent Sobat youth fisheries. The study would also investigate the existing and potential market opportunities and present possible opportunities for donor based interventions to support the development of a successful private sector or public / private partnership in economically viable fisheries along the Sobat River. Additionally the STTA would look at other technical / academic interventions like the Padak Fisheries Training Center in Bor, supported by Borlaug Institute (Texas A & M) and USAID, FAO, UNDP, GTZ, and WCS to present observations and recommendations for linkages over the short- and medium-term (1 to 3 years) between SSTCM and USAID Economic Growth, and between USAID and other donor funded initiatives and government ministries / departments, that might be expected to contribute to the development of an economically viable conflict sensitive fisheries industry based on the Sobat River, and investments to date by USAID SSTCM.

Component 2: Environmental baseline information gathering: This component of the STTA would provide technical expertise to produce appropriate scientific environmental / ecological information to support further investment by USAID directed towards the economic viability of the fisheries activities and the knock-on economic impact and opportunities, whether successfully acted upon or not. This study would engage with the Ministry of Animal Resources and Fisheries (MARF) in Juba, and at the state level, as well as with academic institutions as needed, but the main focus would be on field based investigations to support the preparation of credible environmental / ecological guidance to USAID and other donors, as well as MARF. In collaboration with the RSS MARF, the STTA would engage with other technical / academic interventions like the Padak Fisheries Training Center in Bor, supported by Borlaug Institute (Texas A & M) and USAID, FAO, UNDP and GTZ to collect existing information and documentation related to the environmental and ecological aspects of Sobat River basin fisheries. The MARF government counterpart would play a significant role in providing technical guidance and being a depository of information and scientific data.

Component 3: Economic livelihoods baseline information gathering: This component of the STTA would determine baseline information related to household incomes and livelihoods along the Sobat River communities, and investigate the existing and potential market opportunities and value chain issues for medium to long term engagement in support of the fisheries. The STTA would look carefully at the current markets being utilized by the youth fisheries and all related value chain activities, and investigate public, private and community proposals for expanded economic fisheries related initiatives for viability. The STTA would would also assess the potential for community-based fisheries management, territorial fishing use rights, and strengthening relationships along the value chain as ways of organizing the fishers/processors/ markets and reducing conflicts. The consultant would also investigate possible opportunities for donor based interventions as pilot projects to support the development of a successful private sector or public / private partnership in economically viable fisheries along the Sobat River. Additionally the STTA might look at other technical / academic interventions like the Padak Fisheries Training Center in Bor, supported by Borlaug Institute (Texas A & M) and USAID, FAO, UNDP, GTZ, and WCS to present observations and recommendations for linkages and / or pilot projects over the short- and medium-term (1 to 3 years) between SSTCM and USAID Economic Growth, and between USAID and other donor funded initiatives and government ministries / departments, that might be expected to contribute to the development of an economically viable conflict sensitive fisheries industry based on the Sobat River, and investments to date by USAID SSTCM.

B. SCOPE OF WORK

Component 1 Objectives: Evaluation of the FY2012 SSTCM engagement in the Sobat River Basin youth fisheries projects)

1. To critically assess SSTCM's 2012 interventions to support the development of a nascent youth focused conflict sensitive fisheries along the Sobat River corridor between Nasir and Akobo; especially the impact of the supported activities on localized and state wide conflict issues, as well as at impact on livelihoods and local economic stability and development;

2. To investigate and clearly articulate detailed opportunities within reasonable timeframes/phases for wider engagement in the Sobat River fisheries by other stakeholder groups, investors, government entities and international assistance actors in the establishment of an economically viable, environmentally sound and conflict sensitive fisheries;

3. Assess conflict mitigation and management threats and opportunities of developing the fish sector (e.g., who are the key targets, what rivalries could the intervention create or exacerbate); and

4. To investigate and clearly articulate detailed opportunities for academic and technical advisory services to strengthen the existing Sobat River fisheries, and to link to opportunities identified in objective 2, above.

Component 2 Objectives (Environmental baseline information gathering) :

1. Investigate and clearly articulate the basic fisheries biology and ecology of the Sobat River basin, with respect to community based fisheries, producing a conservative estimate of sustainable yields for each fishery, articulated by species and/or ecological group. The report on these issues should be compatible with the USAID ERF/ ERR format.

2. Evaluate necessary and appropriate means of regulating the potentially growing fishing sector to mitigate risks of over-harvesting and habitat destruction. The report on these issues should be formatted so that it can be used as an IEE for a potential future project.

3. Provide guidance and recommendations for USAID with respect to investment / engagement in the Sobat River fisheries by USAID and by other stakeholder groups, investors, government entities and international assistance actors in the establishment of an economically viable, environmentally sound and conflict sensitive fisheries; and

4. To investigate and clearly articulate detailed requirements and opportunities for additional academic research and technical advisory services to ensure appropriate responses to environmental issues related to the Sobat River fisheries, and to link to opportunities identified in objective 2, above.

Component 3 Objectives (Economic livelihoods baseline information gathering) :

1. Investigate the basic household level economic security and livelihoods for the rural communities along Sobat River, as well as any commercial economic activities that are or may be linked to expanded fisheries related economic activities in the future;

2. Investigate fisheries related value chains from the production / fish catching areas to the local markets, wholesale agents, transport, secondary and tertiary production possibilities (fish drying, smoking, freezing, fish products, etc) and to more prominent market possibilities like Malakal, Bor, Juba and Sudan;

3. Investigate and recommend the possible role of a MYAP *(Multi year Assistance Program)*

C. PRIMARY ROLES AND RESPONSIBILITIES FOR ALL 3 COMPONENTS WILL INCLUDE:

- Engage with the youth fishermen, businessmen, youth associations, and relevant authorities (at *NATIONAL* state and county and payam levels) via focus group consultations and key informant interviews

- Engage with other development assistance actors in the fisheries sector, including JICA/CAMP, FAO, GTZ, JFSP (USAID), WCS (USAID) and others as appropriate, to better understand past, current and future (planned) activities and initiatives implemented by other organizations or actors to better understand the current situation and to support the development of a set of lessons learned and possible avenues for coordination;

- Identify implementable and replicable project activities that will build on previous SSTCM or other projects to improve livelihood options through product quality, enhance market accessibility, access to markets, enhance market opportunities and improve value addition in input and output marketing chains, which may be followed up by USAID, other donor and/or private public partnership programs;

- Provide the SSTCM DCOP with a weekly update, identifying constraints and plans for the following week, reports from focus groups and interviews, and a final report; and

- Any other task or duty that may be requested.

D. LEVEL OF EFFORT: WILL BE SEPARATELY NEGOTIATED AND AGREED UPON FOR EACH OF THE 3 COMPONENTS:

Total level of effort not to exceed (TBD in specific SOWs) days (6 day work weeks), inclusive of travel. An estimate of LOE per STTA component would be:

1. Initial consultations with USAID EG and OTCM and SSTCM - 2 days
2. Field work - 21 - 36 days
3. Production of a draft SSTCM assessment report - 4- 6 days
4. Engagement with other development assistance actors, government, academic and private sector actors - Malakal, Bor, Juba - 6- 12 days
5. Follow up field visits - 0 - 12 days
6. Workshop / presentation with USAID Economic Growth team and partners in Juba - 2 days
7. Modification of materials and report writing (interim and final), and working with translators - 3 - 6 days
8. Travel days to and from South Sudan up to 4 full or part days.

E. DELIVERABLES:

1. Work plan to be approved by USAID OTCM in consultation with EG with a detailed timeline and benchmarks for the consultancy.
2. Submission of weekly updates (as per prior consultant's format)
3. Presentation of findings and recommendations to USAID
4. Submission of an interim report focused on the field work
5. Submission of a final report consolidating findings and highlighting areas of opportunity for ongoing engagement and investment in the fisheries sector.

F. SUPERVISION

SSTCM DCOP or COP

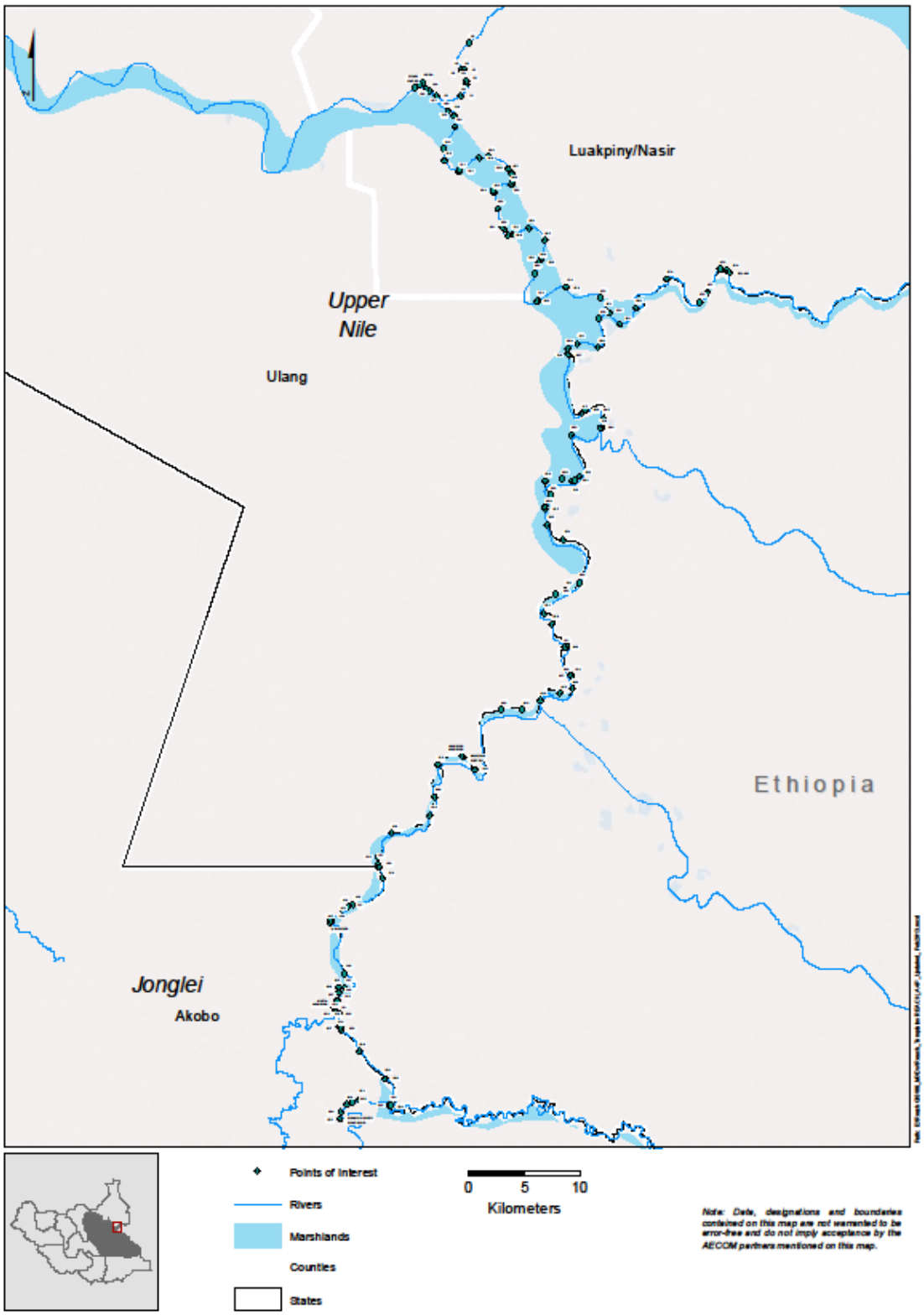
G. QUALIFICATIONS AND EXPERIENCE

- Demonstrated experience and understanding of rural fisheries, constraints and opportunities;
- Good analytical and interpersonal skills;
- Ability and willingness to travel and work in remote, poorly serviced locations with risk of insecurity;
- Proven communications, assessment and report writing skills; and
- South Sudan experience an asset.

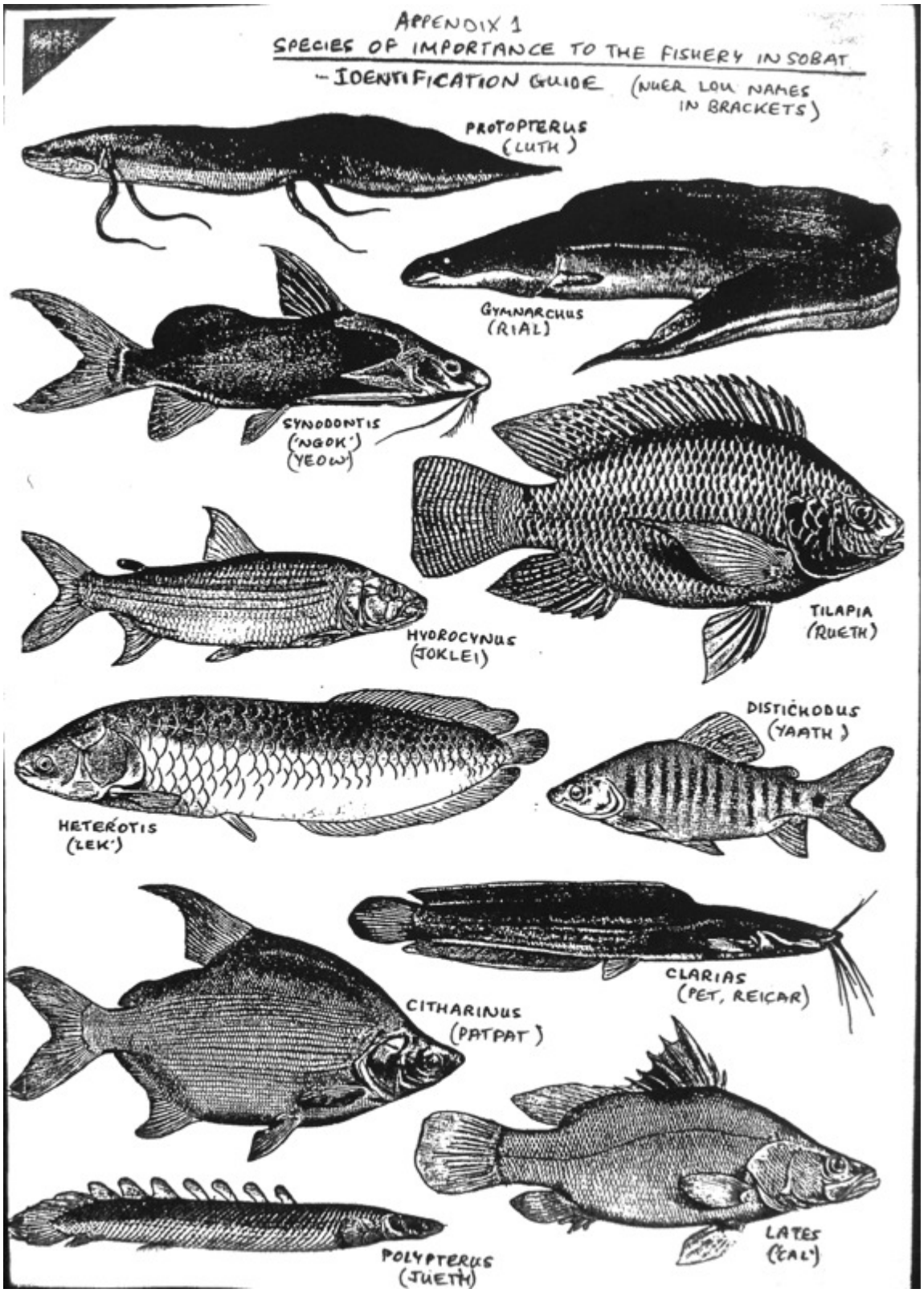
H. FIELD CONDITIONS

Field conditions will be basic and primitive. There is likely to be considerable walking or travel by boat in wet muddy conditions and irregular access to infrastructure or mobile phone network; a satellite phone will be provided.

APPENDIX 2: MAP OF SURVEY AREA



APPENDIX 3: DRAWINGS FROM BOULENGER 1907 TO IDENTIFY FISH



APPENDIX 4: FISHERIES SEASONAL CALENDAR

APPENDIX 5: BIOLOGICAL SYNOPSES OF FAMILIES OR SPECIES OF IMPORTANCE TO THE FISHERY

The following are some notes on the biology of the important species / groups:

Clarias gariepinus. Adults occur mainly in quiet waters, lakes and pools but may also occur in fast flowing rivers and in rapids. Widely tolerant of extreme environmental conditions. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions. They remain in the muddy substrates of ponds and occasionally gulp air through the mouth. Can leave the water at night using its strong pectoral fins and spines in search of land-based food or can move into the breeding areas through very shallow pathways. Are bottom feeders which occasionally feed at the surface. Feed at night on a wide variety of prey like insects, plankton, invertebrates and fish but also take in young birds, rotting flesh and plants. Migrate to rivers and temporary streams to spawn. Also caught with dragnets. During intra-specific aggressive interactions, this species was noted to generate electric organ discharges that were monophasic, head-positive and lasting from 5-260 ms. Known as sharptooth catfish in aquaculture, a highly recommended food fish in Africa.

Heterotis niloticus. Young found in swampy places among aquatic vegetation; adults live in the open water of rivers and lakes, where they can be found in the pelagic zone as well as the littoral zone. Are able to survive in deoxygenated waters; the hardiness of this fish, together with its great growth rate make it a candidate for aquaculture in Africa and it has been transported to a number of countries for this purpose. Escapees from ponds into the wild resulted in established populations, which form the basis for fisheries. Are considered as mud-feeders, but in West Africa also as phytoplankton feeders. Feed mostly on plankton, being the only plankton-feeders of the Osteoglossidae. It has a suprabranchial organ which has a sensory function, but also a mechanic function in concentrating the little food particles. During breeding, mature adults create a circular nest in swamps. The young leave the nest after a few days and are guarded by the male.

Gymnarchus niloticus. Following flooding of the river banks this species builds large elliptical floating nests in densely vegetated swamps at depths of about 1-1.5 m; lays about 1000 `amber-like' eggs; larvae hatching after 5 days. Feeds on crustaceans, insects and fish. No pelvic, anal or caudal fins. Possesses an electric organ that extends along almost the entire trunk to the tip of the tail.

Lates niloticus. Inhabits channels, lakes and irrigation canals. Adults inhabit deep water, while juveniles are found in shallow water. Feeds on fish especially clupeids and *Alestes*; smaller fish also feed on larger crustaceans and insects. Juveniles are planktivorous.

Oreochromis (Tilapia) niloticus. Occur in a wide variety of freshwater habitats like rivers, lakes, sewage canals and irrigation channels. Mainly diurnal. Feed mainly on phytoplankton or benthic algae. Oviparous. Mouthbrooding by females.

Polypterus bichir. Likes shallow water and will often lie basking fo hours near the surface, but when swimming the fish is very pliant, and can turn and twist like an eel. The eggs are deposited in weeds, where the adult fish guards the eggs and young. It feeds on bottom-feeding fish and is essentially piscivorous.

Citharinus citharus. Common in large rivers of the Sudan region.

Hydrocynus lineatus. Prefers warm, well-oxygenated water, mainly larger rivers and lakes. All but the largest form roving schools of like-sized fish; fierce and voracious. Feeds on whatever prey is most abundant but Brycinus, Micralestes, Barbus, and Limnothrissa are favored.

Synodontis schall. Omnivore, feeds on insect nymph, larvae, eggs and detritus. Also feeds on fish, bivalves in the Sudd and snails in Gezira irrigation canals. Oviparous. Breeding occurs during the flood season.

Heterobranchus longifilis. An uncommon species which inhabits large rivers. Occurs in large deep rivers within the mainstream or in deep pools and lakes. Most active at night, feeding on any available food, including invertebrates and insects when small, fish and other small vertebrates when large. Scavenges off large carcasses and offal from riverside villages. Lives for 12 or more years.

Distichodus niloticus. Macro-herbivores, feed on submerged water plants, Eichhornia roots and periphyton. Oviparous.

Mormyridae (several species). Nocturnal, shoaling, hunt in a shoal using electric fields.

APPENDIX 6: CREEL SURVEY RESULTS

Figure 1. Length-frequency for Heterobranchus

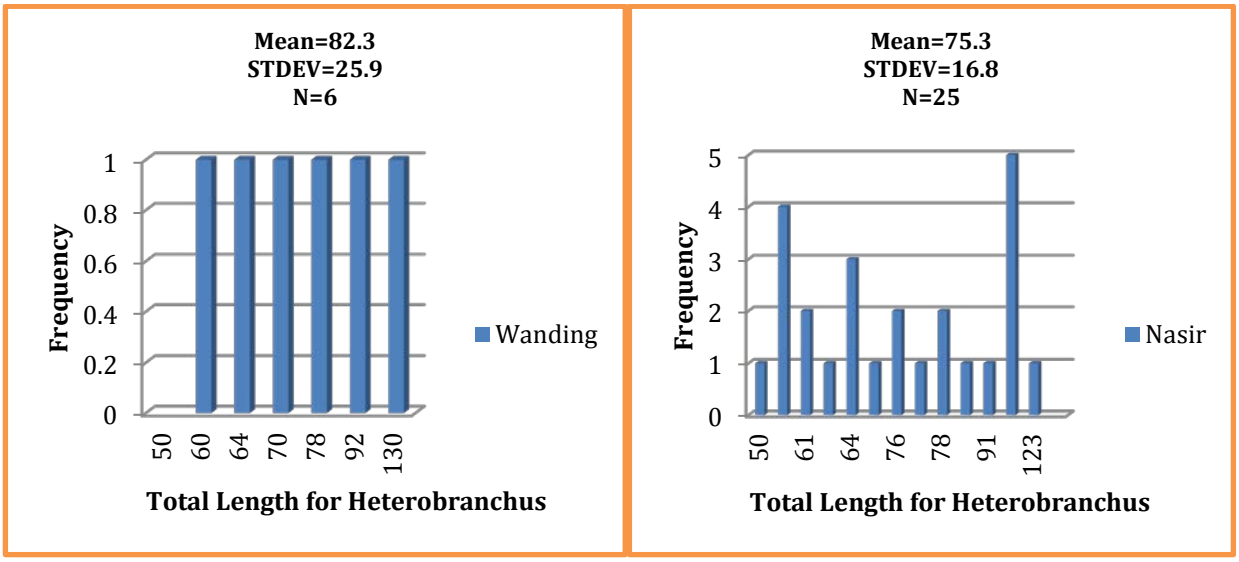


Figure 2. Length-frequency for Gymnarchus

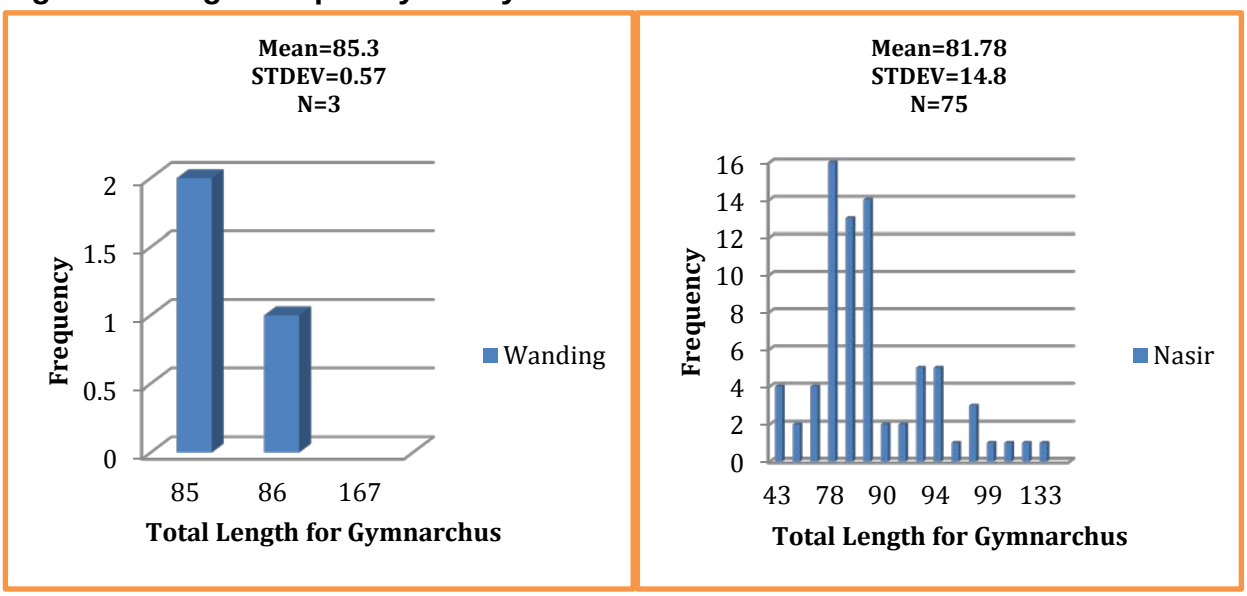
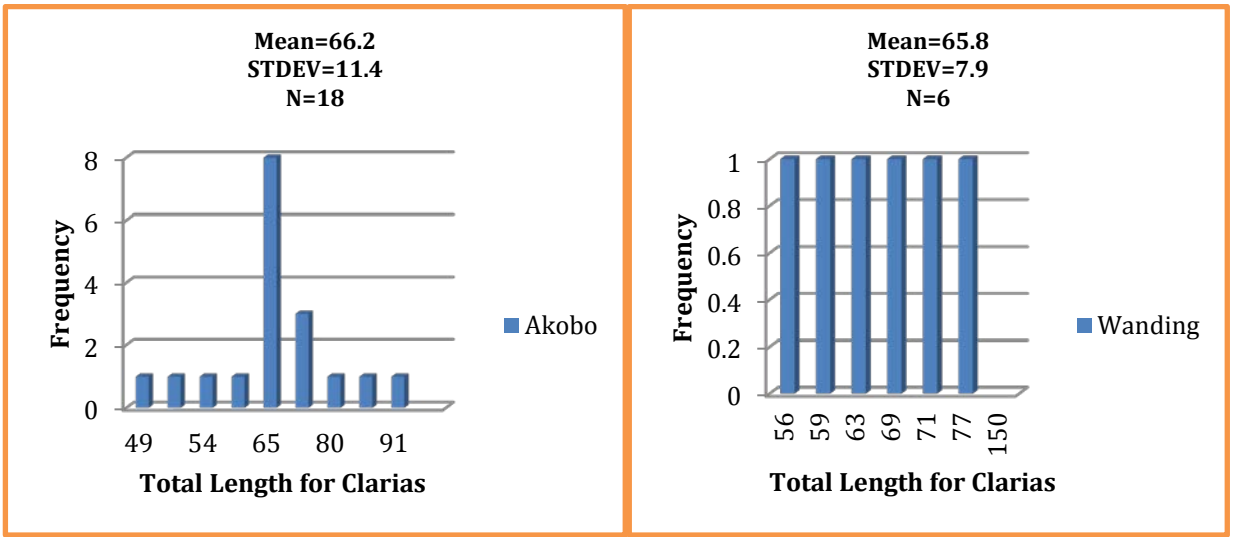


Figure 3. Length-frequency for Clarias



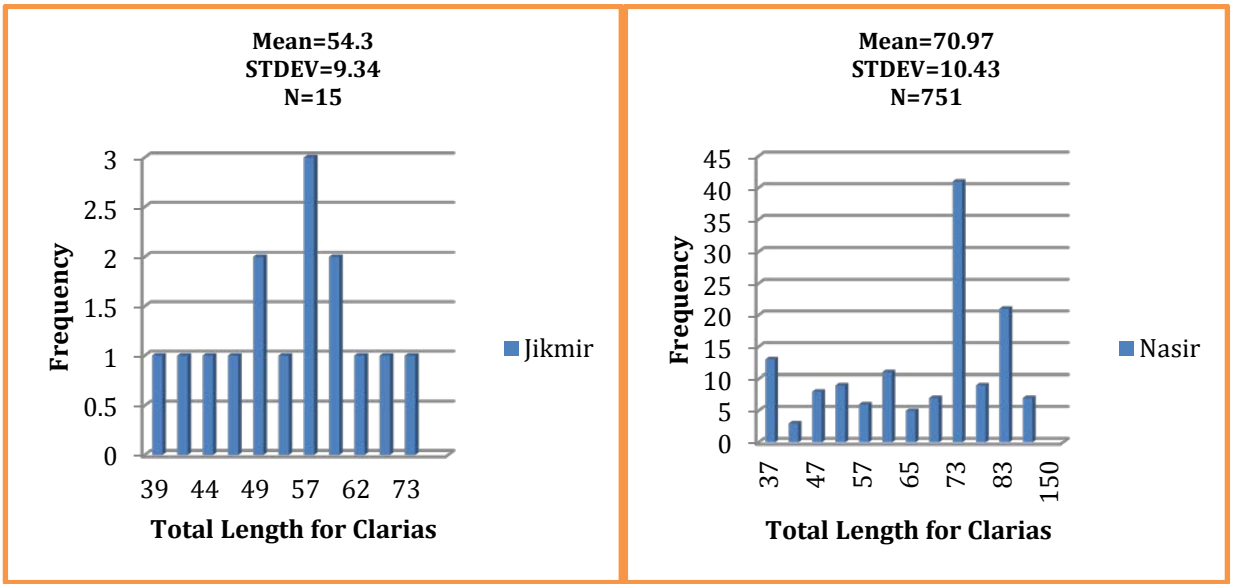


Figure 4. Length-frequency for Heterotis

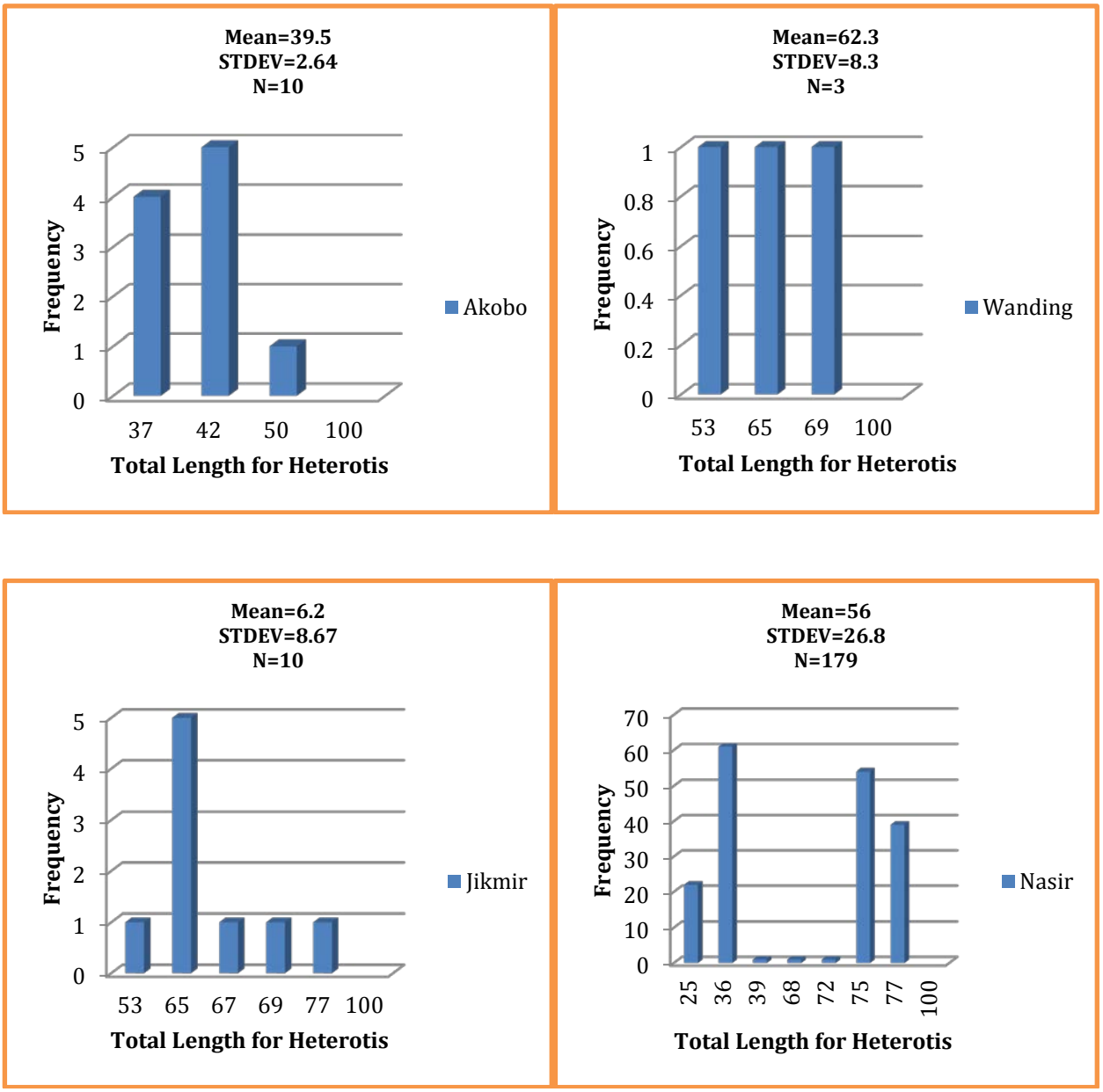


Figure 5. Length-frequency for Distichodus

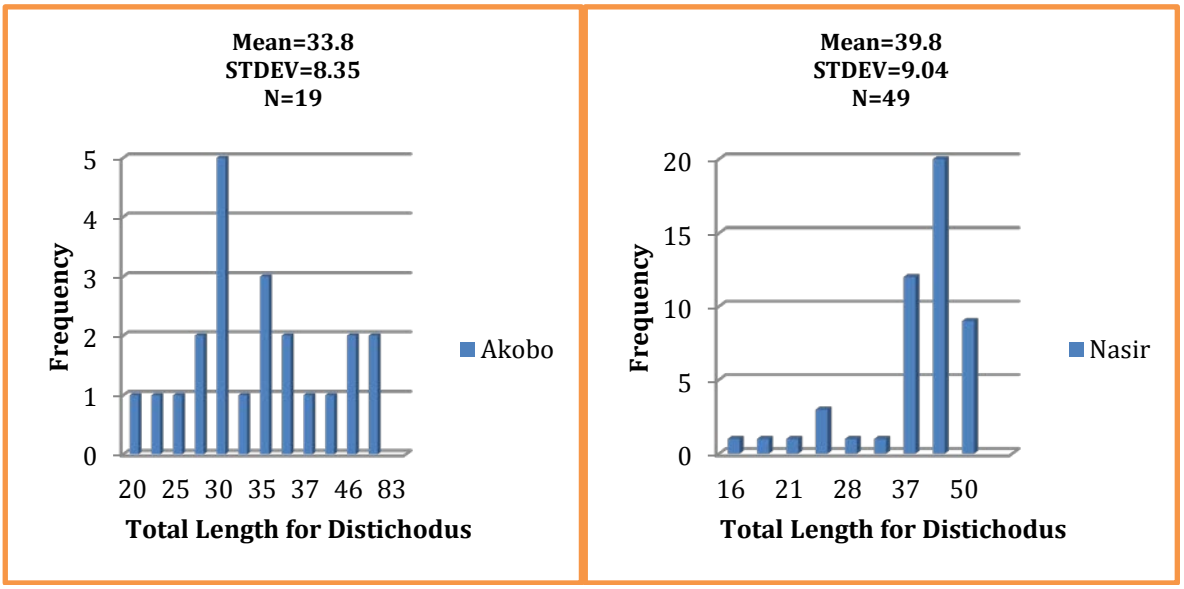


Figure 6. Length-frequency for Citharinus

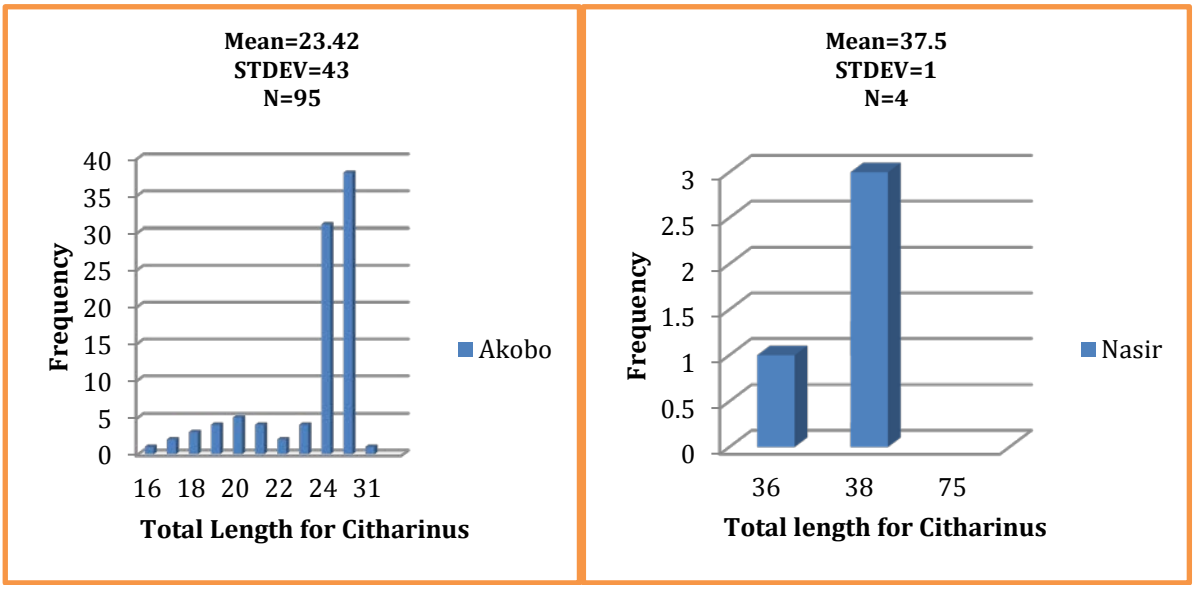


Figure 7. Length-frequency for Hydrocynus

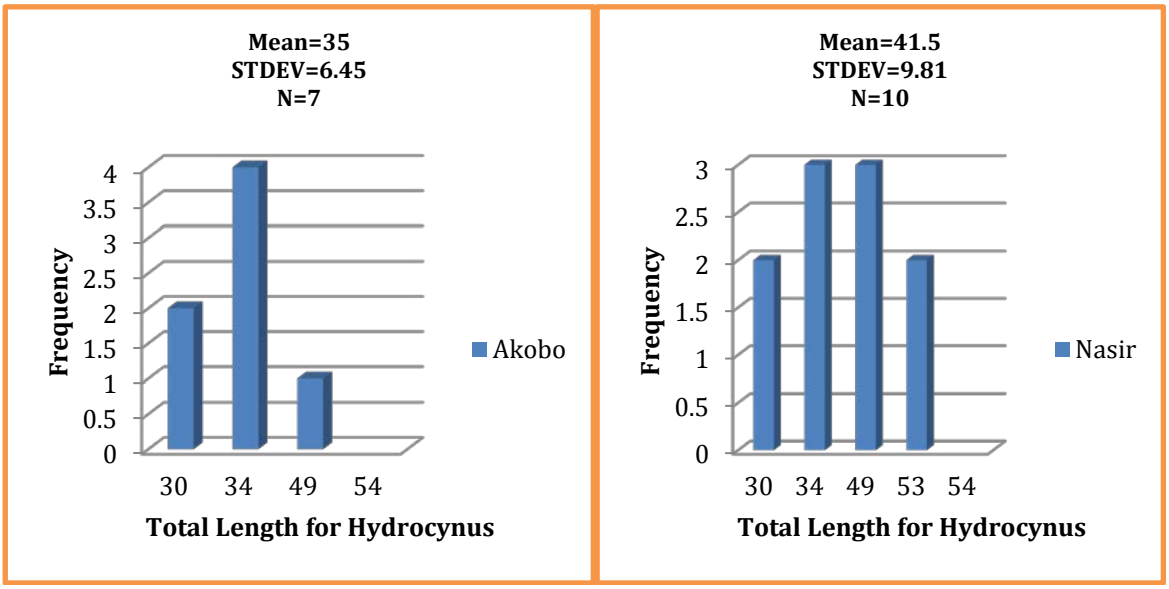


Figure 8. Length-frequency for Tilapia

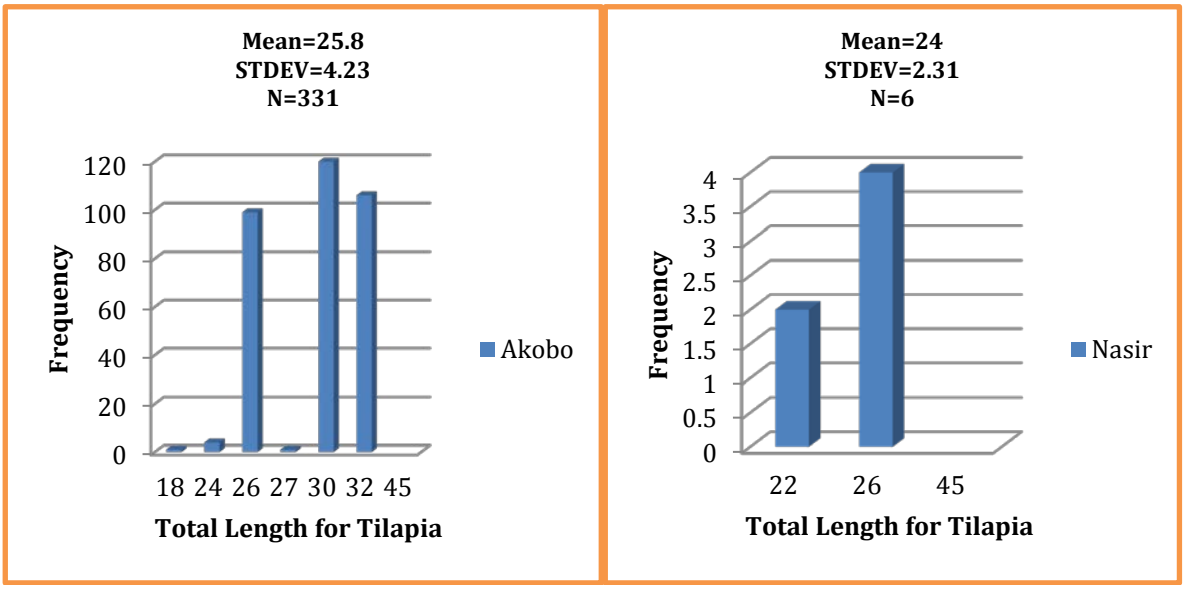


Figure 9. Length-frequency for Nile Perch

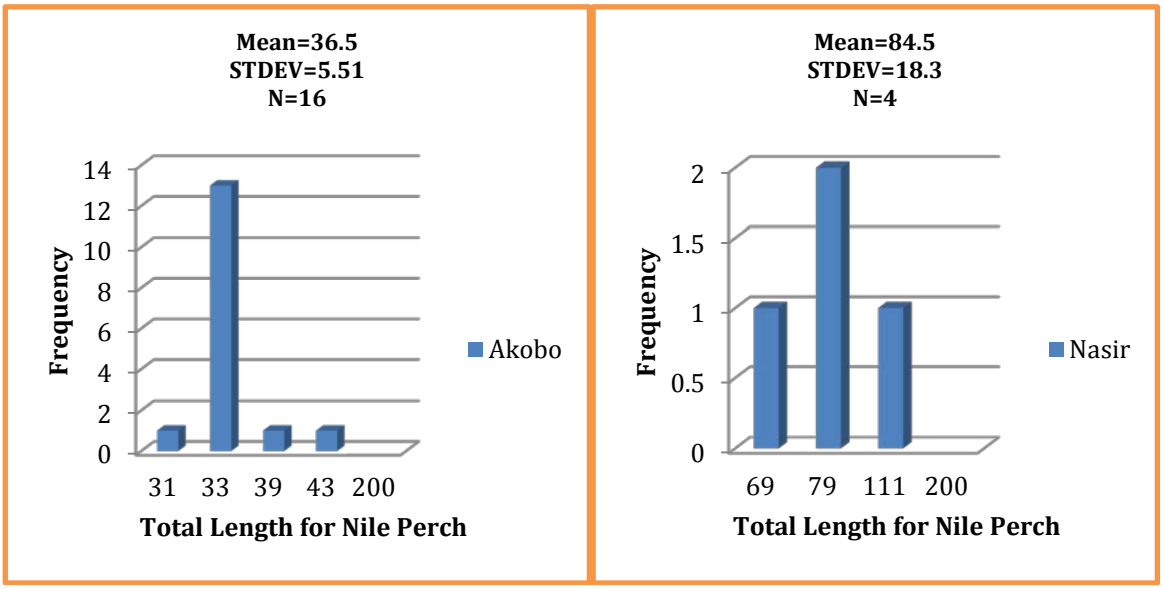


Figure 10. Length-frequency for Synodontis

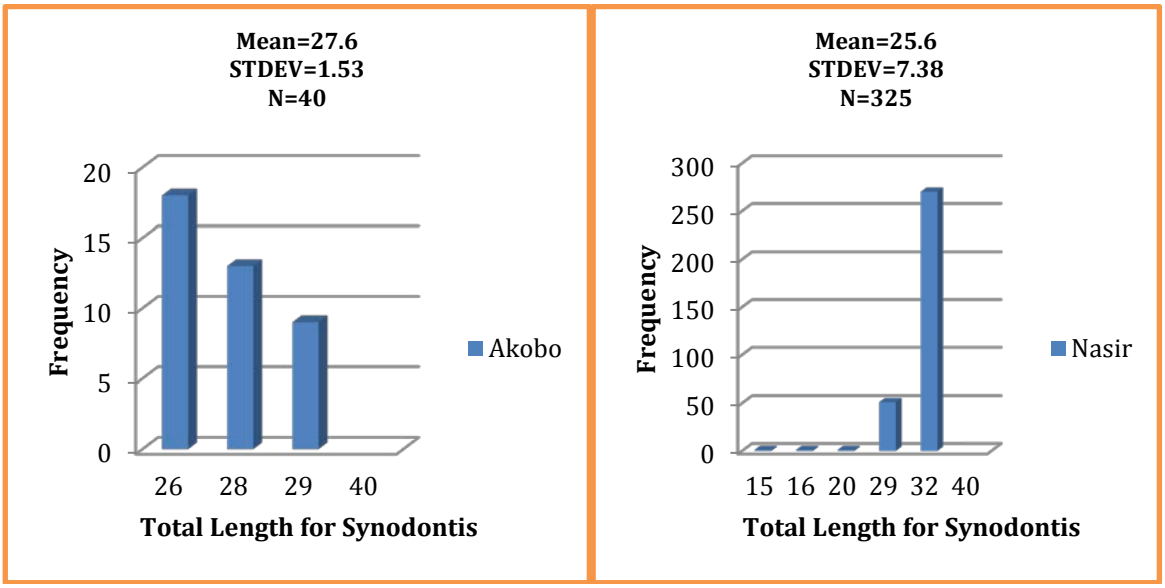


Table 1. Length-frequency for Clarias

Date	Location	Species	Below Min Length 25cm	Min length 50cm	Common Length 90cm	Max Length 150cm	Mean	STDEV	Number
3/6/2013	Akobo	Clarias	1	16	2	0	66.2	11.43	18
16/6/2013	Wanding	Clarias	0	6	0	0	65.8	7.9	6
18/6/2013	Jikmir	Clarias	6	6	9	0	54.3	9.34	15
20/6/2013	Nasir	Clarias	19	745	6	0	70.97	10.43	751

Table 2. Length-frequency for Gymnarchus

Date	Location	Species	Below Min Length 25cm	Min length 50cm	Common Length 85cm	Max Length 167cm	Mean	STDEV	Number
3/6/2013	Akobo	Gymnarchus	0	0	0	0	0	0	0
16/6/2013	Wanding	Gymnarchus	0	0	3	0	85.3	0.57	3
18/6/2013	Jikmir	Gymnarchus	0	0	0	0	0	0	0
20/6/2013	Nasir	Gymnarchus	4	741	6	3	81.78	14.82	75

Table 3. Length-frequency for Heterobranchus

Date	Location	Species	Below Min Length 25cm	Min length 50cm	Common Length 75cm	Max Length 150cm	Mean	STDEV	Number
3/6/2013	Akobo	Heterobranchus	0	0	0	0	0.0	0.0	0.0
16/6/2013	Wanding	Heterobranchus	0	0	5	1	82.3	25.9	6
18/6/2013	Jikmir	Heterobranchus	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Heterobranchus	0	12	12	1	75.3	16.8	0

Table 4. Length-frequency for Distichodus

Date	Location	Species	Below Min Length 17cm	Min length 23cm	Common Length 45cm	Max Length 85cm	Mean	STDEV	Number
3/6/2013	Akobo	Distichodus	0	17	4	0	33.8	8.35	19
16/6/2013	Wanding	Distichodus	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Distichodus	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Distichodus	2	16	31	0	39.8	9.04	49

Table 5. Length-frequency for Citharinus

Date	Location	Species	Below Min Length 15cm	Min length 20cm	Common Length 35cm	Max Length 75cm	Mean	STDEV	Number
3/6/2013	Akobo	Citharinus	7	88	0	0	23.42	43	95
16/6/2013	Wanding	Citharinus	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Citharinus	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Citharinus	0	0	4	0	37.5	1	4

Table 6. Length-frequency for Heterotis

Date	Location	Species	Below Min Length 20cm	Min length 35cm	Common Length 60cm	Max Length 100cm	Mean	STDEV	Number
3/6/2013	Akobo	Heterotis	0	10	0	0	39.5	2.64	10
16/6/2013	Wanding	Heterotis	0	1	2	0	62.3	8.3	3
18/6/2013	Jikmir	Heterotis	0	1	9	0	6.2	8.67	10
20/6/2013	Nasir	Heterotis	0	80	99	0	56	26.8	179

Table 7. Length-frequency for Hydrocynus

Date	Location	Species	Below Min Length 13cm	Min length 17cm	Common Length 30cm	Max Length 54cm	Mean	STDEV	Number
3/6/2013	Akobo	Hydrocynus	0	0	7	0	35	6.45	7
16/6/2013	Wanding	Hydrocynus	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Hydrocynus	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Hydrocynus	0	0	8	2	41.5	9.81	10

Table 8. Length-frequency for Tilapia

Date	Location	Species	Below Min Length 13cm	Min length 17cm	Common Length 30cm	Max Length 54cm	Mean	STDEV	Number
3/6/2013	Akobo	Tilapia	0	113	218	25.8	25.8	4.23	331
16/6/2013	Wanding	Tilapia	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Tilapia	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Tilapia	0	6	0	0	29	2.31	6

Table 9. Length-frequency for Nile Perch

Date	Location	Species	Below Min Length 35cm	Min length 60cm	Common Length 100cm	Max Length 200cm	Mean	STDEV	Number
3/6/2013	Akobo	Nile Perch	16	0	0	0	36.5	5.51	16
16/6/2013	Wanding	Nile Perch	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Nile Perch	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Nile Perch	0	3	1	0	84.5	18.3	4

Table 10. Length-frequency for Synodontis

Date	Location	Species	Below Min Length 10cm	Min length 16cm	Common Length 25cm	Max Length 40cm	Mean	STDEV	Number
3/6/2013	Akobo	Synodontis	0	0	40	0	27.6	1.53	40
16/6/2013	Wanding	Synodontis	0	0	0	0	0.0	0.0	0.0
18/6/2013	Jikmir	Synodontis	0	0	0	0	0.0	0.0	0.0
20/6/2013	Nasir	Synodontis	0	0	325	0	25.6	7.38	325

APPENDIX 7: SSTCM YOUTH FISHERIES PROJECT 2011-2012 INPUTS

SSTCM Youth Fisheries Project in the Sobat Corridor

Item	Wanding	Dengjok	Nyandit	Makak	Jikmir	Nassir	Comments
Hooks # 7	114 Boxes	68 boxes	68 boxes	68 boxes	68 boxes	114 boxes	for first dist, 100 boxes for Wanding and Nasir and 60 for others
Hooks # 8	114 boxes	68 boxes	68 boxes	68 boxes	68 boxes	114 boxes	for first dist, 100 boxes for Wanding and Nasir and 60 for others
Fishing twines 210/D ply 9 (500 gr)	500 spool (10 per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	500 spool (10 per youth)	First distribution should be HALF the amount.
Fishing twines 210/D ply 12 (500 gr)	500 spool (10 per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	500 spool (10 per youth)	First distribution should be HALF the amount.
Fishing twines 210/D ply 15 (500 gr)	500 spool (10 per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	500 spool (10 per youth)	First distribution should be HALF the amount.
Fishing twines 210/D ply 18 (500 gr)	500 spool (10 per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	500 spool (10 per youth)	First distribution should be HALF the amount.
Fishing twines 210/D ply 21 (500 gr)	500 spool (10 per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	300 Spool (ten per youth)	500 spool (10 per youth)	First distribution should be HALF the amount.
Process Inputs							
Processing Knives	25	15	15	15	15	25	
Mosquito net	50	30	30	30	30	50	
Search head light	20	12	12	12	12	20	
Washing Basin	50	30	30	30	30	50	
Plastic sheet	12	12	12	12	12	10	
Common Salt	36	36	36	36	36	60	
Plastic Barrels	12	12	12	12	12	20	
Plastic Bucket	24	24	24	24	24	40	
Spring balance	6	6	6	6	6	10	
Empty plastic sack	900	900	900	900	900	1500	
Nylon rope	90	90	90	90	90	150	
Needle	12	12	12	12	12	20	
Canoes	10	6	6	6	6	10	

APPENDIX 8: CATCH PER ANNUM ANALYSIS OF SSTCM YOUTH FISHERIES PROJECT

According to the distribution list for the fishing gear provided under the SSTCM Youth Fisheries Project in the Sobat Corridor in 2011-2012, 1,000 boxes of 100 hooks in two sizes, and 11,000 spools of twine x 500 g in 5 different ply ratings, were distributed to 220 beneficiaries (identified as "youth"). Based on this list and the assumption that the fishing gear was divided amongst the beneficiaries equally, each beneficiary would have received a total of 4.5 boxes of hooks (sizes 7 and 8), and 50 spools (10 of each of 5 varying ply sizes: 9, 12, 15, 18 and 21).

The following analysis was made of the potential ecological, nutritional and economic impact of an intervention where all the fishing gear provided under this project is put into action at the same time – which is not a likely scenario, but the percentage of simultaneous use has not been obtained -- incorporates some educated assumptions and approximations, as follows:

- It is assumed that all the gear is put into use at once. This report provides such a "worst-case scenario" from an ecological perspective in order to assess what might be the worst consequences if such intense fishing is conducted. In practice, this assumption needs to take into consideration discount factors, including, amongst others: (1) any loss or destruction of fishing gear (to the extent such loss (if stolen) would not catch fish as effectively elsewhere); (2) the sharing of assets and division of labor among fishers such that they may not use all the fishing gear simultaneously, but may alternate responsibilities to include processing of fish; (3) the market capacity to absorb such an increase in supply without infrastructure and consistent trade routes to facilitate trade as fishers find a balance between their supply and demand; (4) the engagement of fishers in cultivation or other activities towards the start of the rainy season (though calculating the potential catch for six months instead of a full 12 month per annum accounts for cultivation during the bulk of the rainy season); (5) the time required to construct nets out of twine; (6) management of.fishing rights that may prevent fishers with gear from fishing in certain areas; and (7) the natural cycle of areas with an abundance of fishing during certain time periods coupled with the need and ability to relocate to areas with more efficient fishing as time progresses during the fishing season.
- 100 hooks, made into a hook-line, can catch 2-4 fish (*Clarias* or *Heterotis*) weighing in total 5 – 10 kg each day.
- 1 spool of twine, made into a gill-net, can likewise catch the same amount.
- 1 box of hooks has a market value of SSP 35 in Akobo, Wanding and Nasir.
- Likewise, a spool of twine sells for a similar amount.
- One medium-sized fish (wet weight of 2.5 kg), once dried, has a market value of SSP 5.
- Hook-lines and nets can be used at the same time but often are not, depending on prevailing conditions. They are initially considered together and a supplementary analysis is made for 21-ply twine alone.
- The analysis is based on a cumulative 6 months' fishing over the course of a year, based on two factors: a) it is assumed that in total perhaps half of a year's fishing days are productive to the extent used in the calculation; and b) while a 21-ply net should give service for up to two years, its effectiveness diminishes over time: the first year's fishing should follow the CPUE guidelines. (Note that the smaller ply ratings deteriorate faster with their diminishing size).

Analysis	Wanding	Dengjok	Nyandit	Makak	Jikmir	Nasir	Total
INPUTS:							
Total hook boxes into location (@100 hooks)	228	136	136	136	136	228	1,000
Total twine into location (@500g spools)	2,500	1,500	1,500	1,500	1,500	2,500	11,000
BENEFICIARIES:							
Total beneficiaries	50	30	30	30	30	50	220
Total boxes @ 100 hooks per beneficiary	4.5	4.5	4.5	4.5	4.5	4.5	
Total spools per beneficiary	50	50	50	50	50	50	
INTRINSIC MARKET VALUE OF GEAR (2013 values):							
Value of hooks per beneficiary (SSP) [1]	156	156	156	156	156	156	
Value of twine per beneficiary (SSP) [2]	1,750	1,750	1,750	1,750	1,750	1,750	
Total value of gear per beneficiary (SSP)	1,906	1,906	1,906	1,906	1,906	1,906	
FISH CATCHABILITY OF GEAR:							
Hooks catch per day per beneficiary (number of fish) [3]	9 - 18 fish	9 - 18 fish	9 - 18 fish	9 - 18 fish	9 - 18 fish	9 - 18 fish	
Twine catch per day per beneficiary (number of fish) [4]	100 - 200	100 - 200	100 – 200	100 - 200	100 - 200	100 - 200	
Hooks catch per day per beneficiary (kg) [3]	22 - 45	22 - 45	22 – 45	22 - 45	22 - 45	22 - 45	
Twine catch per day per beneficiary (kg) [4]	250 - 500	250 - 500	250 – 500	250 - 500	250 - 500	250 - 500	
Combined catch per day per beneficiary (number of fish)	109 - 218	109 - 218	109 – 218	109 - 218	109 - 218	109 - 218	
Combined catch per day per beneficiary (kg)	272 - 545	272 - 545	272 – 545	272 - 545	272 - 545	272 - 545	
MONETARY VALUE OF FISH CATCH (DRIED):							
Value of catch (dried) per day per beneficiary (SSP)[5]	545 – 1,090	545 – 1,090	545 – 1,090	545 – 1,090	545 – 1,090	545 – 1,090	

Combined value over 6 months per beneficiary (SSP)	99,000 - 198,000	99,000 - 198,000	99,000 - 198,000	99,000 - 198,000	99,000 - 198,000	99,000 - 198,000	
IMPACT ON STANDING STOCK (PER LOCATION):							
Hooks total catch per day (number of fish)	456 - 912	272 - 544	272 - 544	272 - 544	272 - 544	456 - 912	
Twine total catch per day (number of fish)	5,000 - 10,000	3,000 - 6,000	3,000 - 6,000	3,000 - 6,000	3,000 - 6,000	5,000 - 10,000	
Combined catch per day (number of fish)	5,456 - 10,912	3,272 - 6,544	3,272 - 6,544	3,272 - 6,544	3,272 - 6,544	5,456 - 10,912	
Combined catch per day (kg)	20,450 - 27,280	8,180 - 19,360	8,180 - 19,360	8,180 - 19,360	8,180 - 19,360	20,450 - 27,280	
Combined catch per year (cumulative 6 months) (number of fish)	993,000 - 1,986,000	595,000 - 1,191,000	595,000 - 1,191,000	595,000 - 1,191,000	595,000 - 1,191,000	993,000 - 1,986,000	**4,366,000 - 8,736,000**
Combined catch per year (cumulative 6 months) (Metric Tonnes)	3,722 - 4,965	1,488 - 3,524	1,488 - 3,524	1,488 - 3,524	1,488 - 3,524	3,722 - 4,965	**13,396 - 24,026 MT**
ASSUMING 21-PLY ALONE (see text):							
21-ply twine catch per day per beneficiary (fish)	20 - 40	20 - 40	20 - 40	20 - 40	20 - 40	20 - 40	
21-ply twine catch per day per beneficiary (kg)	50 - 100	50 - 100	50 - 100	50 - 100	50 - 100	50 - 100	
Catch per day (number of fish)	1,000 - 2,000	600 - 1,200	600 - 1,200	600 - 1,200	600 - 1,200	1,000 - 2,000	
Catch per day (kg)	2,500 - 5,000	1,500 - 3,000	1,500 - 3,000	1,500 - 3,000	1,500 - 3,000	2,500 - 5,000	
Catch per 6 months (number of fish)	182,000 - 364,000	109,000 - 218,000	109,000 - 218,000	109,000 - 218,000	109,000 - 218,000	182,000 - 364,000	800,000 - 1,600,000
Catch per 6 months (Metric Tonnes)	455 - 910	273 - 546	273 - 546	273 - 546	273 - 546	455 - 910	2,002 – 4,004 MT
NOTES:							
[1] 1 box hooks Akobo / Wanding SSP 30-35, Nasir SSP 35							
[2] 1 spool 500g twine Akobo / Wanding SSP 30-35, Nasir SSP 35							
[3] Assume 100 hooks catch 5-10 kg wet weight per day = 2-4 medium *Clarias* / *Heterotis*							
[4] Assume I spool catches 5-10 kg wet weight per day = 2-4 medium *Clarias* / *Heterotis*							
[5] 1 medium dry fish Akobo / Wanding / Nasir = SSP 5							

The supplementary analysis of 21-ply twine is made because of the five different ply ratings on the distribution list, this Consultant considers only the 21-ply is of real relevance in the Sobat fishery, though others may differ in opinion. While the other four sizes will have been used, they are too thin and light. The lower ply twines have major disadvantages and limitations. They do not last as long as the larger and they encourage fishers to make destructive small-meshed nets. In the Pibor – Sobat system, as with most of South Sudan, the smallest ply rating that should be considered is 21

APPENDIX 9: MAP OF GAMBELA AND BOMA NATIONAL PARKS