A survey of the fisheries in Kavango, Namibia

B.C.W. VAN DER WAAL

University of Venda, P/Bag X2220, Sibasa, Venda, South Africa

Received March 1990; accepted July 1990

ABSTRACT

Nine traditional and four modern types of fishing techniques were used for subsistence fishing along the Kavango River, each with a different species selectivity. The most commonly used fish funnel collected around 200 g of fish per h, comprising small fish species or 71% of the species recorded for the Kavango River. Other fishing equipment apparatus was more selective and caught mainly larger cichlids and mormyrids. A survey of fishing and fish-eating habits revealed that the whole human population living along the river ate fish, with 85% willing to buy fish. 32% of the population living along the river, caught fish for consumption. The total annual crop removed from the river and its floodplains, was estimated at 840 000 kg or 19,4 kg ha-1. The scarcity of larger fish species is ascribed partly to the use of selective gear such as gill nets and large seine nets. Urgent protection of the river valley and banks is required to prevent habitat deterioration and a drop in productivity.

INTRODUCTION

The fishes of the Okavango system have received some attention by fisheries scientists, especially in the lower swamp region (Jubb 1961, 1967; Jubb & Gaigher 1971; Ladiges 1964; Poll 1967; Fox 1976; Gilmore 1976; Bruton 1980; Skelton et al. 1983, 1985; Merron & Bruton 1984a, 1984b; Merron et al. 1984, 1985, 1987; Skelton & Merron 1984, 1985, 1986, 1987; Minshull 1985; Merron & Bruton 1989), but relatively little work has been done on the exploitation of the fishes of this system (Gilmore 1976; Bruton et al. 1984). Apart from an unpublished survey (Van der Waal 1977), the fishery in the Kavango River just north of the swamps where the river forms a 415 km border with Angola, has not been studied. The southern bank is densely populated, and concern by the Departments of Agriculture and Nature Conservation over the possible over-utilisation of the fish socks, initiated this survey.

METHODS

After a preliminary survey in October 1977 a second survey was undertaken from 16-21 July 1987, when water levels approach minimum levels and when fishing by the local people is practised on a small scale. Information on the catches of fishermen was obtained by direct personal inspection. An inflatable dinghy was used to travel a total of 170 km on the river, divided into nine stretches of 7-25 km and covering major human concentrations and habitats (Fig. 1). Any fishing activity observed, apparatus used and the environment where it was employed, was recorded. The catches of 79 fishermen were inspected, sorted according to species, counted, weighed (using a spring scale with 10g sensitivity) and subsamples measured on a measuring board (total length in mm).

A separate survey was also undertaken from 15-24 July 1987 to establish the intensity of fishing activities. Major villages along the river were all visited by two extension officers of the Directorate of Agriculture, Kavango Administration. Information from 201 homesteads was gathered by means of a questionnaire on the possession and use of fishing gear, fish eating habits and preferences.

RESULTS AND DISCUSSION

Traditional fishing gear recorded in Kavango

Fish funnel - Sikuku, Chikuku, Shikuku

A large, funnel shaped structure, 110-170 cm long with an 80-150 cm wide mouth, was constructed from locally abundant materials: giant *Aristida* sp. grass stems, reinforced at regular intervals with groups of *Grewia* spp. twigs, tied together with petioles of *Cyperus* spp. or strips of *Hyphaene* palm leaf. This left 2-5 mm wide gaps, effective to catch almost the smallest fish. The funnel was reinforced by a wooden hoop at the mouth and another one halfway to the apex.

Fish funnels were constructed and used exclusively by women only, in all five tribes occupying Kavango. Fish funnels were used most effectively in shallow weedy bays, backwaters and along weedy sandbanks, as well as in shallow rocky areas where rocks were placed in circles to attract fish by providing shelter. They were used in water 10-110 cm deep and could be used singly. More commonly they were operated by up to 40 women and children forming a line and fishing communally (Plate 2). The funnels were all placed in the water, side by side, while the water was churned up by the people in front of the funnels. At a given signal, all funnels were lifted and the catch collected in floating pots or calabashes. A new line was formed some 2-5 m further and the process repeated. According to three parties questioned, a bay or weedy sandbank was worked over repeatedly for a few days until catches drop. On two occasions the trampling effects of such communal fishing was clearly visible three weeks later.

Fish corral trap - Sintunga

Rectangular sleeping mat-like structures of 80-110 cm long by 70-90 cm high were driven into the substrate in a kidney shape, leaving a gap of 10-30 mm in the concave side. They were constructed from the woody stems of a local weed and fastened with the petioles of sedges. This mat had 3-5 mm gaps between the stems which were sharpened at one end to facilitate penetration into the sandy bottom. Traps were often baited with mussel flesh or mahango (millet) porridge and set at the edge of weed beds or in bays. Fish corral traps were used singly or a group were staked out together in a favourable spot. They were used mostly by women during the warmer months when the small fish were more plentiful and active.

Fish fence (Masasa) with valved traps (Muduwa) and corrals (Erera)

Reed fences, up to 35 m long and 150-210 cm high were staked with poles at intervals of about 5m across bays or channels. The fences were constructed of reeds or straight sticks tied together with sedges, palm leaves or rope made from the inner bark of *Acacia* trees. At irregular intervals one to more than six corrals

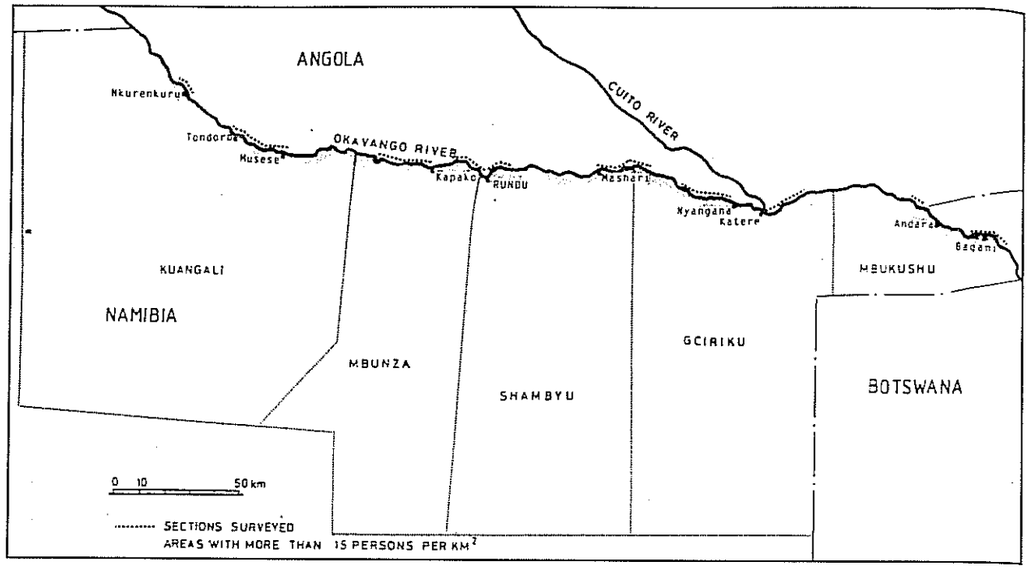

FIGURE 1: Map of the Kavango Territory, Namibia, showing human concentrations along the river (1978 census, Page 1979) and stretches of river covered during the 1987 survey.

of up to 1,5 m diameter led to valved traps in which the fish were collected. The traps themselves could be up to 200 cm long and 45-80 cm in diameter. The slits in the fence were around 30 mm, but those of the corrals and traps varied between 8 and 25 mm, and were effective for larger fishes only. These fences were positioned on carefully selected sites and were built and managed by men after consent by the local headman.

Scoop basket (Tambi)

Oval shaped baskets, 80-120 cm by 50-70 cm and 40-70 cm deep were constructed with strong transverse handles across the mouths by which they could be pulled through aquatic vegetation. They were constructed from split *Phragmites* reeds tied together on wooden hoops at the mouth with sedge petioles, leaving gaps of only 2-4 mm to catch the smallest fishes hiding in the dense mats of vegetation in bays and along the shallows. Scoop baskets were effective when floods receded and were used mainly by women.

Fish trap for large fish (Kanguwa)

This funnel shaped trap 50-80 cm long, had a mouth 20 cm wide, tapered gradually to 5 cm so that large fishes entering the trap, became lodged. It was constructed from split stems of woody shrubs, woven together with the tough stems of a creeper, leaving slits of 4-6 cm and was placed amongst reeds or other aquatic vegetation in water 30-150 cm deep. The *kanguwa* was made and used exclusively by men.

Push basket (Sididi)

A conical basket 100-120 cm long with a 50-70 cm wide mouth was dropped over fish swimming in shallow (5-40 cm), murky water. It had a hole in the side through which fishes could be removed and was made of the wooden stems of a locally abundant weed, tied to two wooden hoops to strengthen the structure. These baskets were used mainly by women and children in pools that were drying up.

Fish bow and arrow (Ngumba)

A large bow of 100-150 cm and reed arrows of the same length were used by men to shoot larger fish rising near the surface or found in shallow water (eg. nesting cichlids). A dugout canoe *(Wato)* was commonly used to stalk the fish. The arrows were provided with 20 cm long steel shanks ending in sharp points and large, 20 mm long barbs and were balanced in such a way that when a fish was missed, arrows would float in a vertical position.

Set fish hook (Egondo)

A large fish hook was baited with fish or mussel flesh and tied to a short line of 30-60 cm attached to a bundle of dried reeds. This was then left in weedy patches to catch *Clarias* and *Hepsetus*.

Fish spear (Muho)

A thin pole of 200-300 cm length was fitted with a sturdy iron shaft shaped into a tapering square with barbs along the four edges. It was used by men from *watos* to collect large fish in shallow areas and also for protection against crocodiles.

Modern apparatus

Hook and line (Erowo)

Large (for catfish) or small (for barbs, mochokids, schilbeids and tilapias) fish hooks were tied to a 5 m piece of nylon line and reed and fished with a float from the bank or more often from *watos* by men, women and children. More modern fishing gear, including artificial lures and reels, were observed at a few localities. Members of the white community participated in sport angling, preferring tigerfish and other predators, and had an active angling club at Rundu.

Gill nets

Modern nylon gill nets originating in Angola, discarded galjoen

TABLE 1: Fish species observed in catches of fishermen using four gear types, Kavango River, July 1987.

Fish species	Funnels	Fences & traps	Fishing lines	Nets
Mormyridae	6	0	0	1
Hippopotamyrus ansorgii	+	-	-	-
H. discorhynchus	+	-	-	-
Marcusenius macrolepidotus	+	-	-	+
Mormyrus lacerda	+	-	-	-
Petrocephalus catostoma	+	-	-	-
P. castelnaui	+	-	-	-
Characidae	1	0	1	0
Brycinus lateralis	+	-	+	-
Hydrocynus vittatus	-	-	-	-
Micralestes acutidens	-	-	-	-
Rhabdalestes maunensis	-	-	-	-
Hepsetidae	1	1	1	1
Hepsetus odoë	+	+	+	+
Distichodontidae	2	0	0	0
Hemigrammocharax machadoi	+	-	-	-
H.multifasciatus	+	-	-	-
Nannocharax macropterus	-	-	-	-
Cyprinidae	15	0	1	1
Barbus afrovernayi	+	-	-	-
B. barotseensis	+	-	-	-
B. barnardi	+	-	-	-
B. bifrenatus	+	-	-	-
B. codringtoni	-	-	-	-
B. eutaenia	+	-	-	-
B. fasciolatus	+	-	-	-
B. huasianus	+	-	-	-
B. multilineatus	+	-	-	-
B. paludinosus	+	-	-	-
B. poechii	+	-	+	-
B. radiatus	+	-	-	-
B. tangandensis	+	-	-	-
B. thamalakanensis	+	-	-	-
B. unitaeniatus	+	-	-	-
Coptostomabarbus wittei	+	-	-	-
Labeo cylindricus	-	-	-	+
L. lunatus	-	-	-	-
Mesobola brevianalis	-	-	-	-
Opsaridium zambezense	-	-	-	-
Bagridae	0	0	0	0
Auchenoglanis ngamensis	-	-	-	-
Leptoglanis rotundiceps	-	-	-	-
L. sp.	-	-	-	-
Schilbeidae	1	1	1	1
S. mystus	+	+	+	+
Amphiliidae	0	0	0	0
Amphilius uranoscopus	-	-	-	-
Clariidae	4	0	2	2
Clarias dumerilii	-	-	-	-
C. gariepinus	+	-	+	+
C. ngamensis	+	-	+	+
C.stappersii	+	-	-	-
C.theodorae	+	-	-	-
Mochokidae	3	0	3	0
Chiloglanis fasciatus	-	-	-	-
Synodontis leopardinus	+	-	+	-
S. macrostigma	+	-	-	-
S. nigromaculatus	-	-	+	-
S. woosnami	+	-	+	-
Poeciliidae	3	0	0	0
Aplocheilichthys hutereaui	+	-	-	-
A. johnstonii	+	-	-	-
A. katangae	+	-	-	-
Cichlidae	14	6	8	10
Hemichromis elongatus	-	-	-	-
Oreochromis andersonii	+	+	+	+
O. macrochir	+	+	-	+
Pharyngochromis darlingi	+	-	+	-
Pseudocrenilabrus philander	+	-	-	-

Fish species	Funnels	Fences & traps	Fishing lines	Nets
TABLE 1 cont.				
Serranochromis (Sargochromis) carlottae	+	-	-	+
S. (Sarg.) codringtoni	+	-	+	+
S. (Sarg.) giardi	+	-	+	+
S. (Sarg.) greenwoodi	-	-	-	-
S. (S.) angusticeps	+	+	+	+
S. (S.) longimanus	-	-	-	-
S. (S.) macrocephalus	+	+	+	+
S. (S.) robustus jallae	+	+	-	-
S. (S.) thumbergi	+	-	-	+
Tilapia rendalli rendalli	+	-	+	+
T. ruweti	+	-	-	-
T. sparrmanii	+	+	+	+
Anabantidae	2	0	0	0
Ctenopoma intermedium	+	-	-	-
C. multispinis	+	-	-	-
Mastacembelidae	0	0	0	0
Afromastacembelus frenatus	-	-	-	-
A. vanderwaali	-	-	-	-

nets from the coast or even home made nets were recorded. Nets measured 10-60 m long with 50-150 mm stretched meshes and were observed in backwaters and across side channels.

Seine nets

Modern type seine nets measuring 50-110 m long by 3-6 m deep with 50-100 mm meshes were constructed from a number of unmounted gill net panels and mounted with weights and floats. Nets were laid out from *watos* in bays and side channels with little water flow and pulled in on gently sloping banks.

Wire mesh fykes

Modern home-made fykes constructed from 20 mm steel mesh were used in the western part of Kavango. Fykes observed were 100-120 cm long and supplied with a valve at the entrance, preventing escape.

FISH SPECIES COLLECTED BY KAVANGO FISHERMEN

Fish species occurring in the Kavango River bordering Namibia, are listed by Bethune (this volume). Those fish species that were identified in the catches of fishermen, are listed in Table 1. Catches of the following fishing gear were not observed during the study period: small corral traps, scoop baskets, push baskets, *kanguwa*, set fish hooks, fish bows and arrows and fish spears. These gear types were used infrequently, and only during the warmer months or only in certain advantageous situations.

The most commonly used fish funnel was effective to collect 71% of the 73 fish species recorded from the Kavango River bordering Namibia. As the survey was conducted over a short period and under cold conditions, not all potential fish species were recorded. Based on the habitat preferences of fish species, the following were expected to be collected additionally by fish funnels: *Hydrocynus vittatus* (young), *Micralestes acutidens*, *Rhabdalestes maunensis*, *Labeo cylindricus*, *Mesobola brevianalis*, *Auchenoglanis ngamensis*, *Synodontis argochromis nigromaculatus*, *Hemichromis elongatus*, *Serannochromis (Sargochromis) greenwoodi*, and *Afromasta-cembelus frenatus*. This would bring the total to 62 species (85%).

Fences in conjunction with traps caught only eight species. This may be an underestimate of the number of species caught with fences as only a few traps inspected had any fish. It can be expected that the following fish species that grow large enough to be collected by this method, could also be caught by traps and fences: *Mormyrus lacerda*, *H. vittatus*, *Barbus codringtoni*, *Labeo lunatus*, *A. ngamensis*, *Clarias gariepinus*, *C. ngamensis*, *C. stappersii*, *Synodontis* spp. *H. elongatus*, *Serrancochromis (Sargochromis) carlottae*, *S. (Sarg.) codringtoni*, S. *(Sarg.) greenwoodi*, *S. (Serranochromis) longimanus*, S. *(S.) thumbergi and Tilapia rendalli*.

Fish lines and nets caught 17 and 16 species respectively. The following species could additionally be expected to be caught in small numbers by fishing lines: *Hippopotamyrus discorhynchus*, *Marcusenius macrolepidotus*, *Mormyrus lacerda*, *Hydrocynus vittatus*, *Barbus codringtonii*, *Labeo lunatus*, *Clarias stappersii*, *C. theodorae*, *Synodontis macrostigma*, *Hemichromis elongatus*, *Oreochromis macrochir*, *Serannochromis (Sarg.) carlottae*, *S. (Sarg.) greenwoodi*, *S. (S.) longimanus*, *S. (S.) robustus jallae*, *and S. (S.) thumbergi*. Small mesh gill and seine nets would also collect most of these species additionally to those listed in Table 1.

SELECTIVITY OF FISHING APPARATUS

Species caught using various gear types are summarized in Table 2. For comparison, data are included on abundance of fish species determined by experimental methods at 25 sites along the river in July 1986 by Skelton & Merron (1987). The composition of funnel catches comes closest to the known fish community data. The following species, however, show discrepancies: *M. macrolepidotus* and *P. catostoma* - the high representation in funnel catches probably reflects collection in the preferred daytime habitat in dense aquatic vegetation. The small cichlids *O. philander* and *T. sparrmanii* show a similar trend. Funnels collected considerably lower numbers of the open water loving *M. acutidens*, *S. mystus* and *Synodontis* spp. than reported by Skelton & Merron (1987).

The catches of fences, fishing lines and nets differed greatly from either funnel catches or the fish population determined by Skelton & Merron (1987). It appears that all three of these gear types are selective for mormyrids and especially the larger cichlid species.

Maximum lengths measured of larger fish species in 12 fish funnel catches (Table 3) indicate that juvenile and subadults

TABLE 2: Species composition and their differential catchability (expressed as percentage of the total catch) by various fishing methods in the Kavango River, July 1987.

	FISHING METHOD				
Fish species	Fishing Experimental Gear July 1986 (Skelton & Merron)	Funnels	Fences & traps	Fishing lines	Nets
Mormyridae	*9.91*	*29.52*	-	-	*41.8*
Hippopotamyrus ansorgii	-	0.04	-	-	-
H. discorhynchus	0.25	0.09	-	-	-
Marcusenius macrolepidotus	0.29	5.15	-	-	40.6
Mormyrus lacerda	0.13	0.02	-	-	1.2
Petrocephalus catostoma	2.38	16.62	-	-	-
P. catostomus	6.86	7.60	-	-	-
Characidae	*13.39*	*0.10*	-	*1.9*	-
Brycinus lateralis	0.82	0.10	-	1.9	-
Hydrocynus vittatus	0.13	-	-	-	-
Micralestes acutidens	12.44	-	-	-	-
Rhabdalestes maunensis	-	-	-	-	-
Hepsetidae	*0.20*	*0.04*	*7.4*	*0.9*	*0.8*
Hepsetus odoë	0.20	0.04	7.4	0.9	0.8
Distichodontidae	*4.69*	*1.29*	-	-	-
Hemigrammocharax machadoi	0.18	0.83	-	-	-
H. multifasciatus	4.39	0.46	-	-	-
Nannocharax macropterus	0.12	-	-	-	-
Cyprinidae	*28.86*	*22.17*	-	*13.2*	-
Barbus afrovernayi	0,12	0.63	-	-	-
B. barnardi	0,02	2.02	-	-	-
B. barotseensis	0,02	0.19	-	-	-
B. bifrenatus	0,09	1.74	-	-	-
B. codringtoni	0.02	-	-	-	-
B. eutaenia	1.87	1.56	-	-	-
B. fasciolatus	0.04	1.02	-	-	-
B. haasianus	5,03	0.23	-	-	-
B. multilineatus	0,02	5.17	-	-	-
B. paludinosus	7,08	4.77	-	-	-
B. poechii	3.28	0.51	-	13,2	-
B. radiatus	0.37	2.50	-	-	-
B. tangandensis	0.20	0.23	-	-	-
B. thamalakanensis	1,39	0.07	-	-	-
B. unitaeniatus	3,64	0.65	-	-	-
Coptostomabarbus wittei	0,29	0.88	-	-	-
Labeo cylindricus	3,35	-	-	-	0.4
L. lunatus	0,79	-	-	-	-
Mesobola brevianalis	-	-	-	-	-
Opsaridium zambezense	1,24	-	-	-	-
Bagridae	*0,23*	-	-	-	-
Auchenoglanis ngamensis	0,07	-	-	-	-
Leptoglanis rotundiceps	-	-	-	-	-
L.sp	0.16	-	-	-	-
Schilbeidae	*8,47*	*1.13*	*7.4*	*26.5*	*5.0*
S. mystus	8,47	1.13	7,4	26,5	5.0
Amphiliidae	*0.16*	-	-	-	-
Amphilius uranoscopus	0.16	-	-	-	-
Clariidae	*0.64*	*1.08*	-	*2.8*	*1.2*
Clarias dumerilii	0.15	-	-	-	-
C. gariepinus	0,04	0.33	-	1.9	0.8
C. ngamensis	0.31	0.12	-	0.9	-
C. stappersii	0.07	0.05	-	-	-
C. theodorae	0,07	0.58	-	-	0.4
Mochokidae	11,14	*2.69*	-	*6.5*	-
Chiloglanis fasciatus	0.18	-	-	-	-
Synodontis leopardinus]		2.55	-	2.8	-
S. macrostigma]		0.14	-	-	-
S. nigromaculatus }	10,96	-	-	0.9	-
S. woosnami]		-	-	2.8	-
Poeciliidae	*7.05*	*3.15*	-	-	-
Aplocheilichthys hutereaui	*1.19*	0.04	-	-	-
A. johnstonii	5.75	1.86	-	-	-
A. katangae	*0.11*	1.25	-	-	-
Cichlidae	*15.09*	*37.95*	*85.2*	*48.2*	*50.8*
Hemichromis elongatus	0,07	-	-	-	-
Oreochromis andersonii	0.09	0.04	55.6	3.8	24.7

Fishing

Fish species	Experimental Gear July 1986 (Skelton & Merron)	Funnels	Fences & traps	Fishing lines	Nets
TABLE 2 cont.					
O. macrochir	0,64	0,02	14,8	-	12,8
Pharyngochromis darlingi	2,78	0,30	-	10,4	-
Pseudocrenilabrus philander	2,85	25,38	-	-	-
Serranochromis (Sargochromis) carlottae]	-	0,11	-	-	0,8
S. (Sarg.) codringtoni]	1,90	0,07	-	2,8	2,1
S. (Sarg.) giardi]		-	-	11,3	2,1
S. (Sarg.) greenwoodi	0,02	-	-	-	-
S. (S.) angusticeps	0,24	0,93	3,7	1,9	2,5
S. (S.) longimanus	-	-	-	-	-
S. (S.) macrocephalus	0,68	0,79	3,7	14,2	2,5
S. (S.) robustus jallae	0,46	0,37	3,7	-	0,4
S. (S.) thumbergi	-	0,07	-	-	0,4
Tilapia rendalli rendalli	2,43	0,04	-	1,9	2,1
T. ruweti	-	0,88	-	-	-
T. sparrmanii	2,93	8,95	3,7	1,9	0,4
Anabantidae	0,15	0,88	-	-	-
Ctenopoma intermedium	0,02	0,19	-	-	-
C. multispinis	0,13	0,69	-	-	-
Mastacembelidae	0,02	-	-	-	-
Afromastacembelus frenatus	0,02	-	-	-	-
A. vanderwaali	-	-	-	-	-
Total number sampled	5463	5687	27	106	240
No. of collections	25	50	3	15	11
No. of species collected	60	52	8	17	18
Efficiency of gear types:					
Mean No. caught per hour	-	68	0,6	4	22
Mean mass, g	-	2,85	172,6	59,3	111,7
Mass caught per h (g)	-	193	97	242	102
Percentage species growing to:					
Less than 250 mm	63	96	4	35	43
More than 250 mm	27	4	96	65	57

formed the majority of the catch of the widely used fish funnels. Length distribution of the catches of 10 recorded commercial seine net efforts is summarized in Table 4. No adult fish were collected. Surveys by Skelton & Merron (1987), Van der Waal (1977) and Van Zyl (1987) all indicate low catches of adult larger fish species in gill nets. Additionally, Van Zyl (1987) reports lower maximum ages for three larger cichlids than in either the Barotse Flood Plains or Lake Liambezi. This may indicate a high mortality and predation level on the large cichlids of the Kavango River that would make these fish species highly vulnerable to fishing pressure.

EFFICIENCY OF FISHING EQUIPMENT

The most widely used equipment, fish funnels, caught nearly 200 g of fish per hour, consisting of 68 individual fishes (Table 2). The efficiency of fishing lines in terms of mass was even higher, but that of nets (mainly seine nets) and fences was about half that of funnels. As 24 of the women questioned fished for 2 h, and only two fished for 4 h, a daily catch of 200-500 g is assumed. This would then represent enough protein for about 3 persons per day.

Regular fishing for direct consumption may thus be regarded as an essential activity and could play an important role in the provision of fresh protein in the local subsistence economy.

INTENSITY OF FISHING ACTIVITIES

During the survey of fishing and related activities, 201 kraals situated 100 to 6000 m from the river were visited (Table 5). One senior member of a family served as respondent at each kraal.

To facilitate comparison, data are presented for each tribal area in Fig. 1. At least 32% of the population along the river fished during seven months of the year, and were in posession of fishing gear in 1987. Almost every woman owned and used a fish funnel and one or more small corral trap. Men and boys caught fish with fishing lines, fences with valved traps, bow and arrow and nets. Men, however, formed only a small (21%) portion of the fishing community.

Assuming that 78% of the total population of 120 000 inhabitants of Kavango lives within 5 km of the river (Page 1979, Fig. 1), then there were about 35 000 persons fishing in Kavango. It is possible that the information from questionnaires was affected by the cold weather experienced, during the survey. Frost which is rare in Kavango, occurred on 21 July 1987 during the survey. Observations on fishing activities previously made in October 1977 indicated a higher frequency of fishing activities than observed during this survey (Table 5). The computed 29 days of active fishing per year per fisherman, based on the survey (Table 5) is regarded as an underestimate because of the cold weather and short duration of the surveys. A value of 40 days of fishing per year is, therefore, proposed as an estimate of fishing effort.

CROPPING RATE AND PRODUCTION OF THE KAVANGO RIVER

The total crop removed annually from the Kavango River can be estimated with knowledge of the efficiency of gear, frequency of usage and total effort. However, with only one brief survey and some previous observations (Van der Waal 1977), the following assumptions are required:

TABLE 3: Maximum fish lengths recorded from twelve funnel catches in the Kavango River, July 1987.

Fish species	cm	Maximum total fish length in number of funnels																					
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
M. macrolepidotus							2	2	2													
M. lacerda											1			1								
P. eastostoma			1	4																		
P. castelnaui				1	1			1	1							1						
H. odoë																						
B. paludinosus				5																		
L. cylindricus		1																				
S. mystus					3	3																
C. gariepinus											1									1		
C. ngamensis									1		1			1								
C. theodorae					1										1							
S. leopardinus		3	1					1	1	1												
S. macrostigma						1		1														
O. andersonii				1																		
O. macrochir					1																	
P. darlingi			2	2	4	1																
Ps. philander							1															
S. (Sarg.) carlottae							1															
S. (Sarg.) codringtoni						1	1		2	2	2		1	1			1				1	
S. (S.) angusticeps					2		1	2	2	2	2	2		1			1				1	
S. (S.) macrocephalus								3	1	1			1									
S. (S.) robustus						1				1		1										
S. (S.) thumbergi					1																	
T. r. rendalli			1	2																		
T. ruweti			1	1	3	2																
T. sparrmanii					1		1															
C. multispinis																						

TABLE 4: Length distribution of fishes caught in nets, Kavango River, July 1987.

Fish species	Total fish length, cm																
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
M. macrolepidotus					21	31	30	14	4	2	1						
M. lacerda																2	1
L. cylindricus							1										
S. mystus			1	2	1	4	3		1								
O. andersonii					1	1	2	5	5	6	14	3	6	3	7	4	
O. macrochir	1	1	4	2	2	9	9	3	5	1	1						
S. (Sarg.) codringtoni								1				1	1				
S. (Sarg.) giardi				2		1							1				
S. (S.) angusticeps						1	2	1		1					1		
S. (S.) macrocephalus				1			2	2			1						
T. r. rendalli				1			1	3		3		1					
T. sparrmanii						1											

Enough fish is caught for one meal by one family every day by a fisherman. With about 30% of the people fishing for own consumption, one person has to supply about 600 g of fish for a meal. This is quite possible with a funnel and will take 3 h of fishing per day.

If this is the case, 35 000 fishing persons fishing 40 days per year would remove an estimated 840 000 kg of fish annually.

The total surface area of the river and other permanent water bodies of the Kavango River bordering Namibia, determined from 1:5 000 maps, is about 11 900 ha. Including the floodplain, it comprises about 43 400 ha. If the annual crop is 840 000 kg, it would represent 19,35 kg ha^{-1} or a low water production of 70,6 kg ha^{-1}. These figures should be considered as conservative as catches using small corral traps owned by 90 percent of the women could not be included. The catch on the Angolan side of the river is also unknown; three parties of Angolans indicated that they fish regularly, subsisting on fish and water lily tubers.

The estimated catch of 1 799 kg km^{-1} of river fits well within the range of predicted production of African rivers with 1 km-wide floodplains (Welcomme 1975) and with production figures of the Kafue Floodplains where 14 kg ha^{-1} was reported (based on total floodplain area, Welcomme 1974). In the shallow Lake Liambezi, the cropping rate fluctuated between 4-21 kg ha^{-1} over a three year period, but there only gill nets were used (Van der Waal 1980).

Van der Waal (1977), Skelton & Merron (1987) and Van Zyl (1987) all commented on the low frequency of larger fish species and large specimens in the large mesh (>100 mm) experimental gill net samples. Table 4 shows the absence of larger specimens in 10 seine netting efforts. Fish funnels collect only a very small portion of larger fish species or their young (Tables 2 & 3). Other equipment, in particular nets and fences do, however, seem to select for the larger fish species, especially cichlids (Table 2). During low water conditions these larger fish are vulnerable to the high fishing intensity which is then at its peak. The unrestricted use of fishing apparatus selecting for the small resident population of these larger cichlids and clariids, may thus be regarded as detrimental to a balanced fish community.

TABLE 5: Fishing and related activities in the five tribal areas of Kavango, July 1987.

	Tribal area					
	Kuangali	Mbunza	Sambiyu	Geiriku	Mbukushu	Total
No. of persons surveyed-	502	399	148	481	252	1782
No. actively fishing	160	116	57	146	40	519
Percentage fishing	31.8	29.1	38.5	30.4	15.9	32.2*
Number of fishing gear recorded:-						
Funnels	114	80	40	105	32	371
Fences/traps	92	155	49	64	0	359
Bow and arrow	0	0	0	12	0	12
Fishing lines	36	37	10	54	5	142
Gill nets	4	6	0	12	0	22
Seine nets	1	3	2	2	3	11
Watos (dugout canoes)	6	11	4	4	11	39
Percentage of men fishing	23.1	31.0	5.2	27.4	17.5	20.8
No. of funnels per fishing woman	0.9	1.0	0.7	1.0	1.0	0.7
No. of corral traps per fishing woman	0.7	1.9	0.9	0.6	0.0	0.8
Percentage of fishermen having fishing lines	22.5	31.9	17.5	37.0	12.5	28.6
No. of watos per kraal	0.1	0.3	0.2	0.3	0.2	0.2
Months fished per year -	9.6	9.5	6.2	6.9	2.8	7.8*
Days fished per year	22.3	14.6	13.5	43.8	3.4	20.3*

*Computed by considering data on population distribution and population census, 1986 (Piek 1986).

HABITAT DEGRADATION THROUGH OVER UTILISATION

During the river survey, serious signs of uncontrolled over utilisation by the concentrated human population and their livestock was observed. This may affect the long term production potential in terms of fish. Firstly, large scale soil erosion observed in densely populated areas, especially west and east of Rundu and also from Andara to south of Bagani, may cause the sedimentation of the important deeper refuge oxbows and side channels. Sand and silt eventually reach the river itself where unstable, shallow, migrating sandbanks are formed, causing the smothering of reedbeds and the widening of the river. During floods, the shallow river bed cannot handle the volume of water present and unstable meandering results, which cuts into the red sand cliffs that are additionally often deforested.

Intensive grazing of reedbeds by herds of cattle west and east of Rundu during the dry season, damages and weakens stable, overgrown sandbanks. Repeated fish funnel drives in shallow bays and on weedy sandbanks by parties of up to 40 women destroy aquatic growth and with it, decrease the available refuge areas for small fishes.

ECONOMIC ASPECTS OF THE FISHING ACTIVITIES

Almost all fishing in Kavango was done for subsistence. No fish funnel catches were for sale during the survey. There was, however, a growing awareness of the economical value of fish. 85% of the respondents indicated that they would buy fish if obtainable at prices ranging from R15.00 per kg of large fish or R12.00 per kg of small fishes. No person questioned, indicated that they did not eat fish. More than 60 percent were uncertain about fish prices, reflecting the absence of a commercial market. Only two parties of seine netters had their catch for sale, at R1.50 - R4.00 kg^{-1}.

Only 3% of the respondents indicated that they used fish to barter for maize meal, and Angolans complained that they had nothing to eat but the fish they caught. Fish must play an important role in the traditional subsistence economy. The economic contribution of the present fishery can be valued at a minimum of R1,8m annually if we assume a fresh fish price of R3.00 kg^{-1}.

RECOMMENDATIONS

The precarious situation of the fish life in Kavango with an ever increasing fishing pressure, requires efficient and practical management that is acceptable to the human population. The following recommendations attempt to give some directives:

Maintenance of the productivity of the river system

No clear signs of overexploitation of the fish community were found by Skelton & Merron (1984, 1985, 1987), but the low frequencies of larger fish species in experimental and commercial catches may indicate otherwise. The long term effects of siltation and destabilization of the river bed may seriously affect the fish production potential of the system and thus the availability of fresh, high quality protein for the local population. Control and protection of the river valley by creating cattle free zones along the river and simultaneous development of the hinterland (Page 1979; Piek 1986) is supported. Deterioration of the river valley may eventually affect the fragile Okavango Swamp ecosystem lower down the river.

Management of the fishery

Traditional fishing for own consumption at the present level is not considered to be harmful to the fish community. However, with a quickly expanding human population, monitoring of fish populations and cropping rates is urgently required. The effects of repeated trampling of aquatic vegetation by communal fish drives should also receive attention. Netting activities may have to be controlled through licensing and eventual restriction. The need for fish sanctuary areas in the more intensely cropped areas should also be investigated. After further study the introduction

of small mesh gill nets (60 mm) might, however, be allowed to selectively fish for *Schilbe mystus* and adults of other smaller fish species that are usually not cropped in either funnels or large mesh nets (Van der Waal 1980; Merron & Bruton 1989).

Formation of a Fisheries Department

With fish playing such an important role in the local community, an independent Fisheries Department would be required to manage the fishery. It should cover conservation, extension, monitoring, aquaculture development, research and law enforcement activities.

Aquaculture development

With the growing human population and concurrent increasing demand for fish, development of aquaculture projects should be stimulated by the Fisheries Department. Isolated oxbows, lakes, side channels and the inlet of Omuramba Omatako during low water periods have a total surface area of about 330 ha and offer the potential for extensive fish production projects. Intensive aquaculture can be integrated with existing and future irrigation projects, dairy farms, the hydro-electric power system at Andara and sewerage treatment schemes. A fish hatchery producing suitable local fish species would be required to provide fingerlings for communal and commercial projects.

Location of the extraction point of the Eastern National Water Carrier (ENWC)

The extraction of the planned 3 cumecs of water at Rundu (Ravenscroft 1985) cumulative to irrigation extraction, may pose a serious threat to aquatic life between Rundu and Katere. Many parts of this stretch of river are shallow so that a further reduction in flow by the ENWC (that can draw as much as 47% of the total flow at Rundu in a 1 in 50 year low flow, Cashman et al. 1986), may endanger the system during low periods. If the point of extraction of the planned ENWC could be positioned below the Kavango-Cuito confluence, the effects would be minimal as the Cuito has a strong base flow (Cashman et al. 1986).

Research needs

This survey has pointed out the importance of fish life to the Kavango people and also the importance of rational development and resource use. Without a sound data base and management plan, this will not be possible. Long term monitoring of the fish community and fishery is required to manage this resource wisely.

ACKNOWLEDGEMENTS

This work would not have been possible without the active support of the acting Director of Agriculture in Rundu, Mr Jan Piek, who arranged and organised the visit. I would also like to thank his kind colleagues Messrs. Reino Asindi, Kim Arayo, Severinus Haingura, Nehemia Kasoma, Loupie Loubser, Mika Ngambo and Andre Potgieter for their help during the survey, map work, conducting surveys on fishery activities, accommodation and transport. Mrs Liz Kibble and Mr Gomes Lopez are thanked especially for their hospitality and the South African Defence Force for the use of an inflatable dinghy. Dr Paul Skelton once again kindly helped to verify fish identifications and the referees improved this paper.

REFERENCES

BRUTON, M.N. 1980. Preliminary report on the 1980 Rhodes University expedition to Lake Ngami, Botswana. JLB Smith Institute of Ichthyology, Investigational Report No. 1: 37 pp. (Unpublished).

BRUTON, M.N., SKELTON, P.H. & MERRON, G.S. 1984. Brief synopsis of the main findings and objectives of the Okavango Fish Research Programme performed by the JLB Smith Institute of Ichthyology. JLB Smith Institute of Ichthyology, Grahamstown: 6 pp. (Unpublished)

CASHMAN, A., HARRIS, M., PLETTENBERGER, H. & VOLKMAN, B. 1986. Preliminary reconnaissance report on irrigation possibilities along the Okavango River in the Kavango. Department of Water Affairs, Windhoek, Report 2500/2/29/p2. (Unpublished).

FOX, P.J. 1976. Preliminary observations on fish communities of the Okavango Delta. In: Proceedings of the symposium on the Okavango Delta and its future utilization. Botswana Society, Gaborone.

GILMORE, K.S. 1976. Development potential and constraints of a fishing industry in the Okavango Delta. In: Proceedings of the sYmposium on the Okavango Delta and its future utilization. Botswana Society, Gaborone.

JUBB, R.A. 1961. An illustrated guide to the freshwater fishes of the Zambezi River, Lake Kariba, Pungwe, Sabi, Lundi and Limpopo Rivers. Bulawayo: Stuart Manning: 171 pp.

JUBB, R.A. 1967. Freshwater fishes of southern Africa. Cape Town: Balkema: 248 pp.

JUBB, R.A. & GAIGHER, I.G. 1971. Check list of the fishes of Botswana. *Arnoldia Rhod.* 5 : 1-22.

LADIGES, W. 1964. Beiträge zur Zoogeographie and Oekologie der Süsswasserfische Angolas. *Mitt. Hamburg Zool. Mus. Inst.* 61 : 221-272.

MERRON, G.S. & BRUTON, M.N. 1984a. Report on the October-November 1983 expedition to the Okavango Delta, Botswana. J.L.B. Smith Institute of Ichthyology, Investigational Report No 8: 21 pp. (Unpublished).

MERRON, G.S. & BRUTON, M.N. 1984b. Report on the June-July 1984 expedition to the Okavango Delta, Botswana. J.L.B. Smith Institute of Ichthyology, Investigational Report No 12 : 21 pp. (Unpublished).

MERRON, G.S. & BRUTON, M.N. 1989. Recent fisheries research in the Okavango Delta. *S. Afr. J. Sci.* 85: 416-417.

MERRON, G.S., BRUTON, M.N. & SKELTON, P.H. 1984. Report on the March-April 1984 expedition to the Okavango Delta, Botswana. J.L.B. Smith Institute of Ichthyology, Investigational Report No 10: 27 pp. (Unpublished).

MERRON, G.S., BRUTON, M.N. & SKELTON, P.H. 1985. Report on the October-December 1984 expedtion to the Okavango Delta, Botswana. J.L.B. Smith Institute of Ichthyology, Investigational Report No 15: 35 pp. (Unpublished).

MINSHULL, J.L. 1985. A collection of fish from the lower Okavango Swamp, Botswana, with comments on aspects of their ecology. *Arnoldia Zimbabwe* 9 : 287-290.

PAGE, D. 1979. 'n Raamwerk vir ontwikkeling van Kavango. Instituut vir Beplanningsnavorsing. Universiteit van Stellenbosch, Report No 28 (2 vols).

PIEK, J.C. 1986. Inligtingstuk - Landbou en Bosbou in die Kavango. Internal report, Directorate of Agriculture and Forestry, Administration for Kavango, Rundu: 44 pp. (Unpublished).

POLL, M. 1967. Contribution à la faune Ichthyologique de l'Angola. *Diamang. Publ. Culturais* No 75: 381 pp.

RAVENSCROFT, W. 1985. The Eastern National Water Carrier. *S.W.A. Annual*, 1985: 11-18.

SKELTON, P.H. & MERRON, G.S. 1984. The fishes of the Okavango River in South West Africa, with reference to the possible impact of the Eastern National Water Carrier on fish distribution. J.L.B. Smith Institute of Ichthyology, Investigational Report No 9: 32 pp. (Unpublished).

SKELTON, P.H. & MERRON. G.S. 1985. A second survey of the fishes of the Okavango River in South West Africa with reference to the possible impact of the Eastern National Water Carrier. J.L.B. Smith Institute of Ichthyology. Investigational Report No 14: 26 pp. (Unpublished).

SKELTON, P.H. & MERRON, G.S. 1987. A third survey of the fishes of the Okavango River in South West Africa with reference to the possible impact of the Eastern National Water Carrier. J.L.B. Smith Institute of Ichthyology. Investigational Report No 24: 21 pp. (Unpublished).

SKELTON, P.H., HOCUTT, C.H., BRUTON, M.N. & MERRON, G.S. 1983. Report on the December 1982 expedition to Lake Ngami, Botswana. J.L.B. Smith Institute of Ichthyology, Investigational Report No 5: 6pp. (Unpublished).

SKELTON, P.H., BRUTON, M. N., MERRON, G.S. & VAN DER WAAL, B.C.W. 1985. The fishes of the Okavango drainage system in Angola, South West Africa and Botswana: Taxonomy and distribution. *Ichthyol. Bull. J.L.B. Smith Inst. Ichthyol.* No 50: 1-21.

VAN DER WAAL, B.C.W. 1977. Visseryondersoek, Kavango 8-22 November 1977. Internal report, Department of Cooperation and Development, Pretoria: 16 pp. (Unpublished).

VAN DER WAAL, B.C.W. 1980. Aspects of the fisheries of Lake Liambezi Caprivi. *J. Limnol. Soc. sth Afr.* 6 : 19-31.

VAN ZYL, B. 1987. Verslag oor visboerderypotensiaal van die Okavango na aanleiding van navorsing gedoen in die Okavangorivier op drie kurperspesies. Internal report, Department of Agriculture and Nature Conservation, Windhoek: 27 pp. (Unpublished).

WELCOMME, R. L. 1974. A brief review of the floodplain fisheries of Africa. *Afr. J. Trop. Hydrobiol. Fish.* Special Issue 1: 67-76.

WELCOMME, R. L. The fisheries ecology of African floodplains. *CIFA Tech. Pap.* 5: 51 pp.

PLATE 2(a): Communal fishing by women and children on a backwater of the Kavango River, Namibia. © B.C.W. Van der Waal. See Van der Waal, this volume.

Plate 2(b). A *mokoro* on the confluence of the Cuito and Kavango rivers, on the Namibian - Angolan border. © S. Bethune. See Bethune, this volume.