A FISH ECOLOGICAL STUDY OF RIVERS AND FLOODPLAINS IN THE EASTERN CAPRIVI, NAMIBIA

by

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ABSTRACT

A pre-requisite for the formulation of a responsible fisheries management programme for an aquatic ecosystem is a comprehensive fish ecological study, which focuses on the various ecological and biological aspects of the fish population and related fisheries data. The fish ecological and fisheries data must be considered during the decision making process of management.

The freshwater fish of the Eastern Caprivi, Namibia, has enormous value in terms of the local subsistence fishery. Fish is an affordable protein source in this region, and is of socio-economic importance, as it generates income for up to 82% of the local households. Unfortunately commercialisation of the resource is becoming more and more prevalent in this region, as local commercial fishermen take advantage of the readily available fish resource, by the callous use of non-selective fishing gears such as drag nets. Unregulated fishing methods, such as the use of drag nets, is detrimental to the fish population and ecology of an aquatic ecosystem.

The Ministry of Fisheries and Marine Resources (MFMR), Namibia, recognised the need for a fisheries management programme in the Eastern Caprivi region. Proper fisheries legislation, in terms of the recommended fishing gears which may be used by local fishermen, is however needed to achieve the goals set by such a management programme.

The MFMR realised the need for a comprehensive fish ecological study in the Eastern Caprivi, which would thus aid in the formulation of legislation measures. Five, flood related, fish ecological surveys were consequently conducted in the Eastern Caprivi, between 1997 to 1999. The relevant ecological, biological, and fisheries data was gathered. This data will lay the basis for future studies in this region, and will aid management in their decision making process. Results derived from the experimental gill net data is of the most importance in the formulation of fisheries legislation.

The data collected in the Eastern Caprivi was processed and the results presented and discussed in this study. Conclusions are made concerning the biological and ecological aspects of the fish species and the fish population. Recommendations, concerning the fisheries data, are made to the management of the Ministry of Fisheries and Marine Resources in aid of their legislation process.

The Eastern Caprivi is a productive and intricate wetland system, consisting of rivers, floodplains, canals, lakes, swamps and marshlands. Three perennial rivers, the Zambezi, Chobe, and Kwando Rivers with their associated floodplains were studied. A total of 82 fish species occur in the Eastern Caprivi, of which 69 were recorded during this study.

OPSOMMING

‘n Voorvereiste vir die formulering van ‘n verandwoordelike visserye bestuursprogram vir ‘n akwatiese ekosisteem is ‘n samevattende vis ekologiese studie, wat fokus op die verskeie ekologiese en biologiese aspekte van die vis populasie en die relevante visserye data. Die vis ekologiese en visserye data moet in ag geneem word tydens die besluitnemingsproses van die bestuur.

Die varswater vis in die Oos Caprivi, Namibië, is van groot belang vir die plaaslike vissery bevolking. Vis is ‘n goedkoop proteïen bron in die streek, en is van sosio-ekonomiese belang deurdat dit ‘n inkomste vir tot 82% van die plaaslike huishoudings genereer. Ongelukkig vind kommersialisering van die visbron in die streek al hoe meer en meer plaas. Plaaslike kommersiele vissermanne maak misbruik van die maklik bekombare visbron, d.m.v onoordeelkundige gebruik van nie-selektiewe visvang metodes soos treknette. Ongereguleerde visvangmetodes, soos die treknette, is nadelig vir die vis populasie en ekologie van ‘n akwatiese ekosisteem.

Die Ministerie van Visserye en Mariene Hulpbronne (MVMH), Namibië, het die noodsaaklikheid van ‘n visserye bestuursprogram in die Oos Caprivi begryp. Volledige visserye wetgewing, in terme van die aanbevole visvang metodes wat deur die plaaslike vissery bevolking gebruik mag word, is egter nodig om die doelwitte van die bestuursprogram te bereik.

Die MVMH het die noodsaaklikheid vir ‘n samevattende vis ekologiese studie in die Oos Caprivi raakgesien, wat dus moet bydra tot die formulering van die visserye wetgewing. Vyf, vloed verwante, vis ekologiese opnames is gevolglik in die Oos Caprivi uitgevoer gedurende 1997 tot 1999. Die relevante ekologiese, biologiese, en visserye data is versamel. Die data sal die grondslag lê vir toekomstige studies in die streek, en sal bydra tot die bestuur se besluitnemingsproses. Resultate van die kiefnet vangste is van die grootste belang vir die formulering van visserye wetgewing. Die data wat in die Oos Caprivi versamel is, is verwerk en die resultate word aangetoon en bespreek in die studie. Gevolgtrekkings word gemaak aangaande die biologiese en ekologiese aspekte van die vis spesies en die vis populasie. Aanbevelings, met betrekking tot visserye data, word gerig aan die bestuur van die Ministerie van Visserye en Mariene Hulpbronne.

Die Oos Caprivi is ‘n produktiewe en intrinsieke akwatiese sisteem, wat bestaan uit riviere, vloedvlaktes, kanale, mere, vleie en moerasse. Drie standhoudende riviere naamlik die Zambezi, Chobe, en Kwando Riviere en hul vloedvlaktes is bestudeer. ‘n Totaal van 82 vis spesies kom in die Oos Kaprivi voor, waarvan 69 versamel is gedurende die studie.

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1 INTRODUCTION

Freshwater fishery plays an important role in several regions of Namibia, and it is the lifeblood of the Eastern Caprivi. Most of the inhabitants of this region rely on the fish resource for subsistence and income during the course of everyday life. Freshwater fish in this region is an affordable and easily obtainable protein source, and is caught with various fishing methods. The socio-economical implications surrounding the fish resource in the Eastern Caprivi has tremendous value in terms of commercial fishery, and subsistence fishery. The people of Namibia also rely on tourism and foreign currency to generate an income, and therefore freshwater fish in the Eastern Caprivi has an additional value in terms of sport fishing and tourism in the area.

Næsje *et. al.* (2001) highlights the economical value of the fish in the Eastern Caprivi, after the socio-economic impacts of an angling competition in the Zambezi River were studied. The total economy of this competition was estimated at N$ 108,000. It was then surmised that each of the 831 fish caught generated approximately N$ 130 for the local economy and business.

The Ministry of Fisheries and Marine Resources, Namibia, realises that legislation is essential in order to protect and utilise the fish resource of the Eastern Caprivi in a sustainable manner. Legislation is in process, and will focus on the protection of the fish resource, and will include the possible proclamation of conservation or breeding areas for fish, breeding seasons when fishing for certain species are prohibited, and licensed netting. Licensed netting will include legislation concerning gill net area (m^2), gill net mesh size, placing of nets (orientation in stream), and the allocation of a predetermined amount of gill net permits in different areas of the Eastern Caprivi. Applicable legislation concerning other fishing methods, such as seine or drag netting which is currently prohibited, will also be announced. Traditional subsistence fishing methods, such as reed traps and spears, should undergo positive discrimination in the legislation process as these fishing methods often have the lowest impact on the fish population.

The Ministry of Fisheries and Marine Resources, Namibia, recognized the need for a comprehensive fish ecological study of the rivers and the floodplains of the Eastern Caprivi. This dissertation focuses on the fish ecology, fish population dynamics, sampling gear selectivity, and species distribution in the rivers and floodplains of the Eastern Caprivi, and will contribute to the fisheries legislation process of the Ministry of Fisheries and Marine Resources, and will serve as baseline study and future reference.

Five surveys were conducted between 1997 and 1999, as part of an ongoing long-term research project, which is coordinated by the Ministry of Fisheries and Marine Resources, Namibia. The surveys were flood related, and low and high flood surveys were conducted (August-September (spring/low) and April-May (autumn/high)). Forty stations (sampling areas) were surveyed regularly during these surveys, and fish were sampled intensively and methodically with various sampling techniques. Fish sampling data, ecological data, biological data and geographical distribution data were recorded at each station.

The Eastern Caprivi research is ongoing, and surveys are conducted regularly in order to compile and maintain a fisheries database, which will enable the Ministry of Fisheries to formulate fisheries legislation, and to institute control measures to utilize and protect the fish resource of the Eastern Caprivi in a sustainable manner.

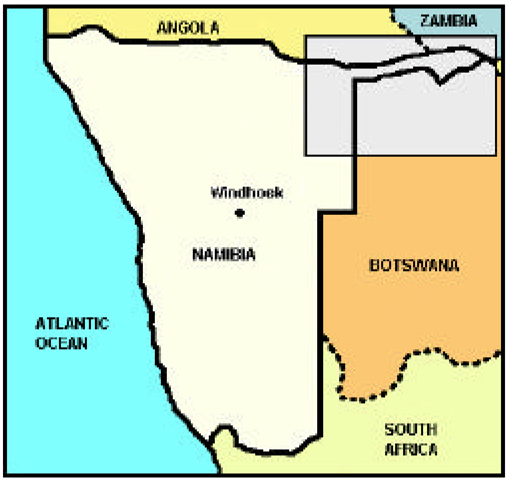
1.1 BACKGROUND ON STUDY AREA

The Eastern Caprivi is a finger-like extension to the northeastern corner of Namibia (Figure 1.1). In the Eastern Caprivi the Zambezi River forms the northeastern border between Namibia and Zambia. In the west, south and to the southeast the Kwando, Linyanti and Chobe Rivers, respectively, form the border between Namibia and Botswana.

Forty stations were surveyed in the Eastern Caprivi and its associated river systems (Figure 1.2). The Eastern Caprivi lies between 17º30' and 18º30' South and 23º15' and 25º15 East (Van der Waal & Skelton, 1984). The region has a surface area of 1,16 million ha (11 655 km^2), and averages 930m above sea level. More than 30% of the Eastern Caprivi is floodplains, which are formed by the rivers during annual floods. The river systems of the Eastern Caprivi form an intricate network of lakes, swamps and floodplains. Floodplains form as a result of the junction between the Zambezi and the Chobe Rivers, and are intermittently inundated with Lake Liambezi during high floods (Van der Waal, 1976). Lake Liambezi has been dry since 1985, but has received some water at the time of writing (2003).

The Eastern Caprivi is flat with a marginal height difference of 100 m between its highest and lowest points of 1024 and 924 metres above sea level. The climate is sub-tropical, with defined wet and dry seasons. The rain season is from October to April, with 34% of the rainfall occurring during October to December, and 65% during January to April. The average rainfall is around 706,5mm per year, with the highest rainfalls occurring during February (Grobler, 1987).

Temperatures of up to 39.4ºC, and a relative humidity of 80% during wet seasons and 40% during the dry seasons have been measured in Katima Mulilo (Van der Waal, 1976).



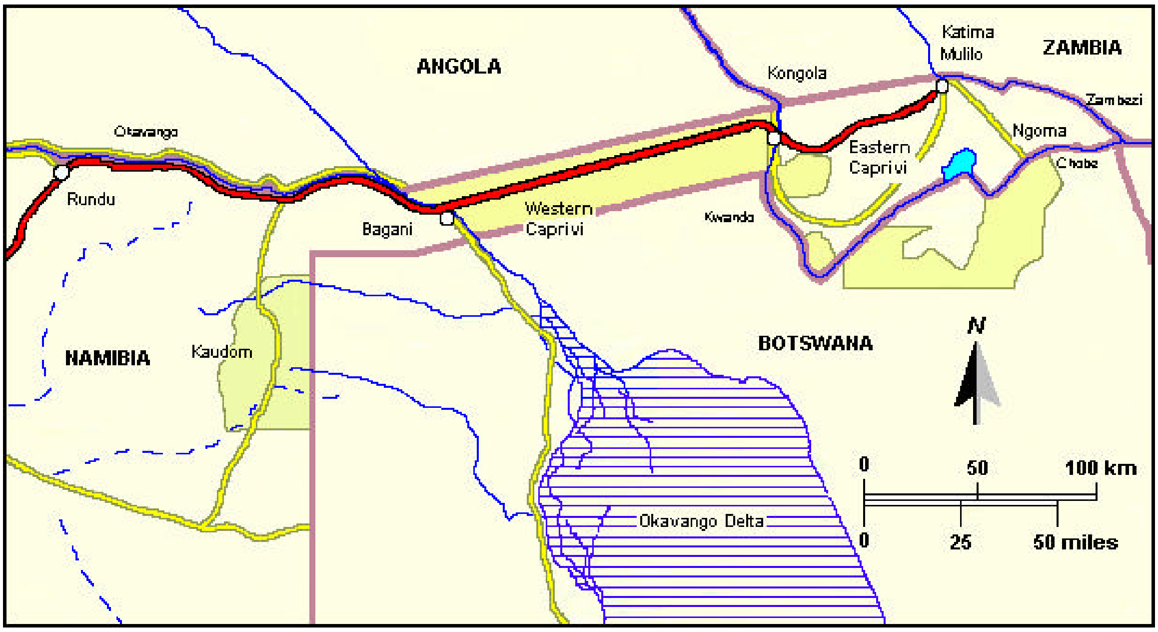


Figure 1.1: Maps showing the situation of the Eastern Caprivi, Namibia (Revilio, 1994).

The wetlands of the Eastern Caprivi are divided into five geographically distinct zones (Schlettwein *et al*., 1991), namely:

- Upper Kwando River.
- Lower Kwando River and Linyanti Swamps.
- Lake Liambezi.
- Chobe Marsh.
- Chobe River and Zambezi River, with Floodplains.

The Zambezi River flows to the east in the northern part of the Caprivi (Figure 1.1 and 1.2). In the western part of the Eastern Caprivi the Kwando River flows southeast into the Linyanti wetlands. In the south the Linyanti River flows northeast towards Lake Liambezi. The Linyanti River was not flowing during the time of the study, and formed isolated pools towards the northeast. The Chobe River seems to serve as a canal between the Zambezi River and Lake Liambezi, and the direction of flow in the Chobe River seems to be flood dependent. When the Zambezi River is in high flood (March-July) the Chobe River will flow southwest, towards Lake Liambezi. During low flood (September-January) the Chobe River will flow northeast into the Zambezi River. Van der Waal (1976) indicates that the flood levels from 1973 to 1975 varied from high flood during March to June, to low flood during August to December.

At the junction of the Zambezi and Chobe Rivers at Impalila Island vast swamps and marshes exist. Additional floodplains configure inland, to the east and south, during high floods in this area. It is a common phenomenon for water to flow in any direction in the interconnecting canals, which drain the wetlands in the Impalila Island area.

Several wetland habitats exist in the Eastern Caprivi region, such as the rivers, canals, side streams, pools, marshes, floodplains, backwaters and lakes. Lake Liambezi is the biggest lake in the Eastern Caprivi, but it is not permanent. Currently it is dry and it has been dry for several years. Lake Lisikili was surveyed as a substitute for a lake type habitat, although it is much smaller than Lake Liambezi.

During early spring (pre-flood surveys) the water level is low. The water is mainly confined to the mainstreams, the larger channels, and the large, adjoining, permanent backwaters of the rivers. The fish are therefore also confined to these areas, and mainly sampled in these habitats. During this time the rivers all flow in a general Easterly direction.

During autumn (post-flood surveys) the water levels are still high and surrounding floodplains are inundated, giving rise to several new habitats, which do not exist during the low pre-flood season. Fish are not confined to the mainstreams any more, which can make sampling more difficult, as the fish are distributed over larger areas. At this time the Chobe River changes direction, and it will flow in a south-westerly direction (towards Lake Liambezi), as water flows from the Chobe-Zambezi floodplains into the Chobe River.

The exception to the rule is the Kwando River, which does not show any noticeable rise or drop in water level during August-September and April-May, the reason being that this river flood at a later time during June (refer to section 1.8).

The part of the Kwando River that was surveyed flows through the Mudumu and Mamili Nature Reserves, and therefore it can be seen as a control area for the study.

Floodplains serve as spawning and nursery grounds, and a large variety of floodplain species occur here. During the post-flood period water flows slowly from the floodplains, back to the rivers via canals and over low-lying vegetated areas fringing the floodplains and mainstreams. These areas, where the water flows from the floodplains into the mainstream, are popular feeding grounds for predatory fish, due to the fry and juvenile fish leaving the floodplains to migrate, or start life in the mainstream.

Van der Waal (1996) stated that the Upper Zambezi was still in a relatively pristine condition during that time. Fishery and overgrazing of floodplains in the Eastern Caprivi are possibly the activities with the highest impact on the environment and fish community. Pollution in the area is negligible and large-scale development and urbanisation is not yet noticeable, therefore the physical characteristics and water quality of each river system does not change drastically from one area to another. Dams and weirs do not occur along any of the parts of the rivers that were surveyed.

It seems that erosion occurs naturally in areas, due to high floods. Erosion also occurs in areas where locals have removed the natural riverbank vegetation, for access to the rivers.

The local human population lives a rural life style, and depends heavily on subsistence fishery as an affordable source of protein (Tvedten, 1994). Commercialisation of the fish resource is a possible problem for the future, especially in the more densely populated areas such as Katima Mulilo and Lisikili.

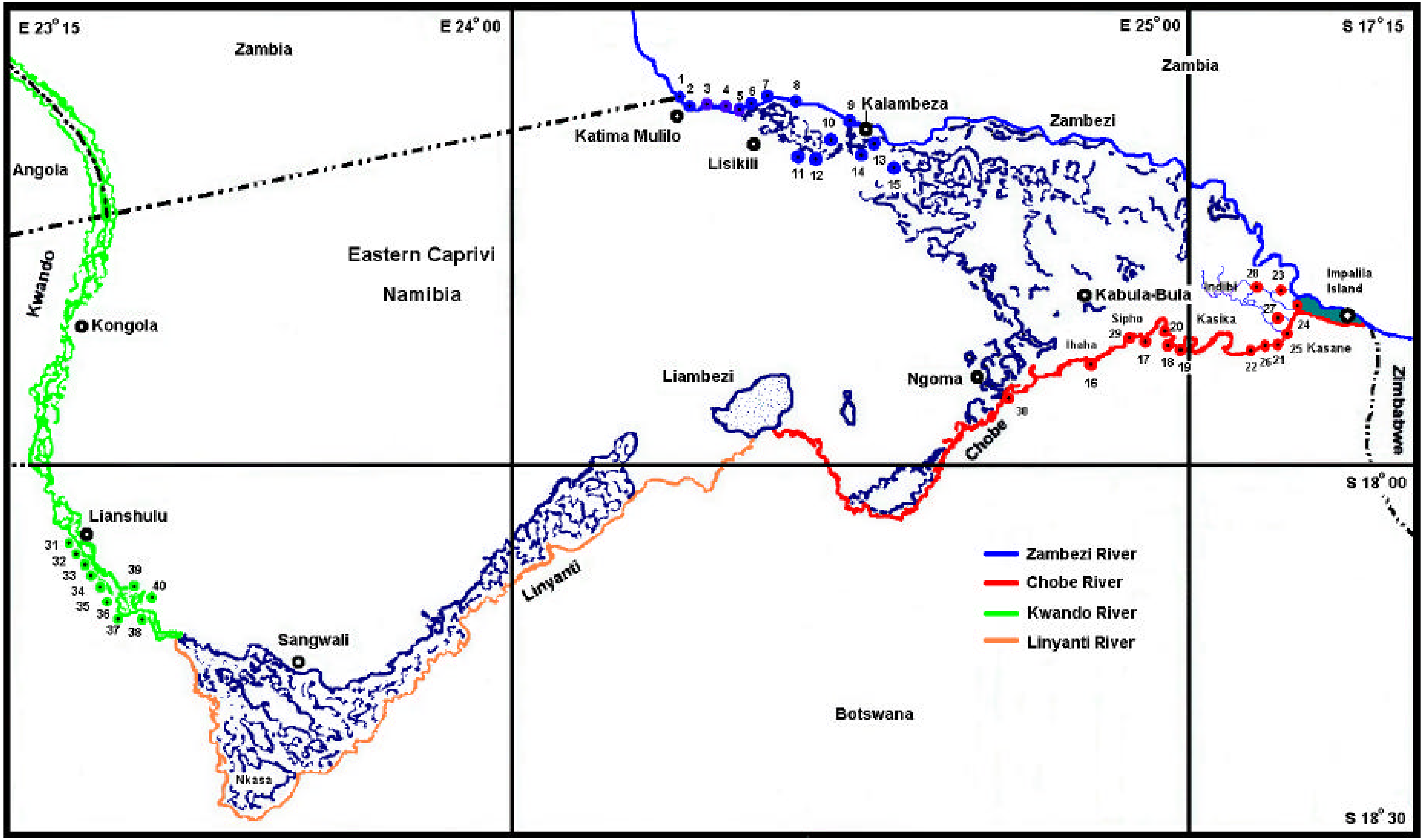


Figure 1.2: Map of the Eastern Caprivi, and the sampling stations for the Zambezi, Chobe, and Kwando Rivers.

1.2 PREVIOUS STUDIES

The most prominent fish ecological studies in the Eastern Caprivi were conducted by Van der Waal (1976) and Grobler (1987), and focused on Lake Liambezi with reference to the local fishery in the area. Several fish collections were made in the upper Zambezi and the Okavango Delta in the past, but few reports of fish collection from the Eastern Caprivi area itself have been published (Van der Waal & Skelton, 1984). Van der Waal and Skelton (1984) mention the previous fish collection expeditions in the upper Zambezi system, and the Eastern Caprivi and cite the following authors Fowler (1935), Van den Berg (1956), Jubb (1958), Guy (1962) and Jubb & Gaigher (1969).

A checklist of the fishes of the Caprivi was published by Van der Waal and Skelton (1984), with special reference to species distribution in each river system, and habitat preference. This publication outlined the distribution of fish in the Eastern Caprivi.

Bethune and Roberts (1991) as cited by Hay *et al.* (1999) published a checklist of the fishes of Namibia for each wetland region. Hay and van Zyl (1999) reported on the distribution of freshwater fish in Namibia with checklists for the Upper Zambezi System, Chobe and Kwando Rivers, with reference to the endemic and non-endemic distribution patterns of the Zambezi province (after Skelton 1994).

Other fish related studies include fisheries studies on the Barotse floodplains (Zambia) by Jackson (1961), Kelly (in FAO, 1968), Duerre (in FAO, 1969), Weiss (in FAO, 1970), and Bell-Cross (1971 and 1974), as cited by Van der Waal (1976). This data is valuable, but the Barotse floodplain differs however from the Eastern Caprivi floodplains and conditions, and it is in this light that this ecological study of the fishes of the Eastern Caprivi came to being.

Previous studies which are valuable for comparison reasons, include ecological research on the same fish species that occur elsewhere (Zambia and Zimbabwe), such as the tiger fish (*Hydrocynus vittatus*) (Kenmuir, 1973) and the threespot tilapia (*Oreochromis andersonii*) (Mortimer, 1960), as well as the catfish (*Clarias gariepinus*) which has been studied in the then Transvaal by Van der Waal in 1972 (authors as cited by Van der Waal, 1976).

Comparative ecological studies of *Serranochromis* and *Sargochromis* species, (Winemiller, 1991), catfishes (Winemiller & Kelso-Winemiller, 1996), and of the African pike and the tigerfish (Winemiller & Kelso-Winemiller, 1994) in the upper Zambezi River drainage of Zambia (Barotse floodplain) also provide valuable comparative data. Van der Waal (1996) also published some observations on fish migration in the Eastern Caprivi.

1.3 FLOW REGIMES IN THE EASTERN CAPRIVI

The Zambezi River upstream from Katima Mulilo has a catchment area of 284 000 km², reaching from East Angola to West Zambia (Du Toit, 1926, as cited by Van der Waal, 1976). The Zambezi River has an average flood height of 5.2 m at Katima Mulilo, and a low flow of 0.5 m. Flood levels may vary from 3 to 8.2 m (Kruger, 1963, as cited by Van der Waal, 1976).

The height difference of the Zambezi River between Katima Mulilo in the West and Impalila Island in the East (a distance of approximately 70 km) is only 10m (Du Toit, 1926, as cited by Van der Waal, 1976), and a flood of 8.2 m at Katima Mulilo stands at 4.8 m at Kasane at the eastern edge of the Eastern Caprivi floodplains. The gradient of the Chobe River from Lake Liambezi is even smaller (7m), and as a result the Zambezi water flows into the Chobe River Westward towards Ngoma (Van der Waal, 1976).

The Kwando River has its origin in the Eastern parts of Angola with a catchment area of 57 000 km² (Colquhoun, 1968, as cited by Van der Waal, 1976). Floodwaters only reach the Eastern Caprivi by July-August due to a winding mainstream and reed marshes. High floods can be up to 2 m higher than the low flood level, but it is usually in the area of 1 m. The flood is usually less than 1 m in the Linyanti marsh where the river spreads into a reed marsh-like delta. The reed marsh has an enormous water retention capability, and ultimately a flood of only 30cm high reaches Lake Liambezi (Van der Waal, 1976). The flow regime and hydrology of the Eastern Caprivi is discussed in further detail by Van der Waal (1976) and Grobler (1987).

1.4 VEGETATION IN THE EASTERN CAPRIVI

Terrestrial vegetation:

The vegetation is diverse in the Eastern Caprivi albeit aquatic or terrestrial. The Eastern Caprivi is situated south of the *Brachystegia*-belt, which reaches from Eastern-Zimbabwe to Western-Zambia and Angola, and the typical vegetation type can be described as dense savanna and bushveld (Van der Waal, 1976).

The somewhat higher lying north-western areas west of Katima Mulilo are typified by higher woodland type trees which are valued timber species, such as *Baikiaea plurijuga* (Zambezi teak), *Erythophleum* spp., *Lonchocarpus* spp., *Ricinodendron* sp., *Combretum* spp., *Acacia* spp., *Bauhinia* spp., and *Baphia* sp. (Van der Waal, 1976).

The somewhat lower lying central area with its sand reefs, loam soils and mopane turf, which include the rain pan area, is dominated by *Colophospermum mopane* (mopane) and

Terminalia sericea. Other trees include *Burkea africana, Peltophorum* sp., *Acacia* sp., *Adansonia digitata, Parinari* spp., and *Combretum* spp. (Van der Waal, 1976).

The most common trees on riverbanks and islands in the Kwando and Linyanti floodplains are *Phoenix* sp. (wild date), *Garcinia* sp., *Diospyros* sp., *Ficus* spp. (wild fig), *Piliostigma* sp., *Acacia* spp., *Combretum* spp., *Afzelia cuanzensis, Kigelia africana* (sausage tree), *Syzygium guineenze* (water pear) (Van der Waal, 1976).

Tree species used for construction of mikolo (local Lozi language for boat) are indicated in Table 1.1, some of which are rare and valuable timber species.

Table 1.1: Tree species that occur in the Eastern Caprivi, and which are used for the construction of mikolo (Van der Waal, 1990).

Species	Common Name	Lozi (Local Language)
Pterocarpus angolensis	Kiaat	Mulombe
Baikiaea plurijuga	Zambezi teak	Mukusi
Guibourtia coleosperma	False mopane	Muzauli
Kigelia africana	Sausage tree	Mupolota
Afzelia quanzensis	Pod mahogany	Mwande
Acacia nigrescens	Knobthorn	Mukotokoto
Acacia albida	Ana tree	Muunga
Combretum hereroense	Russet Bushwillow	Mububu
Lonchocarpus capassa	Apple leaf	Mupanda

Aquatic vegetation:

Phragmites mauritianus, Typha capensis and *Cyperus papyrus* is dominant in the reed swamps of the Kwando and Linyanti Rivers. Other species include *Sesbania sesban*, and smaller *Cyperaceae* and water grasses (Van der Waal, 1990; 1976; and Grobler 1987). Papyrus usually lines the channels in the marsh areas.

Water lilies (*Nymphea* sp.) occur in quiet water areas, and may cover large water surface areas (Grobler, 1987). The eastern floodplains of the Zambezi and Chobe are covered by coarse perennial grasses, with thick-stemmed aquatic grasses (*Echinochloa* spp. and *Vossia* spp.) in lower lying areas (Van der Waal, 1990). Trees occur on the higher lying sandy outcrops and on islands.

Salvinia molesta is a common and well-known alien aquatic weed species in the Eastern Caprivi, and it was mostly observed in quiet water areas.

Permanent water bodies are marginally lined by *Syzygium guineense, Phragmites mauritianus* and *Cyperus papyrus.* Water grasses such as *Vossia cuspidata* and *Echinochloa* sp. occur next to the Zambezi River and its side channels (Van der Waal, 1976).

A wide range of aquatic vegetation in the permanent waters of the Eastern Caprivi and its floodplains, include *Nymphaea caerulea, Nymphoides indica, Ceratophyllum demersum, Lagarosiphon major, Najas pectinata, Potamogeton* spp., *Urtricularia* spp., *Myriophyllum spicatum, Trapa natans, Ottelia* spp., *Chara* sp., *Azolla pinnata* and *Pistia stratiotes* (Van der Waal, 1976).

The aquatic vegetation was however not studied in detail, as this was a fisheries study. Muller *et al.* (1985), and Grobler (1987) also gives a comprehensive list of plants in and around Lake Liambezi.

1.5 FISH SPECIES AND THEIR COMMON NAMES

Table 1.2 presents the fish species list, of 82 species, for the Eastern Caprivi (from Van der Waal & Skelton, 1984; and Skelton, 1993). Families and species are sorted in the same order as in Skelton (1993), and the original author with the year of publication of the name follows the species name. The common names in English and Afrikaans are also provided for each species in Table 1.2 (Skelton, 1993).

Species not sampled during this study are indicated with NS (Not Sampled), and some of the *Synodontis* species, which were likely sampled during the study, but which were difficult to identify, were indicated with NI (Not Identified) (Table 1.2).

Table 1.2: Fish species of the Eastern Caprivi and their common names (Van der Waal & Skelton, 1984; and Skelton, 1993).

	Species List for the Caprivi	Author	English Name	Afrikaans Name
Table 1.2				
	Mormyridae			
1	*Mormyrus lacerda*	Castelnau, 1861	Western bottlenose	Westelike bottelneus
2	*Hippopotamyrus ansorgii*	Boulenger, 1905	Slender stonebasher	Slanke klipstamper
3	*Hippopotamyrus discorhynchus*	Peters, 1852	Zambezi parrotfish	Zambezi-pappegaaivis
4	*Marcusenius macrolepidotus*	Peters, 1852	Bulldog	Snawelvis
5	*Petrocephalus catostoma*	Günther, 1866	Churchill	Stompkoppie
6	*Pollimyrus castelnaui*	Boulenger, 1911	Dwarf stonebasher	Dwerg- klipstamper
	Cyprinidae			
7	*Mesobola brevianalis*	Boulenger, 1908	River sardine	Riviersardyn
8	*Opsaridium zambezense*	Peters, 1852	Barred minnow	Balkghieliemientjie
9	*Barbus barotseensis*	Pellegrin, 1920	Barotse barb	Barotse-ghieliemientjie
10	*Barbus lineomaculatus* **(NS)**	Boulenger, 1903	Line-spotted barb	Lynkol-ghieliemientjie
11	*Barbus unitaeniatus*	Günther, 1866	Longbeard barb	Langbaard-ghieliemientjie
12	*Barbus bifrenatus*	Fowler, 1935	Hyphen barb	Skakel-ghieliemientjie

Species List for the Caprivi		Author	English Name	Afrikaans Name
Table 1.2				
13	*Barbus brevidorsalis* **(NS)**	Boulenger, 1915	Dwarf barb	Dwerg-ghieliemientjie
14	*Barbus thamalakanensis*	Fowler, 1935	Thamalakane barb	Thamalakane-ghieliemientjie
15	*Barbus barnardi*	Jubb, 1965	Blackback barb	Swartrug-ghieliemientjie
16	*Barbus fasciolatus*	Günther, 1868	Red barb	Rooi- ghieliemientjie
17	*Barbus radiatus*	Peters, 1853	Beira barb	Beira- ghieliemientjie
18	*Barbus haasianus*	David, 1936	Sickle-fin barb	Sekelvin-ghieliemientjie
19	*Coptostomabarbus wittei*	David & Poll, 1937	Upjaw barb	Boel- ghieliemientjie
20	*Barbus poechii*	Steindachner, 1911	Dashtail barb	Streepstert-ghieliemientjie
21	*Barbus cf. eutaenia*			
22	*Barbus multilineatus*	Worthington, 1933	Copperstripe barb	Koperstreep-ghieliemientjie
23	*Barbus afrovernayi*	Nichols & Boulton, 1927	Spottail barb	Kolstert- ghieliemientjie
24	*Barbus paludinosus*	Peters, 1852	Straightfin barb	Lynvin (Moeras)-ghieliemientjie
25	*Barbus kerstenii* **(NS)**	Peters, 1868	Redspot barb	Rooikol- ghieliemientjie
26	*Barbus codringtonii*	Boulenger, 1908	Upper Zambezi yellowfish	Bo-Zambezi-geelvis
27	*Labeo cylindricus*	Peters, 1852	Redeye Labeo	Rooioog-moddervis
28	*Labeo lunatus*	Jubb, 1963	Upper Zambezi Labeo	Bo-Zambezi-Moddervis
	Distichodontidae			
29	*Hemigrammocharax machadoi*	Poll, 1967	Dwarf citharine	Dwerg-sitarien
30	*Hemigrammocharax multifasciatus*	Boulenger, 1923	Multibar citharine	Veelbalk-sitarien
31	*Nannocharax macropterus* **(NS)**	Pellegrin, 1925	Broadbar citharine	Breëbalk-sitarien
	Characidae			
32	*Brycinus lateralis*	Boulenger, 1900	Striped robber	Streep-rower
33	*Micralestes acutidens*	Peters, 1852	Silver robber	Silwer-rower
34	*Rhabdalestes maunensis*	Fowler, 1935	Slender robber	Slanke rower
35	*Hydrocynus vittatus*	Castelnau, 1861	Tigerfish	Tiervis
	Hepsetidae			
36	*Hepsetus odoe*	Bloch, 1794	African pike	Afrika-greepvis
	Claroteidae			
37	*Parauchenoglanis ngamensis*	Boulenger, 1911	Zambezi grunter	Zambezi-knorbaber
	Amphiliidae			
38	*Leptoglanis rotundiceps* **(NS)**	Hilgendorf, 1905	Spotted sand catlet	Gevlekte-sandbabertjie
39	*Leptoglanis cf. dorae*	non Poll, 1967	Chobe sand catlet	Chobe-sandbabertjie
40	*Amphilius uranoscopus* **(NS)**	Pfeffer, 1889	Common or stargazer mountain fish	Gewone bergbaber
	Schilbeidae			
41	*Schilbe intermedius*	Rüppell, 1832	Silver catfish (Butter barbell)	Silver – or Botterbaber, Makriel
	Clariidae			
42	*Clarias gariepinus*	Burchell, 1822	Sharptooth catfish	Skerptandbaber
43	*Clarias ngamensis*	Castelnau, 1861	Blunttooth catfish	Stomptandbaber
44	*Clarias stappersii*	Boulenger, 1915	Blotched catfish	Gevlekte baber
45	*Clarias liocephalus* **(NS)**	Boulenger, 1898	Smoothhead catfish	Sagkopbaber
46	*Clarias theodorae*	Weber, 1897	Snake catfish	Slangbaber
47	*Clariallabes platyprosopos*	Jubb, 1964	Broadhead catfish	Breëkopbaber
	Mochokidae			
48	*Chiloglanis fasciatus* **(NS)**	Pellegrin, 1936	Okavango suckermouth	Okavango-suierbekkie
49	*Chiloglanis neumanni*	Boulenger, 1911	Neumann's suckermouth	Zambezi-suierbekkie
50	*Synodontis nigromaculatus*	Boulenger, 1905	Spotted squeaker	Spikkel-skreeubaber
51	*Synodontis woosnami* **(NI)**	Boulenger, 1911	Upper Zambezi squeaker	Bo-Zambezi-skreeubaber
52	*Synodontis macrostigma*	Boulenger, 1911	Largespot squeaker	Grootvlek-skreeubaber
53	*Synodontis macrostoma* **(NI)**	Skelton & White, 1990	Largemouth squeaker	Grootbek-skreeubaber
54	*Synodontis leopardinus* **(NI)**	Pellegrin, 1914	Leopard squeaker	Luiperdkol-skreeubaber

	Species List for the Caprivi	Author	English Name	Afrikaans Name
Table 1.2				
55	*Synodontis thamalakanensis* **(NI)**	Fowler, 1935	Bubblebarb squeaker	Borrelbaard-skreeubaber
56	*Synodontis vanderwaali*	Skelton & White, 1990	Finetooth squeaker	Fyntand-skreeubaber
	Aplocheilidae			
57	*Nothobranchius* sp. **(NS)**		Caprivi killifish	Gestreepte kuilvissie
	Cyprinodontidae			
58	*Aplocheilichthys johnstoni*	Günther, 1893	Johnston's topminnow	Johnston se lampogie
59	*Aplocheilichthys hutereaui*	Boulenger, 1913	Meshscaled topminnow	Tralielampogie
60	*Aplocheilichthys katangae*	Boulenger, 1912	Striped topminnow	Streeplampogie
	Cichlidae			
61	*Hemichromis elongatus*	Guichenot, 1859	Banded jewelfish	Balk-juweelvis
62	*Pseudocrenilabrus philander*	Weber, 1897	Southern mouthbrooder	Suidelike mondbroeier
63	*Pharyngochromis acuticeps*	Steindachner, 1866	Zambezi happy	Zambezi-happie
64	*Sargochromis carlottae*	Boulenger, 1905	Rainbow happy	Reënboog-happie
65	*Sargochromis codringtonii*	Boulenger, 1908	Green happy	Groen-happie
66	*Sargochromis giardi*	Pellegrin, 1903	Pink happy	Ligroos-happie
67	*Sargochromis greenwoodi* **(NS)**	Bell-Cross, 1975	Greenwood's happy	Greenwood se happie
68	*Serranochromis altus*	Winemiller & Kelso-Winemiller, 1990	Humpback largemouth	Kromkop-grootbek
69	*Serranochromis angusticeps*	Boulenger, 1907	Thinface largemouth	Smalkop-grootbek
70	*Serranochromis longimanus*	Boulenger, 1911	Longfin largemouth	Langvin-grootbek
71	*Serranochromis macrocephalus*	Boulenger, 1899	Purpleface largemouth	Perskop-grootbek
72	*Serranochromis robustus*	Günther, 1864	Nembwe	Olyfkurper
73	*Serranochromis thumbergi*	Castelnau, 1861	Browspot largemouth	Bruinkol-grootbek
74	*Tilapia sparrmanii*	A. Smith, 1840	Banded Tilapia	Vleikurper
75	*Tilapia ruweti*	Poll & Audenaerde, 1965	Okavango Tilapia	Okavango-kurper
76	*Tilapia rendalli*	Boulenger, 1896	Redbreast Tilapia	Rooiborskurper
77	*Oreochromis andersonii*	Castelnau, 1861	Threespot Tilapia	Driekolkurper
78	*Oreochromis macrochir*	Boulenger, 1912	Greenhead Tilapia	Groenkop-kurper
	Anabantidae			
79	*Microtenopoma intermedium*	Pellegrin, 1920	Blackspot climbing Perch	Swartkol-kurper
80	*Ctenopoma multispine*	Peters, 1844	Manyspined climbing Perch	Stekelrige kurper
	Mastacembelidae			
81	*Aethiomastacembelus frenatus*	Boulenger, 1901	Longtail spiny eel	Langstert-stekelpaling
82	*Aethiomastacembelus vanderwaali*	Skelton, 1976	Ocellated spiny eel	Kolvin-stekelpaling

NS = Not Sampled
NI = Not Identified

1.6 LOCAL HUMAN POPULATION AND SOCIO-ECONOMICS

The language most commonly used in the Eastern Caprivi is Lozi. Two main groups use it, the Mafwe in the West and the Basubia in the East, who are descendants from the Aluyi and Malozi tribes from Barotse land, Western Zambia (Van der Waal, 1976; and Grobler, 1987).

The main food sources in the area include, produce from various agricultural activities (maize, beans, sorghum, pumpkins and peanuts), cattle farming, and the local freshwater fishery (Grobler, 1987).

Urbanization in the sixties led to a rise in food demand, and this formed the foundation of a fish market in the Katima Mulilo area (Grobler, 1987), where fish is still being sold on a daily basis.

The ever-increasing food demand constantly increases the pressure on the fish resource of the Eastern Caprivi as an affordable protein food resource. As a result, exploitation and the commercialisation of the fish resource occurs in certain areas of the Eastern Caprivi especially near areas where the demand for a cheap food source is high, such as in Katima Mulilo. These areas are fished with gill nets, which are obtained from dealers in Zambia at low cost. The low cost of nets and the relative ease with which fish are caught makes commercial fishery an attractive prospect for potential entrepreneurs. Additionally drag netting, which is not favoured by the local *Khuta* (traditional governing system), is becoming increasingly popular under the subsistence fishermen in the Eastern Caprivi.

One of the purposes of this study was therefore to monitor the catches from the experimental gill nets and other gear to determine the sampling gear selectivity and catch per unit effort of the different gears, in an effort to make recommendations to the management body of the Ministry of Fisheries and Marine Resources, Namibia, concerning the use of gill nets in the Eastern Caprivi. At the time of the study formal governmental legislation concerning the use of gill nets in the Eastern Caprivi was not yet finalised, and the data from this study was to be used in comparison with local gill net catch data to formulate legislation, which will ensure the sustainable use of the natural fish resource in the Eastern Caprivi.

Van der Waal (1976) discusses the most popular fishing methods in the Eastern Caprivi, and Table 1.3 presents the local fishing methods most often observed during the study.

Table 1.3: Local fishing methods.

FISHING METHODS
TRADITIONAL REED-FENCE TRAP
MOSQUITO DRAG NET (fine mesh)
LONG DRAG NET (often large meshes are used – 45mm to 150mm)
TRADITIONAL SPEAR
TRADITIONAL CONICAL TWIG FUNNEL
ANGLING
GILL NET NETS
BOTTLE TRAPS

The callous use of dragnets, with fine meshes, by local commercial fishermen in the Eastern Caprivi may prove to be devastating to the fish population, as fish is caught indiscriminately. The use of dragnets with large mesh sizes may also be detrimental to the fish population as the larger specimens (breeding stock) may be targeted.

Local fishermen take advantage of fish migrations, during which time high numbers of juvenile fish are caught with makeshift dragnets made from fine meshed mosquito nets. These catches were studied (by the author) and some individuals netted up to 20 kg of fish per hour. The catches consisted of mostly small juvenile fish, and a catch of 20 kg consisted of an estimated 15000 specimens. The fish were sold fresh or dried at the local market, and reached prices of up to N$ 125 per 20 kg.

With the high prices reached at the fish market it is obvious why locals would turn to fishing for an income. Fish migration and distribution therefore play a role in this study, which will enable the Namibian Government to investigate the feasibility of introducing fishing seasons and conservational areas in the Eastern Caprivi, which will in turn protect the juvenile migrating fish species and their nursery areas.

The local fish market in Katima Mulilo was surveyed (by the author) and the average price for fish was between N$6 and N$9 per kilogram depending on the freshness of the fish. Local vendors earned an average estimated salary of N$1575 per month.

Fish is the main source of protein for most of the local people in the Eastern Caprivi, and for some it is a source of income, as 72% of the cash flow in this area is generated by the selling of fish (Tvedten, 1994).

Other socio-economical data for the Eastern Caprivi include (from Tvedten, 1994):

- 44% of the households eat fish on a daily basis.
- Another 44% eat fish on a weekly basis.
- More than 51% of the households sell more than half of their catches, emphasizing the commercial value of fresh water fish in the Eastern Caprivi.
- 82% of households market fish.
- 15% of families are totally dependant on fish for an income or as subsistence.
- 8000 fishermen operate in the Eastern Caprivi area.
- The estimated total fish production is estimated at 1500 metric tons.
- The average value of fish during 1994 was N$ 6/kg.
- The estimated value of the fishery in the Eastern Caprivi during 1994 was N$ 9 million per annum.
- The monthly income of local fishermen ranged from N$ 474 to N$ 3941 during 1994.
- Freshwater fish are important to the tourist industry in terms of angling.
- Fishing lodges generate income to the local community.

The fish resource of the Eastern Caprivi is of great value for obvious reasons, and should be managed and protected for future generations. Van der Waal (1976) recommended that as many as 750 000 kg of fish may be harvested from Lake Liambezi per year, without any obvious detrimental effect on the fish population. Grobler (1987) states that Lake Liambezi covers an area of approximately 10 000 ha when the water level remains stable, and estimated that water birds utilised 37 000 kg of fish and that local fishermen removed a further 137 000 kg of fish during a twelve month period. Grobler (1987) also states that these numbers are conservative estimates, which are far below the estimated potential of the lake. Although Lake Liambezi was dry at the time of the study, these estimations serve to give some indication of the enormous fisheries potential of the Eastern Caprivi.

During this study (1997-1999) it was determined that the average value of the fish sold at the market varied according to season (availability), freshness and size. It was a matter of supply and demand and when fish was readily available the value of the fish decreased, although prices were never lower than a minimum of N$ 6/kg. The prevalence of sea fish sold at the market also seemed to increase over the study period, but the socio-economic impacts concerning this issue was not studied in detail.

Table 1.4 provides the average fish prices, fresh and dried, at the time of this study for some of the preferred fish species, sold at the Katima Mulilo market. Fresh bream (Cichlidae) reached the highest price at the market with N$ 14/kg, followed by the silver catfish (*Schilbe intermedius*) with N$ 11/kg. The tiger fish (*Hydrocynus vittatus*), pike (*Hepsetus odoe*) and catfish (*Clarias* spp.) all reached maximum prices of N$ 10/kg. Fresh fish were preferred and therefore reached higher prices than the dried fish. Larger specimens also reached higher prices than small specimens (Table 1.4).

Table 1.4: Average fish prices (per kilogram fresh and dry weight) recorded at the Katima Mulilo Fish Market, Eastern Caprivi (1997-1999).

Species	Fresh ($/kg)	Dry ($/kg)
Bottle nose (*Mormyrus lacerda*)	7 $/kg	5 $/kg
Small shoaling fish (Smaller Characidae)	7 $/kg	4 $/kg
Tiger fish (*Hydrocynus vittatus*)	10 $/kg	5 $/kg
African pike (*Hepsetus odoe*)	8 $/kg	5 $/kg
Silver catfish (*Schilbe intermedius*)	11 $/kg	5 $/kg
Catfish (Larger *Clarias* spp.)	7 $/kg	5 $/kg
Squeaker (*Synodontis* spp.)	5 $/kg	4 $/kg
Bream (Larger Cichlidae)	14 $/kg	10 $/kg

1.7 OBJECTIVES

- To determine the species composition in the Eastern Caprivi river systems, and to compile comprehensive species lists.
- To record species distribution in the Eastern Caprivi.
- To determine the effect of seasonal changes, and the flood cycle on the fish community.
- To develop a database to explain future tendencies in the fish community.
- To determine the state of the fish recource in the Caprivi.
- To study the population dynamics of the different species.
- To identify problem areas where possible exploitation of the resource may occur.
- To analyse gear catches to determine selectivity and catch per unit efforts, and
- To supply information, which will enable the Namibian Government to formulate legislation.

2 SURVEYS, STATIONS AND HABITATS

2.1 INTRODUCTION

Five surveys were conducted between 1997 and 1999 in the Eastern Caprivi. The surveys were flood related. Three surveys were conducted during high floods (autumn) during the months of April to May, and two during low floods (spring) during the months of September to October (Table 2.1). Forty stations were surveyed methodically. The stations with its habitats were representative of the river systems.

2.2 MATERIALS AND METHODS

2.2.1 Surveys

The five surveys were conducted in the three major river systems in the Eastern Caprivi: The Zambezi, Chobe and Kwando Rivers including the Floodplains. Lake Lisikili (part of the Zambezi system) was surveyed as a lake type habitat. Internal isolated rain pools were also surveyed in search of the *Nothobranchius* sp.

Table 2.1 indicates the date, season, and flood type, of each of the five surveys. The surveys were conducted during the high and low floods to determine the possible impact of the flood levels on the fish population. Breeding patterns, gonad maturation, migration, habitat preferences, length frequencies, distribution, catch per unit effort and species density are some of the fisheries parameters and fish behaviour patterns studied, that could differ from season to season.

Table 2.1: Survey dates, seasons and floods.

Survey	Date	Season	Flood
1	April-May 1997	Autumn	High
2	September-October 1997	Spring	Low
3	April-May 1998	Autumn	High
4	September-October 1998	Spring	Low
5	April-May 1999	Autumn	High

2.2.2 Stations

Forty stations were identified. Stations were chosen with the aim to have a variety of habitats present in the area of the station. The stations with its habitats had to be representative of each river system. The stations included areas where possible external influences such as fishery, overgrazing, pollution and urbanisation could affect the ecosystem. Logistically the stations had to be easily accessible.

The longitude and latitude readings for every station was recorded with a Global Positioning System (GPS), and habitat descriptions were done at each station. The species distribution and habitat preference of the fish species was thus recorded.

Fish were sampled in the different habitats at the 40 stations with various sampling methods to minimize the effect of gear selectivity. The sampling gear used at every station was recorded. The sampling methods are described in Chapter 3.

Fisheries parameters for each fish sampled were recorded at each station. The species name, length (cm), weight (g), sex and gonadal development were the most important parameters recorded. The fork length was recorded for fish with forked caudal fins, and the total length was recorded for fish with truncate or rounded caudal fins.

Stations were chosen and identified in every system and the station name, code, and a GPS reading was recorded (Table 2.2).

Fifteen stations were surveyed regularly in the Zambezi River during both high and low floods. Most habitats at these stations remained consistent during the surveys, with only the flood level fluctuating. During high floods Station 1, a rocky habitat, was not surveyed because the habitat was submerged. Floodplain habitats, when present, were surveyed during high floods (Table 2.2).

Fifteen stations were surveyed in the Chobe River. Stations 16 to 20 and station 29 were mostly surveyed during spring at times of low flood, when these areas were accessible by road. Stations 21 to 28 were mostly surveyed during autumn at times of high flood, when the roads were flooded and these areas were more easily accessible by boat. During autumn most of the spring stations were flooded and surveying in these areas was not possible due to logistical reasons. Station 30 at Ngoma was floodplains, surveyed during high floods (Table 2.2).

Ten Stations were regularly surveyed in the Kwando River during both seasons. The Kwando River usually flooded a month later during June-July, and the total effect of the rising floods had not yet made an impact in this area during the time of the surveys. Overgrown riverbeds and floodplains further upstream towards Angola also delayed and minimised the impact of floods in this area. Locals reported that poaching occurs in the area, and that the numbers of Hippopotamus, which often keeps river channels open, may be dwindling (Table 2.2).

Table 2.2: Names, codes and GPS readings for each of the 40 stations surveyed in the Eastern Caprivi.

Station Name	Code	System	Latitude	Longitude
Near Katima Mulilo Ferry	1	Zambezi	S17°28' 32.2"	E24°14' 53.3"
Katima Mulilo	2	Zambezi	S17°29' 18.8"	E24°15' 29.1"
Zambezi Lodge	3	Zambezi	S17°29' 09.3"	E24°17' 06.8"
Katima Nature Conservation	4	Zambezi	S17°29' 15.7"	E24°18' 09.8"
Hippo Island	5	Zambezi	S17°29' 44.0"	E24°19' 44.9"
Hippo Lodge	6	Zambezi	S17°29' 46.6"	E24°19' 56.3"
5km East of Hippo Lodge	7	Zambezi	S17°28' 35.7"	E24°22' 34.9"
Between Katima and Kalambeza	8	Zambezi	S17°28' 32.4"	E24°24' 33.4"
3km West of Kalambeza Island	9	Zambezi	S17°30' 16.2"	E24°29' 44.7"
Skelm Channel, Kalambeza, West	10	Zambezi	S17°32' 29.6"	E24°30' 17.1"
Between Lisikili and Kalambeza	11	Zambezi	S17°33' 17.8"	E24°29' 25.6"
Lake Lisikili	12	Zambezi	S17°32' 32.2"	E24°29' 49.9"
Kalambeza Channel Mouth East	13	Zambezi	S17°31' 46.5"	E24°32' 57.6"
Kalambeza Channel	14	Zambezi	S17°32' 37.9"	E24°31' 22.2"
Kalizo Lodge	15	Zambezi	S17°32' 25.0"	E24°33' 55.3"
Ihaha (Kabula-Bula Region)	16	Chobe	S17°50' 10.2"	E24°52' 45.5"
Sipho (Kabula-Bula Region)	17	Chobe	S17°48' 00.9"	E24°56' 59.7"
5km N-East of Sipho	18	Chobe	S17°48' 38.0"	E24°58' 17.2"
10km N-East of Sipho	19	Chobe	S17°49' 30.3"	E24°58' 33.3"
15km N-East of Sipho	20	Chobe	S17°48' 59.5"	E24°58' 47.8"
Kasikili Island	21	Chobe	S17°48' 21.5"	E25°08' 22.0"
Kasika Village	22	Chobe	S17°49' 11.5"	E25°06' 24.3"
Kasai Channel near Impalila Island	23	Chobe - Zambezi	S17°44' 35.9"	E25°08' 43.8"
Impalila Island	24	Chobe	S17°46' 36.6"	E25°09' 43.1"
Kasane	25	Chobe	S17°47' 59.0"	E25°08' 41.3"
Kings Den Lodge	26	Chobe	S17°48' 27.3"	E25°07' 29.0"
Indibi Channel Chobe Marsh	27	Chobe	S17°47' 35.8"	E25°08' 52.1"
Indibi Channel near Impalila Island	28	Chobe	S17°44' 39.7"	E25°07' 47.7"
Nanyanga (Kabula-Bula Region)	29	Chobe	S17°49' 07.4"	E24°55' 52.0"
Ngoma	30	Chobe	S17°53' 23.3"	E24°42' 57.2"
Lianshulu Lodge	31	Kwando	S18°08' 05.7"	E23°22' 47.6"
New Lianshulu Bush Camp	32	Kwando	S18°09' 07.3"	E23°22' 54.5"
2km West of Buffalo Trails	33	Kwando	S18°08' 47.3"	E23°22' 56.7"
1km West of Buffalo Trails	34	Kwando	S18°08' 43.2"	E23°22' 46.2"
Buffalo Trails	35	Kwando	S18°09' 23.6"	E23°23' 03.9"
2km East of Buffalo Trails	36	Kwando	S18°09' 50.4"	E23°23' 15.6"
Nakatwa Island	37	Kwando	S18°11' 06.5"	E23°24' 48.9"
15km East of Nakatwa	38	Kwando	S18°12' 09.2"	E23°27' 34.8"
Nakatwa	39	Kwando	S18°10' 21.6"	E23°25' 13.3"
2km East of Nakatwa	40	Kwando	S18°10' 33.6"	E23°26' 31.1"

2.2.3 Habitat descriptions

Categorised habitat types were identified to simplify the habitat description and habitat identification process at each of the stations. Main habitats were broken down in sub-habitats and given a short descriptive name. Table 2.3 indicates the habitat types with a short description of the habitat and the most commonly used gears for that habitat.

Table 2.3: Short description of categorised habitat types with most commonly used sampling gear.

Habitat	Short Description and Gear Used
Table 2.3	
Rocky Habitats	
Rapids deep	**Rocky** substrate, fast flowing **mainstream**, clear water, angling
Rapids shallow	**Rocky** substrate, fast flowing **mainstream**, clear water, rotenone, seine, shock
Rocks	**Rocky** substrate, clear **pools** and **shallow side streams**, quiet to intermediate flow, rotenone, seine, shock
Pebbles	**Pebble** substrate, clear, shallow, slow flowing water, seine, shock, rotenone
Mainstream Habitats	
Mainstream deep	**Deep Mainstream with no vegetation**, open water or near margin, slow to fast flow, angling, cast and gill nets
Mainstream deep vegetation	**Deep Mainstream with vegetation**, usually near margin, slow to fast flow, gill nets and angling
Mainstream shallow	**Mainstream with no vegetation,** usually near margin, clear water, slow to intermediate flow, seine, traps
Mainstream shallow vegetation	**Mainstream with vegetation,** near margin, clear water, slow to intermediate flow, seine, shock, traps
Riverbank vegetation	**Riverbank between marginal vegetation**, very shallow, quiet to slow flowing clear water, seine, rotenone, shock, traps
Riverbank sand	**Riverbank with no vegetation**, very shallow with sandy substrate, slow to fast flowing clear water, seine, shock, traps
Mainstream sand bank	**In the mainstream, shallow clear water running over clean sand**, seine
Mainstream sand bay	**Shallow sand bay with no vegetation**, sometimes with siltation and murky water, no flow, seine
Mainstream vegetation bay	**Shallow vegetated bay**, sometimes with siltation, no flow, seine
Isolated Pool Habitats	
Isolated pool next to river, vegetation	**Vegetated pool**, shallow and muddy, murky water with terrestrial and aquatic vegetation, seine
Isolated pool next to river	**Shallow pool**, muddy, murky water with no vegetation, seine
Isolated floodplain pool, vegetation	**Isolated pools on floodplains**, usually shallow water with terrestrial and aquatic vegetation, sometimes muddy, seine, shock, rotenone, traps
Backwater pool, vegetation	**Shallow backwater pools that are drying up**, muddy substrate and water, **aquatic vegetation**, seine, rotenone, shock, cast net
Backwater pool	**Shallow backwater pools that are drying up**, muddy substrate and water, **no vegetation**, seine, rotenone, shock, cast net
Rain pool	**Isolated, inland rain pools**, muddy substrate and water, submerged terrestrial vegetation, seasonal, seine
Floodplain Habitats	
Floodplain	**Floodplains,** clear, standing to very slow flowing water, submerged terrestrial vegetation (inundated field and grassland), seine, rotenone, shock
Backwater Habitats	
Backwater deep	**Deep, open water areas of backwaters with no vegetation**, gill nets, cast net
Backwater shallow	**Shallow areas of backwaters with no vegetation**, usually near margin, shock, seine, rotenone, cast net, traps
Backwater deep vegetation	**Deep areas of backwaters with vegetation**, usually near margin, gill nets, cast net, traps
Backwater shallow vegetation	**Shallow areas of backwaters, usually near margin with aquatic vegetation,** shock, seine, rotenone, cast net, traps
Backwater bank vegetation	**Backwater bank between marginal aquatic vegetation**, very shallow, sometimes muddy, seine, traps, rotenone, shock
Backwater bank sand	**Backwater bank with sandy substrate**, very shallow with clear water, seine, traps, rotenone, shock
Lake Habitats	
Lake deep	**Deep open water in lake**, usually away from margin, no vegetation, cast net, gill nets
Lake deep vegetation	**Deep vegetated areas of lake usually near margin**, cast net, gill nets, traps
Lake bank sand	**Lake bank,** sandy, clear water, very shallow, seine, rotenone, traps
Lake bank vegetation	**Lake bank between aquatic vegetation**, very shallow, sometimes muddy with siltation, seine, rotenone, traps
Side Stream Habitats	

Habitat	Short Description and Gear Used
Table 2.3	
Clear sandy side stream	**Clear sandy side streams with no vegetation**, narrow and shallow, with slow to intermediate flow, rotenone, seine, shock
Clear sandy side stream, vegetation	**Clear sandy side streams with aquatic vegetation**, narrow and shallow, with slow to intermediate flow, rotenone, seine, shock
Channel Habitats	
Deep narrow channel	**Deep open water of channels,** usually in marsh areas, 3-10m wide, clear water, slow flow, gill nets, cast net
Deep narrow channel, vegetation	**Deep vegetated areas of channel,** clear water, marginal aquatic vegetation, slow flow, gill nets, cast net

2.2.4 Station name and habitat selection

Every system was surveyed separately for every season, and the information was recorded in separate tables. The station name usually contains the name of the closest approximate town or village.

The date, gear used, station name, station code and habitat type was recorded at every different or new habitat surveyed in the area of the station. The same habitat types were often surveyed in different areas of the station especially if it occurred frequently.

2.3 RESULTS AND DISCUSSION

2.3.1 The Zambezi River

Tables 2.4 – 2.8 indicate the stations, habitats and the gear used during the different surveys in the Zambezi River during the study.

Table 2.4: Date, gear used, station with code, and habitats surveyed in the Zambezi River, autumn 1997.

Date	Gear	Station	Station Code	Habitat Type
Table 2.4				
23/5/97	Gill net	Hippo Lodge	6	Mainstream deep vegetation
23/5/97	Gill net	Hippo Lodge	6	Mainstream deep vegetation
23/5/97	Gill net	Hippo Lodge	6	Mainstream deep
23/5/97	Traps	Hippo Lodge	6	Riverbank vegetation
23/5/97	Angling	Hippo Lodge	6	Mainstream deep vegetation
23/5/97	15m Seine	Hippo Island	5	Mainstream shallow vegetation
23/5/97	15m Seine	Hippo Island	5	Mainstream shallow vegetation
23/5/97	15m Seine	Hippo Lodge	6	Backwater shallow
23/5/97	15m Seine	Hippo Lodge	6	Backwater shallow
23/5/97	15m Seine	Hippo Island	5	Mainstream shallow vegetation
24/5/97	Gill net	Hippo Lodge	6	Mainstream deep vegetation
24/5/97	Gill net	Hippo Lodge	6	Mainstream deep vegetation
24/5/97	15m Seine	5km East of Hippo Lodge	7	Backwater shallow vegetation
24/5/97	15m Seine	5km East of Hippo Lodge	7	Backwater shallow vegetation

Date	Gear	Station	Station Code	Habitat Type
Table 2.4				
24/5/97	15m Seine	5km East of Hippo Lodge	7	Mainstream sand bank
24/5/97	Scoop net	5km East of Hippo Lodge	7	Mainstream sand bank
24/5/97	15m Seine	Between Katima and Kalambeza	8	Riverbank vegetation
24/5/97	15m Seine	Between Katima and Kalambeza	8	Backwater shallow vegetation
25/5/97	Gill net	Between Katima and Kalambeza	8	Backwater deep vegetation
25/5/97	Gill net	Between Katima and Kalambeza	8	Backwater deep vegetation
25/5/97	Rotenone	Between Katima and Kalambeza	8	Backwater bank vegetation
25/5/97	15m Seine	Kalambeza Channel Mouth East	13	Backwater shallow vegetation
25/5/97	15m Seine	Kalambeza Channel Mouth East	13	Mainstream shallow
25/5/97	15m Seine	Kalambeza Channel Mouth East	13	Riverbank sand
25/5/97	Rotenone	Kalambeza Channel Mouth East	13	Floodplain
26/5/97	Gill net	Kalizo Lodge	15	Mainstream deep
26/5/97	15m Seine	Kalizo Lodge	15	Clear sandy side stream
26/5/97	15m Seine	Kalizo Lodge	15	Clear sandy side stream, vegetation
26/5/97	15m Seine	Kalizo Lodge	15	Backwater shallow vegetation
26/5/97	15m Seine	Kalizo Lodge	15	Mainstream shallow
26/5/97	15m Seine	Kalizo Lodge	15	Mainstream shallow vegetation
26/5/97	15m Seine	Kalizo Lodge	15	Mainstream shallow
26/5/97	15m Seine	Kalizo Lodge	15	Mainstream sand bay
26/5/97	15m Seine	Kalizo Lodge	15	Mainstream vegetation bay
26/5/97	15m Seine	Kalambeza Channel	14	Mainstream sand bay
26/5/97	Gill net	Kalambeza Channel	14	Mainstream deep vegetation
26/5/97	Gill net	Kalambeza Channel	14	Backwater deep vegetation

Table 2.5: Date, gear used, station with code, and habitats surveyed in the Zambezi River, spring 1997.

Date	Gear	Station	Station Code	Habitat Type
Table 2.5				
13/9/97	Gill Nets	Zambezi Lodge	3	Mainstream deep
13/9/97	Gill Nets	Zambezi Lodge	3	Mainstream deep
13/9/97	Rotenone	Near Katima Mulilo Ferry	1	Rocks
13/9/97	Shock	Near Katima Mulilo Ferry	1	Rocks
14/9/97	Gill Nets	Zambezi Lodge	3	Mainstream deep
14/9/97	Gill Nets	Hippo Lodge	6	Mainstream deep
14/9/97	Gill Nets	Hippo Lodge	6	Mainstream deep
14/9/97	15m Seine	Hippo Island	5	Backwater shallow
14/9/97	15m Seine	Hippo Island	5	Isolated pool next to river, vegetation

Date	Gear	Station	Station Code	Habitat Type
Table 2.5				
14/9/97	15m Seine	Hippo Island	5	Backwater shallow
15/9/97	Gill Nets	Hippo Island	5	Mainstream deep vegetation
15/9/97	Gill Nets	Hippo Island	5	Mainstream deep
15/9/97	15m Seine	Kalambeza Channel	14	Mainstream vegetation bay
15/9/97	15m Seine	Kalambeza Channel	14	Riverbank vegetation
15/9/97	15m Seine	Kalambeza Channel	14	Mainstream vegetation bay
16/9/97	Gill Nets	Kalambeza Channel	14	Mainstream deep
16/9/97	15m Seine	3km West of Kalambeza Island	9	Mainstream sand bay
16/9/97	15m Seine	3km West of Kalambeza	9	Mainstream sand bank
16/9/97	15m Seine	3km West of Kalambeza	9	Mainstream vegetation bay
16/9/97	Hand Net	Kalambeza Channel	14	Backwater deep vegetation
16/9/97	Angling	Kalambeza Channel	14	Mainstream deep
16/9/97	Scoop net	Kalambeza Channel	14	Riverbank vegetation
17/9/97	Gill Nets	Kalambeza Channel	14	Backwater deep vegetation
17/9/97	Gill Nets	Between Katima and Kalambeza	8	Backwater deep vegetation
18/9/97	Gill Nets	Kalizo Lodge	15	Backwater deep vegetation
18/9/97	Gill Nets	Kalizo Lodge	15	Mainstream deep
18/9/97	Traps	Zambezi Lodge	3	Riverbank vegetation

Table 2.6: Date, gear used, station with code, and habitats surveyed in the Zambezi River, autumn 1998.

Date	Gear	Station	Station Code	Habitat Type
Table 2.6				
7/5/98	Traps	Zambezi Lodge	3	Mainstream shallow
7/5/98	5m Seine	Zambezi Lodge	3	Mainstream shallow
7/5/98	5m Seine	Katima Mulilo	2	Mainstream sand bay
7/5/98	5m Seine	Katima Mulilo	2	Mainstream shallow vegetation
7/5/98	5m Seine	Katima Mulilo	2	Mainstream vegetation bay
7/5/98	Traps	Zambezi Lodge	3	Riverbank vegetation
7/5/98	5m Seine	Zambezi Lodge	3	Mainstream shallow vegetation
7/5/98	5m Seine	Katima Nature Conservation	4	Mainstream shallow
7/5/98	5m Seine	Katima Nature Conservation	4	Mainstream vegetation bay
7/5/98	5m Seine	Katima Nature Conservation	4	Mainstream shallow vegetation
7/5/98	5m Seine	Katima Nature Conservation	4	Floodplain
8/5/98	Gill Net	Katima Mulilo	2	Mainstream deep
8/5/98	Gill Net	Katima Nature Conservation	4	Backwater deep vegetation
8/5/98	Cast Net	Zambezi Lodge	3	Mainstream deep
8/5/98	Cast Net	Zambezi Lodge	3	Mainstream deep
8/5/98	Angling	Zambezi Lodge	3	Mainstream deep
8/5/98	5m Seine	Hippo Lodge	6	Floodplain
8/5/98	Shock	Hippo Island	5	Isolated pool next to river
8/5/98	5m Seine	Hippo Island	5	Riverbank sand
8/5/98	5m Seine	Hippo Island	5	Riverbank sand

Date	Gear	Station	Station Code	Habitat Type
Table 2.6				
8/5/98	5m Seine	Hippo Lodge	6	Mainstream shallow
8/5/98	5m Seine	Hippo Lodge	6	Backwater shallow
9/5/98	Gill Net	Hippo Lodge	6	Backwater deep vegetation
9/5/98	Gill Net	Hippo Lodge	6	Mainstream deep vegetation
9/5/98	15m Seine	5km East of Hippo Lodge	7	Floodplain
9/5/98	Shock	5km East of Hippo Lodge	7	Floodplain
9/5/98	Shock	5km East of Hippo Lodge	7	Isolated pool next to river, vegetation
9/5/98	5m Seine	5km East of Hippo Lodge	7	Riverbank sand
10/5/98	Gill Net	Between Katima and Kalambeza	8	Backwater deep vegetation
10/5/98	Gill Net	Between Katima and Kalambeza	8	Floodplain
10/5/98	5m Seine	Kalizo Lodge	15	Floodplain
10/5/98	5m Seine	Kalizo Lodge	15	Floodplain
11/5/98	5m Seine	Between Lisikili and Kalambeza	11	Isolated floodplain pool, vegetation
11/5/98	5m Seine	Between Lisikili and Kalambeza	11	Isolated floodplain pool, vegetation
18/5/98	5m Seine	Kalambeza Channel	14	Mainstream sand bay
18/5/98	5m Seine	Kalambeza Channel	14	Floodplain
18/5/98	5m Seine	Kalambeza Channel	14	Floodplain
18/5/98	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
18/5/98	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
18/5/98	Gill Net	Kalambeza Channel	14	Backwater deep vegetation
18/5/98	Gill Net	Zambezi Lodge	3	Mainstream deep vegetation
19/5/98	5m Seine	Kalizo Lodge	15	Mainstream sand bay
19/5/98	5m Seine	Kalizo Lodge	15	Floodplain

Table 2.7: Date, gear used, station with code, and habitats surveyed in the Zambezi River, spring 1998.

Date	Gear	Station	Station Code	Habitat Type
Table 2.7				
5/10/98	5M Seine	Kalizo Lodge	15	Riverbank sand
5/10/98	30M Seine	Kalizo Lodge	15	Riverbank sand
5/10/98	5M Seine	Kalizo Lodge	15	Riverbank vegetation
5/10/98	Rotenone	Kalizo Lodge	15	Isolated pool next to river, vegetation
6/10/98	30M Seine	Kalizo Lodge	15	Isolated floodplain pool, vegetation
6/10/98	5M Seine	Kalizo Lodge	15	Isolated floodplain pool, vegetation
6/10/98	30M Seine	Kalizo Lodge	15	Isolated floodplain pool, vegetation
7/10/98	Gill Net	Kalizo Lodge	15	Backwater deep vegetation
7/10/98	Scoop net	Kalizo Lodge	15	Backwater deep vegetation
7/10/98	5M Seine	Kalizo Lodge	15	Isolated pool next to river
8/10/98	Traps	Kalizo Lodge	15	Backwater bank sand

Date	Gear	Station	Station Code	Habitat Type
Table 2.7				
8/10/98	Traps	Kalizo Lodge	15	Backwater bank vegetation
9/10/98	Gill Net	Kalizo Lodge	15	Backwater deep vegetation
9/10/98	Traps	Kalizo Lodge	15	Backwater bank vegetation
15/10/98	Rotenone	Katima Mulilo Ferry	1	Rocks
16/10/98	Traps	Zambezi Lodge	3	Riverbank vegetation
16/10/98	Gill Net	Zambezi Lodge	3	Mainstream deep
16/10/98	Gill Net	Zambezi Lodge	3	Backwater deep
16/10/98	Rotenone	Zambezi Lodge	3	Rocks
16/10/98	Rotenone	Zambezi Lodge	3	Rocks
16/10/98	Cast Net	Zambezi Lodge	3	Mainstream deep
17/10/98	Gill Net	Zambezi Lodge	3	Mainstream deep
17/10/98	Gill Net	Zambezi Lodge	3	Mainstream deep
17/10/98	5M Seine	Zambezi Lodge	3	Mainstream sand bay
17/10/98	5M Seine	Zambezi Lodge	3	Mainstream sand bank
17/10/98	Cast Net	Hippo Island	5	Mainstream deep
17/10/98	Cast Net	Hippo Island	5	Mainstream shallow
17/10/98	Cast Net	Hippo Island	5	Backwater shallow
17/10/98	Cast Net	Hippo Island	5	Mainstream sand bank
17/10/98	Cast Net	Hippo Island	5	Isolated pool next to river
18/10/98	Gill Net	Hippo Island	5	Backwater deep
18/10/98	Gill Net	Hippo Lodge	6	Mainstream deep vegetation
18/10/98	Angling	Zambezi Lodge	3	Rapids deep
19/10/98	Gill Net	Kalambeza Channel	14	Mainstream deep
19/10/98	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
20/10/98	Cast Net	Kalambeza Channel	14	Mainstream deep
20/10/98	Cast Net	Kalambeza Channel	14	Mainstream sand bay
20/10/98	Cast Net	Kalambeza Channel	14	Riverbank vegetation
20/10/98	Cast Net	Kalambeza Channel	14	Mainstream shallow
20/10/98	Cast Net	Kalambeza Channel	14	Mainstream sand bay
20/10/98	Cast Net	Kalambeza Channel	14	Backwater shallow vegetation
20/10/98	Cast Net	Kalambeza Channel	14	Backwater deep
20/10/98	Cast Net	Kalambeza Channel	14	Backwater deep

Table 2.8: Date, gear used, station with code, and habitats surveyed in the Zambezi River, autumn 1999.

Date	Gear	Station	Station Code	Habitat Type
Table 2.8				
1/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
2/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
2/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep
3/6/99	Gill Net	Kalambeza Channel	14	Backwater deep vegetation
3/6/99	Gill Net	Kalambeza Channel	14	Backwater deep vegetation
3/6/99	Gill Net	Kalambeza Channel	14	Backwater deep vegetation
9/6/99	Trap	Kalambeza Channel	14	Riverbank vegetation
9/6/99	Trap	Kalambeza Channel	14	Riverbank sand
10/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation

Date	Gear	Station	Station Code	Habitat Type
Table 2.8				
10/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep vegetation
10/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep
10/6/99	5M Seine	Between Lisikili and Kalambeza	11	Isolated floodplain pool, vegetation
10/6/99	5M Seine	Between Lisikili and Kalambeza	11	Isolated floodplain pool, vegetation
10/6/99	5M Seine	Between Lisikili and Kalambeza	11	Isolated floodplain pool, vegetation
10/6/99	5M Seine	Kalambeza Channel	14	Floodplain
11/6/99	Gill Net	Kalambeza Channel Mouth, East	13	Mainstream deep vegetation
11/6/99	Gill Net	Kalizo Lodge	15	Backwater deep vegetation
11/6/99	Gill Net	Kalambeza Channel Mouth, East	13	Mainstream deep vegetation
11/6/99	Angling	Kalizo Lodge	15	Mainstream deep
11/6/99	Angling	Kalambeza Channel Mouth, East	13	Mainstream deep vegetation
12/6/99	Gill Net	Skelm Channel Kalambeza, West	10	Mainstream deep
12/6/99	Gill Net	Kalambeza Channel	14	Mainstream deep
12/6/99	Trap	Kalambeza Channel	14	Riverbank sand
13/6/99	Trap	Kalambeza Channel	14	Riverbank sand
13/6/99	Trap	Kalambeza Channel	14	Riverbank vegetation
13/6/99	Trap	Kalambeza Channel	14	Riverbank vegetation
13/6/99	Trap	Kalambeza Channel	14	Riverbank vegetation
13/6/99	Trap	Kalambeza Channel	14	Riverbank vegetation
13/6/99	Gill Net	Between Katima and Kalambeza	8	Mainstream deep
13/6/99	Gill Net	Between Katima and Kalambeza	8	Mainstream deep
14/6/99	Trap	Kalambeza Channel	14	Mainstream deep
15/6/99	5M Seine	Katima Nature Conservation	4	Mainstream sand bay
15/6/99	5M Seine	Hippo Lodge	6	Isolated pool next to river, vegetation
15/6/99	Angling	Katima Nature Conservation	4	Mainstream deep
16/6/99	Gill Net	Zambezi Lodge	3	Mainstream deep vegetation
16/6/99	Gill Net	Zambezi Lodge	3	Mainstream deep vegetation
16/6/99	Gill Net	Katima Nature Conservation	4	Mainstream deep vegetation
16/6/99	Gill Net	Katima Nature Conservation	4	Mainstream deep
16/6/99	Gill Net	Hippo Lodge	6	Mainstream deep
16/6/99	Gill Net	Hippo Lodge	6	Mainstream deep vegetation

2.3.2 Rain Pools and Internal Lakes

Rain pools were surveyed during autumn after the rain season. During early spring (pre-flood) the rain pools were dry. The rain pools were surveyed to determine the distribution of the *Nothobranchius* sp. that is endemic to the Eastern Caprivi. This species only occur in rain pools. These pools were usually very muddy with murky water. During the study 12 pools were surveyed along the road between Katima Mulilo and Bukalo, but the

Nothobranchius sp. was not found. Table 2.9 lists the rain pools that were surveyed, in the search for this species, during the autumn surveys of this study.

Dr. B. van Zyl (Ministry of Fisheries and Marine Resources, Namibia) sampled the *Nothobranchius* sp. during autumn 1995. It was sampled in a muddy rain pool with GPS point: **S** 17º 36’ 03.5” and **E** 24º 23’ 03.1”.

Table 2.9: List of rain pools surveyed during the autumn surveys.

No	Latitude	Longitude	Gear	Water Depth	Substrate
1	17º47’39.0” S	24º55’48.1” E	Shocker & Seine net	0.3-0.5m	Clay
2	17º40’15.4” S	24º27’36.7” E	Seine net	0.3-0.5m	Clay and Gravel
3	17º39’25.0” S	24º26’47.6” E	Shocker & Seine net	0.3-0.5m	Clay
4	17º38’57.5” S	24º25’54.1” E	Shocker & Seine net	0.3-0.5m	Clay
5	17º34’51.0” S	24º22’11.9” E	Seine net	0.3-0.5m	Muddy
6	17º36’03.5” S	24º23’03.1” E	Seine net	0.3-0.5m	Muddy
7	17º39’28.2” S	24º26’46.7” E	Seine net	0.3-0.5m	Muddy
8	17º39’42.5” S	24º26’58.4” E	Seine net	0.3-0.5m	Muddy
9	17º40’15.2” S	24º27’30.1” E	Seine net	0.3-0.5m	Muddy
10	17º45’05.5” S	24º33’37.1” E	Seine net	0.3-0.5m	Muddy
11	17º45’00.3” S	24º33’42.0” E	Seine net	0.3-0.5m	Muddy
12	17º34’50.6” S	24º22’09.5” E	Shocker & Seine net	0.3-0.5m	Clay

2.3.3 The Chobe River

Tables 2.10 – 2.14 indicate the stations, habitats and the gear used during the different surveys in the Chobe River during the study.

Table 2.10: Date, gear used, station with code, and habitats surveyed in the Chobe River, autumn 1997.

Date	Gear	Station	Station Code	Habitat Type
Table 2.10				
15/5/97	Shocker	Ihaha (Kabula-Bula Region)	16	Mainstream shallow vegetation
15/5/97	Shocker	Ihaha (Kabula-Bula Region)	16	Floodplain
15/5/97	15m Seine	Ihaha (Kabula-Bula Region)	16	Floodplain
16/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
16/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
16/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
16/5/97	15m Seine	Sipho (Kabula-Bula Region)	17	Floodplain
16/5/97	15m Seine	Sipho (Kabula-Bula Region)	17	Floodplain
17/5/97	Traps	Ihaha (Kabula-Bula Region)	16	Mainstream shallow vegetation
17/5/97	30m Seine	Ihaha (Kabula-Bula Region)	16	Mainstream shallow vegetation
17/5/97	30m Seine	Ihaha (Kabula-Bula Region)	16	Mainstream vegetation bay
17/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
17/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
17/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep
17/5/97	Rotenone	Ihaha (Kabula-Bula Region)	16	Floodplain

Date	Gear	Station	Station Code	Habitat Type
Table 2.10				
17/5/97	15m Seine	Ihaha (Kabula-Bula Region)	16	Floodplain
18/5/97	15m Seine	Ihaha (Kabula-Bula Region)	16	Mainstream shallow vegetation
18/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation
18/5/97	Gill net	Ihaha (Kabula-Bula Region)	16	Mainstream deep vegetation

Table 2.11: Date, gear used, station with code, and habitats surveyed in the Chobe River, spring 1997.

Date	Gear	Station	Station Code	Habitat Type
21/9/97	Gill net	Nanyanga (Kabula-Bula Region)	29	Backwater deep vegetation
21/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
21/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
21/9/97	Angling	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
21/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Mainstream shallow vegetation
21/9/97	Angling	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
21/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Mainstream shallow vegetation
21/9/97	Rotenone	Sipho (Kabula-Bula Region)	17	Isolated floodplain pool, vegetation
21/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Riverbank vegetation
22/9/97	Shocker	Nanyanga (Kabula-Bula Region)	29	Mainstream shallow vegetation
22/9/97	Trap	Sipho (Kabula-Bula Region)	17	Backwater bank vegetation
22/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
22/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
22/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
22/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Mainstream vegetation bay
22/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Mainstream shallow vegetation
23/9/97	Shocker	Sipho (Kabula-Bula Region)	17	Backwater bank vegetation
23/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
23/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
24/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
24/9/97	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation

Table 2.12: Date, gear used, station with code, and habitats surveyed in the Chobe River, autumn 1998.

Date	Gear	Station	Station Code	Habitat Type
Table 2.12				
11/5/98	5m Seine	Ngoma	30	Floodplain
11/5/98	5m Seine	Ngoma	30	Floodplain
12/5/98	5m Seine	Indibi Channel near Impalila Island	28	Riverbank vegetation
12/5/98	5m Seine	Indibi Channel near Impalila Island	28	Mainstream sand bay

Date	Gear	Station	Station Code	Habitat Type
Table 2.12				
13/5/98	Gill net	Indibi Channel Chobe Marsh	27	Mainstream deep
13/5/98	Gill net	Kasane	25	Backwater deep vegetation
13/5/98	Gill net	Kasane	25	Mainstream deep vegetation
13/5/98	Gill net	Kasane	25	Backwater deep vegetation
13/5/98	5m Seine	Kasika Village	22	Backwater bank sand
13/5/98	5m Seine	Kings Den Lodge	26	Backwater bank sand
13/5/98	5m Seine	Kings Den Lodge	26	Floodplain
13/5/98	Gill net	Kings Den Lodge	26	Backwater deep vegetation
13/5/98	Gill net	Impalila Island	24	Backwater deep vegetation
13/5/98	Gill net	Kasai Channel near Impalila Island	23	Backwater deep vegetation
13/5/98	Traps	Kasane	25	Floodplain
13/5/98	Gill net	Kasai Channel near Impalila Island	23	Backwater deep vegetation
13/5/98	Gill net	Kasai Channel near Impalila Island	23	Backwater deep vegetation
14/5/98	Gill net	Kasika Village	22	Mainstream deep vegetation
14/5/98	5m Seine	Indibi Channel near Impalila Island	28	Floodplain
14/5/98	5m Seine	Indibi Channel near Impalila Island	28	Floodplain
14/5/98	Gill Net	Impalila Island	24	Mainstream deep
14/5/98	Gill Net	Kasai Channel near Impalila Island	23	Mainstream deep vegetation
15/5/98	Rotenone	Impalila Island	24	Backwater deep vegetation
15/5/98	5m Seine	Impalila Island	24	Mainstream shallow vegetation
15/5/98	Gill net	Kasika Village	22	Backwater deep vegetation
15/5/98	Gill net	Kasikili Island	21	Mainstream deep vegetation
16/5/98	Rotenone	Kasane	25	Floodplain
16/5/98	Traps	Kasane	25	Floodplain
16/5/98	5m Seine	Kasikili Island	21	Floodplain
16/5/98	5m Seine	Kasikili Island	21	Mainstream shallow

Table 2.13: Date, gear used, station with code, and habitats surveyed in the Chobe River, spring 1998.

Date	Gear	Station	Station Code	Habitat Type
Table 2.13				
11/10/98	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
11/10/98	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
12/10/98	Rotenone	Sipho (Kabula-Bula Region)	17	Isolated floodplain pool, vegetation
12/10/98	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
12/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Backwater deep
12/10/98	Gill net	Sipho (Kabula-Bula Region)	17	Mainstream deep vegetation
12/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Backwater deep
12/10/98	Cast Net	10km N-East of Sipho	19	Mainstream deep
12/10/98	Cast Net	10km N-East of Sipho	19	Mainstream deep
12/10/98	Cast Net	10km N-East of Sipho	19	Mainstream deep

Date	Gear	Station	Station Code	Habitat Type
Table 2.13				
12/10/98	Gill net	5km N-East of Sipho	18	Mainstream deep vegetation
12/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Backwater deep
12/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Backwater bank sand
12/10/98	Gill net	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
13/10/98	Traps	Sipho (Kabula-Bula Region)	17	Backwater bank sand
13/10/98	Traps	Sipho (Kabula-Bula Region)	17	Backwater deep
13/10/98	Traps	Sipho (Kabula-Bula Region)	17	Backwater bank vegetation
13/10/98	Traps	Sipho (Kabula-Bula Region)	17	Backwater bank vegetation
13/10/98	Traps	Sipho (Kabula-Bula Region)	17	Backwater deep vegetation
13/10/98	Cast Net	15km N-East of Sipho	20	Mainstream deep vegetation
13/10/98	Cast Net	15km N-East of Sipho	20	Backwater deep
13/10/98	Cast Net	15km N-East of Sipho	20	Mainstream deep
13/10/98	Cast Net	15km N-East of Sipho	20	Mainstream shallow
13/10/98	Cast Net	15km N-East of Sipho	20	Mainstream deep
13/10/98	Cast Net	5km N-East of Sipho	18	Mainstream deep
13/10/98	Cast Net	5km N-East of Sipho	18	Mainstream deep
13/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Mainstream shallow
13/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Mainstream shallow
13/10/98	Cast Net	Sipho (Kabula-Bula Region)	17	Mainstream shallow vegetation
13/10/98	Gill net	15km N-East of Sipho	20	Mainstream deep vegetation
13/10/98	Gill net	10km N-East of Sipho	19	Mainstream deep vegetation

Table 2.14: Date, gear used, station with code, and habitats surveyed in the Chobe River, autumn 1999.

Date	Gear	Station	Station Code	Habitat Type
Table 2.14				
5/6/99	Gill Net	Kasikili Island	21	Mainstream deep vegetation
5/6/99	Gill Net	Kasane	25	Mainstream deep vegetation
5/6/99	Gill Net	Kasane	25	Mainstream deep vegetation
5/6/99	Angling	Kasai Channel near Impalila Island	23	Mainstream deep
5/6/99	5M Seine	Kasai Channel near Impalila Island	23	Mainstream sand bank
5/6/99	5M Seine	Kasai Channel near Impalila Island	23	Floodplain
5/6/99	5M Seine	Impalila Island	24	Pebbles
5/6/99	Angling	Kings Den Lodge	26	Mainstream deep
6/6/99	Gill Net	Impalila Island	24	Deep narrow side channel, vegetation
6/6/99	Gill Net	Impalila Island	24	Deep narrow side channel, vegetation
6/6/99	Gill Net	Kasane	25	Backwater deep vegetation
6/6/99	Gill Net	Kasane	25	Backwater deep vegetation
6/6/99	Traps	Kasane	25	Backwater bank vegetation
6/6/99	Traps	Kasane	25	Backwater bank sand
6/6/99	5M Seine	Kasika Village	22	Floodplain
6/6/99	Angling	Kasika Village	22	Riverbank vegetation

Date	Gear	Station	Station Code	Habitat Type
Table 2.14				
6/6/99	5M Seine	Kasika Village	22	Isolated floodplain pool, vegetation
7/6/99	Gill Net	Kasika Village	22	Backwater deep vegetation
7/6/99	Gill Net	Kasika Village	22	Backwater deep vegetation
7/6/99	Gill Net	Kings Den Lodge	26	Mainstream deep
7/6/99	Traps	Kasane	25	Floodplain
7/6/99	Traps	Kasane	25	Riverbank vegetation
7/6/99	Rotenone	Kasane	25	Floodplain

2.3.4 The Kwando River

Tables 2.15 – 2.19 indicate the stations, habitats and the gear used during the different surveys in the Kwando River during the study.

Table 2.15: Date, gear used, station with code, and habitats surveyed in the Kwando River, autumn 1997.

Date	Gear	Station	Station Code	Habitat Type
29/5/97	Gill net	Buffalo Trails	35	Mainstream deep vegetation
29/5/97	Gill net	Buffalo Trails	35	Mainstream deep vegetation
29/5/97	Gill net	Buffalo Trails	35	Mainstream deep
29/5/97	Gill net	Buffalo Trails	35	Mainstream deep vegetation
29/5/97	30m Seine	Buffalo Trails	35	Mainstream shallow vegetation
29/5/97	30m Seine	Buffalo Trails	35	Isolated pool next to river, vegetation
29/5/97	Rotenone	Buffalo Trails	35	Isolated pool next to river, vegetation
29/5/97	15m Seine	1km West of Buffalo Trails	34	Mainstream shallow vegetation
29/5/97	Shocker	Buffalo Trails	35	Mainstream shallow vegetation
30/5/97	Gill net	Nakatwa	39	Backwater deep vegetation
30/5/97	Gill net	Nakatwa	39	Backwater deep vegetation
30/5/97	Shocker	2km East of Nakatwa	36	Backwater shallow vegetation
30/5/97	15m Seine	2km East of Nakatwa	36	Backwater shallow vegetation
30/5/97	15m Seine	2km East of Nakatwa	36	Backwater shallow vegetation
30/5/97	Rotenone	2km East of Nakatwa	36	Backwater bank vegetation
31/5/97	Gill net	Lianshulu Lodge	31	Mainstream deep vegetation
31/5/97	15m Seine	Lianshulu Lodge	31	Backwater shallow vegetation
31/5/97	Shocker	Lianshulu Lodge	31	Backwater shallow vegetation
31/5/97	15m Seine	Lianshulu Lodge	31	Backwater shallow vegetation
31/5/97	Shocker	Lianshulu Lodge	31	Backwater shallow vegetation
31/5/97	Shocker	Lianshulu Lodge	31	Backwater deep vegetation
1/6/97	Shocker	Buffalo Trails	35	Riverbank vegetation
1/6/97	Traps	Buffalo Trails	35	Mainstream shallow

Table 2.16: Date, gear used, station with code, and habitats surveyed in the Kwando River, spring 1997.

Date	Gear	Station	Station Code	Habitat Type
27/9/97	Gill Net	Nakatwa	39	Backwater deep vegetation
27/9/97	Gill Net	Nakatwa	39	Backwater deep vegetation
27/9/97	15m Seine	2km East of Nakatwa	40	Backwater shallow vegetation
27/9/97	Shocker	Nakatwa	39	Backwater pool, vegetation
27/9/97	Rotenone	Buffalo Trails	35	Isolated pool next to river, vegetation
27/9/97	15m Seine	Buffalo Trails	35	Mainstream shallow vegetation
28/9/97	Gill Net	Buffalo Trails	35	Mainstream deep vegetation
28/9/97	Gill Net	2km East of Buffalo Trails	36	Mainstream deep vegetation
28/9/97	Gill Net	1km West of Buffalo Trails	34	Mainstream deep vegetation
28/9/97	Shocker	Nakatwa	39	Backwater bank vegetation
28/9/97	Traps	Nakatwa	39	Backwater bank vegetation
29/9/97	Shocker	Lianshulu Lodge	31	Riverbank vegetation
29/9/97	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
29/9/97	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
29/9/97	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
29/9/97	Shocker	Lianshulu Lodge	31	Mainstream shallow
29/9/97	Shocker	Lianshulu Lodge	31	Mainstream shallow vegetation
28/9/97	Shocker	2km East of Nakatwa	40	Backwater pool

Table 2.17: Date, gear used, station with code, and habitats surveyed in the Kwando River, autumn 1998.

Date	Gear	Station	Station Code	Habitat Type
21/5/98	5m Seine	2km East of Buffalo Trails	36	Riverbank sand
21/5/98	5m Seine	2km East of Buffalo Trails	36	Mainstream shallow vegetation
22/5/98	Gill net	Buffalo Trails	35	Mainstream deep vegetation
22/5/98	Gill net	Buffalo Trails	35	Mainstream deep vegetation
22/5/98	Gill net	2km East of Buffalo Trails	36	Mainstream deep
22/5/98	Gill net	2km East of Buffalo Trails	36	Mainstream deep vegetation
22/5/98	5m Seine	2km West of Buffalo Trails	33	Mainstream sand bay
22/5/98	5m Seine	2km West of Buffalo Trails	33	Mainstream vegetation bay
22/5/98	5m Seine	2km East of Nakatwa	40	Backwater pool, vegetation
22/5/98	5m Seine	Nakatwa	39	Backwater shallow vegetation
22/5/98	Gill net	Nakatwa	39	Backwater deep vegetation
22/5/98	Traps	Nakatwa	39	Backwater deep vegetation
22/5/98	Gill net	Nakatwa	39	Backwater deep vegetation
22/5/98	Traps	Nakatwa	39	Backwater deep vegetation
23/5/98	Traps	Buffalo Trails	35	Mainstream shallow
23/5/98	Traps	Buffalo Trails	35	Mainstream shallow vegetation
23/5/98	Traps	Buffalo Trails	35	Mainstream shallow vegetation
23/5/98	5m Seine	Buffalo Trails	35	Mainstream sand bank
23/5/98	5m Seine	Buffalo Trails	35	Mainstream shallow
23/5/98	5m Seine	Buffalo Trails	35	Riverbank vegetation
23/5/98	Traps	Buffalo Trails	35	Mainstream shallow vegetation

Table 2.18: Date, gear used, station with code, and habitats surveyed in the Kwando River, spring 1998.

Date	Gear	Station	Station Code	Habitat Type
23/10/98	Gill net	2km East of Buffalo Trails	36	Mainstream deep vegetation
23/10/98	Gill net	2km East of Buffalo Trails	36	Mainstream deep vegetation
23/10/98	Gill net	Buffalo Trails	35	Mainstream deep vegetation
23/10/98	Rotenone	Buffalo Trails	35	Riverbank vegetation
24/10/98	Rotenone	Nakatwa	39	Backwater pool, vegetation
24/10/98	Traps	Buffalo Trails	35	Riverbank vegetation
24/10/98	Traps	Buffalo Trails	35	Mainstream deep
24/10/98	Traps	Buffalo Trails	35	Mainstream deep
24/10/98	Traps	Nakatwa	39	Backwater deep
24/10/98	Traps	Nakatwa	39	Backwater bank vegetation
24/10/98	5m Seine	2 km East of Nakatwa	40	Backwater pool, vegetation
24/10/98	Rotenone	2 km East of Nakatwa	40	Backwater pool, vegetation
24/10/98	Gill net	Buffalo Trails	35	Mainstream deep
24/10/98	Gill net	Buffalo Trails	35	Mainstream deep vegetation
24/10/98	Gill net	New Lianshulu Bush Camp	32	Mainstream deep vegetation
24/10/98	Gill net	2km West of Buffalo Trails	33	Mainstream deep vegetation
24/10/98	Gill net	1km West of Buffalo Trails	34	Mainstream shallow
25/10/98	Gill net	Nakatwa	39	Backwater deep vegetation
25/10/98	Gill net	Nakatwa	39	Backwater deep vegetation

Table 2.19: Date, gear used, station with code, and habitats surveyed in the Kwando River, autumn 1999.

Date	Gear	Station	Station Code	Habitat Type
Table 2.19				
28/5/99	5M Seine	15 km East of Nakatwa	38	Mainstream sand bay
28/5/99	5M Seine	2km East of Nakatwa	40	Backwater bank vegetation
28/5/99	5M Seine	Nakatwa Island	37	Clear sandy side stream
28/5/99	5M Seine	Nakatwa Island	37	Clear sandy side stream, vegetation
28/5/99	Rotenone	Nakatwa Island	37	Clear sandy side stream, vegetation
29/5/99	Gill Net	2km West of Buffalo Trails	33	Mainstream deep vegetation
29/5/99	Gill Net	Buffalo Trails	35	Mainstream deep vegetation
29/5/99	Gill Net	Buffalo Trails	35	Mainstream deep
29/5/99	5M Seine	Buffalo Trails	35	Mainstream shallow vegetation
29/5/99	5M Seine	Buffalo Trails	35	Riverbank sand
29/5/99	5M Seine	Buffalo Trails	35	Mainstream shallow vegetation
29/5/99	Rotenone	Buffalo Trails	35	Mainstream vegetation bay
30/5/99	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
30/5/99	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
30/5/99	Gill Net	Lianshulu Lodge	31	Mainstream deep vegetation
30/5/99	Gill Net	2km East of Buffalo Trails	36	Mainstream deep
30/5/99	Gill Net	Buffalo Trails	35	Mainstream deep vegetation
30/5/99	Gill Net	Buffalo Trails	35	Mainstream deep

Date	Gear	Station	Station Code	Habitat Type
Table 2.19				
30/5/99	Traps	Buffalo Trails	35	Riverbank vegetation
30/5/99	Traps	Buffalo Trails	35	Riverbank sand
30/5/99	Traps	Buffalo Trails	35	Riverbank sand
31/5/99	Traps	Nakatwa	39	Backwater deep
31/5/99	Traps	Nakatwa	39	Backwater deep vegetation
31/5/99	Traps	Nakatwa	39	Backwater bank vegetation
31/5/99	Gill Net	Nakatwa	39	Backwater deep
31/5/99	Gill Net	Nakatwa	39	Backwater deep vegetation
31/5/99	Gill Net	Nakatwa	39	Backwater deep vegetation
31/5/99	Cast Net	Nakatwa	39	Backwater deep
31/5/99	5M Seine	New Lianshulu Bush Camp	32	Rain pool

2.3.5 Lake Lisikili

Lake Lisikili was surveyed separately as a lake type habitat, but it is seen as part of the Zambezi River. Lake Liambezi was dry at the time of the surveys.

Table 2.20: Habitats with gear used in Lake Lisikili, autumn 1997.

Date	Gear	Station	Station Code	Habitat Type
20/5/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
21/5/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
21/5/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
21/5/97	Rotenone	Lake Lisikili	12	Lake bank vegetation
21/5/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
21/5/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
22/5/97	Gill net	Lake Lisikili	12	Lake deep vegetation
22/5/97	Gill net	Lake Lisikili	12	Lake deep vegetation

Table 2.21: Habitats with gear used in Lake Lisikili, spring 1997.

Date	Gear	Station	Station Code	Habitat Type
19/9/97	Shocker	Lake Lisikili	12	Lake bank vegetation
19/9/97	15m Seine	Lake Lisikili	12	Lake bank vegetation
19/9/97	Gill net	Lake Lisikili	12	Lake deep vegetation
19/9/97	Gill net	Lake Lisikili	12	Lake deep vegetation
20/9/97	Gill net	Lake Lisikili	12	Lake deep vegetation
25/9/97	15m Seine	Lake Lisikili	12	Backwater pool
25/9/97	Gill net	Lake Lisikili	12	Lake deep vegetation
25/9/97	Gill net	Lake Lisikili	12	Lake deep vegetation

Table 2.22: Habitats with gear used in Lake Lisikili, autumn 1998.

Date	Gear	Station	Station Code	Habitat Type
10/5/98	5m Seine	Lake Lisikili	12	Lake bank vegetation
10/5/98	5m Seine	Lake Lisikili	12	Lake bank sand
10/5/98	5m Seine	Lake Lisikili	12	Lake bank vegetation
10/5/98	5m Seine	Lake Lisikili	12	Lake bank vegetation
19/5/98	Gill net	Lake Lisikili	12	Lake deep vegetation
19/5/98	Gill net	Lake Lisikili	12	Lake deep vegetation
19/5/98	Gill net	Lake Lisikili	12	Lake deep vegetation

Table 2.23: Habitats with gear used in Lake Lisikili, spring 1998.

Date	Gear	Station	Station Code	Habitat Type
8/10/98	Rotenone	Lake Lisikili	12	Lake, bank vegetation
8/10/98	Gill Net	Lake Lisikili	12	Lake deep vegetation
18/10/98	Gill Net	Lake Lisikili	12	Lake deep
18/10/98	Gill Net	Lake Lisikili	12	Lake deep vegetation
19/10/98	Traps	Lake Lisikili	12	Isolated floodplain pool, vegetation
19/10/98	Rotenone	Lake Lisikili	12	Isolated floodplain pool, vegetation
19/10/98	Traps	Lake Lisikili	12	Isolated floodplain pool, vegetation
19/10/98	Rotenone	Lake Lisikili	12	Isolated floodplain pool, vegetation
19/10/98	Trap	Lake Lisikili	12	Lake, bank vegetation
18/10/98	Cast Net	Lake Lisikili	12	Lake, deep
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep vegetation
19/10/98	Cast Net	Lake Lisikili	12	Lake, deep

Table 2.24: Habitats with gear used in Lake Lisikili, autumn 1999.

Date	Gear	Station	Station Code	Habitat Type
13/6/99	5M Seine	Lake Lisikili	12	Floodplain
13/6/99	5M Seine	Lake Lisikili	12	Floodplain
13/6/99	5M Seine	Lake Lisikili	12	Lake, bank vegetation
14/6/99	Gill Net	Lake Lisikili	12	Lake deep vegetation
14/6/99	Gill Net	Lake Lisikili	12	Lake, deep
14/6/99	Gill Net	Lake Lisikili	12	Lake deep vegetation
14/6/99	Gill Net	Lake Lisikili	12	Lake deep vegetation
14/6/99	170mm Net	Lake Lisikili	12	Lake deep vegetation
14/6/99	Traps	Lake Lisikili	12	Lake, bank vegetation

2.4 CONCLUSION

All localities were surveyed during each survey, where logistically possible. These localities were representative of the different habitat types. As this is an ongoing study, it was important that the same localities and areas were surveyed each year, so that the data obtained can be compared with future data.

In each system areas were identified as definite survey points. These areas will have priority in future for the sake of comparison. Some localities exist only during high floods and these can therefore not be surveyed regularly. The physical character of a station (sampling area) may change drastically between seasons and at different times of the flood cycle.

All the rivers have well defined mainstreams with flow and ample marginal vegetation during low floods, and floodplains during high floods. Differences do exist, however, between the different river systems in the Eastern Caprivi as described in Chapter 3, and may have an effect on the species distribution and habitat utilisation.

3 HABITAT UTILISATION AND DISTRIBUTION

3.1 INTRODUCTION

This chapter focuses on the geographical distribution of the species during high and low flood in the rivers and floodplains of the Eastern Caprivi, Namibia.

Pre- and post-flood surveys were conducted over a period of three years between 1997 and 1999. During this time 40 stations in the Eastern Caprivi were surveyed regularly. The geographical distribution of each fish species is discussed, and presented on a map of the area and in tabulated format (Figure 3.1, and Table 3.1). A total number of 56 258 specimens were sampled methodically with various gear types, and the distribution data for 69 species were recorded for the high and low flood seasons. The three main perennial river systems in the Eastern Caprivi are the Zambezi, Chobe and Kwando Rivers.

3.2 MATERIALS AND METHODS

3.2.1 Surveys

As mentioned in chapter two, five surveys were conducted in the Eastern Caprivi, of which three were conducted during autumn (post-flood), and two during spring (pre-flood). Stations in the Eastern Caprivi were chosen to be representative of each river system and its habitat types. Logistical difficulties such as, distance, flood levels, accessibility and safety, were taken in account when stations were to be surveyed. Stations include areas where possible external influences such as fishery, pollution, overgrazing and urbanisation could affect the ecosystem. These stations were often close to populated areas, Katima Mulilo, Lisikili, Kalambeza, Kabula-Bula, Kasika, Impalila Island and Kasane (Figure 3.1).

Longitudes and latitudes were recorded for each station and were plotted on a map to show the distribution of the stations. Station names contain the name of the closest approximate village or known area.

Some habitats (stations) occurred seasonally and could only be surveyed during high or low floods. Examples of habitats that only occur during low floods are, rocky areas and the habitats associated with it, or isolated pools next to the river and small backwaters. Some floodplains and large backwaters only occur during high floods.

3.2.2 Habitat description

The Eastern Caprivi has a diverse wetland system, with various habitat niches, and the aim was to survey all the different habitats at each station to get an indication of the fish population structure in that area.

Bottom substrate, vegetation, stream type, flow, depth, riverbank (slope, erosion and vegetation) and the **turbidity** of the water were used as parameters to describe the river habitats.

The criteria used to describe the **bottom substrate** (where possible, due to depth) were, **sandy**, **muddy**, **rocky** (rocks and stones bigger than 0.3m in diameter), **gravel** (stones smaller than 3cm in diameter) and **pebbles or cobbles** (stones bigger than 3cm and smaller than 0.3m in diameter). The habitat substrate was categorised according to the dominant substrate present. Rocks dominated rocky areas, for example, but a small percentage of pebbles and gravel were also present in these areas. Sandy substrate however is dominant throughout the river systems, and habitats with rock, gravel and pebble substrate were limited.

The categories for the **vegetation** were **marginal aquatic** vegetation (anchored vegetation such as reeds, protruding water grass, roots and other aquatic vegetation, near the margin), **inner aquatic** vegetation (floating or anchored, usually away from margin, such as lilies), **submerged terrestrial** vegetation (land grass, trees and shrubs, mainly on floodplains and submerged banks during high flood). Reeds and grass are the most dominant marginal vegetation during low floods, whereas trees, shrubs, reeds and grass are more dominant during high floods. Overhanging trees, exposed root wads and bank undercut also occur.

The vegetation however was not studied in detail as this was a fisheries study, but the vegetation is diverse as mentioned in chapter one.

The **stream types** can be divided into **mainstream, side streams, backwaters, lakes, floodplains, isolated pools, rapids and channels**.

The **water flow** was measured with a ciclomaster velocity meter. The stream velocity was divided into **four** categories. **No water flow** (standing). Stream velocity less than 0.2 meters per second (m/s) was indicated as **slow**, 0.2 up to 0.7 m/s as **intermediate** and higher than 0.7 m/s as a **fast flow**.

Water **depth** was categorised as **very shallow** (0.1m – 0.3m), **shallow** (0.3m – 1.0m) and **deep** (>1.0m).

The gradient of the riverbank was categorised as **steep** (45° - 90°), **moderate** (30° - 45°) and **low** (5° - 30°).

The **turbidity** of the water in the rivers was mostly low, resulting in **clear water** (with few suspended particles), except for bays and isolated pools where the water was sometimes **murky or muddy** due to agitation of the water by drinking live stock or wild animals (see Chapter 10: Water Quality).

3.2.3 Sampling materials and methods

A wide range of experimental sampling gear was used (adopted from Hay, 1995) to limit gear selectivity:

1. Multifilament gill nets with stretched mesh sizes of 22, 28, 35, 45, 57, 73, 93, 118 and 150mm were used, and each net had a length of 10m and a depth of 1.5m. Gill nets were set during the night for approximately 12 hours.
2. Seine nets of 5m, 15m and 30m were used. The 5m seine net was made from 80% shade netting, and consequently had a very fine mesh, and was ideal for sampling very small specimens. The 15m and 30m seine nets had a stretched mesh size of approximately 10mm, and was mostly used in quiet water habitats, such as backwaters, floodplains and lakes.
3. A cast net with a diameter of 2m, and a stretched mesh size of 20mm was used. The cast net was mostly used in rapids, and open water areas such as lakes, backwaters and the mainstream.
4. Hand scoop-nets, made from 80% shade netting, were used in and under marginal aquatic vegetation.
5. Rotenone was used in areas that were difficult to sample with other gear types, such as rocky habitats and marginally vegetated areas bordering deep water.
6. Traps were set along banks, usually in vegetation and were set overnight for approximately 12 hours.
7. A 12V battery pack electro shocker was used in marginal vegetated areas and rocky habitats.
8. Local seine nets and gill nets were surveyed.
9. Angling was used to sample larger specimens in deep water.

3.3 RESULTS

3.3.1 Description of river systems

Zambezi River

Substrate

The Zambezi River mainstream has a dominantly sandy substrate. Steep, clay riverbanks occur, and are usually next to deep mainstream areas with a strong flow. Gill nets, cast nets and angling were the most frequently used sampling methods in these areas. The gill nets were set marginally. Examples of steep riverbanks are found in the Kalizo Lodge and Kalambeza Island area.

Muddy substrate may be found in isolated pools, bays, backwaters and on floodplains where siltation may occur. These areas usually had no or very little flow and seine nets, rotenone, traps and electro shocking were popular sampling methods.

Side channels, and smaller side streams have a sandy substrate. Sand deposits are found on river bends, and sandbanks are common in the main stream during low flood periods. Few rocky habitats occur in the Zambezi River. Rocks occur near Katima Mulilo, Zambezi Lodge and Impalila Island, and are submerged during the high flood. Pebbles and cobble substrate are found in the Impalila Island area.

Vegetation

The Zambezi River has ample available cover for aquatic biota in the form of marginal terrestrial bank vegetation, which becomes submerged during high floods, as well as marginal aquatic vegetation (reeds), and inner aquatic vegetation.

Marginal terrestrial vegetation in the Zambezi River can be described as fringing vegetation (riparian) or riverbank cover, in the form of terrestrial grass, reeds, overhanging trees and shrubs. The fringing vegetation can be dense in places, with trees, shrubs and reeds making the riverbank impenetrable. In some areas grass and reeds, which grow on sandy riverbanks, substitute the dense vegetation of trees and shrubs, which grow on more stable ground such as clay banks.

Dead submerged trees that occur frequently along the banks, as well as root wads and bank undercut also serve as cover. Bank undercut and root wads usually occurred in areas with steep clay banks.

Inundated grassland, consisting of coarse perennial grasses, is the dominant floodplain vegetation. Submerged trees and shrubs also occur on the floodplains.

Marginal aquatic vegetation is usually confined to the side of the main stream, due to fast or strong currents and consists of submerged aquatic vegetation, reeds and water grass. The aquatic vegetation type in the Zambezi River main stream is mainly marginal, as it is difficult for the plants to anchor in the strong current of the main stream.

Inner aquatic vegetation occur mostly in side channels and backwaters where there is no or little flow, and it is possible for the root systems of the plants to anchor to the riverbed. This type of vegetation consists of floating water lilies, protruding water grass and reeds, and submerged aquatic vegetation. Vegetation of this type may cover or occupy whole backwaters or channels in some areas where the water flow is slow enough.

Floating plants may occur anywhere in the Zambezi, as it is dependent on wind and water currents for its distribution. It is usually found in areas where there are obstacles preventing further distribution. *Salvinia molesta* (exotic) is a common example of a floating plant in the Eastern Caprivi.

Riverbank

The riverbanks showed little signs of erosion where dense vegetation is present. Infrequent areas of erosion do occur, especially where riparian vegetation was removed, by local fishermen or lodges, to attain access to the river. Erosion also occurs in the main stream along bends, usually as a result of high floods.

Part of the riverbank near Kalizo Lodge is a good example of bank erosion. The result of this erosion is the formation of steep, high, clay banks.

Overgrazing also causes erosion in certain areas. The gradient of the riverbank varies from steep to moderate to low.

Steep banks usually consist of a clay substrate, and as the gradient becomes lower the substrate becomes more sandy.

Stream Type

The Zambezi River consists of a deep, wide mainstream, with bends and deep pools. Small, vegetated islands occur in the mainstream. Submerged shallow sandbanks, bays and narrow side streams occur frequently during low flood periods.

Larger slow flowing channels such as the Kalambeza and Kasai Channels also occur. Backwaters, floodplains and isolated pools occur frequently.

Rapids do not occur frequently, and some habitats may be flooded during high floods and some are left dry during low floods.

The stream velocity varies from standing (backwaters and pools) to fast flowing water (rapids). The rapids are deep and fast flowing with a rocky substrate. The narrow side streams are usually clean, clear and shallow with a sandy substrate, and have a slow to intermediate flow, and occur frequently during low flood, winding through sand banks and islands. The water in the Zambezi River is relatively clear with few suspended particles.

Floodplains occur during high flood, as inundated field and grassland, when the Zambezi floods its banks. The substrate of the floodplains is mostly muddy. During floods the water level can rise with up to seven meters (Figure 6.1). When the floods recede, isolated pools and backwaters are formed.

Due to the confluence of the Zambezi and Chobe Rivers a swamp like marsh exists in the Impalila Island area. The vegetation in this area consists mainly of dense impenetrable reeds of which the *Scrirpus* sp. is dominant. Water grass and a variety of other reeds and aquatic vegetation also occur. The substrate on which these reeds grow is a mixture of organic and muddy matter, and it subsequently has a very soft texture. This area gives the impression of a swamped, vast floating mass of reeds, with interconnecting canals cutting through it.

Chobe River

The Chobe River is a complex system consisting of a mainstream or channel, floodplains, marshes, backwaters and side channels. The size of the mainstream and the direction of flow is directly dependant on the flood level.

The Chobe River becomes wider nearer to the confluence with the Zambezi River in the northeast of the Eastern Caprivi, at Impalila Island. In this area marshes occur due to the confluence of the two rivers, and the Chobe River forms a wide and deep mainstream.
To the southwest, from Sipho (Kabula-Bula Region) to Ngoma the Chobe River is narrow and channel like with no or very little flow. The Chobe River can be shallow and overgrown with vegetation in some areas. Typical floodplains (inundated field and grassland) occur south of Kasika during high floods. The Chobe mainstream has a low flow gradient, and the stream flow is slow in most areas.

Wild animals occur along the Chobe River on the Botswana side, due to the Chobe National Park bordering the river, and this area is well protected from human influences.

Substrate

The bottom substrate is mostly sandy, with siltation in the marginal areas, bays and backwaters. During high floods precipitation of organic material (mainly dead plant material and debris carried and deposited by slow flowing water over the floodplains) occurs in the marginal areas of the river and on the floodplains. Few rocky habitats occur.

Vegetation

A variety of aquatic vegetation is present. Where the stream flow is slow in places, especially during low flood it is possible for aquatic vegetation to anchor and grow in the mainstream, and even cover the whole mainstream in width, especially in the southern areas. Reeds, lilies, water grass and water ferns are abundant.

Marginal vegetation such as grasses, reeds and submerged terrestrial vegetation occur everywhere along the river during high floods.

The fringing vegetation is dominantly grass and small shrubs. Overhanging trees occur marginally, but less frequently than in the Zambezi River. Dead submerged trees also occur infrequently.

On the floodplains towards Ngoma the vegetation is inundated field and grassland with shrubs and trees. Near Impalila the vegetation on the floodplains is marsh or swamp-like with dense reeds and a variety of submerged and protruding aquatic plants.

Riverbank

The banks show little sign of erosion, and are well covered with vegetation. The bank gradient is moderate to low, and steep riverbanks do not occur often.

Stream types

The stream is dominantly deep with flat water, and numerous bends. The flow velocity and direction depends on the seasonal floods, but the flow is pre-dominantly slow. The water is mostly clear with few suspended particles. Deep, side channels and backwaters occur, where aquatic vegetation thrives. Shallow floodplains occur in the southwest. In the north, the floodplains differ in the sense that it is more swamp like and deeper with dense reeds. Rocky rapids occur downstream from Impalila Island. Shallow, fast flowing, clear water habitats are scarce in the areas surveyed.

Kwando River

The Kwando River is a diverse system consisting of a main stream, small side streams, floodplains, shallow isolated pools, backwaters and isolated oxbow lakes (large backwaters). The areas surveyed are pristine and situated in conservation areas (Mdumu and Mamili).

Substrate

The bottom substrate of the mainstream is dominantly sand, but siltation may occur on bends. Precipitation of organic plant material is common in areas with slow stream. Marginal areas of the river are muddy in some areas due to animals foraging for roots and drinking from water holes.

The backwaters have a muddy substrate with a layer of organic material. The floodplains are sandy with some muddy areas, and organic material over the bottom substrate is common. No rock or gravel habitats occur in the areas surveyed.

The large amount of organic material in the water is due to the large concentration of wildlife and their associated activities.

Vegetation

The aquatic vegetation is abundant and occurs marginally in the form of reeds, lilies and water grass. Slow stream flow in areas enables aquatic vegetation (lilies and submerged aquatic vegetation) to anchor in the mainstream. Dead submerged trees occur in areas. Marginal terrestrial vegetation consists mostly of grass, shrub and overhanging trees.

Riverbanks

Infrequent areas of erosion occur on bends where the riverbanks are usually steep. Eroded banks occur due to wildlife drinking from the river. The gradient of the riverbank varies from low to steep, but banks are well vegetated with a dominantly low gradient and little erosion.

Stream types

The stream flow is slow. The stream type is dominantly deep stream with flat water and numerous bends. Deep isolated backwaters or oxbow lakes occur during low flood. The backwaters are well vegetated. During high flood, the floodplains are shallow inundated field and grassland. Shallow, faster flowing, clear water habitats occur in the area of Nakatwa Island but are otherwise scarce in the areas surveyed.

Lake Lisikili

The Zambezi River feeds Lake Lisikili from the Kalambeza Channel during high floods, but the lake becomes isolated during low flood. It is a perennial lake and was sampled during this study as a large lake type habitat. The lake is approximately 4km long and 0.5 – 1km wide.

The marginal aquatic vegetation consists dominantly of reeds. The inner aquatic vegetation is mostly submerged aquatic vegetation. Floating plants such as lilies and water grass are also abundant.

Fringing vegetation is dense in areas with numerous large trees. Terrestrial plants, such as grass, shrubs and trees are submerged during high flood. Overflowed grassland and shrubs create a floodplain type habitat around the margin of the lake. In some areas gravel habitats occur with small rocks distributed along the bottom. The bottom substrate is dominantly muddy with organic material occurring marginally. Water flow is not present, but the water is clear. The lake deepens with a low gradient, and is deep (4m) in some areas.

Other water bodies

Lake Liambezi, which can be of importance to local fishery when full, was dry at the time of the surveys and was therefore not surveyed. *Rain pools,* which are not connected to the river systems, were also surveyed after the rainy season. The main purpose of surveying the rain pools being the study of the distribution of the endemic *Nothobranchius* sp. The *Linyanti Swamps* to the west of Lake Liambezi were also dry during the study. The Linyanti (from the Kwando System), Chobe and Zambezi Rivers all supply Lake Liambezi with water during exceptionally high floods.

3.3.2 Stations and gear used

At each station the relevant gear was used, in the habitats present at the time, to sample the species that are representative of that certain area.

Gill nets were usually set marginally, and vegetated and non-vegetated areas were sampled with all gears.

Certain habitats exist only during certain seasons due to varying water levels. Inundated floodplains and certain backwaters exist only during high floods, and shallow mainstream habitats, such as sandbanks and rocky habitats are exposed only during low floods.

The fluctuating water levels made certain areas difficult to reach during certain times, and therefore played a significant role in the logistical planning and the surveying process of the study.

High floods occurred during autumn and low floods during spring (floods in this context referring to water level). The surveys were conducted during these two seasons for comparison reasons to determine the effect of the difference in flood levels on the fish population. In the text high and low floods therefore also refer to the autumn and spring seasons, respectively. Where mentioned that stations were surveyed during both seasons this means autumn and spring, or high and low floods. The words flood and season are therefore used in the same context, to indicate the time of the survey or when a station was surveyed.

<u>Zambezi River</u>

STATION 1: Near Katima Mulilo Ferry

A rocky habitat surveyed during low floods when rocky pools and small rapids were accessible. Aquatic vegetation fringing the rocky habitat in marginal areas was present. Rotenone and electro shocking were used as sampling methods in shallow rapids and rock pools.

STATION 2: Katima Mulilo

Gill nets were used to sample fish in deep, mainstream areas, and a 5m seine net was used to sample fish on marginal floodplains, during high floods. The floodplain vegetation mostly consisted of submerged terrestrial plants, such as grass, shrubs and trees.

STATION 3: Zambezi Lodge

A deep wide mainstream habitat, with rocky habitat in the inner mainstream. Gill nets, 5m seine net, traps, angling, cast net and rotenone were the sampling gear used to sample fish in this area. Gill nets were set in deep mainstream and backwater areas along margins, seine nets and traps were used in the shallow marginal areas of the river, and angling and cast netting were mostly done in the deep mainstream. Rotenone was used in shallow rocky areas. This station was surveyed during both seasons.

STATION 4: Katima Nature Conservation

Gill nets were set in deep mainstream and backwater areas along margins. A 5m seine net was used in shallow marginal areas such as bays and vegetated riverbanks, and angling was used to sample fish in the deeper mainstream areas. Sampled during both seasons.

STATION 5: Hippo Island

Shallow submerged sand banks occurred in some areas. Gill nets were set in deep mainstream and backwater areas along margins. Shallow mainstream areas, banks and bays were surveyed with, the cast net, 15m and 5m seine net. Isolated pools next to the river were surveyed with an electro shocker, a 15m seine net and a cast net. The cast net was also used in deep mainstream and backwater areas away from the margin. Sampled during both seasons.

STATION 6: Hippo Lodge

Gill nets were set in deep mainstream and backwater areas. A 5m seine net was used in shallow marginal areas, and angling was used to sample fish in the deeper mainstream areas away from the margin. Traps were set on riverbanks between aquatic vegetation. Isolated pools next to the river and floodplain habitats were surveyed with a 5m and 15m seine net. Sampled during both seasons.

STATION 7: Approximately 5km East of Hippo Lodge

The 5m and 15m seine nets were used to sample fish in shallow mainstream and backwater habitats. A hand scoop net was used in the mainstream shallow vegetated habitats. A 15m seine net and electro shocker was used to sample on floodplains, and the shocker was used to sample in isolated pools in this area. Sampled during high floods (autumn surveys).

STATION 8: Between Katima and Kalambeza

Gill nets were set in the deep mainstream and backwaters next to margin. Rotenone and the 15m seine net were used in the shallow areas of the mainstream and backwaters in this area. Sampled during both seasons.

STATION 9: 3km West of Kalambeza Island

In this area the river was wide and shallow with submerged sand banks and small clear side streams. A 15m seine net was used to sample fish in the shallow mainstream habitats of this area, during low floods (spring surveys).

STATION 10: Skelm Channel, Kalambeza Mouth, West

A small channel from the Zambezi River that feeds the Kalambeza Channel, on the western side of Kalambeza Island. Gill nets were set in the deep marginal areas of this channel during high floods.

STATION 11: Between Lisikili and Kalambeza

A 5m seine net was used to survey isolated floodplain pools next to the road. Submerged terrestrial grass was the dominant vegetation. Sampled during high floods.

STATION 12: Lake Lisikili

Gill nets and the cast net were used in the deep open water and along marginal vegetated areas. Traps, Rotenone, 5m seine net, 15m seine net and the electro shocker were used in the shallow marginal areas, and isolated pools next to the lake. Sampled during both seasons. Floodplain habitats were surveyed in this area during high floods.

STATION 13: Kalambeza Channel Mouth, East

Gill nets were set marginally in the deep mainstream areas of the channel mouth. Angling was done in the deep open water areas. A 15m seine net was used to sample fish in the shallow marginal areas. Rotenone was used to sample fish on the floodplains. Sampled during high floods. During low floods the mouth is shallow with sand banks.

STATION 14: Kalambeza Channel

Gill nets and a cast net were used to sample fish marginally in the deep mainstream and backwaters in this area. Angling was done in the deep open water. Local gill nets were surveyed. A hand scoop net, traps, the 5m and 15m seine nets and a cast net was used to sample fish in the shallow bays and marginal areas of the channel. Floodplains and isolated pools were surveyed with a 5m seine net. Sampled during both seasons.

STATION 15: Kalizo Lodge

Gill nets were set marginally in deep mainstream and backwater areas. Traps, a hand scoop net, Rotenone and a 5m, 15m and 30m seine net were used in shallow marginal areas of the river, backwaters, floodplains and in isolated pools next to the river. A large isolated floodplain pool occurred in this area and it stayed inundated for most of the year. Angling was used to sample in the deep open water. Sampled during both seasons.

<u>Chobe River</u>

STATION 16: Ihaha (Kabula-Bula Region)

Gill nets were set marginally in deep mainstream habitats. The 15m and 30m seine nets, traps and electro shocker were used to sample fish in the shallow mainstream habitats and on the floodplains. Rotenone was also used to sample fish on the floodplains. Sampled during high floods.

STATION 17: Sipho (Kabula-Bula Region)

Gill nets were set marginally in the deep mainstream and backwater areas. The cast net was used in deep and shallow mainstream and backwater areas. Traps, the 15m seine net and the electro shocker were used in the shallow marginal areas of the mainstream, backwaters, and on floodplains. Rotenone was used in isolated floodplain pools. Angling was done in the deep and shallow mainstream areas, mostly between vegetation. Sampled extensively during both seasons.

STATION 18: 5km N-East of Sipho

Gill nets were set marginally in the deep mainstream areas, and a cast net was used to sample fish in the deep open water areas. Sampled during low floods.

STATION 19: 10km N-East of Sipho

Gill nets were set marginally in the deep mainstream habitat, and a cast net was used to sample fish in the deep open water habitats. Sampled during low floods.

STATION 20: 15km N-East of Sipho

Gill nets were set marginally in the deep mainstream habitats. A cast net was used to sample fish in the deep open water and shallow marginal habitats of the river and backwaters in this area. Sampled during low floods.

STATION 21: Kasikili Island

Gill nets were set marginally in the deep mainstream areas. A 5m seine net was used to sample fish in the shallow mainstream habitats and on the floodplains in the area. Sampled during high floods.

STATION 22: Kasika Village

Gill nets were set marginally in the deep mainstream and backwater habitats. Angling and a 5m seine net was used to sample fish in the shallow marginal habitats of the river and backwaters. A 5m seine net was used to sample fish on the floodplains and in isolated floodplain pools in this area. Sampled during high floods.

STATION 23: Kasai Channel near Impalila Island (Zambezi-Chobe Marsh)

Gill nets were set marginally in the deep mainstream and backwater habitats. A 5m seine net was used to sample shallow mainstream and floodplain habitats in this area. Angling was used to sample in the deep open water habitats. Sampled during high floods.

STATION 24: Impalila Island

Gill nets were set marginally in the deep mainstream and backwater habitats, and in deep narrow side channels in this area. A 5m seine net and Rotenone was used to sample fish in the shallow mainstream habitats. Sampled during high floods.

STATION 25: Kasane

Gill nets were set marginally in the deep mainstream and backwater habitats. Traps were used to sample fish in the shallow mainstream and backwater habitats. Traps and rotenone were used to sample fish on the floodplain in this area. Sampled during high floods.

STATION 26: Kings Den Lodge

Gill nets were set marginally in the deep mainstream and backwater habitats. A 5m seine net was used to sample in the shallow backwater habitats and on the floodplains in this area. Angling was used to sample in the deep open water of the Chobe River. Sampled during high floods.

STATION 27: Indibi Channel South West of Impalila Island (Chobe Marsh)

Gill nets were set marginally in the deep channel habitats. Sampled during high floods.

STATION 28: Indibi Channel near Impalila Island (Chobe Marsh)

A 5m seine net was used to sample fish in the shallow mainstream habitats and on the floodplains in this area. Sampled during high floods.

STATION 29: Nanyanga (Kabula-Bula Region)

Gill nets were set in deep backwater habitats and the electro shocker was used to sample fish in the shallow marginal habitats of the mainstream in this area. Sampled during low floods.

STATION 30: Ngoma

A 5m seine net was used to sample fish on the floodplains in this area, during high floods.

<u>Kwando River</u>

STATION 31: Lianshulu Lodge

Gill nets were used to sample fish in the deep mainstream habitats, and the 15m seine net and electro shocker was used to sample fish in shallow mainstream and backwater habitats. Sampled during both seasons.

STATION 32: New Lianshulu Bush Camp

Gill nets were used to sample fish in the deep, mainstream habitats, during low floods.

STATION 33: 2km West of Buffalo Trails

Gill nets were set in the deep mainstream habitats, and the 5m seine net was used to sample in the shallow water. Sampled during both seasons.

STATION 34: 1km West of Buffalo Trails

Gill nets were set in the deep mainstream habitats, and the 15m Seine net was used to sample in the shallow water. Sampled during both seasons.

STATION 35: Buffalo Trails

Gill nets and traps were set marginally in the deep mainstream habitats. The 5m, 15m and 30m seine nets, traps, Rotenone and electro shocker were used to sample fish in the shallow mainstream and floodplain habitats. Rotenone and the 30m seine net was used to sample in isolated pools next to the river in this area. Sampled during both seasons.

STATION 36: 2km East of Buffalo Trails

Gill nets were set in the deep mainstream habitats, and the 5m Seine net was used to sample in the shallow waters. Sampled during both seasons.

STATION 37: Nakatwa Island

Rotenone and a 5m seine net was used to sample fish in a small clear sandy side stream. Fish were sampled in open water and in vegetated areas. Sampled during high floods.

STATION 38: 15km East of Nakatwa

A 5m seine net was used to sample fish in the shallow mainstream habitats. Sampled during high floods.

STATION 39: Nakatwa

A large, deep, backwater (high flood) or isolated oxbow lake (low flood), surveyed with gill nets, traps and a cast net in the deepwater habitats, and with an electro shocker, traps, Rotenone and a 5m seine net in the shallow water. Sampled during both seasons.

STATION 40: 2km East of Nakatwa

A series of shallow backwater pools, which form part of a large oxbow lake during higher floods, were surveyed with Rotenone, 5m and 15m seine nets and an electro shocker. The bottom substrate was usually muddy, and in some areas the water was murky. Sampled during both seasons.

3.3.3 Species distribution

In Table 3.1 the results of the fish species distribution are presented for the Eastern Caprivi during high and low floods at the 40 stations, for the study period 1997-1999. Species names were used, and the locality numbers for each river where the species were sampled during high and low floods, respectively, are given in Table 3.1.

The aim of the distribution data presented in Table 3.1 is to indicate at which stations certain species are likely to be sampled, and to indicate the general species distribution in the rivers, during high and low flood.

During the high flood surveys 64 species from 14 families were sampled, and during the low floods 65 species from 13 families were sampled. A total of 69 species from 14 families were sampled in the Eastern Caprivi during all the surveys. At the end of Table 3.1 a summary of the total number of species and families is given.

The species distribution was quantified by calculating the percentage of occurrence of each species at the 40 stations (for example: *Mormyrus lacerda* was sampled at seven stations out of the forty stations surveyed, and therefore at 17.5% of the stations).

Mormyridae

Altogether 6 species in the Mormyridae family were sampled in the three rivers during this study (Table 3.1).

Mormyrus lacerda was sampled during both low and high floods in the Eastern Caprivi. *Mormyrus lacerda* was however not sampled in the Chobe River during high floods. This species was sampled at 17.5% of the stations.

Hippopotamyrus ansorgii was sampled at five stations in the Kwando River (during high and low floods). *Hippopotamyrus ansorgii* was not sampled in the Zambezi River during high flood, and it was not sampled in the Chobe River. This species was sampled at 17.5% of the stations.

Hippopotamyrus discorhynchus was sampled in all the rivers, but was not sampled during low flood in the Chobe River. This species was sampled at 35% of the stations.

Marcusenius macrolepidotus, had a wide distribution, and was well represented in all the rivers. This species was sampled at 70% of the stations.

Petrocephalus catostoma had a wide distribution, and was sampled in all the rivers at 65% of the stations, during high and low floods.

Pollimyrus castelnaui was sampled, during high and low floods, in all of the rivers, at 40% of the stations.

Cyprinidae

Altogether 19 species in the Cyprinidae family were sampled in the three rivers during this study (Table 3.1).

Mesobola brevianalis was not sampled in the Zambezi River, and it was not sampled during low flood. In the Kwando River it was sampled in a shallow, clear, sandy side stream (Station 37), and in the shallow mainstream over a sand bank (Station 35), both habitats with flowing water. In the Chobe River it was sampled in an isolated floodplain pool (Station 22). Sampled at 7.5% of the stations.

Opsaridium zambezense was sampled in the Zambezi and Kwando Rivers during high flood, and it was only sampled in the Zambezi River during low flood. In the Kwando it was sampled at the same stations (35 and 37) and habitat as *Mesobola brevianalis. Opsaridium zambezense* was sampled at 33% of the stations.

Barbus barotseensis was sampled during high flood, in the Zambezi and Chobe Rivers. It was not sampled in the Kwando River, and during low flood it was sampled at one station in the Zambezi River. Sampled at 25% of the stations.

Barbus unitaeniatus had a wide distribution in the Eastern Caprivi, and was sampled in all the rivers during high and low floods. This species was sampled at 60% of the stations.

Barbus bifrenatus was sampled in all the rivers, except in the Kwando River during high flood. Sampled at 38% of the stations.

Barbus thamalakanensis was sampled in the Zambezi and Chobe Rivers, and at one station in the Kwando River during high floods. During low flood it was only sampled at one station (15) in the Zambezi River. Sampled at 30% of the stations.

Barbus barnardi was mainly sampled during high floods in the Zambezi and Chobe Rivers. It was recorded at two stations in the Chobe River during low floods. It was not sampled in the Kwando River. Sampled at 28% of the stations.

Barbus fasciolatus was rarely sampled. Some individuals were collected in the Chobe and Kwando Rivers during high flood and only in the Kwando during low flood. Sampled at 7.5% of the stations.

Barbus radiatus was relatively well represented in all the rivers (sampled at 53% of the stations) during high and low floods.

Barbus haasianus was mostly sampled in the Chobe River during high floods. It was sampled at Kalizo (Station 15) in the Zambezi River during both high and low flood, and it was sampled in the Chobe River at Sipho (Station17) during low flood. It was not collected in the Kwando River. Sampled at 15% of the stations.

Coptostomabarbus wittei was mainly sampled during high floods. It was sampled at one locality each of the Zambezi and Chobe Rivers during low flood. Sampled at 20% of the stations.

Barbus poechii was well represented in the Zambezi and Chobe Rivers during both high and low floods. It was not collected in the Kwando River during high flood. Sampled at 65% of the stations.

Barbus cf eutaenia was sampled during high flood in the Zambezi and Chobe Rivers. It was not collected in the Kwando River. During the low flood it was recorded at the rocks near Katima Mulilo Ferry (Station 1) in the Zambezi River only. Sampled at 20% of the stations.

Barbus multilineatus was mostly sampled during high floods in the Zambezi and Chobe Rivers, and was not recorded in the Kwando River. Sampled at 35% of the stations.

Barbus afrovernayi was sampled during high floods in the Zambezi and Chobe Rivers. It was not recorded in the Kwando River. It was collected at only one station in the Zambezi River (14) during low flood. Sampled at 28% of the stations.

Barbus paludinosus was relatively well represented in the Zambezi and Chobe Rivers, and was sampled during high and low floods. It was collected in the Kwando River during both seasons at Station 40. Sampled at 50% of the stations.

Barbus codringtonii was scarce and was only sampled at one station (2.5%), in the rapids at Katima Mulilo Ferry (Station 1) during low flood.

Labeo cylindricus was not sampled in the Kwando River, and it was collected in the Chobe River during high and low flood at two localities respectively. It was also sampled in the Zambezi River during both floods, but during high flood it had a better distribution. Sampled at 30% of the stations.

Labeo lunatus was collected in the Zambezi River during high and low floods. It was sampled in the Chobe River during low flood at Station 18 near Sipho. Sampled at 17.5% of the stations.

Distichodontidae

Two species were sampled from this family during this study (Table 3.1).

Hemigrammocharax machadoi was sampled at 25% of the stations. *Hemigrammocharax machadoi* was not collected in the Kwando River during low flood.

Hemigrammocharax multifasciatus was sampled at 12.5% of the stations. *H. multifasciatus* was not sampled in the Kwando River, and it was not sampled in the Chobe River during low flood.

Characidae

Altogether 4 species in the Characidae family were sampled in the three rivers during this study (Table 3.1).

Brycinus lateralis was one of the species with the widest distribution in the Eastern Caprivi, and it was well represented with a high density in all the rivers, during both seasons. Sampled at 75% of the stations.

Micralestes acutidens was sampled in all the rivers, but it was not collected in the Chobe River during low flood. Sampled at 58% of the stations.

Hydrocynus vittatus was sampled in all the rivers, and it had a wide distribution during both seasons. Sampled at 60% of the stations.

Rhabdalestes maunensis was sampled in all the rivers, but had a better distribution during high floods. Sampled at 45% of the stations.

Hepsetidae

One species from this family was sampled during the study (Table 3.1). ***Hepsetus odoe*** was sampled in all the rivers, during both seasons. Sampled at 55% of the stations.

Claroteidae

One species from this family was sampled during the study (Table 3.1). ***Parauchenoglanis ngamensis*** was sampled in all the rivers, but was not sampled in the Zambezi River during high floods. Sampled at 20% of the stations.

Amphiliidae

One species from this family was sampled during the study (Table 3.1). ***Leptoglanis cf dorae*** is very habitat specific and was only sampled in the Zambezi River during high flood. It was recorded in shallow clear water flowing over clean sand banks. Sampled at 5% of the stations.

Schilbeidae

One species from this family was sampled during the study (Table 3.1). ***Schilbe intermedius*** was sampled in all the rivers during both seasons, and had a wide distribution. Sampled at 80% of the stations.

Clariidae

Altogether 5 species in the Clariidae family were sampled in the three rivers during this study (Table 3.1).

Clarias gariepinus was sampled in all the rivers during both seasons. It had a wide distribution, although large specimens were not sampled regularly. Sampled at 68% of the stations.

Clarias ngamensis was sampled in all the rivers during both seasons. Large specimens were not sampled regularly. Sampled at 38% of the stations.

Clarias stappersii was not sampled during high floods. It was rarely sampled and it was only sampled at one locality in each of the Zambezi and Kwando Rivers during low floods. Sampled at 5% of the stations.

Clarias theodorae was sampled in all the rivers during both floods, but it was not abundantly sampled. Sampled at 33% of the stations.

Clariallabes platyprosopos was scarce and was only found in rocky areas during low floods in the Zambezi River. It is habitat specific for rocky areas with clear water, and could only be sampled when these habitats were exposed. Sampled at 5% of the stations.

Mochokidae

Fives species were identified from this family in the three rivers during this study (Table 3.1).

Chiloglanis neumanni, a habitat specific species, was scarce and only sampled in the rocky habitat at Station 1, in the Zambezi River, during low floods. Sampled at 2.5% of the stations.

The ***Synodontis* spp.** were sampled in all the rivers during both floods. Where possible species were identified and the distribution noted in Table 3.1. *Synodontis* spp. were sampled at 55% of the stations.

Cyprinodontidae

Altogether 3 species from this family were sampled in the three rivers during this study (Table 3.1).

Aplocheilichthys johnstoni was sampled in all the rivers during high and low floods at 52.5% of the stations.

Aplocheilichthys hutereaui was not collected in the Chobe River during high floods and not in the Zambezi River during low floods. Sampled at 17.5% of the stations.

Aplocheilichthys katangae was not sampled in the Zambezi or Kwando Rivers during low floods. It was recorded at one station in each of the Zambezi and Kwando Rivers during high floods. It had a wider distribution in the Chobe River during high floods, while it was sampled at only two stations during low flood. Sampled at 25% of the stations.

Cichlidae

Altogether 17 species in the Cichlidae family were sampled in the three rivers during this study (Table 3.1).

Hemichromis elongatus was not collected in the Chobe River during high floods. Sampled at 43% of the stations.

Pseudocrenilabrus philander was abundant with a wide distribution, and was collected in all the rivers during high and low floods. Sampled at 80% of the stations.

Pharyngochromis acuticeps was abundant with a wide distribution, and was sampled in all the rivers during high and low floods. Sampled at 88% of the stations.

Sargochromis carlottae was recorded in all the rivers during high and low floods. Sampled at 33% of the stations.

Sargochromis codringtonii was not sampled in the Chobe and Kwando Rivers during high floods. Sampled at 20% of the stations.

Sargochromis giardi was only collected in the Kwando River during high and low floods. Although it was only sampled in the Kwando River, anglers and local fishermen do catch this species in the other rivers. Rarely sampled during the study, and only at 5% of the stations.

Serranochromis altus was not sampled in the Chobe River during high flood. Sampled at 22.5% of the stations.

Serranochromis angusticeps was not collected in the Kwando River during low flood. Sampled at 22.5% of the stations.

Serranochromis longimanus was not sampled abundantly, and was not sampled in the Kwando River. It was also not recorded in the Chobe River during high flood. Sampled at 17.5% of the stations.

Serranochromis macrocephalus, was sampled in all the rivers during high and low floods. Sampled at 45% of the stations.

Serranochromis robustus was sampled in all the rivers during high and low floods. Sampled at 45% of the stations.

Serranochromis thumbergi was scarce. It was sampled in the Zambezi and Chobe Rivers during high floods, and only in the Chobe River during low floods. Sampled at 13% of the stations.

Tilapia sparrmanii was sampled regularly and abundantly. It had a wide distribution in all the rivers during both high and low floods. Sampled at 85% of the stations.

Tilapia ruweti was not collected in the Kwando River during high floods. It is a floodplain type species, and had a better distribution during high floods, especially in the Chobe River. Sampled at 38% of the stations.

Tilapia rendalli was sampled in all the rivers during both high and low floods, although it had a better distribution during high floods. Sampled at 75% of the stations.

Oreochromis andersonii was sampled in all the rivers during both floods. Sampled at 48% of the stations.

Oreochromis macrochir had a wide distribution, and was sampled in all the rivers during both floods. Sampled at 73% of the stations.

Anabantidae

Two species from this family were sampled during the study (Table 3.1).

Microctenopoma intermedium was not sampled in the Zambezi River during both floods, and it was not sampled in the Kwando River during the low floods. Sampled at 13% of the stations.

Ctenopoma multispine was collected in all the rivers during both floods. Sampled at 38% of the stations.

Mastacembelidae

Two species from this family were sampled during the study (Table 3.1).

Aethiomastacembelus frenatus was rarely sampled, and was only recorded in the Zambezi River. It was sampled at two localities (at 5% of the stations).

Aethiomastacembelus vanderwaali is habitat specific for rocky areas, and was only sampled at one locality (at 2.5% of the stations) in the Zambezi River during low floods.

Table 3.1: Species distribution for the three rivers surveyed during high and low floods (station numbers recorded), in the Eastern Caprivi, 1997-1999.

Species	High Flood/Autumn			Low Flood/Spring		
	Zambezi	Chobe	Kwando	Zambezi	Chobe	Kwando
Table 3.1						
Mormyridae						
Mormyrus lacerda	12		36	1,12	17,18	31,32
Hippopotamyrus ansorgii			33,35	1,15		31,32,35, 36
Hippopotamyrus discorhynchus	4,8,12,14	22	31,35,36	3,6		31-36,39
Marcusenius macrolepidotus	4,8,12-15	16,22-27	31,33,35, 36,39	3,5,6,8,12, 14,15	17-20,29	31,36,39, 40
Petrocephalus catostoma	4,6,8,10, 12-15	16,21, 22-27	31,35,36, 39	1,3,5,12, 14,15	17	31-33,35, 36,39
Pollimyrus castelnaui	12-15	16,22, 24-26	35,37	1,8,12,14, 15	17,29	35,39
Cyprinidae						
Mesobola brevianalis		22	35,37			
Opsaridium zambezense	3-8,13-15		35,37	1,9		
Barbus barotseensis	3-6,12-15	28		1		
Barbus unitaeniatus	2-7,12-15	21-24,28	31,37,40	1,3,8,12, 15	20	32,39,40
Barbus bifrenatus	2-6,11,12, 14,15	21,22,26		12,15	17,29	31
Barbus thamalakanensis	6,12,14,15	16,21-24, 26,28	37	15		

Species	High Flood/Autumn			Low Flood/Spring		
	Zambezi	Chobe	Kwando	Zambezi	Chobe	Kwando
Table 3.1						
Barbus barnardi	3,6,11, 13-15	16,24,28			17,29	
Barbus fasciolatus		22	37			39
Barbus radiatus	3,4,6,12-15	16,22-26, 28	31,35,36	3,8,12,14, 15	17,29	39
Barbus haasianus	15	16,22,25, 28		15	17	
Coptostomabarbus wittei	12,15	16,22,25	31	14	17	
Barbus poechii	2-8,10-15	16,22,24, 25,30		1,3,5,6,8, 9,12,14,15	17-20	31,32
Barbus cf eutaenia	2,3,6,8,13	16,28		1		
Barbus multilineatus	2,6,12,13, 15	16,21,22, 24-26,28		12	17,29	
Barbus afrovernayi	3,4,6,12, 13, 15	16,21,25, 28		14		
Barbus paludinosus	2-6,11-15	16,21,24, 25,30	40	8,12,14,15	17,18,29	40
Barbus codringtonii				1		
Labeo cylindricus	2-6,11,12, 14,15	24		1,3,5	17	
Labeo lunatus	3,6,8,12, 14			14,15	18	
Distichodontidae						
Hemigrammocharax machadoi	12,13,15	16,25,28	31	14	17,29	
Hemigrammocharax multifasciatus	3,13,15	16,24		15		
Characidae						
Brycinus lateralis	2-4,6-8, 10,12-15	16,17, 21-27	31,35,39, 40	1,3,5,6,8, 12,14,15	17-20	31,35,36, 39,40
Micralestes acutidens	2-8,10, 12-15	23-25,28	31,33,35-37	3,5,9,14		31,35,39
Hydrocynus vittatus	3,4,6,8,10, 12-15	21-27	31,33,35, 36,39	3,5,6,8,14, 15	17	31-33,35, 36,39
Rhabdalestes maunensis	4,7,11,12, 14,15	16,21,22, 25,28	31,35,36, 40	15	17,29	31
Hepsetidae						
Hepsetus odoe	4,6,8,12-15	16,22,25, 26	33,35,36, 39,31	6,9,12,14, 15	17-20	34-36,39
Claroteidae						
Parauchenoglanis ngamensis		16	35	1,3,15	17,18	33,35
Amphiliidae						
Leptoglanis cf dorae	7,15					
Schilbeidae						
Schilbe intermedius	2-4,6,8, 10-15	16,21-27	31,33,35, 36,39,40	3,5,6,8,12, 14,15	17-20,29	31,33-36, 39
Clariidae						
Clarias gariepinus	3,4,8, 10-15	16,17, 21-23, 25,26,30	31,35-37, 39	1,12,14,15	17-20	39,40
Clarias ngamensis	11,12	22,23,25, 30	33,35	5,12,15	17-19,29	31,35
Clarias stappersii				1		39
Clarias theodorae	3,7,8,12, 13,15	16,25	39	1,3,12,15	17,29	35,39
Clariallabes platyprosopos				1,3		
Mochokidae						
Chiloglanis neumanni				1		
Synodontis nigromaculatus	8,12	16		3	18	
Synodontis macrostigma	12	16	35			
Synodontis vanderwaali	13					
Synodontis spp.	3,4,6,8,10, 12-15	16,22, 24-26	36,39	1,3,5,6,8, 12,14,15	17-20	31,36,39
Cyprinodontidae						
Aplocheilichthys johnstoni	4,7,8,12, 15	16,17, 23-25,28	31,33, 35-38,40	9,12,14	17,29	31,35,39, 40

Species	High Flood/Autumn			Low Flood/Spring		
	Zambezi	Chobe	Kwando	Zambezi	Chobe	Kwando
Table 3.1						
Aplocheilichthys hutereaui	15		35-37,40		29	39
Aplocheilichthys katangae	15	16,21,22, 24,25,28	36		17,29	
Cichlidae						
Hemichromis elongatus	2,3,6-8, 12-15		33,35,36	1,3,5,9,12, 14,15	17,20	35
Pseudocrenilabrus philander	3,5-8, 11-15	16,17, 21-26, 28,30	31,33, 35-37, 39,40	1,3,5,9,12, 14,15	17,19,29	31,32,35, 39,40
Pharyngochromis acuticeps	2-8,10-15	16,22- 25,28	31,33-40	1,3,5,6,8, 9,12,14,15	17-20	31-36, 39,40
Sargochromis carlottae	12,14	16,25	35,36,39	12,14,15	17-19	31,34
Sargochromis codringtonii	11-13			12,14,15	17,19	36
Sargochromis giardi			36,39			39
Serranochromis altus	12		31,35	14	17-19	31,36,39
Serranochromis angusticeps	12,13	16	31,35,39	14	17,20	
Serranochromis longimanus	12-15			14	17,19,20	
Serranochromis macrocephalus	11-14	16,24,25	35,36,39	1,6,12,14, 15	17-20	40
Serranochromis robustus	6,11-14	17,22,25, 26	33,39,40	1,3,5,12, 14,15	17,19	35,39,40
Serranochromis thumbergi	3,6	24,25			17	
Tilapia sparrmanii	3,4,6-8, 11-15	16,17,21, 22,24-26, 28, 30	31,34-37, 39,40	1,3,5,8,9, 12,14,15	17-20,29	31,35,39, 40
Tilapia ruweti	4,12,14,15	17,21,22, 24-26, 28,30		12,15	17,29	35,39
Tilapia rendalli	2,3,5-8, 11-15	16,22,23, 25,26,28, 30	33,35-37, 39,40	1,3,5,9,12, 14,15	17-20	35,39,40
Oreochromis andersonii	12,13,15	16,17,23, 25	39	1,12,14,15	17-20,29	40
Oreochromis macrochir	2,7,8, 11-13,15	16,17,21, 22,25,28, 30	31,33, 35-40	5,9,12,14, 15	17-20,29	35,39,40
Anabantidae						
Microctenopoma intermedium		22,25	36		17,29	
Ctenopoma multispine	11-13,15	16,22,23, 25,28,30	37	12,14,15	17,29	35
Mastacembelidae						
Aethiomastacembelus frenatus	8			15		
Aethiomastacembelus vanderwaali				1		
Total Families Per River	**13**	**12**	**12**	**13**	**11**	**10**
Total Families Per Season		**14**			**13**	
Total Species Per River	**53**	**46**	**40**	**54**	**40**	**37**
Total Species Per Season		**64**			**65**	
Total Species sampled in the Caprivi			**69**			

3.4 DISCUSSION

3.4.1 Species distribution (Table 3.1)

Mormyridae

Mormyrus lacerda was sampled in its expected habitat (Skelton, 1993), which were deep, quiet, vegetated waters, such as in Lake Lisikili. It was also sampled in quiet rock pools (Station 1). It was sampled at more stations during low floods. This species was not sampled in large numbers, and the larger water surface area during high floods and the abundance of cover in the form of vegetated areas, as well as migration could have influenced its distribution.

Hippopotamyrus ansorgii was sampled in its expected rocky habitat with flowing water in the Zambezi River (Skelton, 1993). Specimens were however sampled in the Kwando River in vegetated areas. *Hippopotamyrus ansorgii* was not sampled in the Zambezi River during high flood because of the rocky habitats being submerged and inaccessible for surveying purposes. This species mainly had a distribution confined to the rocky habitat in the Zambezi River due to its habitat preference for rocky habitats.

At the time of the surveys the possibility of the occurrence of a second species similar to *Hippopotamyrus ansorgii*, in the Kwando River, was being investigated (pers. comm., Prof. F.H. van der Bank, 1999). This species supposedly has a different habitat preference than expected for *Hippopotamyrus ansorgii*, and that might explain why a ***Hippopotamyrus* sp.** was sampled in mainstream vegetated habitats in the Kwando River.

The absence of *Hippopotamyrus ansorgii* in the areas of the Chobe River that were surveyed might be explained by the absence of rocky habitats. ***Hippopotamyrus discorhynchus*** was sampled in all the rivers in its expected habitat. It was sampled in or near marginally vegetated areas of rivers and backwaters. It had a poor distribution in the Chobe River. According to Skelton (1993) this species favours large river channels and its absence during low floods in the Chobe River may be due to the fact that the areas of river channel that were surveyed during low floods were relatively narrow and shallow, and its preferred habitat therefore absent.

Marcusenius macrolepidotus was recorded from well-vegetated marginal habitats, and the flood levels did not have an impact on its distribution. Local fishermen reported large down stream migrations during mid-winter (June-July) in the Impalila Island area.

Petrocephalus catostoma was sampled in a variety of habitats, but it seemed to prefer quiet well-vegetated areas. *Petrocephalus catostoma* was also sampled in the rocky habitat near Katima Mulilo Ferry during low flood. The occurrence of a second similar species was also being investigated during the time of the surveys (*pers. comm*., Prof. F.H. van der Bank, 1999). The flood levels however did not have a large impact on its distribution, although it was sampled at fewer stations during low floods in the Chobe River.

Pollimyrus castelnaui was sampled in its expected habitat of dense vegetation along margins of rivers and lagoons (Skelton, 1993). It was often collected in shallow water habitats in and under dense aquatic vegetation, during this study. It was also sampled in fringing vegetation at the rocky habitat near Katima Mulilo Ferry during low flood. The flood level did not have a major impact on its distribution.

Cyprinidae

Mesobola brevianalis was sampled during high floods only in the Chobe and Kwando Rivers. It was sampled, as expected, in clear, well-aerated water, in conjunction with a clean sandy substrate (Skelton, 1993). Sandy areas, such as shallow submerged sand banks, and small side streams, were usually dry during low flood, and this might explain why it was not sampled during low flood. This species was sampled in an isolated floodplain pool next to the Chobe River (Station 22), which is not the preferred habitat for this species. It was probably trapped due to fast receding water levels. Its habitat preference probably influenced its distribution, as its habitat is either dry or flooded during the respective low and high flood seasons.

Opsaridium zambezense was sampled, as expected, in clean, clear, flowing water (Skelton, 1993). It was mostly sampled during high floods in the Zambezi and Kwando Rivers in shallow, clean, clear, flowing water, over a sandy substrate. It was sampled during low flood in the Zambezi River, in clear rapids and pools in a rocky habitat (Station 1), and in clear shallow water flowing over sandy areas (Station 9). The Chobe River has a slow flow in the areas surveyed, and has a scarcity of the preferred habitat for this species, which might explain why it was not sampled in the Chobe River. The areas where these habitats occur in the Kwando River are usually dry during low flood. Its distribution is subject to its habitat preference.

Barbus barotseensis was collected, in marginally well vegetated, and floodplain habitats. Sampled mainly during high flood this species seems to prefer floodplain type habitats. During the times of the surveys the Kwando River was usually in its intermediate flood, and the high floods reached the surveyed areas later, during June-July. Floodplain habitats were therefore scarce in the Kwando River during the surveys, and this might explain why this species was not sampled in the Kwando River. Low flood levels had a negative effect on its distribution, and it was sampled only at Station 1, in the marginal vegetation fringing the rocky habitat near Katima Mulilo Ferry. Its preference to floodplain type habitats might explain its poor distribution during low flood.

Barbus unitaeniatus was sampled in a wide range of habitats, but it was usually sampled in quiet, clear, vegetated water near the margin. It was also sampled in clear flowing streams, isolated backwater pools and floodplain type habitats. The flood levels do not seem to have a major effect on its distribution, probably due to its apparent tolerance to different habitats.

Barbus bifrenatus was collected, as expected in shallow, well-vegetated habitats along the margin, and in floodplain type habitats (Skelton, 1993). Although distributed in all the rivers it was not sampled in the Kwando River during autumn, probably due to a scarcity of floodplain type habitats. Its distribution may be affected by the availability of floodplains and vegetation.

Barbus thamalakanensis had a wide distribution during high flood in the Zambezi and Chobe Rivers. It was collected, as expected, in well-vegetated areas and floodplain type habitats (Skelton, 1993). It was sampled at one locality in the Kwando River during autumn. The low floods had a negative effect on its distribution probably due to the absence of floodplains. It was sampled during low flood at one locality only, Kalizo Lodge, where there are isolated floodplain pools in the area that sometimes stay inundated for long periods.

Barbus barnardi was mostly sampled during high floods, and had a fair distribution in the Zambezi and Chobe Rivers. It preferred well-vegetated areas and floodplain habitats. It was sampled in the marshes of the Chobe River in the Indibi Channel. The low floods had a negative effect on its distribution. It was not sampled in the Kwando River.

Barbus fasciolatus was rarely sampled, but as expected it was sampled in clear, well-vegetated side streams and oxbow lakes. It is a species that prefer densely vegetated areas and floodplain type habitats according to Skelton (1993), but due to the fact that so few specimens were sampled, it is difficult to determine the impact that the floods have on its distribution.

Barbus radiatus was collected as expected in marshes and marginal vegetation of streams, rivers and lakes (Skelton, 1993). The flood levels did not have a major impact on its distribution. It was mostly sampled near the margin of rivers in clear water, near or in vegetation.

Barbus haasianus was recorded, as expected, in shallow floodplain and swamp like habitats with dense vegetation (Skelton, 1993). *Barbus haasianus* had a wide distribution during high flood in the Chobe River due to the abundance of its preferred habitat in the Chobe area. *Barbus haasianus* had a better distribution during high flood than low flood, probably due to abundance of floodplains.

Coptostomabarbus wittei had a similar distribution to that of *Barbus haasianus*. It was also found in Lake Lisikili, which has dense vegetation. Both *Coptostomabarbus wittei* and *Barbus haasianus* prefer floodplain type habitat with dense vegetation, and were sampled during low flood in isolated floodplain pools or densely vegetated backwaters in the Kalizo area (Zambezi) and Sipho in the Chobe River.

Barbus poechii had a wide distribution and was commonly sampled. The flood level did not seem to have an impact on the distribution. *Barbus poechii* was sampled in various habitats, but it was most often found in clear water, near or in marginal vegetation.

Barbus cf eutaenia had a relatively wide distribution in the Zambezi River during high flood. This species seems to prefer marginal, densely vegetated areas with clear water. It was not sampled in the Kwando River, and it had a poor distribution during low flood. It was only sampled in the fringing vegetation at the rocky habitat at Station 1 during low flood.

Barbus multilineatus was sampled in its expected habitat of quiet, shallow, densely vegetated water (Skelton, 1993), floodplain type habitats, and in or under marginal vegetation, and usually where there was dense floating aquatic vegetation present. It had a wide distribution during high flood due to inundated floodplains and submerged marginal areas. It was sampled in Lake Lisikili (Zambezi) and in isolated floodplain pools in the Chobe River during low flood.

Barbus afrovernayi was sampled in quiet, often shallow, densely vegetated marginal areas, and it had a wide distribution in the Chobe and Zambezi Rivers during high flood. It was sampled in well-vegetated backwaters, mostly directly under floating vegetation, in the Kalambeza Channel area during low flood. It was not well distributed during low floods, probably due to the absence of preferred inundated vegetated habitat in certain areas.

Barbus paludinosus was sampled in its expected habitat of quiet well-vegetated water (Skelton, 1993). It had a wide distribution during both seasons, and it was mostly sampled in floodplain type habitats and isolated backwater or floodplain pools with ample vegetation. It is a hardy fish that was also sampled in muddy vegetated pools in the Kwando River (Station 40).

Barbus codringtonii was only sampled during low flood in clear flowing water in the rocky rapids at Station 1 in the Zambezi River. The rapids were only accessible during low floods. It is a stream loving species (Skelton, 1993), and therefore it does not have a wide distribution in the Eastern Caprivi, probably due to the lack of rapids in the area.

Labeo cylindricus was sampled in clear flowing water near rocks and marginally vegetated areas. It was sampled in large numbers (juveniles), near the margin of the Zambezi River during high flood (autumn), while migrating upstream. It was sampled in the Zambezi River during low flood in the rocky habitat at Katima Mulilo Ferry (Station 1), in clear, flowing water, and it was also sampled at two other localities (Station 3 and 5) in the mainstream near the vegetated margin. It had a better distribution during high flood in the Zambezi River. It was not sampled in the Kwando River, probably due to a dominantly slow flowing stream, and the absence of rocks and rapids. In the Chobe River it was sampled in gill nets near the vegetated margin during high and low floods.

Labeo lunatus was mostly sampled in quiet, deep, vegetated backwaters and mainstream areas. It was also sampled in Lake Lisikili next to deep well-vegetated areas, with gill nets. Deep, quiet water areas were not abundant in the Kwando River during the surveys, and this might explain why this species was not sampled in the Kwando River. It was sampled in the Chobe River at only one locality during low flood, in a deep vegetated mainstream area. It had a better distribution during high flood in the Zambezi River. Gill nets in deep quiet water were the main sampling method for this species.

<u>Distichodontidae</u>

Hemigrammocharax machadoi and ***Hemigrammocharax multifasciatus*** were sampled with scoop nets, seine nets, rotenone and the electro shocker, usually in and under dense aquatic vegetation such as lilies and other floating vegetation near the margin. Both prefer well-vegetated, quiet waters of river margins, floodplains and backwaters (Skelton, 1993). The distribution of both species was wider during high floods, probably due to the abundance and availability of inundated vegetated areas.

<u>Characidae</u>

Brycinus lateralis had a wide distribution in the Eastern Caprivi and was present in high numbers. This species was collected mostly in clear, open water next to well-vegetated marginal areas. Flood levels did not have a noticeable effect on its distribution. *Brycinus lateralis* was sampled mostly with small mesh sized gill nets set along marginal areas of rivers. Juvenile specimens were also often sampled with seine nets in marginal areas.

Micralestes acutidens had a wide distribution, although not recorded in the Chobe River during low flood. Sampled in clear, open water, near marginal vegetation, usually with some flow present. The absence of flow or open water habitats in the narrow, shallow stream habitats in some areas of the Chobe River (to the south), where vegetation was abundant, might explain why this species was not sampled during low flood in this river.

Hydrocynus vittatus was sampled in deep, clear water near the margin or in open water in the mainstream. Large specimens were also collected in deep-water areas over rocky reefs in the Katima Mulilo area. It had a better distribution in the Chobe River during high flood, probably due to flowing water in more areas. It was also sampled more towards the Impalila Island area where there are large mainstream areas with stronger flowing water.

Rhabdalestes maunensis was mostly collected in floodplain type habitats, and in marginal vegetation, with clear water. It had a wider distribution during high flood, probably due to more preferred habitat (Skelton, 1993) being present.

Hepsetidae

Hepsetus odoe was sampled in deep, clear water next to dense vegetation in quiet areas of the mainstream and backwaters. Juveniles were also collected in the larger isolated floodplain pools. It had a wide distribution during both seasons and the flood levels did not have any effect on the distribution of this species.

Claroteidae

Parauchenoglanis ngamensis was collected, as expected, in rocky habitat or marginal vegetated areas (Skelton, 1993). It was sampled in all the rivers although only at a few localities. It was a fairly scarce species to sample.

Amphiliidae

Leptoglanis cf dorae is very habitat specific and was only sampled at two localities in the Zambezi River. It was collected in shallow medium to fast flowing water over a very clean sand bottom, where it lies under the sand with only the eyes protruding. The sand banks were large and the water depth ranged from 15 to 30cm deep. This habitat occurred frequently during high foods. In areas where siltation occurred this species could not be found.

Schilbeidae

Schilbe intermedius had a wide distribution and was collected in a variety of habitats, but mostly in open water near marginal vegetation. The different flood levels did not have an impact on its distribution.

Clariidae

Clarias gariepinus was sampled in a variety of habitats. It had a wide distribution, but it was sampled at fewer localities during low flood. Large specimens were not sampled frequently, but were caught by local anglers with hook and line. The floods did not seem to have a major impact on its distribution.

Clarias ngamensis was not sampled as regularly as *Clarias gariepinus*. It was mostly collected in quiet deep-water areas such as in the channel and backwater habitats of the

Chobe River. High numbers of catfish were recorded during spring when specimens of both *Clarias ngamensis* and *Clarias gariepinus* were easily sampled with a cast net, in the Sipho area in the Chobe River. The floods did not seem to have an impact on its distribution.

Clarias stappersii was collected in its expected habitat (Skelton, 1993) in the Kwando River. It was sampled in an isolated oxbow lake in shallow water with dense vegetation. Organic material was present on the bottom. In the Zambezi River it was sampled in a rock pool with fringing vegetation (Station 1)

Clarias theodorae was sampled in its expected habitat of dense marginal vegetation and floodplain pools (Skelton, 1993). It was often caught with traps set in the marginal vegetation where there was a slow flow. Flood levels did not seem to have an impact on its distribution.

Clariallabes platyprosopos was sampled in the expected habitat of clear flowing water in the rocky rapids of the Zambezi River (Skelton, 1993). It was also sampled in adjoining rock pools. Sampled during low flood when rocky habitat (at Katima Mulilo) was exposed. Not sampled in the other rivers probably due to the lack of rocky habitats. It was rarely sampled and it seems to be a habitat specific species for rocky habitats with clear water.

<u>Mochokidae</u>

Chiloglanis neumanni was collected in its expected habitat of clear flowing water, in rocky rapids, and in adjoining rock pools (Skelton, 1993). Sampled during low flood when rocky habitat was exposed. This species seems to be habitat specific for habitats with submersed structure (*i.e.* rocks) and clear water.

The ***Synodontis* spp.** were sometimes difficult to identify, therefore most of the specimens sampled were categorised under this name. Where possible some species were identified and the distribution was recorded in Table 3.1. Most specimens were either sampled in rocky habitat with Rotenone or marginally with gill nets. The *Synodontis* spp. were commonly sampled.

Synodontis nigromaculatus was sampled in marginal vegetation in the Zambezi and Chobe Rivers during high and low floods.

Synodontis macrostigma was collected in all three rivers during high flood in densely vegetated areas when floodplain type habitats were abundant.

Synodontis vanderwaali was sampled at one station in the Zambezi River during high flood in marginal vegetation.

Cyprinodontidae

Aplocheilichthys johnstoni was collected in quiet, marginally vegetated mainstreams, backwaters and on floodplains in all the rivers during both floods. Usually sampled near the surface with the 5m seine net. The flood levels did not seem to have an impact on its distribution, although it was better during high floods.

Aplocheilichthys hutereaui, a habitat specific species (Skelton, 1993), was sampled on floodplains and in marsh type habitats. It had a wider distribution during high floods when floodplain habitats were abundant. It was sampled during low flood in floodplain pools and marsh like habitats in the Chobe and Kwando Rivers.

Aplocheilichthys katangae was sampled in all the rivers during high flood, but was sampled more commonly in the Chobe River where it was sampled in dense marginal vegetation of mainstreams, backwaters, and in the canals flowing through the Chobe Marsh areas. Usually sampled under floating vegetation near the surface.

Cichlidae

Hemichromis elongatus was usually sampled in deep water, with gill nets, next to dense marginal vegetation. Specimens were also sampled with angling in deep open water. It was not collected in the Chobe River during high flood. Juvenile specimens were sampled with Rotenone in the marginal vegetation of Lake Lisikili.

Pseudocrenilabrus philander was common and sampled in a variety of habitats, but usually in marginally vegetated areas. Flood levels did not affect its distribution.

Pharyngochromis acuticeps was common, and was collected in a variety of habitats, but usually in marginally vegetated areas. Flood levels did not affect its distribution.

Sargochromis carlottae was mostly sampled in quiet, deep, marginally vegetated backwaters and canals. It was also sampled in Lake Lisikili with its quiet, deep and well vegetated water.

Sargochromis codringtonii was mostly sampled in quiet, deep, marginally vegetated backwaters and canals. It was also sampled in Lake Lisikili with its quiet, deep and well vegetated water. Juveniles were sampled in vegetated bays. It was not sampled in the Chobe and Kwando Rivers during high flood. It was sampled more often during low flood.

Sargochromis giardi is habitat specific for deep, quiet, well-vegetated mainstream and backwater habitats, and lagoons (Skelton, 1993). Large specimens, usually in breeding pairs, were sampled in the Kwando River. Although not collected in the other rivers local and recreational fishermen do catch this species regularly

Serranochromis altus was collected in deep, marginally vegetated mainstreams and backwaters. Sampled in all the rivers, though not abundantly. Not sampled in the Chobe River during high flood.

Serranochromis angusticeps was sampled in deep, quiet, well-vegetated water, such as Lake Lisikili and the Kalambeza Channel. It was not sampled abundantly, and it was not recorded in the Kwando River during low flood.

Serranochromis longimanus was collected in quiet, well-vegetated backwaters and canals. It is an uncommon species (Skelton, 1993). It was not regularly sampled during this study, and it was not recorded in the Kwando River.

Serranochromis macrocephalus had a fairly wide distribution and was sampled mainly near the margin in well-vegetated water. Its distribution was not affected by flood.

Serranochromis robustus was usually collected in deep mainstream areas, but was also sampled in marginally vegetated waters. Flood levels did not affect its distribution.

Serranochromis thumbergi was scarce, and mostly juvenile specimens were sampled in marginal vegetated areas of the mainstream. Mostly collected during high flood.

Tilapia sparrmanii was sampled in various habitats, but mostly in vegetated areas. It had a wide distribution, which does not seem to be affected by the flood levels.

Tilapia ruweti prefers floodplain type habitats with dense vegetation (Skelton, 1993), and was collected fairly commonly on floodplains and in marsh habitats with abundant vegetation. Recorded in all the rivers, with a wide distribution in the Chobe River during high flood, probably due to the abundance of floodplains and marsh like habitats. This species was also abundant in Lake Lisikili.

Tilapia rendalli had a wide distribution during both floods. It was mostly collected in marginally vegetated areas of mainstreams and backwaters. Specimens were also sampled in isolated pools and on floodplains, and in Lake Lisikili. Recorded in all the rivers. This species was often targeted by the subsistence fisher folk, especially on floodplains, and in the marsh habitats of the Chobe River near Impalila Island (as observed by the author).

Oreochromis andersonii had a fairly wide distribution during both floods, and was recorded in all the rivers. It was mostly collected in quiet, deep water of mainstreams, canals and backwaters. It was also sampled in isolated pools.

Oreochromis macrochir had a wide distribution during both floods, and was recorded in all the rivers. It was mostly sampled marginally in quiet, vegetated, deep water of canals and backwaters. Juvenile and immature specimens were collected on floodplains and in isolated pools. Large specimens were sampled in the deep mainstream.

<u>Anabantidae</u>

Microctenopoma intermedium was sampled marginally in and under dense vegetation of marshes, backwaters and on floodplains and floodplain pools. It was not very common, and it was not recorded in the Zambezi River during this study.

Ctenopoma multispine was recorded at more localities during high floods. It was collected in well-vegetated marginal areas of backwaters. It was also sampled on floodplains, in isolated floodplain pools and in marshy areas.

<u>Mastacembelidae</u>

Aethiomastacembelus frenatus was collected in the Zambezi River during both floods, in and under dense marginal vegetation. It was rarely sampled.

Aethiomastacembelus vanderwaali seems to be habitat specific and was only collected during low flood in the rocky habitat at Station 1 in the Zambezi River. It did not have a wide distribution probably due to the lack of rocky habitats in the Eastern Caprivi.

3.4.2 Species not sampled

Following is a list of species that were not found during the time of the study, which should occur in the Eastern Caprivi, according to van der Waal and Skelton (1983), and Skelton (1993).

<u>Distichodontidae</u>

Nannocharax macropterus – Zambezi River.

<u>Cyprinidae</u>

Barbus kerstenii – Zambezi and Chobe Rivers.

Barbus lineomaculatus – Zambezi and Chobe Rivers, and Linyanti Swamp.

Barbus brevidorsalis – Zambezi River.

Amphiliidae

Leptoglanis rotundiceps – Zambezi River.

Amphilius uranoscopus – Zambezi River.

Mochokidae

Chiloglanis fasciatus – Kwando River (Skelton, 1993)

Aplocheilidae

Nothobranchius sp. – Rain Pools.

Cichlidae

Sargochromis greenwoodi – Linyanti Swamp and Kwando River.

3.5 CONCLUSION

The main factors that influenced the distribution of certain species during low or high floods were the availability of preferred habitat due to the level of inundation. If the preferred habitat niches for certain species were unavailable in areas during certain periods of the year (*i.e.* dry or flooded habitats), they were consequently not sampled in these areas. Dry floodplain areas become inundated during high water levels creating new habitat for shallow water species, which prefer vegetated areas. Species that would normally inhabit the shallow vegetated fringes of a river during low flood levels are most likely to colonise this newly inundated shallow water areas, as rising water levels are likely to immerse their previously preferred habitat of the low flood season. When water levels drop species will then move back to the river. The observed fish movements during this study were connected to rising, high and falling water levels.

Longitudinal and lateral migrations of freshwater fish were observed by Van der Waal (1996) in 63 (83%) of the fish in the Upper Zambezi in the Caprivi region, Namibia. Breeding migrations were observed only in *Clarias* spp. and some barbs. Most other fish movements seem to be connected with invasions into newly inundated habitat, escape from desiccation, movement back to permanent water, movement away from areas with temporary high densities in an effort to escape predation or to seek new feeding grounds (van der Waal, 1996) (see Chapter 6, section 6.3.3).

Available cover also plays an important role in the species distribution, as certain species use vegetation, rocks and structures as feeding surfaces and as camouflage against piscivores. Certain species with feeding preferences will also keep to certain areas with its associated food resources (*i.e.* algae on rocks or invertebrates in vegetation).

Clear, flowing water over shallow sandy areas is a good example of a habitat that is sensitive to flood changes. In the Zambezi River it might only exist during low floods in certain areas, but in the Kwando River it exists only during high flood in the areas surveyed. Therefore, it was difficult to find these habitats for habitat specific species during certain periods of the year.

Most specimens were sampled at more localities during high floods, probably due to the higher surface area being covered by the inundating waters, and the formation of a variety of new habitats, and the occupation of these habitats that would otherwise not exist.

During low floods the fish are confined to the mainstream, and in certain areas the habitat diversity may be low (*i.e.* marginal vegetated areas and floodplains may be dry, leaving only a sandy mainstream), and consequently the species diversity will also be low. Species are inclined to migrate to areas where the habitat is suitable, or where preferred habitat is available. This might explain why some species were not sampled in certain areas that were surveyed during low floods.

Flood levels have an impact on distribution in terms of migration and breeding (Van der Waal, 1996). Some species migrate onto floodplains and marshlands to spawn during high flood. These areas are logistically difficult to survey, due to the presence of dense aquatic vegetation, and inaccessible wetland (muddy) areas. It is therefore possible that some species were not sampled in an area due to it spawning in bordering inaccessible marshland areas. Other fish species migrate up or downstream during certain seasons, and this might influence the distribution and abundance of species in a certain area. An example of such a phenomenon was when large numbers of *Labeo cylindricus* were sampled while migrating upstream during high floods. The seine net species catch composition during these times consisted 70% of *Labeo cylindricus*, a species otherwise not sampled regularly. Other species included cyprinids and small barbs.

Logistical problems also played a role. Some habitats fringing deep water, especially during high floods, were usually not sampled with active gears, such as Rotenone, seine nets or the electro-shocker, in fear of crocodile or hippo attacks. Some areas were also unreachable by boat due to densely vegetated, dry or shallow mainstream areas, or by vehicle due to flooded areas. Fish distribution in the Linyanti Swamps and Lake Liambezi were not recorded due to these areas being dry at the time of the surveys.

Floodplains were not sampled regularly during low floods, due to the floodplains being dry. In the Chobe River the marshes were mostly surveyed during high flood when it was accessible by boat. Some fish species may occur in areas that were not surveyed, but one of the factors inhibiting fish distribution may have been habitat specialisation of the different species, and the availability of these habitats.

This chapter aims to give an indication of the most likely distribution patterns in the areas surveyed, and where certain species are most likely to be sampled. It is obvious that certain species that was not sampled in certain areas may still be sampled there in future, due to changing environmental factors. The study of the fishes of the Eastern Caprivi is an ongoing process, and other species previously recorded for this region by other authors have been sampled on later occasions after this study. During these surveys that were not included in this thesis, *Nannocharax macropterus* and *Barbus kerstenii* were sampled in the Zambezi River, by the author (surveys conducted for the Ministry of Fisheries and Marine Resources, Namibia, 1999-2001).

Nannocharax macropterus seems to be habitat specific and was sampled in a strong current, in clear water flowing over a clean sand bank, in standing reeds at Station 13 (Kalambeza Mouth, East), and *Barbus kerstenii* was sampled in dense marginal vegetation in the same area, fringing the sand banks (MFMR surveys, 1999-2001).

Microctenopoma intermedium, which was not recorded in the Zambezi River during this study, was also sampled at Station 13 in marsh-like habitats and dense marginal aquatic vegetation in the area, by the author (MFMR surveys 1999-2001).

The Eastern Caprivi has a sub-tropical climate with warm summers and temperate winters, and water temperature does not seem to play a major role in the species distribution, as the species are adapted to sub-tropical conditions. Temperatures averaged 20ºC during the high flood surveys, and 24ºC during low flood surveys (see Chapter 10: Water Quality). Skelton (1993) states that tropical fauna is restricted to areas where temperatures do not decline below 15ºC-18ºC during the cooler winter months.

Dissolved oxygen values measured in certain areas were adequate for species survival (Chapter 10: Water Quality), and do not seem to play a major role in distribution. Dissolved oxygen levels may fluctuate in the smaller isolated pools on floodplains, but it is likely that the remaining species in these habitats are adapted to these conditions. Some species do prefer flow and well-aerated water and are confined to the mainstream, such as *Barbus codringtonii* and other stream loving species, but will however survive in areas of low flow for certain lengths of time.

The high flood period is the driving force of the Eastern Caprivi system, as it facilitates breeding and production. This is the reason why the Eastern Caprivi is so productive and dynamic, and the species so resilient.

The areas surveyed in the Eastern Caprivi were basically pristine in terms of dams or other manmade structures, which may obstruct species movement, and it therefore did not play a role in the species distribution.

Subsistence fishery may have an impact on the fish population structure, as local people rely heavily on the fish resource as an affordable protein source, but with management the resource can however be protected.

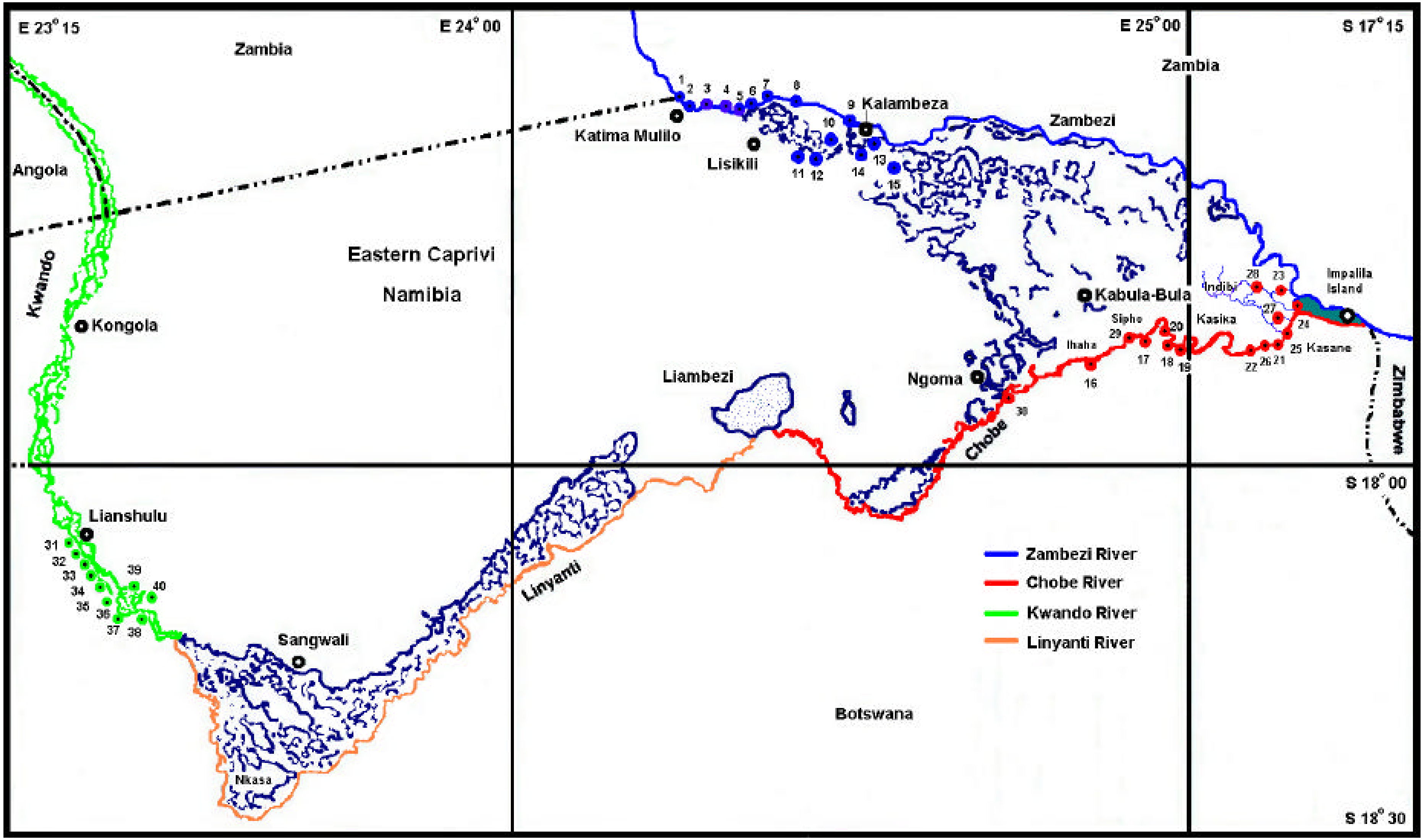


Figure 3.1 Map of Eastern Caprivi rivers and floodplains, and the sampling stations.

4 HABITAT PREFERENCES

4.1 INTRODUCTION

The main aim of this chapter is to list the relative frequency of occurrence of the species in certain habitat conditions, and to indicate the habitat preferences. Some species are habitat specific, and others are tolerant to a variety of habitats and conditions.

The habitat preference of each species needs to be studied in order to identify possible sensitive areas or habitats, where species may be targeted, or negatively impacted by external activities such as fishery, livestock overgrazing, or pollution.

Species that utilise floodplain type habitats for spawning or nursery areas may be negatively affected by overgrazed areas. Other species prefer lake type habitats (Lake Lisikili) and backwaters, and may be targeted there by fishermen. The habitat preference data may be used to identify such areas, which could be declared conservation areas in future, in order to protect certain species.

Table 4.1 indicates the species preference of certain habitat conditions expressed as relative frequency of occurrence. The table indicates where a certain species is most likely to be found.

Table 4.1 also gives an indication of the rarity of some of the species. Rare species were sampled in low numbers, and only in specific habitat conditions, with a low tolerance to the other habitat conditions, whereas the more tolerant and abundant species were sampled more regularly in a variety of habitat conditions.

4.2 MATERIALS AND METHODS

The parameters used to describe the habitats and to indicate preference were, vegetation, substrate, flow, depth and water quality. Each parameter was sub-divided into standard conditions (or categories) familiar to the Eastern Caprivi area. The parameters with sub-divisions (conditions) are listed below, and indicated in Table 4.1.

4.2.1 Vegetation

The conditions or categories for vegetation were, none (no vegetation), dense (well-vegetated) and marginal (marginally vegetated).

Examples where no vegetation occurred were in rocky areas, sandy riverbanks, submerged sand banks and sandy side streams. These areas usually had a medium to fast flow.

Examples of well-vegetated areas are floodplains, marshes and backwaters with a variety of inner, submerged, emergent, marginal and floating aquatic vegetation.

Submerged terrestrial vegetation was the main vegetation type on the floodplains. Well-vegetated areas usually had standing water or a gentle flow.

Marginally vegetated areas were mostly on the margins of lakes, mainstreams and backwaters, usually with open water bordering these areas. The vegetation consisted mostly of aquatic reeds and grass. The flow could be standing to fast.

4.2.2 Substrate

The conditions or categories for substrate were, rocky, sandy and muddy. Sandy substrate was the most common in the areas surveyed, with rocks occurring only in unique areas. Muddy substrate (usually siltation of fine particles and organic material) occurred mostly in areas with standing or slow flowing water.

4.2.3 Flow

Flow was sub-divided into, fast (0.7m/s and higher), medium (0.2 - 0.7m/s), slow (less than 0.2m/s) and none (standing).

4.2.4 Depth

Depth was sub-divided into three categories, deep (>1.0m), shallow (0.3 – 1.0m) and very shallow (0.1 – 0.3m).

4.2.5 Habitat Preference

The habitat preferences are indicated in Table 4.1, by using the habitat parameters and conditions discussed. The habitat conditions (*i.e.* rocky, sandy, muddy) are representative categories of the habitat parameters (*i.e.* substrate) in the Eastern Caprivi.

The habitat preferences of the species are indicated with frequency of occurrence of each species in certain habitat conditions (or categories) representative of the habitat parameters.

The frequency of occurrence of each species in a certain habitat condition (or category) was based on the number of specimens sampled in that habitat condition during the study.

The frequency of occurrence of a species in a certain habitat condition or category is expressed in Table 4.1 as follows:

1. Not sampled, indicated with "-", when a species was not sampled.
2. Rare, indicated with "x", when a species was rarely sampled (<20).
3. Regular, indicated with "xx", when a species was sampled regularly (>20).
4. Abundant, indicated with "xxx", when a species had a high frequency of occurrence (>150).

4.3 RESULTS AND DISCUSSION

The habitat (parameters with conditions) preferences for the species sampled during the study are given in Table 4.1. For example: *Mormyrus lacerda* was rarely sampled (indicated with: x) in marginal vegetation or non-vegetated areas, but regularly sampled (indicated with: xx) in densely vegetated areas; it was not sampled (indicated with: -) in muddy water, but regularly sampled (indicated with: xx) in clear water, etc. The rest of Table 4.1 can be similarly interpreted.

Tolerant species

Species that were tolerant for a variety of habitats were *Schilbe intermedius*, *Barbus unitaeniatus*, *Barbus poechii*, *Clarias gariepinus*, *Clarias ngamensis*, *Pseudocrenilabrus philander*, *Pharyngochromis acuticeps*, *Oreochromis andersonii*, *Serranochromis macrocephalus*, *Serranochromis robustus*, *Tilapia rendalli*, *Oreochromis macrochir* and *Tilapia sparrmanii*.

Habitat specific species

Habitat specific species were *Mormyrus lacerda*, *Hippopotamyrus ansorgii*, *Micralestes acutidens, Rhabdalestes maunensis, Labeo cylindricus*, *Leptoglanis cf dorae*, *Clarias stappersii*, *Clarias theodorae*, *Clariallabes platyprosopos*, *Chiloglanis neumanni*, *Mesobola brevianalis*, *Opsaridium zambezense*, *Barbus codringtonii*, *Aplocheilichthys hutereaui*, *Sargochromis giardi*, *Aethiomastacembelus frenatus* and *Aethiomastacembelus vanderwaali*.

Relatively scarce species

These species were not necessarily rare but sampled in low numbers in certain areas due to their habitat preference. Species include *Mormyrus lacerda* and *Sargochromis giardi,* which are mainly quiet deep-water species; *Parauchenoglanis ngamensis,* which were most likely to occur in quiet well vegetated areas fringing deeper water.

Mesobola brevianalis also relatively rare were sampled in low numbers. It prefers open flowing waters, but is most likely to occur in higher numbers. This is a small species and was mostly sampled with the seine net. It was therefore difficult to sample this species in deep open water areas.

Rare species

These species were rare and sampled in low numbers, and are habitat specific. Species include *Hippopotamyrus ansorgii, Barbus codringtonii, Leptoglanis cf dorae, Clariallabes platyprosopos* and *Chiloglanis neumanni,* which prefer clear flowing water (mostly sampled in rocky habitat).

Other rare species, which were habitat specific for quiet well vegetated habitats, include *Barbus fasciolatus, Barbus cf eutaenia, Clarias stappersii* (sampled in dense vegetation fringing rock pool), *Sargochromis giardi, Microctenopoma intermedium* and *Aethiomastacembelus frenatus.*

Aplocheilichthys hutereaui was sampled in low numbers, but is most likely to occur in higher numbers in difficult to reach areas such as dense marshes and floodplains.

Serranochromis thumbergi is a larger piscivore and was sampled in low numbers in deep marginally well vegetated areas.

Indicator species

Indicator species are sensitive habitat specific species, vulnerable to changes in the environment. They are mostly rare, but some may be sampled in higher numbers where adequate pristine habitat exists. Species fro the Eastern Caprivi may include *Hippopotamyrus ansorgii, Mesobola brevianalis, Opsaridium zambezense, Leptoglanis cf dorae, Clariallabes platyprosopos, Chiloglanis neumanni* and *Aethiomastacembelus vanderwaali*. These species occur in habitats with clear, well aerated, flowing water.

Table 4.1: Habitat preferences of species sampled in the Eastern Caprivi, based on the frequency of occurrence.

Species	Vegetation			Substrate			Flow				Depth			Water Quality	
	None	Dense	Marginal	Rocky	Sandy	Muddy	Fast	Medium	Slow/ Gentle	None	Deep	Shallow	Very Shallow	Clear	Muddy
Table 4.1															
Mormyridae															
Mormyrus lacerda	X	XX	X	X	XX	XX	-	-	X	XX	XX	X	-	XX	-
Hippopotamyrus ansorgii	X	-	X	X	X	-	-	X	X	-	-	X	-	X	-
Hippopotamyrus discorhynchus	-	XX	XX	-	XX	XX	-	-	XX	XX	XX	-	-	XX	-
Marcusenius macrolepidotus	-	XXX	XXX	-	XXX	XXX	-	XX	XXX	XXX	XXX	XXX	-	XXX	-
Petrocephalus catostoma	XX	XXX	XXX	XX	XXX	XX	-	XX	XXX	XXX	XXX	XXX	-	XXX	-
Pollimyrus castelnaui	-	XXX	XXX	X	XXX	XXX	-	-	XXX	XXX	-	XXX	X	XXX	XX
Cyprinidae															
Mesobola brevianalis	X	-	-	-	X	-	-	X	X	X	-	X	-	X	-
Opsaridium zambezense	XXX	-	-	XXX	XXX	-	XXX	XXX	-	-	-	XXX	-	XXX	-
Barbus barotseensis	-	XXX	XX	-	XXX	XX	-	-	XXX	XXX	-	XXX	XX	XXX	XX
Barbus unitaeniatus	XX	XX	XXX	XX	XXX	XX	-	X	XXX	XXX	-	XXX	XX	XXX	X
Barbus bifrenatus	-	XX	XXX	-	XXX	-	-	X	XXX	XXX	-	XXX	XX	XXX	-
Barbus thamalakanensis	-	XXX	XXX	-	XXX	XX	-	-	XXX	XXX	-	XXX	XX	XXX	X
Barbus barnardi	-	XXX	XX	-	XXX	XX	-	-	XXX	XXX	-	XXX	XX	XXX	X
Barbus fasciolatus	-	X	X	-	X	X	-	-	-	X	-	X	-	X	-
Barbus radiatus	-	XX	XXX	-	XXX	-	-	X	XXX	XXX	-	XXX	-	XXX	-
Barbus haasianus	-	XX	XX	-	XX	XX	-	-	X	XX	-	XX	XX	XX	X
Coptostomabarbus wittei	-	XX	XX	-	XX	XX	-	-	X	XX	-	XX	XX	XX	X
Barbus poechii	XX	XXX	XXX	XX	XXX	XX	-	XX	XXX	XXX	XX	XXX	XX	XXX	XX
Barbus cf eutaenia	X	X	X	X	X	-	-	X	X	-	-	X	-	X	-

Species	Vegetation			Substrate			Flow				Depth			Water Quality	
	None	Dense	Marginal	Rocky	Sandy	Muddy	Fast	Medium	Slow/ Gentle	None	Deep	Shallow	Very Shallow	Clear	Muddy
Table 4.1															
Barbus multilineatus	-	XXX	XX	-	XX	XX	-	-	XX	XXX	-	XXX	XXX	XXX	X
Barbus afrovernayi	-	XX	XX	-	XX	X	-	-	XX	XX	-	XX	XX	XX	X
Barbus paludinosus	-	XXX	XXX	-	XXX	XXX	-	-	XX	XXX	-	XXX	XX	XXX	XXX
Barbus codringtonii	X	-	-	X	-	-	X	X	-	-	X	X	-	X	-
Labeo cylindricus	XXX	-	X	XXX	XX	-	X	XXX	XXX	-	X	XXX	-	XXX	-
Labeo lunatus	-	XX	XX	-	XX	XX	-	-	XX	XX	XX	-	-	XX	-
Distichodontidae															
Hemigrammocharax machadoi	-	XXX	XX	-	XXX	XX	-	-	XX	XXX	-	XXX	-	XXX	-
Hemigrammocharax multifasciatus	-	XX	XX	-	XX	XX	-	-	XX	XX	-	XX	-	XX	-
Characidae															
Brycinus lateralis	XXX	-	XX	XX	XXX	-	-	XXX	XXX	XXX	X	XXX	-	XXX	-
Micralestes acutidens	XXX	-	XX	-	XXX	-	-	XXX	-	-	X	XXX	-	XXX	-
Hydrocynus vittatus	XXX	-	XX	XXX	XXX	-	XXX	XXX	XXX	X	XXX	XX	-	XXX	-
Rhabdalestes maunensis	-	XX	XXX	-	XXX	XX	-	-	XXX	XXX	-	XXX	-	XXX	XX
Hepsetidae															
Hepsetus odoe	X	XX	XXX	-	XXX	XX	-	-	XXX	XXX	XXX	XX	-	XXX	X
Claroteidae															
Parauchenoglanis ngamensis	-	-	XX	-	XX	-	-	-	XX	-	XX	XX	-	XX	-
Amphiliidae															
Leptoglanis cf dorae	X	-	-	-	X	-	-	X	-	-	-	X	X	X	-
Schilbeidae															
Schilbe intermedius	XX	XX	XXX	-	XXX	XX	-	XX	XXX	XXX	XXX	XXX	-	XXX	XX
Clariidae															

Species	Vegetation			Substrate			Flow				Depth			Water Quality	
	None	Dense	Marginal	Rocky	Sandy	Muddy	Fast	Medium	Slow/ Gentle	None	Deep	Shallow	Very Shallow	Clear	Muddy
Table 4.1															
Clarias gariepinus	XX	XX	XXX	-	XXX	XXX	-	XX	XXX	XXX	XXX	XX	-	XXX	XXX
Clarias ngamensis	XX	XX	XX	-	XX	XX	-	XX	XX	XX	XX	XX	-	XX	XX
Clarias stappersii	-	X	X	X	-	X	-	-	X	X	X	X	-	X	-
Clarias theodorae	-	-	XX	-	XX	XX	-	-	XX	XX	X	XX	X	XX	XX
Clariallabes platyprosopos	X	-	-	X	-	-	X	X	X	X	-	X	-	X	-
Mochokidae															
Chiloglanis neumanni	X	-	-	X	-	-	-	X	X	X	-	X	X	X	-
Synodontis nigromaculatus	XX	-	XX	XX	XX	-	-	XX	XX	XX	XX	XX	-	XX	-
Synodontis macrostigma	-	XX	XX	-	XX	X	-	-	XX	XX	-	XX	-	XX	-
Synodontis vanderwaali	-	-	X	-	X	-	-	-	X	X	-	X	-	X	-
Synodontis spp.	XXX	XX	XXX	XXX	XXX	XX	-	XX	XXX	XXX	XXX	XXX	-	XXX	XX
Cyprinodontidae															
Aplocheilichthys johnstoni	-	XXX	XXX	-	XXX	XXX	-	-	XXX	XXX	-	XXX	XXX	XXX	XX
Aplocheilichthys hutereaui	-	X	-	-	X	X	-	-	X	X	-	X	X	X	X
Aplocheilichthys katangae	-	XX	XX	-	XX	-	-	-	XX	XX	-	XX	XX	XX	-
Cichlidae															
Hemichromis elongatus	X	X	XXX	X	XXX	-	-	X	XXX	XXX	XXX	XXX	-	XXX	-
Pseudocrenilabrus philander	XX	XXX	XXX	XX	XXX	XX	-	-	XXX	XXX	-	XXX	XX	XXX	XX
Pharyngochromis acuticeps	XX	XXX	XXX	XX	XXX	XX	-	-	XXX	XXX	-	XXX	XX	XXX	XX
Sargochromis carlottae	-	XX	XX	-	XX	XX	-	-	XX	XX	XX	-	-	XX	-
Sargochromis codringtonii	XX	-	XX	-	XX	-	-	-	XX	XX	XX	X	-	XX	-
Sargochromis giardi	-	X	X	-	-	X	-	-	-	X	X	-	-	X	-
Serranochromis altus	-	X	XX	-	XX	X	-	X	XX	XX	XX	-	-	XX	-

Species	Vegetation			Substrate			Flow				Depth			Water Quality	
	None	Dense	Marginal	Rocky	Sandy	Muddy	Fast	Medium	Slow/ Gentle	None	Deep	Shallow	Very Shallow	Clear	Muddy
Table 4.1															
Serranochromis angusticeps	-	x	xx	-	xx	x	-	x	xx	xx	xx	-	-	xx	-
Serranochromis longimanus	-	xx	xx	-	-	xx	-	-	xx	xx	xx	x	-	xx	x
Serranochromis macrocephalus	x	xx	xxx	x	xxx	xx	-	xx	xxx	xxx	xxx	xx	-	xxx	x
Serranochromis robustus	x	x	xxx	x	xxx	x	-	xx	xxx	xxx	xxx	xx	-	xxx	-
Serranochromis thumbergi	-	-	x	-	x	-	-	x	x	-	x	-	-	x	-
Tilapia sparrmanii	xx	xxx	xxx	xx	xxx	xxx	-	xx	xxx	xxx	xxx	xxx	xx	xxx	xx
Tilapia ruweti	-	xxx	xxx	-	xxx	xx	-	-	xx	xxx	-	xxx	xx	xxx	x
Tilapia rendalli	xx	xx	xxx	x	xxx	xxx	-	xx	xxx	xxx	xxx	xxx	xx	xxx	xx
Oreochromis andersonii	x	xx	xxx	x	xxx	xxx	-	x	xxx	xxx	xxx	xxx	xx	xxx	xx
Oreochromis macrochir	x	xx	xxx	-	xxx	xxx	-	x	xxx	xxx	xxx	xxx	xx	xxx	xx
Anabantidae															
Microctenopoma intermedium	-	x	x	-	x	x	-	-	x	x	-	x	x	x	x
Ctenopoma multispine	-	xxx	xxx	-	xxx	xx	-	-	xx	xxx	xx	xxx	x	xxx	xxx
Mastacembelidae															
Aethiomastacembelus frenatus	-	x	x	-	x	x	-	-	x	x	-	x	-	x	x
Aethiomastacembelus vanderwaali	xx	-	-	xx	-	-	-	xx	xx	xx	-	xx	xx	xx	-

Not sampled = -
Rare (<20) = x
Regular (>20) = xx
Abundant (>150) = xxx

4.4 CONCLUSION

Species were sampled in various habitats and at various densities. Most of the species were tolerant for a variety of habitats.

Indicator and rare species were sampled, giving the indication that the status of the resource is most likely still in its natural state. The data for the indicator species sampled in certain areas can serve as reference, for future impact studies.

It is important to conserve the rare species and indicator species for future generations.

The rocky habitats near Katima Mulilo should be considered as sensitive, due to the fact that many of the rare (and indicator) species occur in the rocky rapids of this area. This area should be conserved, and possible future activities, which may negatively impact this area, should be thoroughly assessed.

When there is a healthy population of indicator species in the system, the well-being of the other species present in the system is also insured (DWAF, 1996).

5 RELATIVE DENSITIES AND THE INDEX OF RELATIVE IMPORTANCE (IRI)

5.1 INTRODUCTION

Fish numbers and weight were recorded to determine the contribution each species made to the fish population composition in the Eastern Caprivi, during high and low flood. Relative densities were determined and indicated in percentage for the weight and number of fish sampled.

An Index of Relative Importance (IRI) value (in percentage) was calculated for each of the species to indicate the relative importance of the species in the systems. The frequency of occurrence (F) for each species was also calculated and indicated in percentage, and can be used to highlight species for protection if needed. These values and the relative densities were indicated for the Zambezi, Chobe and Kwando River systems, as well as for the Eastern Caprivi as a whole, for both high and low floods (Tables 5.1 – 5.4).

IRI figures were also used to indicate the relative importance of the species, during high and low flood as well as for the two floods combined (Figures 5.1 – 5.3).

5.2 MATERIALS AND METHODS

Fish were sampled during five surveys and the densities were recorded. The relative densities are given in percentage for the number and mass of fish sampled, for each river and season.

A variety of sampling gears were used to limit selectivity and to prevent a biased representation of the fish population. Sampling methods are described and discussed in Chapter 3.

Fish were weighed and measured directly after sampling, and the weight recorded was the wet weight of the fish. Kern electronic scales were used to measure the weight of each fish sampled in grams and milligrams.

<u>The Index of Relative Importance (IRI)</u>

An Index of Relative Importance (Kolding, 1998) was used to indicate the contribution each fish species made to the catch composition.

The IRI table gives total catch composition in percentage numbers and weight (kg), as well as frequency of occurrence (FREQ) in the settings or sampling efforts (i.e. whether the species was present or not irrespective of the abundance). As a measure of relative abundance or commonness of each species (j) in the catch composition an index of relative importance ($\%IRI$, Kolding 1998) was used:

$$\%IRI_j = \frac{(\%W_j + \%N_j) \bullet \%F_j}{\sum_{i=1}^{S} (\%W_i + \%N_i) \bullet \%F_i} \bullet 100 \qquad (1)$$

where $\%W_j$ and $\%N_j$ is percentage weight and number of each species of total catch, $\%F_j$ is percentage frequency of occurrence of each species in total number of settings (samples), and S is total number of species. The index is shown in table form and graphically. Graphically it combines and shows simultaneously the relative numeric abundance in percentage (%*N*), the percentage weight (%*W*) contribution to the total weight sampled, and the commonness (%*F*) of a species:

$$IRI = (\%N + \%W) * \%F \qquad (2)$$

(Pinkas *et al.* 1971, see also Caddy & Sharp, 1986), displayed as a rectangle (Figures 5.1-5.3). The relative area of a rectangle is given in percentage to all the other species present. The percentage commonness, $\%F$ or %FREQ represents the percentage probability of a species occurring in the catch composition if similar sampling methods (sampling protocol) were used.

The total catch, in numbers and weight for each system, is given at the end of the tables for the high and low flood seasons. Averages of these totals are also provided as there were two low and three high flood surveys. The species were sorted descending in the tables from the highest to the lowest IRI value. The IRI value is a numerical value (given in percentage of the total of the IRI values calculated for the relevant system) assigned to a specific species in the catch composition. The IRI depicts the relative importance of a species in the fish population in terms of its abundance and weight contribution in the relevant catch composition.

5.3 RESULTS AND DISCUSSION

A total of 56 258 specimens were sampled methodically with various gear types, and the relative densities for 69 species were recorded for the high and low flood seasons in the Eastern Caprivi. A total of 1865 fish sampling efforts were made with the various sampling gears during the study, with an average of 384 and 356 sampling attempts per high and low flood, respectively.

5.3.1 IRI and Relative Densities for the Zambezi River

A total of 23 008 specimens were sampled during the three autumn high flood surveys in the Zambezi River, with an average number of 7669 specimens per survey. The total weight of the fish sampled was 452.20 kg with an average of 150.70 kg per autumn survey (Table 5.1).

A total of 13 407 specimens were sampled during the two spring low flood surveys in the Zambezi River, with an average number of 6703 specimens per survey. The total weight of the fish sampled was 108.90 kg with an average of 54.50 kg per spring survey (Table 5.1).

A total of 53 species from 13 families were sampled during high flood, and 54 species from 13 families were sampled during low flood (Chapter 3, Table 3.1). The Zambezi River had the highest species diversity of all the river systems in the Eastern Caprivi.

Brycinus lateralis made the largest contribution to the total number of fish sampled during both seasons. It contributed 36.5% and 30.8% to the total number of fish sampled during high and low flood, respectively. It also received the highest IRI values of 40.7% and 40.4% (Table 5.1).

During high flood *Brycinus lateralis* made the highest contribution (27.9%) to the total weight of fish sampled, and during low flood it made the second highest contribution of (15.8%) after *Hydrocynus vittatus* with the highest weight contribution of 16.4% (Table 5.1).

Petrocephalus catostoma made the second highest contribution (14%) to the total number of fish sampled during high flood, followed by *Schilbe intermedius* (9.5%), *Micralestes acutidens* (4.5%), *Barbus paludinosus* (3.9%) and *Hydrocynus vittatus* (3.2%) (Table 5.1).

During high flood *Schilbe intermedius* was second in weight contribution (20.6%), and *Hydrocynus vittatus* was third in weight contribution with 15.7%, and *Clarias gariepinus* was fourth with 11%. *Petrocephalus catostoma* (6.4%), *Hepsetus odoe* (3.8%) and *Marcusenius macrolepidotus* (3.5%) also made relative contributions to the total weight during high flood (Table 5.1).

The *Synodontis* spp. made the second highest contribution to the total number of fish sampled during low flood with 20.1%, followed by *Tilapia sparrmanii* (8.5%) and *Micralestes acutidens* (5.0%) (Table 5.1).

During low flood *Clarias gariepinus* was third in weight contribution (8.9%), followed by *Hemichromis elongatus* (8.1%). Fifth was the *Synodontis spp*. (7.2%) followed by *Hepsetus odoe* (6.4%) and *Tilapia sparrmanii* (6.0%). *Pharyngochromis acuticeps, Barbus poechii,* *Schilbe intermedius, Marcusenius macrolepidotus, Tilapia rendalli,* and *Oreochromis macrochir* all made relative contributions to the total weight during low flood (Table 5.1).

Table 5.1: IRI, %F, and Relative Densities in percentage for the number and weight of fish sampled in the Zambezi River, during high and low floods.

Autumn - High					Spring - Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.1									
Brycinus lateralis	36.4656	27.8868	24.14	40.73	*Brycinus lateralis*	30.8197	15.8366	22.99	40.4
Schilbe intermedius	9.4619	20.6364	38.48	30.37	*Synodontis* spp.	20.1164	7.1631	10.75	11.04
Hydrocynus vittatus	3.2293	15.6544	21.6	10.69	*Tilapia sparrmanii*	8.4732	5.9887	16.42	8.94
Petrocephalus catostoma	13.9517	6.4188	9.62	5.14	*Hydrocynus vittatus*	0.6489	16.4426	10.75	6.92
Barbus poechii	2.9772	1.6190	15.97	1.92	*Pharyngochromis acuticeps*	3.5578	3.5370	21.19	5.67
Clarias gariepinus	0.1825	11.0265	5.44	1.6	*Hemichromis elongatus*	1.6186	8.1180	14.93	5.47
Micralestes acutidens	4.5202	0.4126	10.89	1.41	*Barbus poechii*	3.3415	2.2827	17.91	3.79
Marcusenius macrolepidotus	2.6034	3.4830	8.35	1.33	*Schilbe intermedius*	2.2376	3.0154	16.42	3.25
Tilapia sparrmanii	2.8425	0.8927	12.7	1.24	*Marcusenius macrolepidotus*	2.5509	3.7004	13.43	3.16
Pharyngochromis acuticeps	1.6994	0.9069	15.43	1.05	*Hepsetus odoe*	0.4774	6.4450	10.45	2.72
Hepsetus odoe	0.3738	3.8021	8.89	0.97	*Tilapia rendalli*	3.0432	3.2202	10.15	2.39
Synodontis spp.	1.3821	1.6081	11.25	0.88	*Oreochromis macrochir*	4.6319	2.4829	4.78	1.28
Barbus paludinosus	3.8726	0.2026	4.9	0.52	*Pseudocrenilabrus philander*	1.7752	0.9522	11.64	1.2
Tilapia rendalli	1.4995	0.3456	7.99	0.39	*Clarias gariepinus*	0.1268	8.9995	2.69	0.92
Hemichromis elongatus	0.5129	1.2800	6.72	0.32	*Barbus paludinosus*	4.6543	1.0945	4.18	0.91
Barbus unitaeniatus	1.9037	0.0619	5.63	0.29	*Micralestes acutidens*	5.0272	0.1947	3.28	0.65
Barbus bifrenatus	1.6864	0.0369	3.99	0.18	*Labeo cylindricus*	1.1710	1.4150	2.69	0.26
Pseudocrenilabrus philander	0.7910	0.0856	6.53	0.15	*Barbus unitaeniatus*	1.2755	0.0468	2.39	0.12
Rhabdalestes maunensis	1.6255	0.0287	2.72	0.12	*Sargochromis carlottae*	0.1492	0.7447	3.28	0.11
Labeo cylindricus	0.9649	0.2421	3.63	0.11	*Serranochromis macrocephalus*	0.0970	1.0908	2.09	0.09
Oreochromis macrochir	1.3995	0.2293	2.36	0.1	*Serranochromis robustus*	0.1343	0.7502	2.69	0.09
Barbus radiatus	0.6911	0.0405	3.63	0.07	*Clarias theodorae*	0.6638	1.0302	1.19	0.08
Barbus barotseensis	0.8432	0.0164	2.9	0.07	*Oreochromis andersonii*	0.1865	0.5711	2.39	0.07
Opsaridium zambezense	0.6737	0.0652	3.27	0.06	*Clarias ngamensis*	0.1343	0.5684	2.39	0.06
Pollimyrus castelnaui	0.4086	0.0993	2.9	0.04	*Ctenopoma multispine*	0.4624	0.5381	1.49	0.06
Labeo lunatus	0.0652	0.4558	2.36	0.03	*Pollimyrus castelnaui*	0.2611	0.1423	3.28	0.05
Barbus multilineatus	0.5868	0.0053	1.63	0.03	*Petrocephalus catostoma*	0.1790	0.1644	3.28	0.04
Aplocheilichthys johnstoni	0.4694	0.0064	1.81	0.02	*Parauchenoglanis ngamensis*	0.2088	0.6666	1.19	0.04
Serranochromis macrocephalus	0.0478	0.3689	1.45	0.02	*Labeo lunatus*	0.0522	0.6042	1.49	0.04
Sargochromis codringtonii	0.0695	0.2530	1.81	0.02	*Clariallabes platyprosopos*	0.0895	0.5362	1.19	0.03
Barbus afrovernayi	0.3042	0.0031	1.81	0.01	*Serranochromis angusticeps*	0.0373	0.4720	1.19	0.02
Barbus thamalakanensis	0.6954	0.0168	0.73	0.01	*Aethiomastacembelus vanderwaali*	0.3207	0.1616	0.9	0.02
Barbus barnardi	0.2390	0.0022	1.81	0.01	*Barbus radiatus*	0.1044	0.0707	2.39	0.02
Serranochromis angusticeps	0.0304	0.2842	1.27	0.01	*Opsaridium zambezense*	0.2238	0.0845	1.19	0.01

Autumn - High					Spring - Low				
Species	% N	% W	% F	% IRI	Species	% N	% W	% F	% IRI
Table 5.1									
Ctenopoma multispine	0.1174	0.0913	1.81	0.01	*Aplocheilichthys johnstoni*	0.2984	0.0037	1.19	0.01
Tilapia ruweti	0.1652	0.0130	2	0.01	*Barbus bifrenatus*	0.2163	0.0147	1.49	0.01
Serranochromis longimanus	0.0435	0.1455	1.63	0.01	*Tilapia ruweti*	0.1268	0.0634	1.79	0.01
Sargochromis carlottae	0.0348	0.2163	1.09	0.01	*Sargochromis codringtonii*	0.0373	0.2341	1.19	0.01
Oreochromis andersonii	0.0869	0.0513	1.81	0.01	*Mormyrus lacerda*	0.0224	0.1331	0.6	0
Clarias ngamensis	0.0174	0.3742	0.54	0.01	*Hippopotamyrus discorhynchus*	0.0448	0.0551	0.9	0
Clarias theodorae	0.0391	0.0632	1.63	0	*Hippopotamyrus ansorgii*	0.0298	0.0450	0.9	0
Hippopotamyrus discorhynchus	0.0782	0.0529	1.27	0	*Serranochromis longimanus*	0.0149	0.0845	0.6	0
Mormyrus lacerda	0.0174	0.1656	0.73	0	*Rhabdalestes maunensis*	0.0298	0.0009	0.9	0
Barbus cf eutaenia	0.0695	0.0027	1.27	0	*Synodontis nigromaculatus*	0.0075	0.0790	0.3	0
Serranochromis altus	0.0043	0.2724	0.18	0	*Barbus afrovernayi*	0.0820	0.0009	0.3	0
Serranochromis robustus	0.0217	0.0274	0.91	0	*Aethiomastacembelus frenatus*	0.0149	0.0606	0.3	0
Hemigrammocharax machadoi	0.0478	0.0002	0.73	0	*Serranochromis altus*	0.0075	0.0679	0.3	0
Synodontis nigromaculatus	0.0130	0.0394	0.36	0	*Barbus barotseensis*	0.0597	0.0028	0.3	0
Coptostomabarbus wittei	0.0304	0.0002	0.54	0	*Hemigrammocharax machadoi*	0.0373	0.0009	0.3	0
Aplocheilichthys katangae	0.0435	0.0002	0.36	0	*Coptostomabarbus wittei*	0.0373	0.0000	0.3	0
Hemigrammocharax multifasciatus	0.0261	0.0004	0.54	0	*Barbus codringtonii*	0.0075	0.0165	0.3	0
Barbus haasianus	0.0174	0.0000	0.54	0	*Barbus haasianus*	0.0224	0.0000	0.3	0
Serranochromis thumbergi	0.0130	0.0009	0.36	0	*Barbus thamalakanensis*	0.0149	0.0009	0.3	0
Aplocheilichthys hutereaui	0.0130	0.0002	0.36	0	*Clarias stappersii*	0.0075	0.0055	0.3	0
Leptoglanis cf dorae	0.0087	0.0000	0.36	0	*Barbus cf eutaenia*	0.0075	0.0000	0.3	0
Synodontis vanderwaali	0.0130	0.0007	0.18	0	*Barbus multilineatus*	0.0075	0.0000	0.3	0
Synodontis macrostigma	0.0043	0.0044	0.18	0	*Hemigrammocharax multifasciatus*	0.0075	0.0000	0.3	0
Aethiomastacembelus frenatus	0.0043	0.0002	0.18	0	*Chiloglanis neumanni*	0.0075	0.0000	0.3	0
TOTAL	**100%**	**100%**		**100%**	**TOTAL**	**100%**	**100%**		**100%**

TOTAL OF 3 SURVEYS		TOTAL OF 2 SURVEYS	
NUMBERS (N)	**WEIGHT (kg)**	**NUMBERS (N)**	**WEIGHT (kg)**
23008	**452.2**	**13407**	**108.906**
AVERAGE OF 3 SURVEYS		**AVERAGE OF 2 SURVEYS**	
NUMBERS (N)	**WEIGHT (kg)**	**NUMBERS (N)**	**WEIGHT (kg)**
7669.3	**150.733**	**6703.5**	**54.453**

Brycinus lateralis received the highest IRI values of 40.7% and 40.4%, during the high and low flood surveys respectively, due to its contribution to the total weight and number of fish sampled. According to the IRI values *Brycinus lateralis* is the most common or abundant species in the Zambezi River, in terms of weight and numbers and it is one of the species most likely to be sampled, if the same sampling protocol is used (Table 5.1).

Brycinus lateralis is a small shoaling species (Skelton, 1993), with a high turnover (growth and reproduction rate) and a relatively high tolerance to a variety of habitat conditions. High numbers of *Brycinus lateralis* in certain areas may indicate the absence of larger species. Larger species, with a low turnover, may be targeted by subsistence fishery in an area, and if there is exploitation of the resource an opening may be left in the total biomass of a fish community, therefore creating the opportunity for other species to fill this opening. Because of its high turnover *Brycinus lateralis* may fill such an opening, and a high contribution to the total weight by this species, or if it is the main contributor, may therefore indicate the absence of other larger species. However, this does not seem to be the case as *Hydrocynus vittatus* made the highest contribution (16.4%) to the total weight recorded during the low flood surveys, followed by *Brycinus lateralis* (15.8%). *Clarias gariepinus* made the third highest contribution (9.0%) to the total weight during low flood (Table 5.1).

Although *Brycinus lateralis* made the highest weight contribution (27.8%) during the high flood surveys, *Schilbe intermedius,* which is omnivorous (Skelton, 1993), and a secondary predator and *Hydrocynus vittatus,* a larger piscivore, also made considerable contributions, of 20.6% and 15.7%, respectively, to the total weight. *Clarias gariepinus* also made a considerable contribution of 11% to the total weight as a large species (Table 5.1).

The IRI is a measure of relative abundance or commonness of each species in the catch composition, where the percentage weight and number of each species of the total catch plays a role. The IRI allocates a higher score to the more abundant species and the species that make a high weight contribution. These would therefore be the primary species that could be considered for harvesting in subsistence fishery.

The rare species, and species with a low weight contribution is scored lower, but having a low IRI value does not necessarily imply that it is not important, in fact it may be a rare or red data species of conservational and aesthetic value.

5.3.2 IRI and Relative Densities for the Chobe River

A total of 6982 specimens were sampled during the three autumn high flood surveys in the Chobe River, with an average number of 2327 specimens per survey. The total weight of the fish sampled was 147.16 kg with an average of 49.05 kg per autumn survey (Table 5.2).

A total of 10166 specimens were sampled during the two spring low flood surveys in the Chobe River, with an average number of 5083 specimens per survey. The total weight of the fish sampled was 144.03 kg with an average of 72.02 kg per spring survey (Table 5.2).

A total of 46 species from 12 families were sampled during high flood, and 40 species from 11 families were sampled during low flood (Chapter 3, Table 3.1). The Chobe River had the second highest species diversity of the three river systems surveyed in the Eastern Caprivi, in terms of the total number of species sampled for each system.

Brycinus lateralis made the largest contribution to the total number of fish sampled during both seasons. It contributed 33.0% and 53.6% to the total number of fish sampled during high and low flood respectively. It also received the highest IRI values of 35.3% and 38.1% (Table 5.2).

Marcusenius macrolepidotus was second in its contribution of 14.6% to the total number of fish sampled during high flood in the Chobe River, followed by *Petrocephalus catostoma* (8.0%)*, Schilbe intermedius* (7.6%) and *Tilapia sparrmanii* (3.0%) (Table 5.2).

Marcusenius macrolepidotus was also second in its contribution of 9.9% to the total numbers during low flood, followed by *Schilbe intermedius* (7.9%), *Synodontis spp.* (6.9%) and *Pharyngochromis acuticeps* (4.4%). *Barbus poechii* (4.0%) and *Tilapia sparrmanii* (3.2%) also made a contribution (Table 5.2).

The species that made the highest contribution to the total weight sampled during high flood was *Clarias gariepinus* (23.2%), followed by *Hydrocynus vittatus* (22.8%), *Schilbe intermedius* (18.8%), *Brycinus lateralis* (13.1%) and *Marcusenius macrolepidotus* (6.2%) (Table 5.2).

Table 5.2: IRI and Relative Densities in percentage for the number and weight of fish sampled in the Chobe River, during high and low floods.

Autumn - High					**Spring – Low**				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.2									
Brycinus lateralis	32.9705	13.0502	21.88	35.33	*Brycinus lateralis*	53.6396	16.7627	31.63	38.11
Schilbe intermedius	7.6339	18.7996	34.65	32.13	*Schilbe intermedius*	7.8890	11.6188	48.98	16.35
Hydrocynus vittatus	1.9335	22.7972	10.94	9.49	*Synodontis* spp.	6.9447	5.8944	42.35	9.3
Marcusenius macrolepidotus	14.6090	6.1564	9.12	6.64	*Hepsetus odoe*	1.7018	15.3131	29.59	8.62
Clarias gariepinus	0.4297	23.1879	5.78	4.78	*Marcusenius macrolepidotus*	9.8957	6.3416	25	6.95
Petrocephalus catostoma	7.9777	3.1693	9.12	3.57	*Pharyngochromis acuticeps*	4.4462	5.3633	36.73	6.17
Pseudocrenilabrus philander	4.4257	0.1937	8.51	1.38	*Tilapia sparrmanii*	3.1674	3.9227	35.2	4.27
Tilapia sparrmanii	3.0077	0.5219	10.33	1.28	*Clarias gariepinus*	0.4623	15.2547	13.78	3.71
Synodontis spp.	1.1744	1.5452	10.94	1.04	*Barbus poechii*	3.9544	1.6246	28.06	2.68
Tilapia ruweti	2.7499	0.3214	5.17	0.56	*Serranochromis macrocephalus*	0.5312	3.8199	18.37	1.37
Tilapia rendalli	2.8645	0.1692	4.56	0.49	*Oreochromis macrochir*	0.5312	2.7688	10.71	0.61
Hepsetus odoe	0.2865	3.1421	3.95	0.48	*Pseudocrenilabrus philander*	1.5837	0.2361	12.24	0.38
Aplocheilichthys johnstoni	2.9361	0.0170	4.56	0.47	*Clarias ngamensis*	0.4820	2.7195	4.59	0.25

Autumn - High					Spring – Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.2									
Barbus poechii	0.8450	0.3153	6.38	0.26	*Serranochromis robustus*	0.1771	1.4719	6.63	0.19
Oreochromis macrochir	1.6041	0.3717	3.65	0.25	*Serranochromis longimanus*	0.3443	0.6367	10.71	0.18
Pharyngochromis acuticeps	0.8594	0.1821	5.78	0.21	*Sargochromis carlottae*	0.2754	1.1949	7.14	0.18
Barbus paludinosus	1.5468	0.0673	3.34	0.19	*Oreochromis andersonii*	0.3541	1.0706	7.14	0.17
Barbus radiatus	1.0169	0.0815	4.86	0.19	*Hydrocynus vittatus*	0.2361	1.1129	6.12	0.14
Clarias ngamensis	0.1719	2.1901	2.13	0.18	*Barbus paludinosus*	0.6591	0.1514	7.14	0.1
Ctenopoma multispine	0.6015	0.2800	4.56	0.14	*Tilapia rendalli*	0.2754	0.4777	6.12	0.08
Hemigrammocharax machadoi	1.8190	0.0149	1.82	0.12	*Serranochromis altus*	0.1180	0.4221	5.1	0.05
Aplocheilichthys katangae	1.0455	0.0075	3.04	0.11	*Parauchenoglanis ngamensis*	0.0590	0.4228	3.06	0.03
Oreochromis andersonii	0.0859	1.4807	1.82	0.1	*Ctenopoma multispine*	0.2361	0.1382	3.57	0.02
Barbus haasianus	1.4179	0.0061	1.82	0.09	*Barbus radiatus*	0.1672	0.0583	5.61	0.02
Barbus multilineatus	0.7161	0.0061	3.04	0.08	*Serranochromis angusticeps*	0.0787	0.2541	3.57	0.02
Rhabdalestes maunensis	0.8450	0.0204	2.13	0.06	*Aplocheilichthys johnstoni*	0.6492	0.0056	1.53	0.02
Clarias theodorae	0.1862	0.3690	3.04	0.06	*Mormyrus lacerda*	0.0885	0.3333	1.53	0.01
Sargochromis carlottae	0.1146	0.7482	1.82	0.06	*Hemichromis elongatus*	0.0492	0.2222	2.04	0.01
Barbus barnardi	0.6875	0.0299	1.82	0.05	*Barbus multilineatus*	0.1672	0.0007	1.53	0
Coptostomabarbus wittei	0.6588	0.0041	1.82	0.04	*Barbus barnardi*	0.0885	0.0007	2.04	0
Barbus unitaeniatus	0.6159	0.0292	1.82	0.04	*Sargochromis codringtonii*	0.0295	0.0875	1.53	0
Pollimyrus castelnaui	0.1719	0.0455	3.04	0.02	*Tilapia ruweti*	0.0492	0.0181	2.04	0
Barbus bifrenatus	0.4154	0.0082	1.52	0.02	*Aplocheilichthys katangae*	0.0787	0.0014	1.53	0
Micralestes acutidens	0.2865	0.0061	1.82	0.02	*Hemigrammocharax machadoi*	0.0787	0.0007	1.53	0
Barbus thamalakanensis	0.2435	0.0048	2.13	0.02	*Pollimyrus castelnaui*	0.0689	0.0062	1.53	0
Serranochromis macrocephalus	0.2435	0.2569	0.91	0.02	*Barbus bifrenatus*	0.0590	0.0007	1.53	0
Serranochromis robustus	0.1146	0.2392	1.22	0.02	*Barbus haasianus*	0.0590	0.0007	1.53	0
Barbus afrovernayi	0.1289	0.0048	1.82	0.01	*Rhabdalestes maunensis*	0.0787	0.0028	1.02	0
Microctenopoma intermedium	0.0716	0.0061	0.91	0	*Clarias theodorae*	0.0197	0.0576	1.02	0
Serranochromis thumbergi	0.0430	0.0109	0.91	0	*Petrocephalus catostoma*	0.0295	0.0111	1.53	0
Hippopotamyrus discorhynchus	0.0286	0.0435	0.61	0	*Synodontis nigromaculatus*	0.0098	0.0861	0.51	0
Labeo cylindricus	0.1289	0.0143	0.3	0	*Labeo lunatus*	0.0098	0.0708	0.51	0
Hemigrammocharax multifasciatus	0.0430	0.0014	0.91	0	*Coptostomabarbus wittei*	0.0590	0.0007	0.51	0
Barbus cf eutaenia	0.0430	0.0014	0.91	0	*Aplocheilichthys hutereaui*	0.0590	0.0007	0.51	0
Synodontis macrostigma	0.0286	0.0292	0.61	0	*Microctenopoma intermedium*	0.0197	0.0014	1.02	0
Mesobola brevianalis	0.0716	0.0007	0.3	0	*Labeo cylindricus*	0.0197	0.0160	0.51	0
Parauchenoglanis ngamensis	0.0143	0.0360	0.3	0	*Serranochromis thumbergi*	0.0098	0.0229	0.51	0
Barbus fasciolatus	0.0430	0.0007	0.3	0	*Barbus unitaeniatus*	0.0098	0.0021	0.51	0
Synodontis nigromaculatus	0.0143	0.0143	0.3	0					
Serranochromis angusticeps	0.0143	0.0007	0.3	0					
Barbus barotseensis	0.0143	0.0007	0.3	0					
TOTAL	**100%**	**100%**		**100%**	**TOTAL**	**100%**	**100%**		**100%**
TOTAL OF 3 SURVEYS					**TOTAL OF 2 SURVEYS**				
NUMBERS (N)		**WEIGHT (kg)**			**NUMBERS (N)**		**WEIGHT (kg)**		
6982		**147.163**			**10166**		**144.034**		
AVERAGE OF 3 SURVEYS					**AVERAGE OF 2 SURVEYS**				

Autumn - High					Spring – Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.2									
NUMBERS (N)		**WEIGHT (kg)**			**NUMBERS (N)**		**WEIGHT (kg)**		
2327.33		**49.054**			**5083**		**72.017**		

During low flood *Brycinus lateralis* made the highest weight contribution of 16.8%, followed by *Hepsetus odoe* (15.3%), *Clarias gariepinus* (15.3%), *Schilbe intermedius* (11.6%), *Marcusenius macrolepidotus* (6.34%), *Synodontis spp.* (5.89%) and *Pharyngochromis acuticeps* (5.36%) (Table 5.2).

Brycinus lateralis contributed to more than half (53.6%) of the total number of fish sampled during low flood. During this time the Chobe River has very little or no flow in some areas, with stretches of quiet open water, and this might be an attribute to the high numbers of *B. lateralis* sampled. It also contributed the most to the total weight sampled (16.8%), but was closely followed by *Hepsetus odoe* (15.3%) and *Clarias gariepinus* (15.3%). *Schilbe intermedius* also made a relative contribution (11.6%), giving the indication that there is a balance between the larger predators and the smaller fish. *Synodontis* spp*., Marcusenius macrolepidotus, Pharyngochromis acuticeps* and *Tilapia sparrmanii* are some of the smaller species that made a relative contribution to the total mass and number of fish sampled during low flood (Table 5.2).

Brycinus lateralis made the largest contribution (33.0%) to the total number of fish sampled during high flood, followed by *Marcusenius macrolepidotus* (14.6%) and *Petrocephalus catostoma* (8.0%). Although more abundant, these smaller species only made a moderate contribution to the total weight. The highest contributions to the total weight during high flood were made by the larger predatory species, *Clarias gariepinus* (23.2%) and *Hydrocynus vittatus* (22.8%), followed by *Schilbe intermedius* (18.8%) (Table 5.2).

During high floods there is more flow in some areas of the Chobe River, and this might explain why *Hydrocynus vittatus* was more abundant during high floods, with relatively large specimens sampled. Some of the prey species preferred by *Hydrocynus vittatus* such as *Marcusenius macrolepidotus* and *Petrocephalus catostoma* were also abundant. *Hepsetus odoe* prefer quiet water, and was sampled less during high flood, probably due to flowing water and the direct competition with *Hydrocynus vittatus.*

During low flood when there was less flow, *Hepsetus odoe* was more abundant with large specimens sampled, and *Hydrocynus vittatus* was sampled less. *Marcusenius macrolepidotus* as one of the preferred prey species was relatively abundant during this time (Table 5.2).

During the time of the high flood surveys the water level was slowly receding, with water flowing from the floodplains. The floodplains serve as nursery areas for the young of several species, after spawning during the rain season. As a result of the receding water, and water flow from the floodplains, juvenile specimens are forced to leave the safety and cover of these areas giving rise to mass migrations. These migrations result in feeding frenzies by predators. The presence of larger predator species during this time might therefore be an indication of such predation, and why large specimens were more abundant in the areas surveyed.

During high flood the floodplain species had a high occurrence, and a higher species diversity was recorded.

Clarias gariepinus and *Clarias ngamensis* were relatively abundant during both seasons with large specimens sampled. The channel like habitats in the Chobe River seemed to have the ideal habitat conditions for these species, as several specimens were collected in these areas.

The high number of *Brycinus lateralis* sampled during low floods contributed to a higher average number of fish (all species included) sampled during low floods than during high floods.

Brycinus lateralis, Schilbe intermedius, Hydrocynus vittatus, Marcusenius macrolepidotus, Clarias gariepinus, Petrocephalus catostoma, Synodontis spp.*, Hepsetus odoe* and *Pharyngochromis acuticeps* were all placed high in the IRI table due to their contribution to either the weight or numbers sampled or both.

5.3.3 IRI and Relative Densities for the Kwando River

A total of 1644 specimens were sampled during the three autumn high flood surveys in the Kwando River, with an average number of 548 specimens per survey. The total weight of the fish sampled was 91.89 kg with an average of 30.63 kg per autumn survey (Table 5.3).

A total of 1051 specimens were sampled during the two spring low flood surveys in the Kwando River, with an average number of 525.5 specimens per survey. The total weight of the fish sampled was 54.06 kg with an average of 27.03 kg per spring survey (Table 5.3).

A total of 40 species from 12 families were sampled during high flood, and 37 species from 10 families were sampled during low flood (Chapter 3, Table 3.1). The Kwando River was third with species diversity in the Eastern Caprivi.

Brycinus lateralis made the highest contribution of 13.0% to the total number of fish sampled during high flood, but it did not make a high contribution to the total weight (0.8%), resulting in a lower IRI value for this species in contrast with the other rivers (Table 5.3).

Micralestes acutidens made the second highest contribution (12.7%) to the total number of fish sampled during high flood, followed by *Pharyngochromis acuticeps* (11.2%), *Pseudocrenilabrus philander* (9.9%), *Petrocephalus catostoma* (9.2%), and *Marcusenius macrolepidotus* (7.3%) (Table 5.3).

The highest weight contribution during high flood was made by *Clarias gariepinus* (23.5%), followed by *Hydrocynus vittatus* (20.9%), *Sargochromis giardi* (12.8%), *C. ngamensis* (9.2%), and *Hepsetus odoe* (6.2%) (Table 5.3).

During low flood *Marcusenius macrolepidotus* made the highest contribution of 14.3% to the total number of fish sampled, followed by *Petrocephalus catostoma* (13.8%), *Pharyngochromis acuticeps* (10.8%), *Pseudocrenilabrus philander* (10.8%), and *Micralestes acutidens* (9.6%) (Table 5.3).

The highest weight contribution during low flood was made by *Hydrocynus vittatus* (38.4%), followed by *Clarias ngamensis* (12.9%), *Marcusenius macrolepidotus* (11.0 %), *Schilbe intermedius* (6.6%) and *Serranochromis altus* (5.8%) (Table 5.3).

Hydrocynus vittatus received the highest IRI value during both high (15.8%) and low (35.4%) floods. *Pharyngochromis acuticeps, Marcusenius macrolepidotus, Petrocephalus catostoma, Schilbe intermedius, Clarias gariepinus, C. ngamensis, Pseudocrenilabrus philander, Micralestes acutidens, Brycinus lateralis, Sargochromis giardi* and *Hippopotamyrus discorhynchus* all received relatively high IRI values during both seasons, due to their contribution to either the weight or numbers sampled, or both (Table 5.3).

Table 5.3: IRI and Relative Densities in percentage for the number and weight of fish sampled in the Kwando River, during high and low floods.

Autumn - High					Spring – Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.3									
Hydrocynus vittatus	2.4331	20.8900	10.26	15.79	*Hydrocynus vittatus*	5.1380	38.4012	20.44	35.42
Pharyngochromis acuticeps	11.1922	0.8858	18.68	14.9	*Marcusenius macrolepidotus*	14.2721	10.9810	25.97	26.09
Marcusenius macrolepidotus	7.2993	4.1375	15.75	11.89	*Petrocephalus catostoma*	13.7964	2.6172	12.71	8.3
Clarias gariepinus	1.1557	23.4941	5.13	8.35	*Pharyngochromis*	10.8468	1.0376	16.57	7.84

Autumn - High					Spring – Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.3									
					acuticeps				
Brycinus lateralis	13.0170	0.7846	9.16	8.34	*Schilbe intermedius*	3.4253	6.6141	13.81	5.52
Pseudocrenilabrus philander	9.8540	0.2231	9.16	6.09	*Hippopotamyrus discorhynchus*	6.4700	2.2713	12.71	4.42
Petrocephalus catostoma	9.1849	1.1622	8.42	5.76	*Pseudocrenilabrus philander*	10.7517	0.3903	7.73	3.43
Schilbe intermedius	3.5888	4.3040	10.26	5.34	*Micralestes acutidens*	9.6099	0.1165	3.87	1.5
Micralestes acutidens	12.7129	0.1415	5.49	4.66	*Clarias ngamensis*	0.6660	12.9194	2.76	1.49
Sargochromis giardi	0.9732	12.7717	4.03	3.66	*Brycinus lateralis*	4.1865	0.2164	6.08	1.06
Oreochromis macrochir	3.9538	3.9623	6.23	3.25	*Serranochromis altus*	0.5709	5.8040	3.31	0.84
Hepsetus odoe	1.2165	6.1562	5.86	2.85	*Aplocheilichthys johnstoni*	4.5671	0.0333	3.87	0.71
Aplocheilichthys johnstoni	5.2311	0.0272	6.59	2.29	*Synodontis spp.*	1.1418	2.2066	4.97	0.66
Tilapia sparrmanii	2.8589	0.2144	6.23	1.26	*Tilapia rendalli*	1.9029	1.6239	3.87	0.54
Clarias ngamensis	0.3650	9.2207	1.83	1.16	*Tilapia sparrmanii*	2.0932	0.3144	4.42	0.42
Tilapia rendalli	2.2506	0.7748	5.49	1.1	*Hepsetus odoe*	0.4757	2.4637	2.76	0.32
Hippopotamyrus discorhynchus	2.0681	0.4864	5.13	0.86	*Clarias gariepinus*	0.3806	3.1184	2.21	0.31
Serranochromis macrocephalus	0.7908	1.8370	3.3	0.57	*Barbus unitaeniatus*	1.7127	0.0740	3.31	0.24
Hemichromis elongatus	2.3114	0.1001	1.83	0.29	*Oreochromis macrochir*	1.4272	1.1393	2.21	0.23
Serranochromis angusticeps	0.3041	2.0611	1.83	0.29	*Mormyrus lacerda*	0.2854	3.1443	1.1	0.15
Synodontis spp.	0.6083	0.9707	2.56	0.27	*Serranochromis robustus*	0.2854	1.7442	1.66	0.13
Serranochromis robustus	0.4866	1.5377	1.83	0.24	*Sargochromis giardi*	0.1903	1.6813	1.1	0.08
Rhabdalestes maunensis	1.7032	0.0141	1.83	0.21	*Clarias theodorae*	0.6660	0.1332	1.66	0.05
Barbus unitaeniatus	1.3382	0.0316	1.47	0.13	*Barbus paludinosus*	0.7612	0.0259	1.66	0.05
Serranochromis altus	0.1825	1.5497	1.1	0.13	*Hippopotamyrus ansorgii*	0.3806	0.0758	2.21	0.04
Sargochromis carlottae	0.2433	0.4919	1.47	0.07	*Oreochromis andersonii*	1.1418	0.2756	0.55	0.03
Oreochromis andersonii	0.1217	1.1492	0.73	0.06	*Pollimyrus castelnaui*	0.3806	0.0388	1.66	0.03
Opsaridium zambezense	0.3650	0.0152	1.47	0.04	*Parauchenoglanis ngamensis*	0.1903	0.1702	1.1	0.02
Aplocheilichthys hutereaui	0.3650	0.0011	1.47	0.04	*Sargochromis carlottae*	0.1903	0.0703	1.1	0.01
Barbus radiatus	0.2433	0.0174	1.1	0.02	*Serranochromis macrocephalus*	0.4757	0.0388	0.55	0.01
Hippopotamyrus ansorgii	0.1825	0.0163	1.1	0.01	*Aplocheilichthys hutereaui*	0.4757	0.0018	0.55	0.01
Parauchenoglanis ngamensis	0.1825	0.0914	0.73	0.01	*Barbus poechii*	0.1903	0.0407	1.1	0.01
Pollimyrus castelnaui	0.2433	0.0065	0.73	0.01	*Tilapia ruweti*	0.1903	0.0148	1.1	0.01
Mormyrus lacerda	0.0608	0.3700	0.37	0.01	*Sargochromis codringtonii*	0.0951	0.1369	0.55	0.01
Barbus paludinosus	0.1217	0.0054	0.73	0.01	*Clarias stappersii*	0.0951	0.0203	0.55	0
Mesobola brevianalis	0.1217	0.0011	0.73	0.01	*Barbus radiatus*	0.0951	0.0148	0.55	0
Aplocheilichthys katangae	0.1825	0.0011	0.37	0	*Hemichromis elongatus*	0.0951	0.0111	0.55	0
Synodontis macrostigma	0.0608	0.0675	0.37	0	*Ctenopoma multispine*	0.0951	0.0092	0.55	0
Clarias theodorae	0.0608	0.0174	0.37	0	*Barbus fasciolatus*	0.0951	0.0037	0.55	0
Ctenopoma multispine	0.0608	0.0044	0.37	0	*Barbus bifrenatus*	0.0951	0.0018	0.55	0
Barbus fasciolatus	0.0608	0.0011	0.37	0	*Rhabdalestes maunensis*	0.0951	0.0018	0.55	0
Barbus thamalakanensis	0.0608	0.0011	0.37	0					
Coptostomabarbus wittei	0.0608	0.0011	0.37	0					
Hemigrammocharax machadoi	0.0608	0.0011	0.37	0					
Microctenopoma intermedium	0.0608	0.0011	0.37	0					
TOTAL	**100%**	**100%**		**100%**	**TOTAL**	**100%**	**100%**		**100%**

Autumn - High					Spring – Low				
Species	% N	% W	% F	% IRI	Species	% N	% W	% F	% IRI
Table 5.3									

TOTAL OF 3 SURVEYS		TOTAL OF 2 SURVEYS	
NUMBERS (N)	WEIGHT (kg)	NUMBERS (N)	WEIGHT (kg)
1644	91.891	1051	54.064
AVERAGE OF 3 SURVEYS		AVERAGE OF 2 SURVEYS	
NUMBERS (N)	WEIGHT (kg)	NUMBERS (N)	WEIGHT (kg)
548	30.63	525.5	27.032

The areas of the Kwando River that were surveyed were pristine, because the areas are situated in a conservation area. Local subsistence fishery does not occur in these areas. Large specimens of the larger species were sampled regularly such as *Hydrocynus vittatus, Clarias gariepinus, C. ngamensis, Sargochromis giardi, Schilbe intermedius, Oreochromis macrochir, Serranochromis altus, Tilapia rendalli, Mormyrus lacerda, Serranochromis robustus* and *Hepsetus odoe.*

Smaller species such as *Brycinus lateralis, Micralestes acutidens, Pseudocrenilabrus philander, Pharyngochromis acuticeps, Marcusenius macrolepidotus, Petrocephalus catostoma, Tilapia sparrmanii* and *Aplocheilichthys johnstoni* were also abundant.

The top ten IRI scorers during both seasons consisted of both small and large species, the smaller species contributing to the total number of fish sampled and the larger species to the total weight. The top ten IRI scorers were mostly the same species during both seasons.

There was a balance in biomass, with large specimens sampled regularly, and the smaller species not being over abundant.

5.3.4 The Eastern Caprivi (all systems combined)

A total of 31634 specimens were sampled during the three autumn high flood surveys in the Eastern Caprivi, with an average number of 10544.6 specimens per survey. The total weight of the fish sampled was 691.25 kg with an average of 230.42 kg per autumn survey (Table 5.4). A total of 24624 specimens were sampled during the two spring low flood surveys in the Eastern Caprivi, with an average number of 12312 specimens per survey. The total weight of the fish sampled was 307.00 kg with an average of 153.50 kg per spring survey (Table 5.4).

A total of 64 species from 14 families were sampled during high flood, and 65 species from 13 families were sampled during low flood (Chapter 3, Table 3.1). A total of 69 species were sampled during both seasons.

The species that made the highest contribution of 34.5% to the total numbers during high flood was *Brycinus lateralis*, followed by *Petrocephalus catostoma* (12.4%), *Schilbe intermedius* (8.8%), *Marcusenius macrolepidotus* (5.5%), *Micralestes acutidens* (4.0%) and *Barbus paludinosus* (3.2%). Other species that made relative contributions to the total numbers were *Hydrocynus vittatus, Tilapia sparrmanii, Pharyngochromis acuticeps, Barbus poechii* and *Pseudocrenilabrus philander* (Table 5.4).

Brycinus lateralis contributed the most to the total weight during high flood with 21.1%, followed by *Schilbe intermedius* (18.1%), *Hydrocynus vittatus* (17.9%), *Clarias gariepinus* (15.3%), *Petrocephalus catostoma* (5.0%), *Marcusenius macrolepidotus* (4.1%) and *Hepsetus odoe* (4.0 %). Other species with relative contributions were *Barbus poechii, Synodontis spp., Clarias ngamensis* and *Sargochromis giardi* (Table 5.4).

During low flood *Brycinus lateralis* contributed the most (39.1%) to the total number of fish sampled, followed by *Synodontis spp.* (13.9%), *Marcusenius macrolepidotus* (6.1%), *Tilapia sparrmanii* (6.0%), *Schilbe intermedius* (4.6%) and *Pharyngochromis acuticeps* (4.2%). Other relative contributions, to the total numbers sampled, were made by *Barbus poechii, Oreochromis macrochir, Pseudocrenilabrus philander, Tilapia rendalli, Barbus paludinosus* and *Micralestes acutidens* (Table 5.4).

The highest contribution of 13.5% to the total weight was made by *Brycinus lateralis* during low flood, followed by *Hydrocynus vittatus* (13.1%), *Clarias gariepinus* (10.9%), *Hepsetus odoe* (9.9%), *Schilbe intermedius* (7.7%), *Marcusenius macrolepidotus* (6.2%), *Synodontis spp.* (5.7%), *Tilapia sparrmanii* (4.0%) and *Pharyngochromis acuticeps* (4.0 %). Other species with relative contributions to the total weight were *Barbus poechii, Hemichromis elongatus, Oreochromis macrochir, Tilapia rendalli, Serranochromis macrocephalus, C. ngamensis, S. robustus* and *S. altus* (Table 5.4).

Table 5.4: IRI and Relative Densities in percentage for the number and weight of fish, sampled in the Eastern Caprivi, during high and low floods.

Autumn - High					Spring - Low				
Species	**% N**	**% W**	**% F**	**% IRI**	**Species**	**% N**	**% W**	**% F**	**% IRI**
Table 5.4									
Brycinus lateralis	34.4756	21.1256	19.95	38.29	*Brycinus lateralis*	39.1041	13.5202	21.07	36.28
Schilbe intermedius	8.7532	18.0743	30.7	28.43	*Synodontis spp.*	13.8686	5.6950	17.98	11.51
Hydrocynus vittatus	2.9019	17.8711	15.87	11.38	*Schilbe intermedius*	4.6215	7.6855	24.72	9.96
Petrocephalus catostoma	12.3854	5.0283	9.19	5.53	*Marcusenius macrolepidotus*	6.0835	6.2220	19.8	7.98
Marcusenius macrolepidotus	5.4972	4.1392	10.32	3.43	*Pharyngochromis acuticeps*	4.2357	3.9537	24.3	6.51

Autumn - High					Spring - Low				
Species	**%N**	**% W**	**%F**	**%IRI**	**Species**	**%N**	**%W**	**%F**	**%IRI**
Table 5.4									
Clarias gariepinus	0.2877	15.2732	5.46	2.94	*Tilapia sparrmanii*	6.0104	4.0198	18.54	6.09
Tilapia sparrmanii	2.8798	0.7236	10.49	1.31	*Hydrocynus vittatus*	0.6701	13.1176	11.94	5.39
Pharyngochromis acuticeps	2.0073	0.7498	13.44	1.28	*Hepsetus odoe*	0.9828	9.9043	13.76	4.9
Barbus poechii	2.3519	1.1262	9.45	1.14	*Barbus poechii*	3.4600	1.5791	16.43	2.71
Micralestes acutidens	4.0115	0.2902	7.03	1.04	*Clarias gariepinus*	0.2762	10.8984	5.62	2.05
Hepsetus odoe	0.3983	3.9745	6.76	1.02	*Hemichromis elongatus*	0.9056	2.9859	7.72	0.98
Synodontis spp.	1.2961	1.5100	9.11	0.88	*Oreochromis macrochir*	2.8021	2.3804	5.76	0.98
Pseudocrenilabrus philander	2.0642	0.1267	7.72	0.58	*Pseudocrenilabrus philander*	2.0793	0.5173	10.81	0.92
Tilapia rendalli	1.8398	0.3653	6.42	0.49	*Tilapia rendalli*	1.8519	1.6521	7.44	0.85
Barbus paludinosus	3.1643	0.1477	3.47	0.4	*Serranochromis macrocephalus*	0.2924	2.1859	6.18	0.5
Oreochromis macrochir	1.5774	0.7560	3.64	0.29	*Barbus paludinosus*	2.8387	0.4638	4.35	0.47
Barbus unitaeniatus	1.5901	0.0509	3.56	0.2	*Clarias ngamensis*	0.3005	3.7527	3.09	0.41
Hemichromis elongatus	0.4931	0.8506	3.64	0.17	*Micralestes acutidens*	3.1473	0.0896	2.53	0.27
Aplocheilichthys johnstoni	1.2613	0.0114	3.73	0.16	*Petrocephalus catostoma*	0.6985	0.5244	5.2	0.21
Rhabdalestes maunensis	1.4573	0.0249	2.34	0.12	*Serranochromis robustus*	0.1584	1.2635	3.51	0.16
Barbus bifrenatus	1.3182	0.0259	2.34	0.11	*Sargochromis carlottae*	0.2031	0.8371	3.79	0.13
Barbus radiatus	0.7397	0.0461	3.38	0.09	*Oreochromis andersonii*	0.2965	0.7534	3.23	0.11
Clarias ngamensis	0.0695	1.9368	1.3	0.09	*Serranochromis altus*	0.0772	1.2443	2.39	0.1
Tilapia ruweti	0.7271	0.0768	2.43	0.07	*Hippopotamyrus discorhynchus*	0.3005	0.4195	3.65	0.09
Sargochromis giardi	0.0506	1.6978	0.95	0.06	*Barbus unitaeniatus*	0.7716	0.0306	2.11	0.06
Labeo cylindricus	0.7302	0.1614	1.82	0.06	*Labeo cylindricus*	0.6457	0.5094	1.4	0.05
Serranochromis macrocephalus	0.1296	0.5402	1.73	0.04	*Serranochromis longimanus*	0.1503	0.3287	3.23	0.05
Opsaridium zambezense	0.5089	0.0447	1.91	0.04	*Aplocheilichthys johnstoni*	0.6254	0.0098	1.97	0.04
Pollimyrus castelnaui	0.3477	0.0755	2.43	0.04	*Ctenopoma multispine*	0.3533	0.2573	1.83	0.04
Barbus multilineatus	0.5848	0.0046	1.65	0.03	*Parauchenoglanis ngamensis*	0.1462	0.4648	1.69	0.03
Barbus barotseensis	0.6164	0.0107	1.47	0.03	*Clarias theodorae*	0.3980	0.4160	1.26	0.03
Oreochromis andersonii	0.0885	0.5016	1.56	0.03	*Mormyrus lacerda*	0.0609	0.7570	0.98	0.03
Ctenopoma multispine	0.2213	0.1199	2.25	0.03	*Pollimyrus castelnaui*	0.1868	0.0603	2.39	0.02
Barbus thamalakanensis	0.5627	0.0120	1.04	0.02	*Serranochromis angusticeps*	0.0528	0.2866	1.54	0.02
Sargochromis carlottae	0.0632	0.3661	1.39	0.02	*Barbus radiatus*	0.1300	0.0547	2.81	0.02
Serranochromis angusticeps	0.0411	0.4600	1.13	0.02	*Labeo lunatus*	0.0325	0.2476	0.84	0.01
Hippopotamyrus discorhynchus	0.1707	0.1085	1.99	0.02	*Tilapia ruweti*	0.0975	0.0335	1.69	0.01
Barbus barnardi	0.3256	0.0080	1.39	0.02	*Sargochromis codringtonii*	0.0365	0.1482	1.12	0.01
Hemigrammocharax machadoi	0.4394	0.0035	0.95	0.01	*Barbus bifrenatus*	0.1462	0.0059	1.26	0.01
Serranochromis robustus	0.0664	0.2733	1.21	0.01	*Clariallabes platyprosopos*	0.0487	0.1902	0.56	0
Labeo lunatus	0.0474	0.2982	1.13	0.01	*A. vanderwaali*	0.1746	0.0573	0.42	0
Barbus afrovernayi	0.2497	0.0030	1.39	0.01	*Sargochromis giardi*	0.0081	0.2961	0.28	0
Clarias theodorae	0.0727	0.1224	1.73	0.01	*Opsaridium zambezense*	0.1218	0.0300	0.56	0
Aplocheilichthys katangae	0.2719	0.0017	1.13	0.01	*Hippopotamyrus ansorgii*	0.0325	0.0293	0.98	0
Barbus haasianus	0.3256	0.0013	0.78	0.01	*Rhabdalestes maunensis*	0.0528	0.0016	0.84	0
Sargochromis codringtoni	0.0506	0.1655	0.87	0.01	*Barbus multilineatus*	0.0731	0.0003	0.56	0
Coptostomabarbus wittei	0.1707	0.0010	0.87	0.01	*Hemigrammocharax machadoi*	0.0528	0.0007	0.56	0

Autumn - High					Spring - Low				
Species	% N	% W	% F	% IRI	Species	% N	% W	% F	% IRI
Table 5.4									
Serranochromis altus	0.0126	0.3842	0.35	0	*Synodontis nigromaculatus*	0.0081	0.0684	0.28	0
Serranochromis longimanus	0.0316	0.0952	0.78	0	*Barbus barnardi*	0.0365	0.0003	0.56	0
Mormyrus lacerda	0.0158	0.1575	0.43	0	*Barbus haasianus*	0.0365	0.0003	0.56	0
Barbus cf eutaenia	0.0601	0.0020	0.87	0	*Aplocheilichthys katangae*	0.0325	0.0007	0.42	0
Hemigrammocharax multifasciatus	0.0285	0.0006	0.52	0	*Aplocheilichthys hutereaui*	0.0447	0.0003	0.28	0
Aplocheilichthys hutereaui	0.0285	0.0001	0.52	0	*Coptostomabarbus wittei*	0.0447	0.0003	0.28	0
Synodontis nigromaculatus	0.0126	0.0288	0.26	0	*Barbus afrovernayi*	0.0447	0.0003	0.14	0
Synodontis macrostigma	0.0126	0.0181	0.35	0	*Barbus barotseensis*	0.0325	0.0010	0.14	0
Serranochromis thumbergi	0.0190	0.0029	0.43	0	*Aethiomastacembelus frenatus*	0.0081	0.0215	0.14	0
Parauchenoglanis ngamensis	0.0126	0.0198	0.26	0	*Clarias stappersii*	0.0081	0.0055	0.28	0
Microctenopoma intermedium	0.0190	0.0013	0.35	0	*Microctenopoma intermedium*	0.0081	0.0007	0.28	0
Mesobola brevianalis	0.0221	0.0001	0.26	0	*Serranochromis thumbergi*	0.0041	0.0107	0.14	0
Hippopotamyrus ansorgii	0.0095	0.0022	0.26	0	*Barbus codringtonii*	0.0041	0.0059	0.14	0
Barbus fasciolatus	0.0126	0.0003	0.17	0	*Barbus thamalakanensis*	0.0081	0.0003	0.14	0
Leptoglanis cf dorae	0.0063	0.0001	0.17	0	*Barbus fasciolatus*	0.0041	0.0007	0.14	0
Synodontis vanderwaali	0.0095	0.0004	0.09	0	*Barbus cf eutaenia*	0.0041	0.0003	0.14	0
Aethiomastacembelus frenatus	0.0032	0.0001	0.09	0	*Hemigrammocharax multifasciatus*	0.0041	0.0003	0.14	0
					Chiloglanis neumanni	0.0041	0.0003	0.14	0
TOTAL	**100%**	**100%**		**100%**	**TOTAL**	**100%**	**100%**		**100%**

TOTAL OF 3 SURVEYS		TOTAL OF 2 SURVEYS	
NUMBERS (N)	**WEIGHT (kg)**	**NUMBERS (N)**	**WEIGHT (kg)**
31634	**691.251**	**24624**	**307.004**
AVERAGE OF 3 SURVEYS		**AVERAGE OF 2 SURVEYS**	
NUMBERS (N)	**WEIGHT (kg)**	**NUMBERS (N)**	**WEIGHT (kg)**
10544.6	**230.417**	**12312**	**153.502**

Brycinus lateralis was the species with the highest IRI value during both seasons. *Schilbe intermedius was* second during high flood and third during low flood. *Synodontis spp.* was second during low flood. Other species with relatively high IRI values during both seasons were *Hydrocynus vittatus, Marcusenius macrolepidotus, Clarias gariepinus, Tilapia sparrmanii, Pharyngochromis acuticeps, Barbus poechii, Hepsetus odoe, Pseudocrenilabrus philander* and *Tilapia rendalli.* These species contributed either in number or weight, or both in the catch composition (Table 5.4).

Local subsistence fishery does occur in the Eastern Caprivi, and although large specimens of the larger species do occur they were not sampled regularly in certain areas. Larger specimens are favoured and targeted first and reach higher prices at local markets, but smaller species or specimens are also caught and sold.

There was a balance in biomass, and the top IRI scorers during both seasons consisted of both small and large species, and were mostly of the same species during both seasons.

5.3.5 IRI Figures

Figures 5.1 – 5.3 graphically show the IRI figures (see section 5.2) for the Eastern Caprivi (all the rivers combined) one for each flood (high and low) (Figure 5.1 - 5.2), and one for both high and low floods combined (Figure 5.3). The two IRI figures for the different floods (Figures 5.1 - 5.2) are given for comparison reasons.

In Figure 5.1 and 5.2 the contribution of the top 15 species to the total catch, sampled during high and low floods respectively, can be studied. The top 15 species composition during both floods is mostly the same.

Brycinus lateralis was the most common species sampled in the Eastern Caprivi, and it made the highest contribution to the total number and weight of fish sampled, during both floods (Figure 5.1 and 5.2).

Although sampled in fewer numbers, *Schilbe intermedius, Hydrocynus vittatus* and *Clarias gariepinus* made large contributions to the total weight during high flood. Few specimens of *Clarias gariepinus* were sampled but the weight contribution it made, is noticeable. *Petrocephalus catostoma* and *Marcusenius macrolepidotus* each made a relative contribution to the total number and weight (Figure 5.1).

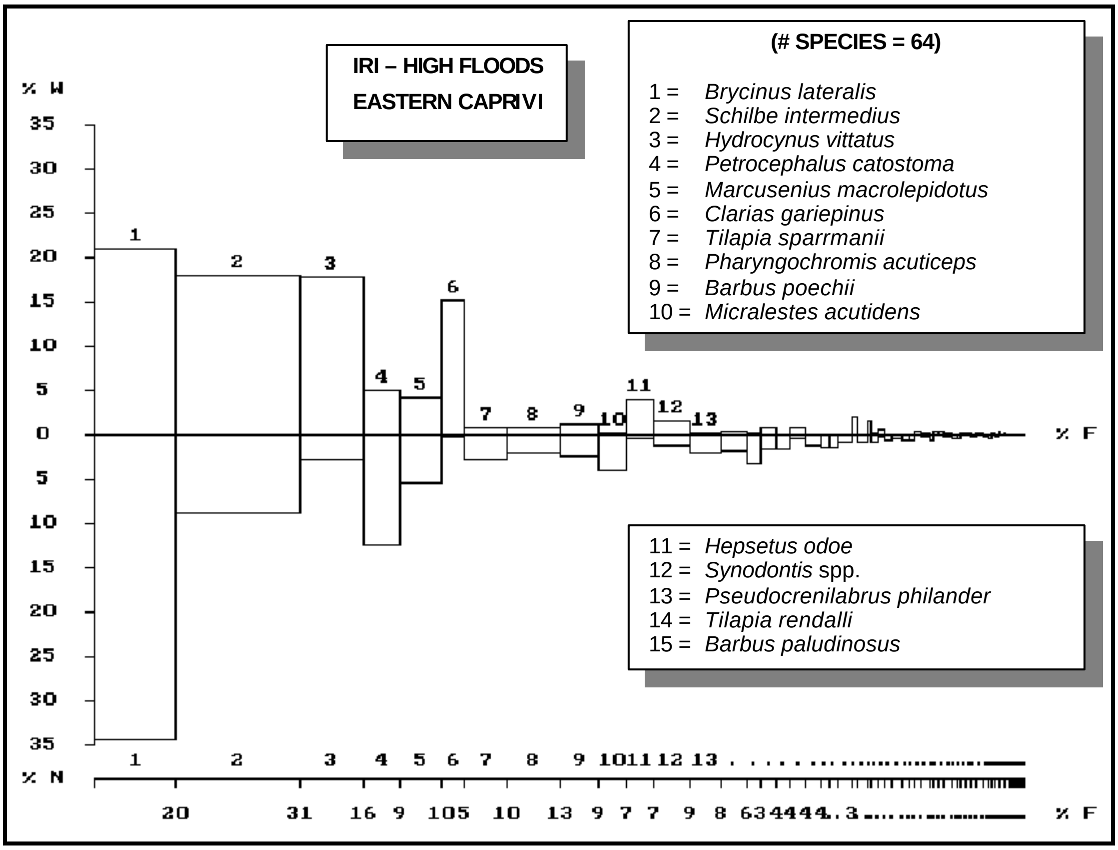


Figure 5.1: IRI for high floods in the Eastern Caprivi.

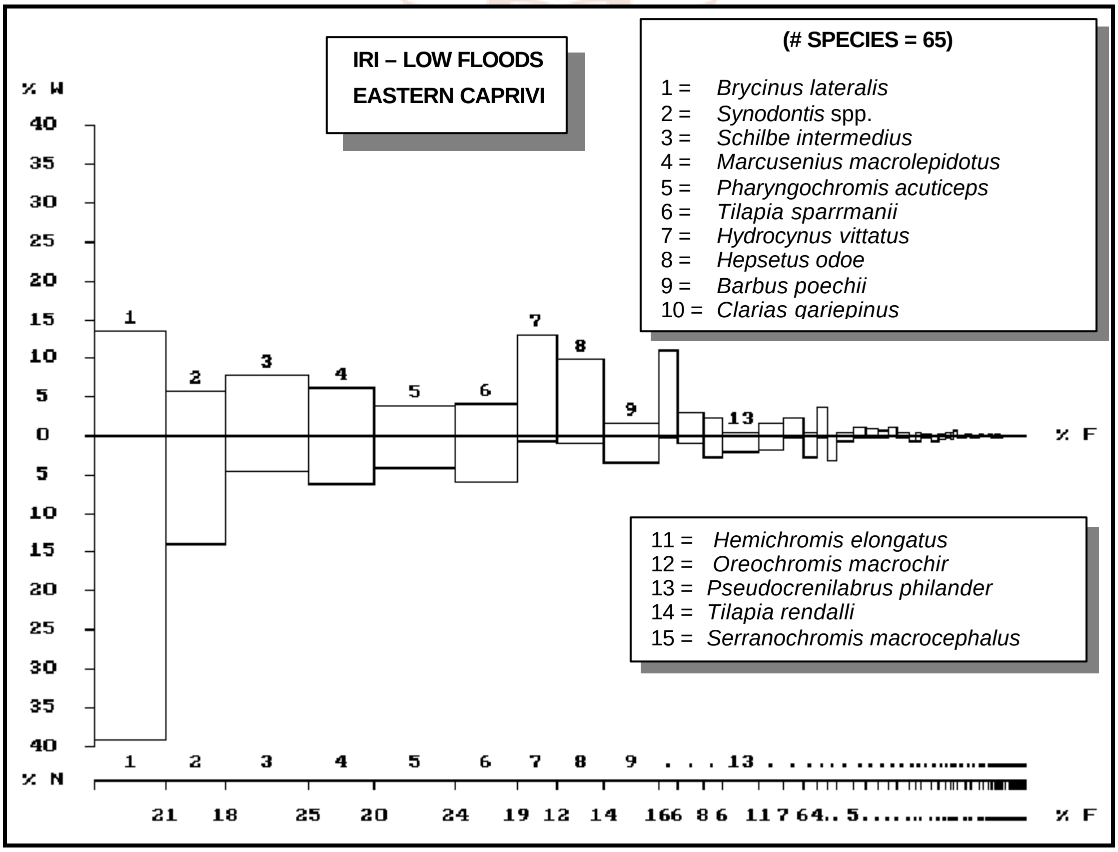


Figure 5.2: IRI for low floods in the Eastern Caprivi.

During low flood a higher density of *Brycinus lateralis* was sampled than during high flood, but it made a lower contribution to the total weight than during high flood. During low flood *Hydrocynus vittatus, Hepsetus odoe* and *Clarias gariepinus* made large contributions to the total weight, but with low numbers sampled. The other species in the top ten all made relative contributions tot the total weight and number of fish sampled, with the contribution in weight and number being relatively equal (Figure 5.2).

Low catch numbers with a high weight contribution gives an indication that specimens of a species were large.

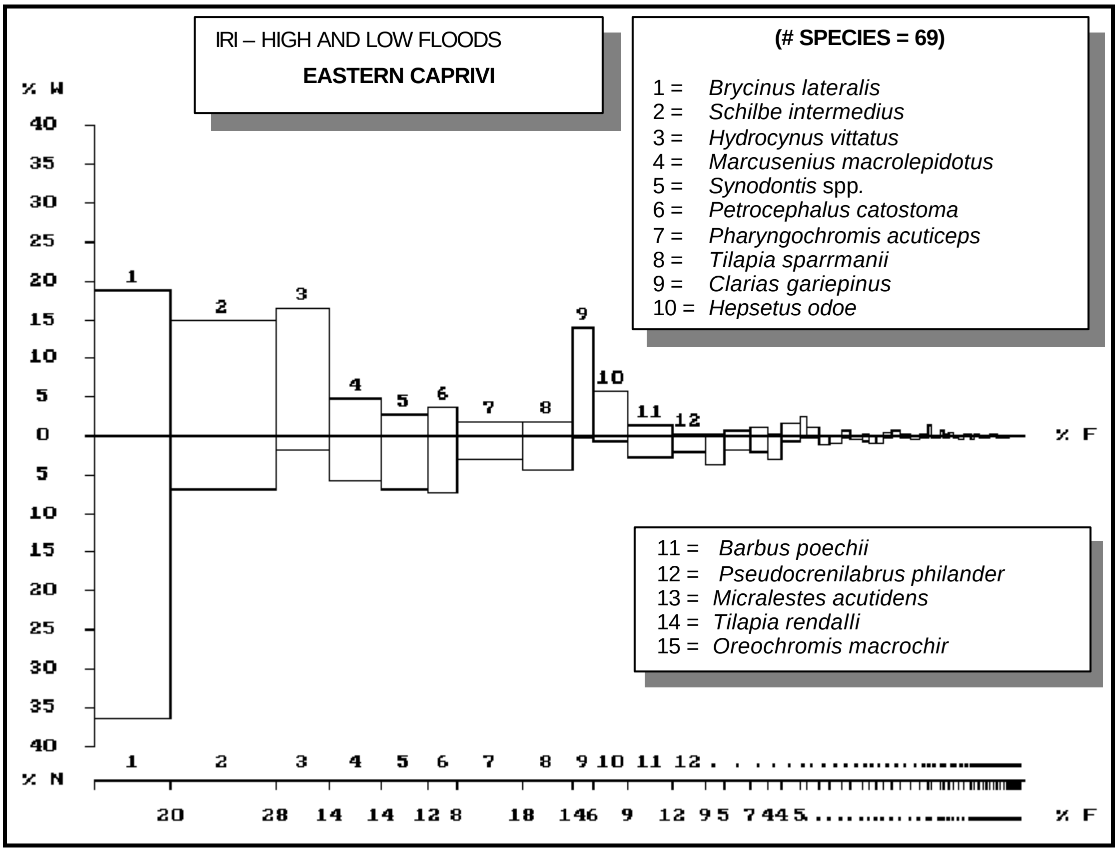


Figure 5.3: IRI for both high and low floods combined in the Eastern Caprivi.

Brycinus lateralis was the most abundant species in the Eastern Caprivi, which also made the highest contribution to the total weight. This is reflected in the IRI (Figure 5.3), which also gave this species the highest IRI value.

Large species were sampled and also had high IRI values due to their weight contribution (Figure 5.3).

5.4 CONCLUSION

High densities of small species will most likely substitute an opening in the biomass of a fish community in a certain area due to the absence of large species. Large species *may* be absent due to pressure from the subsistence fishery, and it is recommended that the subsistence fishery should be more closely studied to make conclusions.

The smaller species, with a higher turnover, reproduce and grow faster to maturity than the larger species with a low turnover. The numbers of some smaller species (*i.e. Brycinus lateralis*) will increase, and high densities may occur, if there is no large piscivores to control their numbers. It may, therefore, be indicative that all is not well, if high numbers of fish are sampled, and if the catch composition (of various gears combined) is dominated by a few specific species, especially if the species are small.

A correlation *may* exist between the densities of the different species sampled and the status of the fish population. For instance, an abundance of small species and the absence of larger species may indicate that the larger species are targeted in an area (*i.e.* with subsistence fishery), and the resource therefore exploited.

The biomass or productivity of a system might therefore be high, but the analysis of fisheries data, and the study of the contribution each species make to the catch composition, will provide a clearer picture to the health of the fish population.

A low abundance of certain species however does not necessarily indicate over fishing, and the main factor affecting species occurrence in certain areas in the Eastern Caprivi was habitat availability, during certain seasons, for species with specific preferences. For example, where there was no flow *Hepsetus odoe* was the predator most commonly sampled, and in areas with flow *Hydrocynus vittatus* was the main predator sampled.

From a universal point of view there seems to be a balance in the weight densities recorded for the Eastern Caprivi (Figure 5.3). Large specimens were sampled in areas with their weight contribution being in equilibrium with that of the smaller species sampled. However problem areas do exist, especially near populated areas where exploitation and commercialisation of the fish resource is rife.

It is important to note that some species, such as from the Cichlidae family, are territorial and do not move around much, and this may make them more susceptible to exploitation. Other species such as the tigerfish, which is a piscivore, that moves over larger areas in search of food, may be impacted to a lesser extent in areas where exploitation is high (Hay, pers. com., 2003).

6 CATCH COMPOSITION AND CPUE

6.1 INTRODUCTION

The aim of this chapter is to compare and study the catch composition and catch per unit efforts (CPUE) of the gears used. The catch composition, CPUE and mass per unit effort (MPUE) data provide a picture of the status of the fish population, and we may explain or predict trends in the fish community. It is generally accepted that the catch per unit effort is directly related to standing crop in the system or at a specific locality (Hay, 1995).

In a pristine river there will always be a surplus of fish production, which can be removed from the river without any detrimental affect to the fish resource (Hay, 1995). In the Eastern Caprivi this surplus may, however, be determined by factors such as an adequate annual flood, which facilitates successful reproduction. The sampling gear may detect any decline in this surplus, if the sampling gear and effort is standardised. Exploitation will cause a deviation in the catches of the different gear used.

When the fish resource is exploited the larger fish are usually targeted first. Welcomme (1979) stated that during the operation of a fishery, a rapid drop in the catches could initially be found as the larger individuals are removed from the river. Lowe-McConnell (1977) stated that the larger, slower growing species are replaced by smaller, faster growing species as the fishery is intensified. Therefore, if exploitation is the case, the different sampling gear may indicate that the larger species are absent, and that there is an exchange of smaller species.

6.2 SAMPLING MATERIALS AND METHODS

6.2.1 Sampling gear

Standard sampling techniques were adopted as described by Hay (1995). A wide range of experimental sampling gear were used in order to limit selectivity:

1. Multifilament gill nets with stretched mesh sizes of 22, 28, 35, 45, 57, 73, 93, 118 and 150mm were used, and each net had a length of 10m and a depth of 1.5m, and consequently an area of 15m^2. Gill net ranges consisting of the above mesh sizes were set during the night for 12 hours in various deep-water habitats.
2. Seine nets of 5m, 15m and 30m were used. The 5m seine net was made from 80% shade netting, and consequently had a fine mesh (approximately 3mm – 5mm), and was ideal for sampling small specimens, and for sampling in areas with flow (due to the fact that it was easy to handle). The 15m and 30m seine nets had a stretched mesh size of 10mm, and was mostly used in shallow areas with no current, such as backwaters, floodplains and lakes.

3. A cast net with a diameter of 2m, and a stretched mesh size of 15mm was used. The cast net was mostly used in rapids, and open water areas usually near the margin.
4. Hand scoop-nets, made from 80% shade netting, were mostly used to sample in and under aquatic vegetation.
5. Rotenone was used in areas that were difficult to sample with other gear types, such as rocky habitats and marginally vegetated areas bordering deep water.
6. Traps were set along banks, usually in vegetation. Traps were set overnight for 12 hours.
7. A 12V battery pack electro shocker was used in marginal vegetated areas and rocky habitats.
8. Local gill nets were surveyed.
9. Angling was used to sample larger specimens, usually in deep open water.

6.2.2 Catch Composition and Standard CPUE

The catch composition and mean standard catch per unit effort (CPUE) by species for gill nets is given in numbers and weight (kg), and displayed in table form. The catch composition and the mean CPUE for the other gear is given. The individual effectiveness of the experimental gear is discussed.

The species composition for the experimental gear was recorded in numbers and weight, and indicated as observed catch. The mean standard catch per unit effort (CPUE) by species, with standard deviations (SD) of the estimated CPUE's are presented for the gill nets (Tables 6.2 – 6.10)

$$CPUE = \frac{1}{y}\sum_{i=1}^{n} W_i \bullet \left(\frac{SU}{U_i}\right) \quad \text{where} \qquad (3)$$

y = effort, e.g. number of net panel (or gear) settings and n = number of samples. If effort is not a variable then $y = n$. W_i = catch (in weight or numbers) in set$_i$ or sample$_i$, SU = standard relative effort unit (size) of a net panel , and U_i = actual effort unit (size) of net$_i$ (Kolding, 1998).

Standard deviations (SD) of the estimated CPUE's are presented. In case where the absolute effort is a recorded variable for each observed catch and the estimated CPUE is the ratio of two variables (usually with the other gear), then SD's were calculated from the Taylor series approximation by the following formula (Cochran, 1977; Krebs, 1989 as cited by Kolding, 1998):

$$SD(CPUE) = \frac{1}{Y}\sqrt{\frac{\sum x^2 - 2\hat{R}\sum xy + \hat{R}^2 \sum y^2}{n-1}} \qquad (4)$$

where $$\hat{R} = CPUE = \frac{\bar{x}}{\bar{y}} \qquad (5)$$

and x is standardised catch, y is effort, and n is sample size (= number of observations).

Each gill net mesh (unit) has a standard net area of 15m^2, and was set at a standard time of 12hours, and therefore had a standard effort. Where gear units had different dimensions than the standard units chosen, the displayed conversion factor (CF) to standard unit will be different from 1.

The gear units for the other gear used (drags, shock, hooks, scoops etc.) have different dimensions, than the standard units chosen for the gill nets. The effort for the other gear was determined for each individual sample (*i.e.* when using a seine net each drag differs in area and time) and was therefore a variable for each observed catch. The mean standard CPUE and standard deviations were not calculated for the other gear, and the catches were not standardised. The mean catch for the other gears were however calculated (Table 6.11 – 6.21).

6.2.3 Mean CPUE/MPUE

Mean catch per unit effort ($CPUE_i$) of each mesh (gear) size$_i$ per species is calculated as the total numbers caught in mesh size$_i$ (n_i) divided by the number of settings or samples (#set$_i$). The same formula is applicable for the mean MPUE.

6.3 RESULTS AND DISCUSSION

6.3.1 Catch composition and Standard CPUE for the gill nets

Each gill net series used to sample fish in the Eastern Caprivi consisted of a range of nine meshes (Table 6.1) randomly tied together. Table 6.1 gives a summary of the catch composition of each mesh used during the study.

The gill nets were set a total of 172 times. The 28mm mesh sampled the highest number of, and weight in, fish. The 22mm mesh sampled the second highest number of fish, and the 35mm mesh sampled the second highest weight in fish (Table 6.1).

The 28mm and 35mm meshes sampled the highest number of species (33), followed by the 45mm mesh (30 species). The 22mm and 57mm meshes sampled 27 species each (Table 6.1).

The 22mm and 28mm meshes were effective in sampling the highest number of fish, and the 35mm and 45mm meshes were effective in sampling the highest weight. These four nets were the most effective with sampling the most species, specimens, and made the highest weight contributions (Table 6.1).

Large specimens were sampled in low numbers in the larger meshes (Table 6.1).

Table 6.1: Summary of catch composition for the gill nets, Eastern Caprivi.

Mesh	No. of species	Total number	Total weight (kg)	Empty sets
22mm	27	14225	71.406	15
28mm	33	15692	178.812	16
35mm	33	3961	130.819	32
45mm	30	2221	130.060	41
57mm	27	802	97.706	47
73mm	23	223	71.715	92
93mm	14	96	70.123	119
118mm	11	64	82.476	132
150mm	6	25	58.790	154

Tables 6.2 – 6.10 indicate the catch composition (selectivity) and CPUE for each of the gill net meshes in the Eastern Caprivi. The fish species were listed according to its relative importance.

22mm Mesh

The 22mm mesh was effective in sampling a high diversity of the smaller species. It sampled a high number of fish and species, with a regular high catch rate and few settings being empty. *Brycinus lateralis, Marcusenius macrolepidotus, Schilbe intermedius, Barbus poechii, Synodontis spp.* and *Micralestes acutidens* were the species most commonly sampled in this net. A few small specimens of the larger species, *Tilapia rendalli, Hydrocynus vittatus,* and *Hepsetus odoe* were also sampled in this mesh (Table 6.2).

MESH SIZE (mm): 22mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 15 (8.72%)

Table 6.2: Species composition and mean standard CPUE for the 22mm mesh net.

No.	Species	Observed Catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Brycinus lateralis*	9963	70	42.764	59.9	57.92	105.48	0.25	0.53
2	*Marcusenius macrolepidotus*	1465	10.3	8.87	12.4	8.52	59.76	0.05	0.37
3	*Schilbe intermedius*	653	4.6	5.741	8	3.8	6.71	0.03	0.07
4	*Hydrocynus vittatus*	12	0.1	3.308	4.6	0.07	0.32	0.02	0.24
5	*Barbus poechii*	475	3.3	2.357	3.3	2.76	7.92	0.01	0.04
6	*Synodontis* spp.	535	3.8	2.109	3	3.11	15.28	0.01	0.05
7	*Micralestes acutidens*	316	2.2	1.577	2.2	1.84	6.41	0.01	0.03
8	*Petrocephalus catostoma*	215	1.5	1.029	1.4	1.25	4.24	0.01	0.02
9	*Barbus paludinosus*	145	1	0.822	1.2	0.84	7.82	0	0.04
10	*Pollimyrus castelnaui*	122	0.9	0.586	0.8	0.71	3.08	0	0.02
11	*Pharyngochromis acuticeps*	107	0.8	0.543	0.8	0.62	1.54	0	0.01
12	*Hepsetus odoe*	8	0.1	0.375	0.5	0.05	0.24	0	0.02
13	*Tilapia sparrmanii*	58	0.4	0.307	0.4	0.34	1.49	0	0.01
14	*Barbus radiatus*	54	0.4	0.298	0.4	0.31	0.98	0	0.01
15	*Hippopotamyrus discorhynchus*	23	0.2	0.177	0.2	0.13	0.55	0	0.01
16	*Hemichromis elongatus*	6	0	0.137	0.2	0.03	0.18	0	0.01
17	*Pseudocrenilabrus philander*	33	0.2	0.122	0.2	0.19	0.84	0	0
18	*Ctenopoma multispine*	7	0	0.089	0.1	0.04	0.35	0	0
19	*Clarias theodorae*	1	0	0.047	0.1	0.01	0.08	0	0
20	*Opsaridium zambezense*	7	0	0.045	0.1	0.04	0.33	0	0
21	*Barbus unitaeniatus*	4	0	0.029	0	0.02	0.15	0	0
22	*Hippopotamyrus ansorgii*	5	0	0.026	0	0.03	0.17	0	0
23	*Tilapia ruweti*	4	0	0.015	0	0.02	0.15	0	0
24	*Serranochromis longimanus*	3	0	0.013	0	0.02	0.17	0	0
25	*Synodontis macrostigma*	1	0	0.01	0	0.01	0.08	0	0
26	*Labeo cylindricus*	1	0	0.006	0	0.01	0.08	0	0
27	*Tilapia rendalli*	2	0	0.006	0	0.01	0.15	0	0
27	**TOTAL**	**14225**	**100**	**71.406**	**100**	**82.7**		**0.42**	

28mm Mesh

The 28mm mesh sampled the most fish with the highest weight contribution, with a high catch rate and regular catches with few settings being empty. It sampled a high diversity of species (33). Small species were dominantly sampled with this mesh. *Brycinus lateralis, Petrocephalus catostoma, Schilbe intermedius, Marcusenius macrolepidotus* and *Barbus poechii* were the species most commonly sampled in this mesh. Of the larger species, although not many, small specimens were sampled of *Hydrocynus vittatus, Hepsetus odoe, Clarias ngamensis, Clarias gariepinus* and several of the larger predatory Cichlidae species (Table 6.3).

MESH SIZE (mm): 28mm - NO. Sets: 172
MEAN CONVERSION FACTOR: 1.00
EMPTY Sets: 16 (9.30%)

Table 6.3: Species composition and mean standard CPUE for the 28mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Brycinus lateralis*	8506	54.2	97.344	54.4	49.45	87.54	0.57	1.21
2	*Petrocephalus catostoma*	3807	24.3	34.328	19.2	22.13	125.08	0.2	1.15
3	*Schilbe intermedius*	777	5	13.787	7.7	4.52	7.01	0.08	0.15
4	*Marcusenius macrolepidotus*	1022	6.5	11.319	6.3	5.94	18.42	0.07	0.2
5	*Barbus poechii*	469	3	6.577	3.7	2.73	10.2	0.04	0.16
6	*Hydrocynus vittatus*	200	1.3	5.098	2.9	1.16	6.16	0.03	0.11
7	*Synodontis* spp.	217	1.4	2.321	1.3	1.26	4.69	0.01	0.04
8	*Pharyngochromis acuticeps*	181	1.2	1.908	1.1	1.05	2.91	0.01	0.03
9	*Tilapia sparrmanii*	233	1.5	1.603	0.9	1.35	7.25	0.01	0.05
10	*Hepsetus odoe*	28	0.2	1.065	0.6	0.16	0.68	0.01	0.03
11	*Hippopotamyrus discorhynchus*	67	0.4	0.738	0.4	0.39	1.52	0	0.02
12	*Parauchenoglanis ngamensis*	5	0	0.449	0.3	0.03	0.2	0	0.02
13	*Labeo cylindricus*	21	0.1	0.446	0.2	0.12	1.02	0	0.02
14	*Clarias ngamensis*	1	0	0.443	0.2	0.01	0.08	0	0.03
15	*Micralestes acutidens*	63	0.4	0.242	0.1	0.37	4.8	0	0.02
16	*Pseudocrenilabrus philander*	28	0.2	0.219	0.1	0.16	0.72	0	0.01
17	*Hemichromis elongatus*	14	0.1	0.193	0.1	0.08	0.64	0	0.01
18	*Clarias theodorae*	2	0	0.127	0.1	0.01	0.11	0	0.01
19	*Ctenopoma multispine*	8	0.1	0.11	0.1	0.05	0.3	0	0
20	*Clarias gariepinus*	4	0	0.098	0.1	0.02	0.24	0	0.01
21	*Serranochromis longimanus*	7	0	0.075	0	0.04	0.2	0	0
22	*Pollimyrus castelnaui*	7	0	0.059	0	0.04	0.27	0	0
23	*Barbus radiatus*	6	0	0.053	0	0.03	0.21	0	0
24	*Hippopotamyrus ansorgii*	3	0	0.047	0	0.02	0.13	0	0
25	*Barbus paludinosus*	5	0	0.046	0	0.03	0.17	0	0
26	*Sargochromis carlottae*	2	0	0.026	0	0.01	0.11	0	0
27	*Tilapia rendalli*	3	0	0.02	0	0.02	0.17	0	0
28	*Serranochromis macrocephalus*	1	0	0.014	0	0.01	0.08	0	0
29	*Serranochromis altus*	1	0	0.012	0	0.01	0.08	0	0
30	*Serranochromis robustus*	1	0	0.012	0	0.01	0.08	0	0
31	*Tilapia ruweti*	1	0	0.012	0	0.01	0.08	0	0
32	*Serranochromis angusticeps*	1	0	0.011	0	0.01	0.08	0	0
33	*Opsaridium zambezense*	1	0	0.009	0	0.01	0.08	0	0
33	**TOTAL**	**15692**	**100**	**178.812**	**100**	**91.23**		**1.04**	

The smaller meshes (22mm and 28mm) sampled few juvenile or immature specimens of the larger species, such as *Hydrocynus vittatus.* This data can possibly be used to indicate that small meshes could be used, as gill nets, by the local fishery to catch fish, without detrimental effect on the fish population.

35mm Mesh

This mesh also sampled a high diversity of species (33), with a high contribution in numbers and weight. Smaller species were still sampled dominantly with this mesh, but the occurrence of small specimens from larger species (*Schilbe intermedius, Hydrocynus vittatus, Hepsetus odoe, Serranochromis angusticeps, Serranochromis altus, Labeo lunatus,* *Serranochromis macrocephalus*) becoming more prevalent than in the 22mm and 28mm meshes. It was effective with regular catches and few empty settings (Table 6.4).

MESH SIZE (mm): 35mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 32 (18.60%)

Table 6.4: Species composition and mean standard CPUE for the 35mm mesh net.

No.	Species	Observed Catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Brycinus lateralis*	1107	27.9	40.002	30.6	6.44	21.75	0.23	1.36
2	*Schilbe intermedius*	1063	26.8	35.082	26.8	6.18	12.44	0.2	0.4
3	*Hydrocynus vittatus*	374	9.4	16.802	12.8	2.17	6.58	0.1	0.27
4	*Marcusenius macrolepidotus*	387	9.8	9.442	7.2	2.25	7.62	0.05	0.19
5	*Hepsetus odoe*	102	2.6	7.389	5.6	0.59	1.7	0.04	0.12
6	*Synodontis* spp.	241	6.1	6.493	5	1.4	4.31	0.04	0.1
7	*Pharyngochromis acuticeps*	287	7.2	5.734	4.4	1.67	5.5	0.03	0.11
8	*Barbus poechii*	77	1.9	1.87	1.4	0.45	1.64	0.01	0.04
9	*Tilapia sparrmanii*	84	2.1	1.177	0.9	0.49	1.45	0.01	0.02
10	*Clarias ngamensis*	2	0.1	1.088	0.8	0.01	0.11	0.01	0.08
11	*Petrocephalus catostoma*	63	1.6	0.98	0.7	0.37	1.16	0.01	0.02
12	*Hemichromis elongatus*	33	0.8	0.896	0.7	0.19	1.04	0.01	0.03
13	*Hippopotamyrus discorhynchus*	29	0.7	0.588	0.4	0.17	0.87	0	0.02
14	*Serranochromis altus*	3	0.1	0.478	0.4	0.02	0.13	0	0.03
15	*Serranochromis macrocephalus*	14	0.4	0.412	0.3	0.08	0.42	0	0.01
16	*Pseudocrenilabrus philander*	28	0.7	0.402	0.3	0.16	1.1	0	0.02
17	*Labeo lunatus*	5	0.1	0.34	0.3	0.03	0.2	0	0.01
18	*Clarias theodorae*	6	0.2	0.328	0.3	0.03	0.18	0	0.01
19	*Serranochromis longimanus*	15	0.4	0.316	0.2	0.09	0.52	0	0.01
20	*Sargochromis carlottae*	8	0.2	0.205	0.2	0.05	0.26	0	0.01
21	*Parauchenoglanis ngamensis*	4	0.1	0.135	0.1	0.02	0.24	0	0.01
22	*Serranochromis angusticeps*	6	0.2	0.134	0.1	0.03	0.24	0	0.01
23	*Mormyrus lacerda*	3	0.1	0.093	0.1	0.02	0.13	0	0
24	*Sargochromis codringtonii*	1	0	0.081	0.1	0.01	0.08	0	0.01
25	*Labeo cylindricus*	2	0.1	0.068	0.1	0.01	0.11	0	0
26	*Ctenopoma multispine*	2	0.1	0.061	0	0.01	0.11	0	0
27	*Synodontis macrostigma*	2	0.1	0.053	0	0.01	0.11	0	0
28	*Oreochromis macrochir*	4	0.1	0.052	0	0.02	0.19	0	0
29	*Tilapia rendalli*	4	0.1	0.05	0	0.02	0.15	0	0
30	*Clarias gariepinus*	1	0	0.038	0	0.01	0.08	0	0
31	*Synodontis nigromaculatus*	1	0	0.021	0	0.01	0.08	0	0
32	*Barbus paludinosus*	2	0.1	0.008	0	0.01	0.11	0	0
33	*Barbus cf eutaenia*	1	0	0.002	0	0.01	0.08	0	0
33	**TOTAL**	**3961**	**100**	**130.819**	**100**	**23.03**		**0.76**	

45mm Mesh

The 45mm mesh sampled mostly specimens from larger and intermediate sized species, with a definite size increase of the fish in comparison to the previous meshes. It occasionally sampled exceptionally large specimens of the smaller species, such as *Brycinus lateralis, Barbus poechii, Pharyngochromis acuticeps* and *Pseudocrenilabrus philander.* It was effective in sampling a large number of 30 species, and relatively high numbers, with a large weight contribution. It sampled regularly with 41 settings being empty (Table 6.5).

MESH SIZE (mm): 45mm - NO. Sets: 172
MEAN CONVERSION FACTOR: 1.00
EMPTY Sets: 41 (23.84%)

Table 6.5: Species composition and mean standard CPUE for the 45mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Schilbe intermedius*	898	40.4	54.591	42	5.22	12.04	0.32	0.68
2	*Hydrocynus vittatus*	282	12.7	27.188	20.9	1.64	5.12	0.16	0.43
3	*Marcusenius macrolepidotus*	277	12.5	12.749	9.8	1.61	7.49	0.07	0.33
4	*Hepsetus odoe*	80	3.6	10.252	7.9	0.47	1.31	0.06	0.17
5	*Synodontis spp.*	152	6.8	6.129	4.7	0.88	2.51	0.04	0.09
6	*Pharyngochromis acuticeps*	87	3.9	3.245	2.5	0.51	1.72	0.02	0.07
7	*Tilapia sparrmanii*	88	4	2.912	2.2	0.51	1.5	0.02	0.05
8	*Brycinus lateralis*	185	8.3	2.681	2.1	1.08	13	0.02	0.18
9	*Hemichromis elongatus*	54	2.4	2.67	2.1	0.31	1.93	0.02	0.1
10	*Clarias gariepinus*	2	0.1	2.02	1.6	0.01	0.11	0.01	0.15
11	*Sargochromis carlottae*	16	0.7	0.772	0.6	0.09	0.39	0	0.02
12	*Serranochromis longimanus*	14	0.6	0.6	0.5	0.08	0.38	0	0.02
13	*Labeo lunatus*	6	0.3	0.562	0.4	0.03	0.18	0	0.02
14	*Serranochromis macrocephalus*	13	0.6	0.562	0.4	0.08	0.34	0	0.01
15	*Parauchenoglanis ngamensis*	5	0.2	0.428	0.3	0.03	0.17	0	0.02
16	*Barbus poechii*	17	0.8	0.427	0.3	0.1	1.07	0	0.03
17	*Hippopotamyrus discorhynchus*	7	0.3	0.367	0.3	0.04	0.23	0	0.02
18	*Ctenopoma multispine*	5	0.2	0.3	0.2	0.03	0.38	0	0.02
19	*Sargochromis codringtonii*	6	0.3	0.25	0.2	0.03	0.18	0	0.01
20	*Serranochromis angusticeps*	4	0.2	0.213	0.2	0.02	0.15	0	0.01
21	*Synodontis nigromaculatus*	3	0.1	0.173	0.1	0.02	0.17	0	0.01
22	*Clarias ngamensis*	2	0.1	0.165	0.1	0.01	0.11	0	0.01
23	*Serranochromis altus*	3	0.1	0.164	0.1	0.02	0.13	0	0.01
24	*Clarias theodorae*	2	0.1	0.144	0.1	0.01	0.11	0	0.01
25	*Serranochromis robustus*	3	0.1	0.139	0.1	0.02	0.13	0	0.01
26	*Oreochromis macrochir*	3	0.1	0.13	0.1	0.02	0.17	0	0.01
27	*Oreochromis andersonii*	3	0.1	0.093	0.1	0.02	0.17	0	0.01
28	*Synodontis macrostigma*	1	0	0.062	0	0.01	0.08	0	0
29	*Mormyrus lacerda*	1	0	0.056	0	0.01	0.08	0	0
30	*Pseudocrenilabrus philander*	2	0.1	0.016	0	0.01	0.11	0	0
30	**TOTAL**	**2221**	**100**	**130.06**	**100**	**12.91**		**0.76**	

57mm Mesh

The 57mm mesh sampled a high diversity of 27 species from only 802 specimens. It sampled regularly with 47 settings being empty. Mostly large species were sampled in this mesh (Table 6.6).

MESH SIZE (mm): 57mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 47 (27.33%)

Table 6.6: Species composition and mean standard CPUE for the 57mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Schilbe intermedius*	322	40.1	31.256	32	1.87	4.89	0.18	0.42
2	*Hepsetus odoe*	73	9.1	18.455	18.9	0.42	0.92	0.11	0.24
3	*Hydrocynus vittatus*	59	7.4	16.029	16.4	0.34	0.91	0.09	0.29
4	*Hemichromis elongatus*	68	8.5	6.179	6.3	0.4	1.72	0.04	0.16
5	*Clarias gariepinus*	24	3	5.595	5.7	0.14	0.65	0.03	0.15
6	*Synodontis spp.*	49	6.1	3.718	3.8	0.28	0.71	0.02	0.06
7	*Tilapia sparrmanii*	60	7.5	3.635	3.7	0.35	1.02	0.02	0.07
8	*Marcusenius macrolepidotus*	44	5.5	3.535	3.6	0.26	0.87	0.02	0.07
9	*Labeo lunatus*	8	1	1.297	1.3	0.05	0.26	0.01	0.04
10	*Serranochromis macrocephalus*	14	1.7	1.259	1.3	0.08	0.33	0.01	0.03
11	*Serranochromis robustus*	9	1.1	1.107	1.1	0.05	0.33	0.01	0.04
12	*Serranochromis angusticeps*	3	0.4	1.055	1.1	0.02	0.13	0.01	0.05
13	*Sargochromis carlottae*	14	1.7	1.031	1.1	0.08	0.38	0.01	0.03
14	*Sargochromis codringtonii*	11	1.4	0.782	0.8	0.06	0.45	0	0.03
15	*Pharyngochromis acuticeps*	11	1.4	0.673	0.7	0.06	0.45	0	0.03
16	*Serranochromis longimanus*	4	0.5	0.443	0.5	0.02	0.19	0	0.02
17	*Oreochromis andersonii*	5	0.6	0.409	0.4	0.03	0.31	0	0.02
18	*Serranochromis altus*	4	0.5	0.323	0.3	0.02	0.19	0	0.02
19	*Clarias ngamensis*	1	0.1	0.17	0.2	0.01	0.08	0	0.01
20	*Oreochromis macrochir*	2	0.2	0.158	0.2	0.01	0.11	0	0.01
21	*Tilapia rendalli*	3	0.4	0.144	0.1	0.02	0.13	0	0.01
22	*Mormyrus lacerda*	1	0.1	0.118	0.1	0.01	0.08	0	0.01
23	*Parauchenoglanis ngamensis*	1	0.1	0.114	0.1	0.01	0.08	0	0.01
24	*Synodontis nigromaculatus*	1	0.1	0.091	0.1	0.01	0.08	0	0.01
25	*Hippopotamyrus discorhynchus*	1	0.1	0.083	0.1	0.01	0.08	0	0.01
26	*Brycinus lateralis*	3	0.4	0.031	0	0.02	0.13	0	0
27	*Micralestes acutidens*	7	0.9	0.016	0	0.04	0.53	0	0
27	**TOTAL**	**802**	**100**	**97.706**	**100**	**4.66**	**6.97**	**0.57**	**0.76**

Catches in the 35mm, 45mm and 57mm meshes were dominated by *Schilbe intermedius* (Table 6.4 – 6.6).

73mm Mesh

The 73mm mesh sampled a diversity of 23 species from 223 specimens. More than half (92) of the settings did not sample any fish, but this mesh still made a large contribution to the number of species sampled and the total weight. Only large species were sampled in this mesh (Table 6.7).

MESH SIZE (mm): 73mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 92 (53.49%)

Table 6.7: Species composition and mean standard CPUE for the 73mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Hydrocynus vittatus*	53	23.8	22.077	30.8	0.31	0.8	0.13	0.34
2	*Hepsetus odoe*	34	15.2	15.15	21.1	0.2	0.58	0.09	0.26
3	*Clarias gariepinus*	22	9.9	13.533	18.9	0.13	0.51	0.08	0.33
4	*Schilbe intermedius*	32	14.3	5.37	7.5	0.19	0.66	0.03	0.1
5	*Serranochromis macrocephalus*	26	11.7	5.011	7	0.15	0.51	0.03	0.1
6	*Clarias ngamensis*	3	1.3	2.907	4.1	0.02	0.13	0.02	0.15
7	*Sargochromis carlottae*	15	6.7	2.031	2.8	0.09	0.54	0.01	0.07
8	*Serranochromis angusticeps*	6	2.7	0.96	1.3	0.03	0.18	0.01	0.03
9	*Synodontis spp.*	7	3.1	0.905	1.3	0.04	0.23	0.01	0.03
10	*Serranochromis robustus*	4	1.8	0.772	1.1	0.02	0.19	0	0.04
11	*Marcusenius macrolepidotus*	5	2.2	0.59	0.8	0.03	0.31	0	0.04
12	*Labeo lunatus*	2	0.9	0.47	0.7	0.01	0.11	0	0.03
13	*Oreochromis macrochir*	3	1.3	0.361	0.5	0.02	0.13	0	0.02
14	*Mormyrus lacerda*	1	0.4	0.34	0.5	0.01	0.08	0	0.03
15	*Sargochromis codringtonii*	2	0.9	0.304	0.4	0.01	0.11	0	0.02
16	*Serranochromis longimanus*	1	0.4	0.184	0.3	0.01	0.08	0	0.01
17	*Hemichromis elongatus*	1	0.4	0.161	0.2	0.01	0.08	0	0.01
18	*Sargochromis giardi*	1	0.4	0.125	0.2	0.01	0.08	0	0.01
19	*Synodontis nigromaculatus*	1	0.4	0.124	0.2	0.01	0.08	0	0.01
20	*Tilapia rendalli*	1	0.4	0.093	0.1	0.01	0.08	0	0.01
21	*Hippopotamyrus discorhynchus*	1	0.4	0.085	0.1	0.01	0.08	0	0.01
22	*Oreochromis andersonii*	1	0.4	0.085	0.1	0.01	0.08	0	0.01
23	*Tilapia sparrmanii*	1	0.4	0.077	0.1	0.01	0.08	0	0.01
23	**TOTAL**	**223**	**100**	**71.715**	**100**	**1.3**		**0.42**	

93mm Mesh

The 93mm mesh sampled a diversity of 14 species and 96 specimens. This mesh did not sample regularly, with 119 empty settings (69.19%), but with the few specimens sampled it still made a large contribution to the total weight, indicating that large specimens and species were sampled with this net (Table 6.8).

MESH SIZE (mm): 93mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 119 (69.19%)

Table 6.8: Species composition and mean standard CPUE for the 93mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Clarias gariepinus*	29	30.2	27.061	38.6	0.17	0.5	0.16	0.48
2	*Hydrocynus vittatus*	18	18.8	22.021	31.4	0.1	0.36	0.13	0.53
3	*Clarias ngamensis*	7	7.3	8.458	12.1	0.04	0.27	0.05	0.32
4	*Serranochromis macrocephalus*	9	9.4	2.624	3.7	0.05	0.22	0.02	0.07
5	*Mormyrus lacerda*	4	4.2	2.249	3.2	0.02	0.19	0.01	0.1
6	*Sargochromis giardi*	4	4.2	1.828	2.6	0.02	0.15	0.01	0.07
7	*Serranochromis altus*	5	5.2	1.753	2.5	0.03	0.17	0.01	0.07
8	*Serranochromis robustus*	5	5.2	1.611	2.3	0.03	0.2	0.01	0.08
9	*Tilapia rendalli*	2	2.1	0.635	0.9	0.01	0.11	0	0.04
10	*Schilbe intermedius*	8	8.3	0.547	0.8	0.05	0.47	0	0.03
11	*Oreochromis macrochir*	2	2.1	0.45	0.6	0.01	0.11	0	0.02
12	*Oreochromis andersonii*	1	1	0.369	0.5	0.01	0.08	0	0.03
13	*Sargochromis carlottae*	1	1	0.366	0.5	0.01	0.08	0	0.03
14	*Hepsetus odoe*	1	1	0.151	0.2	0.01	0.08	0	0.01
14	**TOTAL**	**96**	**100**	**70.123**	**100**	**0.56**		**0.41**	

118mm Mesh

The 118mm mesh sampled 11 species and 64 specimens, with 132 settings being empty (76.7%). The total weight sampled indicates that large specimens and species were sampled (Table 6.9). All the species sampled with the 118mm mesh are of socio-economical value and importance to the fishery in the Eastern Caprivi, as large specimens are preferred on the local markets (Chapter 1).

MESH SIZE (mm): 118mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 132 (76.74%)

Table 6.9: Species composition and mean standard CPUE for the 118mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
	Table 6.9								
1	*Clarias gariepinus*	26	40.7	43.607	52.8	0.15	0.44	0.24	0.78
2	*Hydrocynus vittatus*	9	14.1	17.331	21	0.05	0.25	0.1	0.52
3	*Clarias ngamensis*	5	7.8	6.715	8.1	0.03	0.2	0.04	0.32
4	*Sargochromis giardi*	8	12.5	4.844	5.9	0.05	0.3	0.03	0.19
5	*Serranochromis altus*	4	6.3	3.612	4.4	0.02	0.15	0.02	0.14
6	*Oreochromis macrochir*	4	6.3	2.133	2.6	0.02	0.15	0.01	0.08
7	*Serranochromis angusticeps*	2	3.1	1.441	1.7	0.01	0.11	0.01	0.08
8	*Tilapia rendalli*	2	3.1	1.198	1.5	0.01	0.11	0.01	0.06
9	*Serranochromis robustus*	2	3.1	0.901	1.1	0.01	0.11	0.01	0.07
10	*Marcusenius macrolepidotus*	1	1.6	0.502	0.6	0.01	0.08	0	0.04
11	*Schilbe intermedius*	1	1.6	0.192	0.2	0.01	0.08	0	0.01
11	**TOTAL**	**64**	**100**	**82.476**	**100**	**0.37**		**0.48**	

150mm Mesh

The 150mm mesh did not sample regularly and 154 settings were empty. Large specimens from large species were sampled with this mesh. It sampled a low diversity of 6 species, but made a relative contribution to the total weight sampled with only 25 specimens (Table 6.10). All the species sampled in the 150mm mesh are of socio-economical value and importance to the fishery in the Eastern Caprivi, as large specimens are favoured at the local markets (Chapter 1).

MESH SIZE (mm): 150mm - NO. Sets: 172

MEAN CONVERSION FACTOR: 1.00

EMPTY Sets: 154 (89.53%)

Table 6.10: Species composition and mean standard CPUE for the 150mm mesh net.

No.	Species	Observed catch				Mean standard CPUE			
		No.	%	Kg	%	No.	SD	Kg	SD
1	*Clarias gariepinus*	14	56	44.467	75.6	0.08	0.35	0.26	1.17
2	*Sargochromis giardi*	5	20	5.848	9.9	0.03	0.25	0.03	0.29
3	*Hydrocynus vittatus*	1	4	2.8	4.8	0.01	0.08	0.02	0.21
4	*Oreochromis andersonii*	2	8	2.631	4.5	0.01	0.11	0.02	0.14
5	*Oreochromis macrochir*	2	8	2.004	3.4	0.01	0.11	0.01	0.11
6	*Clarias ngamensis*	1	4	1.04	1.8	0.01	0.08	0.01	0.08
6	**TOTAL**	**25**	**100**	**58.79**	**100**	**0.15**		**0.34**	

6.3.2 Catch composition (selectivity) and Standard CPUE for the other gear

Sets in this chapter refer to the individual efforts of the different gear and are expressed in different values (area, length, number, pulls etc.) and different dimensions (seine nets, local net, lines or traps) than the standard units chosen for the gill nets. The standardised CPUE for these gears were not calculated because of the difficulty involved in calculating the value of the effort for these gears especially for gears such as rotenone, shock, cast net, angling, scoop net and local nets. The effort and dimensions were estimated on site and recorded, but these efforts were estimations and do not give an exact representation of the true effort, and this leaves a large margin for error in calculating the standard CPUE. The mean catch per unit effort (CPUE) in numbers and mass per unit effort (MPUE) in kg is given for the gears in Table 6.11.

Rotenone was the most effective in sampling the highest diversity of fish species (54), followed by the 5m seine net (47), the electro shocker (40) and the 15m seine net (39). Rotenone sampled the highest number of fish (5439), followed by the 15m seine net (5183) and the 5m seine net (5066) (Table 6.11).

Table 6.11: Summary of catch composition for the other gear, Eastern Caprivi.

Gear	No. of species	Total number	Total weight	Total sets	Empty sets	Mean	
						CPUE (n)	MPUE (kg)
Rotenone	54	5439	27.827	26	0	209.192	1.070
5m Seine Net	47	5066	6.271	79	2	64.127	0.079
Electro-Shocker	40	578	1.302	26	3	22.231	0.050
15m Seine Net	39	5183	6.286	49	2	105.775	0.128
Traps	28	993	4.290	53	1	18.736	0.081
Cast Net	28	894	20.302	42	1	21.286	0.483
30m Seine Net	27	569	2.429	7	0	81.285	0.347
Local Net	15	96	6.596	1	0	96.000	6.596
Hand Scoop Net	9	44	0.009	4	0	11.000	0.002
Angling	5	87	31.035	12	1	7.250	2.586

Tables 6.12 – 6.22 indicate the catch composition (selectivity) and mean CPUE for each of the other gears used in the Eastern Caprivi. The fish species were listed according to its relative importance.

15m Seine Net

The 15m seine net was effective in sampling a high diversity of 39 species, and a high number (5183) of fish with 49 drags (efforts). The mean CPUE was 105 and the MPUE 128g, indicating that small species and juvenile fish were sampled with the 15m seine net, with an average mass of 1.21g. This gear was effective in shallow bays and vegetated water of the mainstream, and on floodplains, where juvenile fish and small species were sampled. Clear open water bordering riverbanks, usually sandy, with no vegetation were also surveyed with the 15m seine net, sampling species such as *Brycinus lateralis* and *Opsaridium zambezense* (Table 6.12).

Micralestes acutidens, Oreochromis macrochir, Tilapia sparrmanii and *Tilapia rendalli* are of the species sampled in high numbers. Some of the less common species sampled with this gear were *Aethiomastacembelus frenatus* (Longtail spiny eel), sampled in dense marginal vegetation, and *Leptoglanis cf dorae* sampled in shallow, clear, running water over a clean sandbank (Table 6.12).

GEAR: 15m Seine Net - NO. Sets: 49

EMPTY Sets: 2 (4.08%)

Table 6.12: Species composition and mean CPUE for the 15m seine net.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.12					
1	*Oreochromis macrochir*	927	17.9	1.294	20.6
2	*Tilapia rendalli*	438	8.5	1.113	17.7
3	*Tilapia sparrmanii*	712	13.7	1.032	16.4
4	*Brycinus lateralis*	290	5.6	0.454	7.2
5	*Pharyngochromis acuticeps*	111	2.1	0.318	5.1
6	*Clarias gariepinus*	8	0.2	0.254	4
7	*Hemichromis elongatus*	32	0.6	0.229	3.7
8	*Opsaridium zambezense*	96	1.9	0.160	2.5
9	*Hepsetus odoe*	7	0.1	0.155	2.5
10	*Schilbe intermedius*	10	0.2	0.134	2.1
11	*Pseudocrenilabrus philander*	118	2.3	0.300	4.8
12	*Micralestes acutidens*	1199	23.1	0.104	1.7
13	*Oreochromis andersonii*	16	0.3	0.120	1.9
14	*Barbus poechii*	129	2.5	0.067	1.1
15	*Barbus bifrenatus*	182	3.5	0.065	1
16	*Barbus unitaeniatus*	275	5.3	0.077	1.2
17	*Serranochromis macrocephalus*	4	0.1	0.030	0.5
18	*Barbus radiatus*	83	1.6	0.034	0.5
19	*Sargochromis codringtonii*	2	0	0.019	0.3
20	*Pollimyrus castelnaui*	3	0.1	0.015	0.2
21	*Serranochromis robustus*	7	0.1	0.015	0.2
22	*Rhabdalestes maunensis*	331	6.4	0.112	1.8
23	*Aplocheilichthys johnstoni*	55	1.1	0.021	0.3
24	*Barbus paludinosus*	101	1.9	0.010	0.2
25	*Clarias theodorae*	3	0.1	0.021	0.3
26	*Ctenopoma multispine*	12	0.2	0.008	0.1
27	*Tilapia ruweti*	1	0	0.004	0.1
28	*Labeo cylindricus*	2	0	0.004	0.1
29	*Barbus afrovernayi*	12	0.2	0.003	0.1
30	*Barbus barotseensis*	4	0.1	0.002	0
31	*Aethiomastacembelus frenatus*	1	0	0.001	0
32	*Serranochromis angusticeps*	1	0	0.110	1.7
33	*Hemigrammocharax multifasciatus*	1	0	0.001	0

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.12					
34	*Barbus barnardi*	1	0	0.001	0
35	*Coptostomabarbus wittei*	3	0.1	0.001	0
36	*Hemigrammocharax machadoi*	2	0	0.001	0
37	*Aplocheilichthys katangae*	1	0	0	0
38	*Aplocheilichthys hutereaui*	2	0	0	0
39	*Leptoglanis cf dorae*	1	0	0	0
39	**TOTAL**	**5183**	**100**	**6.286**	**100**
MEAN CPUE		**105.775**		**0.128**	

Rotenone

Rotenone was very effective in sampling the highest species diversity of 54, and the highest number of fish (5439), during 26 sampling efforts. The mean CPUE was 209 and the MPUE was 1070g, indicating that small species and juvenile fish were sampled with an average mass of 5.12g. Rotenone was effective in sampling fish in habitats inaccessible for other gears. Habitats surveyed with Rotenone are rocky habitats and very densely vegetated areas (Table 6.13).

High numbers of *Synodontis spp.* (46.9% of total catch with rotenone) were sampled in rocky habitats, in crevasses and under rocks. Habitat specific and rare species, such as *Clariallabes platyprosopos, Labeo cylindricus, Aethiomastacembelus vanderwaali, Chiloglanis neumanni, Hippopotamyrus ansorgii* and *Barbus codringtonii* were effectively sampled with Rotenone in the rocky habitats. *Opsaridium zambezense* was also sampled in the running water at the rocky habitat (Table 6.13).

Rotenone was effective in sampling in densely vegetated areas where rare floodplain type species were sampled. *Tilapia sparrmanii, Pseudocrenilabrus philander, Tilapia rendalli* and *Pharyngochromis acuticeps* are some of the species that were sampled abundantly in all habitats (Table 6.13).

GEAR: Rotenone - NO. Sets: 26

EMPTY Sets: 0

Table 6.13: Species composition and mean CPUE for Rotenone.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.13					
1	*Synodontis* spp.	2553	46.9	5.436	19.5
2	*Clarias ngamensis*	61	1.1	3.075	11.1
3	*Tilapia sparrmanii*	763	14	3.036	10.9
4	*Hepsetus odoe*	22	0.4	2.059	7.4
5	*Hemichromis elongatus*	88	1.6	1.834	6.6

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.13					
6	*Tilapia rendalli*	179	3.3	1.824	6.6
7	*Clarias gariepinus*	13	0.2	1.800	6.5
8	*Labeo cylindricus*	144	2.6	1.411	5.1
9	*Clarias theodorae*	93	1.7	1.143	4.1
10	*Pharyngochromis acuticeps*	206	3.8	0.766	2.8
11	*Schilbe intermedius*	38	0.7	0.749	2.7
12	*Ctenopoma multispine*	68	1.3	0.649	2.3
13	*Pseudocrenilabrus philander*	374	6.9	0.628	2.3
14	*Mormyrus lacerda*	10	0.2	0.557	2
15	*Serranochromis robustus*	14	0.3	0.545	2
16	*Clariallabes platyprosopos*	10	0.2	0.522	1.9
17	*Parauchenoglanis ngamensis*	22	0.4	0.361	1.3
18	*Oreochromis andersonii*	16	0.3	0.262	0.9
19	*Aethiomastacembelus vanderwaali*	34	0.6	0.152	0.5
20	*Serranochromis macrocephalus*	24	0.4	0.150	0.5
21	*Barbus poechii*	56	1	0.127	0.5
22	*Oreochromis macrochir*	12	0.2	0.114	0.4
23	*Barbus paludinosus*	91	1.7	0.113	0.4
24	*Opsaridium zambezense*	21	0.4	0.080	0.3
25	*Tilapia ruweti*	20	0.4	0.074	0.3
26	*Aethiomastacembelus frenatus*	2	0	0.066	0.2
27	*Marcusenius macrolepidotus*	5	0.1	0.057	0.2
28	*Barbus radiatus*	55	1	0.030	0.1
29	*Pollimyrus castelnaui*	15	0.3	0.029	0.1
30	*Barbus unitaeniatus*	23	0.4	0.021	0.1
31	*Hemigrammocharax machadoi*	112	2.1	0.020	0.1
32	*Micralestes acutidens*	29	0.5	0.018	0.1
33	*Barbus codringtonii*	1	0	0.018	0.1
34	*Petrocephalus catostoma*	1	0	0.016	0.1
35	*Sargochromis codringtonii*	1	0	0.014	0.1
36	*Hippopotamyrus ansorgii*	1	0	0.009	0
37	*Aplocheilichthys johnstoni*	37	0.7	0.008	0
38	*Barbus barotseensis*	36	0.7	0.007	0
39	*Microctenopoma intermedium*	4	0.1	0.007	0
40	*Sargochromis carlottae*	1	0	0.007	0
41	*Barbus haasianus*	78	1.4	0.006	0
42	*Coptostomabarbus wittei*	44	0.8	0.004	0
43	*Barbus barnardi*	11	0.2	0.004	0
44	*Synodontis vanderwaali*	3	0.1	0.003	0
45	*Barbus bifrenatus*	7	0.1	0.003	0
46	*Brycinus lateralis*	1	0	0.003	0
47	*Barbus multilineatus*	20	0.4	0.002	0
48	*Hemigrammocharax multifasciatus*	5	0.1	0.002	0
49	*Barbus afrovernayi*	5	0.1	0.001	0
50	*Serranochromis angusticeps*	1	0	0.001	0
51	*Aplocheilichthys katangae*	5	0.1	0.001	0
52	*Barbus cf eutaenia*	2	0	0	0
53	*Rhabdalestes maunensis*	1	0	0	0
54	*Chiloglanis neumanni*	1	0	0	0

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.13					
54	TOTAL	5439	100	27.827	100
MEAN CPUE		209.192		1.07	

30m Seine Net

The 30m seine net sampled 569 specimens from a diversity of 27 species during seven drags. The CPUE was 81 and the MPUE was 347g, indicating that small species and juvenile fish, with an average mass of 4.27g were sampled. The net was mostly used in floodplain habitats and shallow vegetated areas, sampling mostly species that prefer these habitats (Table 6.14).

GEAR: 30m Seine Net - NO. Sets: 7

EMPTY Sets: 0

Table 6.14: Species composition and mean CPUE for the 30m seine net.

No.	SPECIES	OBSERVED CATCH			
		No.	%	Kg	%
Table 6.14					
1	*Barbus paludinosus*	171	30.1	0.355	14.6
2	*Oreochromis macrochir*	45	7.9	0.302	12.4
3	*Tilapia rendalli*	15	2.6	0.228	9.4
4	*Pharyngochromis acuticeps*	44	7.7	0.157	6.5
5	*Schilbe intermedius*	11	1.9	0.113	4.6
6	*Oreochromis andersonii*	4	0.7	0.076	3.1
7	*Brycinus lateralis*	154	27.1	0.497	20.5
8	*Tilapia sparrmanii*	19	3.3	0.516	21.2
9	*Clarias ngamensis*	1	0.2	0.032	1.3
10	*Rhabdalestes maunensis*	10	1.8	0.024	1
11	*Barbus barnardi*	35	6.2	0.039	1.6
12	*Barbus poechii*	5	0.9	0.013	0.5
13	*Barbus bifrenatus*	20	3.5	0.010	0.4
14	*Micralestes acutidens*	11	1.9	0.010	0.4
15	*Tilapia ruweti*	2	0.4	0.007	0.3
16	*Pseudocrenilabrus philander*	3	0.5	0.003	0.1
17	*Marcusenius macrolepidotus*	1	0.2	0.002	0.1
18	*Opsaridium zambezense*	1	0.2	0.002	0.1
19	*Barbus thamalakanensis*	5	0.9	0.005	0.2
20	*Serranochromis robustus*	1	0.2	0.028	1.2
21	*Aplocheilichthys johnstoni*	1	0.2	0.001	0
22	*Hemigrammocharax machadoi*	1	0.2	0	0
23	*Barbus afrovernayi*	4	0.7	0.004	0.2
24	*Barbus multilineatus*	1	0.2	0.002	0.1
25	*Coptostomabarbus wittei*	2	0.4	0.001	0.1
26	*Aplocheilichthys katangae*	1	0.2	0.001	0
27	*Barbus haasianus*	1	0.2	0	0

No.	SPECIES	OBSERVED CATCH			
		No.	%	Kg	%
Table 6.14					
27	TOTAL	569	100	2.429	100
MEAN CPUE		81.285		0.347	

Traps

The traps sampled 993 specimens from a diversity of 28 species during 53 settings. The CPUE was 18 and the MPUE was 81g, indicating that small species and specimens, with an average mass of 4.32g were sampled. Floodplain type species, or species that prefer vegetated areas were mostly sampled with the Traps, which were usually set in shallow vegetated water (Table 6.15).

GEAR: Traps - NO. Sets: 53

EMPTY Sets: 1 (1.89%)

Table 6.15: Species composition and mean CPUE for the traps.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.15					
1	*Pharyngochromis acuticeps*	323	32.5	1.840	42.9
2	*Tilapia ruweti*	109	11	0.351	8.2
3	*Pseudocrenilabrus philander*	136	13.7	0.331	7.7
4	*Brycinus lateralis*	90	9.1	0.233	5.4
5	*Clarias theodorae*	12	1.2	0.230	5.4
6	*Hemichromis elongatus*	12	1.2	0.225	5.2
7	*Barbus poechii*	80	8.1	0.218	5.1
8	*Synodontis* spp.	15	1.5	0.208	4.8
9	*Ctenopoma multispine*	20	2	0.181	4.2
10	*Micralestes acutidens*	97	9.8	0.108	2.5
11	*Parauchenoglanis ngamensis*	3	0.3	0.077	1.8
12	*Barbus paludinosus*	22	2.2	0.060	1.4
13	*Tilapia sparrmanii*	19	1.9	0.059	1.4
14	*Schilbe intermedius*	11	1.1	0.054	1.3
15	*Barbus unitaeniatus*	17	1.7	0.021	0.5
16	*Clarias gariepinus*	1	0.1	0.020	0.5
17	*Tilapia rendalli*	6	0.6	0.017	0.4
18	*Serranochromis thumbergi*	2	0.2	0.014	0.3
19	*Clarias stappersii*	1	0.1	0.011	0.3
20	*Barbus radiatus*	3	0.3	0.009	0.2
21	*Oreochromis andersonii*	2	0.2	0.008	0.2
22	*Barbus bifrenatus*	6	0.6	0.004	0.1
23	*Opsaridium zambezense*	1	0.1	0.003	0.1
24	*Microctenopoma intermedium*	1	0.1	0.003	0.1
25	*Serranochromis longimanus*	1	0.1	0.002	0.1
26	*Barbus fasciolatus*	1	0.1	0.002	0
27	*Oreochromis macrochir*	1	0.1	0.001	0

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.15					
28	*Aplocheilichthys johnstoni*	1	0.1	0	0
28	**TOTAL**	**993**	**100**	**4.29**	**100**
MEAN CPUE		**18.736**		**0.081**	

Cast Net

The cast net sampled 894 specimens from 28 species, during 42 sampling sessions. The CPUE was 21 and the MPUE was 483g, indicating that larger specimens with an average mass of 22.7g were sampled. Large and small species were sampled, mostly next to marginal vegetation in the mainstream or backwaters. The cast net was effective in sampling larger specimens of *Oreochromis andersonii, Oreochromis macrochir, Tilapia rendalli* and *Hepsetus odoe*, especially in quiet backwaters, where there was ample cover and vegetation. *Brycinus lateralis* and *Barbus poechii* were regularly sampled in the mainstream in the open water next to vegetation (Table 6.16).

GEAR: Cast Net - NO. Sets: 42

EMPTY Sets: 1 (2.38%)

Table 6.16: Species composition and mean CPUE for the cast net.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.16					
1	*Oreochromis macrochir*	71	7.9	4.688	23.1
2	*Brycinus lateralis*	185	20.7	1.880	9.3
3	*Hepsetus odoe*	9	1	1.876	9.2
4	*Tilapia rendalli*	118	13.2	1.827	9
5	*Oreochromis andersonii*	44	4.9	1.654	8.1
6	*Clarias gariepinus*	4	0.4	1.503	7.4
7	*Pharyngochromis acuticeps*	73	8.2	1.189	5.9
8	*Tilapia sparrmanii*	79	8.8	1.145	5.6
9	*Hemichromis elongatus*	23	2.6	0.974	4.8
10	*Schilbe intermedius*	57	6.4	0.781	3.8
11	*Barbus poechii*	137	15.3	0.748	3.7
12	*Clarias ngamensis*	2	0.2	0.706	3.5
13	*Sargochromis carlottae*	7	0.8	0.313	1.5
14	*Hydrocynus vittatus*	2	0.2	0.235	1.2
15	*Serranochromis robustus*	2	0.2	0.193	1
16	*Synodontis* spp.	30	3.4	0.153	0.8
17	*Marcusenius macrolepidotus*	16	1.8	0.104	0.5
18	*Serranochromis angusticeps*	1	0.1	0.085	0.4
19	*Serranochromis altus*	2	0.2	0.060	0.3
20	*Labeo cylindricus*	4	0.4	0.042	0.2
21	*Serranochromis longimanus*	2	0.2	0.034	0.2
22	*Serranochromis thumbergi*	1	0.1	0.033	0.2

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.16					
23	*Barbus paludinosus*	6	0.7	0.029	0.1
24	*Pseudocrenilabrus philander*	6	0.7	0.022	0.1
25	*Micralestes acutidens*	9	1	0.014	0.1
26	*Barbus radiatus*	2	0.2	0.007	0
27	*Petrocephalus catostoma*	1	0.1	0.004	0
28	*Barbus unitaeniatus*	1	0.1	0.003	0
28	**TOTAL**	**894**	**100**	**20.302**	**100**
MEAN CPUE		**21.286**		**0.483**	

Electro Shocker

The electro shocker effectively sampled 578 specimens from a diversity of 40 species. The CPUE was 22, and the MPUE was 50g, indicating that small specimens with an average mass of 2.25g were sampled. Specimens from a large variety of species were sampled with the shocker, mostly in habitats inaccessible with the other gear. Rocky and densely vegetated habitats were usually surveyed with this gear. *Aethiomastacembelus vanderwaali, Clariallabes platyprosopos, Labeo cylindricus* and *Hippopotamyrus ansorgii* are some of the species that are habitat specific, and were regularly sampled in the rocky habitats. Some of the habitat specific species sampled in dense vegetation, and marsh or floodplain type habitats were, *Ctenopoma multispine, Microctenopoma intermedium, Clarias theodorae, Tilapia ruweti, Aplocheilichthys hutereaui* and *Clarias stappersii* (Table 6.17).

GEAR: Shocker - NO. Sets: 26

EMPTY Sets: 3 (11.54%)

Table 6.17: Species composition and mean CPUE for the electro shocker.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.17					
1	*Clarias gariepinus*	2	0.3	0.233	17.9
2	*Pseudocrenilabrus philander*	162	28	0.230	17.7
3	*Ctenopoma multispine*	19	3.3	0.176	13.6
4	*Clarias theodorae*	2	0.3	0.083	6.3
5	*Synodontis* spp.	3	0.5	0.078	6
6	*Clariallabes platyprosopos*	2	0.3	0.062	4.7
7	*Clarias ngamensis*	2	0.3	0.049	3.7
8	*Tilapia sparrmanii*	36	6.2	0.048	3.7
9	*Oreochromis macrochir*	12	2.1	0.034	2.6
10	*Micralestes acutidens*	42	7.3	0.033	2.5
11	*Labeo cylindricus*	7	1.2	0.027	2.1
12	*Aplocheilichthys johnstoni*	132	22.8	0.027	2.1
13	*Pharyngochromis acuticeps*	19	3.3	0.027	2
14	*Aethiomastacembelus vanderwaali*	9	1.6	0.024	1.9

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.17					
15	*Hippopotamyrus ansorgii*	2	0.3	0.023	1.8
16	*Tilapia ruweti*	3	0.5	0.021	1.6
17	*Hemichromis elongatus*	2	0.3	0.018	1.4
18	*Oreochromis andersonii*	1	0.2	0.014	1.1
19	*Brycinus lateralis*	5	0.9	0.013	1
20	*Serranochromis robustus*	1	0.2	0.011	0.9
21	*Barbus poechii*	2	0.3	0.010	0.8
22	*Petrocephalus catostoma*	2	0.3	0.010	0.8
23	*Barbus unitaeniatus*	29	5	0.007	0.6
24	*Pollimyrus castelnaui*	6	1	0.007	0.5
25	*Clarias stappersii*	1	0.2	0.006	0.4
26	*Tilapia rendalli*	2	0.3	0.005	0.4
27	*Rhabdalestes maunensis*	9	1.6	0.004	0.3
28	*Schilbe intermedius*	1	0.2	0.003	0.3
29	*Barbus paludinosus*	4	0.7	0.003	0.3
30	*Marcusenius macrolepidotus*	1	0.2	0.003	0.2
31	*Barbus bifrenatus*	7	1.2	0.002	0.2
32	*Hemigrammocharax machadoi*	11	1.9	0.002	0.2
33	*Aplocheilichthys katangae*	7	1.2	0.002	0.2
34	*Barbus cf eutaenia*	2	0.3	0.002	0.1
35	*Barbus radiatus*	2	0.3	0.001	0.1
36	*Aplocheilichthys hutereaui*	11	1.9	0.001	0.1
37	*Barbus haasianus*	5	0.9	0.001	0
38	*Barbus multilineatus*	9	1.6	0.001	0
39	*Barbus barnardi*	3	0.5	0	0
40	*Microctenopoma intermedium*	1	0.2	0	0
40	**TOTAL**	**578**	**100**	**1.302**	**100**
MEAN CPUE		**22.231**		**0.05**	

Angling

Angling was effective in sampling large specimens of the larger species in open water areas, such as *Hydrocynus vittatus* and *Serranochromis robustus.* Five species were sampled with angling, and the CPUE was 7 per angling session, and the MPUE was 2.586kg, indicating that large specimens with and average mass of 356.69g were sampled (Table 6.18).

GEAR: Angling - NO. Sets: 12

EMPTY Sets: 1 (8.33%)

Table 6.18: Species composition and mean CPUE for angling.

No.	Species	Observed catch			
		No.	%	Kg	%
1	*Hydrocynus vittatus*	69	79.3	30.262	97.5
2	*Synodontis* spp.	6	6.9	0.306	1
3	*Serranochromis robustus*	4	4.6	0.278	0.9
4	*Pharyngochromis acuticeps*	6	6.9	0.107	0.3
5	*Hemichromis elongatus*	2	2.3	0.082	0.3
5	**TOTAL**	**87**	**100**	**31.035**	**100**
MEAN CPUE		**7.25**		**2.586**	

Hand Scoop Net

A diversity of 9 species was sampled with the hand scoop net. The CPUE was 11 and the MPUE was 2g, indicating that very small specimens and species were sampled with an average mass of 0.2g. The hand scoop net was used to scoop in and under floating vegetation, in quiet backwaters (Table 6.19).

GEAR: Scoop Net - NO. Sets: 4

EMPTY Sets: 0

Table 6.19: Species composition and mean CPUE for the hand scoop net.

No.	Species	Observed catch			
		No.	%	Kg	%
1	*Synodontis* spp.	2	4.5	0.004	46.5
2	*Tilapia sparrmanii*	2	4.5	0.001	14
3	*Aplocheilichthys johnstoni*	16	36.4	0.001	12.8
4	*Pseudocrenilabrus philander*	1	2.3	0.001	8.1
5	*Barbus afrovernayi*	11	25	0.001	7
6	*Hemigrammocharax machadoi*	5	11.4	0.001	5.8
7	*Coptostomabarbus wittei*	5	11.4	0	2.3
8	*Leptoglanis cf dorae*	1	2.3	0	2.3
9	*Hemigrammocharax multifasciatus*	1	2.3	0	1.2
9	**TOTAL**	**44**	**100**	**0.009**	**100**
MEAN CPUE		**11**		**0.002**	

Local Nets

The catch of a local net was surveyed to get a picture of the target species of the local fishermen. A two to three inch mesh size net was used in a large backwater in the Kalambeza Channel. The CPUE was 96, and the MPUE was 6.596kg. Relatively large specimens were sampled with an average mass of 68.7g. Large species were targeted with this net (Table 6.20).

GEAR: Local Nets - NO. Sets: 1
EMPTY Sets: 0

Table 6.20: Species composition and mean CPUE for the local nets.

No.	Species	Observed catch			
		No.	%	Kg	%
1	*Tilapia sparrmanii*	35	36.5	1.395	21.2
2	*Hemichromis elongatus*	19	19.8	1.303	19.8
3	*Hepsetus odoe*	2	2.1	0.752	11.4
4	*Hydrocynus vittatus*	4	4.2	0.655	9.9
5	*Marcusenius macrolepidotus*	9	9.4	0.517	7.8
6	*Oreochromis macrochir*	6	6.3	0.473	7.2
7	*Serranochromis macrocephalus*	2	2.1	0.369	5.6
8	*Sargochromis carlottae*	6	6.3	0.351	5.3
9	*Pharyngochromis acuticeps*	5	5.2	0.206	3.1
10	*Labeo lunatus*	2	2.1	0.152	2.3
11	*Sargochromis codringtonii*	1	1	0.144	2.2
12	*Tilapia rendalli*	1	1	0.113	1.7
13	*Serranochromis altus*	1	1	0.074	1.1
14	*Serranochromis angusticeps*	1	1	0.050	0.8
15	*Schilbe intermedius*	2	2.1	0.041	0.6
15	**TOTAL**	**96**	**100**	**6.596**	**100**
MEAN CPUE		**96**		**6.596**	

5m Seine Net

The 5m seine net was very effective in sampling 5066 specimens and a species diversity of 47 during 79 drags. The CPUE was 64, and the MPUE was 79g per drag. Small specimens with an average weight of 1.23g were sampled with this net. Mostly small species and juvenile specimens were sampled with this net in shallow, vegetated, marginal areas of the mainstream and of backwaters. The net was also effectively used in floodplain type habitats.

The 5m seine net was used during one of the high flood surveys to sample fish migrating upstream, and these catches consisted of mostly *Labeo cylindricus*, which would in other circumstances not have been sampled as abundantly with this method. The majority of the species sampled are associated with vegetation; however, non-vegetated, sandy areas with stream were also surveyed, and stream species such as *Opsaridium zambezense, Mesobola brevianalis* and *Micralestes acutidens* were sampled (Table 6.21).

GEAR: 5m - NO. Sets: 79

EMPTY Sets: 2 (2.53%)

Table 6.21: Species composition and mean CPUE for the 5m seine net.

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.21					
1	*Barbus paludinosus*	1153	22.8	0.999	15.9
2	*Pharyngochromis acuticeps*	218	4.3	0.607	9.7
3	*Clarias gariepinus*	10	0.2	0.405	6.5
4	*Oreochromis macrochir*	95	1.9	0.340	5.4
5	*Tilapia rendalli*	262	5.2	0.323	5.2
6	*Tilapia sparrmanii*	202	4	0.401	6.4
7	*Barbus unitaeniatus*	344	6.8	0.288	4.6
8	*Hepsetus odoe*	2	0	0.203	3.2
9	*Labeo cylindricus*	209	4.1	0.675	10.8
10	*Barbus poechii*	149	2.9	0.219	3.5
11	*Pseudocrenilabrus philander*	274	5.4	0.190	3
12	*Micralestes acutidens*	271	5.3	0.159	2.5
13	*Tilapia ruweti*	114	2.3	0.151	2.4
14	*Serranochromis robustus*	7	0.1	0.157	2.5
15	*Hemichromis elongatus*	25	0.5	0.145	2.3
16	*Opsaridium zambezense*	64	1.3	0.102	1.6
17	*Barbus bifrenatus*	231	4.6	0.113	1.8
18	*Barbus thamalakanensis*	175	3.5	0.080	1.3
19	*Schilbe intermedius*	23	0.5	0.093	1.5
20	*Synodontis* spp.	15	0.3	0.063	1
21	*Clarias ngamensis*	8	0.2	0.060	1
22	*Oreochromis andersonii*	6	0.1	0.059	0.9
23	*Barbus barotseensis*	163	3.2	0.068	1.1
24	*Barbus radiatus*	61	1.2	0.055	0.9
25	*Ctenopoma multispine*	16	0.3	0.045	0.7
26	*Aplocheilichthys johnstoni*	311	6.1	0.052	0.8
27	*Rhabdalestes maunensis*	123	2.4	0.037	0.6
28	*Brycinus lateralis*	45	0.9	0.037	0.6
29	*Marcusenius macrolepidotus*	4	0.1	0.025	0.4
30	*Barbus multilineatus*	173	3.4	0.029	0.5
31	*Serranochromis macrocephalus*	6	0.1	0.013	0.2
32	*Pollimyrus castelnaui*	3	0.1	0.010	0.2
33	*Barbus cf eutaenia*	15	0.3	0.010	0.2
34	*Aplocheilichthys katangae*	80	1.6	0.011	0.2
35	*Barbus barnardi*	62	1.2	0.012	0.2
36	*Barbus afrovernayi*	58	1.1	0.012	0.2
37	*Serranochromis thumbergi*	4	0.1	0.006	0.1
38	*Hemigrammocharax machadoi*	21	0.4	0.002	0
39	*Petrocephalus catostoma*	1	0	0.001	0
40	*Barbus fasciolatus*	4	0.1	0.002	0
41	*Hemigrammocharax multifasciatus*	3	0.1	0.001	0
42	*Barbus haasianus*	28	0.6	0.003	0
43	*Aplocheilichthys hutereaui*	7	0.1	0.001	0

No.	Species	Observed catch			
		No.	%	Kg	%
Table 6.21					
44	*Coptostomabarbus wittei*	11	0.2	0.002	0
45	*Mesobola brevianalis*	7	0.1	0.001	0
46	*Microctenopoma intermedium*	2	0	0.001	0
47	*Sargochromis codringtonii*	1	0	0.005	0.1
47	**TOTAL**	**5066**	**100**	**6.271**	**100**
MEAN CPUE		**64.127**		**0.079**	

6.3.3 Possible Flood Related Tendencies in the Fish Population

Figure 6.1 shows the flood levels (m) for the Eastern Caprivi for the years 1991 – 1999. The time when each survey was conducted is indicated in Figure 6.1. Flood levels were obtained from the Department of Water Affairs – Surface Water System, Namibia. The levels were measured at:

Station - Katima Mulilo (No: 230 0M01)
Position Latitude: 17° 25. 002 S
Position Longitude: 24° 12.000 E
Date Station opened: 1968/04/01
Type of Station: Open Sect. Peren. GP

The flood levels were recorded to explain possible tendencies in the fish population, which might be flood related. Certain fish behaviour, such as migration for spawning purposes, is induced by rising or high flood levels (biological response). Certain densities of fish numbers in certain areas can therefore be correlated to the flood levels.

Longitudinal and lateral migrations of freshwater fish were observed by Van der Waal (1996) in 83% of the fish species in the Upper Zambezi in the Caprivi region, Namibia. Results showed that longitudinal upstream migrations were undertaken by most small cyprinids, mormyrids distichodontids, characids, schilbeids, clariids, and mochokids but by only a few of the larger cichlids. Similarly, lateral migrations out of permanent waters were common for young mormyrids, some smaller barbs, small characids, *Schilbe intermedius,* a few mochokids, cyprinodonts, most cichlid species and both anabantids. Breeding migrations were observed only in *Clarias* spp. and some barbs. All other fish movements seem to be connected with invasions into newly inundated habitat, escape from desiccation, movement back to permanent water or else an upstream or downstream movement away from areas with temporary high densities in an effort to escape predation or to seek new feeding ground (van der Waal, 1996).

Van der Waal (1996) divided migrating fish species into three groups:

Group A

Fish species staying in the river

Hippopotamyrus discorhynchus, Barbus cf eutaenia, Barbus lineomaculatus, Labeo cylindricus, Opsaridium zambezense, Hemigrammocharax multifasciatus, Nannocharax macropterus, Parauchenoglanis ngamensis, Amphilius uranoscopus, Chiloglanis neumanni, Synodontis macrostigma and *Hemichromis elongatus* were the species identified that stayed in the river (van der Waal, 1996).

Group B

Fish species staying on the floodplain

Barbus fasciolatus, Coptostomabarbus wittei, Rhabdalestes maunensis, Clarias stappersii, Aplocheilichthys hutereaui, Oreochromis andersonii, Oreochromis macrochir, Sargochromis carlottae, Sargochromis codringtonii, Sargochromis giardi, Serranochromis angusticeps, Serranochromis macrocephalus, Serranochromis robustus, Serranochromis thumbergi, Tilapia ruweti, Microctenopoma intermedium and *Ctenopoma multispine* were the species identified staying on the floodplains (van der Waal, 1996).

Group C

Fish species moving in rivers and onto floodplains

Marcusenius macrolepidotus, Mormyrus lacerda, Petrocephalus catostoma, Pollimyrus castelnaui, Barbus afrovernayi, Barbus barnardi, Barbus barotseensis, Barbus bifrenatus, Barbus multilineatus, Barbus paludinosus, Barbus poechii, Barbus radiatus, Barbus thamalakanensis, Barbus unitaeniatus, Labeo lunatus, Brycinus lateralis, Hydrocynus vittatus, Micralestes acutidens, Hepsetus odoe, Schilbe intermedius, Clarias gariepinus, Clarias ngamensis, Clarias theodorae, Synodontis leopardinus, Synodontis nigromaculatus, Synodontis woosnami, Aplocheilichthys johnstoni, Pharyngochromis acuticeps, Pseudocrenilabrus philander, Tilapia rendalli and *Tilapia sparrmanii* were the species found to be moving in rivers and onto floodplains (van der Waal, 1996).

Fish migrations were observed in the Zambezi River during autumn surveys during this study. The flood level was high, but had started to recede during these surveys. The migrations can therefore be coupled to the receding high floods. The migrations were that of mass movement of small juvenile fish from nursery areas (floodplains) into the river during receding water levels. The dominant migratory species during these surveys were juveniles from the Cyprinidae family, with high numbers of *Labeo cylindricus* (70%). Juveniles from the Characidae family, and Cichlidae family were also observed to migrate during this time. The fish migrated upstream, probably to grow and start life in the river in suitable areas. Van der Waal (1996) also mentions this type of migration where the water levels drop and the juvenile fish have to move from the floodplains back to the mainstream.

Locals also reported on fish migrations during low water levels (June/July). The main migratory fish at these times were members from the Mormyridae family, and the fish migrated down stream. These migrations were, however, not observed and the size, species composition, and reasons for migration are unknown.

Recent radio telemetry studies by the Ministry of Fisheries and Marine Resources, Namibia, and the Foundation of Nature Research and Cultural Heritage Research, Norway, found that adults of *Oreochromis andersonii* and *Sargochromis giardi* were stationary with only small movements during the period with increasing water flow towards the rainy period. Further study is however needed to make definite conclusions (Økland *et al.*, 2000).

Tigerfish were observed to move up to 10km up- and downstream during relatively short periods of time, probably while hunting for prey, as this is a predatory species. *Serranochromis robustus* was observed to be territorial and mostly moved around in the same area. *Serranochromis robustus* is also a predatory species, but it is believed that this species rely on camouflage and ambush to catch its prey (Hay, pers. com., 2002).

This study focused mainly on the fish population as a whole, and certain species were not selected and studied in isolation. Migration behaviour of specific species was therefore not studied in detail. The observed mass migrations were noted for future reference.

High water levels were recorded during the autumns of 1993, 1998 and 1999, and a relatively high flood was recorded during the autumn of 1991. The water levels for the high flood seasons of 1992, 1994 – 1997 were relatively low compared to the other years (Figure 6.1).

The low water levels during high floods might have a negative impact on fish numbers in future, as floodplains, which serve as spawning and nursery areas, are not inundated sufficiently to prolong a stable water level in these areas to sustain fish production. Flood levels influence the fish distribution, and this may have an impact on the numbers sampled in certain areas.

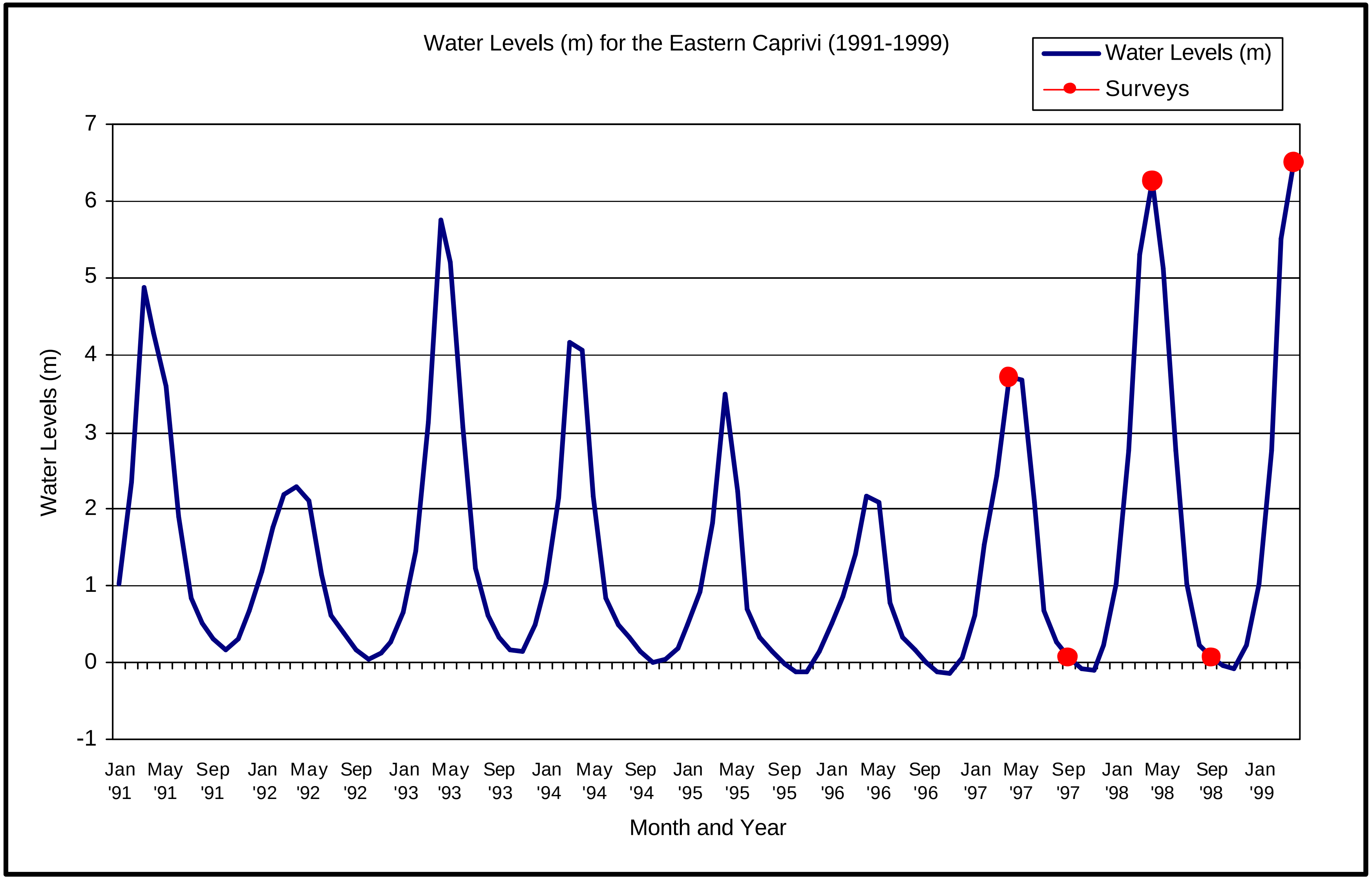


Figure 6.1: Flood levels associated with the surveys in the Eastern Caprivi, 1991 – 1999.

6.3.4 CPUE's and MPUE's for the Gill nets During 3 High and 2 Low Floods

The CPUE's and MPUE's for the gill nets, recorded for each survey (three high and two low floods), are given for each river in the Eastern Caprivi, to determine possible flood related tendencies (Table 6.22 – 6.24).

The CPUE's and MPUE's for the gill nets, recorded for each survey (three high and two low floods) in the Eastern Caprivi (all rivers combined) is also discussed (Table 6.25).

The Zambezi River

The 1999 high flood survey CPUE (460) and MPUE (11.7kg) for the Zambezi River was the highest, followed by the 1998 high flood survey with a CPUE of 279, and a MPUE of 8.6kg (Table 6.22). The 1997 low flood survey had the third highest CPUE (250). There was an increase in the CPUE and MPUE of the 118mm and 150mm meshes towards the later surveys. The average high flood CPUE (280) and MPUE (7.2kg) were higher than the average low flood CPUE (184) and MPUE (2.3kg).

There was an increase in the MPUE sampled in the gill nets as the surveys progressed, especially during the high flood surveys (Table 6.22).

The high flood of 1997 was the highest flood since 1994, followed by an even higher flood during 1998, when the flood level reached a higher peak than previous years. With such high floods the time frame in which the water stays on the floodplains (water retention period) is prolonged. A prolonged adequate water level on the floodplains may benefit fish production, as it provides more time for the fish to spawn. This might explain the relative increase in CPUE's and MPUE's following the high floods of 1997 and 1998 (Table 6.22).

There was an overall increase in the CPUE's in the nets, especially in the larger meshes as the surveys progressed, indicating that more large species and relatively large specimens were sampled, which also contributed to the MPUE (Table 6.22). Large specimens were, however, not sampled regularly in the Zambezi River during the study. This might be an indication of exploitation of the resource in certain areas. Further studies concerning the impact of subsistence fishery in the Zambezi River is however needed to make conclusions.

High floods seem to have a positive effect on fish numbers, but it is important to note that small juvenile fish may be more abundant during autumn after the spawning season (summer) has ended, and before high mortalities have occurred. The overall increase in catch (1997-1999) may therefore be a result of increased spawning, but the time interval of the study was too short to make definite conclusions. Further study is therefore recommended to determine the full effect of higher floods on the fish population.

Table 6.22: The catch and mass per unit efforts of the gill nets (numbers and mass/15m² net/12 hours) for the Zambezi River for five surveys.

Mesh	Mean CPUE in numbers and MPUE in Kilograms									
	High '97		Low '97		High '98		Low '98		High '99	
	N	KG	N	KG	N	KG	N	KG	N	KG
22mm	43.9	0.3	128.4	0.3	49.7	0.4	53.5	0.3	83.1	0.7
28mm	47.5	0.5	104.9	0.6	152.5	2.4	48.8	0.5	254.5	3.0
35mm	5.1	0.1	11.2	0.3	38.2	1.3	8.9	0.2	70.1	2.4
45mm	1.5	0.1	4.0	0.2	24.5	1.6	2.9	0.2	40.5	2.0
57mm	0.8	0.1	1.4	0.1	12.2	1.6	3.0	0.4	8.5	0.8
73mm	0.3	0.1	0.2	0.1	1.6	0.3	0.2	0.1	2.0	0.7
93mm	0.1	0.1	0.1	0.1	0.4	0.6	0.1	0.1	0.7	0.5
118mm	0	0	0.1	0.2	0.2	0.4	0.4	0.3	0.5	0.7
150mm	0	0	0	0	0	0	0.2	0.6	0.3	0.9
Total	**99.2**	**1.3**	**250.3**	**1.9**	**279.3**	**8.6**	**118**	**2.7**	**460.2**	**11.7**

0 = no fish sampled in mesh

The Chobe River

The CPUE and MPUE during low floods were higher than during high floods. The Chobe River is narrow and channel like in some areas, during low flood. During high flood the water enters the floodplains and the Chobe River is changed into a vast marsh-like expanse of water. The increase in water surface area during high floods might have caused the fish population to spread out more, leaving a lower density of fish per surface area. During low flood the fish return to the mainstream, and a decreased surface area, with a new batch of juvenile fish from the floodplains. This might explain why more fish were sampled during low floods (Table 6.23).

The larger meshes sampled regularly, indicating that large specimens are present. The CPUE indicates that large specimens were sampled more regularly during high flood, probably due to mature fish being present in this area, to spawn on the floodplains, and large piscivores hunting for juvenile prey on the floodplain perimeters (Table 6.23).

The fish resource in the Chobe River seems to be in good health, and large specimens occur (Table 6.23).

During the time of the study the subsistence fishery was observed in the Chobe River, especially in the Kasane, Kabula-Bula and Impalila Island areas. Large specimens were still present and were sampled regularly, but the local fishery in this area needs to be studied to determine its full extent, and the impact that it might have on the fish population.

Table 6.23 The catch and mass per unit effort of the gill nets (numbers and mass/15m² net/12 hours) for the Chobe River for five surveys.

Mesh	Mean CPUE in numbers and MPUE in Kilograms									
	High '97		Low '97		High '98		Low '98		High '99	
	N	KG	N	KG	N	KG	N	KG	N	KG
22mm	111.6	0.6	249.3	0.3	23.7	0.2	412.4	1.7	100.8	0.6
28mm	24.0	0.3	41.7	0.4	32.1	0.5	215.6	2.1	99.2	1.3
35mm	7.6	0.3	25.9	1.0	5.5	0.3	69.0	1.6	14.4	0.5
45mm	6.4	0.3	13.8	0.8	6.9	0.5	25.5	1.4	10.7	0.7
57mm	2.1	0.2	7.6	0.9	3.1	0.4	13.6	1.6	3.9	0.7
73mm	0.4	0.1	1.9	0.5	0.9	0.2	4.1	1.0	1.1	0.6
93mm	0.6	0.6	0.7	0.1	0.4	0.3	1.0	0.4	0.3	0.4
118mm	0.1	0.2	0.1	0.5	0.4	0.5	0.1	0.5	0.5	0.9
150mm	0.3	0.8	0	0	0.2	0.3	0	0	0.2	0.7
Total	**153.1**	**3.4**	**341**	**4.5**	**73.2**	**3.2**	**741.3**	**10.3**	**231.1**	**6.4**

0 = no fish sampled in mesh

The Kwando River

The autumn surveys in the Kwando River were conducted at the beginning of the high flood seasons for this river. The full extent of the flood levels was therefore not observed. The CPUE for all the gill nets combined for each survey was relatively constant at 30 (Table 6.24).

Large specimens occur and were sampled regularly. Small specimens were not sampled as regularly as in the other rivers (Table 6.24). The areas surveyed in the Kwando River are pristine and are situated in conservation areas. The resource seems to be in good health and exploitation of the resource does not occur.

Table 6.24: The catch and mass per unit effort of the gill nets (numbers and mass/15m² net/12 hours) for the Kwando River for five surveys.

Mesh	Mean CPUE in numbers and MPUE in Kilograms									
	High '97		Low '97		High '98		Low '98		High '99	
	N	KG	N	KG	N	KG	N	KG	N	KG
22mm	9.6	0.1	5.0	0.5	4.8	0.03	3.3	0.04	6.1	0.1
28mm	14.1	0.1	9.6	0.1	5.0	0.1	14.4	0.3	2.3	0.1
35mm	3.9	0.1	5.3	0.2	10.0	0.4	5.6	0.3	2.3	0.1
45mm	4.4	0.6	5.4	0.4	5.2	0.8	2.4	0.3	1.6	0.2
57mm	2.0	0.4	1.5	0.2	1.4	0.3	1.6	0.3	2.1	0.3
73mm	0.4	0.4	1.6	0.4	1.4	0.4	2.1	0.8	1.6	0.7
93mm	0.9	0.7	1.4	1.3	1.0	0.6	0.6	0.3	1.1	0.8
118mm	1.0	1.1	0.5	0.4	1.0	1.0	0.4	0.2	0.8	0.8
150mm	0.3	0.6	0	0	0.2	0.2	0	0	0.5	0.5
Total	**36.6**	**4.1**	**30.3**	**3.5**	**30**	**3.83**	**30.4**	**2.54**	**18.4**	**3.6**

0 = no fish sampled in mesh

The Eastern Caprivi (all rivers combined)

Large specimens were sampled regularly during all the surveys. The highest CPUE and MPUE were sampled during the 1999 high flood. Better catches were recorded after the high flood of 1998 (Table 6.25).

There was an overall improvement in the recorded catches as the surveys progressed (Table 6.25). The larger meshes caught large specimens, and the MPUE's for these meshes also improved, giving the indication that large specimens occur.

The fish population in the Eastern Caprivi seems to be in good health. The extent of subsistence fishery in the area should, however, be assessed, to determine whether exploitation of the resource is having an effect on the fish population.

Exploitation of the resource might have a detrimental effect on the fish population in certain populated areas, especially in the Zambezi River, and this should be invetigated.

High floods seem to have a positive effect on the fish numbers, as the CPUE's increased in all the rivers after the high flood of 1998.

Table 6.25: The catch and mass per unit effort of the gill nets (numbers and mass/15m² net/12 hours) for the Eastern Caprivi for five surveys.

Mesh	Mean CPUE in numbers and MPUE in Kilograms									
	High '97		Low '97		High '98		Low '98		High '99	
	N	KG	N	KG	N	KG	N	KG	N	KG
22mm	55.1	0.3	131.4	0.4	31.3	0.2	129.9	0.6	67.5	0.5
28mm	31.9	0.4	65.7	0.4	76.8	1.2	80.7	0.8	159.1	1.9
35mm	5.5	0.2	13.7	0.5	19.5	0.7	23.4	0.6	41.6	1.5
45mm	3.7	0.3	6.9	0.4	13.8	1.0	8.6	0.5	24.6	1.3
57mm	1.5	0.2	3.0	0.3	6.5	0.8	5.3	0.7	5.9	0.7
73mm	0.3	0.2	1.0	0.3	1.3	0.3	1.8	0.5	1.7	0.7
93mm	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.2	0.7	0.5
118mm	0.3	0.4	0.2	0.3	0.4	0.5	0.3	0.3	0.5	0.8
150mm	0.2	0.4	0	0	0.1	0.2	0.1	0.2	0.3	0.8
Total	**98.9**	**2.8**	**222.4**	**3**	**150.2**	**5.4**	**250.6**	**4.4**	**301.9**	**8.7**

0 = no fish sampled in mesh

6.3.5 Comparison of Gill Net CPUE During High and Low Flood

The CPUE, mean length and weight sampled, and contribution of the gill net meshes, high flood versus low flood is presented in table format (Table 6.26). The CPUE composition of the gill nets, for all the surveys (both floods) combined is also presented (Table 6.27).

Information in the above-mentioned tables include; number of fish measured and counted, with total numbers sampled in each mesh; contribution in percentage (%) to the total numbers sampled with each mesh; number of efforts and the CPUE for each mesh; and the mean length and mean weight recorded for each mesh. This data was compared to indicate possible flood related differences.

The CPUE of the gill nets at the sampling stations during high and low flood is presented graphically (Figures 6.2 – 6.3). The CPUE for the gill nets at the stations for all the surveys (both floods) combined is also presented (Figure 6.4).

Comparison of Gill Net CPUE's (High Flood versus Low flood)

The CPUE per gill net series was slightly higher during the low floods (25.18) than during the high floods (22.61). The 118mm and 150mm meshes had a higher CPUE during high floods, indicating that large specimens were sampled more regularly during the high flood surveys (Table 6.26). The 22mm and 28mm meshes combined had a higher CPUE during low floods, indicating that small specimens were sampled more regularly in these meshes during the low floods. The 35mm and 45mm meshes sampled a higher CPUE during high floods. The 57mm, 73mm and 93mm meshes sampled relatively similar CPUE's during both seasons. The average mass of the fish sampled in each of the gill net meshes was higher during the high flood season, except for the 150mm mesh which sampled a higher mean weight during the low flood season. The 28mm and 22mm meshes made the highest contribution to the total numbers sampled with the gill nets during both seasons, and the contribution of the meshes to the total numbers sampled decreased with the increase in mesh size during both seasons (Table 6.26).

Table 6.26: CPUE, mean length and weight sampled, and contribution of each gill net mesh, high flood versus low flood, in the Eastern Caprivi.

	AUTUMN/HIGH FLOOD										SPRING/LOW FLOOD									
	22mm	28mm	35mm	45mm	57mm	73mm	93mm	118mm	150mm	Total	22mm	28mm	35mm	45mm	57mm	73mm	93mm	118mm	150mm	Total
Measured	3919	5012	1912	1395	495	132	63	47	23	**12998**	7338	4240	1190	501	267	91	33	17	2	**13679**
Counted	1812	5942	859	325	40	0	0	0	0	**8978**	1156	498	0	0	0	0	0	0	0	**1654**
Total	**5731**	**10954**	**2771**	**1720**	**535**	**132**	**63**	**47**	**23**	**21976**	**8494**	**4738**	**1190**	**501**	**267**	**91**	**33**	**17**	**2**	**15333**
% of Total Catch	26.08	49.85	12.61	7.83	2.43	0.60	0.28	0.21	0.10	100%	55.40	30.90	7.76	3.27	1.74	0.59	0.22	0.11	0.01	100%
EFFORTS	108	108	108	108	108	108	108	108	108	**972**	66	66	66	66	66	66	66	66	66	**594**
CPUE	**53.06**	**101.43**	**25.66**	**15.93**	**4.95**	**1.22**	**0.58**	**0.44**	**0.21**	**22.61**	**128.7**	**71.79**	**18.03**	**7.59**	**4.05**	**1.38**	**0.5**	**0.26**	**0.03**	**25.18**
MEAN LENGTH (cm)	8.2	9.8	13.2	16.2	20.2	28.7	38.7	49	57		8.2	9.9	12.7	15.9	19.6	26.8	35.7	42.7	65.5	
(SD)	1.5	1.8	2.9	3.6	4.7	8.5	14	12.9	19.5		1.1	1.9	2.9	3.8	6	8.5	11	16.8	7.8	
MEAN WEIGHT (g)	7	14	32	63	130	348	804	1310	2248		3	8	28	61	123	283	589	1228	3544	
(SD)	7	14	34	91	93	259	714	685	1129		37	12	25	39	81	184	376	1285	646	

CPUE's for the Gill Nets for All the Surveys Combined

The 28mm mesh was the most effective in sampling a high CPUE of 90.18, followed by the 22mm mesh (81.75) (Table 6.27). The 28mm and 22mm made the highest contribution to the total numbers sampled. The CPUE decreased with an increase in mesh size. The mean length and weight of the fish sampled increased with the increase of mesh size. The 150mm mesh sampled the largest specimens with an average length of 57.6cm and average weight of 2352g. The combined CPUE for the gill nets was 23.82 (Table 6.27).

Table 6.27: CPUE composition of the gill net meshes, for all the surveys combined.

	MESH SIZE									
	22mm	**28mm**	**35mm**	**45mm**	**57mm**	**73mm**	**93mm**	**118mm**	**150mm**	**Total**
Measured	11257	9252	3102	1896	762	223	96	64	25	**26677**
Counted	2968	6440	859	325	40	0	0	0	0	**10632**
Total	**14225**	**15692**	**3961**	**2221**	**802**	**223**	**96**	**64**	**25**	**37309**
% of Total Catch	38.13	42.06	10.62	5.95	2.15	0.59	0.26	0.17	0.07	**100%**
EFFORTS	174	174	174	174	174	174	174	174	174	**1566**
CPUE	**81.75**	**90.18**	**22.76**	**12.76**	**4.61**	**1.28**	**0.55**	**0.37**	**0.14**	**23.82**
MEAN LENGTH (cm)	8.2	9.9	13	16.1	20	27.9	37.7	47.3	57.6	
(SD)	1.3	1.9	2.9	3.6	5.2	8.5	13.1	14.2	18.9	
MEAN WEIGHT (g)	4	11	31	62	128	322	730	1289	2352	
(SD)	30	13	31	81	89	233	625	874	1147	

Seasonal MPUE's (Kg/Sets) for the Gill nets at the Stations:

The MPUE's for the gill nets are represented for the stations for the two seasons, and for all the surveys combined. The aim is to indicate in which areas the highest MPUE's were recorded, in order to identify which areas recorded the highest biomass, and which areas might be the most productive (Figures 6.2 – 6.4). Low MPUE's recorded in certain areas may be an indication of the exploitation of the fish resource. It might also aid in the identification of *sensitive* areas vulnerable to exploitation, where exploitation does not necessarily occur. It is also important to note that some areas are naturally more productive than others, such as areas with ample vegetation and cover for breeding and feeding. Stations were numbered and sorted in the figures from the highest to the lowest MPUE's recorded. MPUE are only given for the stations where gill nets were set.

Autumn/High Flood:

Lake Lisikili in the Zambezi River was the most productive area during high flood, and the highest MPUE for the gill nets was recorded at this station. The stations in the Kalambeza area (Kalambeza Channel Mouth East (2), Kalizo Lodge (3), Kalambeza Channel (5) and Skelm Channel (6)) all had high MPUE's recorded in the gill nets. Kings Den Lodge (4) and Kasika Village (7) were stations in the Chobe River that had relatively high MPUE's recorded. Nakatwa (9) in the Kwando River also had a relatively high MPUE for the gill nets (Figure 6.2).

Low MPUE's were recorded near populated areas such as Katima Mulilo (23) and Impalila Island (22), indicating that the biomass in these areas is low, and that these areas are sensitive to exploitation. Possible exploitation of the resource in these areas might have a negative impact on the fish population (Figure 6.2).

Development and the alteration of natural riverbanks, leading to the loss of natural habitat and available cover in the Katima Mulilo area may also have an impact on the fish population in this reach of the Zambezi River. Sport fishing in the area of lodges may also impact on the fish resource, as large specimens are usually targeted (Figure 6.2).

High flood levels and the availability of suitable habitat may also have had an impact on the MPUE's recorded. High MPUE's were recorded during high flood in areas where fish are most likely to migrate to for spawning. The stations where the highest MPUE's where recorded (1 to 7 in Figure 6.2), are situated near floodplains, backwaters and densely vegetated areas, where a high influx of fish is most likely to occur during natural conditions and high floods. These stations often had ample cover in the form of aquatic vegetation. These areas were, therefore, suitable for spawning and feeding due to the available cover.

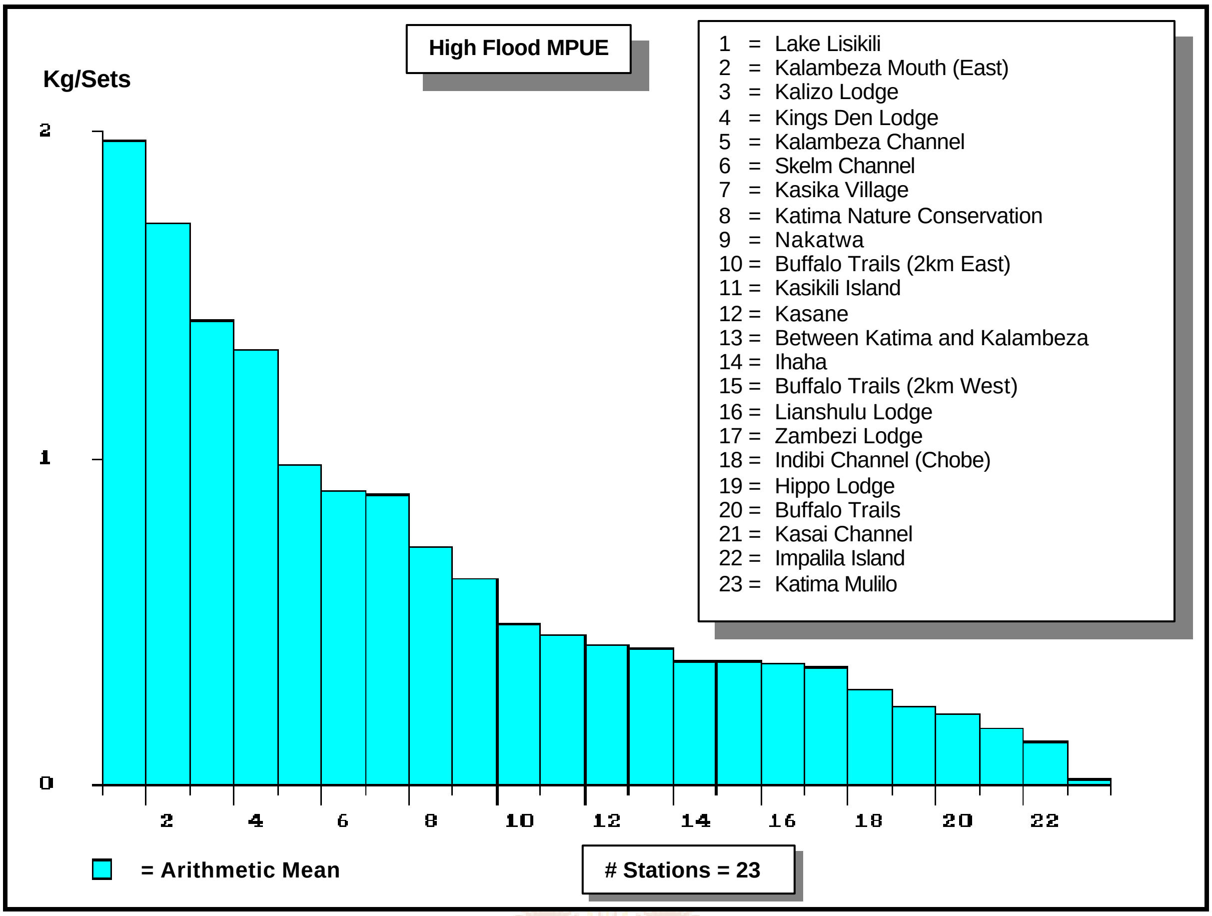


Figure 6.2: MPUE (Kg/Sets) for the gill nets at the stations during high flood, in the Eastern Caprivi.

Spring/Low Flood:

The highest MPUE's were recorded in the Sipho area in the Kabula-Bula region during low floods (Figure 6.3). The higher MPUE's recorded in this area might be due to fish being confined to the mainstream after returning from the floodplains in this area after the high floods. The fish are confined in areas of the Chobe River where the mainstream becomes segmented in long channel like backwaters during low floods.

A much lower MPUE was recorded for the gill nets in Lake Lisikili during low flood (Figure 6.3). This might be an indication of exploitation of the resource during and after high floods. Local fishing is more prevalent in areas where the most fish are likely to occur during a certain flood. Local subsistence fishermen will target the most productive fishing areas first. The local fishing effort or intensity in these areas varies with changes in flood, and are flood related. This seems to be the case with Lake Lisikili where fish is harvested extensively during high floods, and the low MPUE recorded during the low floods might be the result of this exploitation. When local catches decrease in an area the local fishing effort will be focused elsewhere, where the fishing is better.

Lianshulu Bush Camp (16) and Buffalo Trails (18) are situated in pristine areas in the Kwando River, where fishing does not occur. The low MPUE's in these areas serve as indication that the Kwando River would be sensitive to fishery and exploitation (Figure 6.3). Smaller systems can easily be impacted upon. The Kwando River is a smaller system compared to the Zambezi River and is therefore more vulnerable to external impacts, such as exploitation.

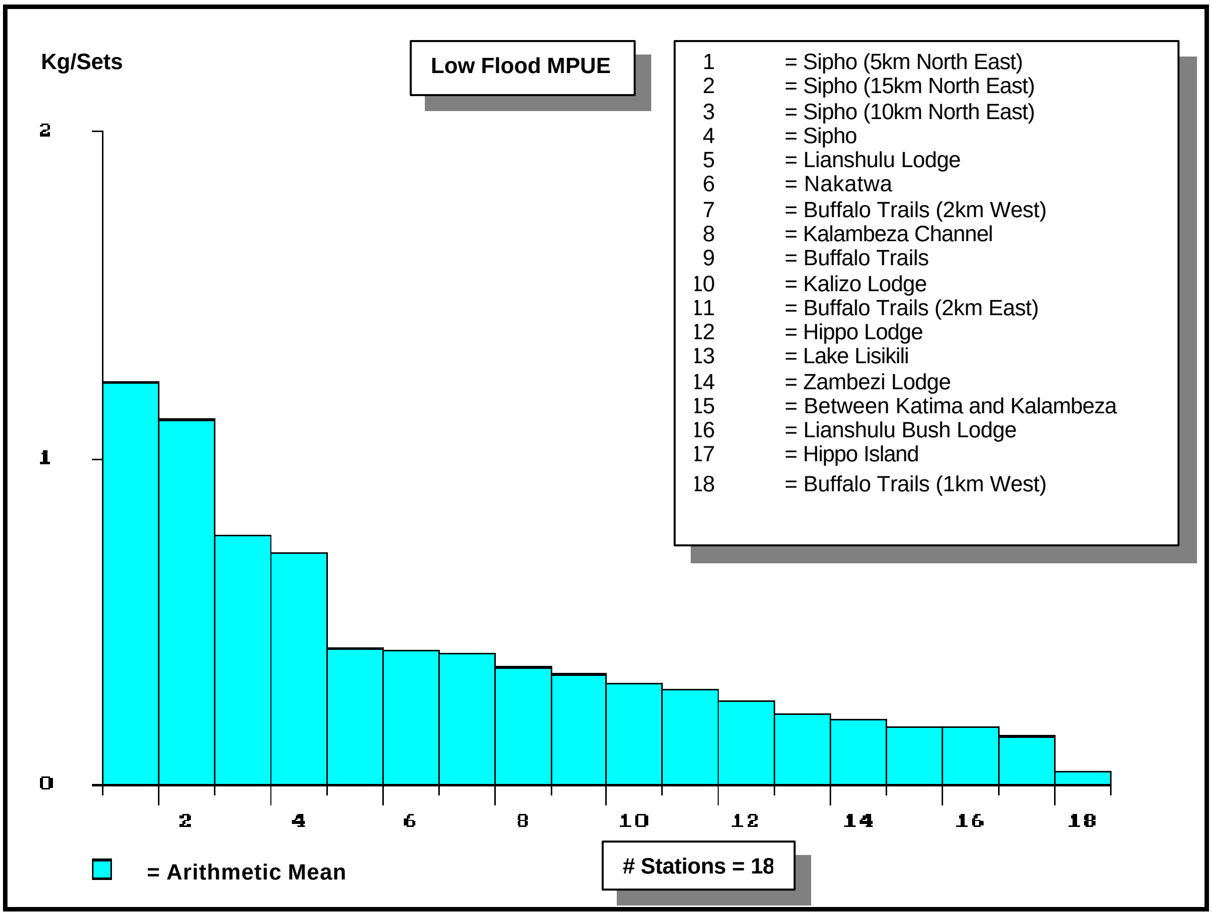


Figure 6.3: MPUE (Kg/Sets) for the gill nets at each station during low flood, in the Eastern Caprivi.

MPUE (Kg/Sets) for the Gill nets in the Eastern Caprivi, All Surveys/Seasons Combined:

The most productive areas in the Zambezi River were in the Kalambeza and Lisikili areas (1 and 4). The most productive areas in the Chobe River were in the Kings Den, Sipho and Kasika Village areas (2,3,5,7). The most productive area in the Kwando River was in the Nakatwa area (13) (Figure 6.4).

Low MPUE's may aid in the identification of sensitive areas, which are vulnerable to fishery. Areas with low MPUE's were mostly populated areas (*i.e.* Katima Mulilo, 30) where subsistence fishery might have a negative impact on the fish population (Figure 6.4).

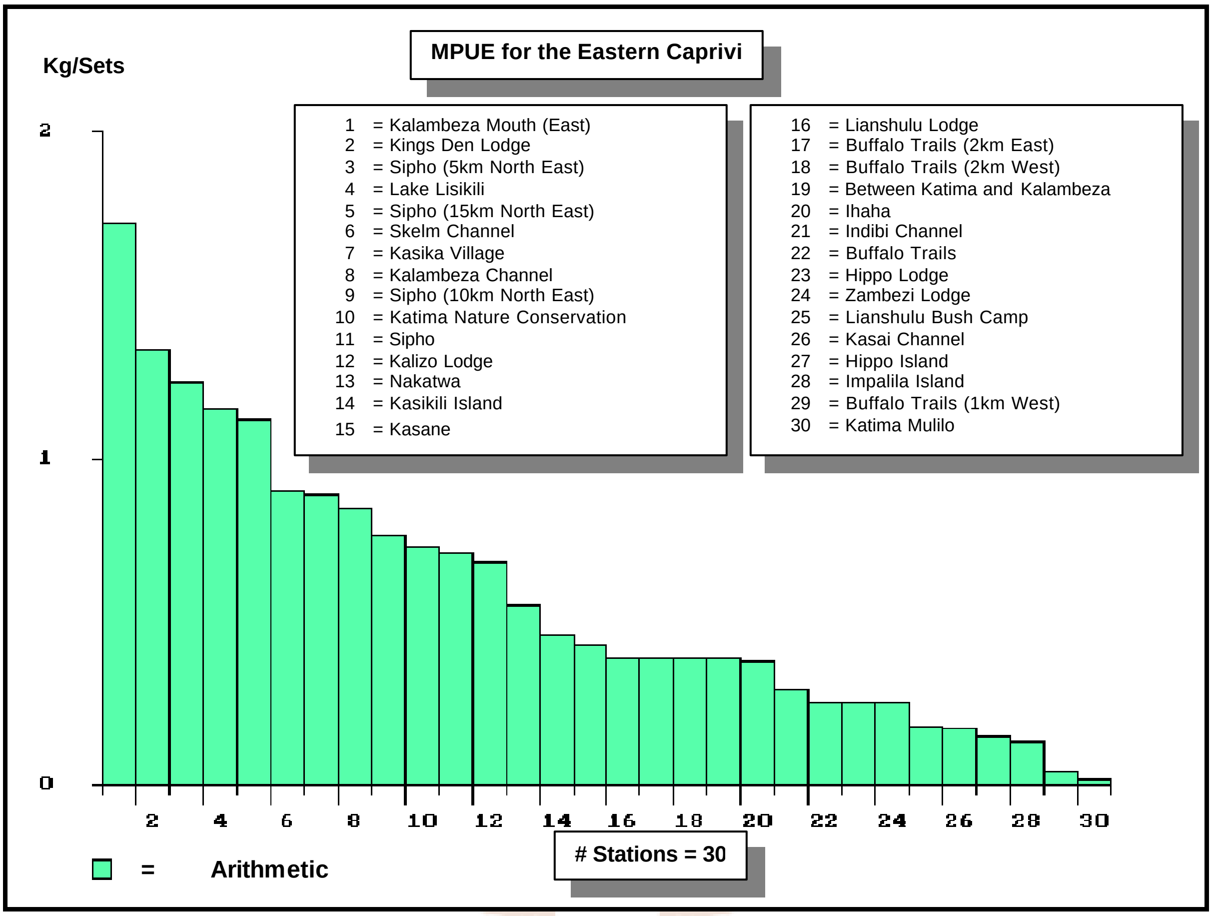


Figure 6.4: MPUE (Kg/Sets) for the gill nets at the different stations during the study, in the Eastern Caprivi.

6.4 CONCLUSION

The smaller meshes (22mm and 28mm) sampled few juvenile or immature specimens of the larger species, such as *Hydrocynus vittatus.* This data can possibly be used to indicate that small meshes could be used, as gill nets, by the local fishery to catch fish, without detrimental effect on the fish population.

Catches in the 35mm, 45mm and 57mm meshes were dominated by *Schilbe intermedius.*

All the species sampled in the 118mm and 150mm meshes are of socio-economical value and importance to the fishery in the Eastern Caprivi.

The gill net data is of importance to formulate legislation. The data can be used to announce regulations on which mesh sizes should be used in the local fishery.

High floods seem to have a positive effect on the fish numbers, as the CPUE's increased in all the rivers after the high flood of 1998.

Low MPUE's recorded in certain areas may be an indication of the exploitation of the fish resource. It might also aid in the identification of *sensitive* areas vulnerable to exploitation, where exploitation does not yet occur.

It is important to note that some areas are naturally more productive than others, such as areas with ample vegetation and cover for breeding and feeding. The availability of suitable habitat may also have had an impact on the species distribution during certain flood levels.

Lake Lisikili in the Zambezi River was the most productive area during high flood, and the highest MPUE for the gill nets was recorded at this station.

Low MPUE's were recorded near populated areas such as Katima Mulilo and Impalila Island, indicating that the biomass and production in these areas are low, and that these areas are sensitive to exploitation. Current exploitation of the resource in these areas might have a negative impact on the fish population.

Development and the alteration of natural riverbanks, leading to the loss of natural habitat and available cover in the Katima Mulilo area may also have an impact on the fish population in this reach of the Zambezi River. Recreational angling near lodges and populated areas may also impact on the fish resource.

7 SAMPLING GEAR SELECTIVITY

7.1 INTRODUCTION

The aim of this chapter is to study the catches of the experimental gill nets used in the Eastern Caprivi to determine the gill net selectivity. This is important for legislation purposes and the regulation of gill net mesh sizes allowed for local fishery. The catches of the other gears (active gear) are also discussed, but conclusions on the selectivity of these gears cannot be made, as the catches were the result of fishing activity (*i.e.* where, how, time, area, etc.).

The number of fish sampled in each length class (1cm intervals) is indicated for each gear used, in table format. The length frequency distribution by mesh size or gear with superimposed mean and modal lengths for each mesh and gear is given graphically. Length based catch curves for the gill nets and other gears are given.

Gill net selectivity curves for selected species and the combined estimated selectivity curves for the mesh sizes are given (four types of selection curves were used to explore gill net selectivity). The length-based catch curves corrected for the estimated selectivity curves are given for the selected species.

7.2 MATERIALS AND METHODS

7.2.1 Sampling gear

A wide range of experimental sampling gear, as adopted from Hay (1995) were used:

1. Multifilament gill nets with stretched mesh sizes of 22, 28, 35, 45, 57, 73, 93, 118 and 150mm were used, and each net had a length of 10m and a depth of 1.5m. Gill nets were set during the night for 12 hours.
2. Seine nets of 5m, 15m and 30m were used. The 5m seine net was made from 80% shade netting, and consequently had a very fine mesh, and was ideal for sampling small specimens, and for sampling in areas with flow. The 15m and 30m seine nets had a stretched mesh size of 12mm, and was mostly used in areas with no current, such as backwaters, floodplains and lakes.
3. A cast net with a diameter of 2m, and a stretched mesh size of 15mm was used. The cast net was mostly used in rapids, and open water areas such as lakes, backwaters and the mainstream.
4. Hand scoop-nets, made from 80% shade netting, were used in and under marginal aquatic vegetation.
5. Rotenone was used in areas that were difficult to sample with other gear types, such as rocky habitats and marginally vegetated areas bordering deep water.

6. Traps were set along banks, usually in vegetation. Traps were usually set overnight for 12 hours.
7. A 12V battery pack electro shocker was used in marginal vegetated areas and rocky habitats.
8. Local seine nets and gill nets were surveyed.
9. Angling was used to sample larger specimens in deep water.

7.2.2 Length Frequency Distribution (Kolding, 1998):

Length frequency distribution (1cm intervals) is given for each mesh size in the experimental nets, and for the other experimental gear, in table form (Table 7.1 and 7.2), and graphically (Figure 7.1 and 7.3) with superimposed modal and mean lengths. Length based catch curves for the nets and other gear are given in Figure 7.2 and 7.4.

7.2.3 Indirect estimation of gill net selectivity curves:

The fish retained in a gear is usually only an unknown proportion of the various size classes available in the fished population. Selectivity is a quantitative expression of this proportion and represented as a probability of capture of a certain size of fish in a certain size of mesh, Kolding (1998).

The mesh selectivity was indirectly estimated from comparative data of observed catch frequencies across a series of mesh sizes. The statistical model (SELECT) is described in Millar (1992), and the specific application on gill nets is described in Millar & Holst (1997).

For a given length class, j, the number of fish, Y_{ji}, that encounter gill net i are assumed to be observations of independent Poisson variables

$$Y_{ji} \sim Po(p_i l_j) \qquad (6)$$

where the expected count, $p_i l_j$, is the product of the abundance of length class j fish, and the relative fishing intensity of gill net i. Fishing intensity can also be considered as a combination of fishing effort and fishing power (Millar 1992).

We denote the relative selectivity (catch or retention probability) of a length class j fish in gill net i by $s_i(j)$. The number of length j fish caught in gill net i is then Poisson distributed (Millar & Holst 1997)

$$N_{ji} \sim Po(p_i l_j s_i(j)) \qquad (7)$$

Without loss of generality it can be assumed that the selection curves $s_i(\cdot)$ for each net have unit height because any difference in fishing powers is modelled through the relative fishing intensities p_i. This is the full general model (Kolding, 1998).

The nets were fished with equal effort, and the relative fishing intensities p_i is considered equal with standardized effort (i.e. number of settings of standardized panel area and time set). The form of the population length distribution is not assumed.

Four selection curves $s_i(\cdot)$ were used: normal, log-normal, gamma and bi-modal, to determine selectivity. The principle of geometric similarity (i.e. length of maximum retention and spread of selection curve are both proportional to the mesh size (Baranov 1948)) applies to the normal scale shift selection curve.

The other three models all include asymmetrical retention modes (i.e. skewed distributions). The bi-modal curve is appropriate if the fish were caught by different mechanisms, e.g. both wedged by the gills and entangled in the mesh sizes.

A) Normal scale shift

$$\exp\left(-\frac{(L_j - k_1 \bullet m_i)^2}{2(k_2 \bullet m_i)^2}\right) \qquad (8)$$

where both the modes (maximum retention length) and the spreads of the selection curves are increasing with mesh size m_i (i.e. the principle of geometric similarity).

B) Log Normal:

$$\frac{1}{L_j}\exp\left[m_1 + \log\left(\frac{m_i}{m_1}\right) - \frac{s^2}{2} - \frac{\left(\log(L_j) - m_1 - \log\left(\frac{m_i}{m_1}\right)\right)^2}{2s^2}\right] \qquad (9)$$

C) Gamma:

$$\left(\frac{L_j}{(a-1)\bullet k \bullet m_i}\right)^{a-1} \bullet \exp\left(a - 1 - \frac{L_j}{k \bullet m_i}\right) \qquad (10)$$

D) Bi-modal:

$$\exp\left(-\frac{(L_j - k_1 \bullet m_i)^2}{2(k_2 \bullet m_i)^2}\right) + w \bullet \exp\left(-\frac{(L_j - k_3 \bullet m_i)^2}{2(k_4 \bullet m_i)^2}\right) \qquad (11)$$

where m_i = mean size (length) of fish caught in mesh size $i = k_1 \bullet m_i$

s_i = standard deviation of the size of fish in mesh $i = k_2 \bullet m_i$ or $a \bullet m_i$

L_j = mean size of fish in size (length) class j

In all cases of the above considerations and models, the Poisson distribution of N_{ji} was used to apply maximum likelihood for purposes of statistical inferences and estimation fits.

In order to explore the possible shapes of the selection curve $S_i(\bullet)$ and whether the principle of geometric similarity seems applicable, the mean, standard deviation and degree of skewness were estimated for each of the observed catch frequencies in mesh size i. Two models or function types were used. A standard normal model:

$$E(n_{ij}) = \frac{n_i}{s_i\sqrt{(2p)}} \exp^{-(L_j - m_i)^2/2s_i^2} \quad (12)$$

and a skew-normal function type (Helser *et al.;* 1991;1994), for species that also have some degree of entanglement:

$$E(n_{ij}) = \frac{n_i}{s_i\sqrt{(2p)}} \exp^{-(L_j - m_i)^2/2s_i^2} \cdot \left\{1 - \tfrac{1}{2} q_i s_i^{2/3} \left[\frac{(L_j - m_i)}{s_i} - \frac{(L_j - m_i)^3}{s_i^3}\right]\right\} \quad (13)$$

q_i = skewnwess coefficient of the distribution of fish in mesh i, when $q_i = 0$ the model reduces to the standard normal distribution.

n_{ij} = catch of fish of size class j in mesh i

n_i = total catch if fish in mesh $i(= \sum_j n_{ij})$ (14)

The model parameters (m_i, s_i, q_i) are estimated by an iterative numerical search of the minimum sum of squares, $\left(= \sum(observed - predicted)^2\right)$ between the expected catch based on the model, $E(n_{ij})$, and the observed catch (n_{ij}).

The total relative selectivity (catch or retention probability) of the gear is computed as:

$$S_{ij} = \sum_i s_i(j) / \max_j \qquad (15)$$

where each estimated mesh specific selectivity curve$_i$ (j) is weighed by the number of settings (effort) of that net. The total relative selectivity is used to estimate the corrected catch frequency in each size class (N_j) from the observed catches, computed as

$$N_j = \sum_i n_{ij} / S_{ij} \qquad (16) \quad \text{where} \quad S_{ij} = 1 \quad \text{if} \quad S_{ij} \leq 0.1$$

S_{ij} = total relative selectivity by length groups (Kolding, 1998).

The estimated selectivity for the gill nets was explored, and the corrected length based catch curves were given.

7.3 RESULTS AND DISCUSSION

7.3.1 Length Frequencies by Mesh Size

Table 7.1 presents the number of fish sampled in each length class (1cm intervals) in the different gill net mesh sizes. The total number of fish sampled in each length class is given, with the contribution made to the total number of fish sampled. The mean weight (g) for each length class is also given in Table 7.1. The number of fish measured and counted, with the total sampled in each mesh is indicated at the bottom of the table.

The 22mm and 28mm meshes sampled the highest number of fish (80%) in the gill nets. In the 22mm mesh specimens measured in the 7-9cm length class made the highest contribution (93%) to the catches in this mesh, and in the 28mm mesh fish in the 9-10cm length class were the most abundant (71%). Most (64%) of the fish measured from the gill net catches were in the 7-10cm length range (Table 7.1).

Fish in the 10-17cm length class were the most commonly (88%) measured in the 35mm mesh, and in the 45mm mesh fish in the 13-19cm length class were mostly measured (76%). The 57mm mesh mostly sampled fish in the 16-22cm length class (60%). The 73mm mesh sampled fish in a variety of length classes, but most (77%) had a length between 19-34cm. The 93mm mesh sampled fish from 17cm to 71cm with none of the fish in a certain length class dominating the catches. The 118mm mesh sampled fish from 25cm to 85cm, with the most fish (ten) sampled in the 57cm length class. The 150mm mesh sampled only sampled

25 fish in a range from 32-87cm. Fish with a length range of 2cm to 87cm were sampled in all the gill net meshes (Table 7.1). MW in Table 7.1 refers to the mean weight in gram of a specimen sampled in a length class.

Table 7.1: Gill net selectivity by number of fish sampled in each length class (1cm intervals), for the Eastern Caprivi.

Length (cm)	Gill net mesh size									TOT	% of N measured	MW (g)
	22mm	28mm	35mm	45mm	57mm	73mm	93mm	118mm	150mm			
Table 7.1												
1										0	0	
2	2									2	0	0.7
3	1									1	0	0.9
4	3	1			1					5	0	1.6
5	133	6	2	2						143	0.5	3.32
6	382	39	2	4	2					429	1.6	4.2
7	2565	342	2	7	8					2924	11	5.39
8	6079	913	42	6	5					7045	26.4	7.51
9	1782	3722	107	37	1					5649	21.2	11.38
10	151	2806	354	36	2					3349	12.6	15.46
11	32	733	784	74	4					1627	6.1	20.36
12	16	288	357	79	5					745	2.8	24.15
13	13	116	323	174	25					651	2.4	30.98
14	29	98	345	191	33	1				697	2.6	36.98
15	8	59	282	154	34					537	2	43.4
16	10	43	145	241	67	3				509	1.9	54.84
17	9	31	147	340	83	6	1			617	2.3	63.29
18	8	23	84	227	61	5	3			411	1.5	72.07
19	25	7	47	122	47	19	4			271	1	85.5
20	2	6	31	54	74	9	3			179	0.7	100.68
21	1	4	15	50	76	15	1			162	0.6	114.4
22	2	2	11	41	43	19	3			121	0.5	132.44
23	1	3	8	14	28	10	2			66	0.2	151.27
24	1	1	3	14	18	10	1			48	0.2	178.83
25		1	2	7	22	6	3	1		42	0.2	206.69
26		2	2	8	23	6	4	1		46	0.2	231.76
27		1		5	24	6	5	2		43	0.2	257.23
28			2	1	14	6	2	3		28	0.1	305.39
29	1	1	1	1	19	11	2	2		38	0.1	330.92
30		1	1	3	17	9	3	4		38	0.1	380.79
31					10	15		2		27	0.1	382.15
32			1		4	11	1	1	1	19	0.1	450.21
33					6	8	1	1	1	17	0.1	481.24
34		1			3	12		1	2	19	0.1	479.05
35		1	1		1	5	3		2	13	0	562.38
36					1	7	3	2		13	0	497
37					1	3	5	2	1	12	0	697.67
38		1		1		2	1	2	1	8	0	824.75
39						2	2			4	0	696
40				1		3	3			7	0	830.71

Length (cm)	Gill net mesh size									TOT	% of N measured	MW (g)
	22mm	28mm	35mm	45mm	57mm	73mm	93mm	118mm	150mm			
Table 7.1												
41						1				1	0	565
42							1		1	2	0	1146.5
43						1	2	1		4	0	935.25
44						2	2	3		7	0	1072
45						1	2			3	0	777
46						1	2	2		5	0	987.6
47							5			5	0	843.6
48						2	1	1		4	0	1063.7
49						1	3			4	0	912.5
50			1			1	5		1	8	0	1046.1
51							1			1	0	1019
52						1	2	1	1	5	0	1533.4
53							2			2	0	1080.5
54							4			4	0	1106.5
55						1	1	1	1	4	0	1730
56				1			2	5		8	0	2098.5
57								10		10	0	1373.2
58							1	3		4	0	1476.5
59								3		3	0	1562.6
60	1					1		4	1	7	0	2531.8
61							1			1	0	1659
62							1	1		2	0	1694
63							1	1		2	0	2992
64								1		1	0	2000
65				1				1		2	0	1908
69									1	1	0	3000
71							1		2	3	0	2941.3
72									1	1	0	3360
73						1				1	0	395
74									2	2	0	3000
76								1	3	4	0	3506
78									1	1	0	2500
80									1	1	0	3983
85								1		1	0	4466
87									1	1	0	4000
Measured	**11257**	**9252**	**3102**	**1896**	**762**	**223**	**96**	**64**	**25**	**26677**		
Counted	2968	6440	859	325	40	0	0	0	0	**10632**		
Total	**14225**	**15692**	**3961**	**2221**	**802**	**223**	**96**	**64**	**25**	**37309**		**75.04**

The number of fish sampled in the gill nets decreased with the increase of mesh size. The mean weight of the fish showed a steady increase with the increase in length, and the average weight of specimens increased with the increase of mesh size. A total number of 37309 specimens were sampled with the gill nets (Table 7.1).

The smaller species and specimens were sampled in the small mesh sizes and the larger species and specimens in the large meshes. Some species were caught by different mechanisms, e.g. both wedged by the gills or by some degree of entanglement, and therefore specimens with lengths not normally expected in a mesh size were sometimes sampled. *Barbus paludinosus, Schilbe intermedius, Clarias* spp. and *Synodontis* spp. are examples of such species, which are entangled by their serrated dorsal or pectoral spines in the nets. *Hydrocynus vittatus* and *Hepsetus odoe* were occasionally entangled in the nets by their teeth (Table 7.1).

A decrease in numbers with an increase of mesh size occurred, however, an increase in the average weight with the increase in mesh size also occurred, making the contribution of the larger meshes to the total weight considerable (Table 7.1).

Each gill net mesh is selective for fish in a certain length range, which can be seen in Table 7.1, but there was an overlap of fish lengths recorded from mesh to mesh, indicating that the gill nets were effective in sampling fish in the 2cm to 87cm range (Table 7.1).

The length frequency distribution of the fish sampled with the gill nets is shown graphically (Figure 7.1). The mean and modal lengths of the fish sampled in the gill net meshes are also given in this figure. The **modal length** indicates the specific length, for a mesh, in which fish are likely to be sampled, and the **mean length** indicates the average length sampled in a mesh. The number of fish measured in each mesh is indicated.

Fish sampled in the 22mm mesh were most likely to be in the 5cm to 10cm length range (Figure 7.1). Fish sampled in the 28mm mesh were most likely to be in the 6cm to 13cm length range. Fish sampled in the 35mm mesh were most likely to be in the 9cm to 19cm length range. Fish sampled in the 45mm mesh were most likely to be in the 11cm to 22cm length range. Fish sampled in the 57mm mesh were most likely to be in the 13cm to 30cm length range. Fish sampled in the 73mm mesh were most likely to be in the 16cm to 37cm length range. Fish sampled in the 93mm mesh were measured in the 17cm to 7cm length range, and a modal length of 28cm was recorded. Fish sampled in the 118mm mesh were measured in the 17cm to 85cm length range, and a modal length of 58cm was recorded. Fish sampled in the 150mm mesh were measured in the 32cm to 87cm length range, and a modal length of 76cm was recorded (Figure 7.1).

Figure 7.2 illustrates the length based catch curve for the gill nets, and indicates that most of the fish sampled in the gill nets were between 6cm and 20cm of length. The highest number (26%) of fish was measured in the 7-8cm length class. Second was the 8-9cm length class with 21%, followed by the 9-10cm length class (13%).

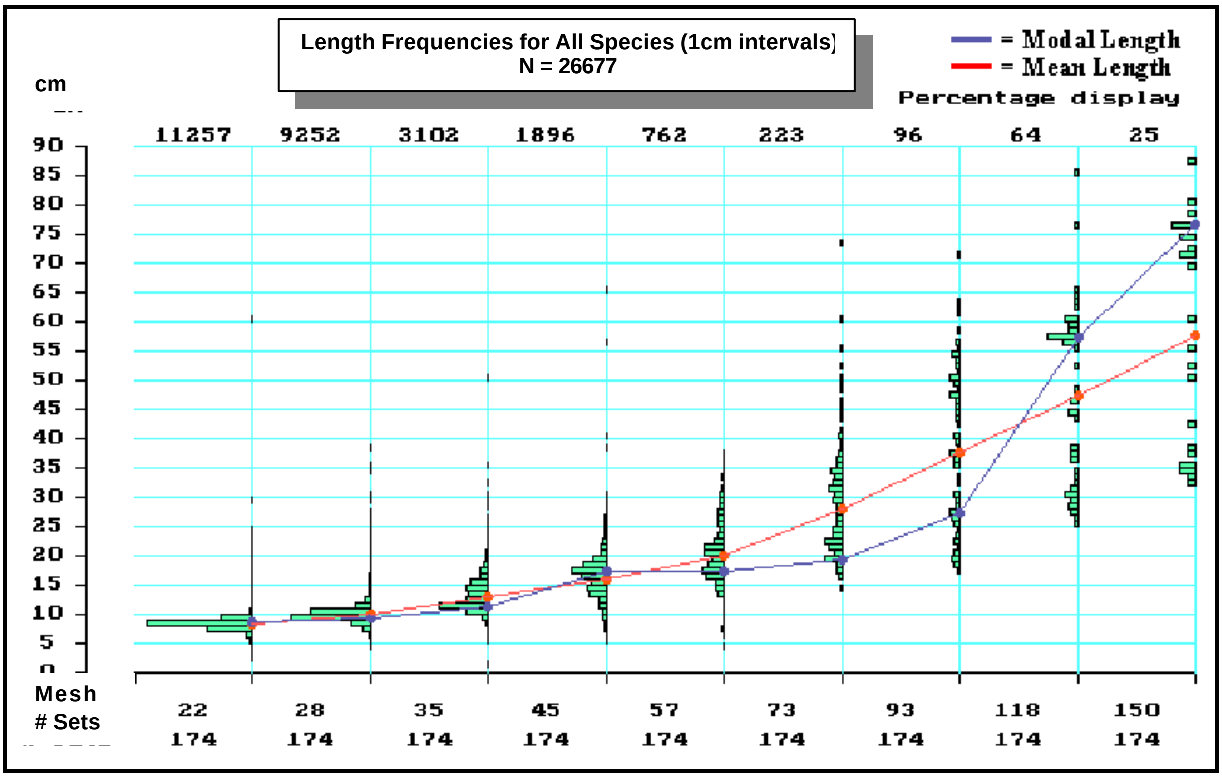


Figure 7.1: The length frequency distribution by mesh size with superimposed mean and modal lengths, for the Eastern Caprivi.

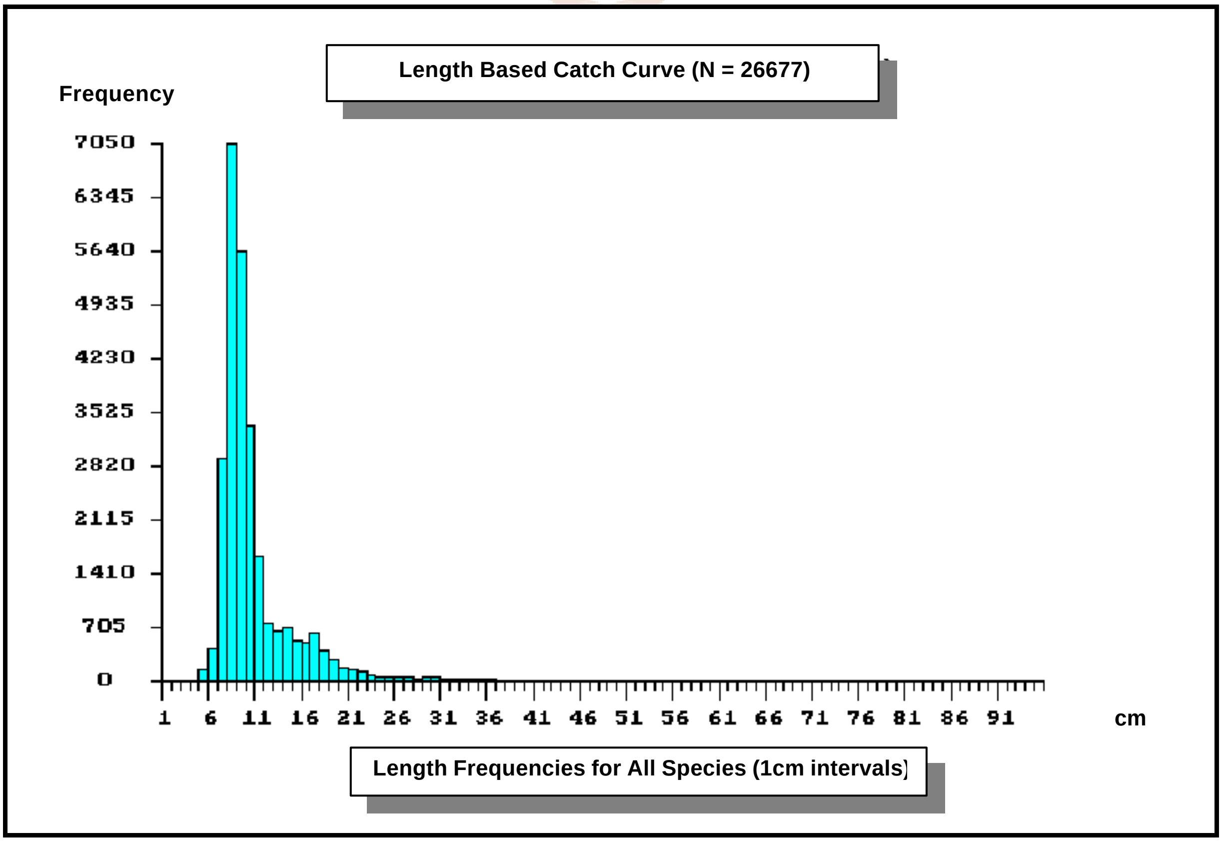


Figure 7.2: Length based catch curve for the gill nets, for the Eastern Caprivi.

7.3.2 Length Frequencies by Other Gear

Table 7.2 indicates the number of fish sampled in each length class (1cm intervals) by the other gears. The total number of fish sampled in each length class is given, with the contribution made to the total number of fish sampled. The mean weight (g) for each length class is also given in Table 7.2. The number of fish measured and counted, with the total sampled with each gear is indicated at the bottom of the table.

Specimens were sampled in length classes from 1 to 54cm (Table 7.2). A total number of 18949 specimens were sampled with the other gear. Large specimens were sampled with the cast net and angling, but most of the specimens sampled with the other gear were in the 1cm to 12cm length range. These gears were effective in sampling small specimens (juveniles) and species in the 1-5cm length range. The selectivity of the other gears is, however, not relevant due to the fact that these gears and their efforts have different dimensions. The different fishing efforts for each gear were not constant (*i.e.* area surveyed, time, etc.).

Large specimens were sampled with angling, the cast net and the local nets because it was mostly used in deep water. Specimens sampled with these gears contributed mostly to the total weight recorded (Table 7.2). The other gears were mostly used in shallow areas where the smaller species and specimens were targeted. Specimens sampled with these gears contributed mostly to the total numbers sampled.

Specimens sampled were well distributed over the total length range with the larger specimens contributing to the weight rather than numbers (Table 7.2).

MW in Table 7.2 refers to the mean weight in gram of a specimen sampled in a length class.

Figure 7.3 illustrates the length frequency distribution of the fish sampled with the other gear. The mean and modal lengths for each gear are also given in this figure.

Figure 7.4 illustrates the length based catch curve for the other gear, and indicates that most of the fish sampled in these gears were between 1cm and 11cm of length.

Table 7.2: Other gear selectivity by number of fish sampled in each length class (1cm intervals).

Length cm	Other gear										TOT	% of measured	MW (g)
	Scoop Net	5m Seine	15m Seine	30m Seine	Shock	Traps	Rotenone	Cast Net	Local Nets	Angling			
Table 7.2													
1	5	116	11	2	14		109				257	2	0.12
2	23	818	385	2	146	7	223				1604	12.2	0.19
3	14	1062	1050	56	158	79	220	2			2641	20.2	0.51
4	1	780	669	140	130	191	325	14			2250	17.2	1.14
5		351	943	112	31	248	298	26			2009	15.3	2.22
6	1	163	453	71	32	174	392	48			1334	10.2	3.77
7		62	301	45	21	120	222	193			964	7.4	5.66
8		36	110	21	17	63	130	155		1	533	4.1	8.05
9		20	117	14	6	41	99	110			407	3.1	11.49
10		6	24	13	8	31	68	88	4		242	1.8	15.19
11		4	5	7	1	16	50	66	15	1	165	1.3	21.52
12		8	2	3	5	2	43	67	12	5	147	1.1	26.18
13		1	2	5	1	9	39	40	10	3	110	0.8	32.42
14		4	1	3	4	6	29	23	8	4	82	0.6	37.26
15			3			1	29	15	12	1	61	0.5	44.21
16		1	1	3		3	15	9	16		48	0.4	58.39
17		2			2		16	4	8	5	37	0.3	68.35
18							15	4	2		21	0.2	51.24
19		1	1			1	7	6	1	2	19	0.1	91.67
20			1				15	4	3	1	24	0.2	99.72
21		1					5	5		1	12	0.1	146.61
22				1		1	11	3		3	19	0.1	104.17
23							6		1		7	0.1	157.86
24							6	5		1	12	0.1	143.38
25					1		10	2	1	1	15	0.1	105.29
26		1					2			1	4	0	157
27							3			4	7	0.1	221.71
28										7	7	0.1	293.5
29									1	7	8	0.1	332.13
30			4				5		2	12	23	0.2	332.12
31										6	6	0	393.33
32					1			1		3	5	0	397.4
33										2	2	0	528
34								1		1	2	0	555
35								1		4	5	0	643.2
36							1				1	0	313
37										1	1	0	733
38										2	2	0	624.5
40										2	2	0	965
41								1		1	2	0	738.5
43								1		1	2	0	933
44										1	1	0	1085
50										2	2	0	1000
54										1	1	0	1200

Length cm	Other gear										TOT	% of measured	MW (g)
	Scoop Net	5m Seine	15m Seine	30m Seine	Shock	Traps	Rotenone	Cast Net	Local Nets	Angling			
Table 7.2													
Measured	**44**	**3438**	**4083**	**498**	**578**	**993**	**2393**	**894**	**96**	**87**	**13104**		
Counted	0	1628	1100	71	0	0	3046	0	0	0	**5845**		
Total	**44**	**5066**	**5183**	**569**	**578**	**993**	**5439**	**894**	**96**	**87**	**18949**		**12682**

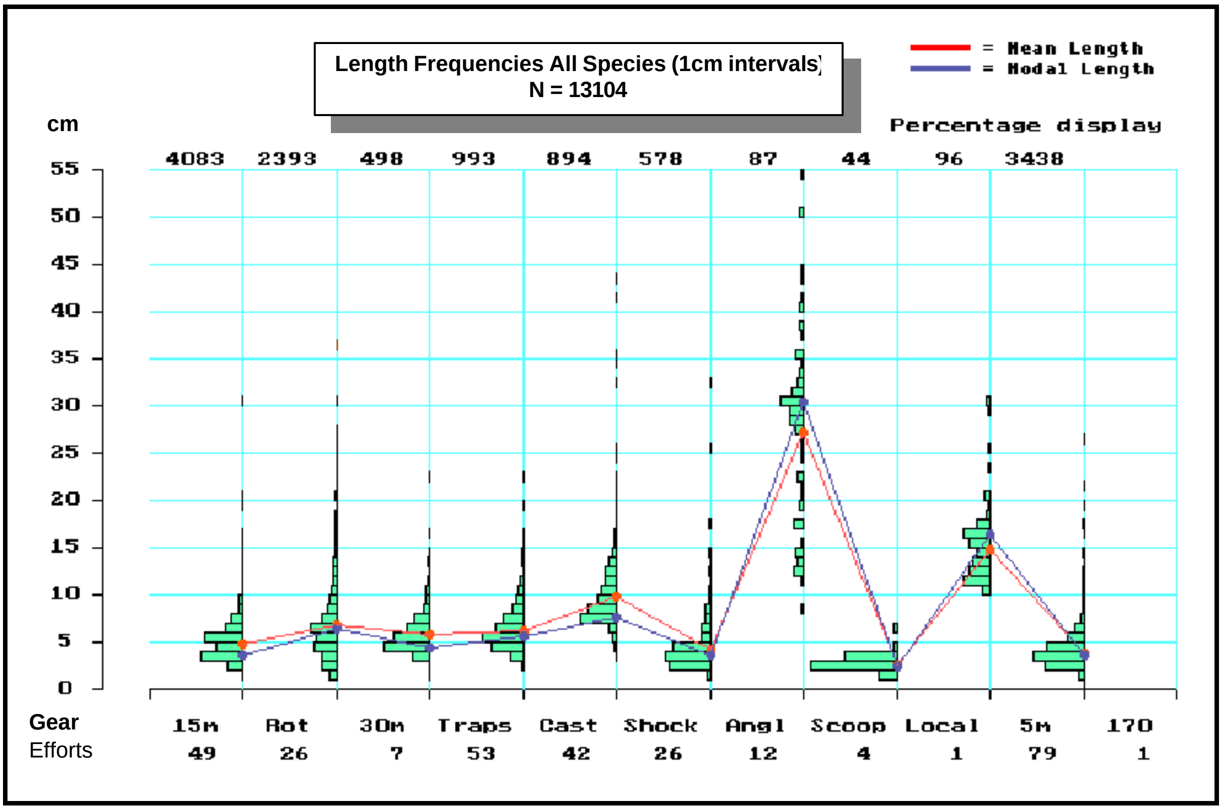


Figure 7.3: The length frequency distribution by other gear with superimposed mean and modal lengths, for the Eastern Caprivi.

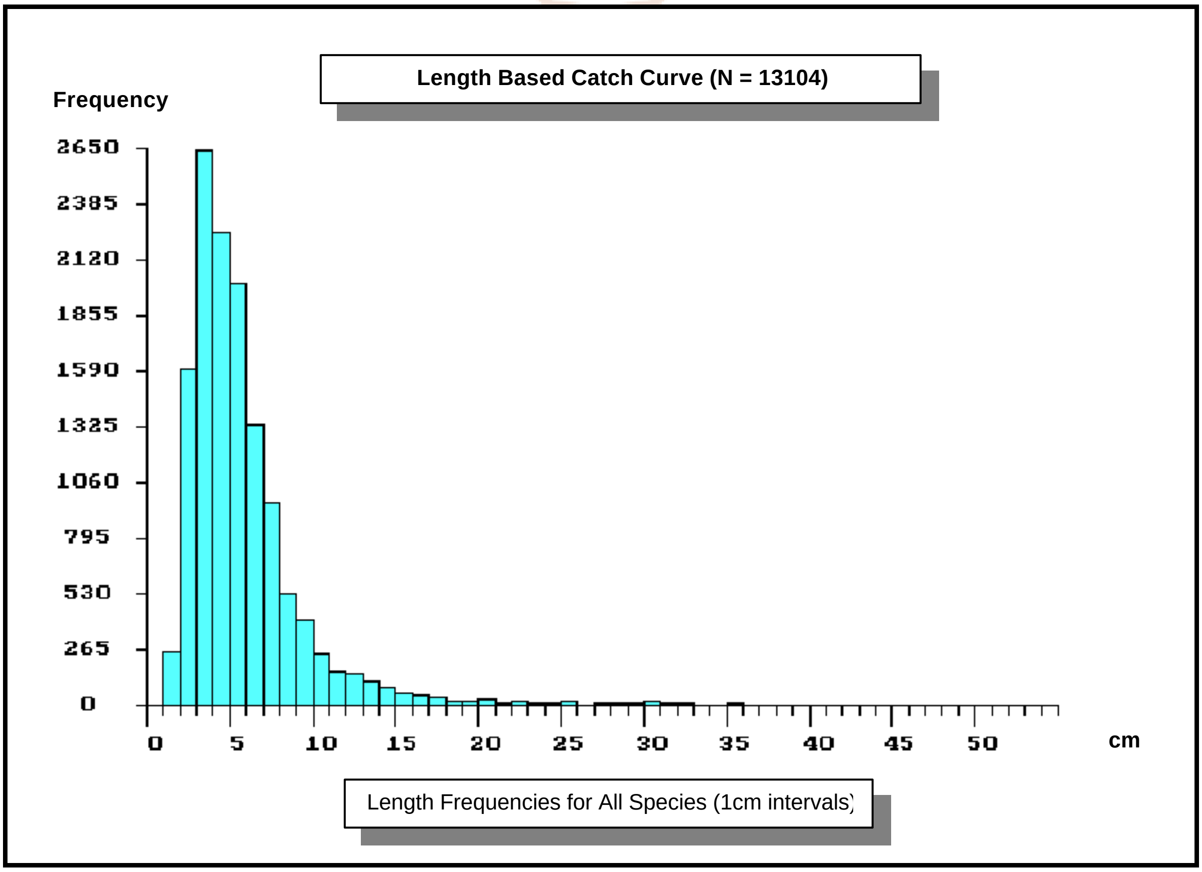


Figure 7.4: Length based catch curve for the other gear, for the Eastern Caprivi.

7.3.3 Gill net selectivity

In this section the estimated gill net selectivity curves for certain species are presented. The combined estimated selectivity curve for the different mesh sizes are given, and the length based catch curves corrected for the estimated selectivity are also given, for the species.

Four selection curves $s_i(\cdot)$, normal, log-normal, gamma and bi-modal, were considered when gill net selectivity was determined.

The gill net selectivity was explored for the species, which received high RI values (see Chapter 5), and for grouped species with the same basic anatomical shape from the same family (*i.e. Sargochromis* spp. from the Cichlidae family, etc.).

There are species that were sampled in the Eastern Caprivi that are more likely to get entangled by their spines or teeth, but this was not necessarily always the case. *Schilbe intermedius* and *Synodontis* spp. were the two species most often entangled by their spines, and *Hydrocynus vittatus* and *Hepsetus odoe* were the species most likely to get entangled by their teeth in the gill nets, usually after attempting to catch entangled prey species.

Exploration of gill net selectivity curves:

The aim in the exploration of the selectivity curve for each mesh is to determine the effectiveness of the gill net range (nine different meshes combined) in sampling length groups, which are representative of the fish population in the Eastern Caprivi.

A mesh size was effective in sampling a species length class if the combined estimated selectivity curve for that mesh and the length class is close to one (*i.e.* high probability). Hence, the gill nets were effective in sampling length groups, which are representative of a species population in an area, if the combined estimated selectivity curve, for a species, are high for each different mesh (*i.e.* probability closer to one).

The combined estimated selectivity curve (indicated with a red line in the figures) indicates the effectiveness of the gill net range in sampling a specified species. It is important to note, that small species will not be sampled in the larger mesh sizes, and a low probability value (for small species being sampled in the large gill net meshes) does therefore not reflect on the effectiveness of these meshes.

Brycinus lateralis

The gill net selectivity curves for each mesh, and the combined estimated selectivity curve are relatively high. The probability of fish being sampled in the 22mm to 57mm meshes, in the recorded length classes is therefore high (Figure 7.5). *Brycinus lateralis* is a relatively small species, and specimens in the of 7cm to 20cm length range were sampled effectively in the 22mm to 57mm meshes. *Brycinus lateralis* was not sampled in the larger meshes (73mm to 150mm meshes). Fish with lengths ranging from 7.5cm to 2.5cm were the most likely to be sampled in the 22mm to 57mm meshes. Small specimens in the 1cm to 6cm length class were not sampled, and the probability of these lengths being sampled with the gill nets used is low.

The length based catch curve corrected for selectivity, for the gill nets, indicates that specimens in the 5cm to 6cm length class are absent from the gill net catches (Figure 7.26). This indicates that the gill net catch composition was not totally representative of the entire species population. Smaller specimens, in the 1cm to 6cm length class, were however sampled with the other gear, as can be seen from the recorded length frequencies in the length based catch curve for all the gears combined (Figure 9.2, Chapter 9). The lengths of the specimens sampled in the gill nets are, however, representative of the species length classes likely to be sampled in the different gill net meshes

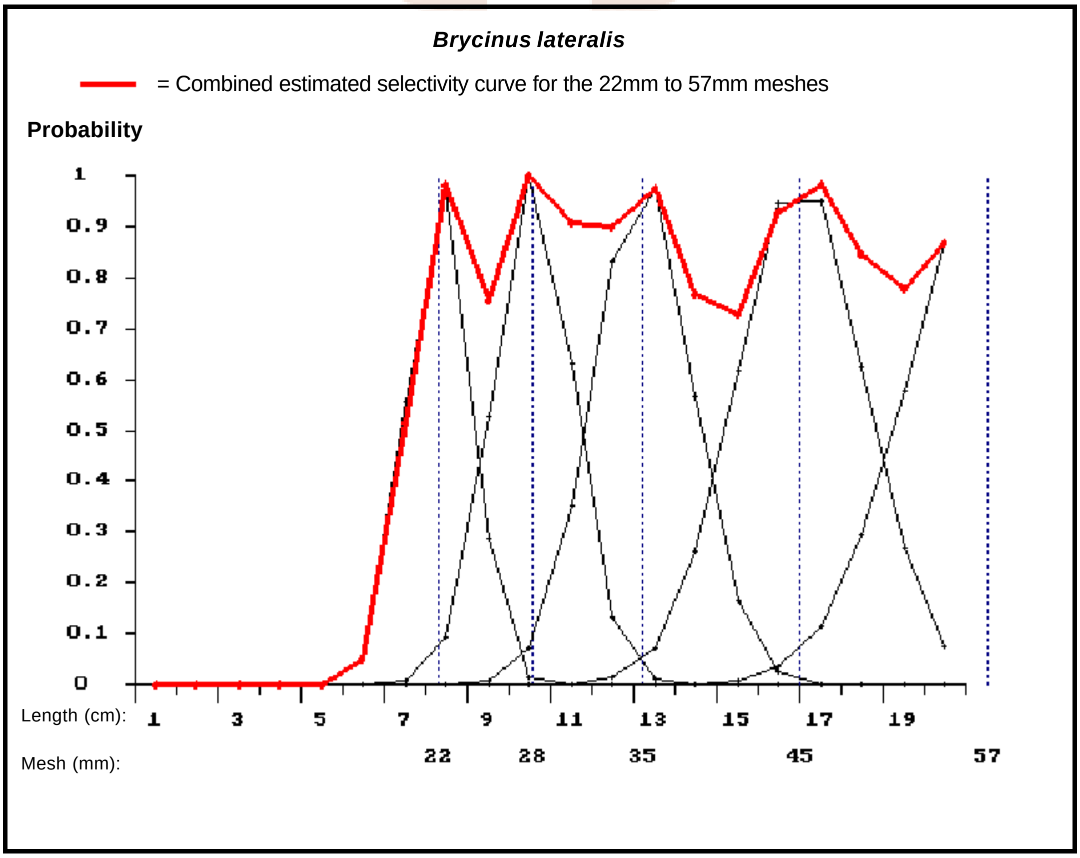


Figure 7.5: Gill net selectivity curves for *Brycinus lateralis* and the combined estimated selectivity curve for the gill net meshes.

Schilbe intermedius

The gill net selectivity curves for each mesh, and the combined estimated selectivity curve indicate that the probability of sampling specimens in the 8cm to 35cm length classes with the 22mm to 93mm meshes is high. This is an indication that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes, and that the gill nets were effective in sampling specimens from this length range. The probability of sampling specimens in the 2cm to 7cm length range was however low (Figure 7.6).

The length based catch curve corrected for selectivity indicates that smaller specimens, in the 2cm to 7cm length class were absent from the gill net catches (Figure 7.26). The recorded length frequencies in the length based catch curve for all the sampling gears combined indicate however that specimens in this length range were sampled with the other gears (Figure 9.4, Chapter 9). Specimens of *Schilbe intermedius* were therefore sampled effectively in the length classes representative of the species length range for the Eastern Caprivi.

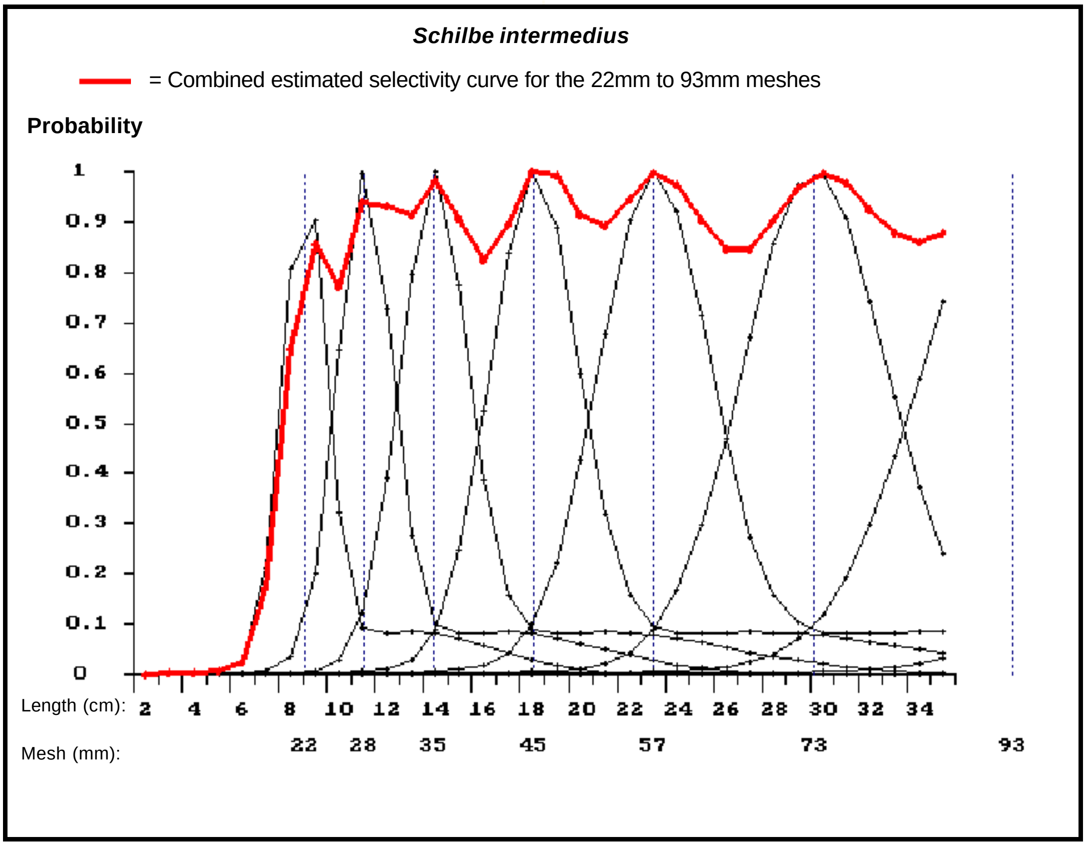


Figure 7.6: Gill net selectivity curves for *Schilbe intermedius* and the combined estimated selectivity curve for the gill net meshes.

Hydrocynus vittatus

Hydrocynus vittatus is a large species, and the gill net selectivity curves, and combined estimated selectivity curve indicate that specimens in the 10cm to 63cm length range were the most likely to be sampled with the 22mm to 150mm meshes. And the probability of sampling specimens in each of the length classes representative of the different meshes was high (Figure 7.7). The probability of sampling specimens smaller than 10cm in length, with the gill nets, is however low.

The length frequencies recorded in the gill net catches are representative of the length classes of *Hydrocynus vittatus* likely to be sampled in the different gill net meshes. The length based catch curve corrected for selectivity (Figure 7.26), and the length frequencies indicated in the length based catch curve for all the gears combined (Figure 9.6, Chapter 9) supports this observation. Specimens in the 9cm length class were sampled with the other gears (Figure 9.6, Chapter 9).

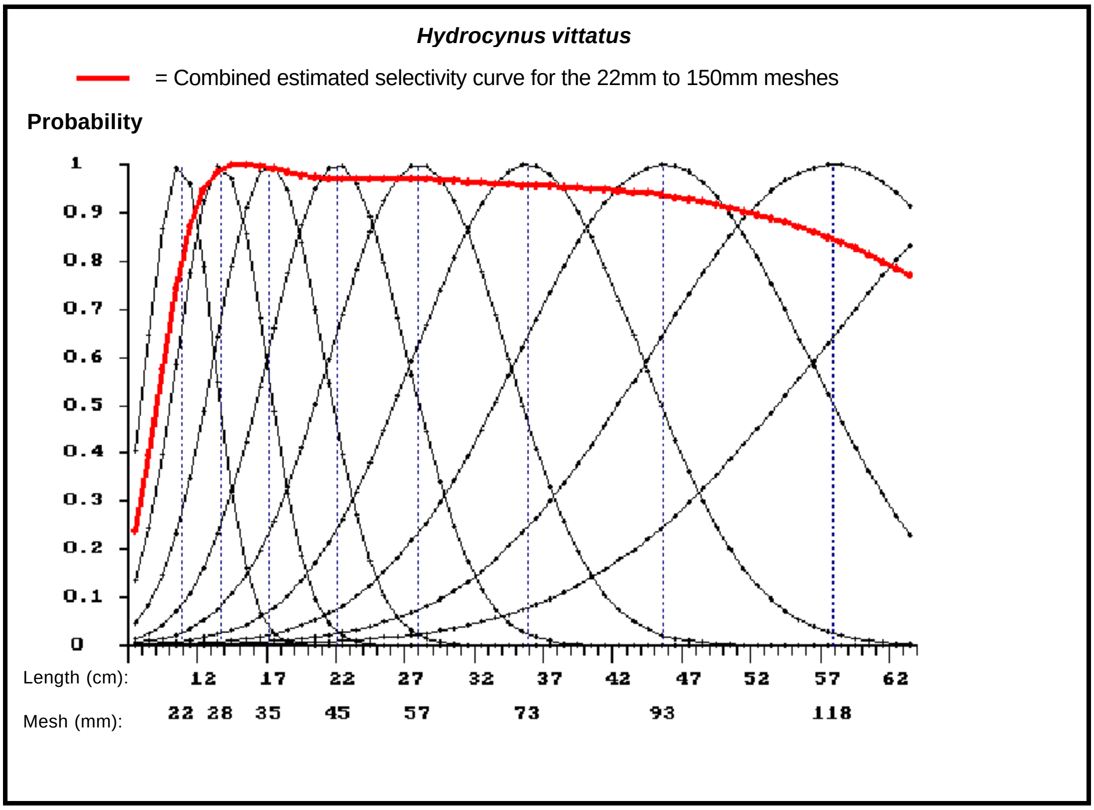


Figure 7.7: Gill net selectivity curves for *Hydrocynus vittatus* and the combined estimated selectivity curve for the gill net meshes.

Petrocephalus catostoma

The gill net selectivity curves for the 22mm to 35mm meshes, and the combined estimated selectivity curve, indicate that specimens in the 7.2cm to 10.5cm length range were the most likely to be sampled, in these meshes (Figure 7.8). *Petrocephalus catostoma* is a small species and was therefore not sampled in the larger meshes.

Small specimens in the 5cm length class were sampled with the other gear (Figure 9.8, Chapter 9). There is a slight correction in the length based catch curve corrected for selectivity (Figure 7.26), but the length frequencies recorded for *Petrocephalus catostoma* indicate that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

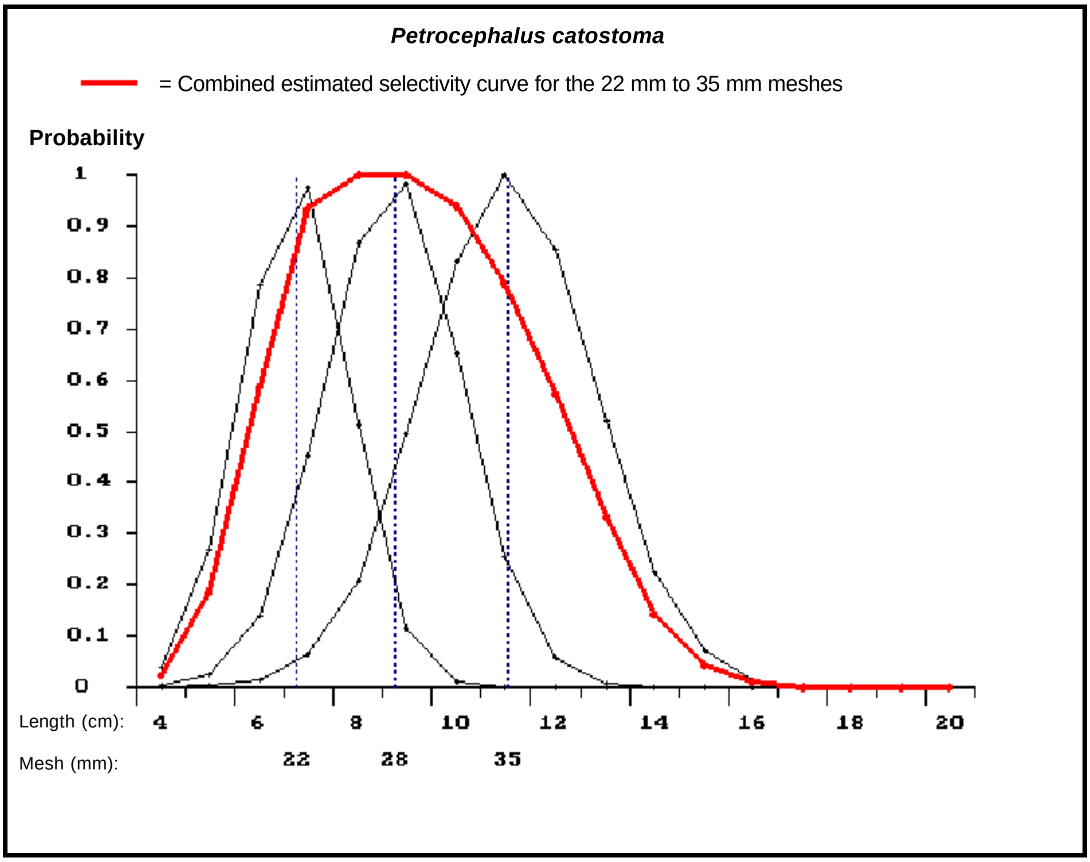


Figure 7.8: Gill net selectivity curves for *Petrocephalus catostoma* and the combined estimated selectivity curve for the gill net meshes.

Marcusenius macrolepidotus

The gill net selectivity curves and the combined estimated selectivity (probability) is high, and specimens in the 7cm to 26cm length range were the most likely to be sampled in the 22mm to 73mm meshes. The probability of each mesh size sampling its representative lengths is high, giving the indication that the lengths recorded were representative of the species length range (Figure 7.9).

The length based catch curve corrected for selectivity indicates that specimens in the 5cm length class were absent from the gill net catches (Figure 7.26). Length frequencies indicated in the length based curve for all the sampling gears combined show, however, that smaller specimens were sampled with the other gear (Figure 9.10, Chapter 9). The lengths recorded for *Marcusenius macrolepidotus* for the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

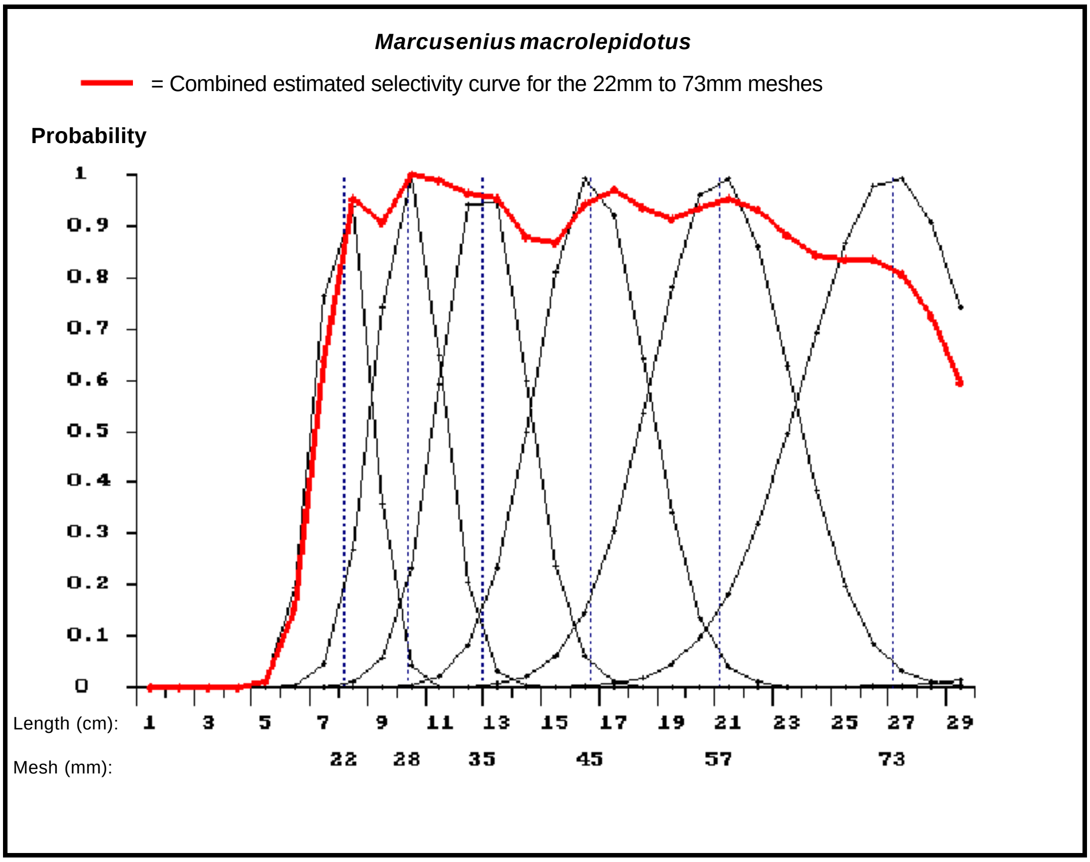


Figure 7.9: Gill net selectivity curves for *Marcusenius macrolepidotus* and the combined estimated selectivity curve for the gill net meshes.

Clarias gariepinus

The probability of sampling specimens of *Clarias gariepinus*, with the 28mm to 150mm mesh sizes, in the 15cm to 83cm length range, with length classes representative of each mesh size was high. The graph indicates a degree of skewness (bi-modal selectivity curve), which is characteristic of species caught by different mechanisms (see section 7.2.3) (Figure 7.10). *Clarias gariepinus* was often entangled by its spines.

The length based catch curve corrected for selectivity (Figure 7.26) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Small specimens in the 4cm to 14cm length range were sampled with the other gear (Figure 9.12, Chapter 9). The length frequencies recorded are representative of the species length range. The maximum length recorded for *Clarias gariepinus* was 87cm.

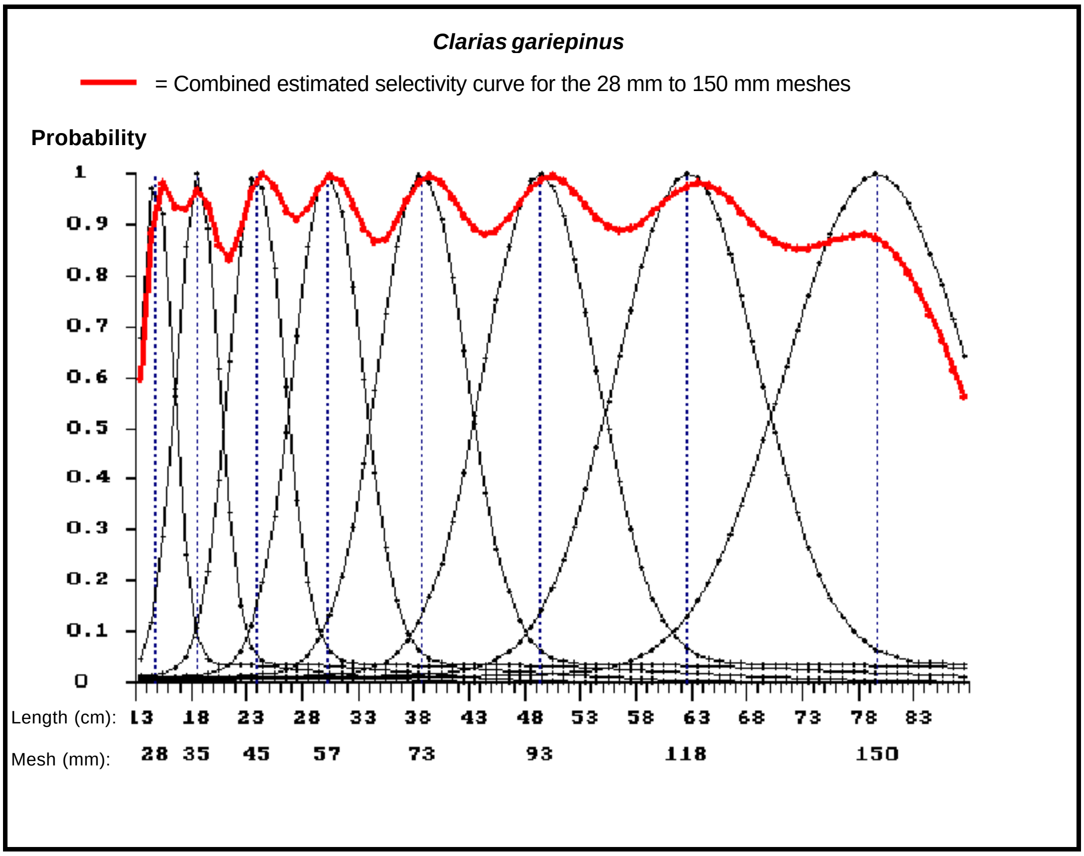


Figure 7.10: Gill net selectivity curves for *Clarias gariepinus* and the combined estimated selectivity curve for the gill net meshes.

Tilapia sparrmanii

The probability of sampling *Tilapia sparrmanii*, with the 22mm to 57mm mesh sizes, in the 5cm to 16cm length range, with length classes representative of each mesh size was high (Figure 7.11).

The length based catch curve corrected for selectivity (Figure 7.26) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 1cm to 6cm length range were however sampled with the other gear (Figure 9.14, Chapter 9). The length frequencies recorded are representative of the species length range.

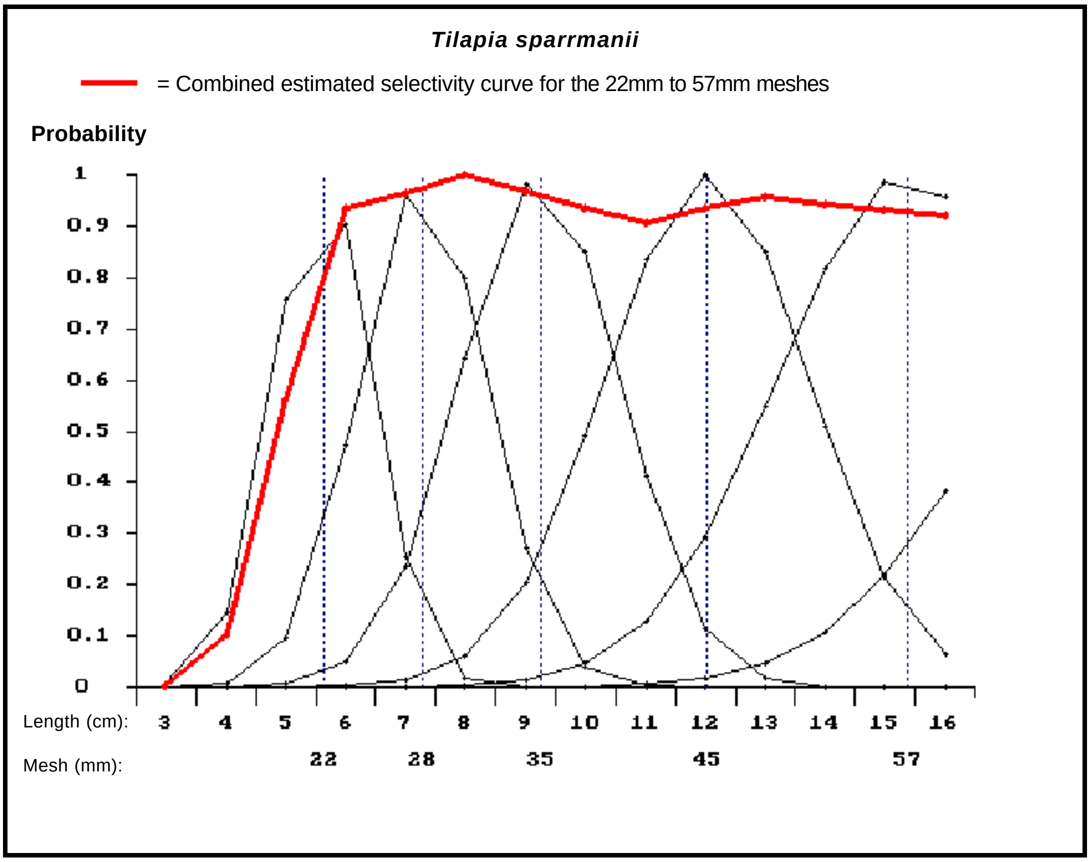


Figure 7.11: Gill net selectivity curves for *Tilapia sparrmanii* and the combined estimated selectivity curve for the gill net meshes.

Pharyngochromis acuticeps

The probability of sampling *Pharyngochromis acuticeps*, with the 22mm to 57mm mesh sizes, in the 6cm to 17cm length range, with length classes representative of each mesh size was high (Figure 7.12).

The length based catch curve corrected for selectivity (Figure 7.26) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 1cm to 6cm length range were, however, sampled with the other gear (Figure 9.16, Chapter 9). The length frequencies recorded are representative of the species length range.

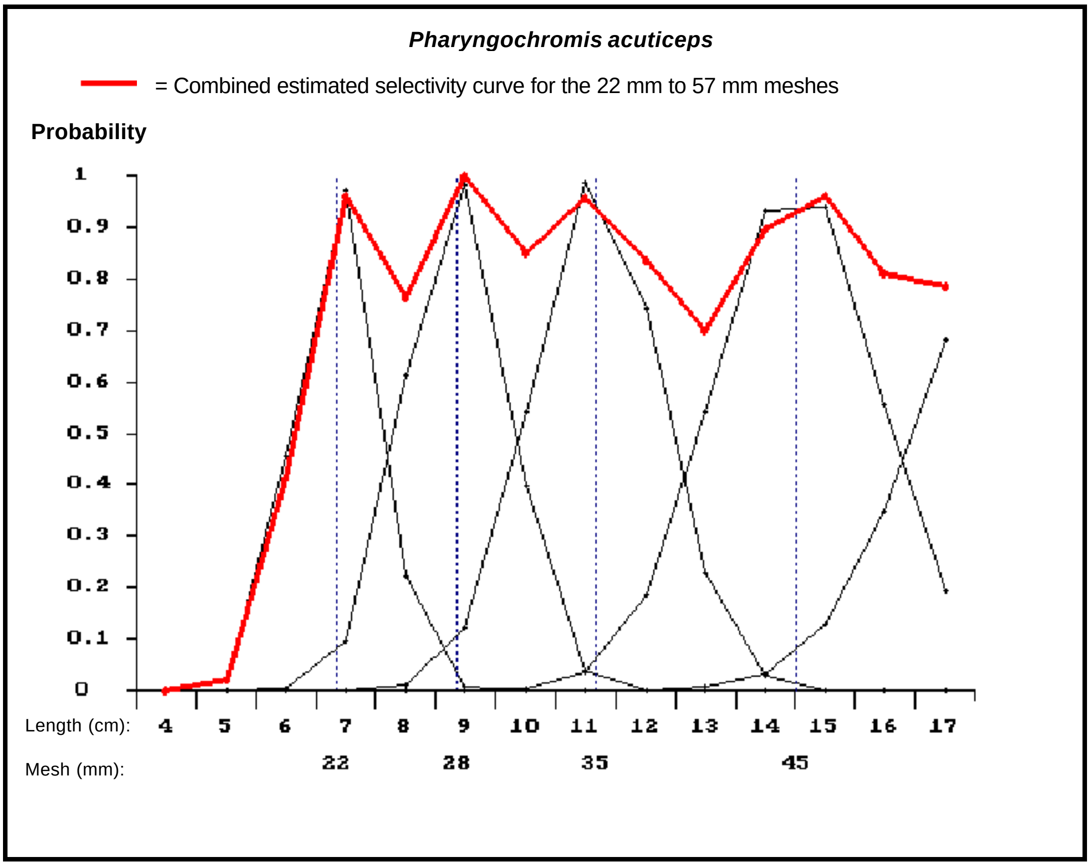


Figure 7.12: Gill net selectivity curves for *Pharyngochromis acuticeps* and the combined estimated selectivity curve for the gill net meshes.

Barbus poechii

The probability of sampling *Barbus poechii*, with the 22mm to 45mm mesh sizes, in the 7cm to 12cm length range, with length classes representative of each mesh size was high (Figure 7.13).

The length based catch curve corrected for selectivity (Figure 7.27) shows the absence of specimens in the 5cm length class from the gill net catch composition. The other lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 3cm to 6cm length range were however sampled with the other gear (Figure 9.18, Chapter 9). The length frequencies recorded are representative of the species length range.

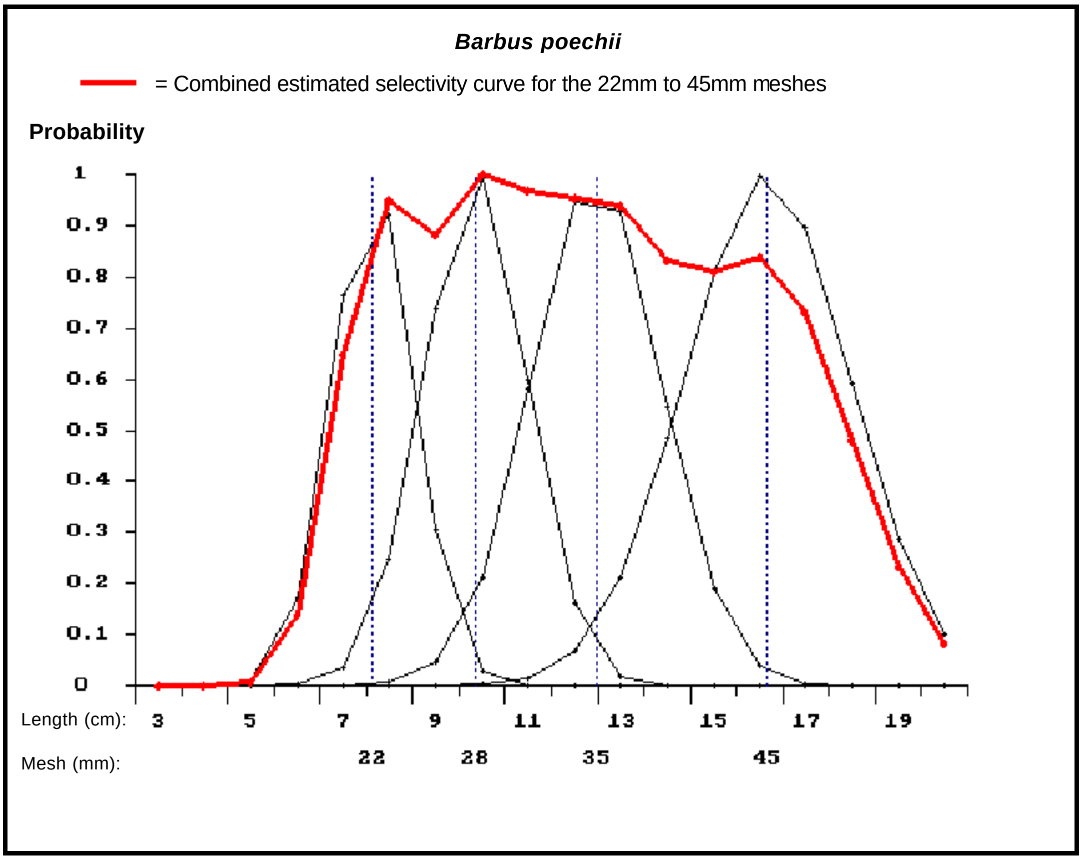


Figure 7.13: Gill net selectivity curves for *Barbus poechii* and the combined estimated selectivity curve for the gill net meshes.

Hepsetus odoe

The probability of sampling *Hepsetus odoe*, with the 22mm to 73mm mesh sizes, in the 11cm to 29cm length range, with length classes representative of each mesh size was high. The graph indicates a degree of skewness (bi-modal selectivity curve), which is characteristic of species caught by different mechanisms (see section 7.2.3) (Figure 7.14). *Hepsetus odoe* was often entangled by its teeth.

The length based catch curve corrected for selectivity (Figure 7.27) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 3cm and 10cm length classes were however sampled with the other gear (Figure 9.22, Chapter 9). The length frequencies recorded are representative of the species length range.

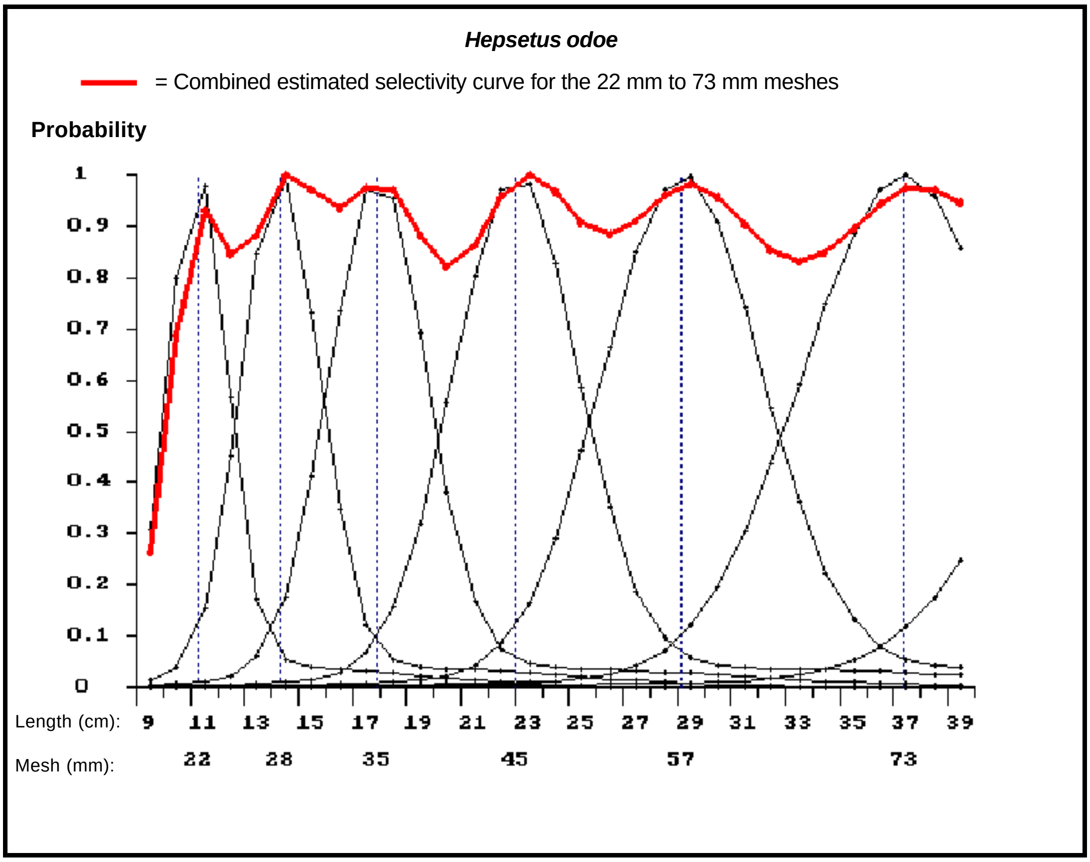


Figure 7.14: Gill net selectivity curves for *Hepsetus odoe* and the combined estimated selectivity curve for the gill net meshes.

Pseudocrenilabrus philander

The probability of sampling *Pseudocrenilabrus philander*, with the 22mm to 35mm mesh sizes, in the 5cm to 10cm length range, with length classes representative of each mesh size is high (Figure 7.15).

The length based catch curve corrected for selectivity (Figure 7.27) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 1cm to 9cm length range were however sampled with the other gears (Figure 9.24, Chapter 9). The length frequencies recorded are representative of the species length range.

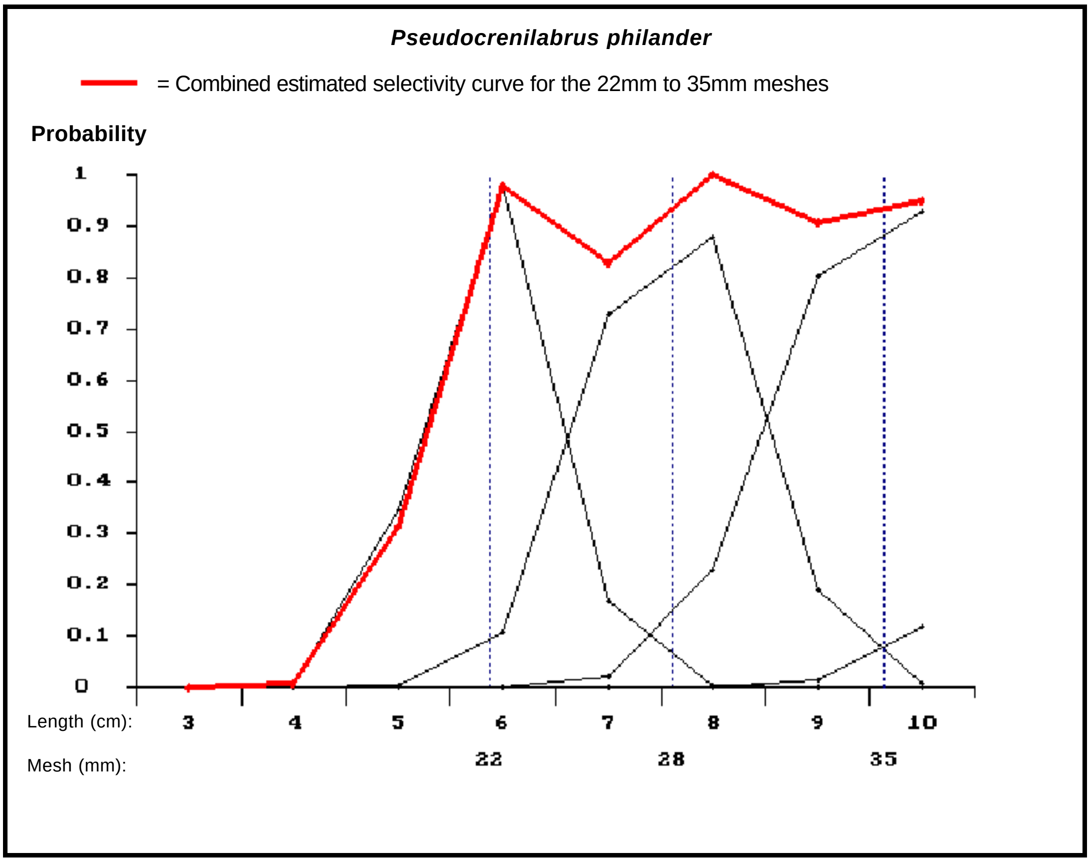


Figure 7.15: Gill net selectivity curves for *Pseudocrenilabrus philander* and the combined estimated selectivity curve for the gill net meshes.

Tilapia rendalli

Few specimens of *Tilapia rendalli* were sampled in the gill nets (N = 15). The probability of sampling *Tilapia rendalli*, with the 22mm to 118mm mesh sizes, in the 5cm to 31cm length range, with length classes representative of each mesh size was high, except for the 45mm mesh with length class 10cm to 13cm (Figure 7.16). This species was difficult to collect as it occurred mostly on floodplains and in marsh like areas, which were difficult to survey. The local fishermen, however, caught this species regularly probably due to the effectiveness and manoeuvrability of their mikolo's (narrow wood carved boats) in these areas.

The length based catch curve corrected for selectivity (Figure 7.27) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 1cm to 14cm length range were however sampled with the other gear (Figure 9.26, Chapter 9). The length frequencies recorded are representative of the species length range, although large specimens were not abundant.

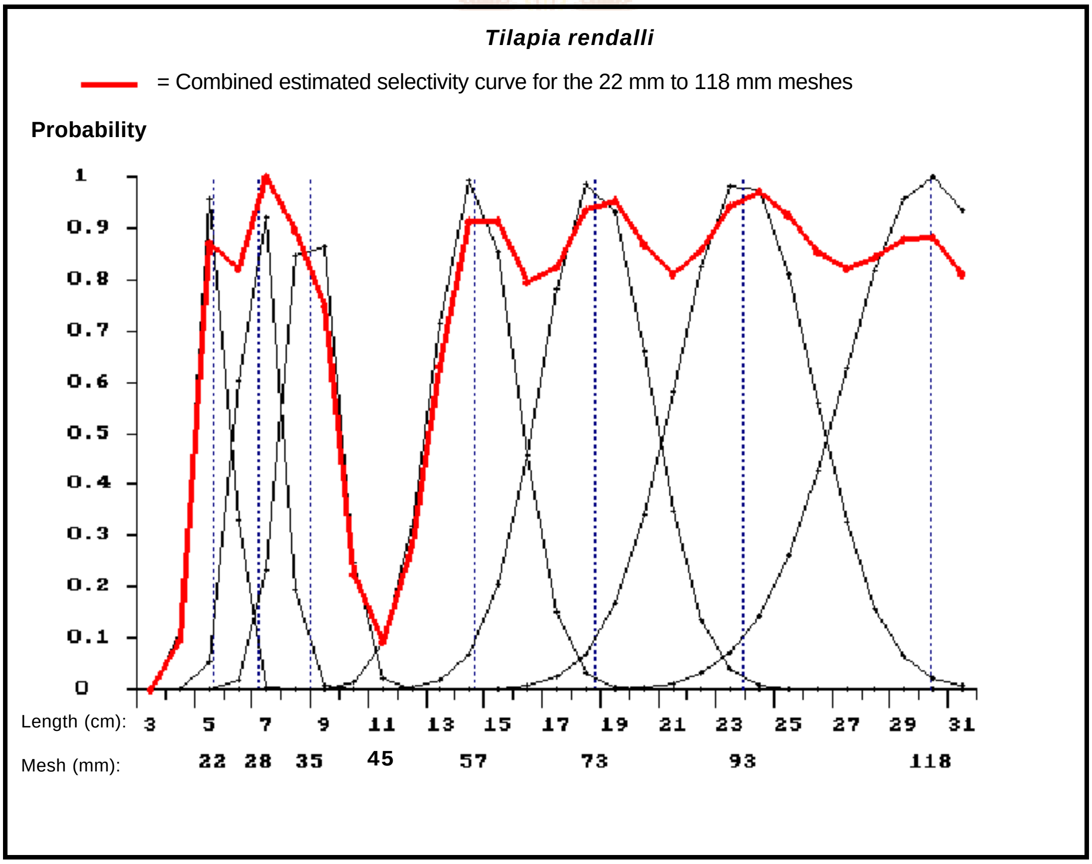


Figure 7.16: Gill net selectivity curves for *Tilapia rendalli* and the combined estimated selectivity curve for the gill net meshes.

Hemichromis elongatus

The probability of sampling *Hemichromis elongatus*, with the 22mm to 57mm mesh sizes, in the 5cm to 19cm length range, with length classes representative of each mesh size was high (Figure 7.17).

The length based catch curve corrected for selectivity (Figure 7.27) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 1cm to 10cm length range were however sampled with the other gear (Figure 9.32, Chapter 9). The length frequencies recorded are representative of the species length range.

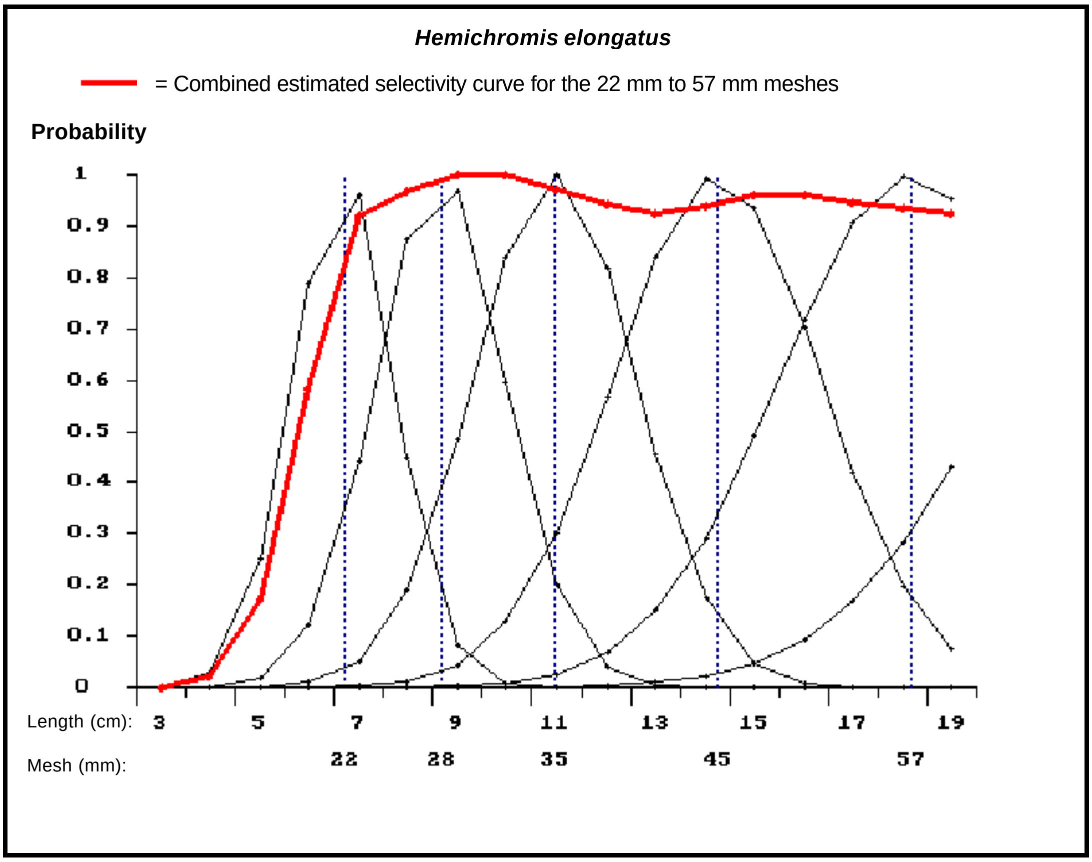


Figure 7.17: Gill net selectivity curves for *Hemichromis elongatus* and the combined estimated selectivity curve for the gill net meshes.

Oreochromis macrochir

The probability of sampling *Oreochromis macrochir*, with the 35mm to 150mm mesh sizes, in the 8cm to 35cm length range, with length classes representative of each mesh size was high (Figure 7.18).

The length based catch curve corrected for selectivity (Figure 7.27) shows minor adjustments to the catch composition, indicating that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens in the 2cm to 7cm length range were however sampled with the other gear (Figure 9.30, Chapter 9). The length frequencies recorded are representative of the species length range.

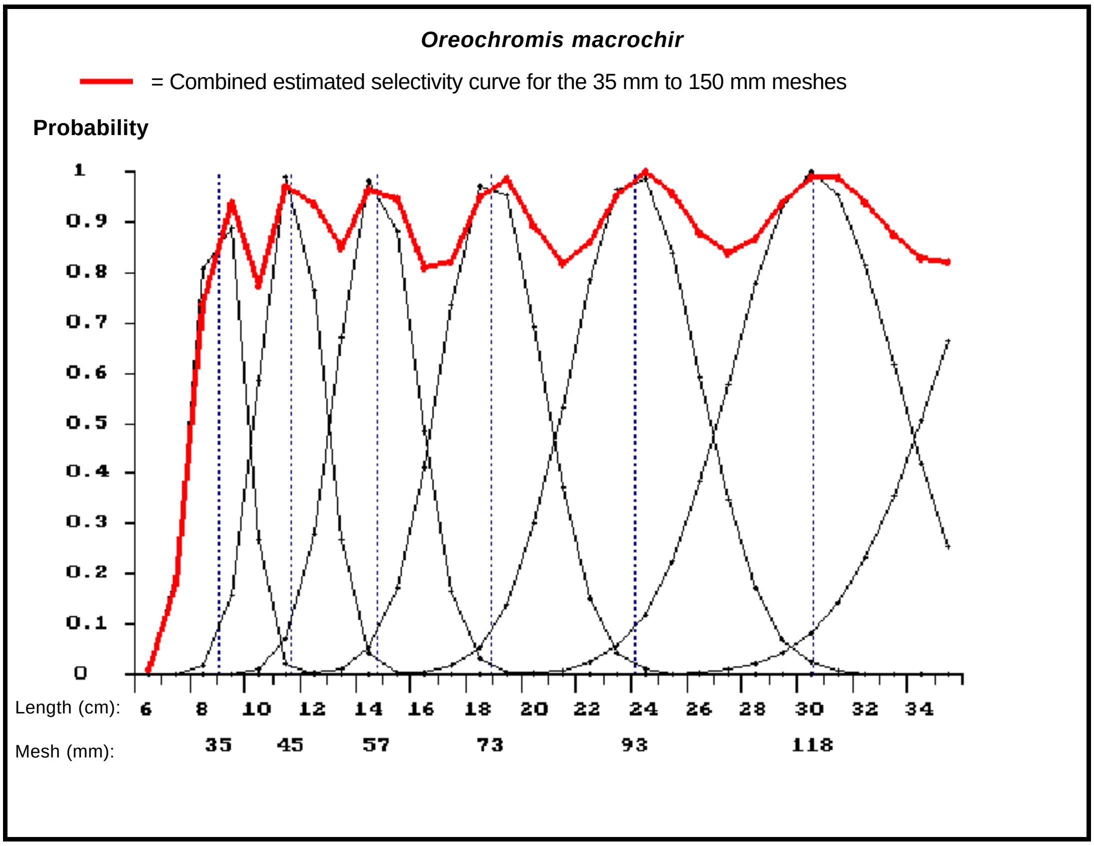


Figure 7.18: Gill net selectivity curves for *Oreochromis macrochir* and the combined estimated selectivity curve for the gill net meshes.

Serranochromis macrocephalus

The probability of sampling *Serranochromis macrocephalus*, with the 28mm to 93mm mesh sizes, in the 10cm to 28cm length range, with length classes representative of each mesh size was high (Figure 7.19).

The length based catch curve corrected for selectivity (Figure 7.27) indicate that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens of *Serranochromis* spp. (some of which were *Serranochromis macrocephalus*) in the 3cm to 11cm length range were sampled with the other gear (Figure 9.41, Chapter 9). The length frequencies recorded are representative of the species length range.

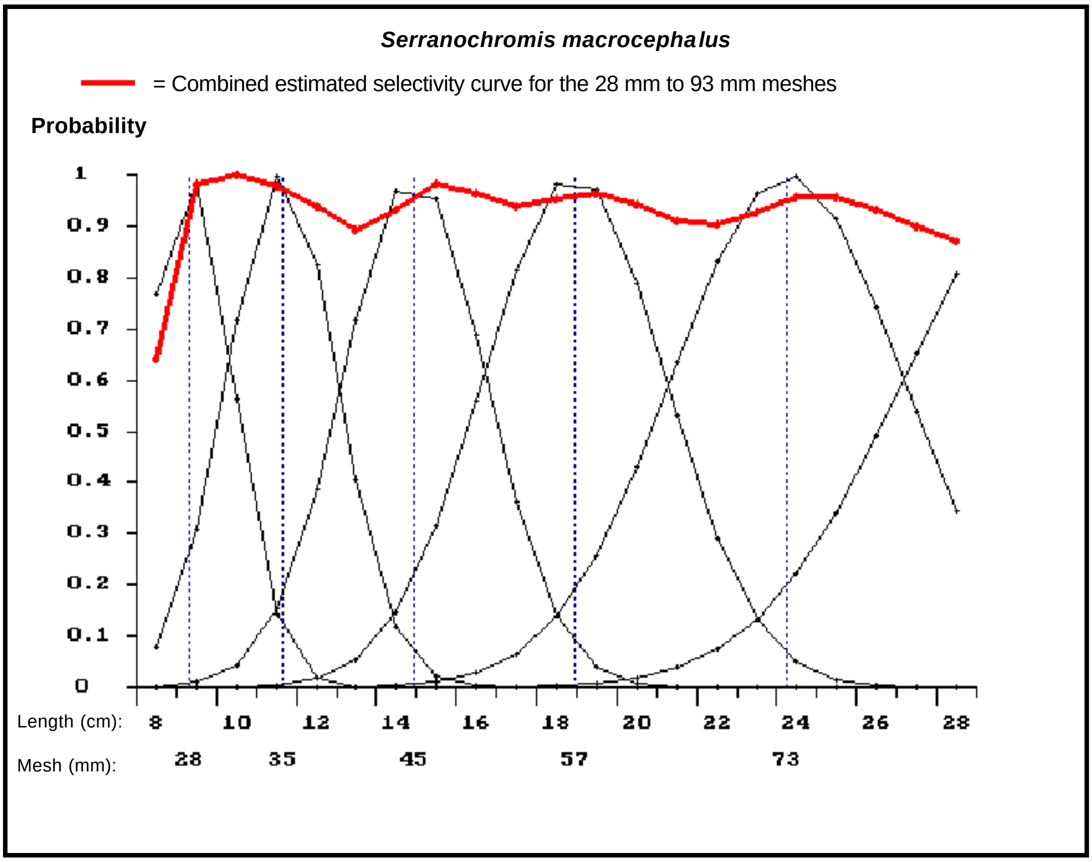


Figure 7.19: Gill net selectivity curves for *Serranochromis macrocephalus* and the combined estimated selectivity curve for the gill net meshes.

Serranochromis robustus

The probability of sampling *Serranochromis robustus*, with the 45mm to 118mm mesh sizes, in the 15cm to 37cm length range, with length classes representative of each mesh size was high. The probability of sampling specimens in the 28mm and 35mm mesh in the 9cm to 14cm length range was however lower. Specimens were not sampled in the 35mm mesh (Figure 7.20).

The length based catch curve corrected for selectivity (Figure 7.27) indicate adjustments for species not sampled in the 9cm to 15cm length range, due to low catches in the 28mm and 35mm meshes. The lengths of the specimens sampled in the 45mm to 118mm gill net meshes are however representative of the species length classes likely to be sampled in these different gill net meshes.

Several small specimens of *Serranochromis* spp. (some of which were *Serranochromis robustus*) in the 3cm to 11cm length range were sampled with the other gear (Figure 9.41, Chapter 9). The length frequencies recorded are representative of the species length range.

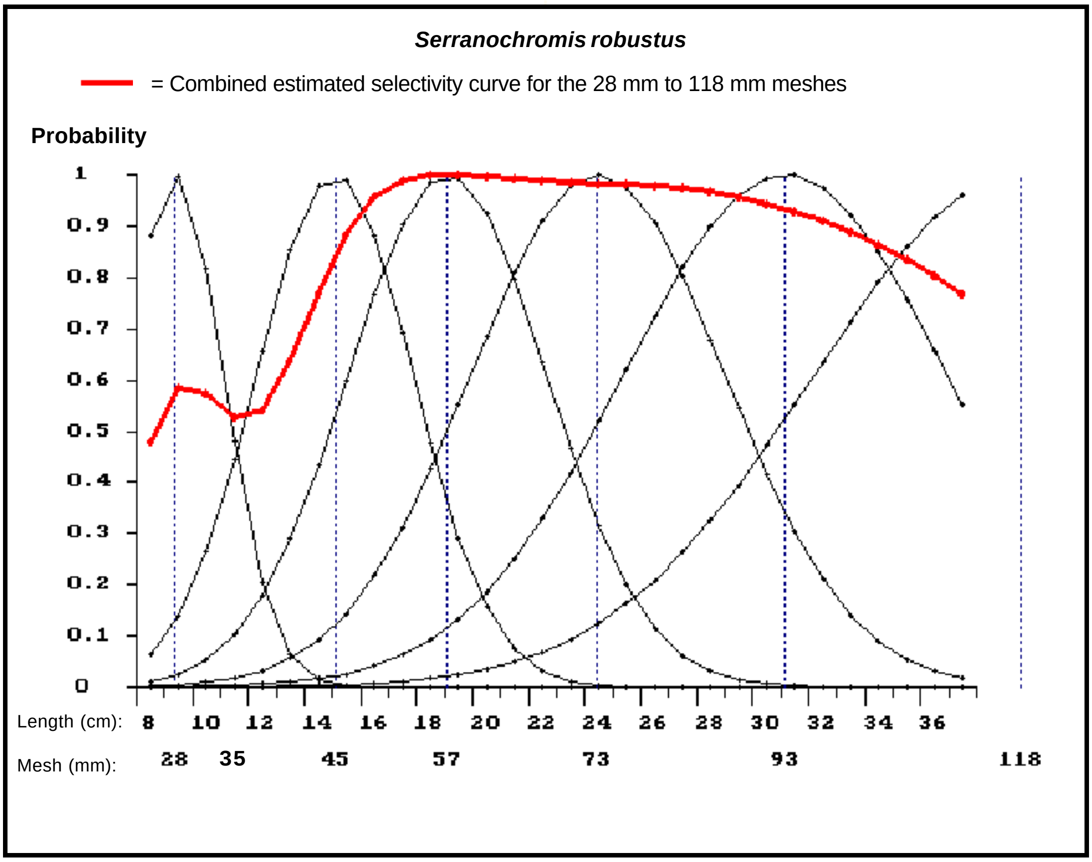


Figure 7.20: Gill net selectivity curves for *Serranochromis robustus* and the combined estimated selectivity curve for the gill net meshes.

Sargochromis **spp.**

The probability of sampling the *Sargochromis* spp. (*Sargochromis codringtonii, Sargochromis giardi, Sargochromis carlottae*), with the 28mm to 118mm mesh sizes, in the 9cm to 38cm length range, with length classes representative of each mesh size was high (Figure 7.21).

The length based catch curve corrected for selectivity (Figure 7.28) indicate that the lengths of the specimens sampled in the gill nets are representative of the species length classes likely to be sampled in the different gill net meshes.

Several small specimens of the *Sargochromis* spp. in the 7cm to 9cm length range were sampled with the other gear (Figure 9.40, Chapter 9). The length frequencies recorded are representative of the length range for this group of species.

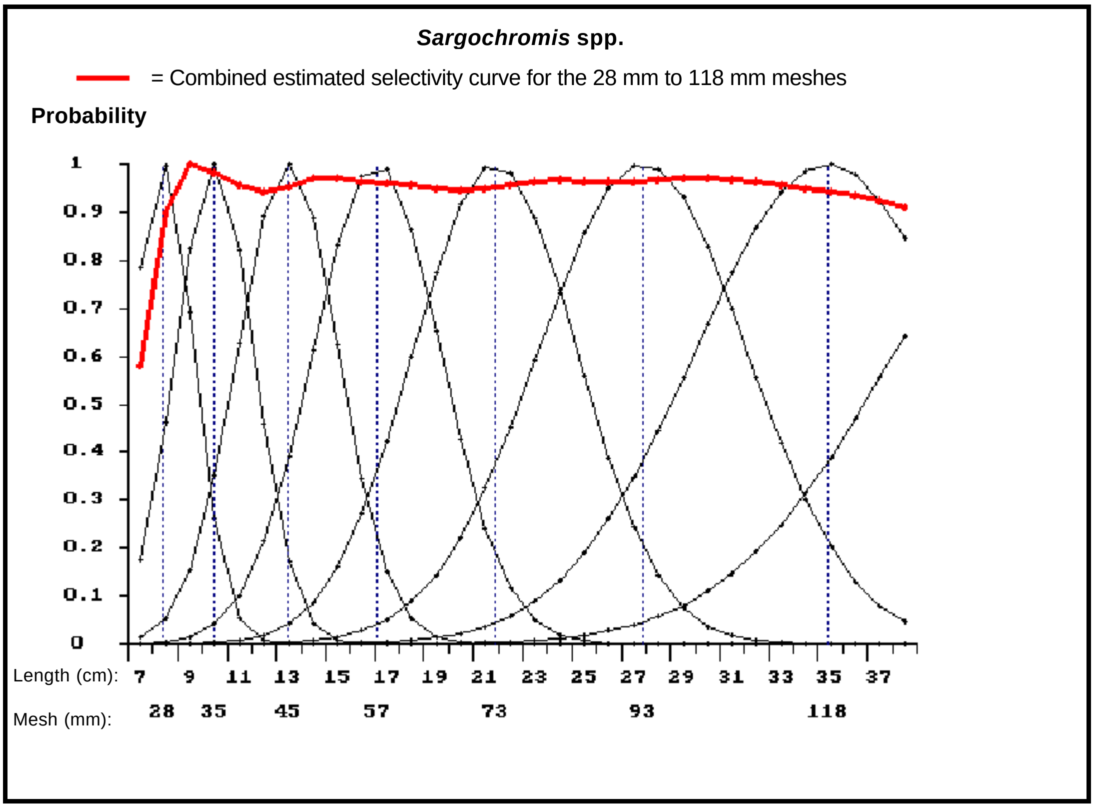


Figure 7.21: Combined gill net selectivity curves for *Sargochromis giardi, Sargochromis carlottae* and *Sargochromis codringtonii*, and the combined estimated selectivity curve for the gill net meshes.

Serranochromis spp.

The probability of sampling the *Serranochromis* spp. (*Serranochromis angusticeps, Serranochromis altus, Serranochromis longimanus*), with the 22mm to 118mm mesh sizes, in the 7cm to 43cm length range, with length classes representative of each mesh size was high (Figure 7.22). These species were grouped due to the similarity in their narrowly shaped bodies. *Serranochromis longimanus* is a smaller species however, and large specimens were not sampled. This species was mostly sampled in the 22mm to 35mm meshes.

The length based catch curve corrected for selectivity (Figure 7.28) indicate that the lengths of the specimens, from this group of species, sampled in the gill nets are representative of the length classes likely to be sampled in the different gill net meshes.

Several small specimens of the *Serranochromis* spp. in the 3cm to 9cm length range were sampled with the other gear (Figure 9.41, Chapter 9). The length frequencies recorded are representative of the length range for this group of species.

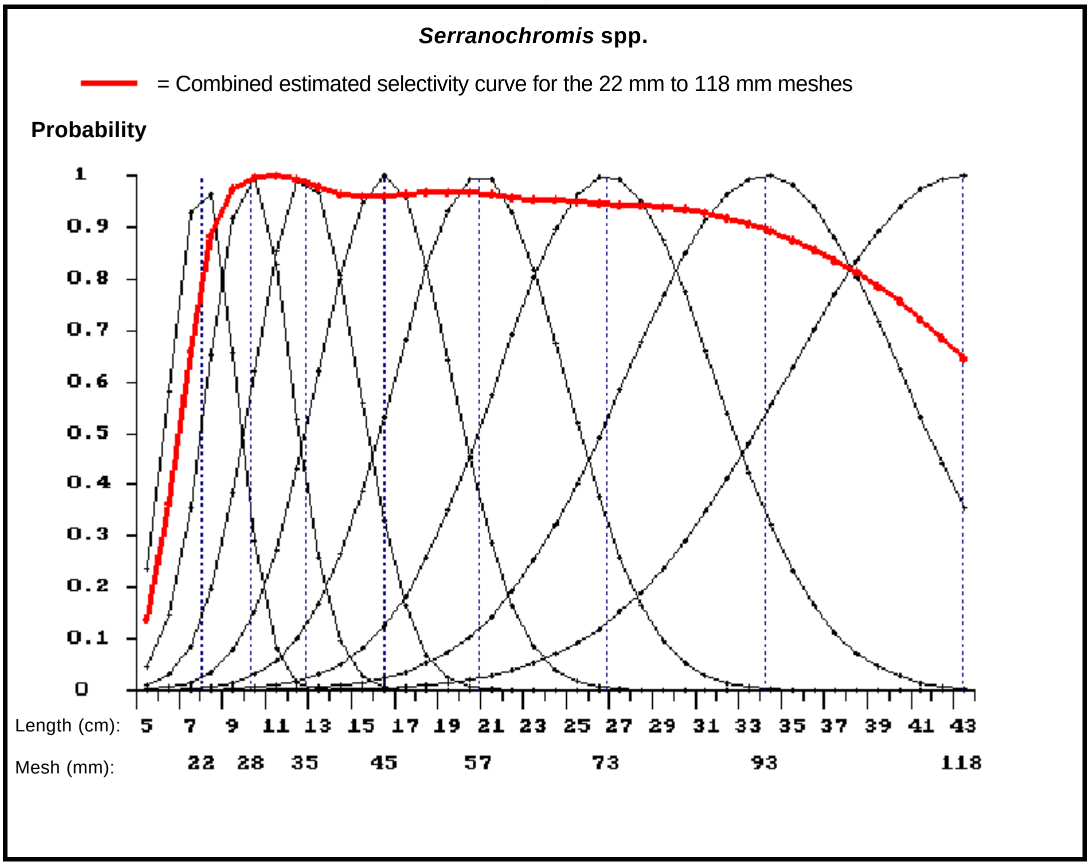


Figure 7.22: Gill net selectivity curves for *Serranochromis altus, Serranochromis angusticeps* and *Serranochromis longimanus*, and the combined estimated selectivity curve for the gill net meshes.

Ctenopoma multispine

The probability of sampling *Ctenopoma multispine*, with the 22mm to 35mm mesh sizes, in the 7cm to 17cm length range, with length classes representative of each mesh size was high (Figure 7.23).

The length based catch curve corrected for selectivity (Figure 7.28) indicates adjustments for species not sampled in the 7cm to 10cm length range. The lengths of the specimens sampled are however representative of the species length classes likely to be sampled in these gill net meshes.

Several small specimens in the 3cm to 7cm length range were sampled with the other gear (Chapter 9), and the length frequencies recorded are representative of the species length range.

Figure 7.23 indicates that it is the most likely to sample specimens in the 7.6cm to 17cm range.

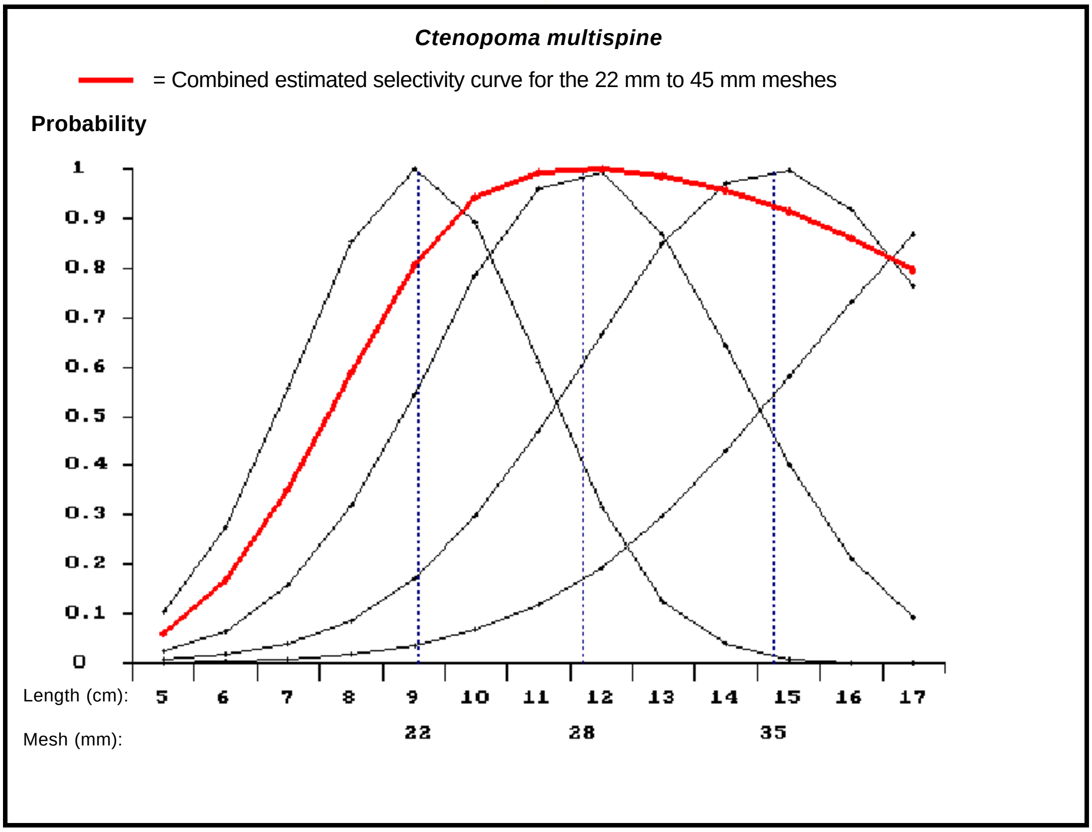


Figure 7.23: Gill net selectivity curves for *Ctenopoma multispine* and the combined estimated selectivity curve for the gill net meshes.

Labeo lunatus

The probability of sampling *Labeo lunatus*, with the 35mm to 57mm mesh sizes, in the 14cm to 26cm length range, with length classes representative of each mesh size was high (Figure 7.24).

The length based catch curve corrected for selectivity (Figure 7.28) indicates minor adjustments for species not sampled in the 14cm to 18cm length range. The lengths of the specimens sampled are however representative of the species length classes likely to be sampled in these gill net meshes.

Small specimens in the 1cm to 13cm length range were not sampled during the study (Figure 9.36, Chapter 9).

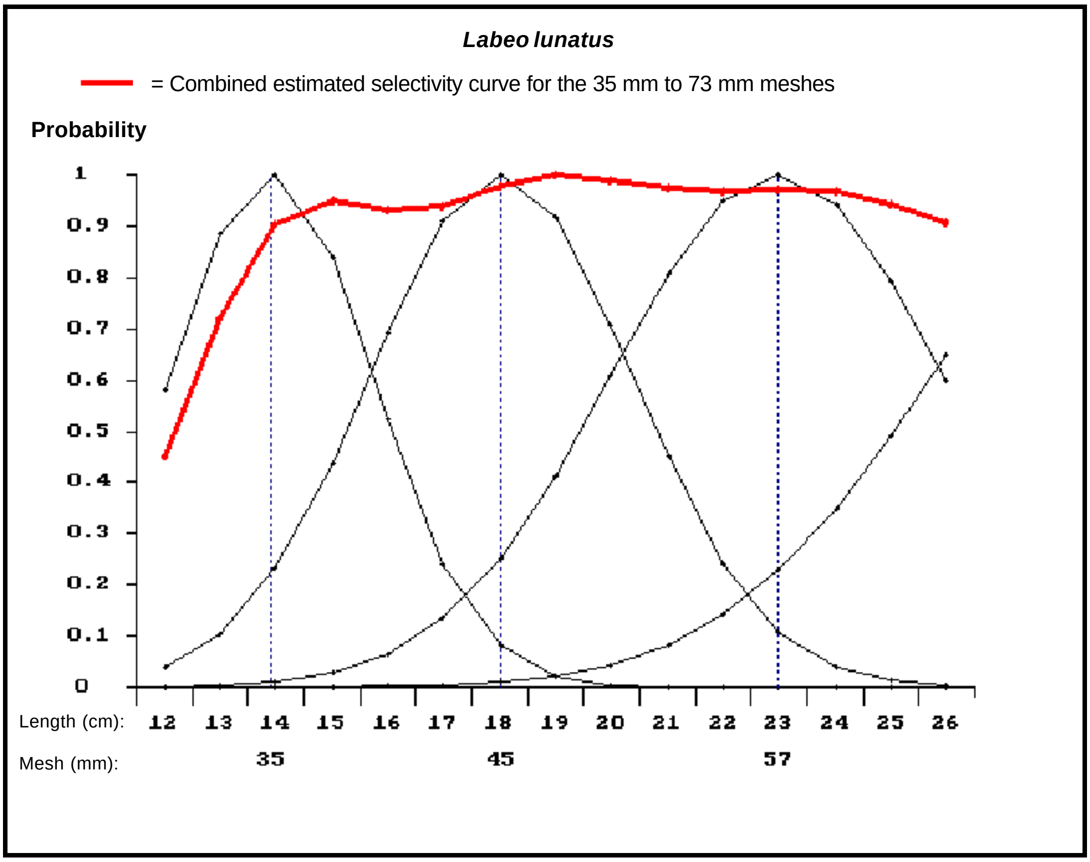


Figure 7.24: Gill net selectivity curves for *Labeo lunatus* and the combined estimated selectivity curve for the gill net meshes.

Labeo cylindricus

The probability of sampling *Labeo cylindricus*, in length ranges 8.6cm to 9.3cm in the 22mm mesh, 10.9cm to 11.6cm in the 28mm mesh, and 13.7cm to 14cm in the 35mm mesh, were the most likely (Figure 7.25).

The length based catch curve corrected for selectivity (Figure 7.28) indicates adjustments for species sampled in the 8cm length class. The lengths of the specimens sampled are however representative of the species length classes likely to be sampled in these gill net meshes.

Several specimens (206) of *Labeo cylindricus* were however sampled in the 4 – 14cm length range with the gill nets and the other gear (Figure 9.36, Chapter 9). *Labeo cylindricus* is not a large species, and specimens were sampled in the species length range.

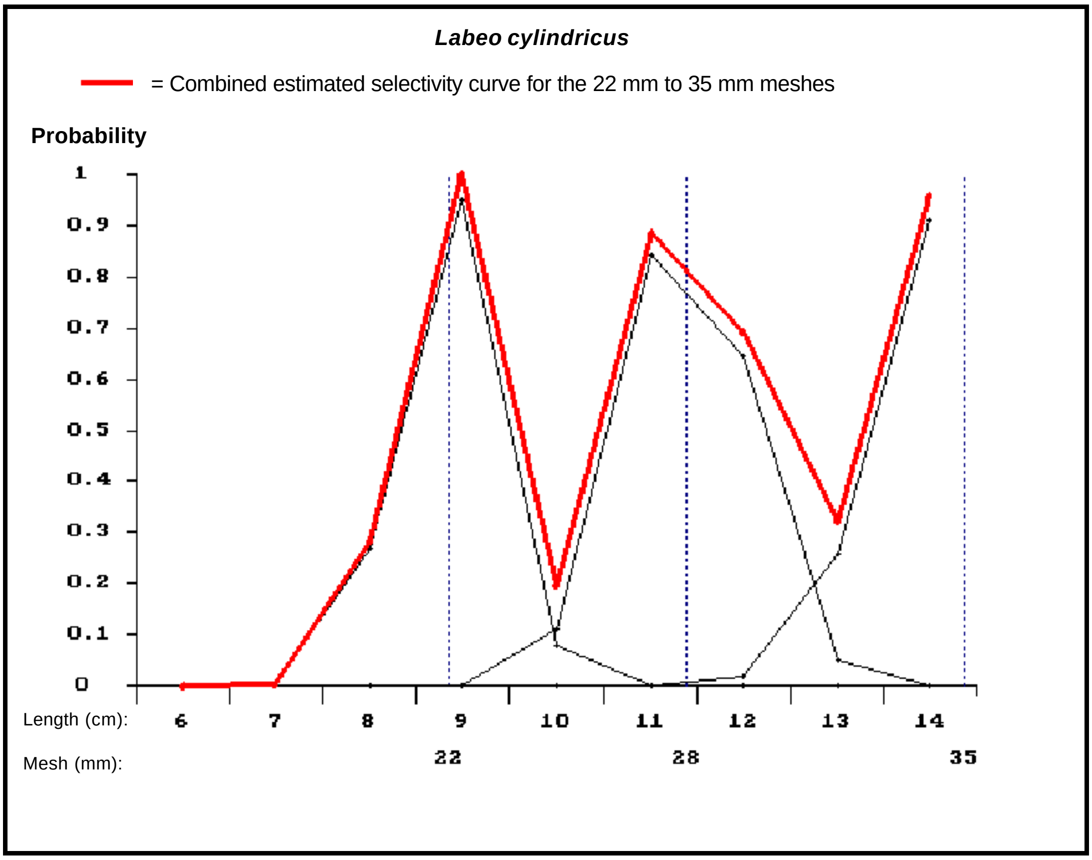


Figure 7.25: Gill net selectivity curves for *Labeo cylindricus* and the combined estimated selectivity curve for the gill net meshes.

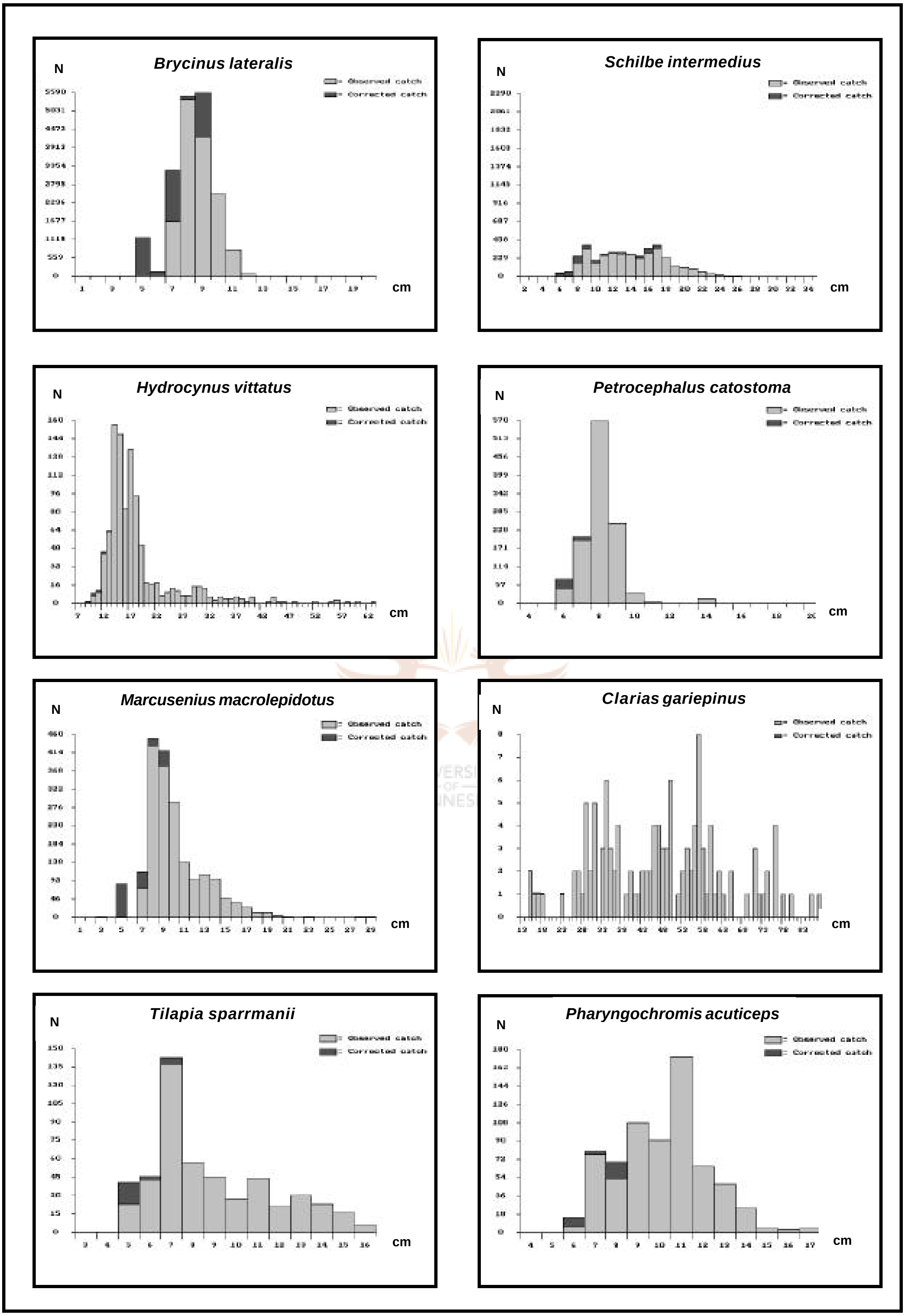


Figure 7.26: Length based catch curves corrected for estimated selectivity, for selected species, sampled with the gill nets (22mm to 150mm mesh sizes).

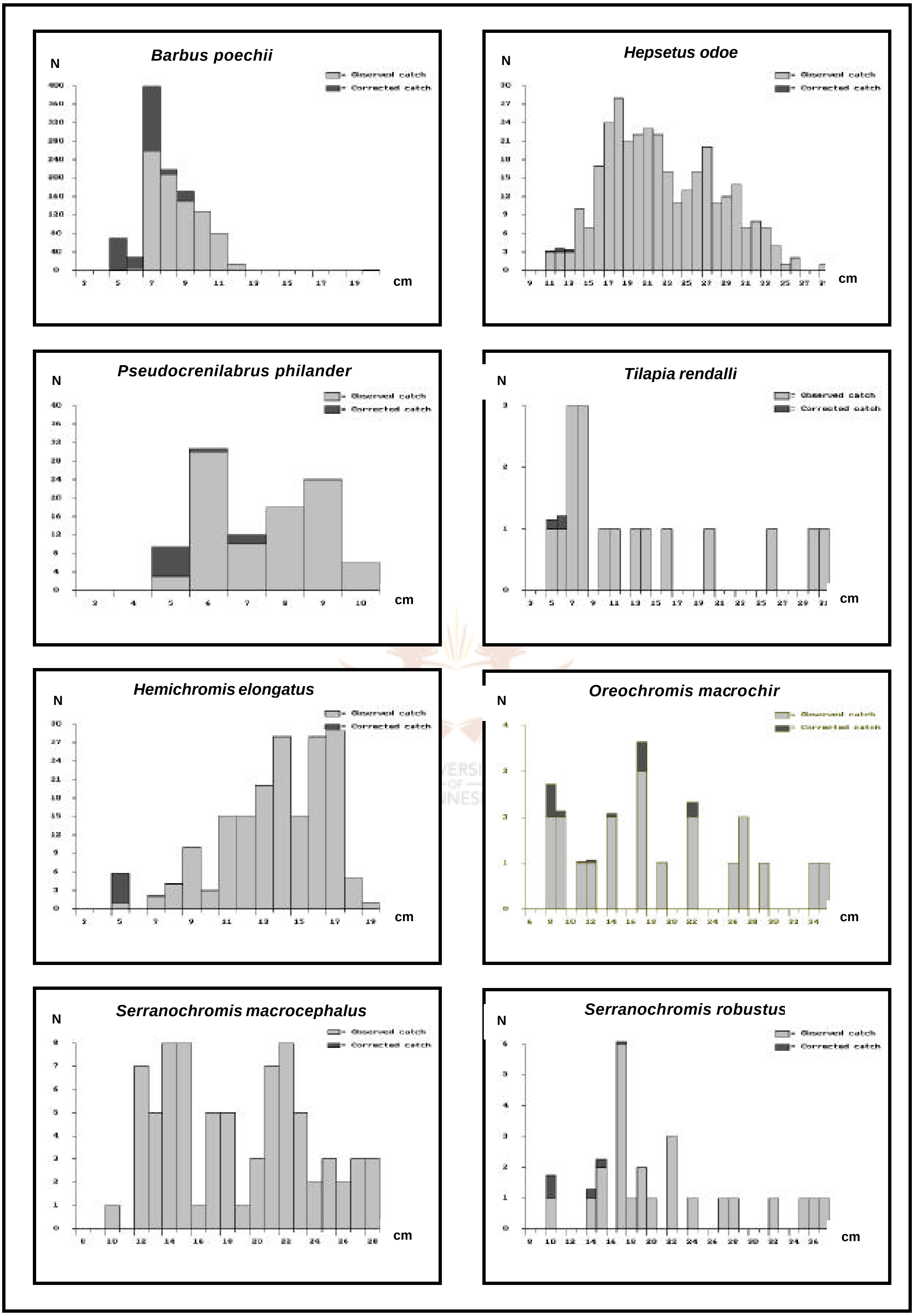


Figure 7.27: Length based catch curves corrected for estimated selectivity, for selected species, sampled with the gill nets (22mm to 150mm mesh sizes).

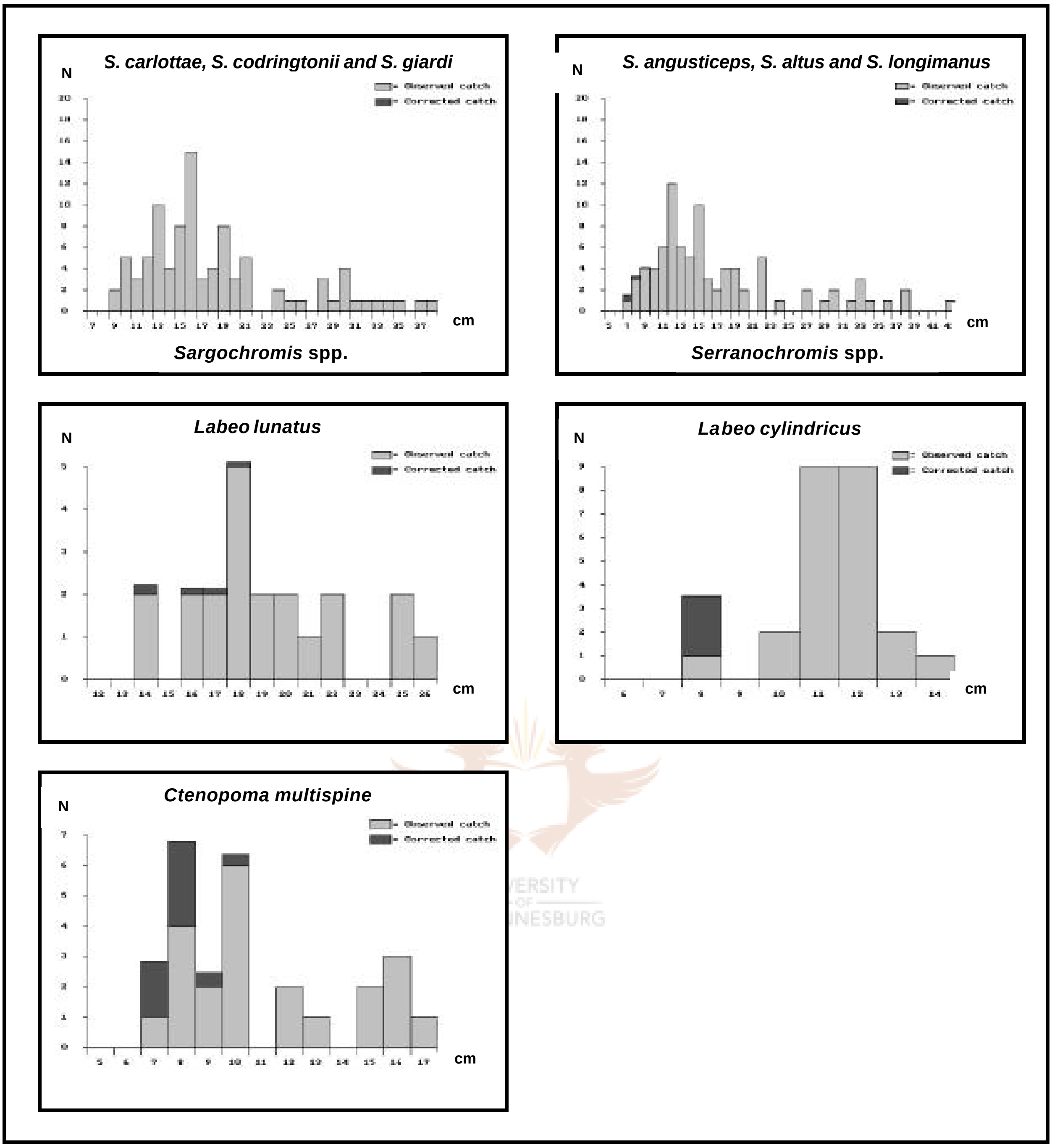


Figure 7.28: Length based catch curves corrected for estimated selectivity, for selected species, sampled with the gill nets (22mm to 150mm mesh sizes).

The length based catch curves corrected for estimated selectivity apply for the gill nets only, and may indicate corrections in the sampling results of the gill nets. These corrections are usually overcome by the other sampling gear, which usually sampled specimens in the length ranges absent from the length ranges sampled with the gill nets (see Chapter 9).

7.4 CONCLUSION

The gill net selectivity data may be of importance in the formulation of legislation. The data provides information on which species is targeted with certain mesh sizes. Legislation can then be formulated to protect certain vulnerable or sensitive species. Regulation on gill nets should therefore include mesh sizes from which sensitive species are excluded.

Mature specimens from the larger species may be protected, as breeding stock. If certain length ranges with representative adult specimens is identified for sensitive species, the relevant mesh sizes should be selected to exclude these species lengths from the local gill net catches (see Chapter 8, for average lengths at maturity).

The length frequency data and estimated gill net selectivity in this chapter indicated that representative lengths for most of the species were recorded from the fish population. The other gears used helped to sample specimens in length classes that may have been missed with the gill nets.

The estimated gill net selectivity for each mesh also indicates that the different meshes were effective in sampling the relevant length frequencies from the fish population.

8 GONAD MATURATION

8.1 INTRODUCTION

In this chapter the gonad maturation was recorded for the fish sampled, during high and low flood, in the Eastern Caprivi. The gonad maturation indices indicate which species showed signs of gonadal development during the two seasons (spring and autumn). With this data it can then be determined during which season the species are likely to spawn, and whether they spawn more than once a year (serial/multiple spawners). The gonadal development is linked to the flood cycle and temperature, and we can surmise if spawning, for some species, is flood induced. One of the methods of determining this is by studying the gonads.

With the gonadal development data and length frequency data it is possible to determine whether fish are reproducing successfully. Length cohorts recorded in the length frequency data may be used to indicate juvenile, immature and mature specimens. The length cohorts may therefore give an indication whether fish spawned successfully during previous seasons (see Chapter 9).

8.2 MATERIALS AND METHODS

Two gonad maturation indices, high and low flood, are given in Table 8.1 and 8.2. Included in the tables are male to female ratio, stages for males and females, and the mean length of the males and females studied for gonadal development.

Gonad development were categorized in five stages:

1 = Immature or juvenile

2 = Noticeable egg/sperm development, early stage (Adult)

3 = Ready for spawning or fully developed eggs/sperm (Adult)

4 = Spent gonads (Post-spawning) (Adult)

5 = Resting/latent (Adult)

The gonad maturation was studied and categorized after the specimens were sampled. The data listed in the gonad maturation indices were for sexually mature individuals. The mean length was recorded for these specimens, and this may give an indication of the average length at maturity (males and females separately).

8.3 RESULTS

8.3.1 High Flood/Autumn Maturities

Mormyridae

Only two specimens from the males that were sexed, in the Mormyridae family, showed noticeable sperm development (stage 2), the rest of the males (476) all had resting or latent gonads (stage 5). Twelve females showed the early stages of noticeable gonad development (stage 2), and 233 female specimens had spent gonads (stage 4), indicating that spawning had taken place before the survey. The rest of the females (554) were resting, and had latent gonads. None of the males or females in the Mormyridae family had ripe gonads ready for spawning during the high flood surveys (Table 8.1).

Cyprinidae

One male from the Cyprinidae family showed early stages of gonadal development during high flood, but the rest of the males (46) had resting or latent gonads. The gonads of the females that were sexed indicated some spawning activity, 21 specimens showed early stages of gonadal development, and three specimens had ripe gonads, ready for spawning. Three specimens of the females that were examined had spent gonads, and 86 had resting gonads (Table 8.1).

Characidae

Of the specimens studied in this family *Brycinus lateralis* had 568 males with early stages of gonadal development, one that had ripe gonads, five had spent gonads, and 1469 specimens had resting gonads. Of the females of *Brycinus lateralis*, 159 had developing gonads (stage 2), three had ripe gonads, 757 specimens had spent gonads, and 1691 had resting gonads (Table 8.1).

Most of the *Micralestes acutidens* specimens (male and female) had resting gonads, and only two females had spent gonads. *Hydrocynus vittatus* had two males and two females with early stages of gonadal development, three females had spent gonads, and the rest of the males (35) and females (90) had resting gonads (Table 8.1)

Hepsetidae

The *Hepsetus odoe* males all had resting gonads, but 15 females showed early stages of gonadal development, and one had ripe gonads. Of the females 36 specimens had resting gonads (Table 8.1).

Claroteidae

Parauchenoglanis ngamensis had one mature female with resting gonads.

Schilbeidae

Male specimens of *Schilbe intermedius* mostly had resting gonads (384), with three showing early stages of gonadal development. Of the females, 23 had gonads with early egg development, one was ripe, and 12 had spent gonads. The majority of the females (699) were resting (Table 8.1).

Clariidae

Most of the males examined in this family (38) had resting gonads, except for *Clarias gariepinus*, which had two males with early gonadal development. Most of the females (40) were also resting, except for three females from *Clarias gariepinus*, which had spent gonads, and five females from *Clarias theodorae*, which had five ripe females ready for spawning (Table 8.1).

Mochokidae

Most of the specimens in this family were resting, except for one female with developing eggs, and another with spent gonads.

Cichlidae

Most of the males in this family had resting gonads (110), and six males showed early stages of gonadal development. Fourteen females (from different species) showed early stages of egg development, 35 had spent gonads, and 80 were resting.

Anabantidae

Ctenopoma multispine had two males with developing gonads, and one female with spent gonads. The rest of the specimens in the family were resting (Table 8.1).

Table 8.1: Gonad maturation index (in numbers) for the species sampled during high floods, in the Eastern Caprivi.

Species	Autumn										
	M:F Ratio	Stages								Mean Length (cm)	
		Males (%)				Females (%)					
		2	3	4	5	2	3	4	5	M	F
Table 8.1											
Mormyridae											
Mormyrus lacerda	3:1				3				1	29.3	17
Hippopotamyrus ansorgii	1:1				1	1				7.2	8
Hippopotamyrus discorhynchus	1:2.3				16			3	33	10.9	9.1
Marcusenius macrolepidotus	1.2:1	1			185	5		48	101	12.5	12.5
Petrocephalus catostoma	1:2.4	1			254	6		181	411	8	8.5
Pollimyrus castelnaui	1.7:1				17			1	9	6.9	7.3
Cyprinidae											
Opsaridium zambezense	3.5:1				7				2	8.5	8.8

Species	M:F Ratio	Autumn									
		Stages								Mean Length (cm)	
		Males (%)				Females (%)					
		2	3	4	5	2	3	4	5	M	F
Table 8.1											
Barbus radiatus	1:4.3				3	7	2	1	3	8	8.4
Barbus poechii	1:2.5	1			33	11		2	73	10.1	10.6
Barbus cf eutaenia	0:1						1				4.7
Barbus paludinosus	1:3				2	3			3	6.8	8.1
Labeo lunatus	1:5				1				5	14	22.9
Characidae											
Brycinus lateralis	1:1.3	568	1	5	1469	159	3	757	1691	8.8	9.2
Micralestes acutidens	1:5.2				42			2	216	7	7
Hydrocynus vittatus	1:2.6	2			35	2		3	90	28.6	29
Hepsetidae											
Hepsetus odoe	1:1.9				28	15	1		36	27.3	29.4
Claroteidae											
Parauchenoglanis ngamensis	0:1								1		14.1
Schilbeidae											
Schilbe intermedius	1:1.9	3			384	23	1	12	699	15.9	17.9
Clariidae											
Clarias gariepinus	1:1.4	2			26			3	35	59.3	51.7
Clarias ngamensis	1.8:1				7				4	56.4	42
Clarias theodorae	1:1.2				5		5		1	21.2	21.6
Mochokidae											
Synodontis nigromaculatus	1:2				1				2	14	15.5
Synodontis macrostigma	0:1							1			10.5
Synodontis spp.	1:2				4	1			7	13.5	16.5
Cichlidae											
Hemichromis elongatus	1:1.3				29	1		14	23	13.9	14.2
Pseudocrenilabrus philander	1:8				1			1	7	3.4	6.8
Pharyngochromis acuticeps	1:1.2	1			21	2		10	14	10.5	10.3
Sargochromis carlottae	2:1	2			6	1			3	19.3	18.3
Sargochromis codringtonii	1:0				1					21	
Sargochromis giardi	1:1				8	4			4	31.1	28.9
Serranochromis altus	1:1				2	1		1		36.5	31.5
Serranochromis angusticeps	1:1.25				2	1		1	3	27	27
Serranochromis longimanus	2:1				2				1	21	20
Serranochromis macrocephalus	1:1	1			5	1		4	1	26	21.1
Serranochromis robustus	3:1				3	1				25	35
Tilapia sparrmanii	1:1.2	1			19	2		2	19	13	12.2
Tilapia ruweti	2:0				2					7.3	
Tilapia rendalli	1:1.6				3				5	13.2	14.8
Oreochromis andersonii	3:1	1			2			1		32.3	26
Oreochromis macrochir	4:1				4			1		29.5	22
Anabantidae											
Microctenopoma intermedium	1:0				1					6.2	
Ctenopoma multispine	1:1.5	2			4			1	8	10	13.3

8.3.2 Low Flood/Spring Maturities:

Mormyridae

Most of the males (334) in this family had latent gonads, but 51 males had gonads that showed early stages of sperm development (stage 2). Two *Marcusenius macrolepidotus* males had ripe gonads, and were ready to spawn. Of the females, 108 had developing gonads, 20 had ripe gonads ready to spawn, and 84 had spent gonads (Table 8.2).

Cyprinidae

Barbus unitaeniatus and *Barbus radiatus* had one female each with developing gonads. *Barbus poechii* had three males and 13 females with developing gonads (stage 2), one female had ripe gonads, and six had spent gonads, several males and females were sexed with latent gonads (stage 5). *Barbus paludinosus* had three males with ripe gonads, and 12 females with resting gonads. *Labeo lunatus* had one female with developing gonads, and two males and one female with resting gonads (Table 8.2).

Characidae

Several specimens from this family had developing, ripe and spent gonads during the low flood surveys (Table 8.2).

Hepsetidae

Hepsetus odoe had 13 females with developing gonads, and one with spent gonads. Twenty males and 24 females had resting gonads (Table 8.2).

Claroteidae

Parauchenoglanis ngamensis had one female with developing gonads, and one female with ripe gonads. Eight males and two females had latent gonads (Table 8.2).

Schilbeidae

Schilbe intermedius had seven males with ripe gonads, seven females with developing gonads, two females with ripe gonads, and three females with spent gonads. Several males and females had latent gonads (Table 8.2).

Clariidae

Most female and male specimens examined in this family had resting or latent gonads, except for *Clarias gariepinus* and *Clariallabes platyprosopos,* which had one female each with developing gonads (Table 8.2).

Mochokidae

Ten male specimens of the *Synodontis* spp. had ripe gonads (Table 8.2).

Cichlidae

Several of the males and females in this family had developing gonads (stage 2). *Pharyngochromis acuticeps* and *Sargochromis carlottae* had both males and females with ripe gonads, and several of the other species in the Cichlidae family had females with ripe gonads. *Pseudocrenilabrus philander, Tilapia sparrmanii* and *Serranochromis macrocephalus* had females with spent gonads (Table 8.2).

Anabantidae

The specimens of *Microctenopoma multispine* that were examined all had resting gonads (Table 8.2).

Mastacembelidae

Aethiomastacembelus frenatus had two females with developing gonads (Table 8.2).

Table 8.2: Gonad maturation index (in numbers) for the species sampled during low floods, in the Eastern Caprivi.

Species	Spring										
	M:F Ratio	Stages								Mean Length (cm)	
		Males (%)				Females (%)					
		2	3	4	5	2	3	4	5	M	F
Table 8.2											
Mormyridae											
Mormyrus lacerda	1:1				2	2				27.5	36
Hippopotamyrus ansorgii	1:3	1				2	1			11.5	10.2
Hippopotamyrus discorhynchus	1.8:1	32			11	18	5		1	10.5	10.4
Marcusenius macrolepidotus	1:1.5	16	2		269	61	11	3	299	11.2	10.4
Petrocephalus catostoma	1:2.8	2			40	25	2	81	10	8	8.7
Pollimyrus castelnaui	1:1.2				12		1		13	7	7
Cyprinidae											
Barbus unitaeniatus	0:1					1					9.5
Barbus radiatus	0:1					1			1		8.3
Barbus poechii	1:1.3	3			79	13	1	6	85	8.5	9.3
Barbus paludinosus	1:4		3						12	7.5	8.3
Labeo lunatus	1:1				2	1			1	19.5	19
Characidae											
Brycinus lateralis	1:1.5	609	152	1	326	693	490	15	459	8.8	9.3
Micralestes acutidens	0:1					14	1		10		7.3
Hydrocynus vittatus	1:1.9	6	9		5	5	8	2	22	31	27.8
Hepsetidae											
Hepsetus odoe	1:1.9				20	13		1	24	24.5	25.5
Claroteidae											
Parauchenoglanis ngamensis	2:1				8	1	1		2	17.6	20.2
Schilbeidae											
Schilbe intermedius	1:7		7		58	7	2	3	440	14.7	14.1
Clariidae											
Clarias gariepinus	1:6				7	1			40	51.4	33.1
Clarias ngamensis	1:1.8				5				9	54	28.7
Clarias theodorae	1:5				3				14	20.3	15.9

Species	M:F Ratio	Spring									
		Stages								Mean Length (cm)	
		Males (%)				Females (%)					
		2	3	4	5	2	3	4	5	M	F
Table 8.2											
Clariallabes platyprosopos	2:1				2	1				22	30
Mochokidae											
Synodontis nigromaculatus	1:0				1					20	
Synodontis spp.	8:1		10						1	6.6	17
Cichlidae											
Hemichromis elongatus	1.2:1				47	16			23	14.5	14.2
Pseudocrenilabrus philander	1:1.25	1			11			5	9	8.8	9.2
Pharyngochromis acuticeps	1:1.25	88	1		52	132	33		19	11.4	10.8
Sargochromis carlottae	1.25:1	6	2		7	5	5		2	15.5	13.9
Sargochromis codringtonii	1:1.5				2	1			2	14.5	14.5
Sargochromis giardi	0:1								1		30
Serranochromis altus	1.5:1	5			3		1		4	26.8	19.1
Serranochromis angusticeps	1:1				3	1			2	14.5	21
Serranochromis longimanus	1.5:1				12	3			4	13.3	14.5
Serranochromis macrocephalus	1:1.25	4			12	4	2	1	13	19.1	18.4
Serranochromis robustus	2:1	2			10	1	3		2	19.9	23.3
Tilapia sparrmanii	1:1	6			47	5	14	4	26	12.5	10.6
Tilapia ruweti	1:1.5	2				3				6.4	6.5
Tilapia rendalli	1:2	1			5		11		1	14.2	10.3
Oreochromis andersonii	0:1								6		13.5
Oreochromis macrochir	2:1	2			6				4	17.9	10.6
Anabantidae											
Ctenopoma multispine	1:1				9				10	13.2	11.8
Mastacembelidae											
Aethiomastacembelus frenatus	0:1					2					25.5

8.4 DISCUSSION

Mormyridae

During the high floods (autumn) most specimens had spent and resting gonads, none had ripe gonads, and very few had developing gonads, indicating that the fish had spawned before the high flood surveys, and the fish were not spawning during these surveys.

During the low flood surveys specimens had developing and ripe gonads, with some already spent, indicating that the fish was spawning during low flood surveys, and would probably carry on spawning towards the summer rain season.

Cyprinidae

Opsaridium zambezense specimens had latent gonads during high flood, indicating that this species was not spawning during the high flood surveys.

Barbus radiatus had females with developing, ripe and spent gonads during high flood, and during low flood female specimens did not have ripe or spent gonads indicating that this species was spawning during high floods.

Barbus poechii had developing and spent gonads during both seasons, and this species probably spawned more than once a year.
Barbus paludinosus had ripe males during low flood. During high flood some females had developing gonads, but none were ripe or spent. This species probably spawn during the rain season in summer.

Labeo lunatus had resting gonads during high flood, and one female with developing gonads during low flood. This species probably spawn during the rain season in summer.

Characidae

Brycinus lateralis had several specimens with developing and ripe gonads during low flood, and some with spent gonads, indicating that spawning started during the low flood season. Spawning continued throughout the Summer rain season, as several specimens had spent gonads during the high floods after the rain season.

Micralestes acutidens had mostly specimens with resting gonads, and two with spent gonads, during high floods. Specimens had developing and ripe gonads during low flood, indicating that spawning probably started with the beginning of the rain season, and continued towards the high floods.

Hydrocynus vittatus had developing, ripe, and spent gonads during the low floods, and developing and spent gonads during high floods, indicating that spawning started during low flood, and continued through the rain season towards the high floods.

Hepsetidae

Hepsetus odoe is a multiple spawner (Skelton, 1993). Females had developing gonads during both seasons. One female had ripe gonads during high flood and one had spent gonads during low flood, indicating that spawning probably occurred more than once a year.

Hepsetus odoe females often show gonadal development in the winter, probably in an effort to breed before *Hydrocynus vittatus,* the reason being competition. Gonadal studies elsewhere such as in the Cunene River where tigerfish does not occur may shed some light on this issue (Hay, pers. com., 2003).

Claroteidae

Specimens of *Parauchenoglanis ngamensis* that were examined during high floods had latent gonads, and specimens sexed during low floods had developing and ripe gonads, indicating that this species probably spawned during the start of the rain season.

Schilbeidae

Schilbe intermedius had developing, ripe and spent gonads during both seasons, indicating that it spawned more than once a year, or probably from the low flood season, through the rain season, towards the high floods.

Clariidae

Females in this family had developing gonads during low flood, with ripe and spent gonads during high flood, indicating that the fish spawned during the rain season

Mochokidae

Specimens with ripe gonads during low flood, and specimens with spent gonads during high flood were sampled, indicating that the members of this family probably spawned during the rain season before a rise in water levels. Members from this family (*Synodontis* spp.) were not studied in detail due to the difficulty experienced in species identification, time limitation, and the vast numbers of all the fish collected.

Cichlidae

Several specimens in this family were sampled with developing and ripe gonads and some with spent gonads during low floods. During high floods, none of the females had ripe gonads, but several had spent gonads, indicating that spawning started during low floods, and continued into the rain season. Winemiller (1990) also found, in the Upper Zambezi River floodplains, that four *Serranochromis* species (*Serranochromis altus, Serranochromis angusticeps, Serranochromis macrocephalus* and *Serranochromis robustus*) appeared to be preparing for initiation of spawning prior to the beginning of the rain season and flooding.

Anabantidae

One specimen of *Ctenopoma multispine* had spent gonads during high flood, indicating that it probably spawned during the rain season and high floods. Not enough specimens were sampled and studied, however, to make definite conclusions.

Mastacembelidae

Aethiomastacembelus frenatus had developing gonads during low floods, indicating that it probably spawned during the rain season and high floods.

8.5 CONCLUSION

Most of the species studied seem most likely to spawn during the rain season, when there is a rise in temperature and inflow of rainwater, before the full extent of the high floods can be seen. Therefore, a high flood level was not the main contributing factor to induce spawning for many of the species. Some species are however likely to make use of the high flood (water levels) to enter newly inundated floodplains for breeding purposes. The floodplain areas provide protection in the form of cover for species to spawn, and the eggs to develop.

Mormyridae

Data indicates that members from this family spawn during summer and the beginning of the rain season, before the major rise in water levels. High floods did therefore not play a role in inducing spawning. The main spawn inducing factors were most likely the rise in temperature and factors associated with the rain season (*i.e.* inflow of rainwater).

Cyprinidae

Most species studied from this family seemed to spawn during the rain season before a rise in the flood level. However *Barbus poechii* and *Barbus radiatus* seemed to spawn during high floods. Rising temperatures and the onset of the rain season are therefore the most likely factors to induce spawning in most of the species studied, from the Cyprinidae family.

Characidae

Members from this family (*Brycinus lateralis, Micralestes* acutidens and *Hydrocynus vittatus*) was most likely to start spawning at the onset of the summer rain season (low flood), and continued spawning throughout the rain season towards the high floods. Rain and a rise in temperature are the most likely factors, which induced spawning in these species.

Hepsetidae

It seems that *Hepsetus odoe* may start spawning before the rain season during low water level (spring or early summer), possibly due to competition with other piscivores. Further study in this regard is however needed to make definite conclusions.

Claroteidae

Data indicates that this species most likely spawn at the start of the rain season (low flood), with rain and a rise in temperature.

Schilbeidae

It is most likely that *Schilbe intermedius* has a prolonged spawning period from low to high floods. This might explain why this species was sampled more abundantly than most of the larger species, as it seems to be adapted to be more productive.

Clariidae

The members from this family are most likely to spawn at the onset of, and during the rain season, with a rise in temperature.

Mochokidae

Members from this family probably spawn during the rain season, but more study is needed.

Cichlidae

Spawning for members in this family most likely occur during the rain season and into the high flood season. Some species are likely to spawn on the floodplains during rising water levels, explaining why spent gonads were found during high flood surveys.

Anabantidae

Few specimens from this family were studied, and definite conclusions can not be made.

Mastacembelidae

Aethiomastacembelus frenatus seem to spawn during the rain season, but too few were sampled to make definite conclusions.

9 LENGTH FREQUENCIES, CPUE PER SPECIES AND AVERAGE WEIGHT

9.1 INTRODUCTION

The aim of this chapter is to compare the length frequencies recorded for the species during the different surveys. By studying the length frequencies, and length cohorts, we can determine whether the fish has spawned successfully during previous seasons, and whether recruitment was successful. The length frequencies of the species sampled also give an indication of the population structure and health. The average mass, in grams, of each species sampled during the high and low flood seasons in the Eastern Caprivi is also provided in this chapter. The CPUE per species per survey (high and low floods) is also presented in the tables and discussed.

9.2 MATERIALS AND METHODS

The length frequencies were recorded for the species sampled in the Eastern Caprivi. The length frequencies for the fish with the highest IRI (Chapter 5, Index of Relative Importance) values and species with the most specimens sampled (most abundant) during the surveys are presented in table form and graphically.

The length frequencies are indicated for each survey in table form and graphically, and a length based catch curve is given graphically for these species. The mean and modal lengths are also indicated for each species. The modal length is the optimal length whereby a species was sampled in a gear (in this chapter it is for all the sampling gear combined) (Kolding, 1998). Lengths are given in one cm intervals. High floods were during April-May, and low floods during September-October.

The fork length was recorded for fish with forked caudal fins, and the total length was recorded for fish with rounded caudal fins (Hay, 1995). In Chapter 8, the average length of the mature specimens examined for gonadal development is listed in Tables 8.1 and 8.2.

Length frequencies were grouped for similar species which were sampled in lower numbers or which had lower IRI values, such as the *Serranochromis* spp. or *Sargochromis* spp. The combined length based catch curves are given for these species.

The length frequencies of the species sampled in low numbers, with low IRI values, and which could not be grouped were discussed in less detail. The recorded length frequencies, of the species sampled in low numbers, may not give an accurate representation of the existing length frequencies in the species populations, and assumptions are made about the specific species.

Species with low IRI values are not necessarily of lower importance and value, as the IRI value is expressed in terms of abundance and size. These species are mostly rare and habitat specific. These species may very well be some of the most important species, as they could serve as indicator species, especially during future impact studies. These species are usually of conservational value.

When fish were sampled in high numbers, specimens were counted (due to time constraints) after representative length frequencies (length ranges) of the sample were recorded. Measured and counted fish were indicated in the tables. The species length frequencies presented in the graphs were derived from the measured lengths and are representative of the sampled length ranges.

The CPUE per species was calculated as follows:

$$CPUE = \frac{M + C}{S} \qquad (17)$$

where M = Total number of fish measured for lengths,

C = Total number of fish counted, and

S = Total number of sets or sampling efforts per survey.

The average weight, in grams, of each species sampled during both seasons in the Eastern Caprivi, is given in Table 9.18, for each river.

9.3 RESULTS AND DISCUSSION

Brycinus lateralis

Small specimens of 1-3cm were sampled during the high flood surveys, indicating that this species did spawn successfully during the previous seasons. High numbers of this species were sampled regularly in length classes ranging from 1 – 20cm. Specimens in the length class 7-11cm were the most abundant. Large specimens of up to 20cm were sampled on occasion. The CPUE or number of specimens sampled per set (sampling effort) remained fairly constant, and fluctuations in the CPUE for *Brycinus lateralis* did not occur (Table 9.1).

Large, mature specimens (8 - 11cm) of this species were sampled regularly during each survey. This species has a high turnover, and matures within a year. It spawned successfully during the time of the study, as small juvenile specimens (1 - 3cm) were sampled during the May, low flood surveys. This species probably spawned during the summer rain season (November – March), as juveniles were sampled during autumn (Figure 9.1).

Table 9.1: Length frequencies of *Brycinus lateralis* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
1					1	1	0
2	11		11		1	23	0.1
3	78		16	1	3	98	0.6
4	107	5	18	18	6	154	1
5	52	5	6	31	9	103	0.7
6	33	4	4	6	7	54	0.4
7	319	626	236	338	223	1742	11.3
8	833	2548	369	1144	569	5463	35.6
9	616	1316	993	745	616	4286	27.9
10	195	797	437	691	414	2534	16.5
11	17	130	182	208	264	801	5.2
12	2	1	14	50	28	95	0.6
13				1	4	5	0
15			1			1	0
18			2			2	0
19			1			1	0
20					1	1	0
MEASURED	**2263**	**5432**	**2290**	**3233**	**2146**	**15364**	
COUNTED	**72**	**0**	**580**	**964**	**3554**	**5170**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**7.7**	**15.3**	**7.8**	**11.8**	**11.8**		
MEAN LENGTH (cm)	**8.1**	**8.7**	**9.1**	**9**	**9.2**		
(SD)	**1.6**	**0.9**	**1.4**	**1.2**	**1.3**		
MEAN WEIGHT (g)	**7**	**7**	**13**	**7**	**12**		
(SD)	**4**	**5**	**5**	**7**	**6**		

High numbers of mature specimens in the 8 - 11cm length class, and immature specimens in the 4 - 7cm length class were sampled during the study. Juveniles in the 1 - 3cm length class were also sampled. *Brycinus lateralis* is a small species and does not grow very large, and attains a standard length of 14cm (Skelton, 1993). The catch curve indicates that spawning occurred, and that a healthy population of immature and mature specimens existed during the time of the study. There was a good representation of the length spectrum of this species by the specimens sampled (Figure 9.2).

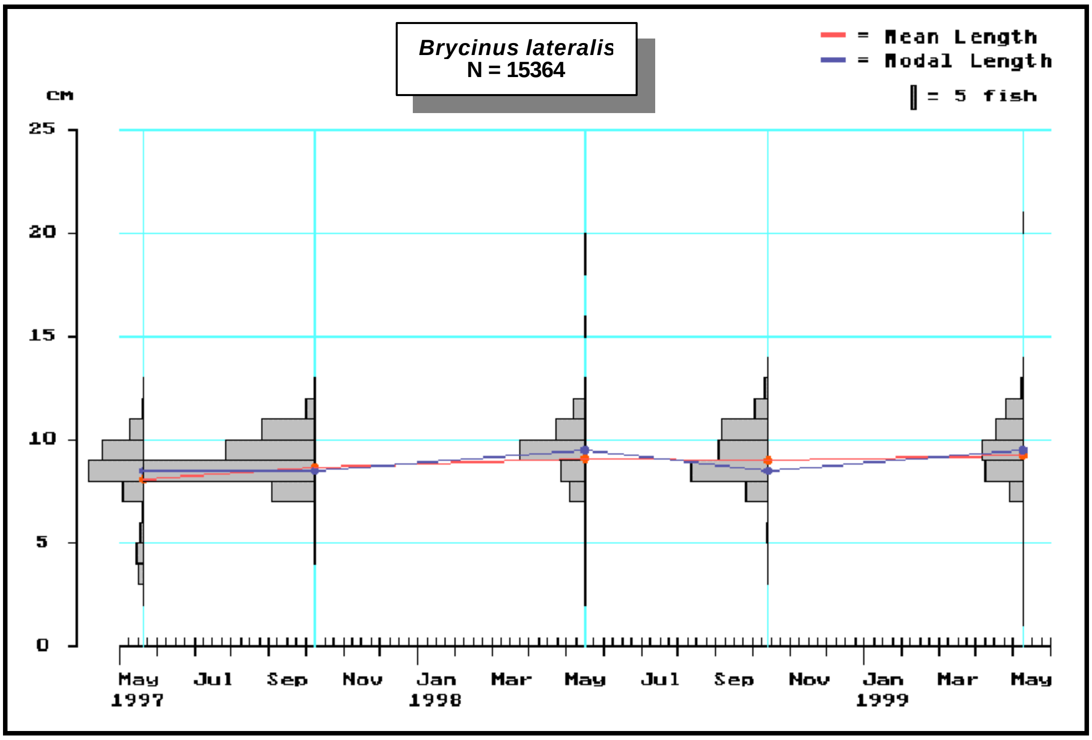


Figure 9.1: Length frequencies of *Brycinus lateralis* during five surveys in the Eastern Caprivi.

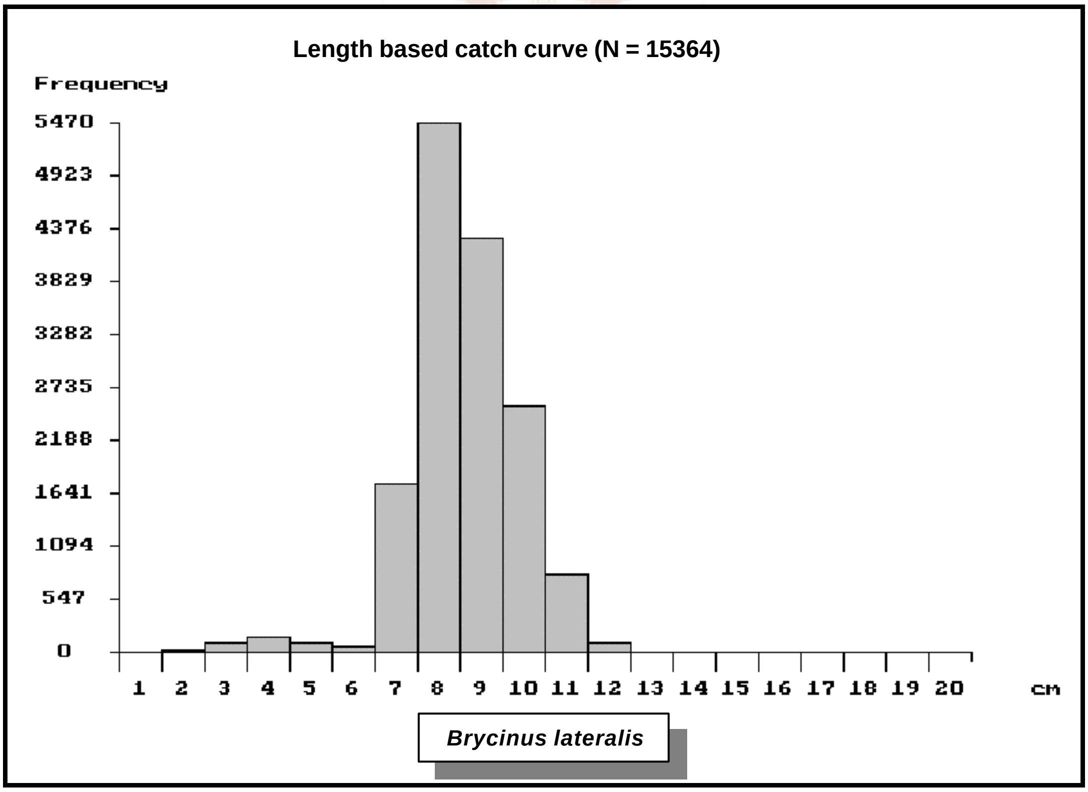


Figure 9.2: Length frequencies of *Brycinus lateralis* for the Eastern Caprivi, 1997-1999.

Schilbe intermedius

Several specimens of *Schilbe intermedius* were sampled over a length spectrum of 2 – 35cm. Juvenile specimens in the length range of 6 – 8cm were sampled regularly during all the surveys indicating that this species spawned successfully and regularly during the study period. Two small specimens of 2cm were sampled during the 1999 high flood, indicating that this species spawned during the previous summer rain season. The largest specimen sampled was 35cm. The CPUE for *Schilbe intermedius* increased as the surveys progressed, with the highest CPUE's recorded during the 1998 and 1999 high floods (Table 9.2).

Several length classes or cohorts were recorded during each survey, indicating that *Schilbe intermedius* spawned regularly and successfully during the previous seasons. Mature specimens from 16cm (Chapter 8), and juveniles were sampled regularly (Figure 9.3).

Length cohorts of 6 - 10cm, 10 - 15cm, and 15 - 20cm are indicated in Figure 9.4, giving the indication that this species spawned regularly, and that a few generations, juveniles, immature and mature fish exist in the population, and that the length spectrum of this species was well represented.

Table 9.2: Length frequencies of *Schilbe intermedius* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.2							
2					2	2	0.1
6	2	1	5	1		9	0.3
7	1		18	10		29	0.8
8	3	93	45	32	19	192	5.5
9	7	148	76	57	68	356	10.2
10	3	54	38	33	52	180	5.1
11	6	95	37	42	98	278	7.9
12	7	119	42	30	105	303	8.6
13	8	42	35	33	174	292	8.3
14	6	25	35	45	160	271	7.7
15	6	29	55	49	97	236	6.7
16	15	6	124	23	124	292	8.3
17	24	16	131	38	141	350	10
18	9	14	80	27	105	235	6.7
19	6	10	65	19	36	136	3.9
20	1	6	58	3	44	112	3.2
21	3	7	47	3	37	97	2.8

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.2							
22	2	7	17	5	25	56	1.6
23	3	3	10	1	17	34	1
24		2	6	2	11	21	0.6
25		1	3	1	4	9	0.3
26			3	5	2	10	0.3
27					4	4	0.1
28		1				1	0
29					1	1	0
35			1			1	0
MEASURED	**112**	**679**	**931**	**459**	**1326**	**3507**	
COUNTED	**0**	**0**	**2**	**0**	**398**	**400**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.4**	**1.9**	**2.6**	**1.3**	**3.6**		
MEAN LENGTH (cm)	**15.1**	**11.7**	**15.3**	**13.4**	**14.9**		
(SD)	**3.7**	**3.3**	**4.3**	**3.9**	**3.6**		
MEAN WEIGHT (g)	**44**	**16**	**53**	**27**	**43**		
(SD)	**31**	**30**	**39**	**33**	**38**		

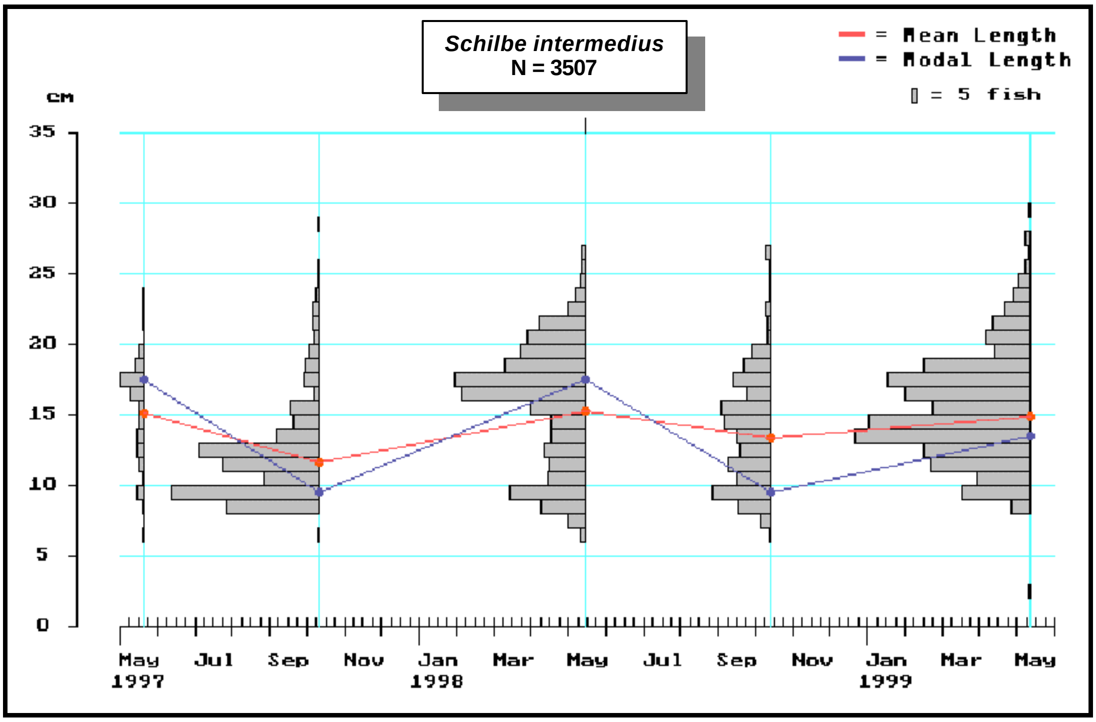


Figure 9.3: Length frequencies of *Schilbe intermedius* during five surveys in the Eastern Caprivi.

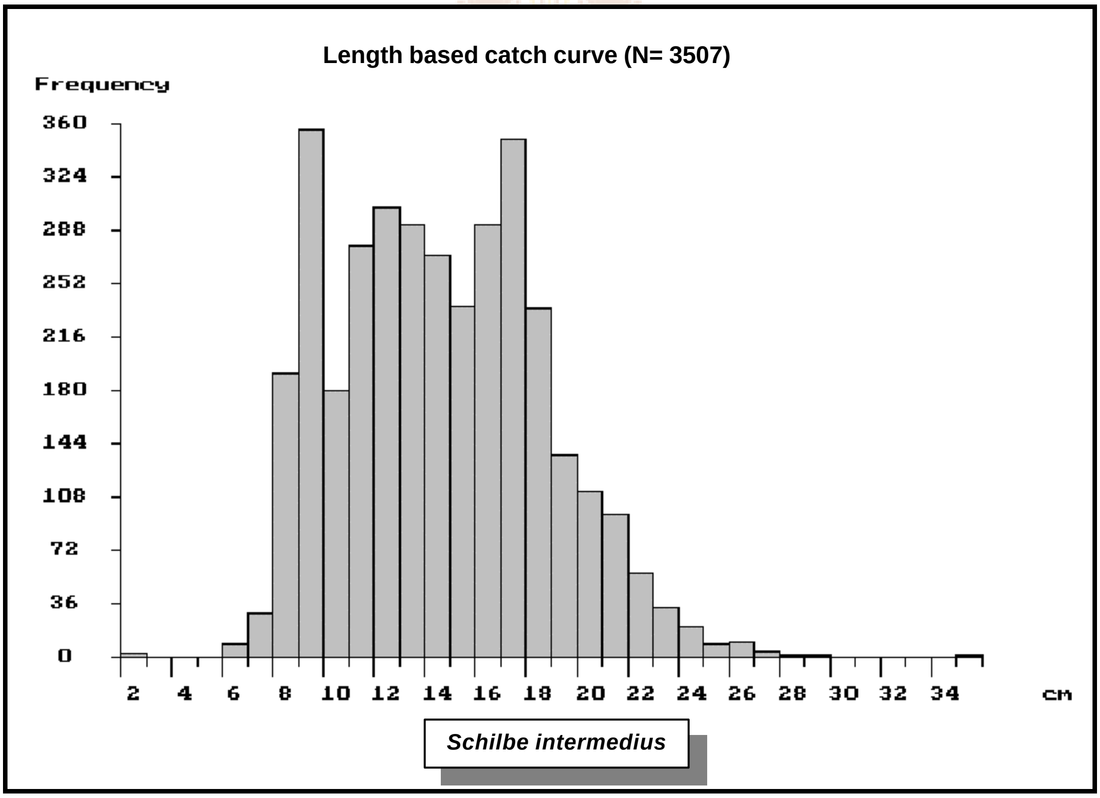


Figure 9.4: Length frequencies of *Schilbe intermedius* for the Eastern Caprivi, 1997-1999.

Hydrocynus vittatus

Several specimens of *Hydrocynus vittatus* were sampled in a length range of 9 - 63cm. Juveniles and immature fish were sampled regularly during all the surveys, indicating successful spawning during previous seasons. The CPUE for *Hydrocynus vittatus* increased as the surveys progressed (Table 9.3).

Table 9.3: Length frequencies of *Hydrocynus vittatus* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.3							
9				1		1	0.1
10					7	7	0.7
11		2			8	10	0.9
12		3			40	43	4
13	3	1	6		53	63	5.9
14	9	9	25	4	112	159	14.8
15	3	19	23	2	102	149	13.9
16	6	6	13	2	56	83	7.7
17	1	9	19	3	104	136	12.7
18	4	6	17	1	67	95	8.8
19		9	10	1	31	51	4.7
20	2		4	2	11	19	1.8
21	1	7	3	3	5	19	1.8
22	2	6	1	6	6	21	2
23	1	4	1		2	8	0.7
24	2		1	3	5	11	1
25	2	5	1	2	4	14	1.3
26		2		5	5	12	1.1
27		1	1	3	6	11	1
28			4	1	9	14	1.3
29	1	1	2	4	15	23	2.1
30	1		5	3	18	27	2.5
31		1	3	3	12	19	1.8
32			1	3	5	9	0.8
33			1	1	3	5	0.5
34	1		1	4	1	7	0.7
35				4	4	8	0.7
36				2	2	4	0.4
37		2	1		4	7	0.7
38	3		1		2	6	0.6
39					1	1	0.1
40			3	1	3	7	0.7
41					1	1	0.1
43		1		1		2	0.2

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.3							
44		1	1	1	3	6	0.6
45		1				1	0.1
46			1			1	0.1
48				1		1	0.1
50	2					2	0.2
52		1			1	2	0.2
54	1					1	0.1
55	1					1	0.1
56	1				2	3	0.3
58					1	1	0.1
60		1			1	2	0.2
63			1			1	0.1
MEASURED	**47**	**98**	**150**	**67**	**712**	**1074**	
COUNTED	**0**	**0**	**0**	**0**	**9**	**9**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.2**	**0.3**	**0.4**	**0.2**	**1.5**		
MEAN LENGTH (cm)	**23.3**	**20.1**	**19.5**	**26.3**	**18.1**		
(SD)	**12.4**	**8.4**	**7.8**	**8**	**6.8**		
MEAN WEIGHT (g)	**298**	**185**	**168**	**331**	**118**		
(SD)	**570**	**422**	**394**	**344**	**283**		

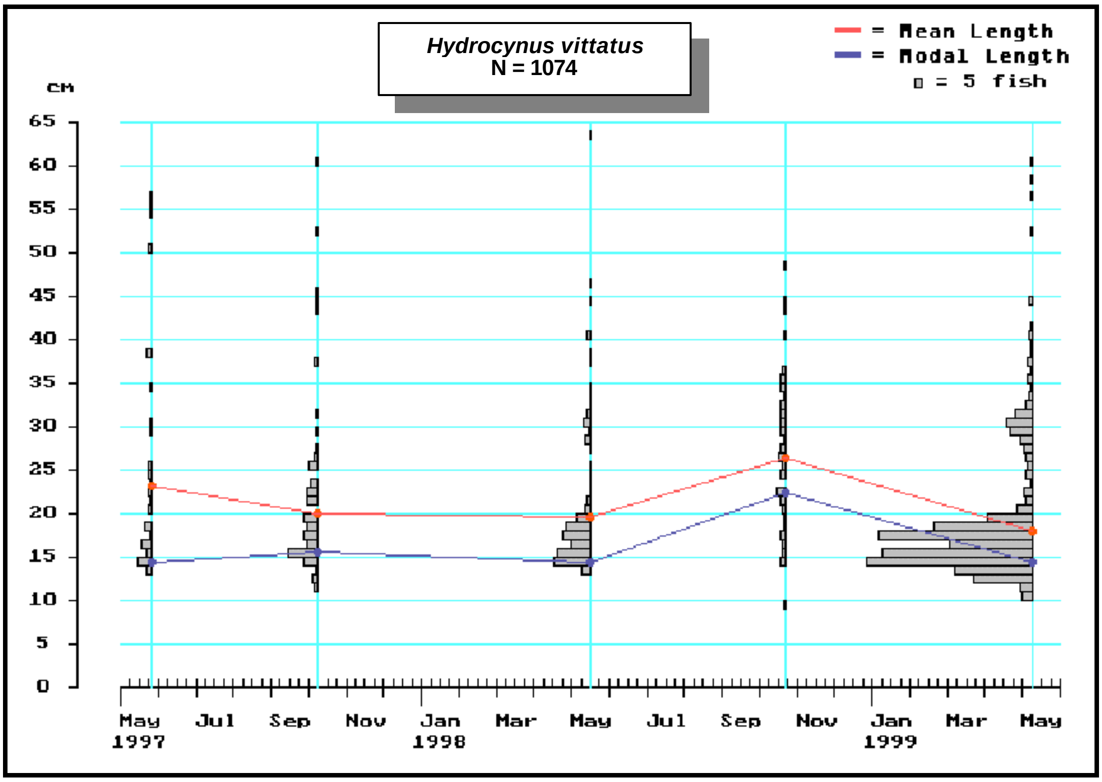


Figure 9.5: Length frequencies of *Hydrocynus vittatus* during five surveys in the Eastern Caprivi.

There was an increase in numbers sampled as the surveys progressed. Very small specimens (<9cm) were not sampled, but juveniles were sampled regularly during each survey, indicating that *Hydrocynus vittatus* spawned successfully during previous seasons (Figure 9.5).

Most specimens sampled were in the 14 – 15cm range. Several cohorts, 12 – 16cm, 16 – 19cm, 23 – 27cm, and 27 – 33cm were recorded for *Hydrocynus vittatus*, indicating that this species spawned successfully during previous seasons. Specimens in a wide length range were sampled, although large specimens were not sampled regularly (Figure 9.6).

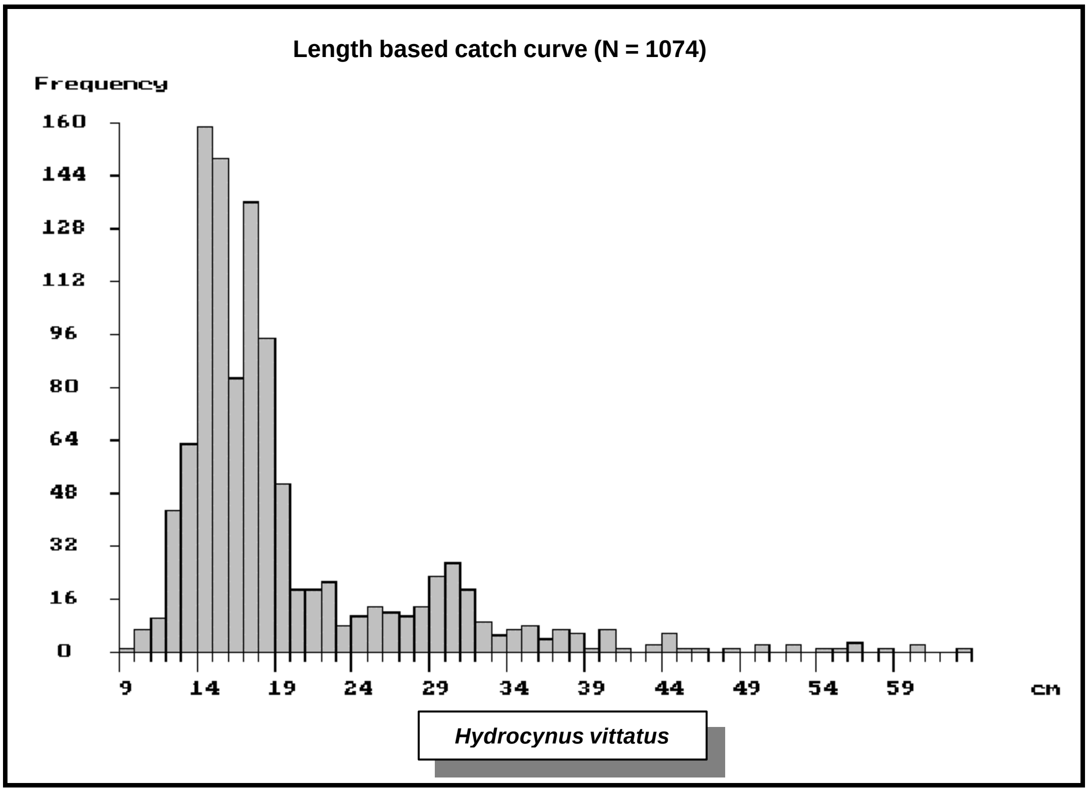


Figure 9.6: Length frequencies of *Hydrocynus vittatus* for the Eastern Caprivi, 1997-1999.

Petrocephalus catostoma

Petrocephalus catostoma is not a large species, and several specimens were sampled in a length range of 4 – 14cm. Specimens in the 7 – 9cm length class were sampled the most. Higher CPUE's were recorded during the high floods. Exceptionally high numbers of this species were sampled during the 1999 high flood survey (especially in Lake Lisikili) (Table 9.4).

Immature specimens (4 – 6cm) of *Petrocephalus catostoma* were sampled during the surveys, indicating that this species did spawn successfully during previous seasons. Most of the specimens sampled were between 7cm and 9cm. Large specimens of 14cm were sampled during the 1999 high flood (Figure 9.7).

Immature (4 – 7cm), and mature (8 – 14cm) specimens (Chapter 8) were sampled, indicating that this species did spawn during the time of the surveys. The largest specimens of 14cm were sampled during the 1999 high flood. The length spectrum of this species was well represented by the specimens sampled (Figure 9.8).

Table 9.4: Length frequencies of *Petrocephalus catostoma* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
4	1					1	0.1
5			1	1		2	0.2
6	2	1	30	1	10	44	3.9
7	26	20	47	3	100	196	17.5
8	63	42	55	48	362	570	51.0
9	45	20	57	32	97	251	22.5
10	5	2	9	2	14	32	2.9
11	2		1		4	7	0.6
14					14	14	1.3
MEASURED	**144**	**85**	**200**	**87**	**601**	**1117**	
COUNTED	**0**	**0**	**0**	**0**	**2973**	**2973**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.5**	**0.2**	**0.6**	**0.2**	**7.4**		
MEAN LENGTH (cm)	**8.5**	**8.3**	**8.1**	**8.6**	**8.5**		
(SD)	**0.9**	**0.7**	**1.4**	**0.7**	**1.1**		
MEAN WEIGHT (g)	**7**	**8**	**8**	**11**	**8**		
(SD)	**3**	**3**	**6**	**3**	**5**		

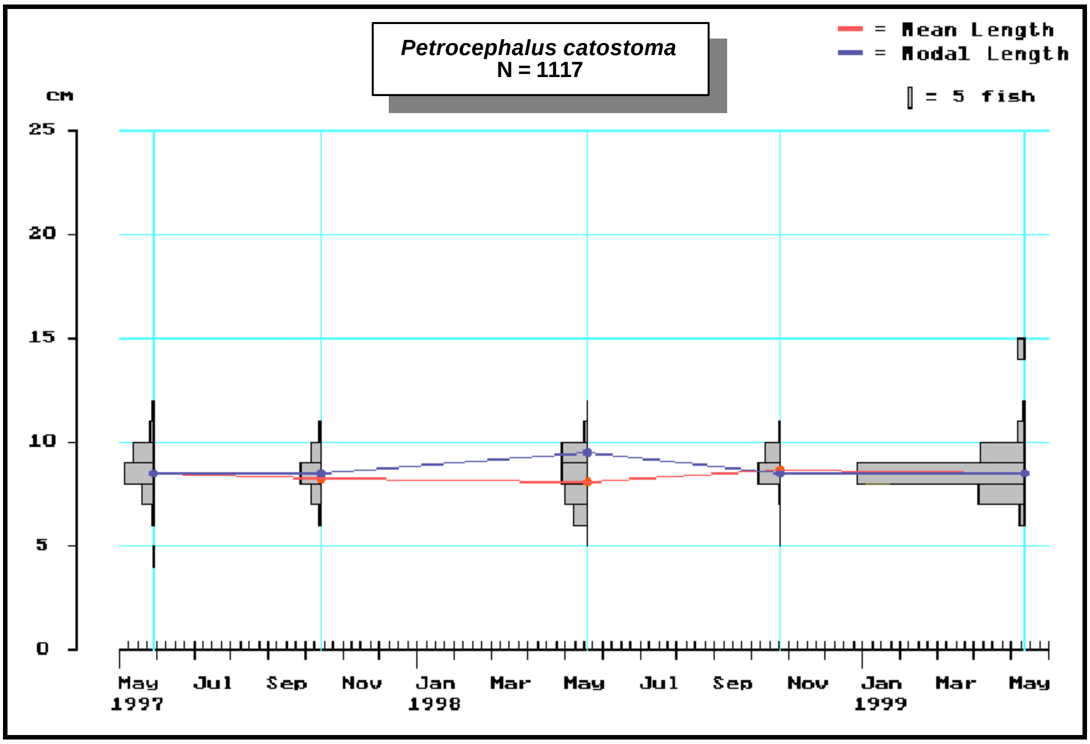


Figure 9.7: Length frequencies of *Petrocephalus catostoma* during five surveys in the Eastern Caprivi.

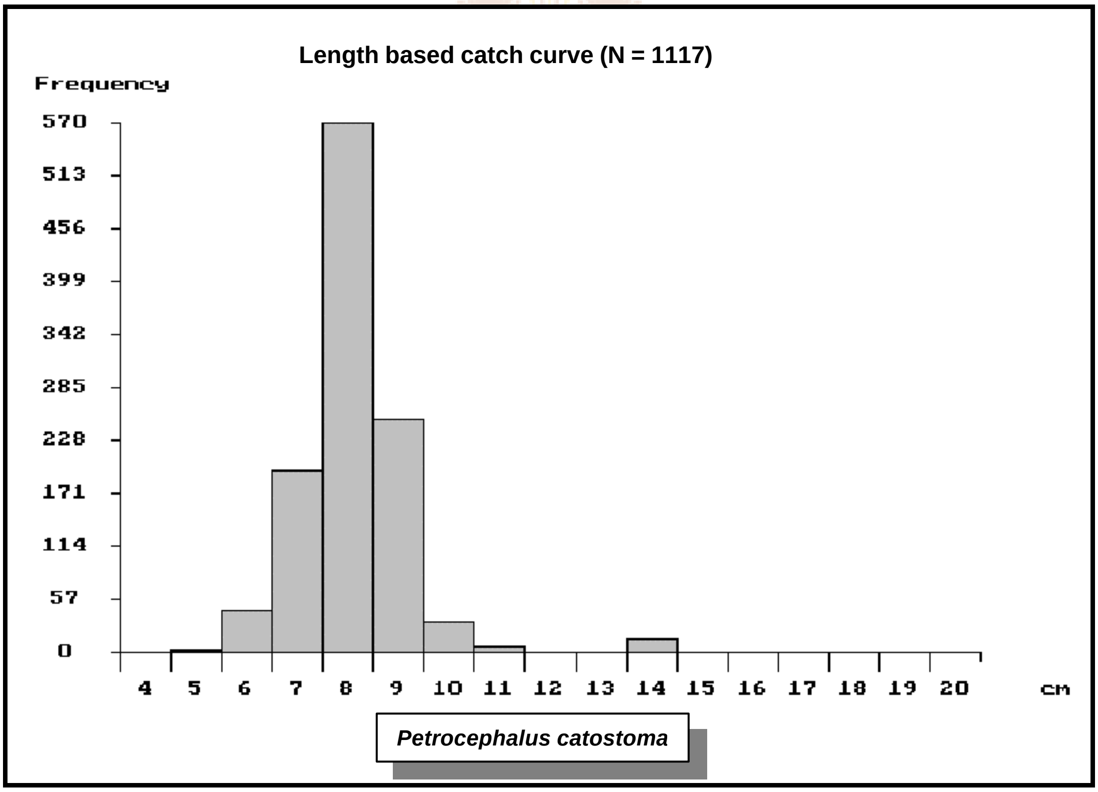


Figure 9.8: Length frequencies of *Petrocephalus catostoma* for the Eastern Caprivi, 1997-1999.

Marcusenius macrolepidotus

A total of 1788 specimens were sampled in various length classes in a length range of 3 – 29cm during the five surveys. Most of the specimens sampled were in the 8 – 10cm length range. Juvenile specimens (3 – 5cm) were sampled, indicating successful spawning during the time of the surveys. Higher CPUE's were recorded during the last two surveys (Table 9.5).

Table 9.5: Length frequencies of *Marcusenius macrolepidotus* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.5							
3				1		1	0.1
5	1			1		2	0.1
6		1				1	0.1
7	1	6	3	22	42	74	4.1
8	3	83	10	269	75	440	24.6
9	3	38	9	232	106	388	21.7
10	1	34	55	174	30	294	16.4
11	4	29	53	43	11	140	7.8
12	9	31	18	20	17	95	5.3
13	6	22	18	25	36	107	6
14	4	7	8	12	67	98	5.5
15	11	18	5	4	13	51	2.9
16	9	13	3	3	13	41	2.3
17	4	9	5	3	6	27	1.5
18	1	5	2	1	2	11	0.6
19	1	5	3	1	1	11	0.6
20		1		1	1	3	0.2
21			1			1	0.1
23		1				1	0.1
28				1		1	0.1
29				1		1	0.1
MEASURED	**58**	**303**	**193**	**814**	**420**	**1788**	
COUNTED	**0**	**0**	**0**	**381**	**1068**	**1449**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.2**	**0.9**	**0.5**	**3.4**	**3.1**		
MEAN LENGTH (cm)	**13.4**	**11.1**	**11.5**	**9.6**	**10.8**		
(SD)	**2.9**	**3.1**	**2.3**	**1.9**	**2.8**		
MEAN WEIGHT (g)	**35**	**22**	**24**	**11**	**23**		
(SD)	**21**	**23**	**18**	**27**	**21**		

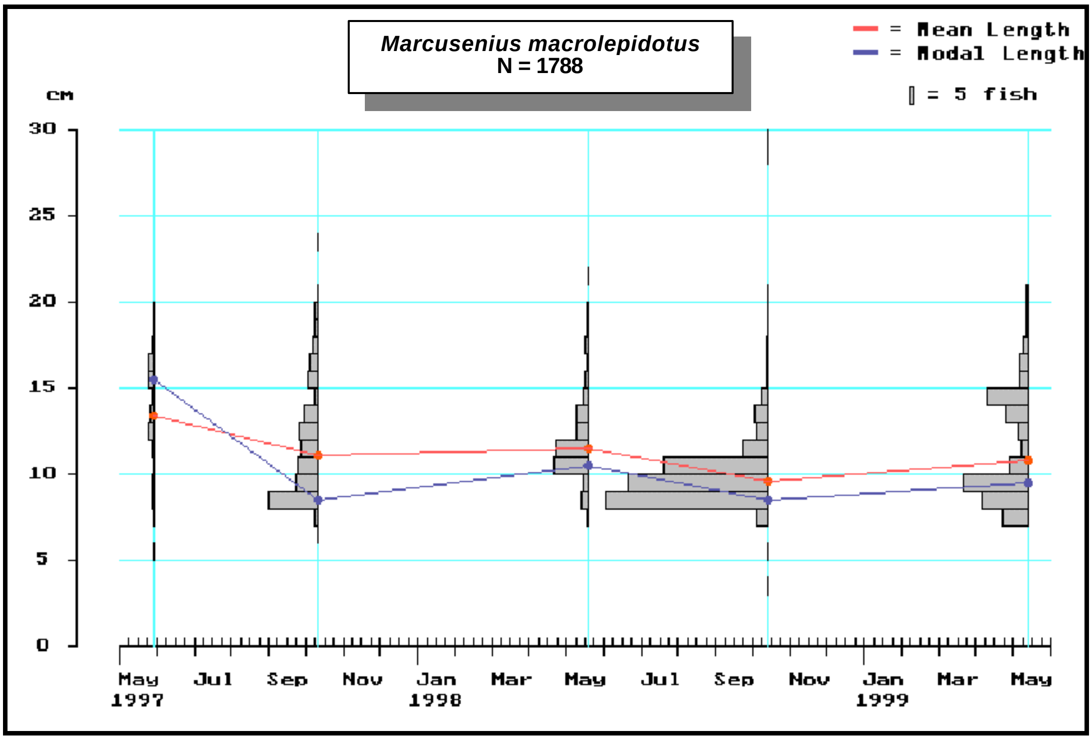


Figure 9.9: Length frequencies of *Marcusenius macrolepidotus* during five surveys in the Eastern Caprivi.

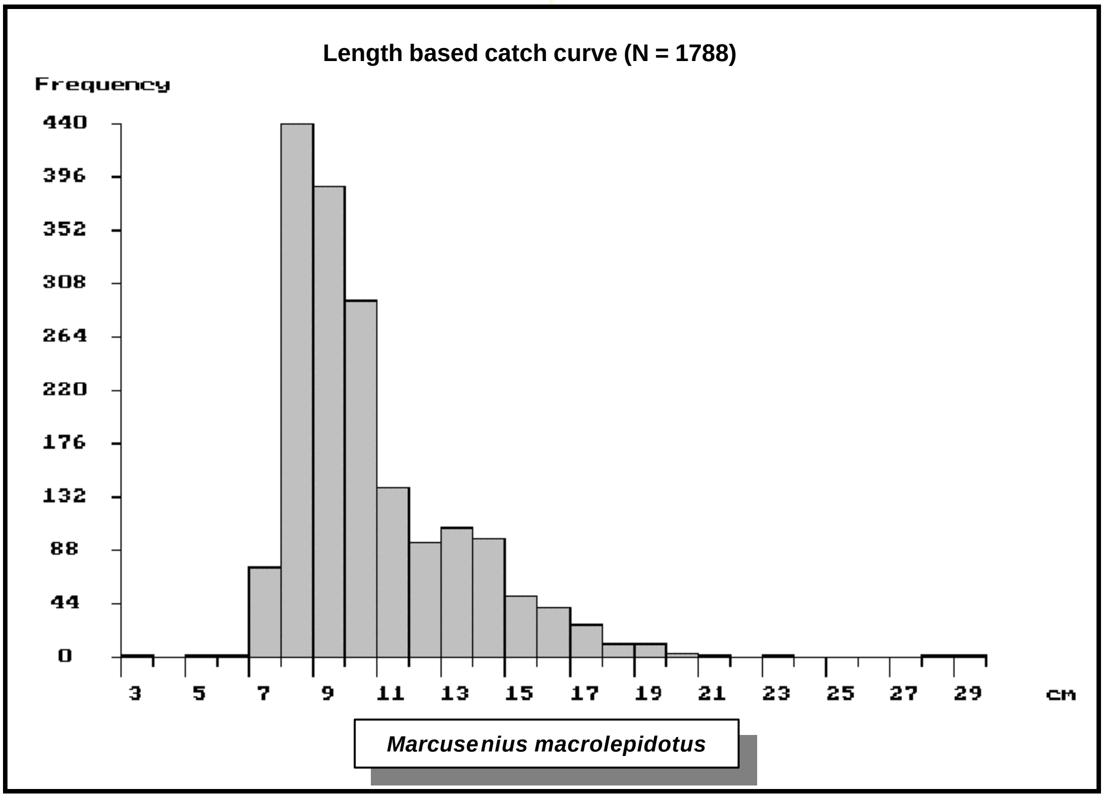


Figure 9.10: Length frequencies of *Marcusenius macrolepidotus* for the Eastern Caprivi, 1997-1999.

Immature specimens in the 6 – 10cm range were sampled regularly during all the surveys. Mature specimens from the 12cm range (Chapter 8) were also sampled regularly. Large specimens in the 20 – 30cm length range were also sampled (Figure 9.9).

The various length classes recorded for *Marcusenius macrolepidotus* indicate successful spawning during the time of the surveys. Although large specimens were not abundant, the length spectrum of this species was well represented by the specimens sampled (Figure 9.10).

Clarias gariepinus

The largest specimen of *Clarias gariepinus* that was sampled had a length of 87cm. Specimens were sampled in a length range of 4cm – 87cm. The CPUE remained fairly constant during the surveys. Juvenile specimens were sampled during the surveys, indicating successful spawning during the time of the study (Table 9.6).

Figure 9.11 indicate a variety of length classes for *Clarias gariepinus* recorded during each of the five surveys. Small specimens sampled indicate successful spawning during previous seasons. The many different length classes indicate a stable population, and that large specimens are present.

Several length cohorts for *Clarias gariepinus* were recorded in Figure 9.12. The length cohorts indicate juveniles (4cm), immature fish from several previous breeding seasons (7–10cm, 11-15cm, 16-18cm, 19-24cm, 25-29cm), and mature fish from 30cm (Chapter 8) in several more length classes. It spawned regularly during previous seasons and during the time of the study, and there is a good representation of lengths from the length spectrum of this species (Figure 9.12).

Table 9.6: Length frequencies of *Clarias gariepinus* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.6							
4	1					1	0.6
6	1	1				2	1.3
7	1					1	0.6
8			1			1	0.6
9			2			2	1.3
10		1				1	0.6
11	1					1	0.6
12	1		1		1	3	1.9
14			3			3	1.9
15				2		2	1.3
16				1		1	0.6
17			3			3	1.9
18				1		1	0.6
19		1	1			2	1.3
21			1	1	1	3	1.9
22				1		1	0.6
23			1			1	0.6
26				3		3	1.9
27				3		3	1.9
28				1		1	0.6

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.6							
29				5		5	3.1
30		5		5		10	6.3
31		1		4		5	3.1
32		1				1	0.6
33				3		3	1.9
34				6	1	7	4.4
35				4		4	2.5
36				3		3	1.9
37		1		2	1	4	2.5
39				1		1	0.6
40			1		1	2	1.3
41				1	1	2	1.3
42			1			1	0.6
43				1	1	2	1.3
44	1			1		2	1.3
45				1	1	2	1.3
46			1		3	4	2.5
47	1	1			2	4	2.5
48					3	3	1.9
49	1				2	3	1.9
50			3	1	2	6	3.8
52	1					1	0.6
53	1				1	2	1.3
54	1				2	3	1.9
55	2					2	1.3
56					4	4	2.5
57	3		2		3	8	5
58	1				2	3	1.9
59					1	1	0.6
60			2	1	1	4	2.5
61			1			1	0.6
62					2	2	1.3
63					1	1	0.6
65			2			2	1.3
69					1	1	0.6
71	1			1	1	3	1.9
72					1	1	0.6
73				1		1	0.6
74					2	2	1.3
76				1	3	4	2.5
78	1					1	0.6
80					1	1	0.6
85		1				1	0.6
87	1					1	0.6
MEASURED	**20**	**13**	**26**	**55**	**46**	**160**	
COUNTED	**0**	**0**	**0**	**0**	**0**	**0**	

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	Low	High		
Table 9.6							
SETS	303	355	366	357	484	1865	
CPUE (# per set)	0.1	0.04	0.1	0.2	0.1		
MEAN LENGTH (cm)	45.7	32.1	34.5	34.2	54.2		
(SD)	24.5	19.1	21	12.3	13.9		
MEAN WEIGHT (g)	1154	514	690	487	1438		
(SD)	1004	1212	732	807	1042		

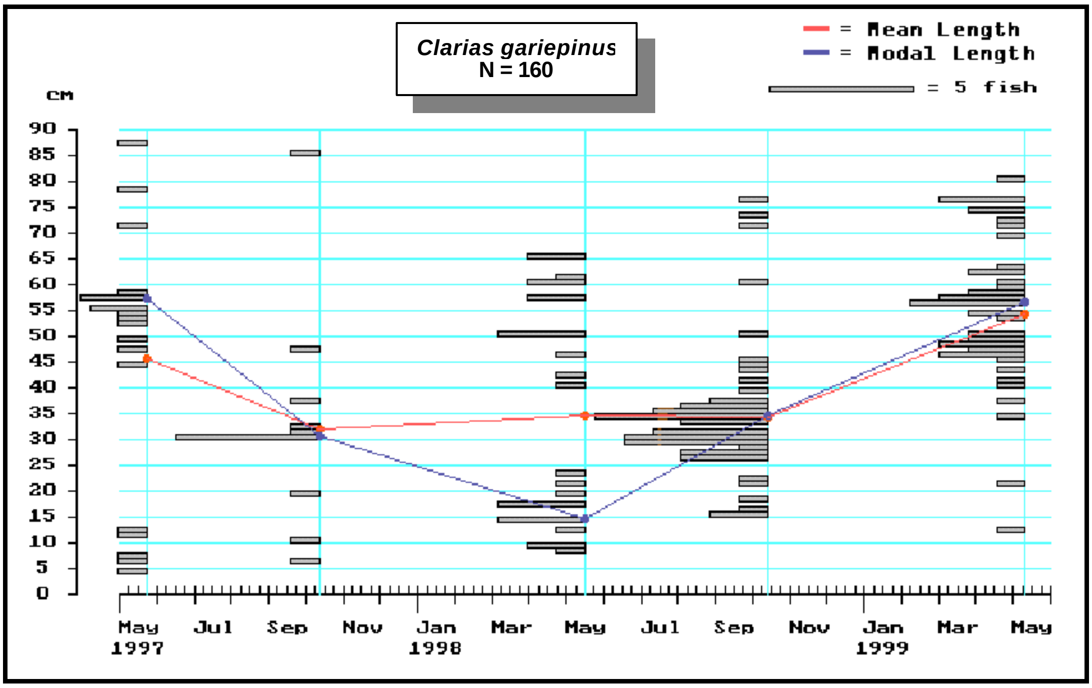


Figure 9.11: Length frequencies of *Clarias gariepinus* during five surveys in the Eastern Caprivi.

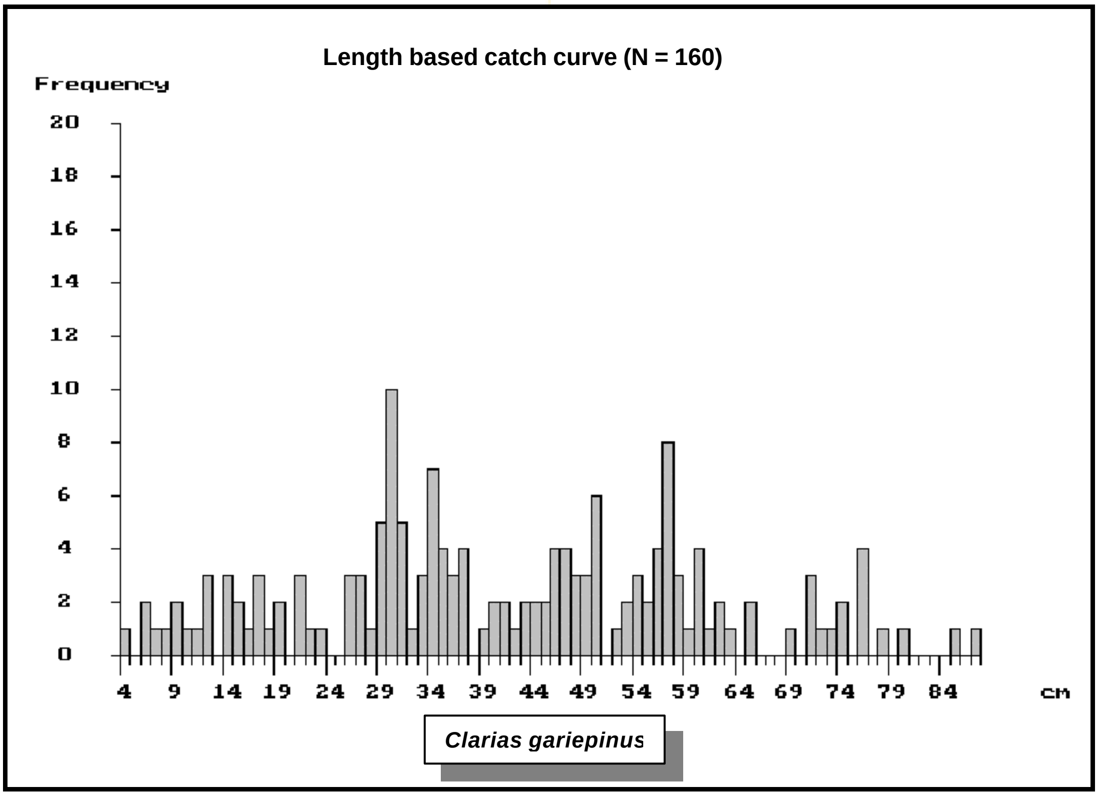


Figure 9.12: Length frequencies of *Clarias gariepinus* for the Eastern Caprivi, 1997-1999.

Tilapia sparrmanii

Higher CPUE's were recorded for *Tilapia sparrmanii* during the low floods. Specimens were sampled in a length range of 1 – 20cm. Most specimens sampled fell in the 4 – 7cm length range. Small, juvenile specimens in the 1 – 2cm length range were sampled mostly during high floods (Figure 9.7).

Table 9.7: Length frequencies of *Tilapia sparrmanii* during five surveys in the Eastern Caprivi.

Length (cm)	**Year**					**Total**	**%**
	1997		**1998**		**1999**		
	Flood		**Flood**		**Flood**		
	High	**Low**	**High**	**Low**	**High**		
1	1					1	0.1
2	11		12	1	1	25	1.5
3	43	15	21	1	12	92	5.5
4	95	94	67	4	22	282	17
5	47	223	61	41	17	389	23.4
6	10	62	26	132	18	248	14.9
7	9	32	3	145	36	225	13.5
8	7	26	2	63	9	107	6.4
9	3	18	1	24	6	52	3.1
10	5	12		17	6	40	2.4
11		22	2	27	12	63	3.8
12	3	14	2	17	6	42	2.5
13	1	18	2	19	5	45	2.7
14	1	8	4	7	5	25	1.5
15		10	3	3		16	1
16		1	4	1	1	7	0.4
18				1		1	0.1
20		1				1	0.1
MEASURED	**236**	**556**	**210**	**503**	**156**	**1661**	
COUNTED	**162**	**0**	**95**	**421**	**52**	**730**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**1.3**	**1.6**	**0.8**	**2.6**	**0.4**		
MEAN LENGTH (cm)	**4.9**	**6.5**	**5.5**	**7.9**	**7.5**		
(SD)	**1.9**	**2.9**	**2.8**	**2.3**	**3**		
MEAN WEIGHT (g)	**4**	**8**	**7**	**12**	**12**		
(SD)	**7**	**18**	**17**	**14**	**16**		

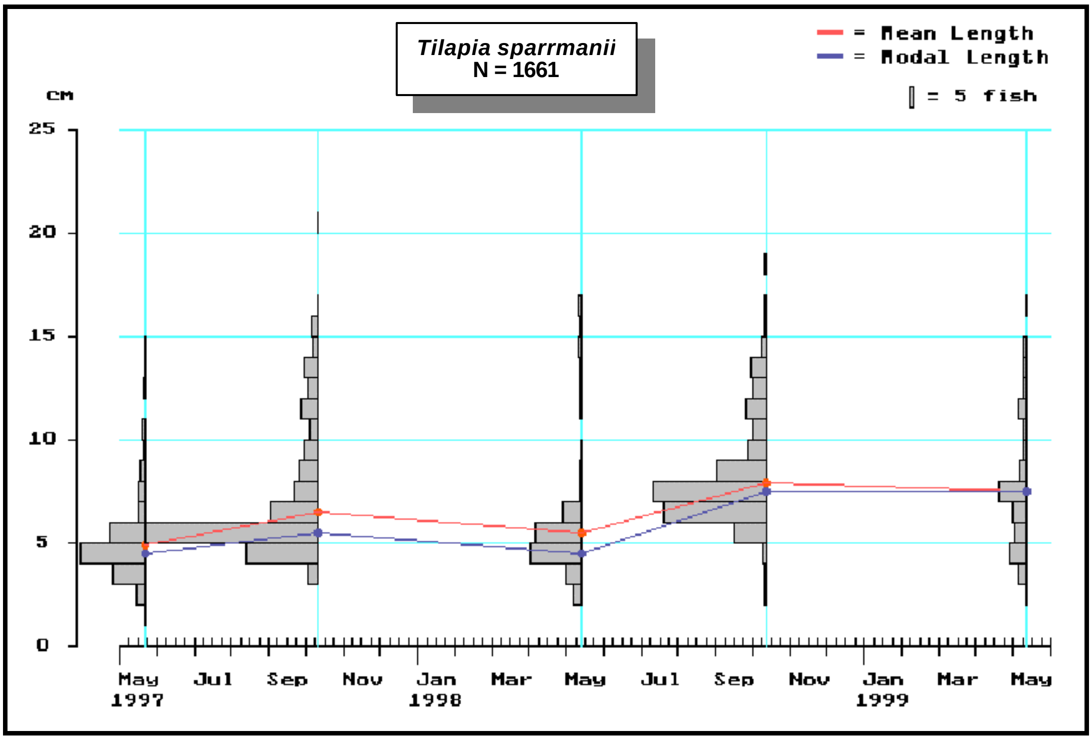


Figure 9.13: Length frequencies of *Tilapia sparrmanii* during five surveys in the Eastern Caprivi.

Juveniles were mostly sampled during high floods, indicating that this species preferred to spawn during the rain season (Nov – March) preceding the high floods. Immature (4-11cm) and mature fish from 12cm and more (Chapter 8) were sampled regularly, during all the surveys, indicating successful spawning during the previous seasons.

Large specimens of up to 20cm were sampled, and this species does not grow much larger (Skelton, 1993) (Figure 9.13).

The lengths recorded indicate a healthy population of *Tilapia sparrmanii* in the Eastern Caprivi (Figure 9.14).

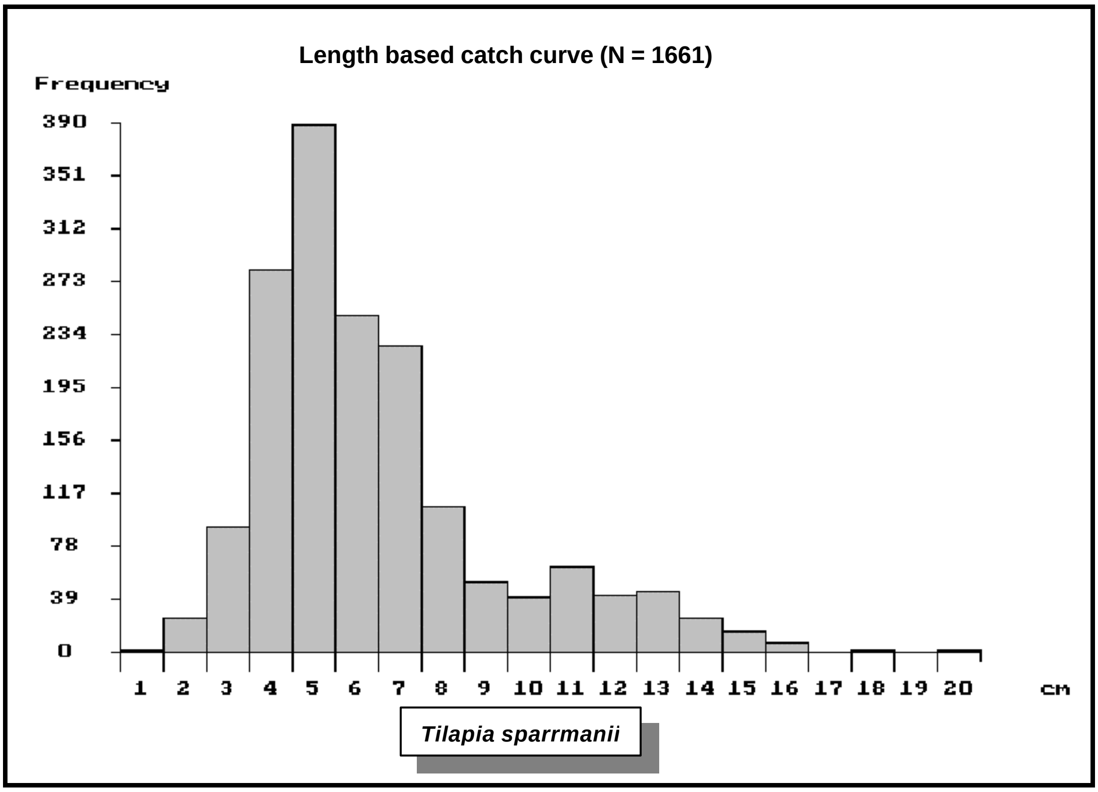


Figure 9.14: Length frequencies of *Tilapia sparrmanii* for the Eastern Caprivi, 1997-1999.

Pharyngochromis acuticeps

Several specimens were sampled in several length classes, in the 1 – 17cm length range. Juveniles in the 1 – 2cm length class were sampled regularly during most surveys, indicating successful spawning during the time of the study. Most specimens were sampled in the 5 – 7cm length class. A higher CPUE for this species was recorded during low floods (Table 9.8).

Table 9.8: Length frequencies of *Pharyngochromis acuticeps* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.8							
1				31	1	32	1.9
2	9		9	25	11	54	3.3
3	26	1	12		19	58	3.5
4	33	6	32	7	28	106	6.4
5	39	12	42	46	30	169	10.2
6	30	30	42	90	19	211	12.7
7	11	44	19	113	22	209	12.6
8	5	33	11	74	17	140	8.4
9	5	36	9	87	29	166	10
10	1	23	5	76	26	131	7.9
11	7	25	2	145	26	205	12.3
12	1	11	1	50	14	77	4.6
13	1	5	2	33	19	60	3.6
14	1	2		18	6	27	1.6
15		2		1	4	7	0.4
16	1			1	2	4	0.2
17		1			4	5	0.3
MEASURED	**170**	**231**	**186**	**797**	**277**	**1661**	
COUNTED	**0**	**0**	**0**	**15**	**2**	**17**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.6**	**0.7**	**0.5**	**2.3**	**0.6**		
MEAN LENGTH (cm)	**5.7**	**8.7**	**6**	**8.7**	**8.3**		
(SD)	**2.3**	**2.3**	**2**	**3**	**3.6**		
MEAN WEIGHT (g)	**4**	**10**	**4**	**12**	**14**		
(SD)	**7**	**9**	**5**	**10**	**17**		

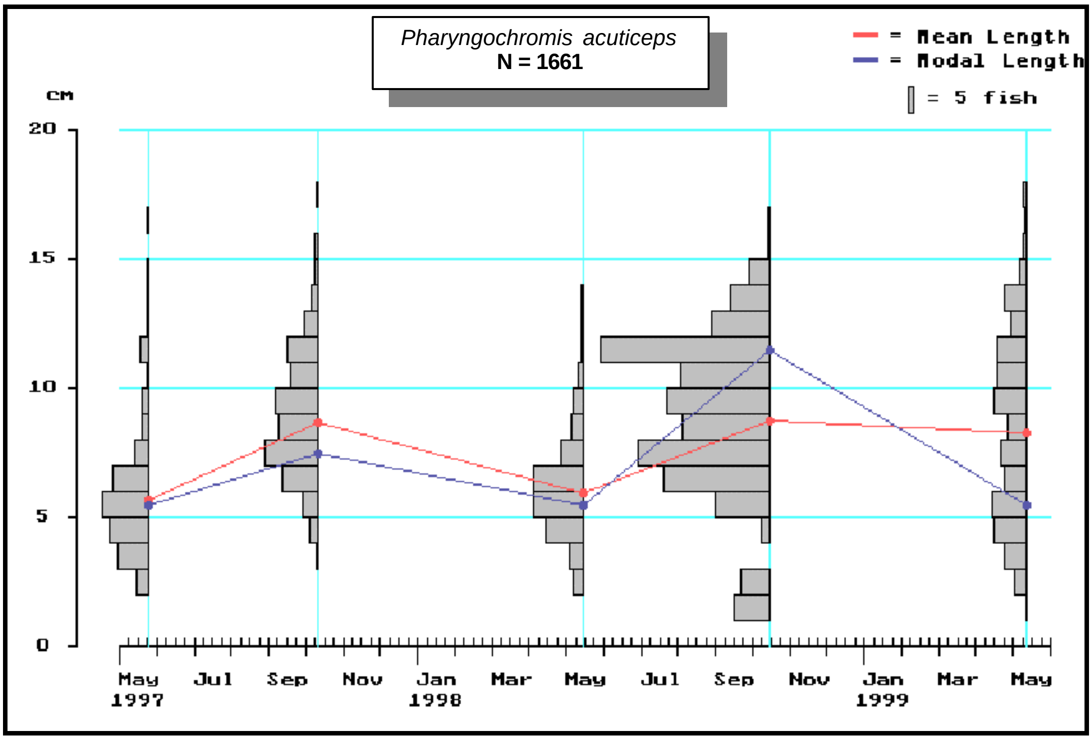


Figure 9.15: Length frequencies of *Pharyngochromis acuticeps* during five surveys in the Eastern Caprivi.

Several length classes were recorded during all the surveys, with several small specimens of 1 - 2cm sampled during the 1998 low flood, indicating that this species spawned in the months preceding the survey probably during the 1998 high flood. Mature specimens from around 11cm (Chapter 8) were sampled regularly (Figure 9.15).

Pharyngochromis acuticeps does not grow very large and specimens in the whole length range were sampled, indicating a healthy population (Figure 9.16).

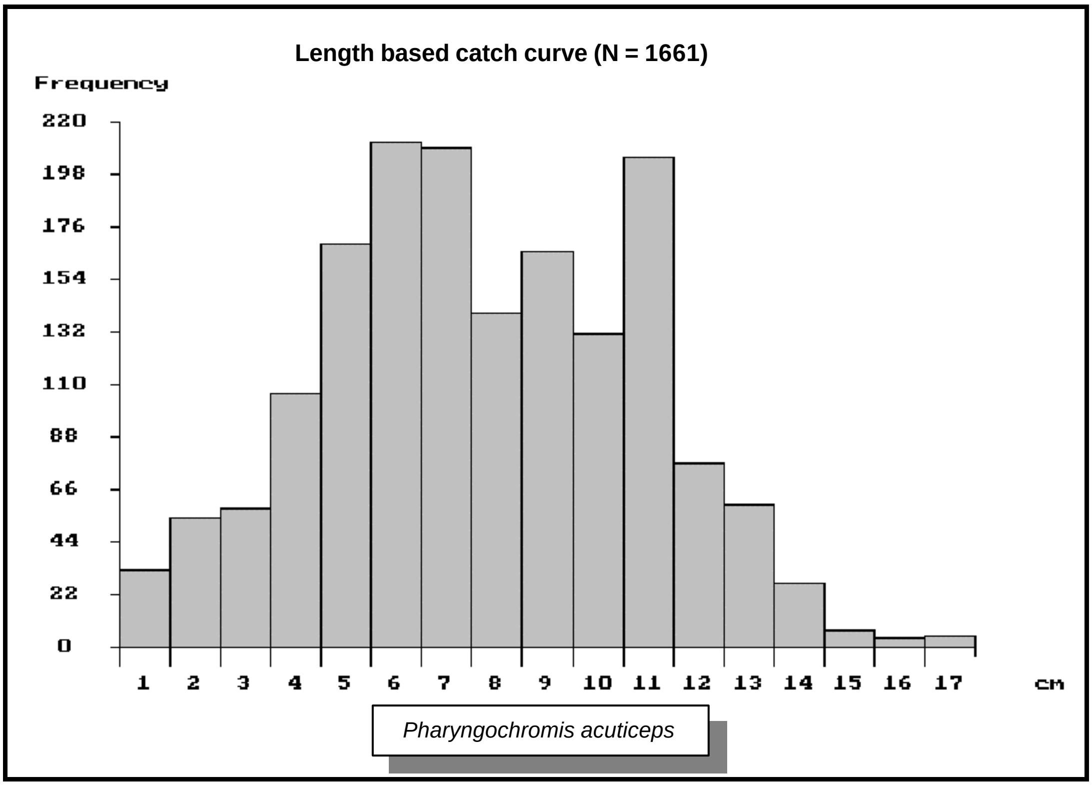


Figure 9.16: Length frequencies of *Pharyngochromis acuticeps* for the Eastern Caprivi, 1997-1999.

Barbus poechii

Several specimens from the different length classes were sampled in a length range of 3 – 12cm. *Barbus poechii* attains a standard length of 11cm (Skelton, 1993), and the specimens sampled represented the whole length range of this species. The CPUE for this species increased as the surveys progressed (Table 9.9).

Small specimens sampled during high floods indicate that this species spawned successfully during the previous rain seasons. Immature and mature fish were sampled during all the surveys (Figure 9.17).

Figure 9.18 indicate a stable population with juveniles, immature and mature specimens sampled over the whole length spectrum of *Barbus poechii* during the study.

Table 9.9: Length frequencies of *Barbus poechii* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
3	4		24			28	2.1
4	17		53	21	5	96	7
5	5	4	43	46	16	114	8.4
6	1	68	18	48	9	144	10.6
7		52	16	268	41	377	27.6
8	1	47	4	121	53	226	16.5
9	5	53	6	40	48	152	11.1
10	9	18	4	31	71	133	9.8
11	6	8	6	23	38	81	5.9
12	2	3		1	7	13	1
MEASURED	**50**	**253**	**174**	**599**	**288**	**1364**	
COUNTED	**34**	**0**	**110**	**0**	**88**	**232**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.3**	**0.7**	**0.8**	**1.7**	**0.8**		
MEAN LENGTH (cm)	**7.2**	**7.9**	**5.6**	**7.6**	**9**		
(SD)	**3.1**	**1.6**	**1.9**	**1.4**	**1.9**		
MEAN WEIGHT (g)	**8**	**5**	**4**	**6**	**13**		
(SD)	**8**	**6**	**5**	**5**	**7**		

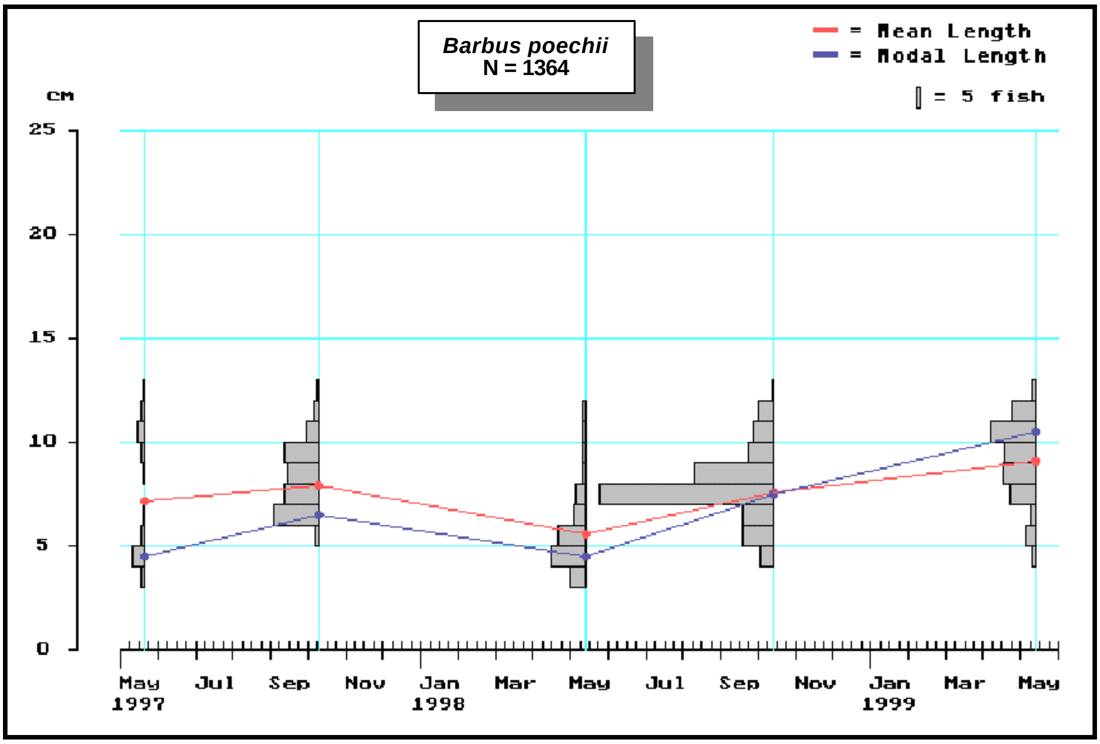


Figure 9.17: Length frequencies of *Barbus poechii* during five surveys in the Eastern Caprivi.

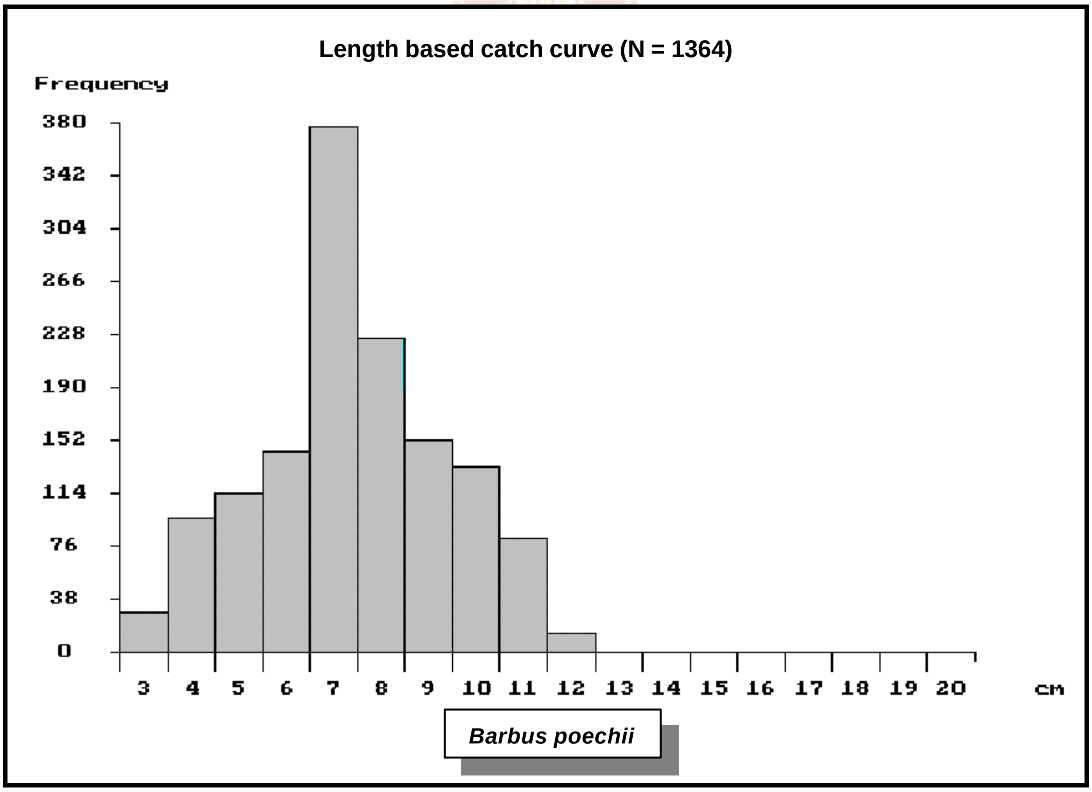


Figure 9.18: Length frequencies of *Barbus poechii* for the Eastern Caprivi, 1997-1999.

Micralestes acutidens

This species does not grow very large, 8cm standard length (Skelton, 1993), and specimens representing the whole length spectrum (1 – 9cm) of *Micralestes acutidens* were sampled during the study. The CPUE decreased as the surveys progressed (Table 9.10).

Small juvenile specimens were sampled more regularly during high floods, indicating that this species spawned during the preceding rain seasons (Figure 9.19).

Lengths recorded during the study (Figure 9.20), indicate two different generations, and a healthy population, 1 – 6cm represent juveniles and immature fish, and 7 – 9cm indicate the mature fish (Chapter 8).

Table 9.10: Length frequencies of *Micralestes acutidens* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
1	1				2	3	0.2
2	266	5	10		9	290	14.5
3	297	304	99	32	45	777	38.9
4	29	206	61	21	17	334	16.7
5	9	174		5	13	201	10.1
6	26		39	2	12	79	4
7	130	5	55	19	83	292	14.6
8	5	1		1	11	18	0.9
9					3	3	0.2
MEASURED	**763**	**695**	**264**	**80**	**195**	**1997**	
COUNTED	**0**	**0**	**6**	**0**	**41**	**47**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**2.5**	**2**	**0.7**	**0.2**	**0.5**		
MEAN LENGTH (cm)	**3.9**	**4**	**4.8**	**4.9**	**5.8**		
(SD)	**1.7**	**0.8**	**1.6**	**1.6**	**1.9**		
MEAN WEIGHT (g)	**1**	**0**	**2**	**2**	**3**		
(SD)	**2**	**1**	**2**	**2**	**3**		

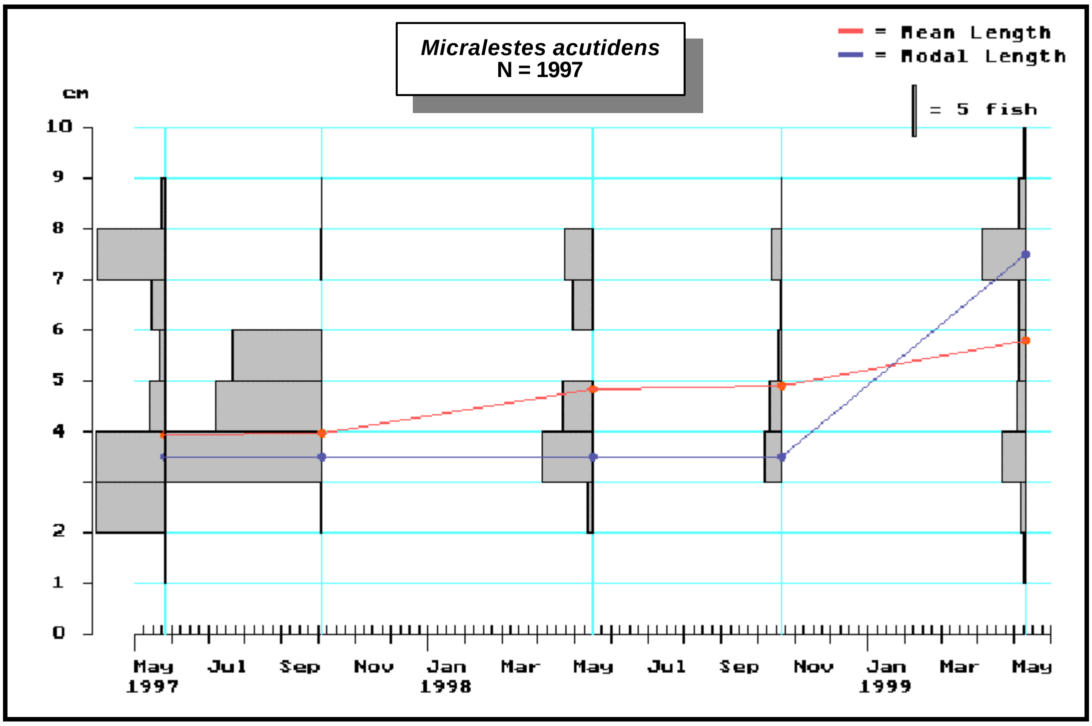


Figure 9.19: Length frequencies of *Micralestes acutidens* during five surveys in the Eastern Caprivi.

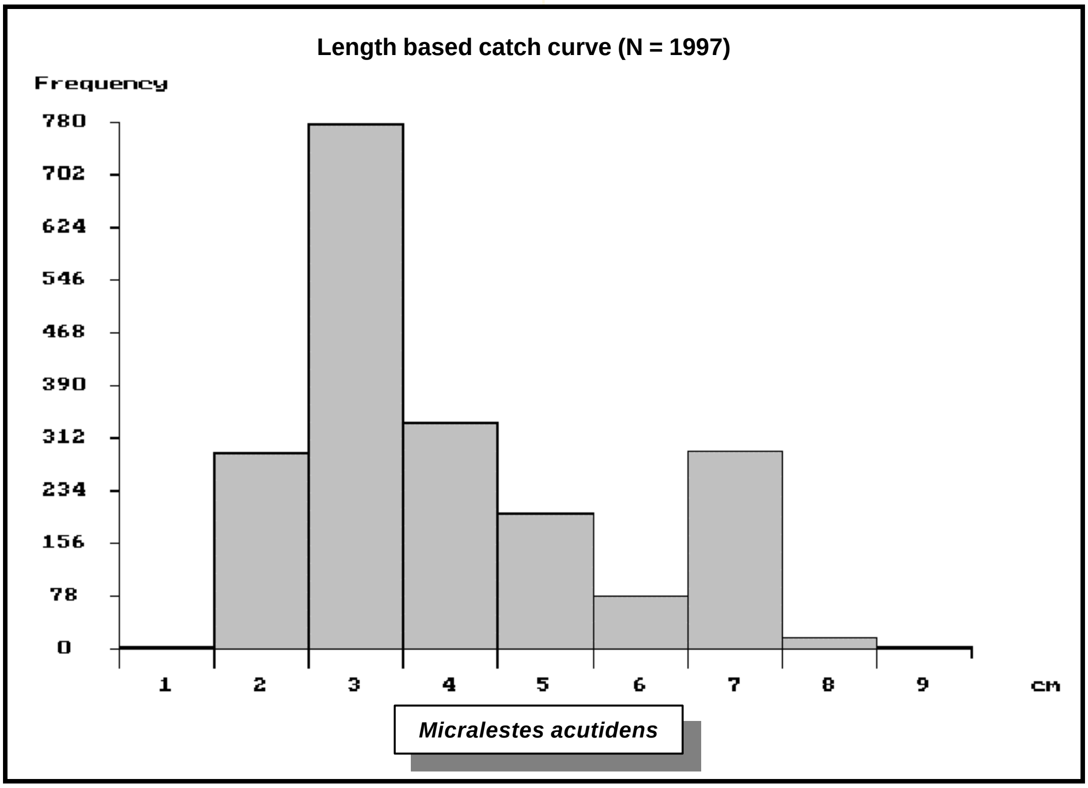


Figure 9.20: Length frequencies of *Micralestes acutidens* for the Eastern Caprivi, 1997-1999.

Hepsetus odoe

Several length classes were recorded in a 3 – 39cm range. A juvenile specimen of 3cm was sampled during the 1997 high flood, indicating successful spawning during the preceding summer season (Table 9.11). *Hepsetus odoe* is a multiple spawner during summer, and grows rapidly to maturity in the second year, mature from 20 – 25cm (Skelton, 1993). The CPUE for this species was relatively constant (Table 9.11).

Juveniles, immature and mature specimens were sampled regularly. Several generations exist in the population as several cohorts were recorded, indicating successful spawning during previous seasons. Large specimens are present in the system, and a healthy breeding stock exists (Figure 9.21).

Several size classes (3cm, 9-13cm, 14-19cm, 20-24cm, 25-28cm, 29-31cm, 31-36cm) were recorded, indicating that several generations exist and that spawning was successful during past seasons. A healthy population exist, and the specimens sampled were representative of the length spectrum of *Hepsetus odoe* (Figure 9.22).

Table 9.11: Length frequencies of *Hepsetus odoe* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.11							
3	1					1	0.3
10	1	2	1		3	7	1.9
11		2			1	3	0.8
12		3				3	0.8
13		1			2	3	0.8
14		7			3	10	2.7
15	2	7		1		10	2.7
16		11			7	18	4.9
17		13		6	5	24	6.5
18		16		5	8	29	7.9
19		13	1	4	3	21	5.7
20		7		17	2	26	7.1
21		5		25		30	8.2
22	1	3	1	24	1	30	8.2
23		10		10		20	5.4
24		2	2	5	3	12	3.3
25		2	7	4	1	14	3.8
26		1	8	3	5	17	4.6
27	1	3	7	6	3	20	5.4
28	1	3	3	3	1	11	3

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.11							
29	2	3	1		6	12	3.3
30	1	5	2	2	6	16	4.3
31		1		1	5	7	1.9
32		2		2	5	9	2.4
33		2	1		4	7	1.9
34					4	4	1.1
35					1	1	0.3
36					2	2	0.5
39					1	1	0.3
MEASURED	**10**	**124**	**34**	**118**	**82**	**368**	
COUNTED	**0**	**0**	**0**	**0**	**0**	**0**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.03**	**0.4**	**0.1**	**0.3**	**0.2**		
MEAN LENGTH (cm)	**20.9**	**19.8**	**25.8**	**22.1**	**24.3**		
(SD)	**9.3**	**5.3**	**3.7**	**3.2**	**7.6**		
MEAN WEIGHT (g)	**167**	**116**	**221**	**136**	**223**		
(SD)	**146**	**121**	**71**	**75**	**189**		

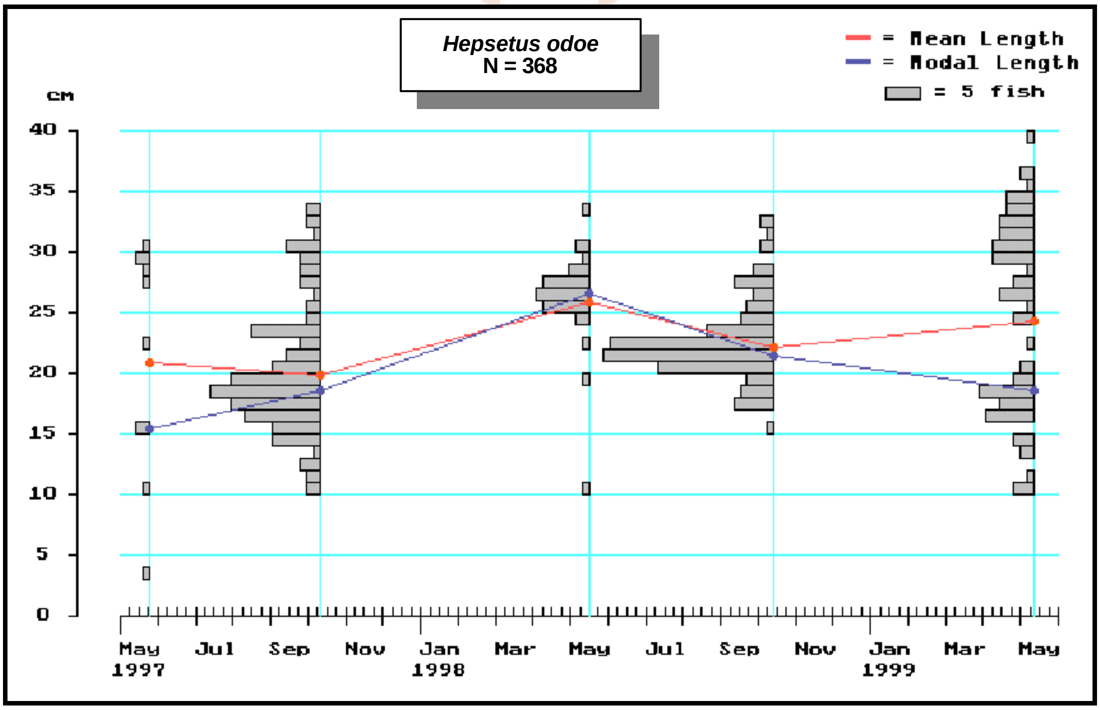


Figure 9.21: Length frequencies of *Hepsetus odoe* during five surveys in the Eastern Caprivi.

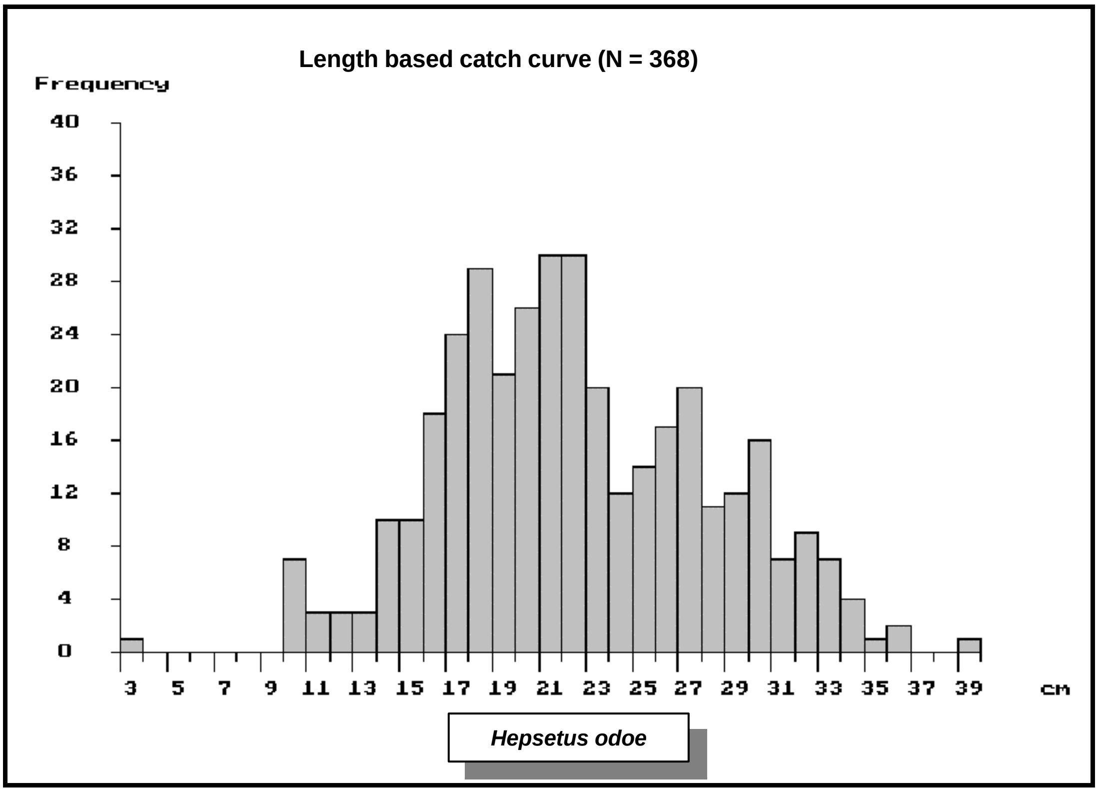


Figure 9.22: Length frequencies of *Hepsetus odoe* for the Eastern Caprivi, 1997-1999.

Pseudocrenilabrus philander

Several length classes were recorded for *Pseudocrenilabrus philander* during the five surveys, with juveniles sampled regularly, indicating that this species spawned regularly and successfully. The CPUE decreased as the surveys progressed (Table 9.12).

This species breed from early spring to late summer (Skelton, 1993). Juvenile specimens in the 1cm class were sampled during all the surveys, indicating that this species did spawn successfully during late summer and early spring, during the time of the study (Figure 9.23).

Table 9.12: Length frequencies of *Pseudocrenilabrus philander* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
1	4	1	10	28	3	46	4.2
2	49	41	87	9	34	220	19.9
3	59	55	61	6	43	224	20.3
4	51	55	23	47	29	205	18.6
5	29	45	29	50	14	167	15.1
6	20	44	6	34	9	113	10.2
7	12	20	2	19	4	57	5.2
8	5	16	2	11	1	35	3.2
9	5	21		4		30	2.7
10		5		1		6	0.5
MEASURED	**234**	**303**	**220**	**209**	**137**	**1103**	
COUNTED	**11**	**0**	**51**	**0**	**0**	**62**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.8**	**0.9**	**0.7**	**0.6**	**0.3**		
MEAN LENGTH (cm)	**4.3**	**5.1**	**3.4**	**5**	**3.9**		
(SD)	**1.7**	**2.1**	**1.3**	**2**	**1.3**		
MEAN WEIGHT (g)	**2**	**3**	**1**	**3**	**1**		
(SD)	**3**	**4**	**1**	**3**	**1**		

Several lengths were recorded (juvenile to mature fish), indicating a healthy population of *Pseudocrenilabrus philander* (Figure 9.24).

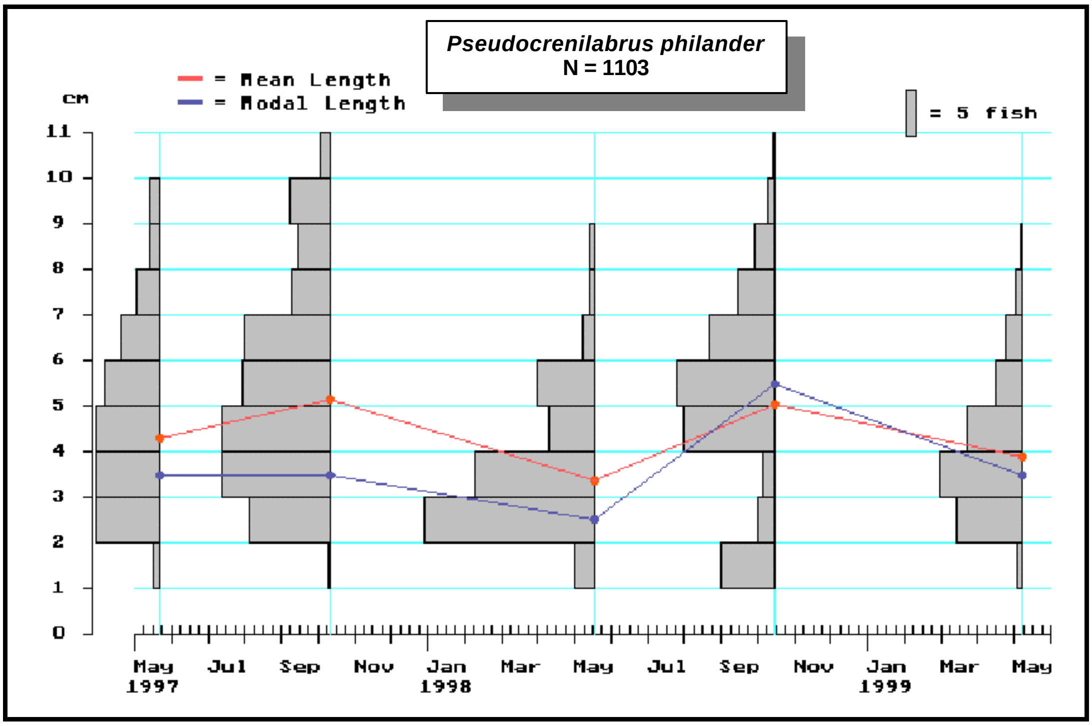


Figure 9.23: Length frequencies of *Pseudocrenilabrus philander* during five surveys in the Eastern Caprivi.

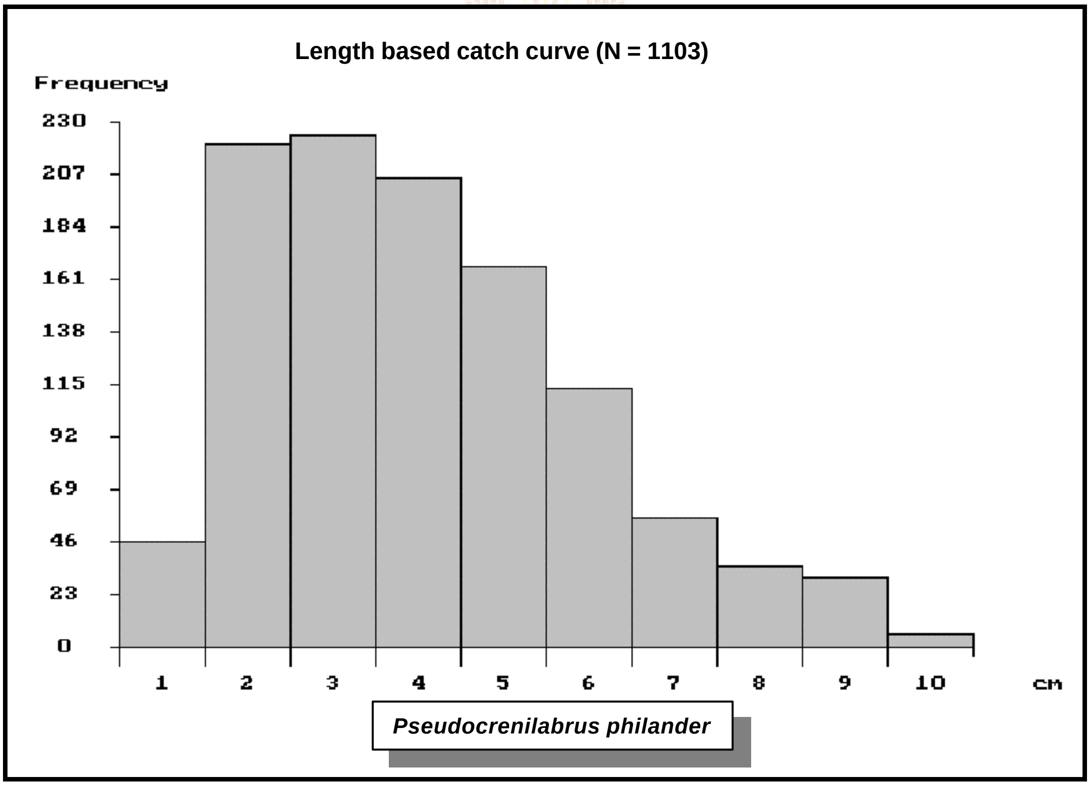


Figure 9.24: Length frequencies of *Pseudocrenilabrus philander* for the Eastern Caprivi, 1997-1999.

Tilapia rendalli

Specimens were sampled in a length range of 1 – 31cm. Small juvenile specimens were sampled regularly, with the most juveniles sampled during high floods, indicating that this species spawned successfully during the summer rain seasons preceding the high floods. The CPUE for this species remained fairly constant, except for a low CPUE during the 1999 high flood survey (Table 9.13). Most of the specimens sampled were immature and in the 1cm to 9cm length class. Larger specimens of up to 31cm were sampled, indicating that large specimens are present (Figure 9.25).

Table 9.13 Length frequencies of *Tilapia rendalli* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
1			3			3	0.3
2	7		106	1	6	120	13.2
3	13	1	61		4	79	8.7
4	22	10	36	1	17	86	9.5
5	32	48	17	22	2	121	13.3
6	58	65	4	43	2	172	18.9
7	30	41	4	55	1	131	14.4
8	3	14	4	50	3	74	8.1
9	4	2	2	39		47	5.2
10	1	10		19	1	31	3.4
11	1	2		11		14	1.5
12	2			9		11	1.2
13	1			4	1	6	0.7
14	1			2	1	4	0.4
16				2	1	3	0.3
17		1		1		2	0.2
20					1	1	0.1
22				1		1	0.1
26			1			1	0.1
30				1		1	0.1
31		1				1	0.1
MEASURED	**175**	**195**	**238**	**261**	**40**	**909**	
COUNTED	**127**	**0**	**2**	**0**	**0**	**129**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**1**	**0.6**	**0.7**	**0.7**	**0.1**		
MEAN LENGTH (cm)	**6**	**6.6**	**3.6**	**8.3**	**5.8**		
(SD)	**1.8**	**2.4**	**2**	**2.6**	**4**		
MEAN WEIGHT (g)	**5**	**5**	**3**	**15**	**13**		
(SD)	**8**	**48**	**28**	**35**	**36**		

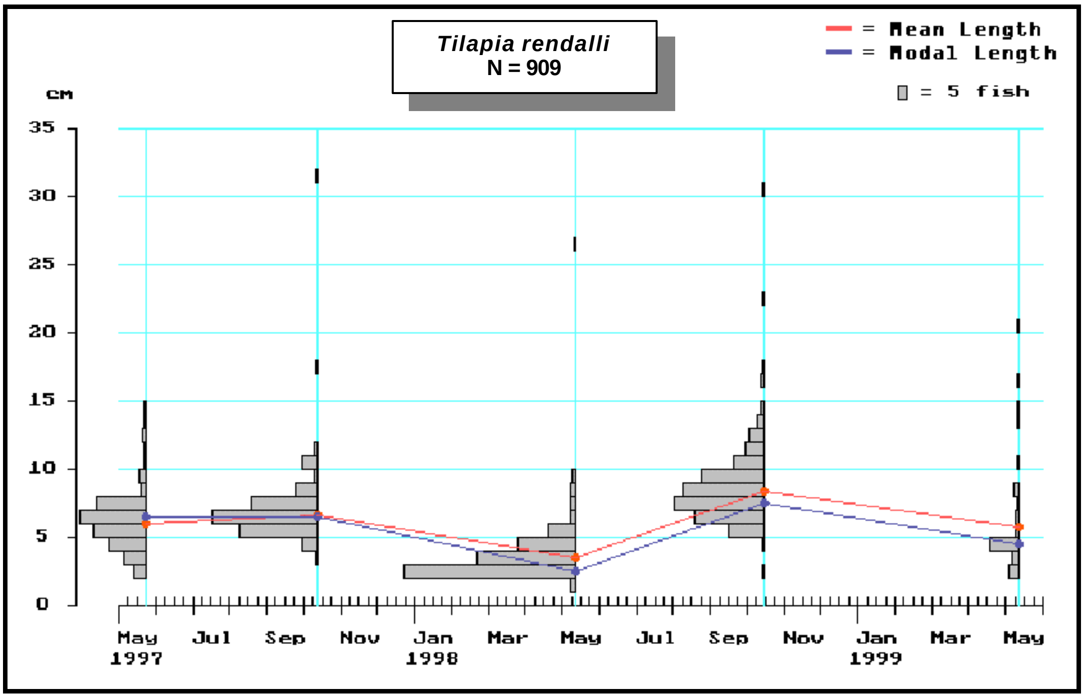


Figure 9.25: Length frequencies of *Tilapia rendalli* during five surveys in the Eastern Caprivi.

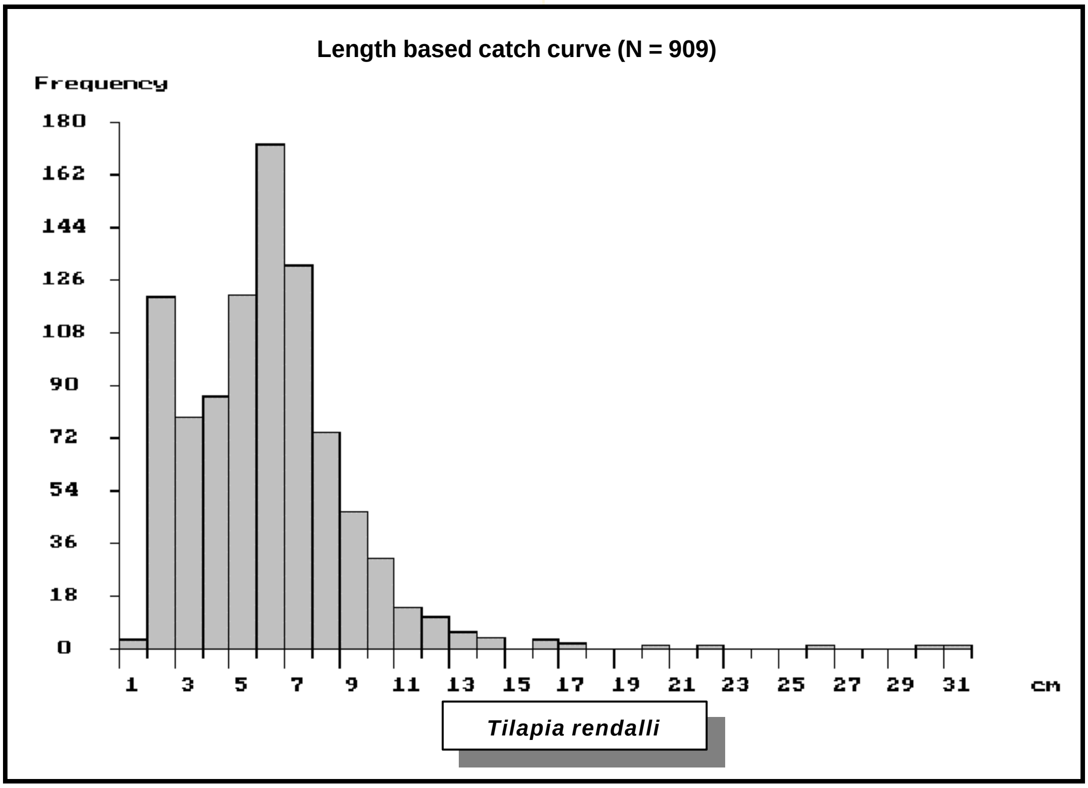


Figure 9.26: Length frequencies of *Tilapia rendalli* for the Eastern Caprivi, 1997-1999.

Large specimens were sampled, but not regularly. *Tilapia rendalli* is a popular target species in the local fishery, and the low numbers of larger specimens sampled may be an indication of exploitation of this species. Its preferred habitat (floodplain and vegetated areas) was also difficult to sample. High numbers recorded in the smaller length classes indicate successful spawning during the time of the study. Specimens sampled were representative of the length spectrum of *Tilapia rendalli*, although large specimens were not abundant (Figure 9.26).

Barbus paludinosus

Several specimens in several length classes were sampled, with an increase in the CPUE for this species during the first four surveys, and a drop during the fifth (Table 9.14).

Small specimens were sampled regularly, indicating successful spawning during the time of the study (Figure 9.27).

Barbus paludinosus is a small species, and the specimens sampled were representative of the length spectrum for this species. The catch curve indicates a healthy population (Figure 9.28).

Table 9.14: Length frequencies of *Barbus paludinosus* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
1					2	2	0.3
2	1	3	7	1	14	26	3.4
3	1	2	104	20	24	151	20
4	2	3	143	55	7	210	27.9
5		88	19	61	10	178	23.6
6	1	10	2	41	8	62	8.2
7	5	4		55	4	68	9
8	2	10	2	29	7	50	6.6
9		1		5		6	0.8
10	1					1	0.1
MEASURED	**13**	**121**	**277**	**267**	**76**	**754**	
COUNTED	**0**	**0**	**630**	**311**	**5**	**946**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.04**	**0.3**	**2.5**	**1.6**	**0.2**		
MEAN LENGTH (cm)	**6.4**	**5.4**	**4.1**	**5.9**	**4.4**		
(SD)	**2.2**	**1.2**	**0.7**	**1.6**	**1.9**		
MEAN WEIGHT (g)	**3**	**1**	**1**	**3**	**2**		
(SD)	**3**	**2**	**1**	**2**	**2**		

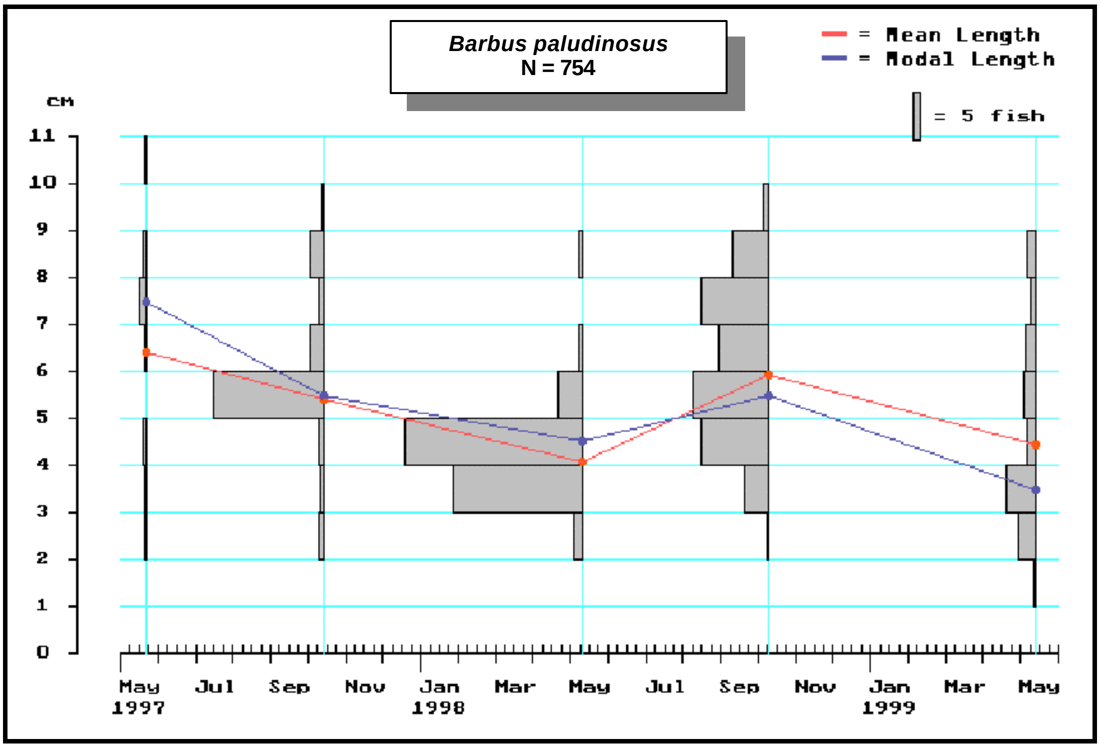


Figure 9.27: Length frequencies of *Barbus paludinosus* during five surveys in the Eastern Caprivi.

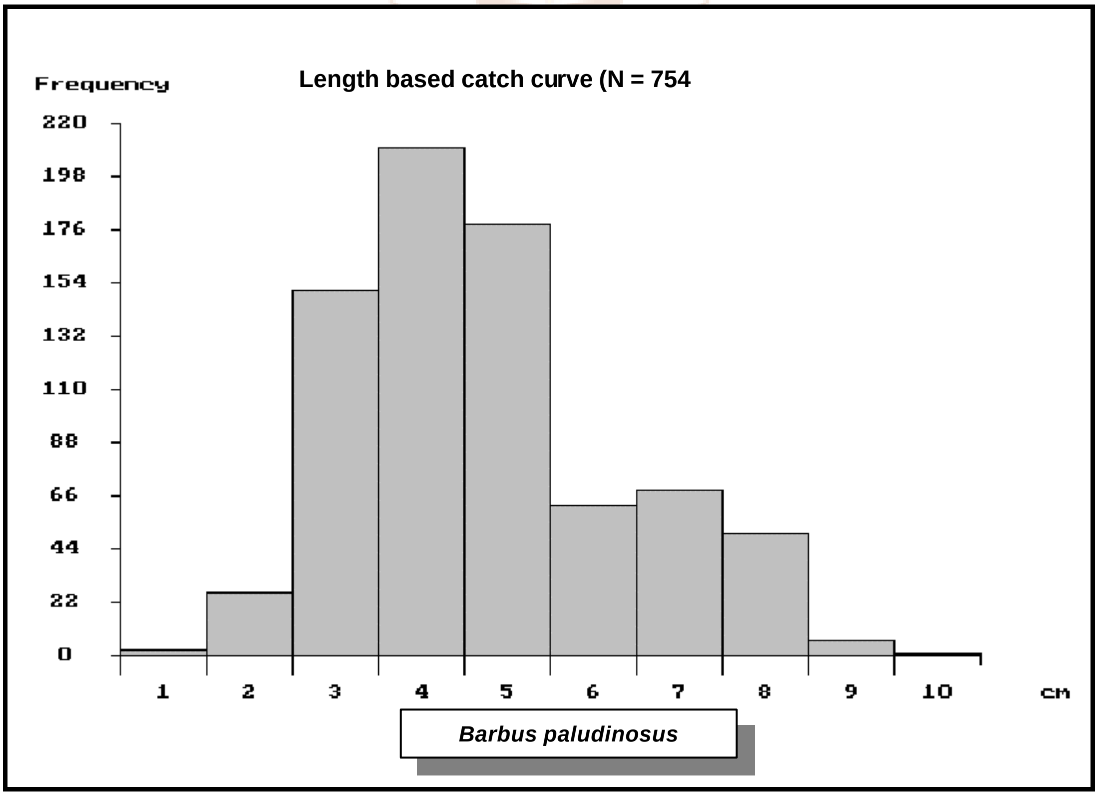


Figure 9.28: Length frequencies of *Barbus paludinosus* for the Eastern Caprivi, 1997-1999.

Oreochromis macrochir

Specimens in a 2 – 35cm length range were sampled. There was a decrease in the CPUE for this species after the first two surveys. Juveniles were sampled regularly during high floods, indicating that this species spawned during the preceding Summer rain seasons (Table 9.15).

Specimens in the 4 – 9cm length class were sampled regularly, indicating successful spawning during the time of the study. Other length cohorts recorded indicate several generations and successful spawning during previous seasons (Figure 9.29).

Large specimens of *Oreochromis macrochir* are present and were sampled, but not regularly. As this is a target fishery species the low number of large specimens sampled may be an indication of exploitation of this species. Mostly small specimens in the 2 – 9cm length class were sampled, with specimens in length classes representing the length spectrum of *Oreochromis macrochir* (Figure 9.30).

Table 9.15: Length frequencies of *Oreochromis macrochir* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.15							
2	1		2		1	4	0.4
3	17		11		7	35	3.6
4	62	21	15		4	102	10.6
5	41	182	18			241	25.1
6	31	108	17	1	1	158	16.5
7	20	136	1	1		158	16.5
8	7	42	2	4	1	56	5.8
9	2	95		8	1	106	11.1
10	1			14		15	1.6
11		3		18		21	2.2
12		3		9		12	1.3
13				10		10	1
14		2		9		11	1.1
15				2		2	0.2
16		1		1		2	0.2
17				7		7	0.7
18		1				1	0.1
19		2		2		4	0.4
20				2		2	0.2
22	1				1	2	0.2
24				3		3	0.3

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.15							
25				1		1	0.1
26				1		1	0.1
27	1	1				2	0.2
29					1	1	0.1
34					1	1	0.1
35					1	1	0.1
MEASURED	**184**	**597**	**66**	**93**	**19**	**959**	
COUNTED	**220**	**0**	**10**	**0**	**0**	**230**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**1.3**	**1.7**	**0.2**	**0.3**	**0.04**		
MEAN LENGTH (cm)	**5.5**	**6.8**	**5.1**	**13**	**9.8**		
(SD)	**2.4**	**2**	**1.3**	**4**	**11.1**		
MEAN WEIGHT (g)	**7**	**2**	**3**	**63**	**16**		
(SD)	**37**	**22**	**2**	**79**	**35**		

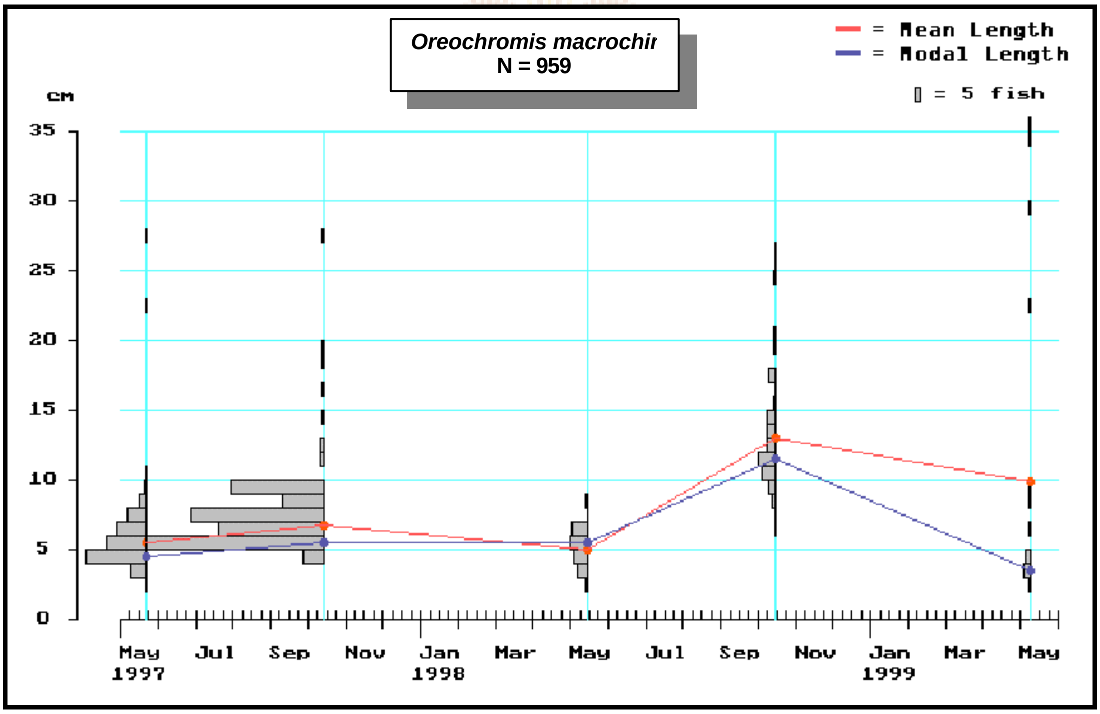


Figure 9.29: Length frequencies of *Oreochromis macrochir* during five surveys in the Eastern Caprivi.

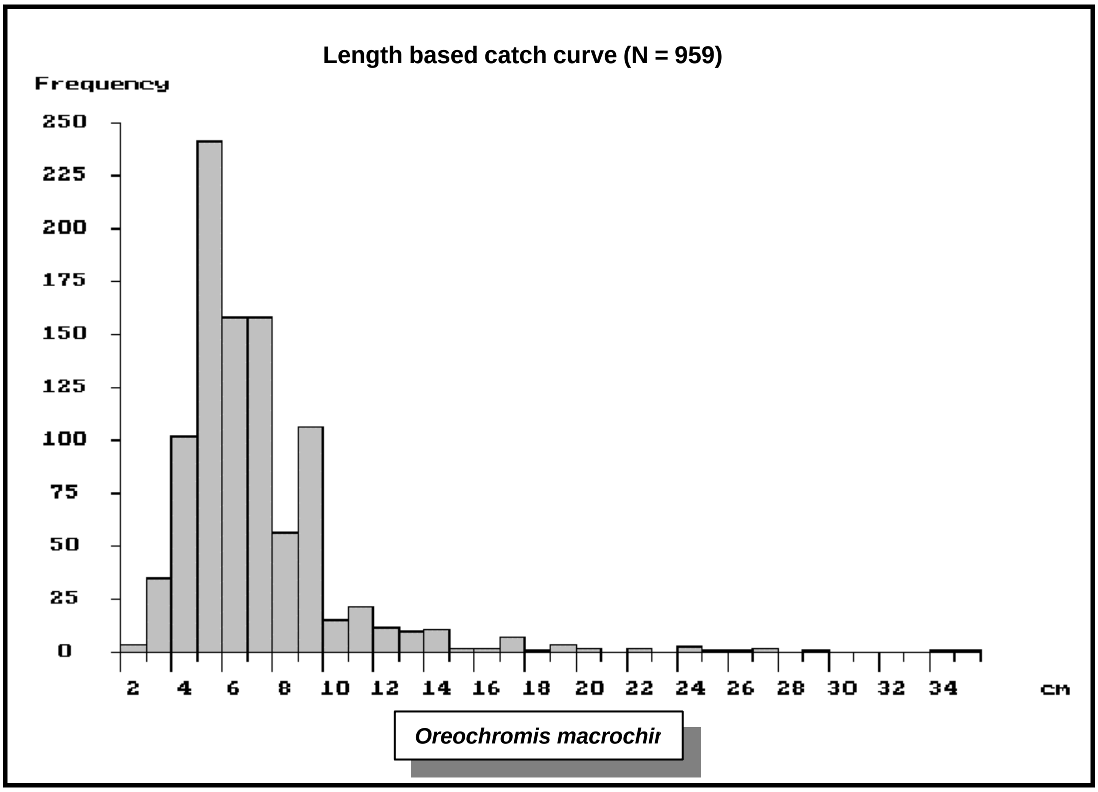


Figure 9.30: Length frequencies of *Oreochromis macrochir* for the Eastern Caprivi, 1997-1999.

Hemichromis elongatus

The CPUE for this species increased during the first four surveys, with a drop in CPUE during the fifth. Specimens were sampled in a length range of 2 – 19cm. Juveniles were sampled regularly during high floods, indicating that this species spawned during the Summer rain seasons (Table 9.16).

Table 9.16: Length frequencies of *Hemichromis elongatus* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
Table 9.16							
2	1		1		2	4	1.1
3	3		6		10	19	5
4	8		2		4	14	3.7
5	1	2	4	1	8	16	4.2
6	1	5	5	2	5	18	4.8
7	2	8	1	4	4	19	5
8		5	2	4	1	12	3.2
9		6		16		22	5.8
10		4	1	11		16	4.2
11		7	7	12	1	27	7.2
12	1	2	6	20		29	7.7
13	1	3	10	14	1	29	7.7
14		6	8	24		38	10.1
15		10	4	15	5	34	9
16		9	8	13	10	40	10.6
17	1	2	10	16	4	33	8.8
18		1	4	1		6	1.6
19			1			1	0.3
MEASURED	**19**	**70**	**80**	**153**	**55**	**377**	
COUNTED	**0**	**0**	**2**	**0**	**0**	**2**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.1**	**0.2**	**0.2**	**0.4**	**0.1**		
MEAN LENGTH (cm)	**6.1**	**11.5**	**12**	**13**	**9.1**		
(SD)	**3.9**	**3.6**	**4.7**	**2.9**	**5.5**		
MEAN WEIGHT (g)	**10**	**35**	**50**	**44**	**31**		
(SD)	**22**	**29**	**41**	**28**	**39**		

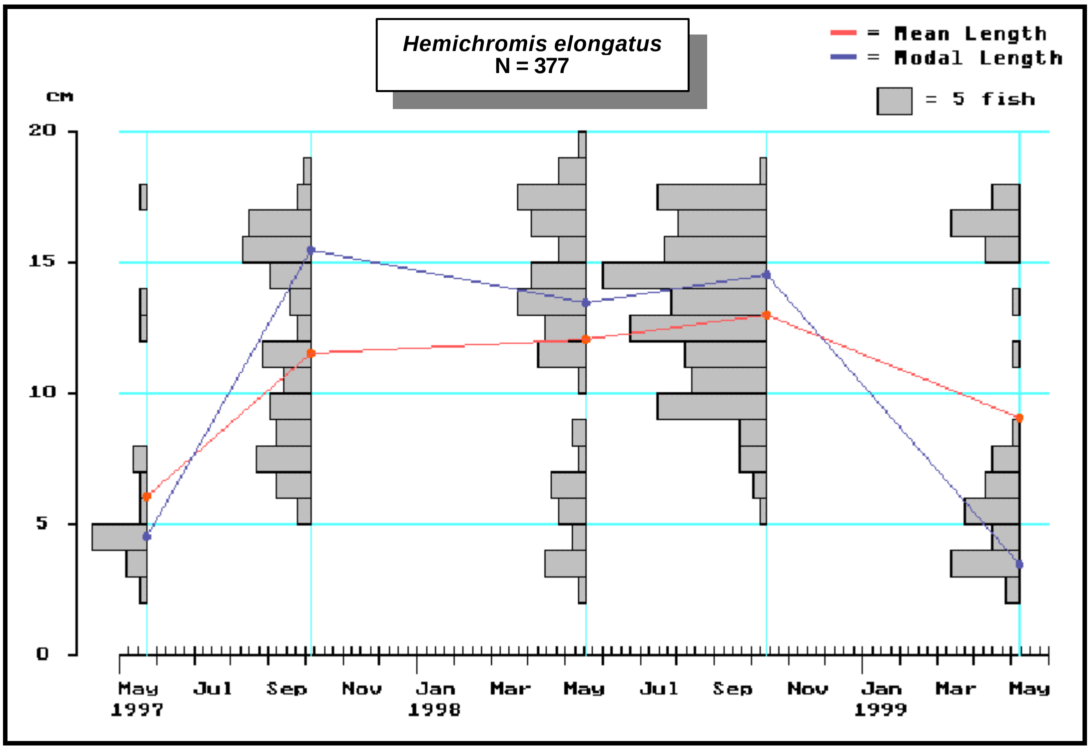


Figure 9.31: Length frequencies of *Hemichromis elongatus* during five surveys in the Eastern Caprivi.

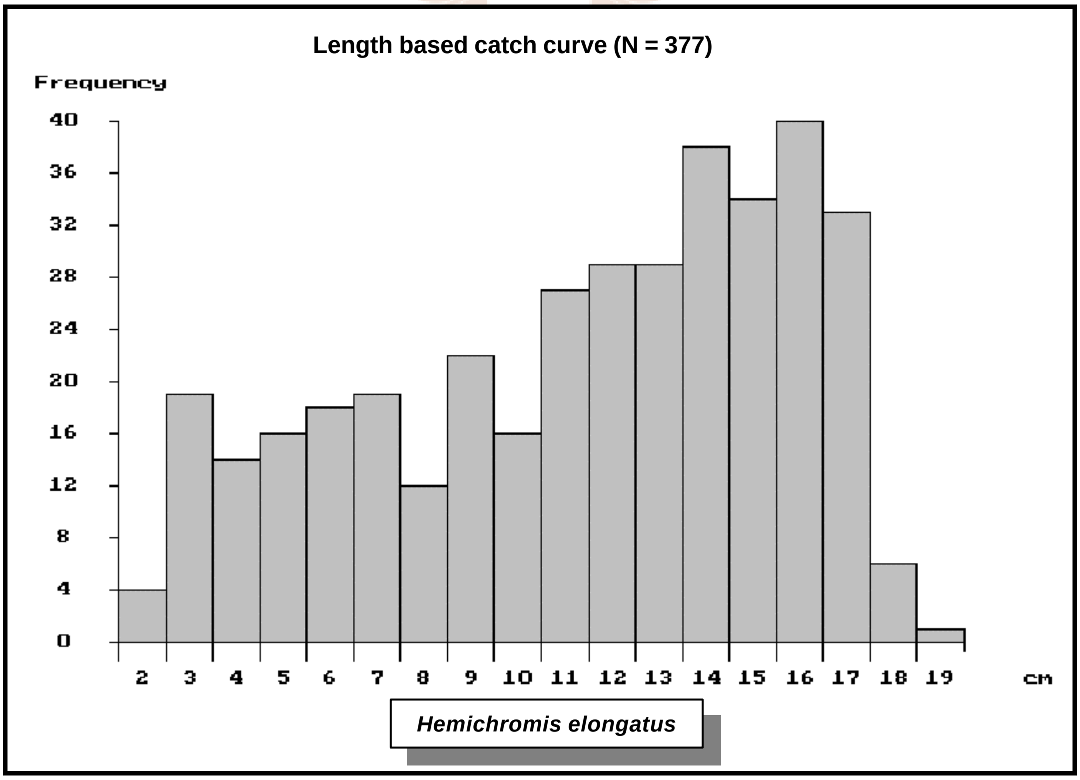


Figure 9.32: Length frequencies of *Hemichromis elongatus* for the Eastern Caprivi, 1997-1999.

Several specimens from several length classes were sampled during each survey, with juveniles sampled regularly, indicating that spawning occurred regularly, and that several generations exist in a healthy population (Figure 9.31).

Large specimens occur and were sampled abundantly, indicating a healthy breeding stock. This species does not grow very large, and it might be that the local fishermen and their gear do not target this species. This might explain why large mature specimens from this species were regularly sampled. Specimens sampled are representative of the length spectrum of *Hemichromis elongatus*, with several cohorts recorded during the study (Figure 9.32).

Oreochromis andersonii

The CPUE's for this species were low during all the surveys. Local subsistence fishery targets *Oreochromis andersonii*, and the low numbers sampled may be an indication of exploitation of this species. More study is needed in terms of local fishery, and the habitat utilisation of this species to make definite conclusions. It is a large species, and specimens in a length range of 3 – 42cm were sampled (Table 9.17).

Table 9.17: Length frequencies of *Oreochromis andersonii* during five surveys in the Eastern Caprivi.

Length (cm)	Year					Total	%
	1997		1998		1999		
	Flood		Flood		Flood		
	High	Low	High	High	Low		
3	1		1			2	2
4					1	1	1
5	2		1	1	1	5	5
6	3			1		4	4
7	5			1		6	5.9
8	2		2	6		10	9.9
9	1			7	1	9	8.9
10	2	1		4		7	6.9
11				12		12	11.9
12				12		12	11.9
13				10		10	9.9
14				6		6	5.9
15				6		6	5.9
16				1	1	2	2
18				1		1	1
19				2		2	2
22				2		2	2
23	1					1	1
26	1					1	1
32			1			1	1
42			1			1	1
MEASURED	**18**	**1**	**6**	**72**	**4**	**101**	
COUNTED	**0**	**0**	**0**	**0**	**0**	**0**	
SETS	**303**	**355**	**366**	**357**	**484**	**1865**	
CPUE (# per set)	**0.1**	**0.003**	**0.02**	**0.2**	**0.01**		
MEAN LENGTH (cm)	**9**	**10**	**16.4**	**12.2**	**9**		
(SD)	**5.9**		**16.3**	**3.1**	**5.5**		
MEAN WEIGHT (g)	**40**	**14**	**442**	**32**	**26**		
(SD)	**97**		**697**	**25**	**40**		

Juveniles were sampled during high floods, indicating successful spawning during the summer rain seasons, during the time of the study. Most specimens sampled were in the 5 – 20cm length range (Figure 9.33).

The specimens sampled were representative of the length spectrum of *Oreochromis andersonii*, although low numbers were recorded. Large specimens are present, but were not sampled regularly, indicating possible exploitation. Different generations exist, indicating successful spawning during previous seasons (Figure 9.34).

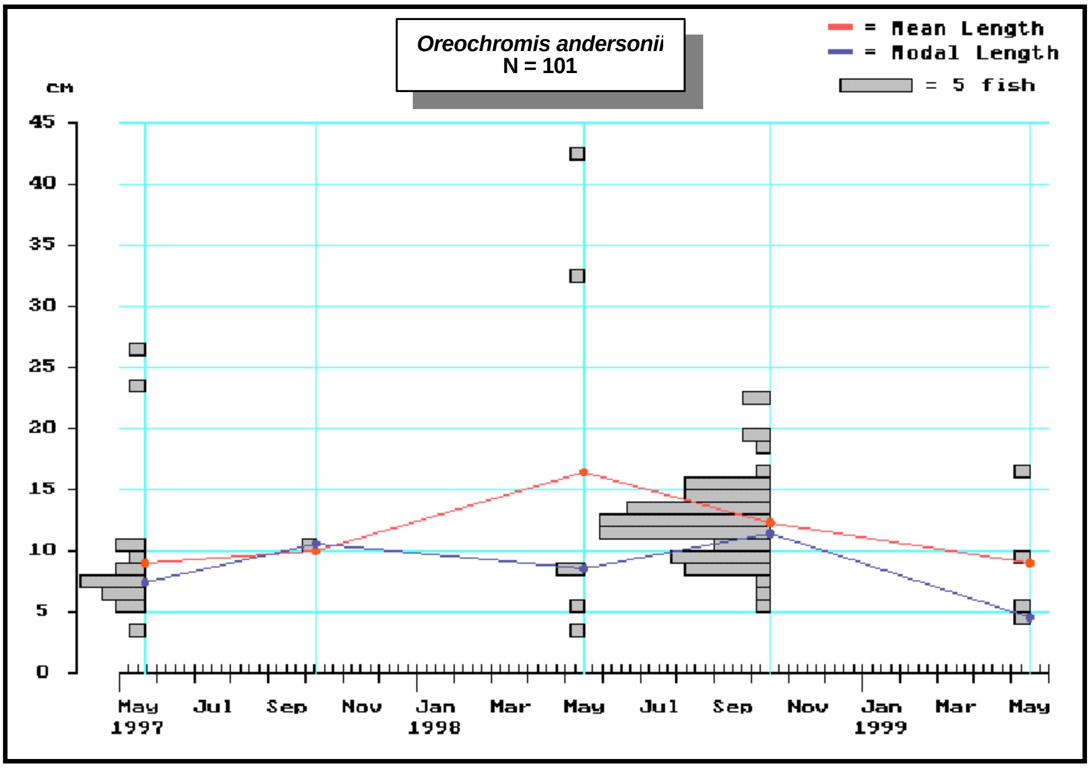


Figure 9.33: Length frequencies of *Oreochromis andersonii* during five surveys in the Eastern Caprivi.

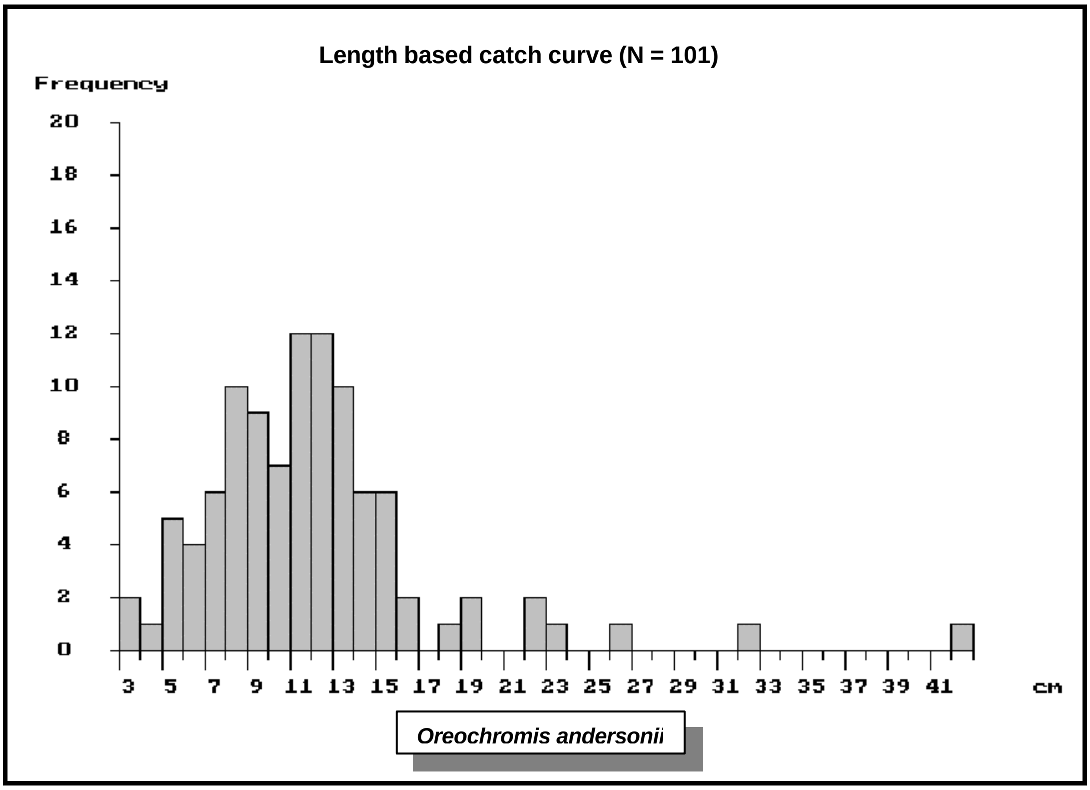


Figure 9.34: Length frequencies of *Oreochromis andersonii* for the Eastern Caprivi, 1997-1999.

Cyprinidae

The species included in the length based catch curve (Figure 9.35) are *Mesobola brevianalis, Opsaridium zambezense,* the *Barbus* spp*. and Coptostomabarbus wittei.* The species were grouped as some were sampled in low numbers, and the graph serves to indicate the length ranges recorded for the species sampled in the Cyprinidae family (see Chapter 5 for the relative densities recorded).

Most of the species in the Cyprinidae family sampled in the Eastern Caprivi are small and fall in the 1 – 12cm length class.

Barbus codringtonii is the only *Barbus* species in the Eastern Caprivi that grows large (39cm, according to Skelton, 1993), and a specimen of 20cm was sampled during low flood. Small specimens of *Barbus codringtonii* were not sampled, and there was no indication of whether this species spawned successfully. This is a habitat specific species which is difficult to sample. More studies are needed concerning this species (Figure 9.35).

Several of the smaller *Barbus* species are floodplain type species or species preferring dense vegetation, and fall in the 1 – 6cm length class. Examples are *Barbus barotseensis, Barbus thamalakanensis, Barbus barnardi, Barbus fasciolatus, Barbus haasianus, Coptostomabarbus wittei, Barbus multilineatus,* and *Barbus afrovernayi* (Figure 9.35).

Mesobola brevianalis falls in the 1 – 7cm length class, and *Opsaridium zambezense* falls in the 1 – 12cm length class, and both are open, clean water species (Figure 9.35).

The other larger *Barbus* species, *Barbus bifrenatus, Barbus unitaeniatus, Barbus radiatus, Barbus poechii, Barbus paludinosus* fall in the 1 – 12cm length class, and were more abundant, and tolerant to a variety of habitat conditions (Figure 9.35).

Small specimens were sampled, indicating that some of the species did spawn during the time of the study, and different length classes were recorded for some species indicating that they did spawn during previous seasons (Figure 9.35).

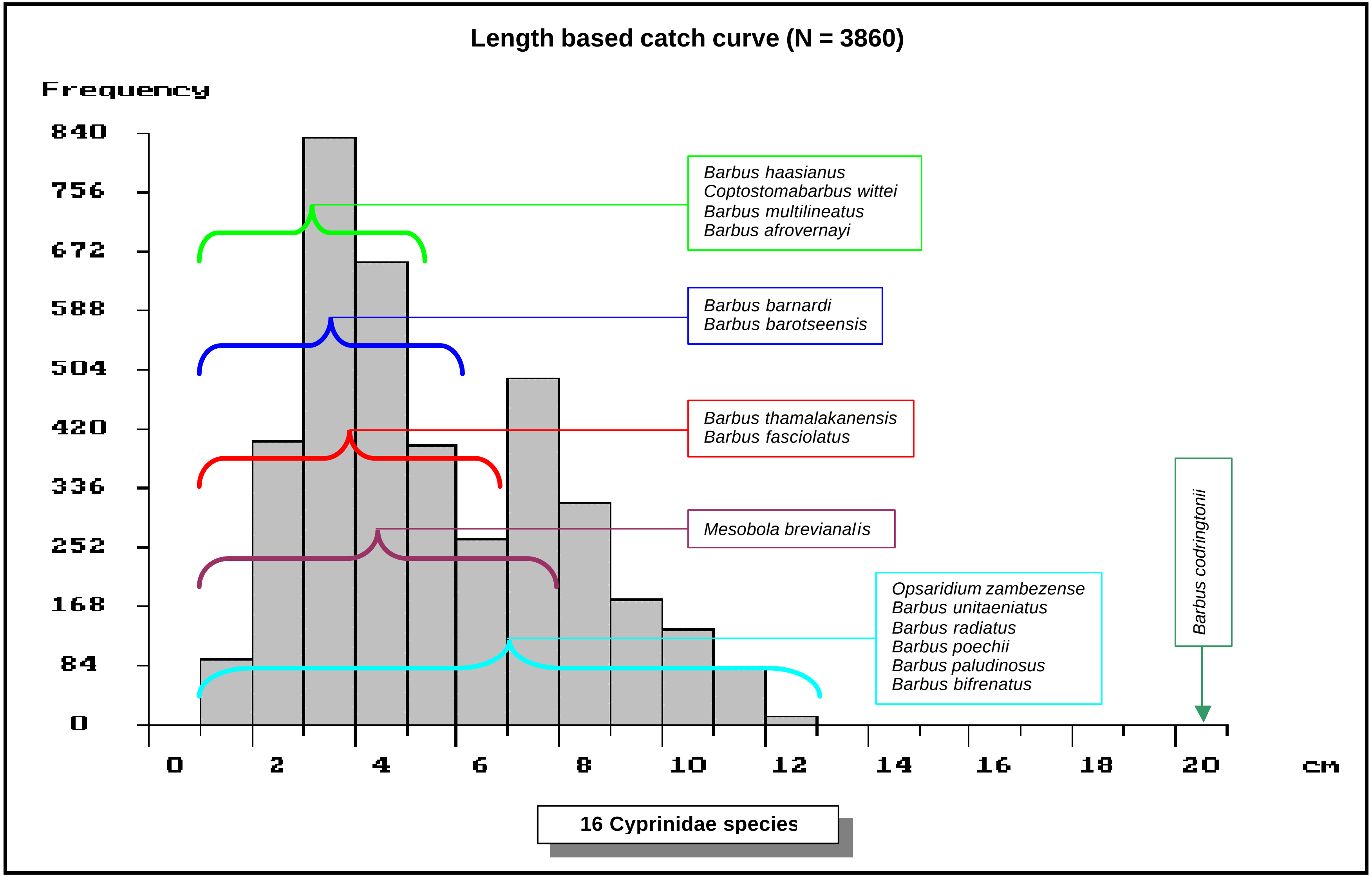


Figure 9.35: Length frequencies of 16 Cyprinidae species for the Eastern Caprivi, 1997-1999.

Two *Labeo* species

Two *Labeo* species were sampled, *Labeo cylindricus* and *Labeo lunatus,* and their combined length frequencies indicated in Figure 9.36. These species also belong to the Cyprinidae family.

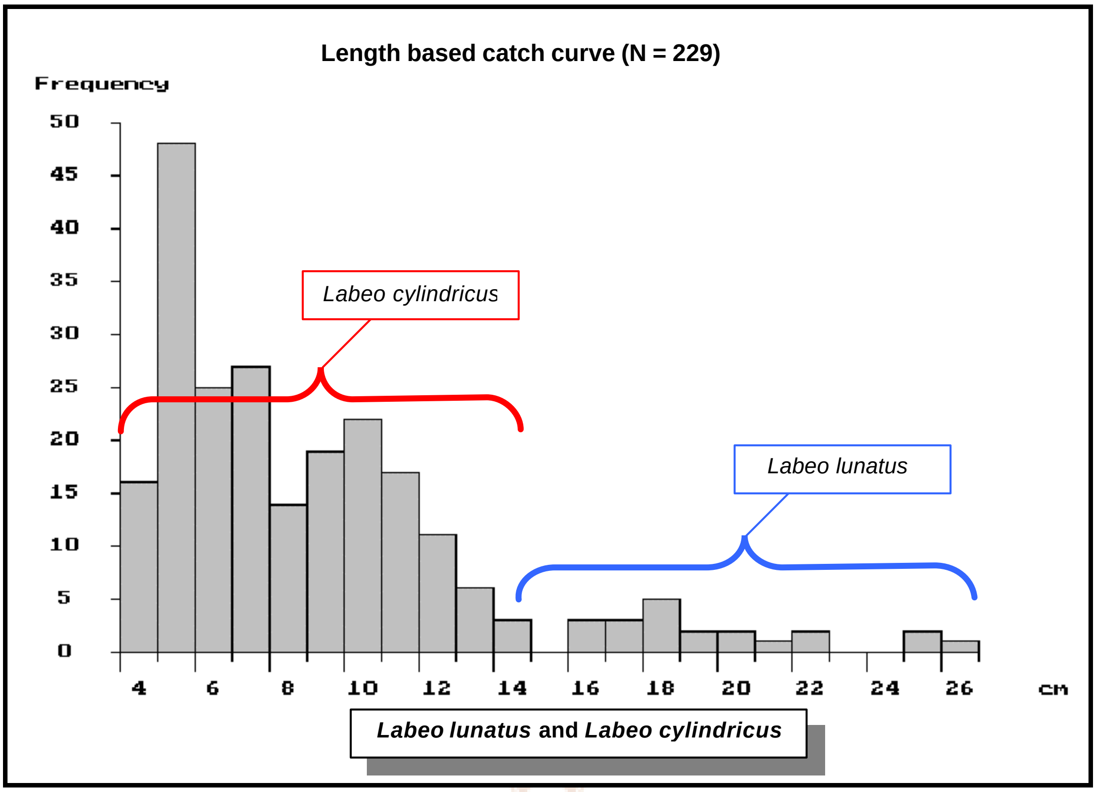


Figure 9.36: Length frequencies of two *Labeo* species for the Eastern Caprivi, 1997-1999.

Several specimens (206) of *Labeo cylindricus* were measured in the 4 – 14cm length range. Different length cohorts indicate successful spawning during previous seasons, and during the time of the study (Figure 9.36).

Twenty-three specimens of *Labeo lunatus* were measured in the 14 – 26cm length class. Different length cohorts indicate spawning during previous seasons, but small specimens (1 – 13cm) of this species were not sampled during the time of the study (Figure 9.36).

Distichodontidae

Two species from this family were sampled, *Hemigrammocharax machadoi* and *Hemigrammocharax multifasciatus* (Figure 9.37).

Hemigrammocharax machadoi attains a standard length of 4cm (Skelton, 1993), and specimens were sampled in the length spectrum of this species. It is a small species, and most specimens sampled were in the 1 – 3cm length class (Figure 9.37).

Hemigrammocharax multifasciatus attains a standard length of 4.5cm, and the specimens sampled were in the length spectrum of the species. A small species, and most of the specimens sampled were in the 2 – 5cm length class (Figure 9.37).

Small juvenile specimens of both species were sampled during the study, indicating that both species spawned successfully (see Chapter 5 for the relative densities recorded).

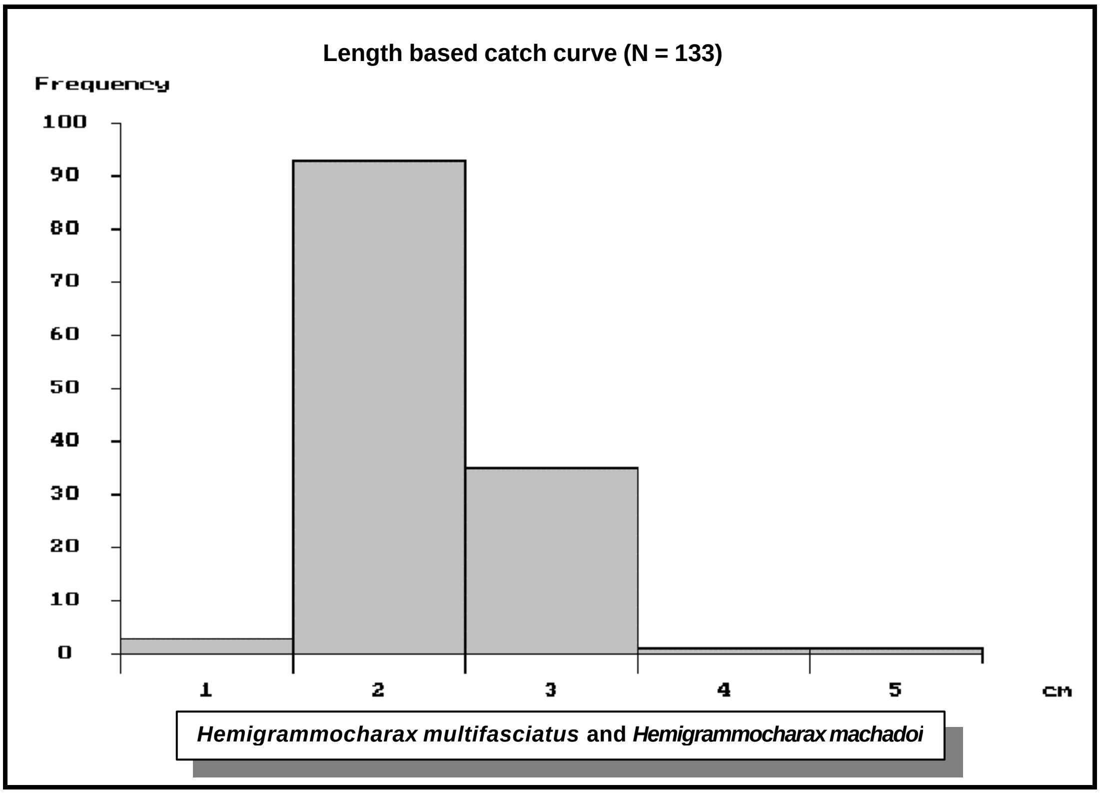


Figure 9.37: Length frequencies of two species, from the Distichodontidae family, for the Eastern Caprivi, 1997-1999.

Mochokidae

The length frequencies were grouped for all the *Synodontis* spp., and *Chiloglanis neumanni*, all from the Mochokidae family (Figure 9.38).

Specimens of *Chiloglanis neumanni* were sampled in the 3cm length class. It is a small species and attains a standard length of 6.5cm. It is a scarce species, which is habitat specific for rock habitats, and few specimens were sampled (Figure 9.38).

Several specimens of the grouped *Synodontis* spp. were sampled in a length range of 3 – 25cm. Juveniles were sampled during low floods, indicating that this species did spawn during the time of the study. Spawning for some species probably occurred during the rain season and the high floods (Figure 9.38) (see Chapter 5 for the relative densities recorded).

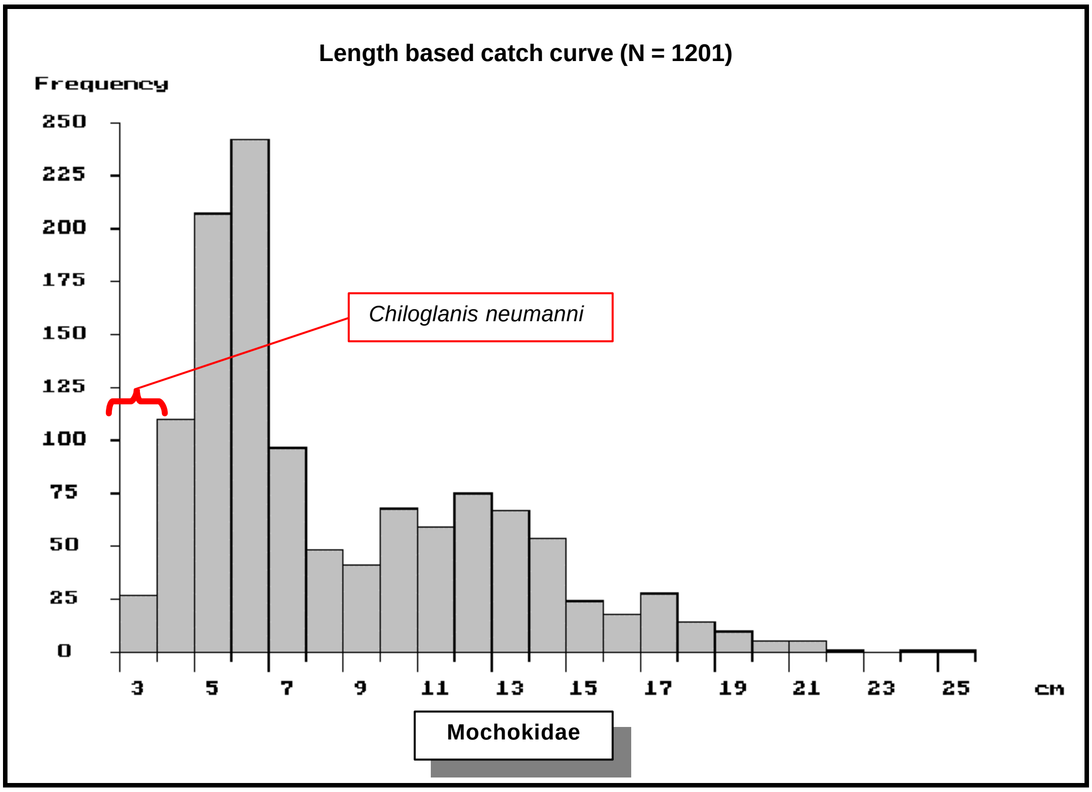


Figure 9.38: Length frequencies of *Chiloglanis neumanni,* and the *Synodontis* spp., from the Mochokidae family, for the Eastern Caprivi, 1997-1999.

Cyprinodontidae

Three species were sampled in this family, *Aplocheilichthys johnstoni, Aplocheilichthys katangae* and *Aplocheilichthys hutereaui* (Figure 9.39) (see Chapter 5 for the relative densities recorded).

All three of the species from the Cyprinodontidae family are small species, and each was sampled in their length spectrum. Juveniles were sampled during each survey, indicating that spawning occurred regularly during the study, and that spawning was not flood dependant (Figure 9.39).

Aplocheilichthys johnstoni and *Aplocheilichthys katangae* attains 5cm, and *Aplocheilichthys hutereaui* attains 3.5cm, total length. These species are serial spawners, and may spawn throughout the warmer months in suitable conditions (Skelton, 1993).

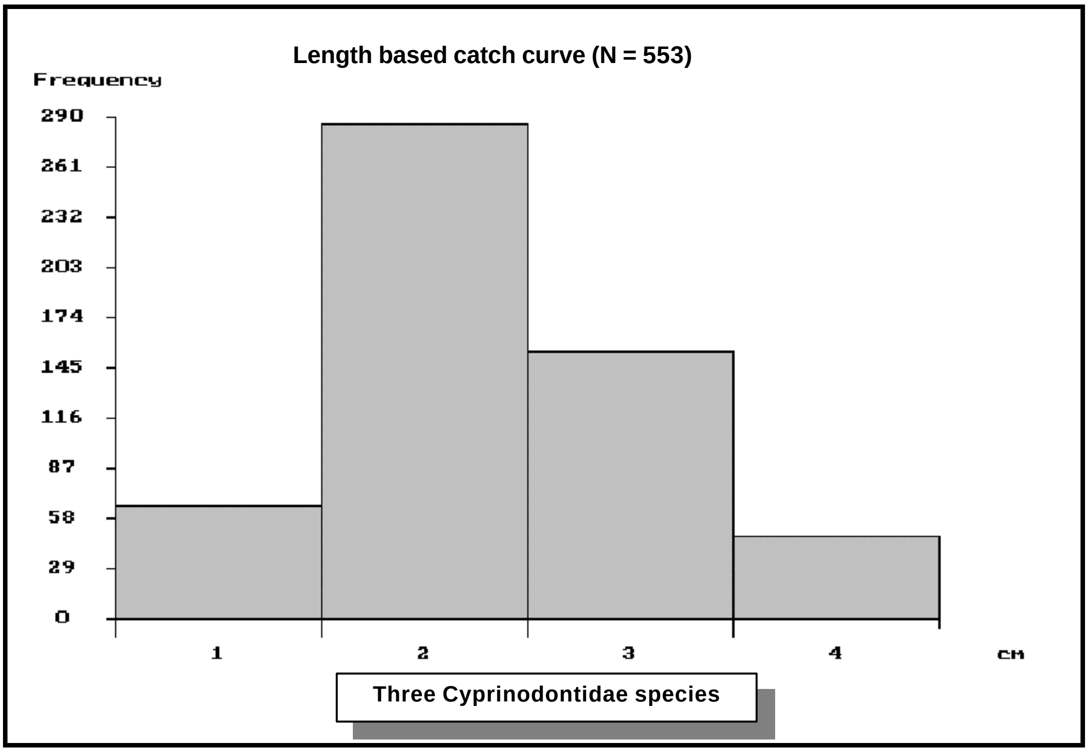


Figure 9.39: Length frequencies of three Cyprinodontidae species for the Eastern Caprivi, 1997-1999.

Three *Sargochromis* species (Cichlidae)

Three species were sampled, *Sargochromis carlottae, Sargochromis codringtonii* and *Sargochromis giardi* (Figure 9.40).

Several length classes were recorded for *Sargochromis carlottae* (70 specimens in the 7 - 26cm length range), and *Sargochromis codringtonii* (25 specimens in the 7 - 21cm length range), indicating that spawning occurred during previous seasons. Specimens in the 7 – 10cm length class were sampled during the 1999 high flood survey, indicating that this two species spawned during the time of the study (Figure 9.40).

Immature or juvenile specimens of *Sargochromis giardi* were not sampled, but 18 specimens in the 18 - 38cm length range were sampled (Figure 9.40).

These species all feed on aquatic insects, crustaceans, snails and bivalves. *Sargochromis carlottae* attains 26cm, *Sargochromis codringtonii* attains 29cm, and *Sargochromis giardi* attains 48cm, total length (Skelton, 1993).

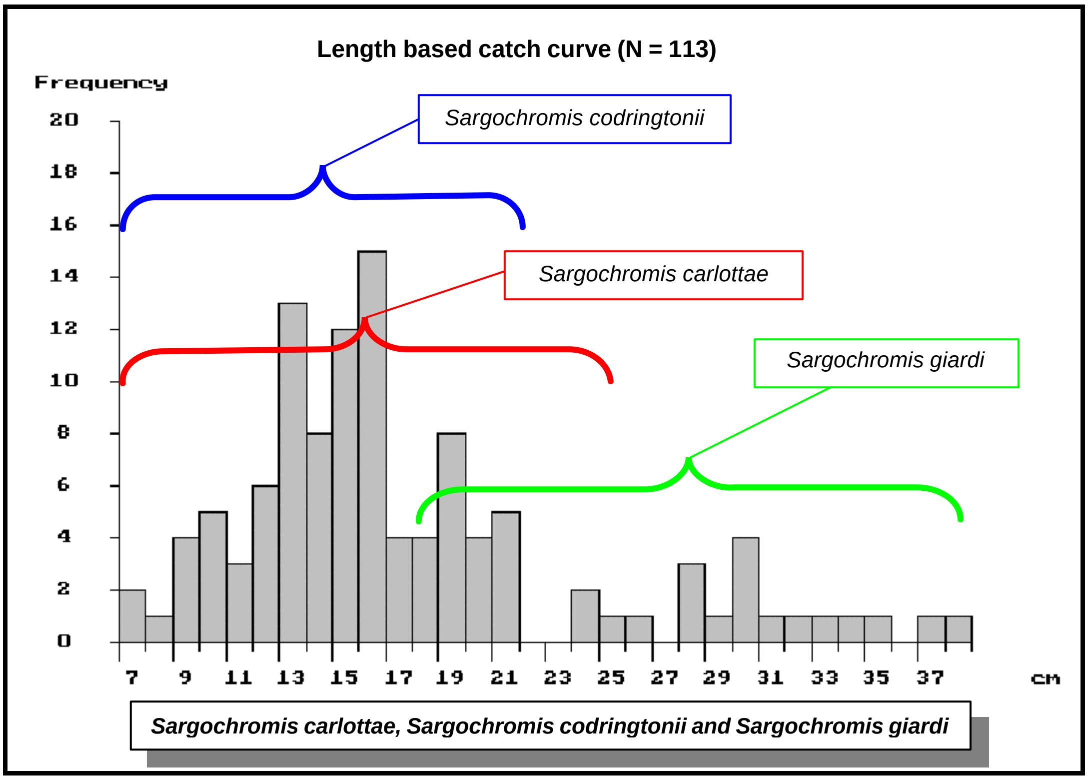


Figure 9.40: Length frequencies of three *Sargochromis* species, from the Cichlidae family, for the Eastern Caprivi, 1997-1999.

Six *Serranochromis* species (Cichlidae)

Six species were sampled (Figure 9.41), all of which are piscivores, *Serranochromis altus* (41cm, SL), *Serranochromis angusticeps* (41cm, SL), *Serranochromis longimanus* (30cm, SL), *Serranochromis macrocephalus* (35cm, SL), *Serranochromis robustus* (45cm, SL) and *Serranochromis thumbergi* (33cm, SL) (standard lengths (SL) from Skelton, 1993).

A length range of 10 – 43cm was recorded for 23 specimens of *Serranochromis altus.* Immature and mature specimens were sampled.

A length range of 5 – 38cm was recorded for 26 specimens of *Serranochromis angusticeps.* Immature and mature specimens were sampled.

A length range of 5 – 22cm was recorded for 47 specimens of *Serranochromis longimanus.* Immature and mature specimens were sampled.

A length range of 3 – 28cm was recorded for 113 specimens of *Serranochromis macrocephalus.* Immature and mature specimens were sampled.

A length range of 3 – 37cm was recorded for 60 specimens of *Serranochromis robustus.* Immature and mature specimens were sampled.

A length range of 4 – 14cm was recorded for 7 specimens of *Serranochromis thumbergi.* Immature and mature specimens were sampled.

Length ranges (Figure 9.41) indicate that spawning occurred successfully during previous seasons, as juveniles and immature specimens were sampled. Specimens were sampled in the species length ranges. Juvenile specimens were sampled regularly during the high flood surveys, indicating that spawning occurred during the summer rain seasons.

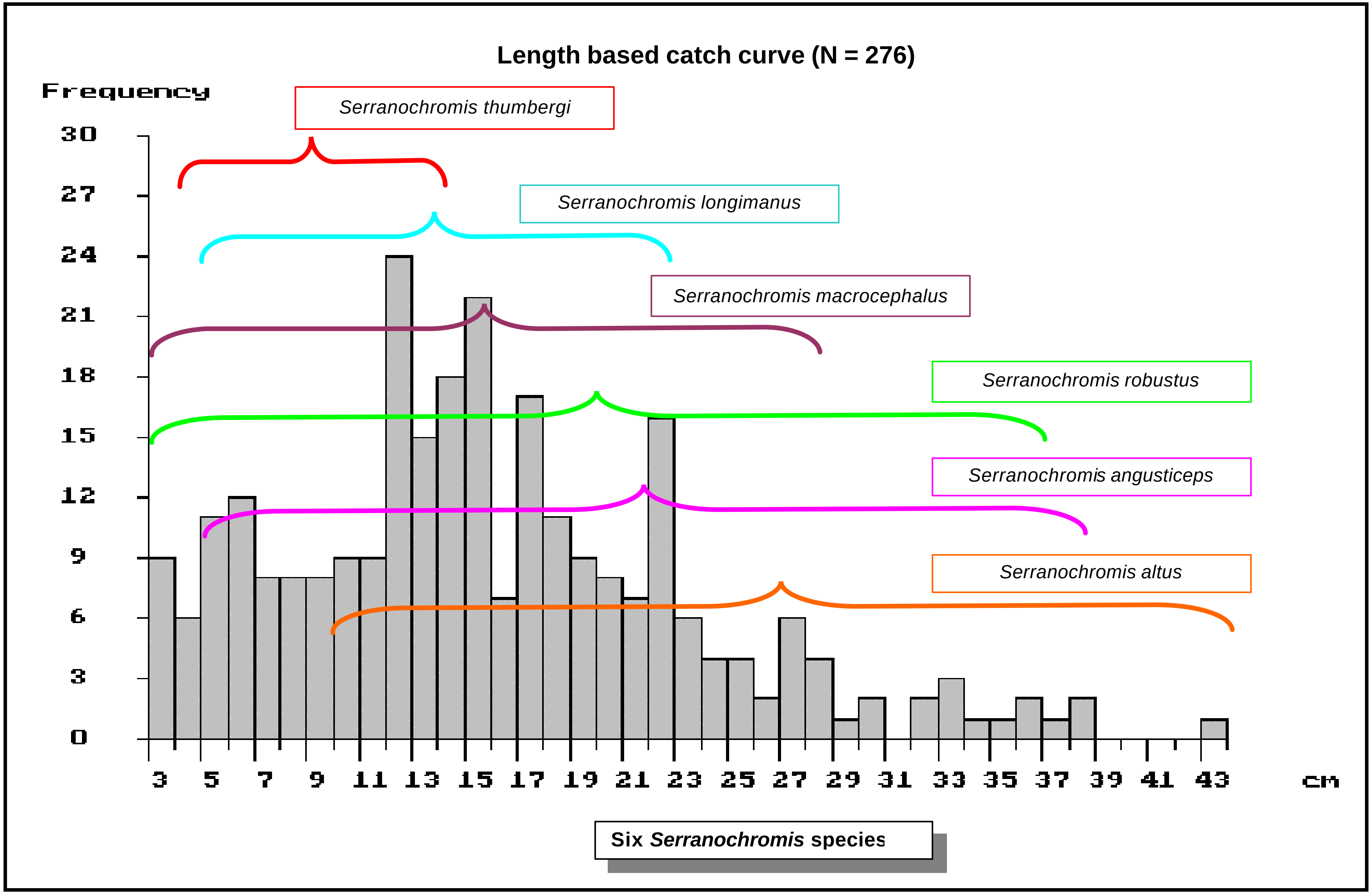


Figure 9.41: Length frequencies of six *Serranochromis* species, from the Cichlidae family, for the Eastern Caprivi, 1997-1999.

Smaller Clariidae

Three of the smaller Clariidae species were sampled, *Clarias stappersii, Clarias theodorae* and *Clariallabes platyprosopos* (Figure 9.42).

Two specimens of *Clarias stappersii* were sampled with length 8cm and 13cm, during low floods. Attains 41cm according to Skelton (1993). This species was scarce and habitat specific.

Several specimens (101) of *Clarias theodorae* were measured in a length range of 4 – 27cm. Juveniles of 4 – 6cm were sampled during high floods, suggesting that it spawned successfully during the summer rain seasons, during the study period. It attains 35cm (Skelton, 1993), and specimens with lengths representing several generations, and the length spectrum of *Clarias theodorae* were sampled. Spawning occurred successfully and regularly (Figure 9.42).

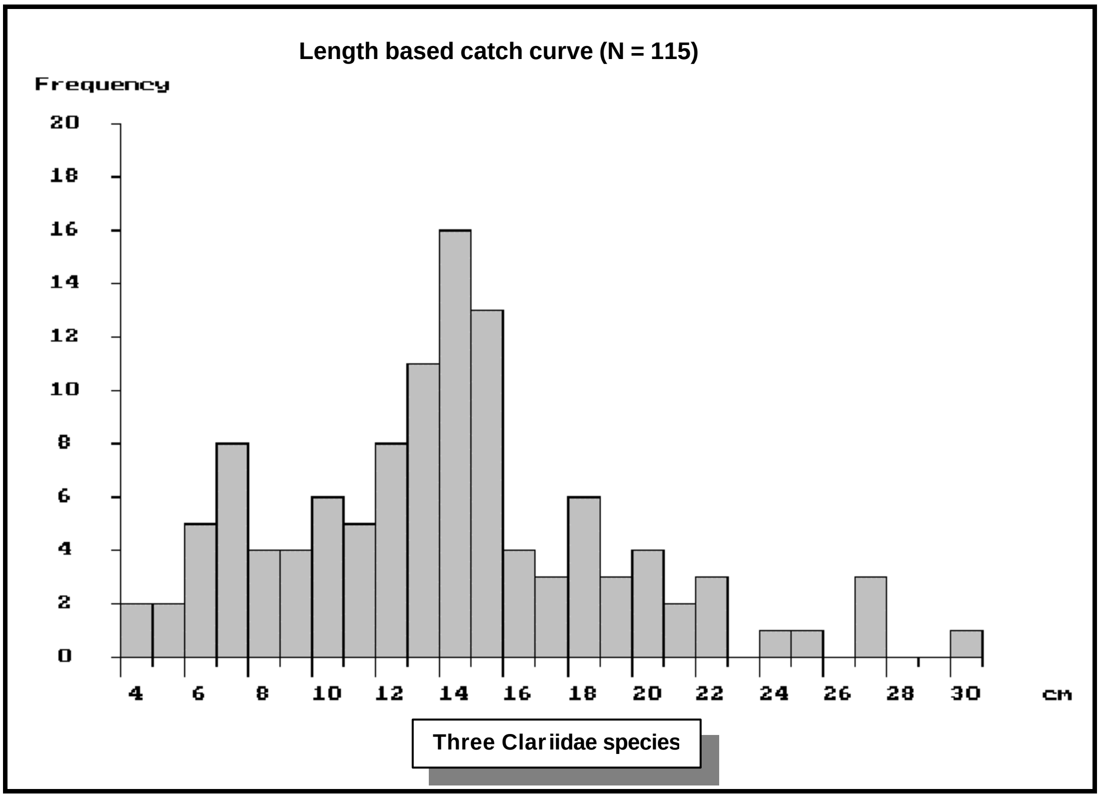


Figure 9.42: Length frequencies of three Clariidae species for the Eastern Caprivi, 1997-1999.

Twelve specimens of *Clariallabes platyprosopos* were sampled in a length range of 6 – 30cm. Skelton (1993) indicates a slightly smaller standard length of 28.3cm for this species. The lengths of the specimens represented the length spectrum of this species, and several generations, indicating that spawning occurred successfully and regularly. Juveniles of 6cm were sampled during the high flood surveys, suggesting that spawning occurred during the summer rain seasons (Figure 9.42).

Mormyrus lacerda

Twenty specimens were sampled (none were counted) in a length range of 14 – 39cm. Juveniles were not sampled, and it is not certain whether this species spawned successfully during the study. *Mormyrus lacerda* is a large species, which attains a standard length of 50cm (Skelton, 1993), and large specimens do occur, although not many were sampled. Different length cohorts recorded suggest different generations, and suggest that the species spawned successfully during previous seasons. Few specimens were sampled and a length frequency graph was therefore not presented.

Hippopotamyrus ansorgii

Eleven specimens were sampled in a length range of 7 – 12cm (none were counted). This species does not grow large, and attains a standard length of 15cm (Skelton, 1993). Specimens were sampled in the species length spectrum, although small specimens (<7cm) were not sampled, and it is not certain whether this species spawned during the time of the study. Length cohorts of 7 – 9cm, and 10 – 12cm were recorded, suggesting that at least two generations, from previous seasons exist. Few specimens were sampled and a length frequency graph was therefore not presented.

Leptoglanis cf dorae

Two specimens of 2 – 3cm were sampled during the 1997 high flood. This species attains a standard length of 2.5cm (Skelton, 1993). Few specimens were sampled and a length frequency graph was therefore not presented.

Aethiomastacembelus frenatus

Three specimens of *Aethiomastacembelus frenatus* were sampled during the study. One specimen of 7cm was sampled during high flood, and two specimens in the 25cm length class were sampled during low flood. The two length classes suggest that spawning did occur during previous seasons. Few specimens were sampled and a length frequency graph was therefore not presented.

Aethiomastacembelus vanderwaali

Several specimens (43) of *Aethiomastacembelus vanderwaali* were sampled during low floods (none were counted). Specimens were sampled in a length range of 7 – 20cm, but most specimens were in the 8 – 14cm length class. Several length classes indicate successful spawning during previous seasons, but more study is needed to make assumptions about this species. A length frequency graph was not presented.

Pollimyrus castelnaui

Pollimyrus castelnaui is a small species with a standard length of 7cm (Skelton, 1993). Several specimens (140) were measured in a 2 – 8cm length class (16 specimens were counted, N = 156). Juvenile specimens (2cm) were sampled during high floods, indicating that spawning probably occurred during the early summer rain season. Two length cohorts were recorded, 2 – 5cm and 6 – 8cm, suggesting that more than one generation with immature and mature specimens exist (Figure 9.43).

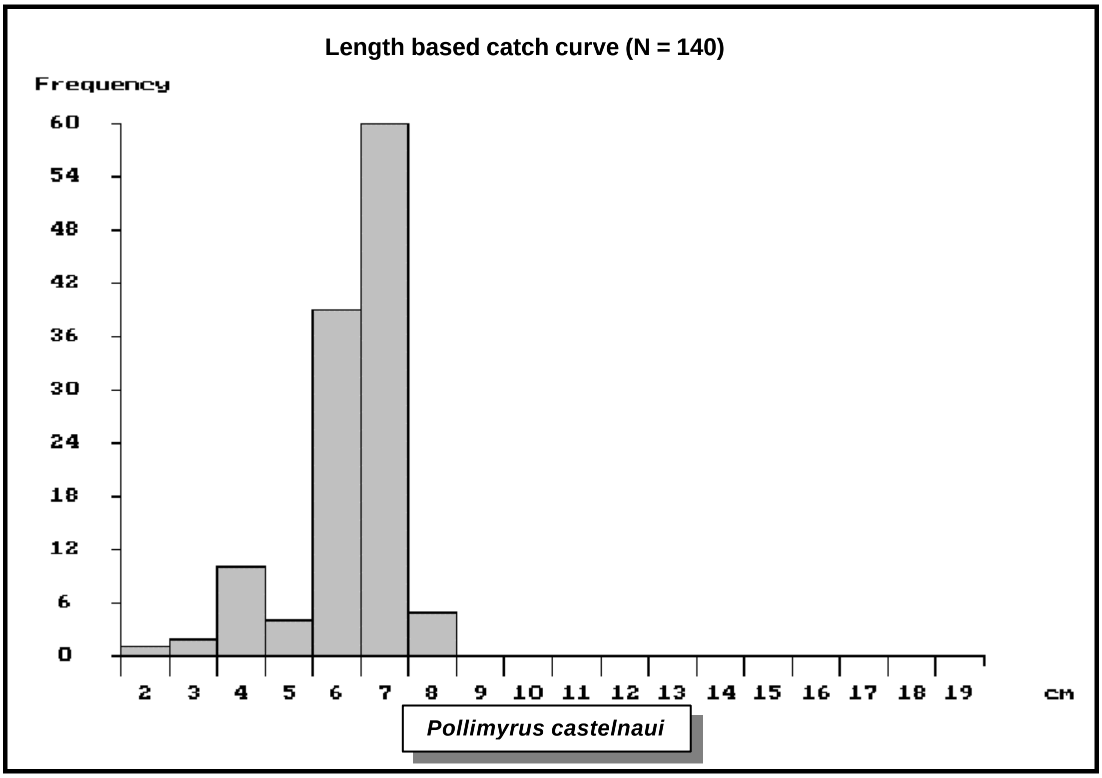


Figure 9.43: Length frequencies of *Pollimyrus castelnaui* for the Eastern Caprivi, 1997-1999.

Rhabdalestes maunensis

Several specimens (253) were measured in a length range of 1 – 6cm (221 were counted, N = 474). This species attains a standard length of 6cm, and breeds during highwater periods (Skelton, 1993). The lengths of the specimens sampled represented, the length spectrum of the species, and a healthy population with immature and mature specimens. Small juvenile specimens of 1cm were sampled during both high and low floods, suggesting that spawning takes place from early summer, when floods start to rise, to autumn, when floods are at its peak (Figure 9.44).

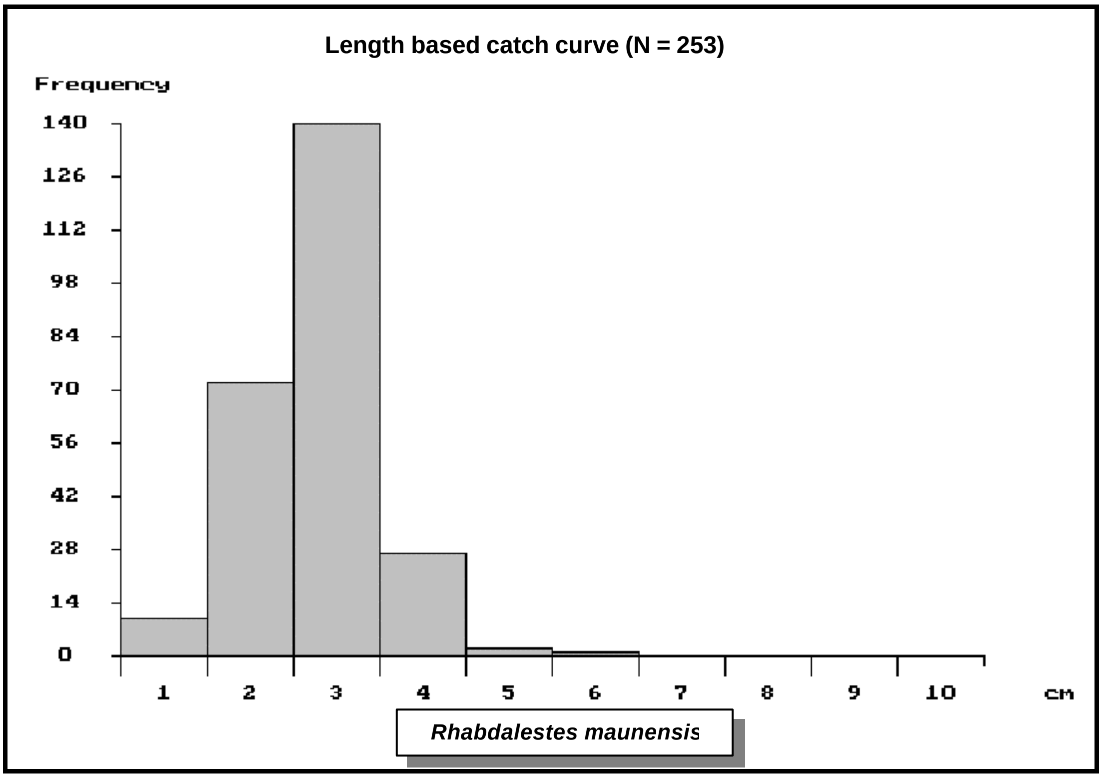


Figure 9.44: Length frequencies of *Rhabdalestes maunensis* for the Eastern Caprivi, 1997-1999.

Parauchenoglanis ngamensis

Forty specimens were measured, with lengths recorded in a range of 6 – 22cm (none were counted). It attains a length of 38cm (Skelton, 1993). Immature specimens in length cohorts of 6 – 8cm and 9 – 14cm, and mature specimens in length cohorts of 16 – 17cm and 19 – 22cm were sampled. This species did spawn successfully during previous seasons. The immature specimens of 6 – 8cm were sampled during the low flood spring season of 1998, suggesting that spawning might have occurred during the previous summer rain season. Most specimens were in the 6 – 14cm length class, and very large specimens were not sampled (Figure 9.45).

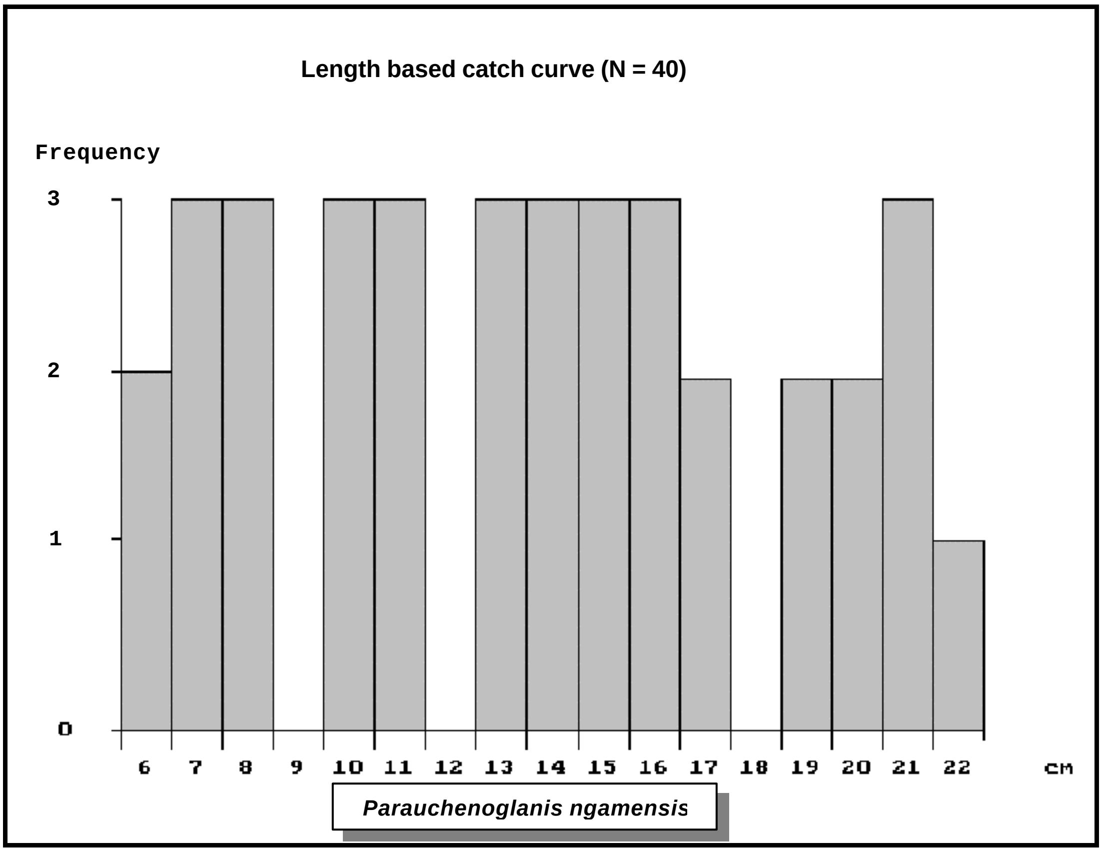


Figure 9.45: Length frequencies of *Parauchenoglanis ngamensis* for the Eastern Caprivi, 1997-1999.

Clarias ngamensis

Several specimens (96) were sampled in a length range of 6 – 64cm (none were counted). Several length cohorts were recorded, suggesting that several generations of *Clarias ngamensis* were present during the time of the study, and that spawning was successful during previous seasons. Juveniles of 6 – 9cm were sampled during high floods, indicating that this species probably spawned during the summer rain season (Figure 9.46).

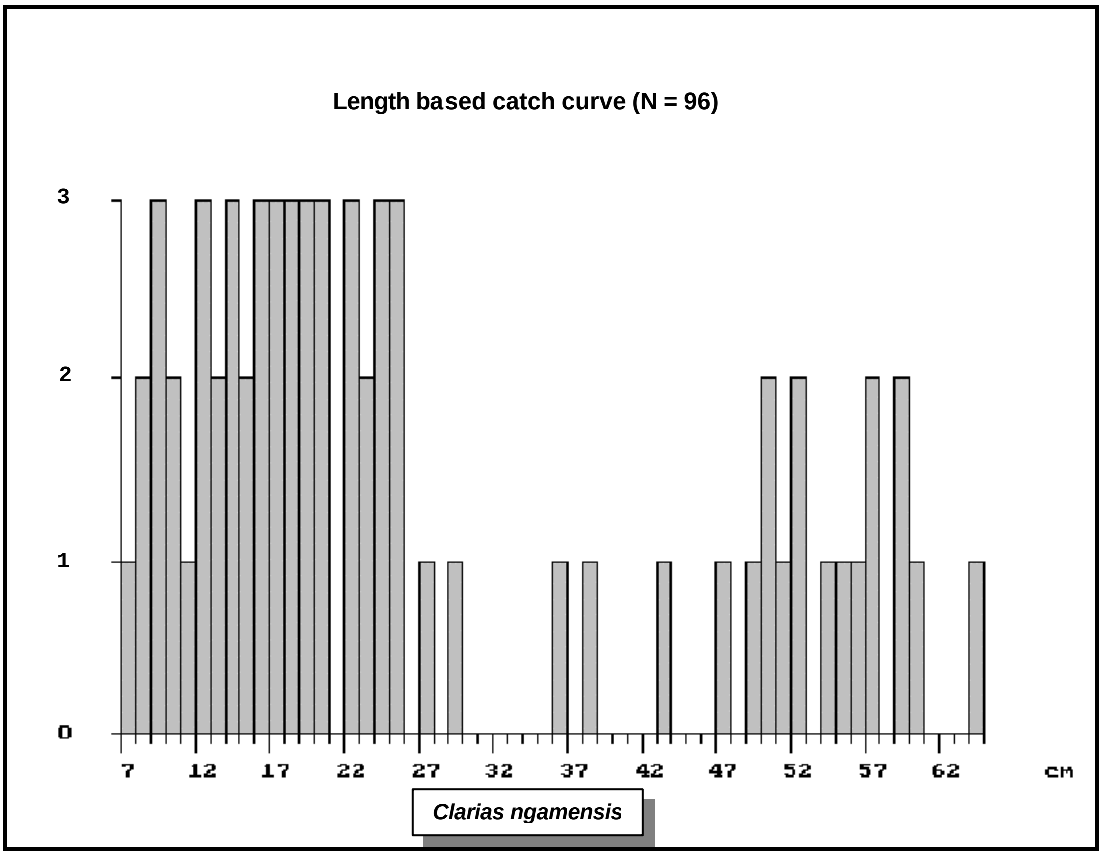


Figure 9.46: Length frequencies of *Clarias ngamensis* for the Eastern Caprivi, 1997-1999.

Tilapia ruweti

Several specimens (254) were measured in a length range of 1 – 8cm (none were counted). Juveniles of 1 – 2cm were sampled during high floods, indicating that this species spawned during the summer rain season. Length cohorts of 1 – 2cm, 3 – 5cm, and 6 – 8cm were recorded for this species. Several generations existed in the *Tilapia ruweti* population, giving the indication that this species spawned regularly and successfully during the study and previous seasons. This species attains a standard length of 10.4cm (Skelton, 1993), and the specimens sampled represented the length spectrum of the species (Figure 9.47).

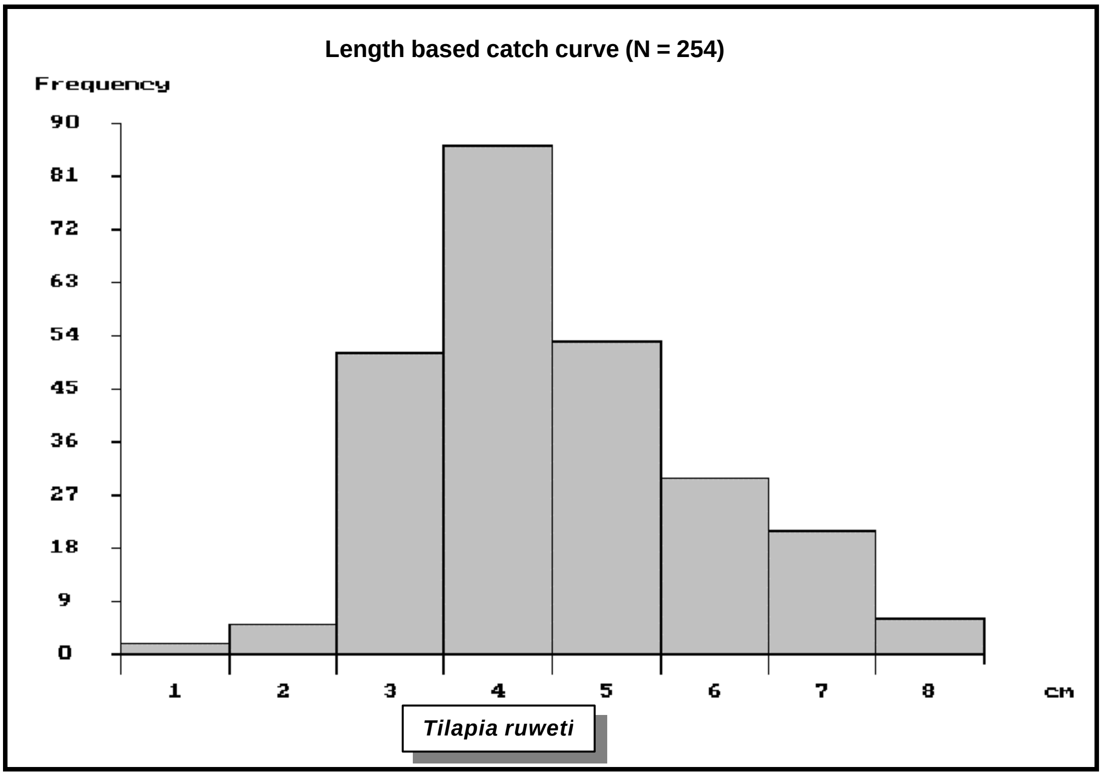


Figure 9.47: Length frequencies of *Tilapia ruweti* for the Eastern Caprivi, 1997-1999.

Microctenopoma intermedium

Eight specimens of *Microctenopoma intermedium* were measured, in a length range of 2 – 6cm (none were counted). Specimens in the 2cm class were sampled during high floods, indicating that this species spawned during the summer rain season. Not many specimens were sampled, but this species did spawn successfully during the study. Specimens sampled represented the length range of the species, as it attains a standard length of 5.5cm (Skelton, 1993). Few specimens were sampled and a length frequency graph was therefore not presented.

Ctenopoma multispine

Several specimens (157) of *Ctenopoma multispine* were sampled in a length range of 3 – 17cm (none were counted). Small specimens in the 3 – 5cm length class were sampled during the high flood surveys, indicating that this species spawned during the early summer rain season. Spawning was successful during previous seasons, as several length cohorts of 3-5cm, 5-7cm, 7-10cm, 11-13cm, and 15-17cm, were recorded during the study. According to Skelton (1993) this species attains a standard length of 13.5cm, but specimens of up to 17cm were sampled during this study in the Eastern Caprivi (Figure 9.48).

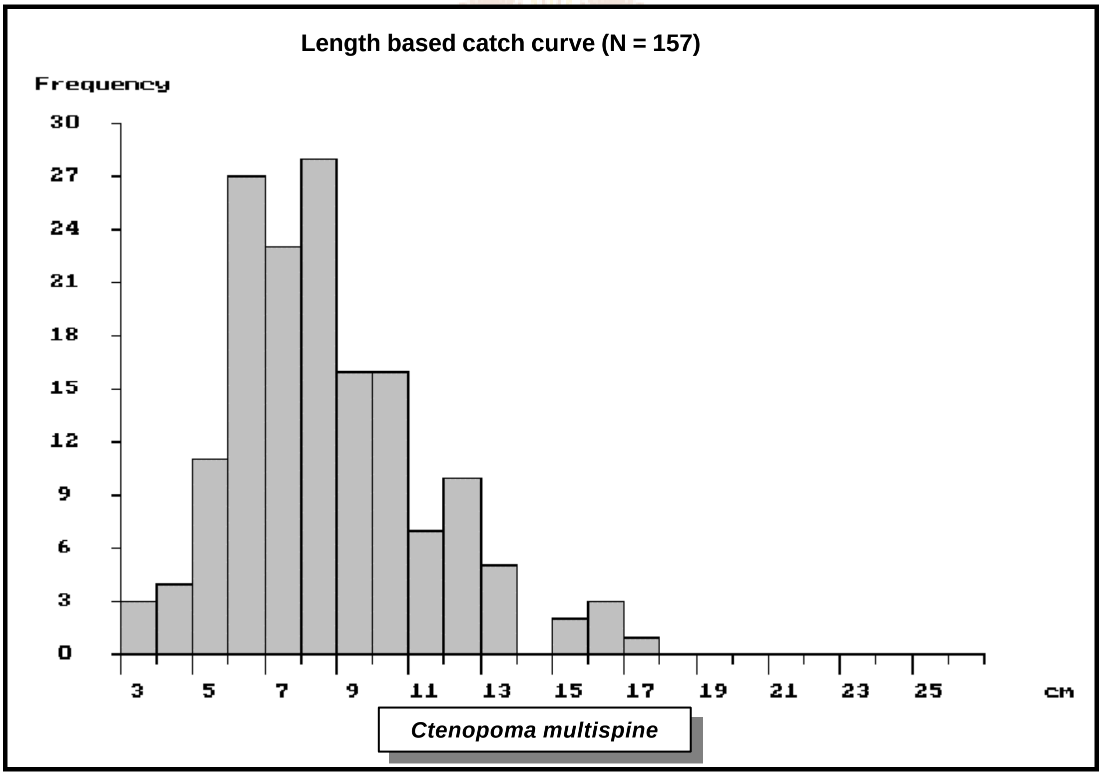


Figure 9.48: Length frequencies of *Ctenopoma multispine* for the Eastern Caprivi, 1997-1999.

9.4 AVERAGE WEIGHTS

Table 9.18 presents the average weight in grams of the species sampled, per flood and per system. On average larger specimens were sampled in the Kwando River, probably due to the fact that the areas surveyed in the Kwando River is pristine and situated in conservation areas. Preferred habitat also played a role in the average size of a species recorded in a system, as larger specimens of a species were often sampled in areas where there is ample suitable habitat. Table 9.18 serves as future reference for species distribution and could indicate in which system larger specimens are likely to be found at certain periods.

Table 9.18: Average weight, in grams, of the species sampled during both seasons in the Eastern Caprivi.

Species	Average Weight (g) High Floods			Average Weight (g) Low Floods		
	Zambezi	Chobe	Kwando	Zambezi	Chobe	Kwando
Table 9.18						
Mormyridae						
Mormyrus lacerda	187		340	48	53	567
Hippopotamyrus ansorgii			5	12		10
Hippopotamyrus discorhynchus	13	32	13	10		18
Marcusenius macrolepidotus	26	9	32	12	9	40
Petrocephalus catostoma	9	8	7	7	5	10
Pollimyrus castelnaui	5	6	2	4	1	5
Cyprinidae						
Mesobola brevianalis		0.1	0.1			
Opsaridium zambezense	2		2	3		
Barbus barotseensis	0.4	0.5		1		
Barbus unitaeniatus	1	1	1	0.5	3	2
Barbus bifrenatus	0.5	0.5		1	0.5	1
Barbus thamalakanensis	0.5	0.5	0.2	1		
Barbus barnardi	0.1	1			0.1	
Barbus fasciolatus		0.2	1			2
Barbus radiatus	1	2	4	5	5	8
Barbus haasianus	0.1	0.1		0.1	0.1	
Coptostomabarbus wittei	0.1	0.1	0.1	0.1	0.1	
Barbus poechii	11	8		6	6	11
Barbus cf eutaenia	1	1		0.5		
Barbus multilineatus	0.1	0.2		0.2	0.1	
Barbus afrovernayi	0.1	1		0.1		
Barbus paludinosus	1	1	3	2	3	2
Barbus codringtonii				18		
Labeo cylindricus	5	2		10	12	
Labeo lunatus	137			94	102	
Distichodontidae						
Hemigrammocharax machadoi	0.1	0.2	0.1	0.2	0.2	
Hemigrammocharax multifasciatus	0.2	1		0.2		
Characidae						
Brycinus lateralis	15	8	3	4	4	3
Micralestes acutidens	2	0.5	1	1		1
Hydrocynus vittatus	95	249	480	206	67	384
Rhabdalestes maunensis	0.3	1	0.2	0.5	0.5	0.1
Hepsetidae						
Hepsetus odoe	200	231	283	110	127	266

Species	**Average Weight (g) High Floods**			**Average Weight (g) Low Floods**		
	Zambezi	**Chobe**	**Kwando**	**Zambezi**	**Chobe**	**Kwando**
Table 9.18						
Claroteidae						
Parauchenoglanis ngamensis		53	28	26	102	46
Amphiliidae						
Leptoglanis cf dorae	0.1					
Schilbeidae						
Schilbe intermedius	43	52	67	11	21	99
Clariidae						
Clarias gariepinus	1187	1137	1136	577	467	422
Clarias ngamensis	423	269	1412	34	80	998
Clarias stappersii				6		11
Clarias theodorae	32	42	17	13	41	10
Clariallabes platyprosopos				49		
Mochokidae						
Chiloglanis neumanni				0.2		
Synodontis nigromaculatus	59	21		86	124	
Synodontis macrostigma	20	21	62			
Synodontis vanderwaali	1					
Synodontis spp.	23	28	89	3	12	99
Cyprinodontidae						
Aplocheilichthys johnstoni	0.2	0.1	0.1	0.2	0.2	0.3
Aplocheilichthys hutereaui	0.1		0.1		0.1	0.1
Aplocheilichthys katangae	0.1	0.2	0.1		0.2	
Cichlidae						
Hemichromis elongatus	49		2	41	64	6
Pseudocrenilabrus philander	2	1	1	4	2	2
Pharyngochromis acuticeps	10	4	4	8	17	5
Sargochromis carlottae	122	138	113	41	61	19
Sargochromis codringtonii	71			51	42	74
Sargochromis giardi			734			455
Serranochromis altus	1232		475	74	51	523
Serranochromis angusticeps	184	1	379	103	46	
Serranochromis longimanus	66			46	26	
Serranochromis macrocephalus	152	22	130	91	102	4
Serranochromis robustus	25	44	177	45	118	314
Serranochromis thumbergi	1	5			33	
Tilapia sparrmanii	6	4	4	6	18	8
Tilapia ruweti	2	2		4	5	4
Tilapia rendalli	5	1	19	9	25	44
Oreochromis andersonii	12	363	528	25	43	12
Oreochromis macrochir	3	5	56	4	74	41
Anabantidae						
Microctenopoma intermedium		2	0.2		1	
Ctenopoma multispine	15	10	4	9	8	5
Mastacembelidae						
Aethiomastacembelus frenatus	1			33		
Aethiomastacembelus vanderwaali				4		
Total Families Per River	**13**	**12**	**12**	**13**	**11**	**10**
Total Families Per Season	**14**			**13**		
Total Species Per River	**53**	**46**	**40**	**54**	**40**	**37**
Total Species Per Season	**64**			**65**		
Total Species sampled in the Caprivi	**69**					

9.5 CONCLUSION

Lower fish numbers were recorded during the 1997 surveys, which were preceded by inadequate high floods. The floods were successively higher during each high flood survey, and the CPUE for most species increased as the surveys progressed during the study. This may be an indication of a positive effect of higher floods on the fish population, and that the fish productivity increased due to adequate high floods.

Several generations existed in most species populations. Most species were productive, with juveniles being sampled regularly. Most species seemed to spawn at the start and during the summer rain season while the flood was rising.

Some species are sensitive to changes, and are scarce, but may serve as indicator species for future impact studies, and river health assessments. These species can also be used in the development of ecological flow requirement guidelines. Species include *Chiloglanis neumanni*, *Barbus codringtonii, Leptoglanis cf dorae, Mesobola brevianalis, Opsaridium zambezense, Rhabdalestes maunensis* and *Clariallabes platyprosopos,* all of which are very habitat specific, for especially clear flowing water. Major external impacts do not seem to occur as these species were sampled, although not regularly or in high numbers, due to its habitat preferences. The fish population in the Eastern Caprivi as a whole was stable and in a good condition at the time of the study.

Several length classes were sampled for most of the species indicating that the species population is healthy, and that spawning occurred regularly during previous seasons.

The length frequencies indicate that most species spawned during the rain season, as juvenile specimens were sampled during the following autumn (high flood) seasons.

Some of the recorded length frequencies for the larger Cichlidae species indicate that some lengths were not recorded. Species such as *Tilapia rendalli* which prefer floodplain type habitats were often difficult to sample, and this may explain why certain lengths were not sampled. The local fishermen also often target floodplain species.

The length frequencies indicate that large specimens from the larger species are not abundant, and this may be an indication that exploitation may be occurring in certain areas.

Legislation should include the protection of larger species and specimens. A healthy breeding stock will ensure the well being of the fish population in future. The Eastern Caprivi is a productive system and the fish population is resilient, and the resource can be protected with management and legislation.

10 WATER QUALITY

10.1 INTRODUCTION

The study in the Eastern Caprivi was mainly a fish ecological study, but water quality data was recorded at times for future reference. Indicator fish species (see Chapter 9, Conclusion), which are sensitive to changes in the water quality, were sampled, giving the indication that the water in the rivers of the Eastern Caprivi is of a good or acceptable quality. From a fish ecological point of view the water quality of the Eastern Caprivi seems to be adequate for the species needs.

The water quality data recorded was compared to the standards set by the South African Water Quality Guidelines (DWAF, 1996). This was done to determine whether the water quality of the Eastern Caprivi comply with the standards and guidelines set by the South African Water Quality Guidelines for Ecosystems (*i.e.* whether the water quality constituents comply with the relevant criteria).

10.2 MATERIALS AND METHODS

In Situ Measurements

Temperatures were measured with a thermometer, and recorded in degrees centigrade. The oxygen content was measured with a Hanna HI 9142 dissolved oxygen meter, and recorded in mg/l. The pH was measured with a pHep 1, pH meter.

Laboratory Analysis

Water samples were collected and sent to the Department of Water Affairs of Namibia, in Windhoek, for analysis.

Water Quality Criteria

The water quality data was evaluated by using the South African Water Quality Guidelines (DWAF, 1996) for aquatic ecosystems.

Water quality criteria are scientific and technical information provided for a particular water quality constituent, in numerical and qualitative form, that describe its potential effects on the health of aquatic ecosystems and the fitness of water for other users (DWAF, 1996).

The derivation of criteria was based on the best available information, using the species representative of major trophic groups occurring in aquatic ecosystems. The rationale for this is that if the most sensitive species within representative trophic groups are protected, then other species within the trophic group will also be protected (DWAF, 1996).

10.3 RESULTS AND DISCUSSION

The water quality data should be studied as a whole as all the constituents play an interactive role (Tables 10.1-10.3).

The water quality data recorded in Tables 10.2 – 10.3 was evaluated by using the South African Water Quality Guidelines (DWAF, 1996) for aquatic ecosystems. The variables measured were found to fall within the ecosystem criteria set by these guidelines.

pH

Strongly hydrolysing metals such as aluminium, which may be harmful in high concentrations, is relatively insoluble in the neutral pH range, but may become mobilised under acidic or alkaline conditions. The pH may affect the availability and toxicity of trace metals. Most fresh waters have a more or less neutral pH. The pH should not vary beyond the average daily norm (DWAF, 1996).

The pH was measured in the relatively neutral pH range of around 7, with no drastic fluctuations. It is favourable for an ecosystem if minimal pH fluctuation is the norm, and the measured pH values for the Eastern Caprivi therefore falls in the criteria for aquatic ecosystems.

High pH values, which may indicate to eutrophication (DWAF, 1996) was not measured.

Temperature

Water temperature should not be allowed to vary from the background average daily norm. The solubilities of gasses such as CO_2 and O_2 decrease with increase of temperature (DWAF, 1996). Low oxygen concentrations due to high temperatures may have an impact on aquatic fauna.

The water temperatures measured in the Eastern Caprivi were normal for the time of year, and drastic fluctuations did not occur.

Dissolved Oxygen

The maintenance of adequate dissolved oxygen concentrations is critical for the survival and functioning of aquatic biota. The typical oxygen saturation concentrations of unpolluted water at sea level, and at TDS (total dissolved salts) values below 3000 mg/l are: 12.77 mg/l at 5ºC; 10.08 mg/l at 15ºC; and 9.09 mg/l at 20ºC. The target oxygen saturation for a sensitive aquatic ecosystem should be between 80% - 120% (DWAF, 1996). The oxygen levels measured in the Eastern Caprivi falls within these criteria.

Nitrogen (Inorganic)

The term inorganic nitrogen includes all the major inorganic nitrogen components ($NH_3 + NH_4^+ + NO_2^- + NO_3$) present in the water. Inorganic nitrogen concentrations in unimpacted, aerobic surface waters are usually below 0.5 mg N/ℓ. Concentrations below 0.5mg N/ℓ are considered to be sufficiently low that they can limit eutrophication and reduce the likelihood of nuisance growths of blue-green algae (DWAF, 1996).

The nitrogen concentrations measured in the Eastern Caprivi complies with the water quality criteria for ecosystems, as all concentrations measured were below 0.5mg/ℓ.

Total dissolved salts (TDS)

TDS represents the total quantity of dissolved material, organic and inorganic, ionised and unionised, in a water sample. The TDS values analysed were relatively low. These values fall in the range for water in contact with precambrian shield areas (DWAF, 1996). Low levels of sulphate (contributing ion) were therefore also measured.

Trace metals

The values of Mn, Cu, Zn, Cd, and Pd all fall within in the *Target Water Quality Range.*

Fluoride

The values of fluoride all fall within in the *Target Water Quality Range.*

Turbidity

The turbidity values were low except for certain backwater areas.

Calcium carbonate

Alkalinity is primarily controlled by carbonate species such as calcium carbonate ($CaCO_3$), and the most important buffering system in fresh water is the carbonate-bicarbonate one (DWAF, 1996). The measured values of calcium carbonate contribute to the buffering capacity of the water, which contributes to less fluctuation in pH values, and which is favourable for aquatic ecosystems.

Nutrients

Plant nutrients include elements such as sodium, potassium, nitrogen, phosphorous, calcium, magnesium, Sulphate and silica. Nutrient levels (Kjeldahl nitrogen) were relatively high in certain areas such as backwaters. This is expected, as the river systems are productive.

Table 10.1 presents the effects of some major physical and chemical water quality variables on riverine ecosystems.

Table 10.1: The effects of some major physical and chemical water quality variables on riverine ecosystems (adapted from Dallas and Day, 1993).

WATER QUALITY VARIABLES	MAJOR EFFECTS
PHYSICAL FACTORS	
Water Temperature	❑ Determines metabolic rate ❑ Determines availability of nutrients and toxins ❑ Determines degree of oxygen saturation ❑ Changes provides cues for breeding, migration, etc.
Turbidity and Suspended solids	❑ Turbidity determines degree of light penetration, hence vision, photosynthesis ❑ Suspended solids reduce light penetration, smother and clog surfaces (e.g. gills) and adsorbs nutrients, toxins, etc.
CHEMICAL FACTORS	
pH	❑ Ionic balance ❑ Chemical species, and therefore availability ❑ Gill functioning
Conductivity, salinity, TDS, individual ions	❑ Osmotic balance ❑ Ionic balance ❑ Water balance
Nutrients	❑ Not toxic *per se*, influence trophic status and therefore community structure
Organic enrichment	❑ Reduction in oxygen content ❑ Increase in nutrient levels
Dissolved oxygen	❑ Respiration ❑ Chemical species, and therefore availability
Biocides	❑ Usually target specific groups (e.g. molluscs, insects, plants) and thus alter community structure
Trace metals	❑ Many essential at low concentrations ❑ Some mutagenic, carcinogenic and teratogenic ❑ Some metabolic inhibitors ❑ Some metabolic catalysts

Table 10.2: Water quality variables recorded for the Eastern Caprivi, autumn 1997.

River	Date	Time	Temperature (°C)	Oxygen Content (mg/l)	pH
Chobe River, floodplains	15/5/97	7:45	19.8°C	7.9 mg/ℓ	6.8
Lake Lisikili	20/5/97	9:00	20°C	7.4 mg/ℓ	7.2
Kalambeza, Zambezi River	26/5/97	12:00	19.5°C	7.8 mg/ℓ	7
Kwando River	30/597	14:00	20°C	8.1 mg/ℓ	8

Table 10.3: Water quality varables recorded for the Eastern Caprivi, spring 1997.

Variable	Description	Unit	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Chobe River	Kwando River
			Canal	Back water	Rock rapids	Main stream	Main stream	Back water	Main stream	Main stream
Table 10.3										
	Date sampled		16/9/97	16/9/97	13/6/97	18/9/97	18/9/97	19/9/97	24/9/97	24/9/97
O_2	Oxygen Content	mg/ℓ	7.2	7.4	8.4	8	8	7.5	7.3	7.8
°C	Temperature	°C	24	24	23	24	24	24	24	24
pH	Hydrogen ion activity		6.8	7.1	7.8	7.1	7.1	7.3	7.6	7.2
Turbidity		NTU	2.53	6.79	0.92	2.16	0.64	39.8	3.02	3.58
EC	Electrical Conductivity	mS/m	8.9	9.8	11.4	8.7	9.4	12.5	30.8	15
TDS	Total dissolved salts	mg/ℓ	59.63	65.66	76.38	58.29	62.98	83.75	206.36	100.5
Na	Sodium	mg/ℓ	4	5	4	5	4	5	29	6
K	Potassium	mg/ℓ	6	6	6	6	6	6	8	9
Ca as $CaCO_3$	Calcium	mg/ℓ	17.5	22.5	32.5	17.5	25	32.5	60	40

Variable	Description	Unit	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Zambezi River	Chobe River	Kwando River
			Canal	Back water	Rock rapids	Main stream	Main stream	Back water	Main stream	Main stream
Table 10.3										
Mg as $MgCO_3$	Magnesium	mg/ℓ	12.5	12.5	12.5	12.5	12.5	12.5	25	8.3
SO_4	Sulphate	mg/ℓ	2	4	3	4	7	2	16	5
NO_3 as N	Nitrate as nitrogen	mg/ℓ	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
NO_2 as N	Nitrite as nitrogen	mg/ℓ	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
KN-N	Kjeldahl nitrogen	mg/ℓ						1.12	0.64	0.32
SiO_2	Silica	mg/ℓ	13	12	10	11	11	11	13	23
F	Fluoride	mg/ℓ	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1
Cl	Chloride	mg/ℓ	2	2	2	3	3	<1	25	2
TAL as $CaCO_3$	Total alkalinity as calcium carbonate	mg/ℓ	38	44	52	38	38	58	98	60
Mn	Manganese	mg/ℓ	0.015	0.05	0.01	0.015	0.01	0.04	0.015	0.03
Cu	Copper	mg/ℓ	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	Zinc	mg/ℓ	0.02	0.043	0.046	0.017	0.046	1.63	0.045	0.054
Cd	Cadmium	mg/ℓ	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	Lead	mg/ℓ	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

10.4 CONCLUSION

- Water quality was not studied in detail, and the data was recorded for future reference.
- The water quality data recorded for the Eastern Caprivi river systems complies with the South African Water Quality Guidelines (DWAF, 1996) for aquatic ecosystems.
- Sensitive indicator species were sampled indicating that the water quality is adequate for their survival, and therefore also for other species in the Eastern Caprivi.

11 CONCLUSION

Research in the Eastern Caprivi is in its infancy stages, and regular seasonal surveys should be conducted to compile and maintain a comprehensive database for future comparison, and to predict future trends. The freshwater fishery in the Eastern Caprivi is very important in terms of its socio-economical value. For the fish resource to be utilized to an optimum it is important to manage and protect the resource responsibly. This can only be achieved with comprehensive research data, which can be used as reference.

The river systems of the Eastern Caprivi were surveyed from 1997 to 1999. One of the objectives was to survey all the habitat types representative of an area, and to record the species distribution in these areas. The habitats representative of each system were described, and the stations that were surveyed consisted of these representative habitats. Each of the localities was described individually. The localities included areas where possible external influences such as fishery, pollution and urbanization could affect the ecosystem. Some localities were identified as regular survey areas, and should have priority in future for the sake of comparison.

The distribution and habitat preferences of the species were determined. The distribution and habitat preferences may aid in the identification of conservation areas, where sensitive species may find sanctuary during spawning, growing and migration periods.

The status of each fish species was determined for the different systems and for the Eastern Caprivi as a whole. It is now possible to ascertain what contribution each species make to the fish population in which area. Species lists were presented for the fish species sampled during the surveys in the Eastern Caprivi.

Different types of sampling gear were used to sample a large variety of species in the Eastern Caprivi. The different gears were used in order to limit the effect of selectivity, and to sample specimens of all shapes and sizes. The sampling gear selectivity was recorded for all the gear used. The sampling gear selectivity gave an indication of which species were targeted by certain gear. This information can be used to aid in the legislation process in an attempt to control local and commercial catches, and to protect sensitive species.

For the gill nets, it was recorded that on average the smaller meshes (22mm – 45mm meshes) sampled more specimens and a higher number of species than the larger meshes (57mm – 150mm meshes).

The status of the fish population may be determined by studying the catches (CPUE's) in the different mesh sizes of the gill nets (*i.e.* whether certain sizes or species are present). Catches from different areas can also be compared to identify sensitive or productive areas.

Large specimens are usually targeted first when a system is exploited by fishery, and the catches of large specimens will drop noticeably (Welcomme, 1979). Large specimens were not sampled abundantly, but conclusions cannot be made however as to whether over-exploitation is taking place. Future surveys will have to be conducted to be able to justify any findings.

Low MPUE's were recorded in certain areas indicating that the biomass and production in these areas are low, and that these areas are sensitive to exploitation. Current exploitation of the resource in sensitive areas might have a negative impact on the fish population.

Sensitive areas were identified, near populated areas where the need for affordable subsistence is higher, and where there is a fisheries trade demand. Such areas include Katima Mulilo, Kalambeza, Lisikili, Impalila Island, and Kasane.

Low MPUE's recorded might also aid in the identification of *sensitive* areas vulnerable to exploitation, where exploitation does not yet occur.

Development and the alteration of natural riverbanks, leading to the loss of natural habitat and available cover in the Katima Mulilo area may also have an impact on the fish population in this reach of the Zambezi River. Recreational angling near lodges and populated areas may also impact on the fish resource.

The larger mesh sized gill nets sampled a higher number of species, and larger specimens, in the Kwando River than in the rest of the Eastern Caprivi systems, probably because the areas surveyed are situated in conservational areas, where fishery does not occur. The Kwando River can be used as a control area for the studies in the Eastern Caprivi.

Of the other sampling gear, the seine nets and rotenone were the most effective sampling gears in sampling high numbers and species diversity. The electro shocker was also effective in sampling a relatively high species diversity.

Imbalanced CPUE's may serve to indicate a disturbance in the equilibrium of the fish population. The occurrence of high numbers of small species, which have a high turnover such as *Brycinus lateralis,* in the small meshes, and the absence of larger species from the larger meshes may indicate to exploitation, as the larger species are usually targeted first.

The CPUE for Lake Lisikili showed that large specimens were scarce in this area and that high numbers of small specimens were sampled. Lake Lisikili is targeted by local fishery and the absence of large specimens is therefore an indication of exploitation of the fish resource.

Lake Lisikili in the Zambezi River was however the most productive area during high floods, and the highest MPUE for the gill nets was recorded at this station, although the catches consisted mostly of small species and specimens.

High floods seem to have a positive effect on the fish numbers, as the CPUE's increased in all the rivers after the high flood of 1998.

It is important to note that some areas are naturally more productive than others, such as areas with ample vegetation and cover for breeding and feeding. The availability of suitable habitat may also have had an impact on the species distribution during certain flood levels.

According to the gonad maturation indexes most of the species studied seem most likely to spawn at the start and during the rain season, when there is a rise in temperature and inflow of rainwater, before the full extent of the high floods can be seen.

High flood levels were therefore not the major contributing factor to induce spawning in most of the species, but rather the start of the rain season (inflow of rain water), and a rise in temperature. Some species are however likely to make use of the high flood (water levels) to enter newly inundated floodplains for breeding purposes. The floodplain areas provide protection in the form of cover where the species can spawn, and the eggs develop.

Flood levels were recorded to explain tendencies such as migration for spawning purposes. Fish migrations were mainly recorded during receding high floods. High floods are important for spawning and fish production. During these times floodplains are formed which serve as spawning and nursery grounds.

The main factors that influenced the distribution of certain species during low or high floods were the availability of preferred habitat due to the level of inundation. The observed fish movements during this study were connected to rising, high and falling water levels.

Available cover also plays an important role in the species distribution, as certain species use vegetation, rocks and other structures as feeding surfaces and as camouflage against piscivores.

Socio-economical statistics were recorded. Fish are of high socio-economical value in the Eastern Caprivi. Some communities are totally dependent on fish as a protein supplement to their diet. Freshwater fish is also an important source of income to the local people in the Eastern Caprivi. The fish are caught with a variety of modern and traditional gear.

The present and projected status of the socio-economics of the resource is that signs of exploitation are present in the form of commercialisation of the fish resource, but it is difficult to determine to what extent. Locals comment on a degradation in the fish population and poor overall catches, and most are in favour of regulating the fishery.

Length frequencies recorded indicate that the species spawned successfully in the past. The length frequency charts also indicate that large specimens are still present in the Eastern Caprivi systems.

Several generations existed in most species populations. Most species were productive, with juveniles being sampled regularly. From the length frequency data most species seem to spawn at the start and during the summer rain season while the flood was rising, as juveniles were often sampled during the autumn surveys.

Some species are sensitive to environmental changes, and are rare due to its habitat preferences. These species may serve as indicator species, such as *Chiloglanis neumanni*, *Barbus codringtonii, Leptoglanis cf dorae, Mesobola brevianalis, Opsaridium zambezense, Rhabdalestes maunensis* and *Clariallabes platyprosopos,* all of which are very habitat specific, for especially clear flowing water.

Indicator and rare species were sampled, giving the indication that the status of the resource is most likely still in its natural state. When there is a healthy population of indicator species in the system, the well-being of the other species present in the system is also insured. The data for the indicator species sampled in certain areas can serve as reference, for future impact studies.

Water quality variables were recorded, but pollution does not seem to occur along the areas that were surveyed. The water quality variables were therefore recorded for future reference and control standards.

The smaller meshes (22mm and 28mm) sampled few juvenile or immature specimens of the larger species, such as *Hydrocynus vittatus.* This data can be used to indicate that small meshes could be used, as gill nets, by the local fishery to catch fish with, without detrimental effect on the fish population.

All the species sampled in the 118mm and 150mm meshes are of socio-economical value and importance to the fishery in the Eastern Caprivi.

The length frequency data and estimated gill net selectivity indicated that representative lengths for most of the species were recorded from the fish population. The other gears used, helped to sample specimens in length classes that may have been missed with the gill nets.

The estimated gill net selectivity for each mesh also indicates that the different meshes were effective in sampling the relevant length frequencies from the fish population.

The fish population in the Eastern Caprivi as a whole was stable and in a good condition at the time of the study.

The surveys were successful in obtaining some of the pre-determined objectives. Systematical monitoring did not exist before 1993, and it is important to survey the Eastern Caprivi regularly to maintain a substantial and comprehensive database, for future reference and comparison.

12 RECOMMENDATIONS

- The gill net data is of importance and should be used to formulate fishery legislation.
- The gill net selectivity and CPUE data should be used to propose regulations on which mesh sizes should be used in the local fishery.
- The gill net data should be used to determine which species is targeted with certain mesh sizes.
- Harvestable species may be identified, and may be specified in the fishery regulations. Sizes to be targeted, may also be specified.
- Legislation should be formulated to protect certain vulnerable or sensitive species.
- It is important to conserve the rare species for future generations.
- Mature specimens from the larger species should be protected, as breeding stock if depleted seriously.
- Identified regular survey areas should have priority in future for the sake of comparison.
- Areas where scarce species occur should be protected.
- Areas where possible over-exploitation might occur should be investigated.
- Identify areas sensitive to exploitation.
- Commercial catches and the commercialisation of the resource must be investigated and controlled.
- Fishing gears such as fine meshed seine nets, long drag nets which target specific species and sizes, and gears which could be detrimental to the fish population, should be evaluated, and identified as gear to be excluded as fishing methods in the regulations.
- Management wise it might be better to fish all through the size classes (non-selective) than just target certain size classes. But fishing effort is important and should in many cases be controlled. The use of gill nets with a range of meshes could be considered in fishery legislation.
- Protect naturally more productive areas, such as areas with ample vegetation and cover for breeding and feeding (sanctuaries).
- Protect floodplain areas, which provide protection and spawning habitat.
- Minimise overgrazing of livestock on floodplains.
- Indicator species are important for future reference.
- Future surveys are essential to maintain a comprehensive database.
- The effect of subsistence fishery on the fish population should be studied in more detail, to make definite conclusions. The effect of fishery on the occurrence of large species and large specimens should be considered.

- The movement of large species in the rivers should be studied, to determine where these species (especially the large mature specimens) are more likely to occur, and where they migrate to during certain periods. These studies and recent reports, by the Ministry of Fisheries and Marine Resources, and the Norwegian Institute for Nature Research, on fish migration may be used to make conclusions on the occurrence of the larger species in certain areas.
- The time frame off this study was short, and further study on the full effect of high floods on the fish population should be done to make definite conclusions.
- This study was conducted to develop a monitoring protocol, and to lay the basis for future studies with the development of a comprehensive database. This thesis may ad to future studies in the Eastern Caprivi, and it may be compared to studies of similar systems elsewhere to explain certain tendencies in the fish population, and to make possible conclusions.
- Management and protection of the resource is essential.
- Cooperation with bordering countries in terms of research and legislation is necessary to achieve long-term goals in terms of conservation.
- The fish resource must be protected and utilised in a sustainable manner.

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