Fish populations, gill net catches and gill net selectivity in the Kunene River, Namibia

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Riverine habitat at Hippopool, Kunene River
(Photo: Clinton J. Hay)

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ABSTRACT

Hay, C.J., Næsje, T.F. & Thorstad, E.B. 2008. Fish populations, gill net catches, and gill net selectivity in the Kunene River, Namibia. - NINA Report 325. 98 pp.

The Kunene River
The Kunene River originates near Huambo in Angola, from where it flows in a southerly direction towards Namibia. The catchment area is 107000 km^2. In Angola, the upper reaches are relatively steep, while the middle sections form floodplain habitats. Once the river reaches Ruacana in Namibia, it turns west towards the sea, forming the border between Angola and Namibia for a distance of approximately 340 km. Floodplains are absent along the Namibian section.

Objective
The objective of this report is to provide baseline information about the fish resources in the Kunene River to form the biological foundation for recommendations for a sustainable management. Based on fish survey data from the period 1994-2004, the fish resources are described through studies of species diversity, relative importance of the different species, life history parameters, catch per unit effort and gill net selectivity.

Methods
Fish were collected at 18 locations with gill nets and seven other sampling methods (collectively called "other gears"), such as seine nets, cast nets, electrofishing apparatus and rotenone. The gill nets (22-150 mm mesh size) were used to survey open, deep-water habitats in the main stream near the shore and in deep backwater areas. Other gears targeted mainly small species and juveniles in shallow, vegetated and rocky habitats. Ten surveys were carried out in the period 1994-2004. A total of 16959 fish were caught, of which 6862 with multi-filament gill nets and 10097 with other gears. The most important species were identified by using an index of relative importance (IRI), which is a measure of the relative abundance or commonness of the species based on number and mass of individuals in the catches, as well as their frequency of occurrence.

Results
A total of 50 fish species were identified, of which four were marine species. In addition, *Synodontis* spp., an unknown freshwater species, an unknown marine species and Gobiidae spp. were recorded. The families represented with the highest number of species were the Cyprinidae and Cichlidae, with 14 and 12 species, respectively.

Thirtyfive species were identified in the multi-filament gill nets catches, of which two were marine species. The four most important species, *Schilbe intermedius*, *Brycinus lateralis*, *Barbus mattozi* and *Labeo ansorgii* constituted together an IRI of 69%. The Schilbeidae (one species) and the Characidae (two species) were the most important families in the gill net catches (IRI of 46%). *Marcusenius macrolepidotus* was the most important species in the gill net catches in the river mouth, whereas *Schilbe intermedius* was the most important species in the rest of the river.

Mean CPUE given as number of fish caught per setting decreased with increasing mesh size. For CPUE given as mass per setting, the opposite was found, as mean CPUE in-

creased with increasing mesh sizes up to a maximum in the 73 and 93 mm mesh size, and thereafter decreasing again in the two largest mesh sizes. The Hippopool station had the highest catch per unit effort (CPUE), both in number of fish and mass caught per setting.

Fortyseven species were identified in the catches by other gears than gill nets, of which three were marine species. The six most important species constituted together an IRI of 81%. *Thoracochromis buysi* was the most important species in the catches with other gears (IRI of 26%), followed by *Mugil cephalus*, *Tilapia rendalli*, *Oreochromis macrochir*, *Aplocheilichthys macrurus* and *Orthochromis machadoi*. The Cichlidae was the most important family in the catches with other gears, constituting an IRI of 60%. *Mugil cephalus* was the most important species in the catches with other gears in the river mouth, whereas *Thoracochromis buysi* was the most important species in the rest of the river.

The body length of the fish caught with multi-filament gill nets and other gears was up to 102.5 cm. The mean body length was larger for fish caught with gill nets (mean 17.1 cm, range 1.2-102.5 cm) than for fish caught with other gears (mean 6.6 cm, range 0.5-55.6 cm).

Endemic species, IUCN Red List species and alien species

Five species are listed as endemic to the Kunene River, which are *Kneria maydelli, Orthochromis machadoi, Sargochromis coulteri, Thoracochromis albolabris* and *Thoracochromis buysi*. The status of the undescribed *Clariallabes* sp. is not known. *Clariallabes* sp. has only been found in the Kunene River and is in the process of being systematically described.

Neither IUCN Red List species nor alien species were recorded in the Kunene River. However, the newly discovered species in the Kunene River, *Clariallabes* sp., might be included in revised versions of the Red List. *Barbus breviceps* and *Kneria maydelli*, which had very restricted distributions, might also be included in revised versions of the Red List. *Barbus breviceps* and *Kneria maydelli* are considered threatened due to their restriction to fountains, of which only three have been identified in the area. Although common in these fountains, any disturbance could lead to the disappearance of entire populations or the species.

Comparison among rivers

The catch per unit effort in the multi-filament gill nets was higher in mass (3.1 kg per setting) for the Kunene River than any of the other Namibian rivers surveyed with similar methods, except the Lower Orange River (3.9 kg per setting in the Lower Orange River, 1.87 kg per setting in the Zambezi/Chobe Rivers, 1.44 kg per setting in the Okavango River and 1.23 kg per setting in the Kwando River). In number of fish per setting, the catches in the Kunene River were higher (24 fish per setting) than in the Lower Orange River (17 fish per setting) and Kwando River (10 fish per setting), but lower than in the Okavango River (28 fish per setting) and Zambezi/Chobe Rivers (89 fish per setting).

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Gill nets at Swartbooisdrif *Photo: Clinton J. Hay*

Ruacana Falls near Hippopool *Photo: Clinton J. Hay*

PREFACE

The White Paper “Responsible Management of the Inland Fisheries of Namibia” was finalized in December 1995, and forms the basis for the new Inland Fisheries Resources Act and Regulations concerning fish resources management in Namibia’s different freshwater systems (Ministry of Fisheries and Marine Resources 1995). All perennial rivers in Namibia are shared with neighbouring countries and also form large sections of the international borders between these countries. With respect to fisheries management, the effects of the subsistence, commercial and recreational fisheries on the fish resources in neighbouring countries must also be taken into consideration. Hence, successful management of the fish resources must be regionally orientated. When implementing fisheries regulations for such complex systems, information on the fish resources and their exploitation in the different water bodies is imperative.

Based on a series of studies of the fish resources in the perennial rivers in Namibia, recommendations are given for management regulations of the fisheries in the different rivers. These management regulations are aimed at involving local, national and international authorities and stakeholders. It is a priority to secure a sustainable utilization of the fish resources for the benefit of local communities and future generations. Important aspects of fisheries management have been studied to form the basis for new management strategies. Studies involve descriptions of the fish resources (Hay *et al*. 2000, 2002, Næsje *et al.* 2004, 2007), and the exploitation of the fish resources, including the socio-economic infrastructure of local societies (Purvis 2001a, b, Næsje *et al.* 2002, Hay *et al.* in prep.), fishing competitions (Næsje *et al.* 2001), catch and release fisheries (Thorstad *et al.* 2004), and movement and habitat use of important fish species (Økland *et al.* 2000, 2002, 2005, 2007, Thorstad *et al.* 2001, 2002, 2003a, b, 2005, 2007).

The studies of fish migrations conclude that certain fish species may migrate between countries, both laterally and longitudinally in the river systems, which emphasize the importance of joint local and regional co-management of the fish resources, both on a national and international scale. Other fish species, however, are more stationary and, hence, more vulnerable to local exploitation. The biological and sociological aspects of the subsistence, semi-commercial and recreational fisheries have documented that in the absence of a strong formal system of fisheries management, the informal (or traditional) management component has been maintained in Namibia. However, there are strong calls from all levels for an improved and effective system for national and multinational fisheries management.

In the present report, the fish populations in the Kunene River are described on the basis of several surveys done between 1994 and 2004. The project is a collaboration between the Freshwater Fish Institute of the Ministry of Fisheries and Marine Resources (MFMR), Namibia, and the Norwegian Institute for Nature Research (NINA). The study has received financial support from the Norwegian Agency for Development Cooperation (NORAD), the Ministry of Fisheries and Marine Resources in Namibia and the Norwegian Institute for Nature Research.

We are thankful to Prof. P. Skelton and Mr. R. Bills from the South African Institute for Aquatic Biodiversity (SAIAB), who verified the identification of some of the fish species.

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1 INTRODUCTION

Namibia is a large country, covering an area of about 823680 km^2. The population of 1.83 million (in 2001, Population and Housing Census, Central statistics Office) is small in relation to the size of the country. Approximately 40% of the people live in urban areas, while the majority of the rural population lives in northern Namibia. Population growth has been at 3% during recent decades, whereas fertility rates and life expectancy both declined with about one-third during the 1990's (Mendelsohn *et al.* 2002).

Approximately 43% of Namibia is allocated as freehold land, while 39% is communal land and 18% governmental land. Nature reserves and national parks make up about 14% of the country, while declared conservancies add another 10% to the protected areas. On a national scale, most of Namibia's wealth comes from the use of natural resources for farming, mining, fishing and tourism (Mendelsohn *et al.* 2002).

Broadly speaking, Namibia can be divided into two geological zones, which are western Namibia with rock formations, escarpments, mountains and large open plains, and eastern Namibia where most of the surface is covered with sand and the landscape is much more uniform (Mendelsohn *et al.* 2002). Most of Namibia is arid for most of the year due to the country's position between two climatic systems, which are the inert-tropical convergence zone and the subtropical high pressure zone, where the latter pushes the moist air back north for most of the year. Most of the rain falls during sporadic rainstorms in the summer months from September to February. The flow of moist air from the climatic systems in the north makes northern Namibia considerably more humid than other parts of the country, especially in contrast to the deserts in the east, along the coast and in the south.

Water is undoubtedly Namibia's most valuable and limiting natural resource (Barnard 1998). The limited amount of rain that falls in most areas seeps into the ground or is rapidly drained into ephemeral rivers. The Namibian rivers vary greatly, from the large perennial rivers that form the country's borders, to a multitude of small rivers and channels that flow at varying frequencies depending on the rainfall. There are also numerous pans of varying sizes that are infrequently covered with shallow water. The large perennial river systems, which form parts of Namibia's borders, drain huge areas in the neighboring countries, and local rainfalls in Namibia contribute little towards the annual run-off of these rivers. The interior of Namibia has several man-made reservoirs, mainly built for human consumption and irrigation. The largest is Hardap Dam in the seasonal Fish River in the south, a tributary to the Lower Orange River.

People depend strongly on the availability of open water bodies for fish to eat and water for domestic and agriculture use. The permanent or regular surface waters of Namibia support a large number of Namibia's inhabitants, as 34% of the population live within 5 km of the perennial rivers or the channels in the Cuvelai System in the north (Mendelsohn *et al.* 2002). As the number of people increases, fishing activities will increase and conflicts may escalate among different stakeholders.

The perennial rivers in the north, the Kavango and Zambezi Rivers, have been physically altered least by human activities as few dams have been built, little artificial channeling occur, and few agriculture chemicals are used in the drainage area (Mendelsohn *et al.*

2002). This is, however, not the situation for the Orange River, forming the southern border of Namibia. Many small and large dams have been built in this river system. This river system also drains large agricultural areas where substantial amounts of chemicals are used. Some alterations have also been done to the water flow of the Kunene River as dams have been built in the catchment areas in Angola, and a hydropower generation scheme has been developed on the border between Namibia and Angola.

The objective of this report is to produce baseline information for the fish populations in the Kunene River to form the biological basis necessary to describe the present state of the fish resource as well as future trends in the fish populations. Fish were collected at 10 different stations with survey gill nets and/or seven other sampling methods from 1994 to 2004. The selected survey stations include most of the important habitat types present in the river, and these stations were selected to include the entire Kunene River system bordering on Namibia. Based on these monitoring data, the fish resources are described through studies of species diversity in different parts of the river, the relative importance of the different species, life history of important fish species, catch per unit effort, and selectivity of gill nets.

The stated policy in the White Paper “Responsible Management of the Inland Fisheries of Namibia” (Ministry of Fisheries and Marine Resources 1995) and the Inland Fisheries Resources Act (2003) is to ensure a sustainable and optimal utilization of the freshwater resources, and to favour utilization by subsistence households over commercialization. The Kunene River is shared with Angola, and the river catchment is mainly in Angola, making it imperative that the river is co-managed by Namibia and Angola to ensure the sustainable utilization of this system. It is believed that this report will initiate the collaboration between the two countries that will result in the joint management of the Kunene River.

2 STUDY AREA

The Kunene River (**figure 2.1**) originates near Huambo in Angola, at approximately 1750 m a.s.l., from where it flows in a southerly direction towards Namibia (Hay *et al.* 1997b). The catchment area of the Kunene River is 107000 km^2, and the annual average water volume of the river in Namibia is 5100 million m^3 (Mendelsohn *et al.* 2002, **figure 2.2**). In Angola, the upper reaches are relatively steep, while the middle sections form floodplain habitats. Once the river reaches Ruacana in Namibia, it turns west towards the sea, forming the border between Angola and Namibia for a distance of approximately 340 km.

The section of the river that forms the border between Angola and Namibia was geologically formed by glaciers 280 million years ago (Mendelsohn *et al.* 2002). In this area, the river is steep and characterized by a narrow channel with fast flowing currents and numerous rapids. There is a waterfall at Ruacana, where the river enters Namibia, with a second major water fall at Epupa, 130 km further downstream. A hydropower station is situated at Ruacana where all (during dry months), or part of the water is diverted to a storage dam for production of electricity. From the Epupa Falls, the river flows through the Baines Mountains before it reaches the Namib Desert, flowing between the sand dunes and entering the Atlantic Ocean.

The rainfall in the upper reaches can be as high as 1500 mm per annum and decreases to approximately 350 mm per annum as the river reaches Ruacana. The rainfall further decreases towards the sea with an annual average of less than 50 mm at the river mouth.

The flood cycle reaches a peak between February and May, and with low flow towards October/November. Local rain, especially during December, can cause smaller local floods in the river. The flow returns to a low flow soon afterwards, until the major flood reaches the area anytime from January onwards. Floodplains are absent along the Namibian section of the river.

The Kunene River falls within the Kunene Region (area: 144255 km^2) in Namibia. People are sparsely distributed in this region (average density 0.6 per km^2), with concentrations mainly near boreholes and along the Kunene River. Although sparsely populated, it is expected that the population in the Kunene Region may decline in the future (Mendelsohn *et al*. 2002). The people living along the Kunene River are not traditionally fish eating people, resulting in very little to no utilization of the fish resource in the Kunene River (the section bordering on Angola). Signs of utilization of the fish resources at Hippopool near Ruacana are presently mainly from people coming from Oshakati and the nearby towns and villages.

The Namibian Inland Fisheries Resources Act (Act No. 1 of 2003) states that nets are allowed in the Kunene River with a minimum stretched mesh size of 76 mm, but no dragging of nets or seins are allowed. A total of four gill nets are allowed per person, who should have a valid license for the nets.

An important human encroachment in the Kunene River is the hydroelectric power generation scheme at Ruacana at the border between Namibia and Angola. A weir has been built inside Angola and the water diverted to a hydroelectric scheme for power generation. This results in a daily fluctuation of the water level in the upper area close to the power station, for example at our sampling station at Hippopool. This water fluctuation diminishes downriver towards the river mouth. There have been some investigations into the possibility of a second hydroelectric scheme at the Epupa Falls, but no decision has yet been made on this matter.

Presently, consumption water is abstracted at Calueque Dam on the Kunene River, transferring water mainly to the Omusati and Oshana Regions in Nambia. This system became operational in 1972, and fish moving through this system invaded the Cuvelai System and was responsible for the transfer of 32 fish species from the Kunene River to the Cuvelai System (Hay *et al.* 1997b).

The Kunene has a low registered diversity of macro-invertebrates and frogs compared with the other perennial rivers in Namibia, such as the Okavango and Zambezi Rivers (Curtis *et al.* 1998). However, the lack of detailed surveys may be the reason for this. Seven mollusc species have been translocated from the Kunene River to the Cuvelai Basin, of which two species hold health risks for humans (such as bilharzia) and animals.

In the past, several studies have been done on the fish resources, although mainly on the systematics of the fish species. One of the first studies was done by Steindachner in 1866 and Boulenger in 1898 and 1910-1916. Other documentations of studies done on the Kunene River are Nichols and Boulton (1927), Vernay-Lang Kalahari expedition as documented in Fowler (1930), Trewavas (1936), Pellegrin (1936), Ladiges and Voelker (1961), Ladiges (1964) and Poll (1967). More detailed studies were done by Hay *et al.* (1997a) on the distribution of the fish in the system, whereas Bell-Cross (1982) reported on the biogeography of the area. Van der Waal (1991) and Bethune and Roberts (1991) also recorded a species list for the Kunene River. Simmons *et al.* (1993) studied the ecology of the system and the possible impacts of the proposed Epupa Dam on the Kunene River. Penrith (1978, 1982) reported on surveys done mainly at the Kunene River mouth.

In total, 46 freshwater fish species were found in the Namibian part of the Kunene River during the present study from 1994 to 2004, of which five species are endemic to the Kunene River (**table 2.1**). In addition, four marine species, Synodontis spp., an unknown freshwater species, an unknown marine species and Gobidae spp. were recorded.

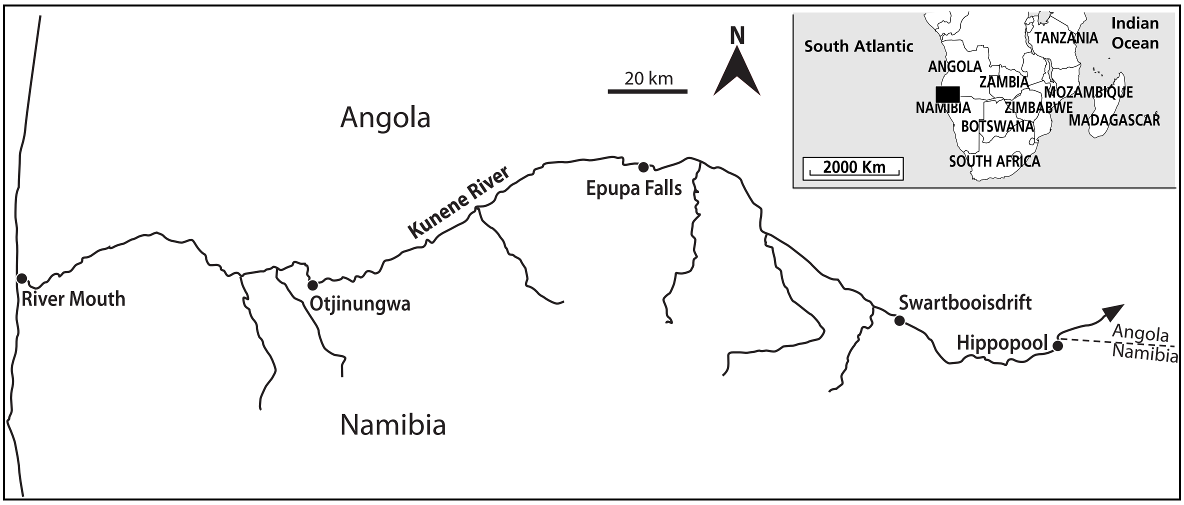

Figure 2.1. *The study area in the Kunene River, on the border between Namibia and Angola.*

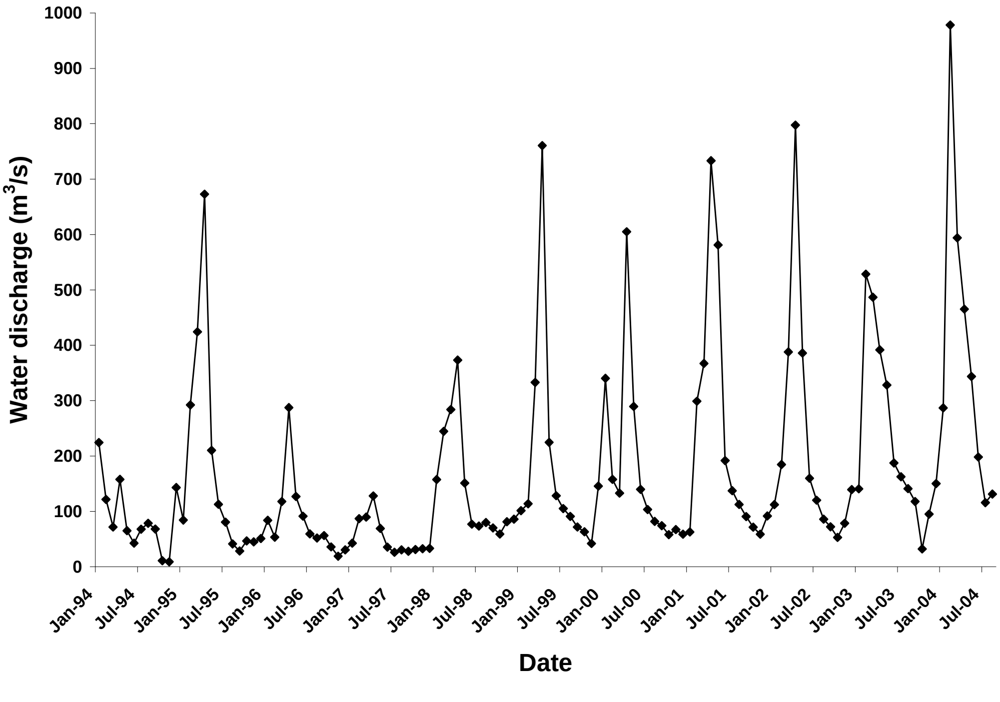

Figure 2.2. *The water discharge in the Kunene River at Ruacana, Namibia, from January 1994 to August 2004. Data was provided by NamPower.*

Table 2.1. *Family name, scientific name, English name and status of freshwater fishes found during the fish surveys in the Kunene River from 1994 to 2004.*

Family	Scientific name	English name	Status
Mormyridae	*Hippopotamyrus ansorgii*	Slender stonebasher	
	Marcusenius macrolepidotus	Bulldog	
	Mormyrus lacerda	Western bottlenose	
	Petrocephalus catostoma	Northern Churchill	
	Pollimyrus castelnaui	Dwarf stonebasher	
Kneriidae	*Kneria maydelli*	Kunene kneria	Endemic Kunene
Characidae	*Brycinus lateralis*	Astriped robber	
	Micralestes acutidens	Silver robber	
Hepsetidae	*Hepsetus odoe*	African pike	
Distichodontidae	*Hemigrammocharax multifasciatus*	Multibar citharine	
Cyprinidae	*Barbus barnardi*	Blackback barb	
	Barbus breviceps	Shorthead barb	
	Barbus eutaenia	Orangefin barb	
	Barbus fasciolatus	Red barb	
	Barbus mattozi	Papermouth	
	Barbus paludinosus	Straightfin barb	
	Barbus poechii	Dashtail barb	
	Barbus radiatus	Beira barb	
	Barbus thamalakanensis	Thamalakane barb	
	Barbus trimaculatus	Threespot barb	
	Barbus unitaeniatus	Longbeard barb	
	Labeo ansorgii	Kunene labeo	
	Labeo ruddi	Silver labeo	
	Mesobola brevianalis	River sardine	
Amphiliidae	*Leptoglanis rotundiceps*	Spotted sand catlet	
Schilbeidae	*Schilbe intermedius*	Silver catfish	
Clariidae	*Clariallabes* sp.	Unidentified broadhead	Status unknown
	Clarias gariepinus	Sharptooth catfish	
	Clarias liocephalus	Smoothhead catfish	
	Clarias ngamensis	Blunttooth catfish	
	Clarias stappersii	Blotched catfish	
	Clarias theodorae	Snake catfish	
Mochokidae	*Chiloglanis neumanni*	Neumann's rock catlet	
	Synodontis spp.	squeakers	
Cyprinodontidae	*Aplocheilichthys macrurus*	White-eye topminnow	
Cichlidae	*Oreochromis andersonii*	Threespot tilapia	
	Oreochromis macrochir	Greenhead tilapia	
	Orthochromis machadoi	Kunene dwarf bream	Endemic Kunene
	Sargochromis coulteri	Kunene bream	Endemic Kunene
	Serranochromis altus	Humpback largemouth	
	Serranochromis angusticeps	Thinface largemouth	
	Serranochromis macrocephalus	Purpleface largemouth	
	Serranochromis thumbergi	Brownspot largemouth	
	Thoracochromis albolabris	Thicklipped river bream	Endemic Kunene
	Thoracochromis buysi	Namib river bream	Endemic Kunene
	Tilapia rendalli	Redbreast tilapia	
	Tilapia sparrmanii	Banded tilapia	

3 MATERIALS AND METHODS

3.1 Surveys and stations

A total of 10 surveys were conducted in the Kunene River from 1994 to 2004 (**table 3.1**). The surveys conducted in the lower part, at the river mouth, were usually separate from the rest of the river due to the logistical problems of surveying the entire river as a once-off. Only the 1996 surveys included both the river mouth and the rest of the river, as an airplane was available for transport between Otjinungwa and the river mouth. Most of the surveys were done during the summer months, while two were done during the winter and one during the autumn. During the first half of the fieldwork (1994 until 2000), 18 different locations were surveyed (**table 3.2**). Later, the number of stations was reduced to five main stations, which were (1) Hippopool, (2) Swartbooisdrif, (3) Epupa, (4) Otjinungwa, and (5) the River Mouth.

Survey stations were chosen to be representative of the river system, to include all main habitat types and to be evenly distributed along the Namibian section of the river. Furthermore, accessibility for the survey team to the river played an important role. Another aspect was to ensure that stations were situated between the major water falls (Ruacana and Epupa Falls) and at the river mouth. Very little fishing took place in the Namibian part of the Kunene River (except at Hippopool where some fishing activity occur) and, hence, did not influence the selection of stations for analysis.

Table 3.1. *Survey year, season, river stretched surveyed and total number of fish caught during the fish surveys in the Kunene River from 1994 to 2004.*

Survey year	Season	River stretch surveyed	Total number of fish caught
1994	Autumn (April)	River mouth	355
1995	Spring (October)	Hippopool to Otjinungwa	1888
1996	Winter (August)	Hippopool to river mouth	1208
1996	Spring (November)	Hippopool to river mouth	3510
1997	Spring (October)	Hippopool to Epupa	1336
1998	Spring (November)	Hippopool to Epupa	1941
2001	Summer (December)	Hippopool to Epupa	1677
2002	Summer (December)	Hippopool to Epupa	1181
2003	Summer (December)	River mouth	1761
2004	Summer (December)	Etaka to Otjinungwa	2102

Table 3.2. *Location name, GPS position and station name of the areas sampled during the fish surveys in the Kunene River from 1994 to 2004. During the first half of the fieldwork (1994 until 2000), 18 different locations were surveyed. Later, the number of stations was reduced to five main stations, which were (1) Hippopool, (2) Swartbooisdrif, (3) Epupa, (4) Otjinungwa, and (5) the River Mouth. Several locations were surveyed at each station, except at Epupa, where only one station was surveyed.*

Location name	Position		Station name
Hippopool	S 17º 24’ 37.2”	E 14º 12’ 44.4”	Hippopool
Opkorongombe	GPS not used		Hippopool
Opatyamaungu	GPS not used		Hippopool
Kunene Stein	S 17º 25’ 56.1”	E 13º 59’ 06.9”	Swartbooisdrif
Ondoodhu	GPS not used		Swartbooisdrif
Ondorusu Falls	S 17º 24’ 28.4”	E 13º 55’ 37.1”	Swarbooisdrif
Swartbooisdrif	S 17º 19’ 28.8”	E 13º 49’ 07.7”	Swartbooisdrif
Otjimbundu	S 17º 16’ 44.9”	E 13º 45’ 02.0”	Once surveyed
Etemba	S 17º 11’ 10.3”	E 13º 35’ 59.0”	Once surveyed
Enyandi	S 17º 08’ 48.0”	E 13º 31’ 38.4”	Once surveyed
Okandombo	S 17º 03’ 43.7”	E 13º 29’ 41.0”	Once surveyed
Oronditi	S 17º 00’ 26.9”	E 13º 25’ 54.6”	Once surveyed
Epupa	S 16º 59’ 44.7”	E 13º 15’ 17.4”	Epupa
Otjinungwa	S 17º 14’ 47.3”	E 12º 26’ 12.5”	Otjinungwa
Hartmanns	S 17º 14’ 16.0”	E 12º 14’ 34.7”	Otjinungwa
Foz do Kunene	S 17º 15’ 07.6”	E 11º 49’ 31.4”	River mouth
Lagoon	S 17º 15’ 10.6”	E 11º 45’ 50.9”	River mouth
River mouth	S 17º 15’ 30.6”	E 11º 46’ 08.3”	River mouth

3.2 Sampling design and methods

A large range of gear types were used to survey the different habitat types to reduce the effects of gear selectivity. All habitat types at all the stations were surveyed to ensure a representative sample of the areas.

An increasing number of gill net mesh sizes were used during the surveys, and from 2003, brown multi-filament gill nets with 11 stretched mesh sizes from 12 to 150 mm were used (**table 3.3**). Each mesh size panel was 10 m in length, except in the first survey year (1994), when the gill nets had 30 m mesh panels. The reduction in panel length after the first survey was done to increase the number of settings, and also to ensure that a gill net set sampled only one particular habitat. With the larger panels, the gill net sets could not always be placed in a particular habitat. The 22 and 28 mm mesh sizes were used from 1994, while the 12 and 16 mm mesh sizes were first used in 2003. Due to inclusion late in the survey, the 12 and 16 mm mesh sizes were not included in analyses where time trends were studied.

The gill nets were set at dusk and retrieved at dawn, resulting in an approximately 12 hour period per gill net setting. The gill nets were mainly set in the main stream, along the sides and in deep open water. Some marginal vegetation was usually present at the gill net stations.

Table 3.3. *Twine and mesh depth (number of vertical meshes) for gill nets of each stretched mesh size used during the surveys in the Kunene River from 1994 to 2004.*

Mesh size (mm)	Twine	Mesh depth
22	210D/4	158.5
28	210D/4	124.5
35	210D/4	99.5
45	210D/4	74.5
57	210D/6	59.5
73	210D/6	49.5
93	210D/9	42.5
118	210D/9	29.5
150	210D/9	24.5

Additional gear types (termed 'other gears' in this report) were used to supplement the catches in the gill nets. These gears were mainly used in areas where gill nets could not be set or where gill nets were considered ineffective. The other gears often targeted smaller and immature individuals of larger fish, small sized species and species with specialized habitats.

The following other gear types were used:

- A 15 m seine net with a depth of 1.5 m, made of 30% shade cloth, was mainly used in shallow water habitats in the main stream, side streams and backwaters.
- Rotenone was used to survey rocky habitats and sometimes along marginal vegetation in slow currents.
- A 30 m seine net with a depth of 1.5 m, made from green anchovy net, was used in open water bodies such as backwaters and along the shoreline in the mainstream, and side channels with slow water currents.
- A 2 m cast net (monofilament nylon twine) with a 20 mm stretched mesh was used to collect fish in deep water habitats in the main stream. The water was either slow or fast flowing.
- A pulsed electro shocker (2 amperes and 600 volts) was used to sample rocky habitats.
- Conical-shaped traps, made from wire with approximately 2 mm mesh size, were placed in deep water along the sides of the main channel. These traps were also used in backwater habitats.
- Angling with rod and reel was used in deep water habitats.

A total of 16959 fish were caught during the surveys from 1994 to 2004 (**table 3.1**). Of these, 6862 fish were caught in gill nets and 10097 fish with other gear types than gill nets.

A total of 50 species were recorded (all gear types) during the surveys when excluding the non-identified species, which were species constituting the *Synodontis* spp. group, an unknown freshwater species, an unknown marine species, Gobiidae spp., *Clarias* sp., *Labeo* sp., *Sargochromis* sp., *Barbus* sp., Mugilidae spp. and Cichlidae spp. (see chapter 5). The *Synodontis* species are difficult to identify morphologically, and these species were therefore grouped as *Synodontis* spp. Five *Synodontis* species have previously been identified from the Kunene River, and these are *Synodontis woosnami, Synodontis macrostigma, Synodontis macrostoma, Synodontis leopardinus* and *Synodontis vanderwaali* (Hay *et al.* 1999, Skelton 2001). *Mugil cephalus* and *Liza falcipinnis* are difficult to separate when they are very small, and were therefore grouped as Mugilidae. Four identified marine species were recorded (*Mugil cephalus*, *Liza falcipinnis*, *Pommadasys commersonii* and *Lichia amia*), all in the river mouth (see chapter 5).

3.3 Data collection and analyses

3.3.1 Biological data

Fish up to 100 mm in length were measured to the nearest millimetre, whereas fish larger than 100 mm were measured to the nearest centimetre. Fork length was measured of fish with a forked caudal fin, while total length was measured of fish with a rounded caudal fin. Fish mass was measured in the field as wet mass. Fish caught in gill nets were weighed to the nearest gram. Fish smaller than 200 g caught with other gears were weighed to the nearest 0.1 g, while larger fish were weighed to the nearest 1 g. After measuring and weighing a large number of individuals of a certain species (often 50 or more), the remaining fish were separated into species, counted, pooled and weighed.

Sexual maturity was classified on a scale from 1 to 5. Immature fish were classified as 1, maturing gonads as 2, mature gonads as 3, spent gonads as 4 and resting gonads as 5.

3.3.2 Selected species

Fourteen species were selected for detailed analyses (chapter 5.3). These species were the most important according to the index of relative importance (IRI), and contributed 55% of the total number sampled and 64% of the total mass. Species included are from the families Cichlidae, Cyprinidae, Characidae, Mormyridae, Schilbeidae and Hepsetidae.

3.3.3 Species diversity

The species diversity is defined as the variety and relative abundance of species. To calculate the relative abundance and diversity of the different species, an index of relative importance (IRI) was used, as well as a measure of the number of species weighted by their relative abundance, expressed as the Shannon diversity index (H'). An index of evenness (J'), which is the ratio between observed diversity and maximum diversity, was also calculated. Information about the species diversity was based on pooled samples from all stations.

<u>Index of Relative Importance (IRI)</u>
The index of relative importance (IRI) was used to find the most important species in terms of number, mass and frequency of occurrence in the catches from the different sampling stations (Kolding 1995, 1999). This index is a measure of relative abundance or commonness of the different species in the catch, and was calculated as:

$$\text{IRI} = \frac{(\%N_i+W_i) \times F_i}{(\%N_j+\%W_j) \times F_j} \times 100 \qquad (1)$$

where j = 1-S, $\%N_i$, and $\%W_i$ is percentage number and mass of each species in the total catch, $\%F_i$ is percentage frequency of occurrence of each species in the total number of settings and S is the total number of species.

Shannon index of diversity (H')
The Shannon index of diversity (H') is a measure of the number of species weighted by their relative abundances (Begon *et al*. 1990), expressed as:

$$H' = \sum p_i \, ln \, p_i, \qquad (2)$$

where p_i is the proportion individuals found in the $_i$th species. Assumptions for the Shannon index are that individuals are randomly sampled from an 'indefinitely large' population, and that all species are represented in the sample. The value of the Shannon diversity index is usually between 1.5 and 3.5. A high value indicates a high species diversity.

Index of evenness (J')
The Shannon index takes into account the evenness of the abundances of species. However, a separate measure of evenness of species diversity was also calculated. We used the ratio of observed diversity to maximum diversity to calculate the index of evenness (J') (Begon *et al*. 1990):

$$J' = H'/H_{max}, \text{ where } H_{max} = \ln (S) \qquad (3)$$

J` is constrained between 0 and 1.0, with 1.0 representing a situation in which all species are equally abundant. 'S' represents the total number of individuals for all species in each sample. As with the Shannon index of diversity, the assumption for this evenness measure is that all species in the area are accounted for in the sample.

3.3.4 Gill net selectivity

Gill nets are selective fishing gears. A specific mesh size catches fish within a certain length category and is often most effective within a narrow length group. In addition, gill nets may discriminate among species according to fish morphology, such as body form and the presence of spines, and fish with different activity levels. The use of gill nets is also restricted to certain habitats, which will also influence the species selectivity of this gear. However, when taking into account the possible problems with the method, the use of standardised gill net series with various mesh sizes catching overlapping length intervals of the fish species, is often the best method to study fish populations.

The body length distribution of fish in the different gill net mesh sizes is the simplest way to express and compare the gill net selectivity of different mesh sizes. For management purposes it is also necessary to calculate the gill net selectivity curve, which is an expression of the probability of capturing a certain size group of fish in a specific gill net mesh size. An analysis of body length distribution in gears, body length of mature fish and gill net selectivity are given for all species caught during the surveys.

The general statistical model for gill net selectivity and its application are described in Millar (1992) and Millar and Holst (1997). When the actual distribution of fish in the sampled area is unknown, as in this study, selectivity estimates are based on the assumption that all fish have the same probability of encountering the gear. This may not always be true, as small individuals within a species may have different behaviour and habitat use compared with larger ones. This uncertainty cannot be quantified without independent information on population structure. Such information, however, is rarely available and difficult to obtain in natural fish populations. A further assumption is that all mesh sizes have the same efficiency on their optimal length class (the so-called 'modal length'). This may also be erroneous due to different behaviour of small and large individuals. Often, the fishing efficiency may increase with mesh size. Several statistical methods are developed to represent the selection curves. Two functions were used in this study. The standard normal function was applied for species that are mainly entangled by their gills, whereas a skewed normal function (Helser *et al.* 1991, 1994) was used for species that to some extent can be caught in other body structures such as fin rays, teeth and spines. The selection curves were standardised to unit height by dividing the number of fish in the modal length class.

3.3.5 Catch per unit effort

When standard fishing gears such as gill nets are used, the catch per unit effort may be used as a rough indicator of the relative density of fish in the area sampled. For a standard series of gill nets in this study, catch per unit effort (CPUE) was defined as the number or mass of fish caught during 12 hours of fishing with a panel length of 10 m gill net.

Measuring catch in number or mass of fish may give very different results. In this report, the results are generally presented in both units, but with an emphasis on mass, as this unit gives a better indication of the amount of fish protein, which is more important to fishers and managers.

3.3.6 Databases and software

All data were compiled in PASGEAR (Kolding 1995, 1999), which is a customized data base intended for experimental fishery data from passive gears. The package is primarily developed to facilitate the entering, storage and analysis of large amounts of experimental data. The program makes data input, manipulation and checking data records easy. PASGEAR also contains predefined extraction, condensing and calculation programs to facilitate data exploration and analysis from survey fisheries. PASGEAR (version May 2000), Excel (version 2003) and SPSS for Windows (version 11.5) were used to perform the calculations and statistical analyses.

4 GENERAL BIOLOGY AND DISTRIBUTION OF THE RECORDED FRESHWATER SPECIES

An overview of the biology and distribution of 47 important freshwater fish species recorded during the surveys in the Kunenes River are given as a background for the results and discussion. Where references are not given, the information is from Skelton (2001). The species are grouped according to their family. The abbreviations TL, FL and SL indicate total length, fork length and standard length, respectively.

Cichlidae

Kunene dwarf bream, *Orthochromis machadoi* (freshwater species, endemic to the Kunene River), occurs only in the Kunene River System. Very little is known about this species, although it is relatively common in the river. It attains a length of 65 mm SL.

Humpback largemouth, *Serranochromis altus* (freshwater species), was first described in 1990 and is found in the Kunene, Okavango, Upper Zambezi and Kafue Rivers. It is found in the vegetated areas of the main river and in deep water lagoons, is a predator and preys mainly on fish. The maximum length recorded in the Zambezi and Chobe Rivers was 535 mm TL (Hay *et al.* 2002), 380 mm TL in the Kwando River (Næsje *et al.* 2004) and 441 mm TL in the Okavango River (Hay *et al.* 2000). *Serranochromis altus* breeds during the early summer months and is important in the subsistence and recreational fisheries.

Thinface largemouth, *Serranochromis angusticeps* (freshwater species), has a wider distribution than the humback largemouth, and is found in the Kunene, Okavango, Upper Zambezi, Kafue and the Congo River Systems. It prefers quiet backwaters with vegetation and lagoons. It is abundant in river channels with vegetation in the Okavango Delta (Merron and Bruton 1988). It preys on small fish such as the robbers and barbs. Merron and Bruton (1988) also recorded some plant material, insects and shrimps in their diet. The maximum length recorded in the Zambezi and Chobe Rivers was 465 mm TL (Hay *et al.* 2002), 380 mm TL in the Kwando River (Næsje *et al.* 2004) and 462 mm TL in the Okavango River (Hay *et al.* 2000). This species matures after one to two years at a length of 250 mm for the males and 175 mm for the females. It breeds throughout the summer months and is important in the subsistence and recreational fisheries.

Purpleface largemouth, *Serranochromis macrocephalus* (freshwater species), is widely distributed in the northern rivers in Namibia and is also found in the Kafue System, Lake Kariba and in the southern tributaries of the Congo System. This species is present in a broad range of habitat types, ranging from main streams to floodplains, channels, lagoons and rapids. It is a predator and feeds on insects and fish. The maximum length recorded in the Zambezi and Chobe Rivers was 280 mm TL (Hay *et al.* 2002), and 270 mm TL in the Kwando River (Næsje *et al.* 2004). *Serranochromis macrocephalus* matures after one to two years, and the minimum length at maturity in the Okavango River was 170 mm TL for males and 140 mm TL for females, with a maximum recorded length of 335 mm TL (Hay *et al.* 2000). Breeding takes place during spring before the flood arrives. *Serranochromis macrocephalus* is a very important fish species for the recreational fishers.

Brownspot largemouth, *Serranochromis thumbergi* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi, Lufira-Lualaba and Zambian Congo systems. It is present in floodplains and lagoons, but prefers open water habitats. It preys mainly on fish, but insects and crabs have also been found in the stomach contents. The maximum length recorded in the Zambezi and Chobe Rivers was 370 mm TL (Hay *et al.* 2002) and 130 mm TL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Lake Liambezi was 140 mm TL for both sexes (Van der Waal 1976). It is occasionally targeted in recreational fisheries, but it is not very important for the subsistence fishery in the Kavango and Caprivi Regions (Hay pers. obs.).

Thicklipped river bream, *Thoracochromis albolabris* (freshwater species, endemic to the Kunene River), favours rocky habitats. Hay *et al.* (1997a) recorded this species from swampy areas, the main stream and from shallow habitats with rocky substrate. Very little data is available on this species. The maximum length recorded in the Kunene River is 200 mm TL (this study). It has no potential for the aquaculture industry due to its small size.

Namib river bream, *Thoracochromis buysi* (freshwater species, endemic to the Kunene River), was found in a wide range of habitats (van Zyl 1992). Van Zyl (1992) recorded a diet mainly consisting of algae and aquatic insects. In earlier surveys in the Kunene River it was found to be dominant, reached a total length of 150 mm TL and an age of four years (van Zyl 1992, Hay *et al.* 1997a). The minimum length at maturity for males was 90 mm TL and for females 70 mm TL (van Zyl 1992). The species matures between one and two years old. Breeding starts in late winter (August) (van Zyl 1992). *T. buysi* is too small to have any potential for aquaculture or for recreational fisheries.

Greenhead tilapia, *Oreochromis macrochir* (freshwater species), is widely distributed in the Kunene, Okavango, Upper Zambezi and Kafue Rivers, and is also present in Lake Kariba and the Buzi River. It has been introduced into the Shashi-Limpopo system and is also present in the Zambian Congo System. This wide distribution was increased due to translocation by man. *Oreochromis macrochir* is found in quiet waters such as backwaters and floodplains. This species feeds mainly on algae and detritus on the bottom. The maximum length recorded in the Zambezi and Chobe Rivers was 335 mm TL, with a minimum length at maturity of 180 mm TL for males and 220 mm TL for females (Hay *et al.* 2002). The minimum length at maturity recorded during a fishing competition in the Zambezi River was 260 mm TL for males and 270 mm TL for females (Næsje *et al.* 2001). The maximum length recorded in the Okavango River was 325 mm TL (Hay *et al.* 2000). It is an important species for the subsistence and recreational fisheries in the Upper Zambezi River (Næsje *et al.* 2001, 2002). This species is also important for aquaculture purposes.

Threespot tilapia, *Oreochromis andersonii* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue River systems. This species prefers slow flowing habitats such as pools and backwaters. It was mainly collected in isolated pools and rapids in the Kunene River, but was not common in this system (Hay *et al.* 1997a). It feeds on detritus, diatoms and zooplankton. The maximum length recorded in the Zambezi and Chobe Rivers was 515 mm TL (Hay *et al.* 2002), 320 mm TL in the Kwando River (Næsje *et al.* 2004) and 500 mm TL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity for fish caught during a fishing competition held in the Zambezi River was 330 mm TL for males and 310 mm TL for females (Næsje *et al.* 2001). It is a very important species for the subsistence fishery (Næsje *et al.* 2002) and the recreation angling (Næsje *et al.* 2001). *Oreochromis andersonii* is also produced in the fish farms in the Caprivi and Kavango Regions.

Banded tilapia, *Tilapia sparrmanii* (freshwater species), is widespread from the Kunene and Orange Rivers and Kwa-Zulu-Natal to the tributaries of the southern Congo. It is also present in Lake Malawi and translocated to south of the Orange River. It prefers vegetated habitats in quiet waterbodies. It was sampled from floodplain areas and well-vegetated pools in the Kunene River (Hay *et al.* 1997a). It has an omnivorous feeding behavior that includes algae, plant material, invertebrates and small fish. The maximum length recorded in the Zambezi and Chobe Rivers was 200 mm TL (Hay *et al.* 2002), 135 mm TL in the Kwando River (Næsje *et al.* 2004), 190 mm TL in the Okavango River (Hay *et al.* 2000) and 150 mm TL in the Lower Orange River (Næsje *et al.* 2007). The minimum length at maturity in the Zambezi and Chobe Rivers was 100 mm TL for males and 60 mm TL for females (Hay *et al.* 2002). In the Kwando River, the minimum length at maturity was 110 mm TL for males and 90 mm TL for females (Næsje *et al.* 2004). In the Okavango River, the minimum length at maturity was 70 mm TL for males and 50 mm TL for females (Hay *et al.* 2000). In the Lower Orange River, the minimum length at maturity was 60 mm TL for both sexes (Næsje *et al.* 2007). It is an important species in the subsistence fishery (Hay pers. obs.).

Redbreast tilapia, *Tilapia rendalli* (freshwater species), is widely distributed in southern Africa and is also present in the Kunene, Okavango and Zambezi River systems and in the rivers on the east coast of South Africa. It is further distributed in Mozambique and the eastern Zaire Basin and the Zambian Congo and Lakes Tanganyika and Malawi. This species prefers well vegetated habitats such as backwaters, floodplains and swamps. *Tilapia rendalli* feeds mainly on aquatic plants and algae, but also on aquatic invertebrates. The maximum length recorded in the Zambezi and Chobe Rivers was 370 mm TL, and the minimum length at maturity was 130 mm TL for males and 90 mm TL for females in this system (Hay *et al.* 2002). The minimum length at maturity for fish caught during a fishing competition held in the Zambezi River was 260 mm TL for males and 280 mm TL for females (Næsje *et al.* 2001). The minimum length at maturity in the Okavango River was 110 mm TL for the males and 140 mm TL for the females (Hay *et al.* 2000). It is a substrate-breeder with several broods during the summer months. It is an important species in the subsistence fishery in the Upper Zambezi River (Næsje *et al.* 2001, 2002), and for aquaculture in some countries in Africa. It may also be used for weed control in dams and canals.

Kunene bream, *Sargochromis coulteri* (freshwater species, endemic to the Kunene River), was found throughout the river system and in slow, shallow water over sandy substrates (Hay *et al.* 1997a). Very little is known about the biology of this species. It may attain a standard length of 216 mm. This species has potential for the aquarium trade.

Cyprinidae

Blackback barb, *Barbus barnardi* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue River systems, and is also present in the Congo System. It is found in well-vegetated habitats in main streams and floodplains. It feeds mainly on aquatic insects and algae. The maximum length recorded in the Zambezi and

Chobe Rivers was 62 mm FL (Hay *et al.* 2002), and 55 mm FL in the Okavango River (Hay *et al.* 2000). Breeding takes place during the summer months. *Barbus barnardi* has some potential for the aquarium trade.

Shorthead barb, *Barbus breviceps* (freshwater species), is present in the Kunene and Okavango River systems. It was not found in the Okavango River bordering on Namibia (Hay *et al.* 2000). It mainly prefers small tributaries and does not seem to be present in the main stream. Very little is known about this species. It attains a length of 77 mm SL, with a maximum length recorded in the Kunene River of 72 mm FL (this study).

Orangefin barb, *Barbus eutaenia* (freshwater species), is present in the Kunene, Okavango and Zambezi River systems and further south to the Phongolo system. It is also present in the Cuanza River, the Congo System and in Lake Tanganyika. This species prefers fast flowing, clear water habitats such as rapids and feeds mainly on insects. It was found to feed on small aquatic insects and periphyton in the Okavango Delta (Merron and Bruton 1988). The maximum length recorded in the Okavango River was 98 mm FL (Hay *et al.* 2000), but it can attain a length of 140 mm SL. Merron and Bruton (1988) stated that spawning was probably taking place during the late summer months with the arrival of the flood. It has some potential for the aquarium trade.

Red barb, *Barbus fasciolatus* (freshwater species), is present in the Kunene, Okavango, Upper and Middle Zambezi, Kafue and the Congo River systems. The preferred habitat is vegetated areas such as floodplains and permanent lagoons. It feeds on small organisms present on plant surfaces. Merron and Bruton (1988) documented that this species feeds on periphyton and aquatic insects. The maximum length recorded in the Zambezi and Chobe Rivers was 50 mm FL (Hay *et al.* 2002), 55 mm FL in the Kwando River (Næsje *et al.* 2004) and 48 mm FL in the Okavango River (Hay *et al.* 2000). According to Merron and Bruton (1988), spawning takes place between September and March in the Okavango Delta. It is an attractive aquarium species.

Papermouth, *Barbus mattozi* (freshwater species), is present in the Limpopo System and in the headwaters of the Kunene and Gwai River systems. It has, however, not been recorded in the Namibian section of the Upper Zambezi and Kwando Rivers (Hay *et al.* 2002). This species has a preference for calm waters such as pool habitats. Being an active predator, it initially consumes crustaceans and insects and, when larger, small fish become its main prey. The maximum length recorded in the Kunene River was 390 mm FL (this study). *Barbus mattozi* matures after three years. Migration, mainly for breeding purposes, takes place during the first flood in the summer months. The larger specimens can be regarded as a good angling species. Its sensitivity towards handling does not make it very suitable for the aquarium trade.

Straightfin barb, *Barbus paludinosus* (freshwater species), is widely distributed and is present from East Africa south to KwaZulu-Natal and from the Congo System to the Orange River. It is also widely distributed in Namibia and is present in several ephemeral rivers (Hay *et al.* 1999). The preferred habitat is well-vegetated areas, swamps and marshes. It was also sampled in rocky habitats in the Kunene River (Hay *et al.* 1997a). It has a wide food preference and feeds on insects, small snails and crustaceans, algae and diatoms. The maximum length recorded in the Zambezi and Chobe Rivers was 105 mm FL (Hay *et al.* 2002), 70 mm FL in the Kwando River (Næsje *et al.* 2004), 90 mm FL in the

Okavango River (Hay *et al.* 2000), and 70 mm FL in the Lower Orange River (Næsje *et al.* 2007). The minimum length at maturity recorded in the Zambezi and Chobe Rivers was 60 mm FL for males and 70 mm FL for females (Hay *et al.* 2002). The minimum length at maturity recorded in the Okavango River was 50 mm FL for males and 60 mm FL for females (Hay *et al.* 2000). Spawning takes place between the vegetation during the summer months. It is important in the subsistence fishery in Namibia (Hay pers. obs.).

Dashtail barb, *Barbus poechii* (freshwater species), is present in the Kunene, Okavango and Zambezi River systems. The systematic status of this species still needs further investigation (Hay *et al.* 1997a). It is present in floodplain habitats, but was also found in riverine habitats. It feeds on insects and small organisms. The maximum length recorded in the Zambezi and Chobe Rivers was 125 mm FL (Hay *et al.* 2002), 95 mm FL in the Kwando River (Næsje *et al.* 2004), and 160 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Zambezi and Chobe Rivers was 70 mm FL for both sexes (Hay *et al.* 2002). In the Okavango River, the minimum length at maturity was 70 mm FL for both sexes (Hay *et al.* 2000). This is an important species for the subsistence fishery (Hay pers. obs.).

Beira barb, *Barbus radiatus* (freshwater species), is widespread and present in the Zambian Congo System, and the Kunene, Okavango, Zambezi Rivers as well as the east coast rivers in South Africa. It is found in marginal vegetation of rivers. It was sampled in swampy areas with aquatic vegetation in the Kunene River (Hay *et al.* 1997a), but not in the floodplains in the Okavango Delta (Merron and Bruton 1988). According to Merron and Bruton (1988), this species feeds on small aquatic insects and periphyton. The maximum length recorded in the Zambezi and Chobe Rivers was 90 mm FL (Hay *et al.* 2002), 90 mm FL in the Kwando River (Næsje *et al.* 2004), and 88 mm FL in the Okavango River (Hay *et al.* 2000). Merron and Bruton (1988) reported that the spawning season is between September and March in well-vegetated habitats. It has a potential for the aquarium trade.

Thamalakane barb, *Barbus thamalakanensis* (freshwater species), is present in the Okavango and Zambezi Rivers. According to Skelton (2001) it is not present in the Kunene River, but was sampled during this study although it is considered uncommon. It is found in well-vegetated habitats in the main stream and in backwaters. It was often found in ephemeral rain pools and floodplains pools in the Okavango Delta (Merron and Bruton 1988). It feeds on insects and periphyton. The maximum length recorded in the Zambezi and Chobe Rivers was 43 mm FL (Hay *et al.* 2002), 36 mm FL in the Kwando River (Næsje *et al.* 2004), and 50 mm FL in the Okavango River (Hay *et al.* 2000). It breeds in the summer months in the vegetation. It was found to be important in the subsistence fishery in the Okavango Delta (Hay *et al.* 2000).

Threespot barb, *Barbus trimaculatus* (freshwater species), is widely spread with a presence from the east coast of Ruvuma to Umvoti in KwaZulu-Natal. It is also present in the Orange River and the Kunene River, but absent from the Okavango and Zambezi River systems. It is found in a variety of habitats. In the Kunene River it was, for example, found in floodplain areas and shallow waters and isolated pools (Hay *et al.* 1997a). It feeds mainly on insects and small organisms. The maximum length recorded in the Lower Orange River was 110 mm FL (Næsje *et al.* 2007). The minimum length at maturity was 50 mm FL for both sexes (Næsje *et al.* 2007). Breeding takes place in the summer months, with an upstream migration of the adults.

Longbeard barb, *Barbus unitaeniatus* (freshwater species), is widely distributed from the Zambian Congo System and the Kunene, Okavango and Zambezi Rivers to the Phongolo System. It was collected from floodplains and shallow water habitats in the Kunene River (Hay *et al.* 1997a). It feeds on aquatic invertebrates and even grass seeds. The maximum length recorded in the Zambezi and Chobe Rivers was 95 mm FL, 40 mm FL in the Kwando River (Næsje *et al.* 2004), and 94 mm FL in the Okavango River (Hay *et al.* 2000). Breeding takes place during the summer months after the rains.

Kunene labeo, *Labeo ansorgii* (freshwater species), has a restricted distribution and is present only in the Kunene and Quanza Systems. Little information is available for this species. It was documented during previous surveys in the Kunene River from shallow swampy areas covered with aquatic vegetation to deep water areas with rocky substrate and in rapids (Hay *et al.* 1997a). According to Hay *et al.* (1997a), it is the dominant of the two *Labeo* species present in the Kunene River. It attains a length of 270 mm SL. The maximum length recorded during the present study was 340 mm FL. *Labeo ansorgii* is too small for recreational angling purposes.

Silver labeo, *Labeo ruddi* (freshwater species), is present in the Limpopo and Incomati Rivers. It is absent from the Zambezi and Okavango Systems, but present in the Kunene River. It prefers quiet water habitats and deep standing pools and feeds mainly on organic sediments. It attains lengths of up to 300 mm SL. A maximum length of 380 mm FL was recorded during the present study. Similar to *Labeo ansorgii*, it moves upstream during the flood for breeding purposes. According to Skelton (2001) it can be considered an occasional angling species.

River sardine, *Mesobola brevianalis* (freshwater species), is present in the Kunene, Okavango and Zambezi Rivers. It is further distributed in the east coastal rivers from the Limpopo River to the Umfolozi River. It is also found in the Lower Orange River. It prefers open flowing water habitats and feeds on planktonic crustaceans and insects. The maximum length recorded in the Zambezi and Chobe Rivers was 26 mm FL (Hay *et al.* 2002), 34 mm FL in the Kwando River (Næsje *et al.* 2004), 34 mm FL in the Okavango River (Hay *et al.* 2000), and 70 mm FL in the Lower Orange River (Næsje *et al.* 2007). The minimum length at maturity in the Lower Orange River was 30 mm FL for both sexes (Næsje *et al.* 2007). Breeding takes place in early summer.

Mormyridae

Slender stonebasher, *Hippopotamyrus ansorgii* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi, Buzi and Pungwe Rivers. An isolated population is also found in the Lower Zambezi River and further distribution is in the Quanza River in Angola. It is mainly restricted to the upper reaches of the Okavango Delta, in fast flowing habitats (Merron and Bruton 1988). It is mainly found in flowing water habitats such as rapids, and feeds on invertebrates. The maximum length recorded in the Zambezi and Chobe Rivers was 128 mm FL (Hay *et al.* 2002), 115 mm FL in the Kwando River (Næsje *et al.* 2004), and 140 mm FL in the Okavango River (Hay *et al.* 2000). It seems to be a late spawner during the annual flood season, although very little information is available (Merron and Bruton 1988).

Bulldog, *Marcusenius macrolepidotus* (freshwater species), is very common and widespread in the Kunene, Okavango, Upper Zambezi and Chobe Rivers. It is also found in the Upper Congo River. It has a wide habitat preference and is widely distributed throughout the Kunene River (Hay *et al.* 1997a). Skelton (2001) indicated that the species favors well vegetated habitats, which was also the case for the Okavango River (Hay *et al.* 1996). Hay *et al.* (1996) classified this species as an invertivore, and Skelton (2001) also stated that it feeds on invertebrates, especially midge and mayfly larvae and pupae. The maximum length recorded was 210 mm FL in the Zambezi and Chobe Rivers (Hay *et al.* 2002), 290 mm FL in the Kwando River (Næsje *et al.* 2004), and 225 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Zambezi and Chobe Rivers was 80 mm FL for both sexes (Hay *et al.* 2002). The minimum length at maturity in the Kwando River was 100 mm FL for males and 110 mm FL for females (Næsje *et al.* 2004). In the Okavango River, the minimum length at maturity was 100 mm FL for both sexes (Hay *et al.* 2000). It breeds during the rainy season in shallow, vegetated areas. It is also an important species for the subsistence fishery and can as well be an interesting aquarium species.

Western bottlenose, *Mormyrus lacerda* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue River Systems. This species is found in deep slow flowing habitats in association with vegetation (Hay *et al.* 1997a). Smaller individuals have also been recorded in rapids (Hay pers. obs.). *Mormyrus lacerda* feeds mainly on invertebrates, small snails and even small fish. It attains a maximum body length of approximately 500 mm. The maximum length recorded was 350 mm FL in the Zambezi and Chobe Rivers (Hay *et al.* 2002), 390 mm FL in the Kwando River (Næsje *et al.* 2004), and 360 mm FL in the Okavango River (Hay *et al.* 2000). Breeding takes place during the rainy season. It is regularly caught in the subsistence fishery in the Caprivi Region (Hay pers. obs.).

Northern Churchill, *Petrocephalus catostoma* (freshwater species), is reported from the Kunene, Okavango and Upper Zambezi Rivers and south to the Save River. It is further distributed in the Zambian Congo River, the Great Lakes and East Africa. The preferred habitats are vegetated habitats such as backwaters and floodplains, but it is also found in rapids and rocky substrates (Hay *et al.* 1997a). It feeds on invertebrates and breeds during the rainy season. It reaches a maximum body length of 130 mm SL, while maximum lengths recorded were 140 mm FL in the Zambezi and Chobe Rivers (Hay *et al.* 2002), 105 mm FL in the Kwando River (Næsje *et al.* 2004), and 119 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity recorded in the Zambezi and Chobe Rivers was 40 mm FL for males and 60 mm FL for females (Hay *et al.* 2002). The minimum length at maturity recorded for this species in the Okavango River was 70 mm FL for males and 60 mm FL for females (Hay *et al.* 2000). During the winter months, large downstream migrations at Impalila in the Chobe River have been recorded (Hay pers. com.), and it is then caught by the subsistence fishers. It may have some potential for the aquarium trade.

Dwarf stonebasher, *Pollimyrus castelnaui* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue Rivers. It is also found in the northern parts of Lake Malawi. It prefers dense vegetation along the rivers and also inhabits floodplains, and feeds on aquatic invertebrates. The maximum length recorded in the Zambezi and Chobe Rivers was 90 mm FL (Hay *et al.* 2002), 75 mm FL in the Kwando River (Næsje *et al.*

2004), and 70 mm FL in the Okavango River (Hay *et al.* 2000). According to Merron and Bruton (1988), spawning in the Okavango Delta takes place during late summer months.

Kneriidae

Kunene kneria, *Kneria maydelli* (freshwater species, endemic to the Kunene River), is distributed in the Kunene River System in Namibia and Angola. Very little information is available on this species. The maximum length recorded in the Kunene River was 72 mm FL (this study).

Characidae

Striped robber, *Brycinus lateralis* (freshwater species), is widely distributed in the Zambezi System, the Okavango and Kunene Rivers and also in several systems in KwaZulu-Natal in South Africa. It is further present in the Congo System and the Save System in Zimbabwe. This is a common species, especially in the Zambezi and Chobe Rivers where it was the most important species recorded (Hay *et al.* 2002). Hay *et al.* (1996) classified this species as omnivorous, whereas Skelton (2001) indicated small aquatic and terrestrial organisms as the preferred food. The maximum lengths recorded were 200 mm FL in the Zambezi and Chobe Rivers (Hay *et al.* 2002), 105 mm FL in the Kwando River (Næsje *et al.* 2004) and 140 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Zambezi and Chobe Rivers was 60 mm FL for males and 50 mm FL for females (Hay *et al.* 2002). In the Okavango River, the minimum length at maturity was 50 mm FL for males and 60 mm FL for females (Hay *et al.* 2000). In the Okavango River, breeding took place during the summer months (Hay 1995). This species is important in the subsistence fishery in the Caprivi Region (Hay pers. obs.). It is too small to have any potential for recreational angling (perhaps only for artificial lure angling) or aquaculture purposes.

Silver robber, *Micralestes acutidens* (freshwater species), is present in the Kunene, Okavango and Zambezi Systems as well as in the east coast rivers down to the Phongolo. Further distribution is in the Congo System. This species prefers open flowing water habitats (Hay *et al.* 1996). *Micralestes acutidens* has an omnivorous feeding behaviour (Hay *et al.* 1996). Maximum lengths recorded were 95 mm FL in the Upper Zambezi and Chobe Rivers (Hay *et al.* 2002), 57 mm FL in the Kwando River (Næsje *et al.* 2004) and 80 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity for the Zambezi and Chobe Rivers was 50 mm FL for both males and females (Hay *et al.* 2002). *Micralestes acutidens* breeds during the summer months, which is probably linked to the annual flooding. This species is too small to have any potential for recreational angling or aquaculture purposes, but is important in the subsistence fishery.

Schilbeidae

Silver catfish, *Schilbe intermedius* (freshwater species), has a wide distribution and is present in the Kunene, Okavango and Zambezi Rivers, and is also present throughout tropical Africa as well as West Africa and the Nile River. This species was very common in the Upper Zambezi and Chobe Rivers (Hay *et al.* 2002) and in the Okavango River (Hay *et al.* 2000). The habitat preference in the Okavango River was backwaters and floodplain areas with a slow flow (Hay 1995). It was seldom collected in rocky habitats. It is feeding on a wide variety of food, which includes fish, insects, fruit, seeds and even snails. According to Skelton (2001), it attains approximately 300 mm SL. Maximum lengths recorded were 350 mm FL in the Zambezi and Chobe Rivers (Hay *et al.* 2002), 280 mm FL in the Kwando River (Næsje *et al.* 2004) and 300 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Zambezi and Chobe Rivers was 80 mm FL for both sexes (Hay *et al.* 2002). In the Okavango River, the minimum length at maturity was 90 mm FL for males and 100 mm FL for females (Hay *et al.* 2000). Spawning takes place during late summer to early autumn in the Okavango River and coincides with the increase in water level (Hay 1995). This species has some potential for recreational angling purposes, but it grows slowly, which limits its potential for aquaculture. It is an important species for subsistence fisheries.

Hepsetidae

African pike, *Hepsetus odoe* (freshwater species) is present in the Kunene, Okavango, Upper Zambezi Rivers and the Kafue System, with further distributions in the Democratic Republic of Congo and West Africa. Skelton (2001) indicated the habitats of this species to be in quiet, deep water, such as in lagoons and floodplains. In the Kunene River, this species was found in floodplains, deep water habitats as well as rapids (Hay *et al.* 1997a). Hay *et al.* (1997) suggested that the wider habitat use in the Kunene River could probably be contributed to the absence of the aggressive tigerfish (*Hydrocynus vittatus*). *H. odoe* is a top predator and feeds mainly on other fish. Juveniles feed on fish and invertebrates. It attains a length of 470 mm FL, and maximum lengths were 360 mm FL in the Upper Zambezi and Chobe Rivers (Hay *et al.* 2002), 390 mm FL in the Kwando River (Næsje *et al.* 2004), and 430 mm FL in the Okavango River (Hay *et al.* 2000). The minimum length at maturity in the Zambezi and Chobe Rivers was 250 mm FL for males and 230 mm FL for females (Hay *et al.* 2002). In the Okavango River, the minimum length at maturity was 280 mm FL for males and 270 mm FL for females (Hay *et al.* 2000). Breeding takes place during the summer months, and breeding pairs construct a floating nest. It has some potential for recreational angling purposes and is often caught by the subsistence fishery.

Distichodontidae

Multibar citharine, *Hemigrammocharax multifasciatus* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue River Systems. It is also present in the Zambian Congo System. It is found along the vegetated fringes of the rivers and in backwaters. It feeds on invertebrates and epiphyton from plants. The maximum length recorded in the Zambezi and Chobe Rivers was 50 mm FL (Hay *et al.* 2002) and 50 mm FL in the Okavango River (Hay *et al.* 2000). This species breeds during the summer months.

Clariidae

Sharptooth catfish, *Clarias gariepinus* (freshwater species), has got the most widely distribution of the freshwater fishes in the Namibian perennial rivers, and is found in all rivers in Namibia and from the Nile to the Orange River. It has also been translocated to several other rivers in South Africa. *Clarias gariepinus* has a wide habitat use and is found in almost any habitat type, but prefer floodplains and large slow flowing rivers. It is usually the last surviving fish species in drying rivers or pools. *Clarias gariepinus* is omnivorous and preys on virtually anything. It can grow to 1.40 m SL, and maximum lengths were 1.05 m TL in the Upper Zambezi and Chobe Rivers during a fishing competition (Næsje *et al.* 2001), 0.79 m TL in the Okavango River (Hay *et al.* 2000) and 1.50 m TL in the Lower Orange River (Næsje *et al.* 2007). The minimum length at maturity in the Zambezi and Chobe Rivers was 460 mm TL for males and 340 mm TL for females (Hay *et al.* 2002). In the Okavango River, the minimum length at maturity was 400 mm TL for males and 380 mm TL for females (Hay *et al.* 2000). The minimum length at maturity recorded in the Lower Orange River was 370 mm TL for both sexes (Næsje *et al.* 2007). It breeds during the summer months, and the annual flood triggers reproduction when they migrate to shallow vegetated habitats. It is important in aquaculture as well as in the subsistence fishery in the Caprivi, Kavango, Omusati and Oshana Regions in Namibia (Hay pers. obs.).

Clariallabes sp. (freshwater species), has only been found in the Kunene River. It is in the process of being systematically described. The maximum length recorded in the Kunene River was 220 mm TL (this study).

Smoothhead catfish, *Clarias liocephalus* (freshwater species) is present in the Kunene, Okavango, Upper Zambezi and Kafue River Systems as well as in the Zambian Congo System through to Lake Victoria. It prefers rocky habitats, but little is known about this species. The maximum length recorded in the Okavango River was 200 mm TL (Hay *et al.* 2000).

Blunttooth catfish, *Clarias ngamensis* (freshwater species), is widely distributed in the Kunene, Okavango, Upper Zambezi, Kafue, Lower Shire, Save, Limpopo and Phongolo River Systems. It is further distributed in the Zambian Congo System and in the Quanza River in Angola. The preferred habitat is vegetated areas and floodplains. It feeds on a variety of food items such as molluscs, insects, crabs and fish. The maximum length recorded in the Zambezi and Chobe Rivers was 600 mm TL (Hay *et al.* 2002), 640 mm TL in the Kwando River (Næsje *et al.* 2004) and 730 mm TL in the Okavango River (Hay *et al.* 2000). Maturity is reached at about 250 mm TL. Breeding takes place during summer months and individuals move into shallow areas during the flooding period. The species is important in the subsistence fishery.

Blotched catfish, *Clarias stappersii* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi and Kafue River Systems. It is further present in the Zambian Congo System. It prefers vegetated habitats such as floodplains and backwaters. It feeds on invertebrates and fish. The maximum length recorded in the Zambezi and Chobe Rivers was 80 mm TL (Hay *et al.* 2002), 135 mm TL in the Kwando River (Næsje *et al.* 2004), and 340 mm TL in the Okavango River (Hay *et al.* 2000). This species breeds during the summer months, probably with the rise of the flood (Merron and Bruton 1988). It is not common, but is caught in the subsistence fishery.

Snake catfish, *Clarias theodorae* (freshwater species), is present in the Kunene, Okavango, Upper Zambezi, Kafue, Lower Zambezi and Limpopo River Systems. It is also present in the Congo System and Lake Malawi catchment and in the Rufigi River. The preferred habitat is dense vegetation along the river banks and floodplains. It feeds on invertebrates, shrimps and fish. The maximum length recorded in the Zambezi and Chobe Rivers was 270 mm TL (Hay *et al.* 2002), 160 mm TL in the Kwando River (Næsje *et al.* 2004), and 264 mm TL in the Okavango River (Hay *et al.* 2000). Merron and Bruton (1988) recorded spawning to take place in the Okavango Delta between September and March in vegetated habitats along the fringes of slow flowing channels.

Amphiliidae

Spotted sand catlet, *Leptoglanis rotundiceps* (freshwater species), is present in the Kunene, Okavango, Zambezi, Buzi and Save River Systems. It utilises a very specific habitat and is found in sandy substrates with a water current. It feeds on minute organisms. Nothing is known about the breeding behavior of this species.

Mochokidae

Neumann's rock catlet, *Chiloglanis neumanni* (freshwater species), is present in the Kunene, Zambezi, Pungwe and Buzi River Systems. It is further found in the catchment area of Lake Malawi and the east coast rivers of Tanzania. It is found mainly in rocky habitats with a water current. The maximum length recorded in the Zambezi and Chobe Rivers was 30 mm FL (Hay *et al.* 2002). It has some potential for the aquarium trade.

Cyprinodontidae

White-eye topminnow, *Aplocheilichthys macrurus* (freshwater species), is present in the Kunene River, but also reported from the upper reaches of the Okavango River and from the Quanza River. It is found in vegetated habitats and floodplains. Not much is known about this species. It attains lengths of 35 mm SL, with the maximum length recorded in the Kunene River of 50 mm TL (this study).

Gill nets in strong current at Hippopool *Photo: Clinton J. Hay*

A large Schilbe intermedius *from the Kunene River* *Photo: Clinton J. Hay*

Gill nets at Swartbooisdrif *Photo: Clinton J. Hay*

5 RESULTS

5.1 Species diversity

During the surveys from 1994 to 2004, a total of 50 species were identified (the non-identified species are excluded, which were species constituting the *Synodontis* spp. group, an unknown freshwater species, an unknown marine species and the Gobiidae spp., **table 5.1**). Of the 50 identified species, 46 were freshwater species and 4 were estuarine/marine species. One of the freshwater species, *Clariallabes* sp., has only been found in the Kunene River and is in the process of being systematically described. Of the 15 fish families recorded, the Cyprinidae and Cichlidae families were the most common with regard to number of species recorded (14 and 12 species, respectively, **table 5.1**).

5.1.1 Catches in all gears

The species caught with gill nets and other gears during all the surveys were ranked based on the index of relative importance (IRI), which takes into account the numbers, mass and frequency of occurrence of the species caught (**table 5.1**). To be able to compare with earlier studies from the Okavango River (Hay *et al.* 2000), Zambezi and Chobe Rivers (Hay *et al.* 2002) and the Kwando River (Næsje *et al.* 2004), the gill net data are based on mesh sizes from 22 to 150 mm used in the period 1994-2004.

Although the families Cyprinidae and Cichlidae dominated with regard to number of species, they only comprised 35% of the total IRI (**table 5.1**), while three species from the Schilbeidae and Characidae families comprised 38% of the total IRI.

According to the IRI, *Schilbe intermedius* was the most important species (24%) in the Kunene River, followed by *Barbus mattozi* (12%), *Labeo ansorgii* (10%) and *Brycinus lateralis* (10%) (**table 5.1**). The remaining species comprised less than 5% each. The endemic species *Thoracochromis buysi* was the fifth most important species (4.7%). Another endemic species, *Orthochromis machadoi*, was also regularly sampled, with an IRI of 1.1%. The other endemic species, *Thoracochromis albolabris, Sargochromis coulteri* and *Kneria maydelli*, had an IRI of less than 0.1% each. No IUCN Red List species or alien species were recorded in the Kunene River.

A total of 1122 kg of fish were caught during the surveys with gill nets and other gears (**table 5.1**). The most important species in mass were *Mugil cephalus* (165 kg, 15%) and *Schilbe intermedius* (155 kg, 14%), followed by *Clarias gariepinus* (139 kg, 12%), *Labeo ansorgi* (124 kg, 11%), *Mormyrus lacerda* (102 kg, 9.1%), *Barbus mattozi* (88 kg, 7.8%) and *Hepsetus odoe* (87 kg, 7.7%). These seven species constituted 77% of the total mass sampled. The remaining species constituted less than 4% each in mass.

A total number of 16959 fish were caught during the surveys with gill nets and other gears (**table 5.1**). The most important species in number was *Brycinus lateralis* (11%), followed by *Mugil cephalus* (9.3%), *Thoracochromis buysi* (8.6%), *Micralestes acutides* (6.3%), *Aplocheilichthys macrurus* (5.8%), *Oreochromis macrochir* (5.4%), *Schilbe intermedius* (5.0%), and *Orthochromis machadoi* (5.0%). These eight species constituted 56% of the total number of fish caught. Two of these species are endemic to the Kunene River (*Thoracochromis buysi* and *Orthochromis machadoi*). The remaining species constituted less than 5% each of the total number of fish caught.

According to the IRI, *Barbus mattozi* was the most important cyprinid (IRI 12%) (**table 5.1**). *Labeo ansorgii* was the most important cyprinid in number of fish caught (3.5%) and mass (11%). *Thoracochromis buysi* was the most important cichlid according to the IRI (4.7%) and number of fish caught (8.6%), while *Oreochromis macrochir* was the most important cichlid according to mass (1.9%). The most important marine species was *Mugil cephalus*, listed as the seventeenth most important species according to IRI 1.0%. However, according to mass it was the most important of all species recorded (15%), and the second most important according to number of fish caught (9.3%).

Eight freshwater species were listed as “not common” in the Kunene River as less than 10 individuals were recorded (**table 5.1**). These were *Serranochromis altus, Clarias liocephalus, Pollimyrus castelnaui, Barbus thamalakanensis, Clarias theodorae, Hemigrammocharax multifasciatus, Barbus barnardi* and *Serranochromis thumbergi*. Of the marine species, *Pommadasys commersonii*, *Lichia amia* and an unknown species were listed as “not common” (**table 5.1**).

A total of 26 individuals were sampled of the newly discovered clariid, *Clariallabes* sp. (**table 5.1**). Two other species, *Barbus breviceps* (81 individuals) and *Kneria maydelli* (82 individuals), had very restricted distributions as they were sampled in only a few fountains. However, they were relatively common in those fountains.

5.1.2 Catches in gill nets

Of the total catch during the surveys, 40% (6862 fish) was caught in the gill nets (**table 5.2**). A total of 35 species were identified (*Synodontis spp.,* the Gobiidae, an unknown species and an unidentified marine species are excluded). Two of the 35 identified species were marine species only caught in the estuary (*Mugil cephalus* and *Pommadasys commersonii*). Eleven fish families were recorded in the gill nets catches. The families Schilbeidae (one species) and the Characidae (two species) was most important according to the IRI (46%) (**table 5.2**), while the most diversified families were the Cyprinidae and Cichlidae, with 9 and 11 species each.

According to the IRI, the most important species caught in the gill nets was *Schilbe intermedius* (29%), followed by *Brycinus lateralis* (16%), *Barbus mattozi* (13%) and *Labeo ansorgii* (11%) (**table 5.2**). These four most important species constituted 69% of the total IRI, 42% of the total mass and 53% of the total number of fish caught. The remaining species constituted less than 7% each of the total IRI. Less than 10 individuals were caught of each of 11 species. Of the two marine species recorded in the gill nets, *Mugil cephalus* was the most important according to IRI (< 1%), mass (0.1%) and number of fish caught (< 0.1%).

Table 5.1. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) and other gears at all stations combined during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Schilbe intermedius	852	5.0	155.243	13.8	329	20.9	394	24.2	0.15	0.04
Barbus mattozi	549	3.2	87.540	7.8	269	17.1	188	11.6	0.111	0.03
Labeo ansorgii	592	3.5	124.299	11.1	184	11.7	170	10.4	0.117	0.03
Brycinus lateralis	1889	11.1	22.694	2.0	203	12.9	170	10.4	0.244	0.06
Synodontis spp.	1335	7.9	43.570	3.9	207	13.1	154	9.5	0.2	0.05
Thoracochromis buysi	1455	8.6	6.183	0.6	132	8.4	76	4.7	0.211	0.05
Marcusenius macrolepidotus	577	3.4	27.771	2.5	184	11.7	69	4.2	0.115	0.03
Hepsetus odoe	154	0.9	86.794	7.7	110	7.0	60	3.7	0.043	0.01
Mormyrus lacerda	188	1.1	101.983	9.1	82	5.2	53	3.3	0.05	0.01
Micralestes acutidens	1074	6.3	4.034	0.4	120	7.6	51	3.1	0.175	0.04
Clarias gariepinus	76	0.4	138.985	12.4	56	3.6	46	2.8	0.024	0.01
Oreochromis macrochir	910	5.4	21.808	1.9	84	5.3	39	2.4	0.157	0.04
Tilapia rendalli	729	4.3	12.355	1.1	89	5.6	30	1.9	0.135	0.03
Serranochromis macrocephalus	244	1.4	25.893	2.3	103	6.5	24	1.5	0.061	0.01
Aplocheilichthys macrurus	983	5.8	0.324	0	61	3.9	23	1.4	0.165	0.04
Orthochromis machadoi	847	5.0	1.629	0.1	54	3.4	18	1.1	0.15	0.04
Labeo ruddi	151	0.9	36.929	3.3	64	4.1	17	1.0	0.042	0.01
Mugil cephalus	1582	9.3	165.451	14.7	11	0.7	17	1.0	0.221	0.05
Hippopotamyrus ansorgii	184	1.1	4.882	0.4	88	5.6	8	0.5	0.049	0.01
Petrocephalus catostoma	162	1.0	2.507	0.2	65	4.1	5	0.3	0.044	0.01
Barbus eutaenia	335	2.0	0.894	0.1	22	1.4	3	0.2	0.078	0.02
Barbus trimaculatus	127	0.7	1.604	0.1	40	2.5	2	0.1	0.037	0.01
Mesobola brevianalis	371	2.2	0.222	0	12	0.8	2	0.1	0.084	0.02
Clarias ngamensis	12	0.1	17.399	1.6	11	0.7	1	0.1	0.005	0
Barbus radiatus	70	0.4	0.579	0.1	35	2.2	1	0.1	0.023	0.01
Serranochromis angusticeps	18	0.1	10.031	0.9	16	1.0	1	0.1	0.007	0
Barbus unitaeniatus	70	0.4	0.596	0.1	34	2.2	1	0.1	0.023	0.01
Mugilidae	648	3.8	1.066	0.1	3	0.2	1	0	0.125	0.03
Chiloglanis neumanni	104	0.6	0.098	0	18	1.1	1	0	0.031	0.01
Oreochromis andersonii	58	0.3	4.175	0.4	13	0.8	1	0	0.019	0
Sargochromis coulteri	24	0.1	3.310	0.3	19	1.2	1	0	0.009	0
Barbus fasciolatus	92	0.5	0.109	0	14	0.9	0	0	0.028	0.01
Barbus poechii	40	0.2	0.422	0	24	1.5	0	0	0.014	0
Unknown freshwater species	30	0.2	2.849	0.3	11	0.7	0	0	0.011	0
Thoracochromis albolabris	48	0.3	0.505	0	14	0.9	0	0	0.017	0
Clariallabes sp.	26	0.2	0.278	0	11	0.7	0	0	0.01	0
Barbus paludinosus	21	0.1	0.097	0	10	0.6	0	0	0.008	0
Barbus breviceps	81	0.5	0.170	0	2	0.1	0	0	0.026	0.01
Kneria maydelli	82	0.5	0.091	0	2	0.1	0	0	0.026	0.01
Tilapia sparrmanii	21	0.1	0.682	0.1	5	0.3	0	0	0.008	0
Clarias stappersii	11	0.1	0.921	0.1	5	0.3	0	0	0.005	0
Leptoglanis rotundiceps	15	0.1	0.003	0	5	0.3	0	0	0.006	0
Serranochromis altus	2	0	2.254	0.2	2	0.1	0	0	0.001	0
Gobiidae	12	0.1	0.057	0	5	0.3	0	0	0.005	0
Liza falcipinnis	28	0.2	1.932	0.2	1	0.1	0	0	0.011	0
Clarias liocephalus	7	0	0.284	0	4	0.3	0	0	0.003	0
Clarias sp.	13	0.1	0.017	0	3	0.2	0	0	0.005	0
Pollimyrus castelnaui	7	0	0.038	0	5	0.3	0	0	0.003	0
Labeo sp.	25	0.1	0.046	0	1	0.1	0	0	0.01	0
Barbus thamalakanensis	6	0	0.004	0	2	0.1	0	0	0.003	0
Clarias theodorae	4	0	0.031	0	2	0.1	0	0	0.002	0
Sargochromis sp.	2	0	0.117	0	2	0.1	0	0	0.001	0
Hemigrammoch. multifasciatus	7	0	0.010	0	1	0.1	0	0	0.003	0
Barbus barnardi	2	0	0.003	0	2	0.1	0	0	0.001	0
Pommadasys commersonii	1	0	0.134	0	1	0.1	0	0	0.001	0
Lichia amia	2	0	0.065	0	1	0.1	0	0	0.001	0
Unknown marine species	1	0	0.084	0	1	0.1	0	0	0.001	0
Barbus sp.	1	0	0.007	0	1	0.1	0	0	0.001	0
Cichlidae	1	0	0.003	0	1	0.1	0	0	0.001	0
Serranochromis thumbergi	1	0	0.002	0	1	0.1	0	0	0.001	0
Total	**16959**	**100**	**1122.062**	**100**	**-**	**-**	**1628**	**100**	**3.117**	**0.76**

Table 5.2. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) at all stations combined during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Schilbe intermedius	840	12.2	152.343	17.0	322	22.5	658	29.4	0.257	0.07
Brycinus lateralis	1789	26.1	22.306	2.5	176	12.3	351	15.7	0.35	0.09
Barbus mattozi	499	7.3	83.877	9.4	255	17.8	296	13.2	0.191	0.05
Labeo ansorgii	504	7.3	118.568	13.2	168	11.7	242	10.8	0.192	0.05
Synodontis spp.	846	12.3	36.737	4.1	183	12.8	210	9.4	0.258	0.07
Marcusenius macrolepidotus	569	8.3	27.477	3.1	180	12.6	143	6.4	0.206	0.06
Hepsetus odoe	145	2.1	84.251	9.4	104	7.3	84	3.7	0.082	0.02
Mormyrus lacerda	186	2.7	101.399	11.3	81	5.7	79	3.5	0.098	0.03
Clarias gariepinus	63	0.9	136.886	15.3	51	3.6	58	2.6	0.043	0.01
Micralestes acutidens	367	5.3	2.784	0.3	65	4.5	26	1.1	0.157	0.04
Labeo ruddi	144	2.1	36.578	4.1	59	4.1	25	1.1	0.081	0.02
Hippopotamyrus ansorgii	170	2.5	4.706	0.5	82	5.7	17	0.8	0.092	0.02
Serranochromis macrocephalus	68	1.0	23.308	2.6	54	3.8	14	0.6	0.046	0.01
Petrocephalus catostoma	161	2.3	2.496	0.3	64	4.5	12	0.5	0.088	0.02
Oreochromis macrochir	81	1.2	11.198	1.2	35	2.4	6	0.3	0.052	0.01
Thoracochromis buysi	80	1.2	1.55	0.2	40	2.8	4	0.2	0.052	0.01
Barbus trimaculatus	62	0.9	1.014	0.1	30	2.1	2	0.1	0.043	0.01
Barbus radiatus	57	0.8	0.523	0.1	29	2.0	2	0.1	0.04	0.01
Clarias ngamensis	11	0.2	17.189	1.9	10	0.7	1	0.1	0.01	0
Serranochromis angusticeps	17	0.2	10.002	1.1	15	1.0	1	0.1	0.015	0
Barbus unitaeniatus	44	0.6	0.48	0.1	29	2.0	1	0.1	0.032	0.01
Tilapia rendalli	23	0.3	5.806	0.6	19	1.3	1	0.1	0.019	0.01
Sargochromis coulteri	24	0.3	3.31	0.4	19	1.3	1	0	0.02	0.01
Barbus poechii	32	0.5	0.383	0	21	1.5	1	0	0.025	0.01
Unknown freshwater species	30	0.4	2.849	0.3	11	0.8	1	0	0.024	0.01
Oreochromis andersonii	15	0.2	4.029	0.4	11	0.8	1	0	0.013	0
Barbus paludinosus	6	0.1	0.057	0	6	0.4	0	0	0.006	0
Serranochromis altus	2	0	2.254	0.3	2	0.1	0	0	0.002	0
Mugil cephalus	3	0	0.552	0.1	3	0.2	0	0	0.003	0
Tilapia sparrmanii	3	0	0.173	0	3	0.2	0	0	0.003	0
Thoracochromis albolabris	5	0.1	0.054	0	2	0.1	0	0	0.005	0
Mugilidae	3	0	0.048	0	2	0.1	0	0	0.003	0
Orthochromis machadoi	3	0	0.014	0	2	0.1	0	0	0.003	0
Clarias stappersii	2	0	0.427	0	1	0.1	0	0	0.002	0
Pollimyrus castelnaui	2	0	0.025	0	2	0.1	0	0	0.002	0
Clarias liocephalus	1	0	0.232	0	1	0.1	0	0	0.001	0
Pommadasys commersonii	1	0	0.134	0	1	0.1	0	0	0.001	0
Sargochromis sp.	1	0	0.115	0	1	0.1	0	0	0.001	0
Unknown marine species	1	0	0.084	0	1	0.1	0	0	0.001	0
Gobiidae	1	0	0.019	0	1	0.1	0	0	0.001	0
Barbus eutaenia	1	0	0.005	0	1	0.1	0	0	0.001	0
Total	**6862**	**100**	**896.238**	**100**	**-**	**-**	**2237**	**100**	**2.525**	**0.68**

A total of 896 kg of fish were caught in the gill nets (**table 5.2**). The most important species according to mass was *Schilbe intermedius* (17%), followed by *Clarias gariepinus* (15%), *Labeo ansorgii* (13%), *Mormyrus lacerda* (11%), *Barbus mattozi* (9.4%) and *Hepsetus odoe* (9.4%). These six most important species according to mass constituted 76% (677 kg) of the total mass, but only 31% of the total catch in numbers. The rest of the species constituted less than 5% each in mass.

Brycinus lateralis was by far the most numerous species in the gill net catches (1789 fish, 26%), followed by *Schilbe intermedius* (12%) (**table 5.2**). Three species were caught in approximately the same number, which were *Marcusenius macrolepidotus* (8.3%), *Labeo* *ansorgii* (7.3%) and *Barbus mattozi* (7.3%), followed by *Micralestes acutidens* (5.3%). These six species constituted 66% of the total number and 46% of the total mass of fish caught. The rest of the species constituted less than 3% each of the total number of fish caught.

5.1.3 Catches by other gears than gill nets

Of the total catch during the surveys, 60% (10097 fish) was caught by other gears than gill nets (**table 5.3**). A total of 47 species were identified (excluding the *Synodontis* spp. and the Gobiidae) from 15 different families were recorded in the catches with other gears. Five families were represented in the catches with other gears that were not recorded in gill net catches. These families were Cyprinodontidae (*Aplocheilichthys macrurus*), Kneriidae (*Kneria maydelli*), Amphiliidae (*Leptoglanis rotundiceps*), Distichodontidae (*Hemigrammocharax multifasciatus*) and Carangidae (*Lichia amia*). Haemulidae (*Pomadasys commersonii*) was the only family only sampled in the gill net catches and not by the other gear types.

According to the IRI, the most important species caught with the other gears was *Thoracochromis buysi* (26%), followed by *Mugil cephalus* (marine species, 13%), *Tilapia rendalli* (12%), *Oreochromis macrochir* (11%), *Aplocheilichthys macrurus* (11%) and *Orthochromis machadoi* (8.4%) (**table 5.3**). The contribution of *Mugil cephalus* to the IRI was mainly due to mass (constituting 73% of the total mass caught). These six most important species caught by the other gears according to IRI constituted 81% of the total IRI, 84% of the total mass and 63% of the total number of fish.

The Cyprinidae family was represented by 14 species and the Cichlidae by 10 species. Despite the high diversity of the Cyprinidae, this family constituted only 4.1% of the total IRI, whereas the Cichlidae constituted 60% of the total IRI.

A total of 226 kg of fish were caught by the other gears, while 58% of the catches in numbers constituted 20% of the total mass (**table 5.3**). This implies that a large number of small individuals dominated the catch by the other gears as opposed to the gill nets. *Mugil cephalus* was by far the most important species according to mass (73%), followed by *Oreochromis macrochir* (4.7%), *Tilapia rendalli* (2.9%), *Labeo ansorgii* (2.5%), *Thoracochromis buysi* (2.1%) and *Barbus mattozi* (1.6%). These six most important species according to mass (196 kg) constituted 87% of the total mass, but only 46% of the total catch in numbers. The rest of the species constituted less than 2% each in mass.

Mugil cephalus was the most numerous species (1579 individuals) followed by *Thoracochromis buysi* (1375 individuals), and these species constituted 16 and 14%, respectively, of the number of fish caught by other gears (**table 5.3**). *Aplocheilichthys macrurus* (9.7%), *Orthochromis machadoi* (8.4%), *Oreochromis macrochir* (8.2%) and *Tilapia rendalli* (7.0%) were also important with respect to abundance. These six species constituted 63% of the total number and 84% of the total mass.

Table 5.3. *The relative importance (IRI) of all species caught by other gears at all stations combined during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Thoracochromis buysi	1375	13.6	4.632	2.1	92	63.4	994	25.6	0.271	0.07
Mugil cephalus	1579	15.6	164.899	73.0	8	5.5	489	12.6	0.290	0.07
Tilapia rendalli	706	7.0	6.549	2.9	70	48.3	477	12.3	0.186	0.05
Oreochromis macrochir	829	8.2	10.611	4.7	49	33.8	436	11.2	0.205	0.05
Aplocheilichthys macrurus	983	9.7	0.324	0.1	61	42.1	416	10.7	0.227	0.06
Orthochromis machadoi	844	8.4	1.614	0.7	52	35.9	325	8.4	0.207	0.05
Micralestes acutidens	707	7.0	1.250	0.6	55	37.9	287	7.4	0.186	0.05
Synodontis spp.	489	4.8	6.833	3.0	24	16.6	130	3.4	0.147	0.04
Serranochromis macrocephalus	176	1.7	2.586	1.1	49	33.8	98	2.5	0.071	0.02
Barbus eutaenia	334	3.3	0.889	0.4	21	14.5	54	1.4	0.113	0.03
Labeo ansorgii	88	0.9	5.731	2.5	16	11.0	38	1.0	0.041	0.01
Mesobola brevianalis	371	3.7	0.222	0.1	12	8.3	31	0.8	0.121	0.03
Brycinus lateralis	100	1.0	0.388	0.2	27	18.6	22	0.6	0.046	0.01
Barbus mattozi	50	0.5	3.663	1.6	14	9.7	20	0.5	0.026	0.01
Chiloglanis neumanni	104	1.0	0.098	0	18	12.4	13	0.3	0.047	0.01
Barbus fasciolatus	92	0.9	0.109	0	14	9.7	9	0.2	0.043	0.01
Schilbe intermedius	12	0.1	2.900	1.3	7	4.8	7	0.2	0.008	0
Barbus trimaculatus	65	0.6	0.591	0.3	10	6.9	6	0.2	0.032	0.01
Thoracochromis albolabris	43	0.4	0.451	0.2	12	8.3	5	0.1	0.023	0.01
Hepsetus odoe	9	0.1	2.543	1.1	6	4.1	5	0.1	0.006	0
Mugilidae	645	6.4	1.018	0.5	1	0.7	5	0.1	0.176	0.04
Clarias gariepinus	13	0.1	2.099	0.9	5	3.4	4	0.1	0.009	0
Clariallabes sp.	26	0.3	0.278	0.1	11	7.6	3	0.1	0.015	0
Barbus breviceps	81	0.8	0.170	0.1	2	1.4	1	0	0.039	0.01
Kneria maydelli	82	0.8	0.091	0	2	1.4	1	0	0.039	0.01
Barbus unitaeniatus	26	0.3	0.116	0.1	5	3.4	1	0	0.015	0
Hippopotamyrus ansorgii	14	0.1	0.176	0.1	6	4.1	1	0	0.009	0
Clarias stappersii	9	0.1	0.494	0.2	4	2.8	1	0	0.006	0
Liza falcipinnis	28	0.3	1.932	0.9	1	0.7	1	0	0.016	0
Labeo ruddi	7	0.1	0.351	0.2	5	3.4	1	0	0.005	0
Oreochromis andersonii	43	0.4	0.146	0.1	2	1.4	1	0	0.023	0.01
Barbus radiatus	13	0.1	0.056	0	6	4.1	1	0	0.009	0
Marcusenius macrolepidotus	8	0.1	0.294	0.1	4	2.8	1	0	0.006	0
Tilapia sparrmanii	18	0.2	0.509	0.2	2	1.4	1	0	0.011	0
Leptoglanis rotundiceps	15	0.1	0.003	0	5	3.4	1	0	0.010	0
Barbus paludinosus	15	0.1	0.040	0	4	2.8	0	0	0.010	0
Gobiidae	11	0.1	0.038	0	4	2.8	0	0	0.007	0
Clarias sp.	13	0.1	0.017	0	3	2.1	0	0	0.009	0
Barbus poechii	8	0.1	0.039	0	3	2.1	0	0	0.006	0
Mormyrus lacerda	2	0	0.584	0.3	1	0.7	0	0	0.002	0
Labeo sp.	25	0.2	0.046	0	1	0.7	0	0	0.015	0
Clarias liocephalus	6	0.1	0.052	0	3	2.1	0	0	0.004	0
Pollimyrus castelnaui	5	0	0.013	0	3	2.1	0	0	0.004	0
Barbus thamalakanensis	6	0.1	0.004	0	2	1.4	0	0	0.004	0
Clarias theodorae	4	0	0.031	0	2	1.4	0	0	0.003	0
Clarias ngamensis	1	0	0.210	0.1	1	0.7	0	0	0.001	0
Hemigrammoch. multifasciatus	7	0.1	0.010	0	1	0.7	0	0	0.005	0
Lichia amia	2	0	0.065	0	1	0.7	0	0	0.002	0
Barbus barnardi	2	0	0.003	0	2	1.4	0	0	0.002	0
Serranochromis angusticeps	1	0	0.029	0	1	0.7	0	0	0.001	0
Petrocephalus catostoma	1	0	0.011	0	1	0.7	0	0	0.001	0
Barbus sp.	1	0	0.007	0	1	0.7	0	0	0.001	0
Cichlidae	1	0	0.003	0	1	0.7	0	0	0.001	0
Sargochromis sp.	1	0	0.002	0	1	0.7	0	0	0.001	0
Serranochromis thumbergi	1	0	0.002	0	1	0.7	0	0	0.001	0
Total	**10097**	**100**	**225.824**	**100**	**-**	**-**	**3886**	**100**	**2.764**	**0.69**

5.1.4 Species diversity and evenness

Several smaller species were only sampled by the other gears, resulting in a lower Shannon diversity index (H') for the gill nets (2.5) compared to the other gears (2.8) (**table 5.2 and 5.3**). The diversity index for all gears combined was 3.1 (**table 5.1**). The evenness index (J') was similar for the other gears and the gill nets (0.69, **table 5.2**). The evenness index for all gears combined was higher, with an index of 0.76 (**table 5.1**).

5.1.5 IUCN Red List species and alien species

Neither IUCN Red List species nor alien species were recorded from the Kunene River. However, the newly discovered species from the Kunene River, *Clariallabes* sp., might be included in revised versions of the Red List. *Barbus breviceps* and *Kneria maydelli*, which had very restricted distributions, might also be included in revised versions of the Red List.

5.2 Species diversity in the river versus the river mouth

5.2.1 Stations in the river

This section on stations in the river includes results from all stations except those at the river mouth, which are Foz do Kunene, the lagoon and the river mouth stations. The IRI for the species caught in this section of the river are listed in **table 5.4**, **table 5.5** and **table 5.6**.

5.2.1.1 Catches by all gears

The families Cyprinidae (14 species) and Cichlidae (12 species) dominated the catches with regard to number of species, but they only constituted 25% and 11% of the total IRI (**table 5.4**). The Schilbeidae (one species) and the Characidae (two species) constituted 25% and 14% of the total IRI.

According to the IRI, *Schilbe intermedius* was the most important species (25%) in this section of the river, followed by *Barbus mattozi* (12%), *Labeo ansorgii* (11%) and *Brycinus lateralis* (11%) (**table 5.4**). The remaining species constituted less than 5% each of the total IRI. *Thoracochromis buysi*, an endemic species in the Kunene River, was the fifth most important species with an IRI of 4.6%. The other endemic species, *Orthochromis machadoi, Thoracochromis albolabris, Sargochromis coulteri* and *Kneria maydelli*, all constituted an IRI of less than 0.1% each.

A total of 908 kg of fish were caught with gill nets and other gears (**table 5.4**). The most important species in mass were *Schilbe intermedius* (17%), *Clarias gariepinus* (14%), *Labeo ansorgii* (13%), *Mormyrus lacerda* (10%), *Barbus mattozi* (9.5%) and *Hepsetus odoe* (9.4%). These species constituted 74% of the total mass of all the fish caught.

Table 5.4. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) and other gears at all stations, excluding those in the estuary, during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Schilbe intermedius	838	5.9	151.236	16.6	317	22.7	512	25.0	0.166	0.04
Barbus mattozi	540	3.8	86.511	9.5	262	18.8	250	12.2	0.124	0.03
Brycinus lateralis	1883	13.2	22.626	2.5	201	14.4	226	11.0	0.267	0.07
Labeo ansorgii	582	4.1	122.172	13.4	178	12.8	224	10.9	0.130	0.03
Synodontis spp.	1289	9.0	41.950	4.6	197	14.1	193	9.4	0.217	0.05
Thoracochromis buysi	1418	9.9	5.425	0.6	125	9.0	94	4.6	0.229	0.06
Hepsetus odoe	152	1.1	85.826	9.4	108	7.7	81	4.0	0.048	0.01
Marcusenius macrolepidotus	513	3.6	24.082	2.7	160	11.5	72	3.5	0.120	0.03
Micralestes acutidens	1017	7.1	3.919	0.4	116	8.3	63	3.1	0.188	0.05
Mormyrus lacerda	174	1.2	94.538	10.4	73	5.2	61	3.0	0.054	0.01
Clarias gariepinus	72	0.5	129.027	14.2	52	3.7	55	2.7	0.027	0.01
Oreochromis macrochir	836	5.9	16.299	1.8	73	5.2	40	2.0	0.166	0.04
Serranochromis macrocephalus	242	1.7	25.361	2.8	102	7.3	33	1.6	0.069	0.02
Tilapia rendalli	681	4.8	8.367	0.9	78	5.6	32	1.6	0.145	0.04
Aplocheilichthys macrurus	983	6.9	0.324	0	61	4.4	30	1.5	0.184	0.05
Orthochromis machadoi	847	5.9	1.629	0.2	54	3.9	24	1.2	0.168	0.04
Labeo ruddi	150	1.1	36.736	4.0	63	4.5	23	1.1	0.048	0.01
Hippopotamyrus ansorgii	184	1.3	4.882	0.5	88	6.3	12	0.6	0.056	0.01
Petrocephalus catostoma	162	1.1	2.507	0.3	65	4.7	7	0.3	0.051	0.01
Barbus eutaenia	335	2.3	0.894	0.1	22	1.6	4	0.2	0.088	0.02
Barbus trimaculatus	117	0.8	1.449	0.2	35	2.5	2	0.1	0.039	0.01
Mesobola brevianalis	371	2.6	0.222	0	12	0.9	2	0.1	0.095	0.02
Clarias ngamensis	12	0.1	17.399	1.9	11	0.8	2	0.1	0.006	0
Serranochromis angusticeps	18	0.1	10.031	1.1	16	1.1	1	0.1	0.008	0
Barbus radiatus	70	0.5	0.579	0.1	35	2.5	1	0.1	0.026	0.01
Barbus unitaeniatus	70	0.5	0.596	0.1	34	2.4	1	0.1	0.026	0.01
Chiloglanis neumanni	104	0.7	0.098	0	18	1.3	1	0	0.036	0.01
Sargochromis coulteri	24	0.2	3.310	0.4	19	1.4	1	0	0.011	0
Barbus fasciolatus	89	0.6	0.106	0	13	0.9	1	0	0.032	0.01
Barbus poechii	40	0.3	0.422	0	24	1.7	1	0	0.016	0
Unknown freshwater species	30	0.2	2.849	0.3	11	0.8	0	0	0.013	0
Thoracochromis albolabris	48	0.3	0.505	0.1	14	1.0	0	0	0.019	0
Oreochromis andersonii	51	0.4	1.553	0.2	8	0.6	0	0	0.020	0.01
Clariallabes sp.	26	0.2	0.278	0	11	0.8	0	0	0.011	0
Barbus paludinosus	21	0.1	0.097	0	10	0.7	0	0	0.010	0
Barbus breviceps	81	0.6	0.170	0	2	0.1	0	0	0.029	0.01
Kneria maydelli	82	0.6	0.091	0	2	0.1	0	0	0.030	0.01
Tilapia sparrmanii	21	0.1	0.682	0.1	5	0.4	0	0	0.010	0
Clarias stappersii	11	0.1	0.921	0.1	5	0.4	0	0	0.006	0
Leptoglanis rotundiceps	15	0.1	0.003	0	5	0.4	0	0	0.007	0
Serranochromis altus	2	0	2.254	0.2	2	0.1	0	0	0.001	0
Clarias liocephalus	7	0	0.284	0	4	0.3	0	0	0.004	0
Clarias sp.	13	0.1	0.017	0	3	0.2	0	0	0.006	0
Labeo sp.	25	0.2	0.046	0	1	0.1	0	0	0.011	0
Pollimyrus castelnaui	6	0	0.018	0	4	0.3	0	0	0.003	0
Barbus thamalakanensis	6	0	0.004	0	2	0.1	0	0	0.003	0
Clarias theodorae	4	0	0.031	0	2	0.1	0	0	0.002	0
Sargochromis sp.	2	0	0.117	0	2	0.1	0	0	0.001	0
Hemigrammoch. multifasciatus	7	0	0.010	0	1	0.1	0	0	0.004	0
Cichlidae	1	0	0.003	0	1	0.1	0	0	0.001	0
Barbus barnardi	1	0	0.003	0	1	0.1	0	0	0.001	0
Serranochromis thumbergi	1	0	0.002	0	1	0.1	0	0	0.001	0
Total	**14274**	**100**	**908.459**	**100**	**-**	**-**	**2050**	**100**	**3.035**	**0.76**

A total number of 14274 fish were caught during the surveys with gill nets and other gears (**table 5.4**). The most important species in number was *Brycinus lateralis* (13%), followed by *Thoracochromis buysi* (9.9%), *Aplocheilichthys macrurus* (6.9%), *Orthochromis machadoi* (5.9%), *Oreochromis macrochir* (5.9%) and *Schilbe intermedius* (5.9%). These species constituted 48% of the total number of fish recorded. Two of these species, *Thoracochromis buysi* and *Orthochromis machadoi,* are endemic to the Kunene River.

According to the IRI, *Barbus mattozi* was the most important cyprinid (12%), while *Labeo ansorgii* was the most important cyprinid in number (4.1%) and in mass (13%). *Thoracochromis buysi* was the most important cichlid with regard to IRI (4.6%) and number (9.9%). *Serranochromis macrocephalus* was the most important cichlid in mass (2.8%).

Several species can be listed as not common in this section of the river, with less than 10 individuals sampled during the surveys (**table 5.4**). These were *Serranochromis altus, Clarias liocephalus, Pollimyrus castelnaui, Barbus thamalakanensis, Clarias theodorae, Hemigrammocharax multifasciatus, Barbus barnardi* and *Serranochromis thumbergi*.

5.2.1.2 Catches in gill nets

Forty-seven percent (6644 fish) of the total catch was caught in the gill nets (**table 5.5**). Eight fish families were recorded in the catches. The Cichlidae (11 species) and the Cyprinidae (9 species) dominated the catches with regard to number of species. The Schilbeidae (1 species) and the Cyprinidae (9 species) constituted 30% and 26% of the total IRI, respectively. Despite the fact that the Cichlidae was the most diverse family with 11 species, this family only constituted 1.0% of the total IRI.

According to the IRI, the most important species caught in the gill nets was *Schilbe intermedius* (30%), followed by *Brycinus lateralis* (17%), *Barbus mattozi* (14%), *Labeo ansorgii* (11%), *Marcusenius macrolepidotus* (5.2%) and *Hepsetus odoe* (3.9%) (**table 5.5**). These species constituted 80% of the total IRI, 56% of the total mass and 64% of the total number of fish caught. The rest of the species constituted less than 4% each of the total IRI. In the gill nets catches, 10 species could be listed as not common, with less than 10 individuals caught of each species.

A total of 857 kg of fish were caught in the gill nets. The most important species according to mass was *Schilbe intermedius* (17%), followed by *Clarias gariepinus* (15%), *Labeo ansorgii* (14%), *Mormyrus lacerda* (11%), *Hepsetus odoe* (9.7%) and *Barbus mattozi* (9.7%) (**table 5.5**). These six species constituted 76% of the total mass, but only 31% of the total number of fish caught. The remaining species constituted less than 5% each in mass.

Brycinus lateralis was by far the most numerous species in the gill net catches (1787 fish, 27%), followed by *Schilbe intermedius* (12%), *Marcusenius macrolepidotus* (7.6%), *Labeo ansorgii* (7.5%), *Barbus mattozi* (7.4%) and *Micralestes acutidens* (5.5%) (**table 5.5**). These six species constituted 67% of the total number of fish caught and 46% of the total mass. The remaining species constituted less than 3% each of the total number of fish caught.

Table 5.5. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) at all stations, excluding those in the estuary, during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Schilbe intermedius	827	12.4	148.730	17.3	311	24.7	735	29.7	0.259	0.07
Brycinus lateralis	1787	26.9	22.270	2.6	175	13.9	410	16.6	0.353	0.1
Barbus mattozi	493	7.4	83.010	9.7	249	19.8	338	13.7	0.193	0.05
Labeo ansorgii	498	7.5	116.803	13.6	164	13.0	275	11.1	0.194	0.05
Synodontis spp.	802	12.1	35.240	4.1	174	13.8	223	9.0	0.255	0.07
Marcusenius macrolepidotus	506	7.6	23.834	2.8	157	12.5	130	5.2	0.196	0.05
Hepsetus odoe	143	2.2	83.283	9.7	102	8.1	96	3.9	0.083	0.02
Mormyrus lacerda	172	2.6	93.954	11	72	5.7	77	3.1	0.095	0.03
Clarias gariepinus	59	0.9	126.929	14.8	47	3.7	59	2.4	0.042	0.01
Labeo ruddi	144	2.2	36.578	4.3	59	4.7	30	1.2	0.083	0.02
Micralestes acutidens	364	5.5	2.773	0.3	64	5.1	29	1.2	0.159	0.04
Hippopotamyrus ansorgii	170	2.6	4.706	0.5	82	6.5	20	0.8	0.094	0.03
Serranochromis macrocephalus	66	1.0	22.776	2.7	53	4.2	15	0.6	0.046	0.01
Petrocephalus catostoma	161	2.4	2.496	0.3	64	5.1	14	0.6	0.090	0.02
Oreochromis macrochir	57	0.9	8.181	1.0	29	2.3	4	0.2	0.041	0.01
Thoracochromis buysi	74	1.1	1.212	0.1	37	2.9	4	0.1	0.050	0.01
Barbus radiatus	57	0.9	0.523	0.1	29	2.3	2	0.1	0.041	0.01
Barbus trimaculatus	58	0.9	0.912	0.1	27	2.1	2	0.1	0.041	0.01
Clarias ngamensis	11	0.2	17.189	2.0	10	0.8	2	0.1	0.011	0
Serranochromis angusticeps	17	0.3	10.002	1.2	15	1.2	2	0.1	0.015	0
Barbus unitaeniatus	44	0.7	0.480	0.1	29	2.3	2	0.1	0.033	0.01
Sargochromis coulteri	24	0.4	3.310	0.4	19	1.5	1	0	0.020	0.01
Barbus poechii	32	0.5	0.383	0	21	1.7	1	0	0.026	0.01
Tilapia rendalli	15	0.2	4.168	0.5	13	1.0	1	0	0.014	0
Unknown freshwater species	30	0.5	2.849	0.3	11	0.9	1	0	0.024	0.01
Oreochromis andersonii	8	0.1	1.407	0.2	6	0.5	0	0	0.008	0
Serranochromis altus	2	0	2.254	0.3	2	0.2	0	0	0.002	0
Barbus paludinosus	6	0.1	0.057	0	6	0.5	0	0	0.006	0
Tilapia sparrmanii	3	0	0.173	0	3	0.2	0	0	0.003	0
Thoracochromis albolabris	5	0.1	0.054	0	2	0.2	0	0	0.005	0
Orthochromis machadoi	3	0	0.014	0	2	0.2	0	0	0.003	0
Clarias stappersii	2	0	0.427	0	1	0.1	0	0	0.002	0
Clarias liocephalus	1	0	0.232	0	1	0.1	0	0	0.001	0
Sargochromis spp.	1	0	0.115	0	1	0.1	0	0	0.001	0
Pollimyrus castelnaui	1	0	0.005	0	1	0.1	0	0	0.001	0
Barbus eutaenia	1	0	0.005	0	1	0.1	0	0	0.001	0
Total	**6644**	**100**	**857.331**	**100**	**-**	**-**	**2473**	**100**	**2.496**	**0.69**

5.2.1.3 Catches by other gears than gill nets

A total number of 7630 fish was caught by other gears than gill nets, constituting 53% of the total number of fish caught during the surveys (**table 5.6**). A total of 44 species from 12 families were identified. Four families were represented in the catches with the other gears that were not present in the gill net catches. These were the families Cyprinodontidae, Kneriidae, Amphiliidae and Distichodontidae. All families represented in the gill net catches were also represented in the catches with other gears.

Table 5.6. *The relative importance (IRI) of all species caught by other gears at all stations, excluding those in the estuary, during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Thoracochromis buysi	1344	17.6	4.213	8.2	88	65.7	1698	27.9	0.306	0.08
Oreochromis macrochir	779	10.2	8.117	15.9	44	32.8	856	14.1	0.233	0.06
Tilapia rendalli	666	8.7	4.199	8.2	65	48.5	822	13.5	0.213	0.05
Aplocheilichthys macrurus	983	12.9	0.324	0.6	61	45.5	615	10.1	0.264	0.07
Orthochromis machadoi	844	11.1	1.614	3.2	52	38.8	552	9.1	0.244	0.06
Micralestes acutidens	653	8.6	1.145	2.2	52	38.8	419	6.9	0.210	0.05
Synodontis spp.	487	6.4	6.709	13.1	23	17.2	335	5.5	0.176	0.05
Serranochromis macrocephalus	176	2.3	2.586	5.1	49	36.6	269	4.4	0.087	0.02
Labeo ansorgii	84	1.1	5.370	10.5	14	10.4	121	2.0	0.050	0.01
Barbus eutaenia	334	4.4	0.889	1.7	21	15.7	96	1.6	0.137	0.04
Barbus mattozi	47	0.6	3.502	6.8	13	9.7	72	1.2	0.031	0.01
Mesobola brevianalis	371	4.9	0.222	0.4	12	9.0	47	0.8	0.147	0.04
Brycinus lateralis	96	1.3	0.356	0.7	26	19.4	38	0.6	0.055	0.01
Hepsetus odoe	9	0.1	2.543	5.0	6	4.5	23	0.4	0.008	0
Schilbe intermedius	11	0.1	2.506	4.9	6	4.5	23	0.4	0.009	0
Chiloglanis neumanni	104	1.4	0.098	0.2	18	13.4	21	0.3	0.059	0.02
Clarias gariepinus	13	0.2	2.099	4.1	5	3.7	16	0.3	0.011	0
Barbus fasciolatus	89	1.2	0.106	0.2	13	9.7	13	0.2	0.052	0.01
Thoracochromis albolabris	43	0.6	0.451	0.9	12	9.0	13	0.2	0.029	0.01
Barbus trimaculatus	59	0.8	0.537	1.0	8	6.0	11	0.2	0.038	0.01
Clariallabes sp.	26	0.3	0.278	0.5	11	8.2	7	0.1	0.019	0
Clarias stappersii	9	0.1	0.494	1.0	4	3.0	3	0.1	0.008	0
Hippopotamyrus ansorgii	14	0.2	0.176	0.3	6	4.5	2	0	0.012	0
Barbus unitaeniatus	26	0.3	0.116	0.2	5	3.7	2	0	0.019	0
Barbus breviceps	81	1.1	0.170	0.3	2	1.5	2	0	0.048	0.01
Kneria maydelli	82	1.1	0.091	0.2	2	1.5	2	0	0.049	0.01
Tilapia sparrmanii	18	0.2	0.509	1.0	2	1.5	2	0	0.014	0
Marcusenius macrolepidotus	7	0.1	0.247	0.5	3	2.2	1	0	0.006	0
Oreochromis andersonii	43	0.6	0.146	0.3	2	1.5	1	0	0.029	0.01
Barbus radiatus	13	0.2	0.056	0.1	6	4.5	1	0	0.011	0
Labeo ruddi	6	0.1	0.158	0.3	4	3.0	1	0	0.006	0
Mormyrus lacerda	2	0	0.584	1.1	1	0.7	1	0	0.002	0
Barbus paludinosus	15	0.2	0.040	0.1	4	3.0	1	0	0.012	0
Leptoglanis rotundiceps	15	0.2	0.003	0	5	3.7	1	0	0.012	0
Clarias sp.	13	0.2	0.017	0	3	2.2	0	0	0.011	0
Barbus poechii	8	0.1	0.039	0.1	3	2.2	0	0	0.007	0
Clarias liocephalus	6	0.1	0.052	0.1	3	2.2	0	0	0.006	0
Clarias ngamensis	1	0	0.210	0.4	1	0.7	0	0	0.001	0
Labeo sp.	25	0.3	0.046	0.1	1	0.7	0	0	0.019	0
Pollimyrus castelnaui	5	0.1	0.013	0	3	2.2	0	0	0.005	0
Clarias theodorae	4	0.1	0.031	0.1	2	1.5	0	0	0.004	0
Barbus thamalakanensis	6	0.1	0.004	0	2	1.5	0	0	0.006	0
Hemigrammoch. multifasciatus	7	0.1	0.010	0	1	0.7	0	0	0.006	0
Serranochromis angusticeps	1	0	0.029	0.1	1	0.7	0	0	0.001	0
Petrocephalus catostoma	1	0	0.011	0	1	0.7	0	0	0.001	0
Cichlidae	1	0	0.003	0	1	0.7	0	0	0.001	0
Barbus barnardi	1	0	0.003	0	1	0.7	0	0	0.001	0
Sargochromis sp.	1	0	0.002	0	1	0.7	0	0	0.001	0
Serranochromis thumbergi	1	0	0.002	0	1	0.7	0	0	0.001	0
Total	**7630**	**100**	**51.128**	**100**	**-**	**-**	**6091**	**100**	**2.677**	**0.69**

According to the IRI, the most important species caught with the other gears was *Thoracochromis buysi* (28%), followed by *Oreochromis macrochir* (14%), *Tilapia rendalli* (14%), *Aplocheilichthys macrurus* (10%), *Orthochromis machadoi* (9.1%) and *Micralestes acutidens* (6.9%) (**table 5.6**). These six species constituted 82% of the total IRI, 38% of the total mass and 69% of the total number of fish caught.

The Cyprinidae was represented by 14 species and the Cichlidae by 10 species. Despite the high diversity of the Cyprinidae, this family constituted only 6.0% of the total IRI, whereas the Cichlidae constituted 69% of the total IRI.

A total of 51 kg of fish were caught by the other gears, which means that 52% of the catches in numbers constituted only 6% of the total mass sampled (**table 5.6**). This implies that a large number of small individuals dominated the catch by the other gears as opposed to the gill nets. The most important species according to mass was *Oreochromis macrochir* (16%), followed by *Labeo ansorgii* (11%), *Thoracochromis buysi* (8.2%), *Tilapia rendalli* (8.2%), *Barbus mattozi* (6.8%) and *Serranochromis macrocephalus* (5.1%). These six species constituted 55% of the total mass (28 kg) and 41% of the total catch in numbers. The remaining species constituted less than 5% each in mass.

Thoracochromis buysi was the most numerous species (1344 individuals) and constituted 18% of the total catch with the other gears, followed by *Aplocheilichthys macrurus* (13%), *Orthochromis machadoi* (11%), *Oreochromis macrochir* (10%), *Tilapia rendalli* (8.7%) and *Micralestes acutidens* (8.6%) (**table 5.6**). These six species constituted 69% of the total number of fish caught and 38% of the total mass. The remaining species constituted less than 5% each of the total number of fish caught.

5.2.1.4 Species diversity and evenness

Several smaller species were only sampled by the other gears, resulting in a lower Shannon diversity index (H') for the gill nets (2.4) compared to the other gears (2.7) (**table 5.5, table 5.6**). The diversity index (H') for all gears combined was 3.0 (**table 5.4**). The species composition in the catches by other gears was similar to the catches in the gill nets (0.69) (**table 5.5, table 5.6**). The evenness index for all gears combined was higher, with a value of 0.76 (**table 5.4**).

5.2.2 Stations in the river mouth

This section includes all stations in the river mouth, which are Foz do Kunene, the Lagoon and the River Mouth stations. The IRI for the species caught in this section of the river is listed in **table 5.7**, **table 5.8** and **table 5.9**.

5.2.2.1 Catches by all gears

The families Cyprinidae (6 species) and Cichlidae (5 species) dominated the catches with regard to number of species, but they only constituted 0.8% and 6.1% of the total IRI (**table 5.7**). The marine family Mugilidae, was represented by only two species and constituted 82% of the total IRI.

According to the IRI, *Mugil cephalus* (78%) was the most important species in the river mouth, followed by *Marcusenius macrolepidotus* (5.1%), *Oreochromis macrochir* (3.0%) and *Tilapia rendalli* (2.1%) (**table 5.7**). The remaining species constituted less than 2% each of the total IRI. *Thoracochromis buysi* was the only endemic species recorded in the river mouth, constituting only 0.6% of the total IRI.

A total of 214 kg of fish were caught during the surveys in the river mouth with gill nets and other gears (**table 5.7**). The most important species in mass was *Mugil cephalus* (78%), followed by *Clarias gariepinus* (4.7%), *Mormyrus lacerda* (3.5%), *Oreochromis macrochir* (2.6%), *Schilbe intermedius* (1.9%) and *Tilapia rendalli* (1.9%). These species constituted 92% of the total mass of the fish caught.

A total number of 2685 fish were caught during the surveys with gill nets and other gears (**table 5.7**). The most important species in number of fish caught was *Mugil cephalus* (59%), followed by *Oreochromis macrochir* (2.8%), *Marcusenius macrolepidotus* (2.4%), *Tilapia rendalli* (1.8%), *Thoracochromis buysi* (1.4%) and *Mormyrus lacerda* (0.5%). These six species constituted 68% of the total number of fish sampled.

According to the IRI, *Labeo ansorgii* was the most important cyprinid (0.4%), and was also the most important in mass (1.0%) and in number together with *Barbus trimaculatus* (0.4%) (**table 5.7**). *Oreochromis macrochir* was the most important cichlid according to IRI (3.0%), number of fish caught (2.8%) and mass (2.6%).

Only one individual was collected from several species in this section of the river (**table 5.7**). These were *Labeo ruddi, Pommadasys commersonii, Pollimyrus castelnaui* and *Barbus barnardi*.

5.2.2.2. Catches in gill nets

Only 8% (218 fish) of the total catch in the river mouth was caught in the gill nets (**table 5.8**). Altogether 11 families were recorded. The Cichlidae had the highest number of species in the gill net catches (5 species). The Mormyridae (3 species) and the Cichlidae (5 species) constituted 58% and 12% of the total IRI, respectively.

According to the IRI, the most important species caught in the gill nets was *Marcusenius macrolepidotus* (46%), followed by *Mormyrus lacerda* (12%), *Schilbe intermedius* (8.8%), *Clarias gariepinus* (5.7%), *Oreochromis macrochir* (5.9%) and *Oreochromis andersonii* (2.6%) (**table 5.8**). These species constituted 81% of the total IRI, 78% of the total mass and 57% of the total number of fish caught. The remaining species constituted less than 3% each of the total IRI. Two identified species were represented with only one individual each.

Table 5.7. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) and other gears at the stations in the estuary during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Mugil cephalus	1582	58.9	165.451	77.5	11	6.0	824	77.7	0.312	0.09
Marcusenius macrolepidotus	64	2.4	3.690	1.7	24	13.2	54	5.1	0.089	0.03
Mugilidae	648	24.1	1.066	0.5	3	1.6	41	3.8	0.343	0.1
Oreochromis macrochir	74	2.8	5.510	2.6	11	6.0	32	3.0	0.099	0.03
Tilapia rendalli	48	1.8	3.988	1.9	11	6.0	22	2.1	0.072	0.02
Mormyrus lacerda	14	0.5	7.445	3.5	9	4.9	20	1.9	0.027	0.01
Schilbe intermedius	14	0.5	4.008	1.9	12	6.6	16	1.5	0.027	0.01
Synodontis spp.	46	1.7	1.620	0.8	10	5.5	14	1.3	0.070	0.02
Clarias gariepinus	4	0.1	9.958	4.7	4	2.2	11	1.0	0.010	0
Thoracochromis buysi	37	1.4	0.757	0.4	7	3.8	7	0.6	0.059	0.02
Micralestes acutidens	57	2.1	0.115	0.1	4	2.2	5	0.5	0.082	0.02
Labeo ansorgii	10	0.4	2.127	1.0	6	3.3	5	0.4	0.021	0.01
Oreochromis andersonii	7	0.3	2.622	1.2	5	2.7	4	0.4	0.016	0
Barbus mattozi	9	0.3	1.029	0.5	7	3.8	3	0.3	0.019	0.01
Gobiidae	12	0.4	0.057	0	5	2.7	1	0.1	0.024	0.01
Barbus trimaculatus	10	0.4	0.156	0.1	5	2.7	1	0.1	0.021	0.01
Liza falcipinnis	28	1.0	1.932	0.9	1	0.5	1	0.1	0.048	0.01
Hepsetus odoe	2	0.1	0.968	0.5	2	1.1	1	0.1	0.005	0
Brycinus lateralis	6	0.2	0.068	0	2	1.1	0	0	0.014	0
Serranochromis macrocephalus	2	0.1	0.532	0.2	1	0.5	0	0	0.005	0
Labeo ruddi	1	0	0.193	0.1	1	0.5	0	0	0.003	0
Barbus fasciolatus	3	0.1	0.002	0	1	0.5	0	0	0.008	0
Lichia amia	2	0.1	0.065	0	1	0.5	0	0	0.005	0
Pommadasys commersonii	1	0	0.134	0.1	1	0.5	0	0	0.003	0
Unknown marine species	1	0	0.084	0	1	0.5	0	0	0.003	0
Pollimyrus castelnaui	1	0	0.020	0	1	0.5	0	0	0.003	0
Barbus sp.	1	0	0.007	0	1	0.5	0	0	0.003	0
Barbus barnardi	1	0	0.001	0	1	0.5	0	0	0.003	0
Total	**2685**	**100**	**213.603**	**100**	**-**	**-**	**1061**	**100**	**1.393**	**0.41**

A total of 39 kg of fish were caught in the gill nets (**table 5.8**). The most important species according to mass was *Clarias gariepinus* (26%), followed by *Mormyrus lacerda* (19%), *Marcusenius macrolepidotus* (9.4%), *Schilbe intermedius* (9.3%), *Oreochromis macrochir* (7.8%) and *Oreochromis andersonii* (6.7%). These six species constituted 78% (30 kg) of the total mass and 40% of the total number of fish caught. The remaining species constituted less than 5% each in mass.

Marcusenius macrolepidotus was the most numerous species in the gill net catches in the river mouth (29%), followed by *Oreochromis macrochir* (11%), *Mormyrus lacerda* (6.4%), *Schilbe intermedius* (6.0%), *Tilapia rendalli* (3.7%) and *Oreochromis andersonii* (3.2%) (**table 5.8**). These species constituted 59% of the total number of fish caught and 57% of the total mass. The remaining species constituted less than 2% each of the total number caught.

Table 5.8. *The relative importance (IRI) of all species caught by multi-filament gill nets (22-150 mm) at the stations in the estuary during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Marcusenius macrolepidotus	63	28.9	3.643	9.4	23	13.5	515	46.0	0.359	0.11
Mormyrus lacerda	14	6.4	7.445	19.1	9	5.3	135	12.0	0.176	0.06
Synodontis spp.	44	20.2	1.496	3.8	9	5.3	126	11.3	0.323	0.1
Schilbe intermedius	13	6.0	3.613	9.3	11	6.4	98	8.8	0.168	0.05
Oreochromis macrochir	24	11.0	3.016	7.8	6	3.5	66	5.9	0.243	0.08
Clarias gariepinus	4	1.8	9.958	25.6	4	2.3	64	5.7	0.073	0.02
Oreochromis andersonii	7	3.2	2.622	6.7	5	2.9	29	2.6	0.110	0.04
Tilapia rendalli	8	3.7	1.638	4.2	6	3.5	28	2.5	0.121	0.04
Barbus mattozi	6	2.8	0.867	2.2	6	3.5	17	1.6	0.099	0.03
Labeo ansorgii	6	2.8	1.765	4.5	4	2.3	17	1.5	0.099	0.03
Thoracochromis buysi	6	2.8	0.338	0.9	3	1.8	6	0.6	0.099	0.03
Mugil cephalus	3	1.4	0.552	1.4	3	1.8	5	0.4	0.059	0.02
Hepsetus odoe	2	0.9	0.968	2.5	2	1.2	4	0.4	0.043	0.01
Barbus trimaculatus	4	1.8	0.102	0.3	3	1.8	4	0.3	0.073	0.02
Mugilidae	3	1.4	0.048	0.1	2	1.2	2	0.2	0.059	0.02
Serranochromis macrocephalus	2	0.9	0.532	1.4	1	0.6	1	0.1	0.043	0.01
Micralestes acutidens	3	1.4	0.010	0	1	0.6	1	0.1	0.059	0.02
Brycinus lateralis	2	0.9	0.036	0.1	1	0.6	1	0.1	0.043	0.01
Pommadasys commersonii	1	0.5	0.134	0.3	1	0.6	0	0	0.025	0.01
Unknown marine species	1	0.5	0.084	0.2	1	0.6	0	0	0.025	0.01
Pollimyrus castelnaui	1	0.5	0.020	0.1	1	0.6	0	0	0.025	0.01
Gobiidae	1	0.5	0.019	0	1	0.6	0	0	0.025	0.01
Total	**218**	**100**	**38.907**	**100**	**-**	**-**	**1120**	**100**	**2.349**	**0.75**

5.2.2.3 Catches by other gears than gill nets

A total number of 2467 fish were caught by the other gears, and constituted 89% of the total number of fish caught in the river mouth (**table 5.9**). A total of 16 species from nine families were identified in the catches by other gears. Only one family (Carangidae) was represented in the catches by other gears that was not represented in the gill net catches. Two families (Hepsetidae and Pomadasysidae) were represented in the gill net catches and not in the catches by other gears.

According to the IRI, the most important species caught with the other gears was *Mugil cephalus* (94%), followed by *Oreochromis macrochir* (1.3%), *Tilapia rendalli* (1.1%), *Micralestes acutidens* (0.5%), *Thoracochromis buysi* (0.4%) and *Liza falcipinnis* (0.2%) (**table 5.9**). These species constituted 98% of the total IRI, 99% of the total mass and 72% of the total number of fish caught.

The Cyprinidae had the highest species diversity with six species recorded in the catches, but constituted only 0.1% of the total IRI (**table 5.9**). Mugilidae was only represented by two species, but constituted 96% of the total IRI.

A total of 175 kg of fish were caught by the other gears, which means that 89% of the catches in numbers constituted 82% of the total mass sampled (**table 5.9**). The marine species dominated the catch in mass, constituting 96% of the total catch. The most important species according to mass was *Mugil cephalus* (94%), followed by *Oreochromis* *macrochir* (1.4%), *Tilapia rendalli* (1.3%), *Liza falcipinnis* (1.1%), *Thoracochromis buysi* (0.2%) and *Schilbe intermedius* (0.2%). According to mass, these species constituted 99% (172 kg) of the total mass and 70% of the total number of fish caught. The remaining species constituted less than 0.2% each in mass.

Mugil cephalus was the most numerous species (1579 individuals) and constituted 64% of the total catch with the other gears, followed by *Micralestes acutidens* (2.2%), *Oreochromis macrochir* (2.0%), *Tilapia rendalli* (1.6%), *Thoracochromis buysi* (1.3%) and *Liza falcipinnis* (1.1%) (**table 5.9**). These species constituted 72% of the total number of fish caught and 9% of the total mass. The remaining species constituted less than 0.5% each of the total number of fish caught. The marine species dominated the catch in number, constituting 92% of the total catch.

Table 5.9. *The relative importance (IRI) of all species caught by other gears at the stations in the estuary during surveys in the Kunene River during 1994-2004. The IRI takes into account the number of individuals (No), mass (W) and frequency of occurrence (Frq) of the individuals caught. Values are given in absolute values and as percentage of total catch. The contribution of each species to the Shannon index of diversity (H') and the index of evenness (J') is also given.*

Species	No	%No	W (kg)	%W	Frq	%Frq	IRI	%IRI	H'	J'
Mugil cephalus	1579	64.0	164.899	94.4	8	72.7	11520	94.2	0.286	0.10
Mugilidae	645	26.1	1.018	0.6	1	9.1	243	2.0	0.351	0.12
Oreochromis macrochir	50	2.0	2.494	1.4	5	45.5	157	1.3	0.079	0.03
Tilapia rendalli	40	1.6	2.350	1.3	5	45.5	135	1.1	0.067	0.02
Micralestes acutidens	54	2.2	0.105	0.1	3	27.3	61	0.5	0.084	0.03
Thoracochromis buysi	31	1.3	0.419	0.2	4	36.4	54	0.4	0.055	0.02
Liza falcipinnis	28	1.1	1.932	1.1	1	9.1	20	0.2	0.051	0.02
Gobiidae	11	0.4	0.038	0	4	36.4	17	0.1	0.024	0.01
Labeo ansorgii	4	0.2	0.362	0.2	2	18.2	7	0.1	0.010	0
Barbus trimaculatus	6	0.2	0.054	0	2	18.2	5	0	0.015	0
Schilbe intermedius	1	0	0.394	0.2	1	9.1	2	0	0.003	0
Barbus mattozi	3	0.1	0.161	0.1	1	9.1	2	0	0.008	0
Brycinus lateralis	4	0.2	0.031	0	1	9.1	2	0	0.010	0
Synodontis spp.	2	0.1	0.124	0.1	1	9.1	1	0	0.006	0
Labeo ruddi	1	0	0.193	0.1	1	9.1	1	0	0.003	0
Barbus fasciolatus	3	0.1	0.002	0	1	9.1	1	0	0.008	0
Lichia amia	2	0.1	0.065	0	1	9.1	1	0	0.006	0
Marcusenius macrolepidotus	1	0	0.046	0	1	9.1	1	0	0.003	0
Barbus sp.	1	0	0.007	0	1	9.1	0	0	0.003	0
Barbus barnardi	1	0	0.001	0	1	9.1	0	0	0.003	0
Total	**2467**	**100**	**174.695**	**100**	**-**	**-**	**12232**	**100**	**1.075**	**0.36**

5.2.2.4 Species diversity and evenness

The Shannon diversity index (H') was higher for the gill nets (2.3) than for the other gears (1.1) (**table 5.8, table 5.9**). The diversity index for all gears combined was 1.4 (**table 5.7**). The evenness index (J') also differed between the gill nets (0.75) and the other gears (0.36) (**table 5.8, table 5.9**). The evenness index for all gears combined was 0.41 (**table 5.7**).

5.3 Body length distribution, life history and gill net selectivity

5.3.1 Body length distribution in gill nets and other gears

The body length distribution was significantly different between fish caught with gill nets and with other gears, as a wider range of body length classes were caught in the gill nets (**figure 5.1, figure 5.2**). Fish with body lengths from 1.2 to 102.5 cm were caught in the gill nets, whereas fish with body lengths from 0.5 to 55.6 cm were caught with the other gears (**figure 5.1**). The mean body length was also larger for fish caught with gill nets (17.1 cm) than with the other gears (6.6 cm). Modal length was 9.0-9.9 for the gill net catches and 3.0-3.9 cm for the other gears.

5.3.2 Body length at maturity

The minimum length at maturity varied among species and sexes. The species with the smallest minimum size at maturity was *Thoracochromis buysi* for males (minimum length at maturity of 6.8 cm) and *Micralestes acutidens* for females (minimum length at maturity of 6.5 cm). The species with the largest minimum size at maturity was *Hepsetus odoe* for males (minimum length at maturity of 27.0 cm) and *Mormyrus lacerda* for females (minimum length at maturity of 28.5 cm).

5.3.3 Life history and gill net selectivity

A total of 50 species were identified in the survey catches, of which 35 species were caught in the gill nets and 47 species in the other gears. These species represent large variation in biology, distribution and body sizes. Aspects of the life history and gill net selectivity of 14 of the most important freshwater species are analyzed in detail in the following section.

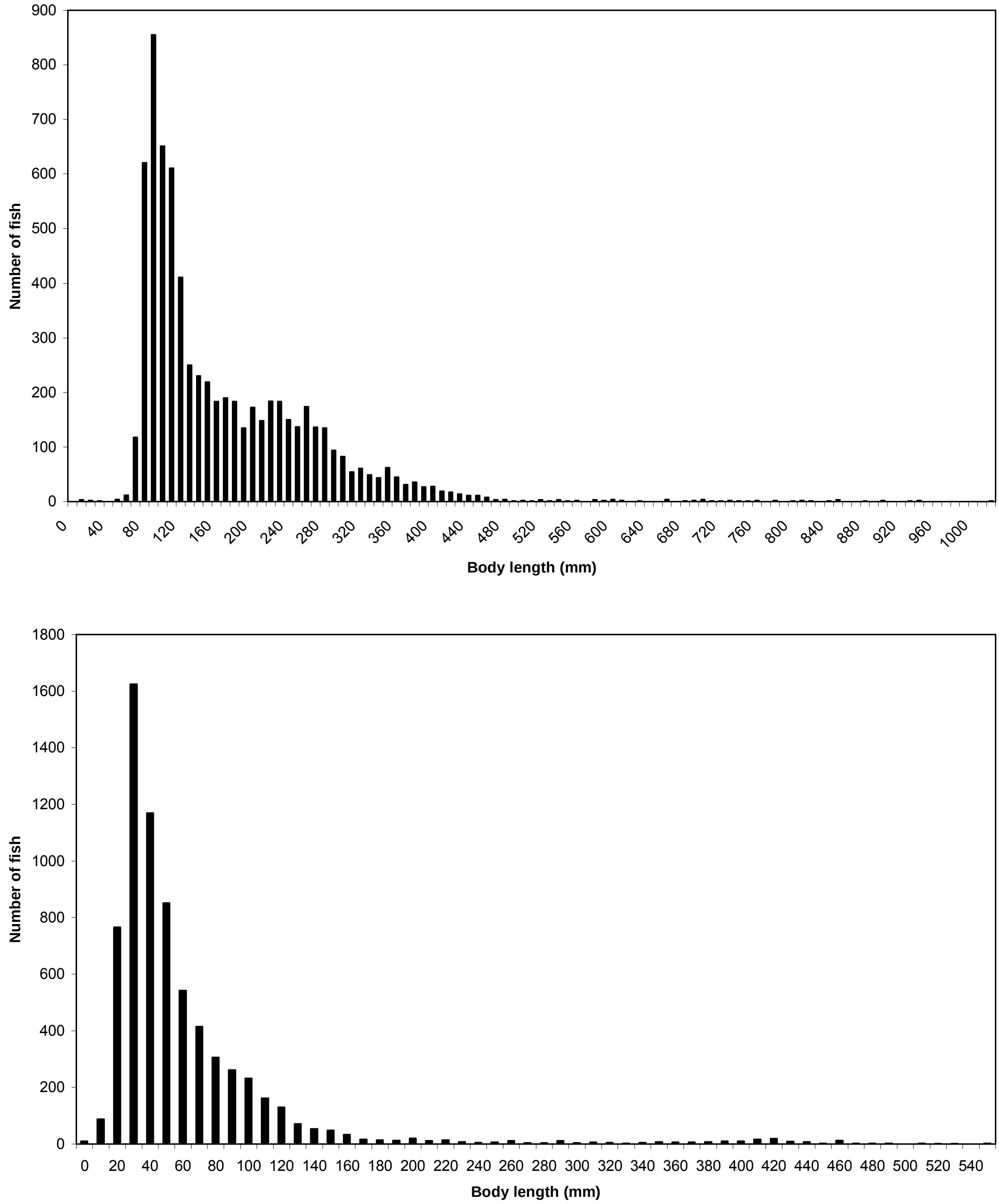

Figure 5.1 *Length distribution of all fish caught with 22-150 mm mesh size gill nets (upper panel, n = 6862) and other gears (lower panel, n = 7054) during surveys in the Kunene River during 1994-2004. Note the different scales on the x- and y-axes.*

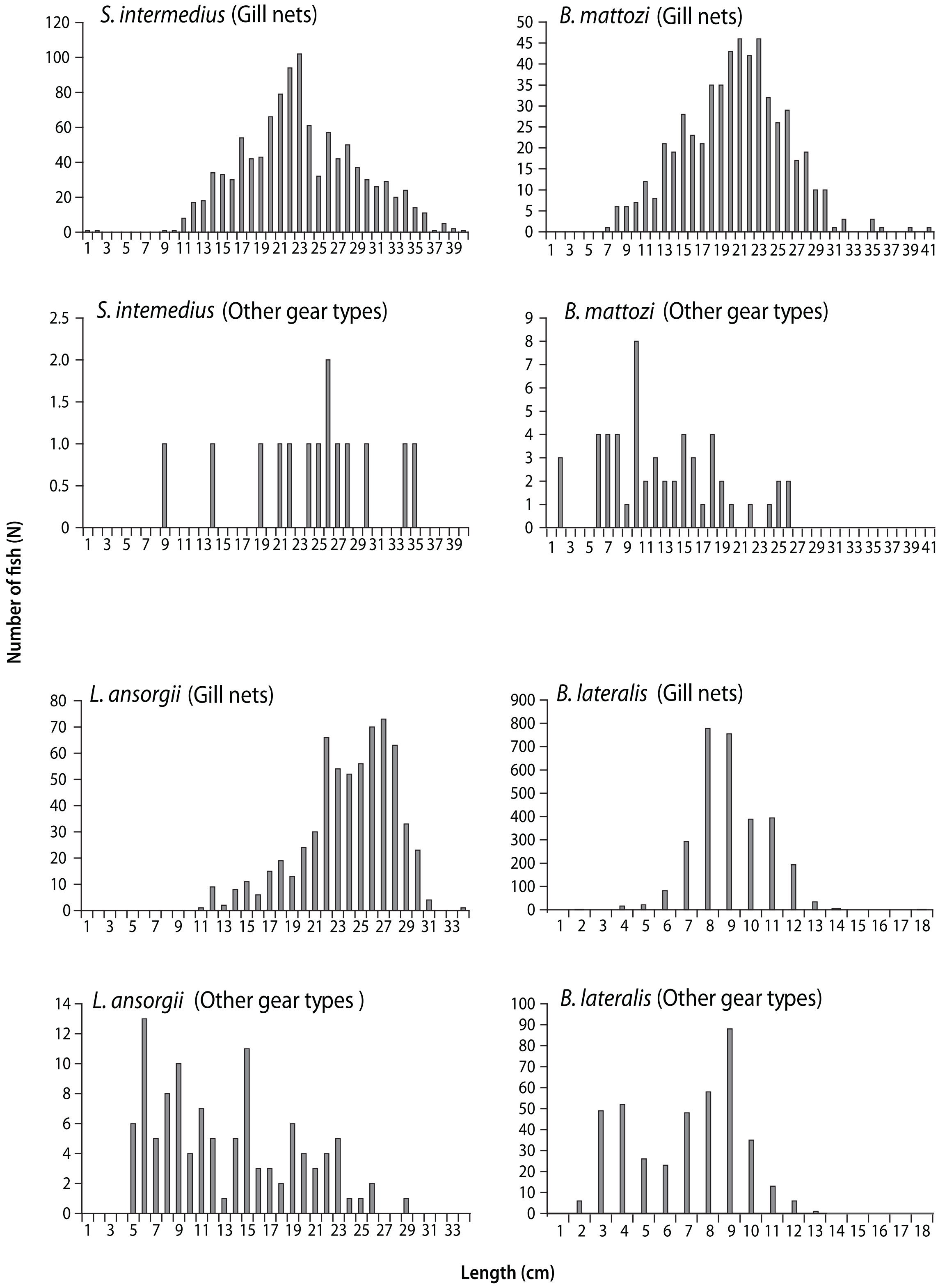

Figure 5.2. *Length distribution of important fish species caught with gill nets (22-150 mm) and other gears in the Kunene River during 1994-2004. Note the different scales on the x- and y-axes. The figure continues on the next pages.*

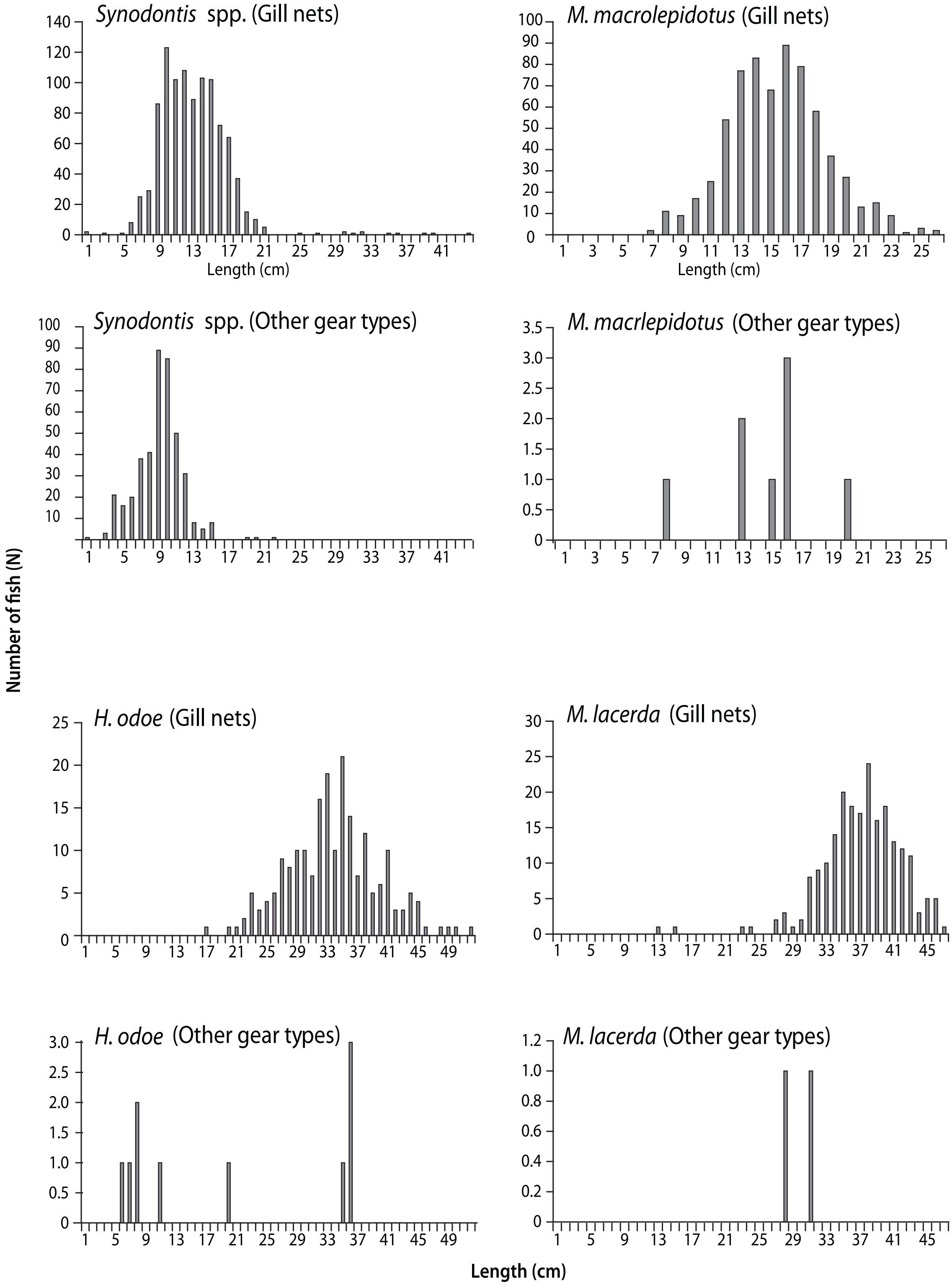

Figure 5.2. Continued.

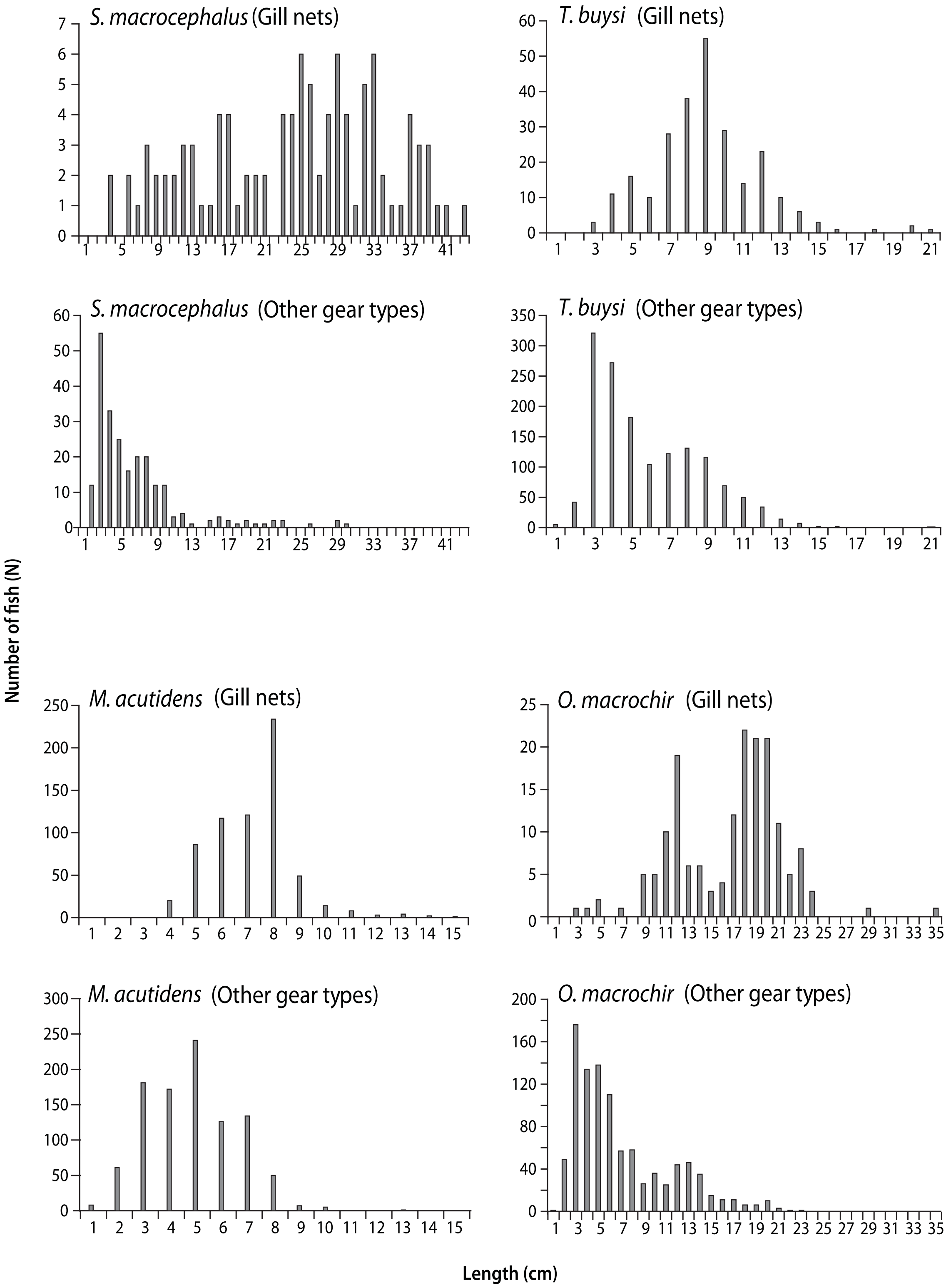

Figure 5.2. Continued.

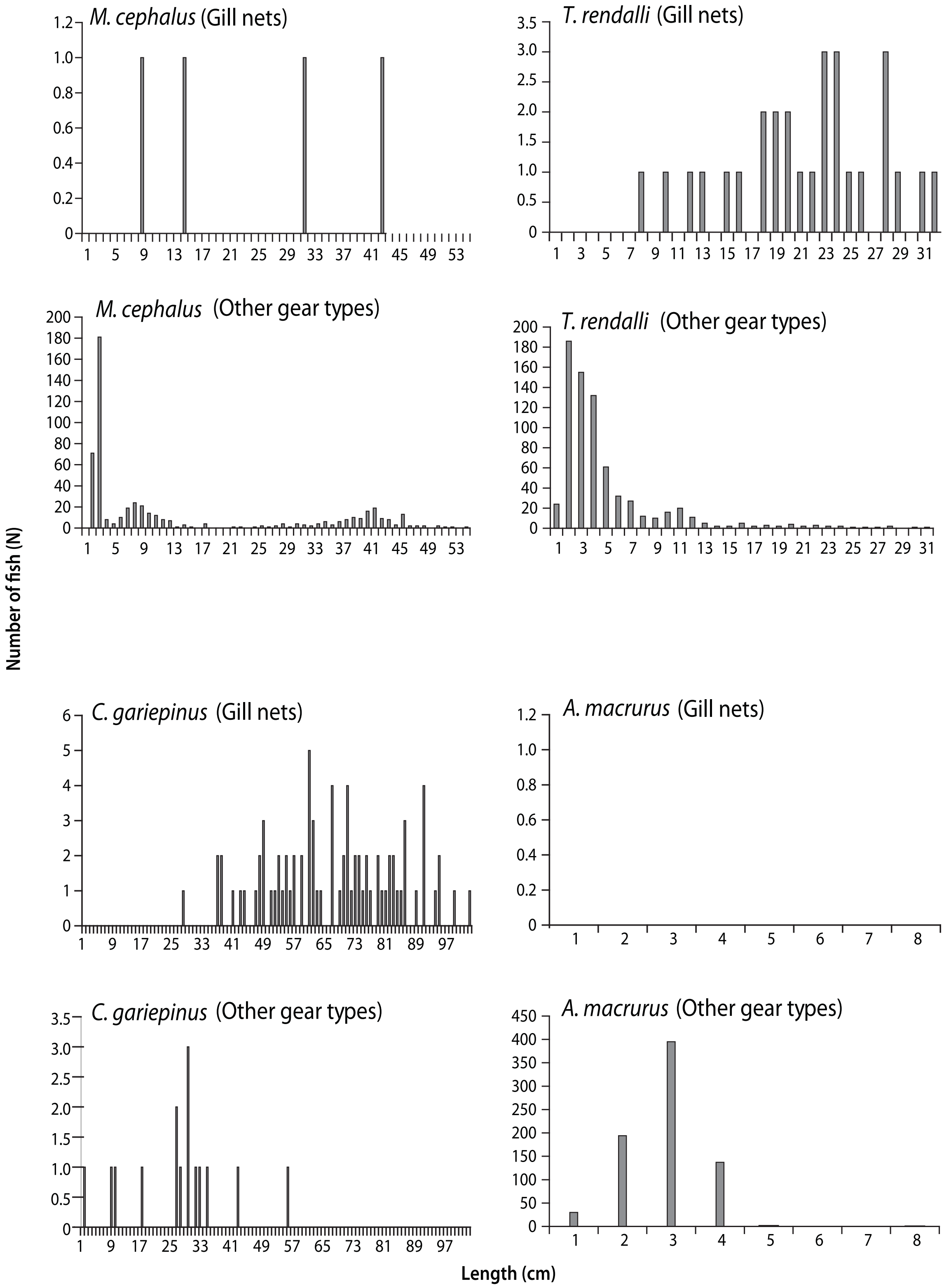

Figure 5.2. Continued.

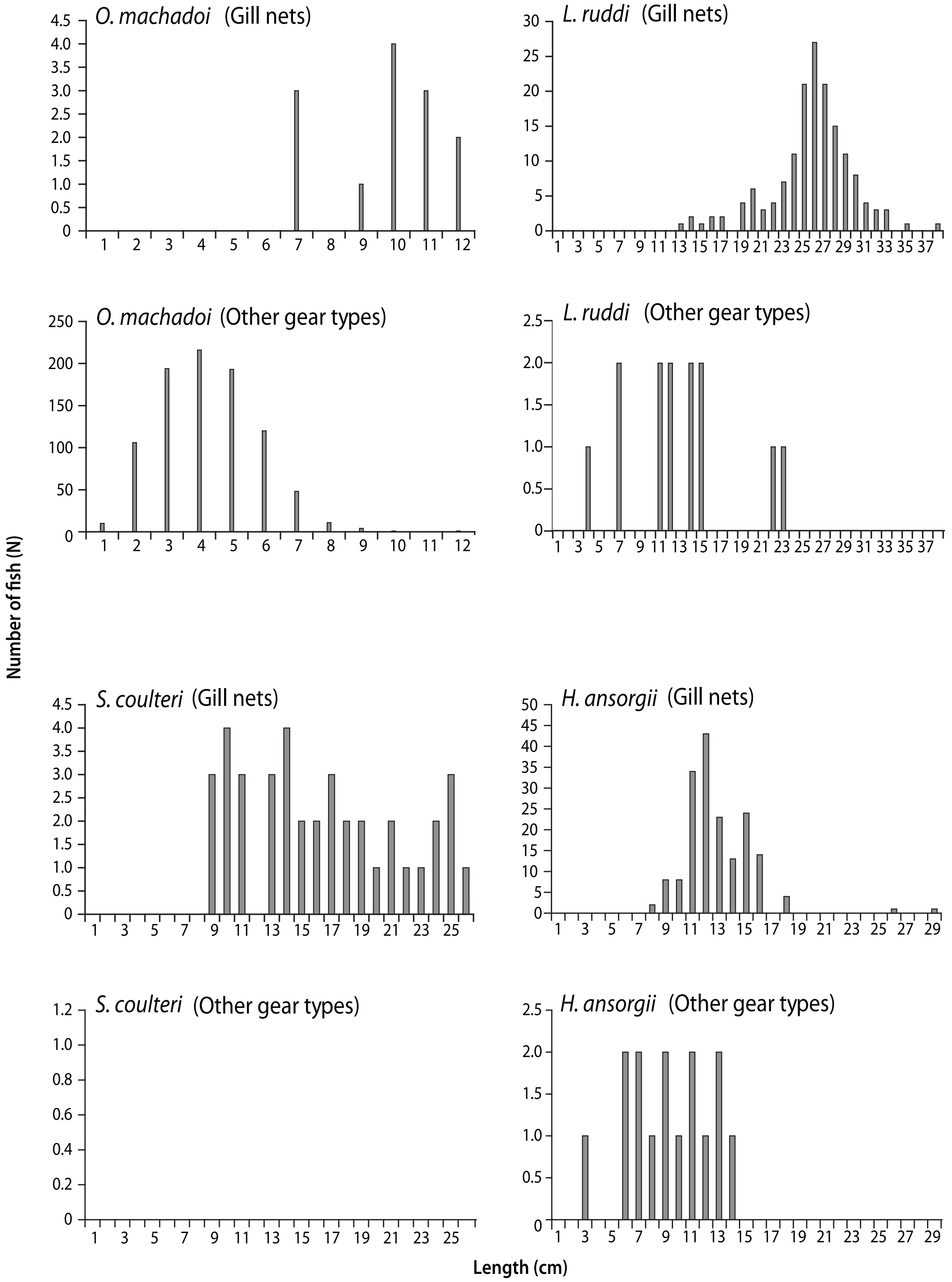

Figure 5.2. Continued.

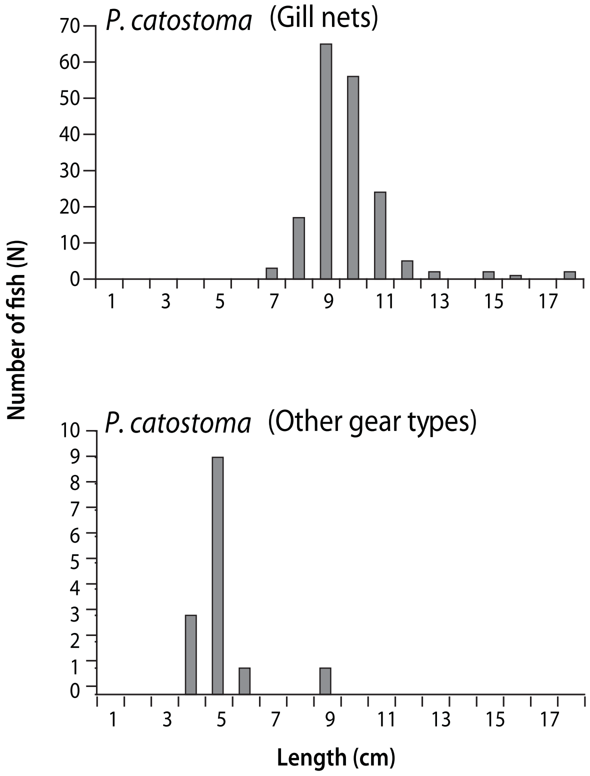

Figure 5.2. Continued.

Thoracochromis buysi (Namib river bream):
Overall IRI = 4.6%

Thoracochromis buysi was the third most important species in the pooled catches in gill nets and other gears with regard to numbers (n = 1455, 8.4%), the fifteenth most important species in the gill net catches (IRI = 0.2%), and the most important in the catches with other gears (IRI = 26%). The minimum body length at maturity was 6.8 cm for males (6.8 cm in the gill net catches) and 8.8 cm for females (9.0 cm in the gill net catches).

A total of 80 individuals were caught in gill nets, with body lengths from 5.3 to 21.8 cm (mean 11.0 cm, modal length 9.0-9.9 cm) (**figure 5.2**). Few fish larger than 15 cm were caught in the gill nets. A total of 1375 individuals were caught by other gears, of which 1070 individuals were length measured. The body lengths of these fish were between 1.0 and 21.0 cm (mean length 5.8 cm, modal length 3.0-3.9 cm) (**figure 5.2**).

Thoracochromis buysi was only caught in the mesh sizes 22 to 57 mm. The 28 mm mesh size had the highest catch in terms of number of fish per setting (0.95 fish/setting) (**table 5.10**). Fish caught with this mesh size (n = 31) had an average body length of 10.2 cm. The 35 mm mesh size had the highest catch in terms of mass per setting (n = 20 fish; 0.016 kg/setting).

The size group of *Thoracochromis buysi* most efficiently caught in the gill nets was fish with body lengths between 8 and 18 cm. They were caught in gill net mesh sizes from 22 to 57 mm (**figure 5.3**).

Table 5.10. *Gill net selectivity for* Thoracochromis buysi *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	21	8.2	0.66	0.005
28	31	10.2	0.95	0.011
35	20	12.8	0.63	0.016
45	3	13.8	0.09	0.003
57	5	18.4	0.16	0.014
73	0	0	0	0
93	0	0	0	0
118	0	0	0	0
150	0	0	0	0
All mesh sizes	**80**	**11.0**	**0.28**	**0.005**

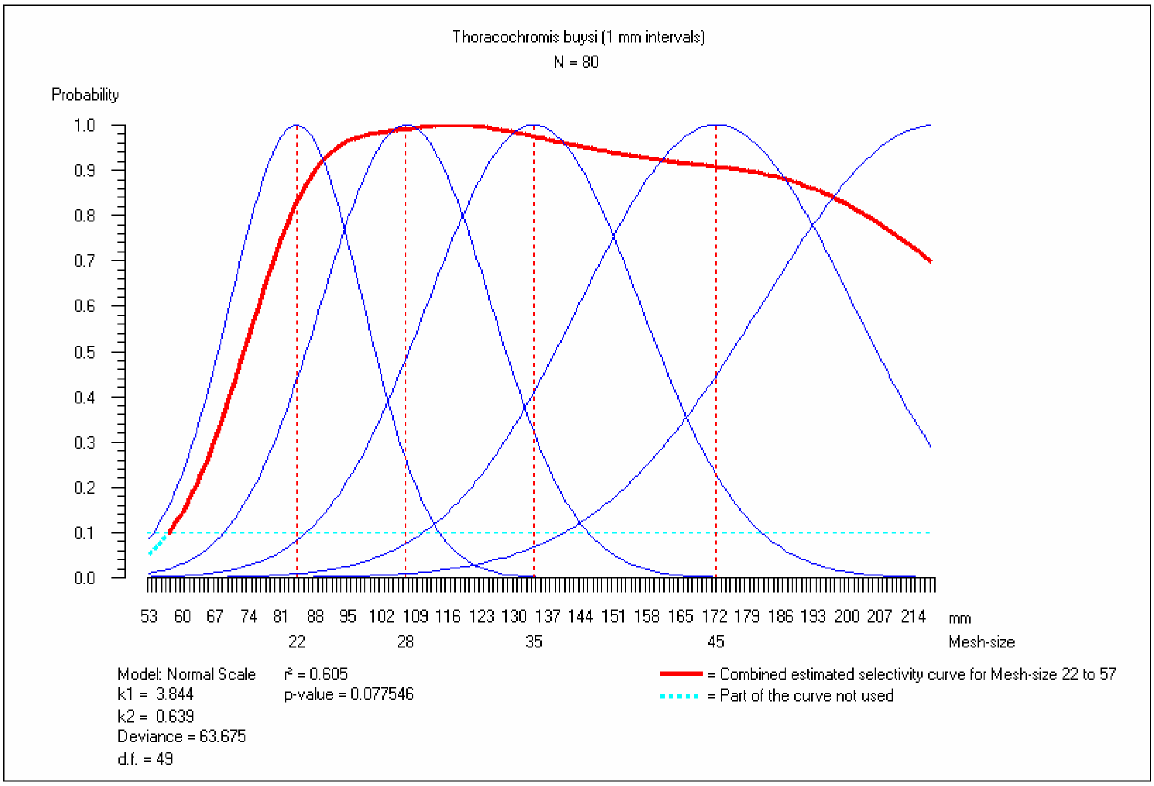

Figure 5.3. *Gill net selectivity for* Thoracochromis buysi *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Oreochromis macrochir (Greenhead tilapia):
Overall IRI = 0.3%

Oreochromis macrochir was the sixth most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 910, 5.2%), the fourteenth most important species in the gill net catches (IRI = 0.3%), and the fourth most important in the catches with other gears (IRI = 11%). The minimum body length at maturity was 13.1 cm for males (17.5 cm in the gill net catches) and 9.0 cm for females (11.0 cm in the gill net catches).

A total of 81 individuals were caught in gill nets, with body lengths from 7.5 cm to 35.0 cm (mean 18.8 cm, modal length 18.0-18.9 cm) (**figure 5.2**). Few fish larger than 24 cm were caught in the gill nets. A total of 829 individuals were caught by other gears, of which 751 individuals were length measured. The body lengths of these fish were between 1.3 and 22.0 cm (mean length 6.9 cm, modal length 3.0 cm) (**figure 5.2**).

Oreochromis macrochir was caught in mesh sizes 28 mm to 118 mm. The 73 mm mesh size had the highest catch in terms of number of fish per setting (1.6 fish/setting) (**table 5.11**). The fish caught with this mesh size had an average body length of 18.8 cm. The 73 mm mesh size also had the highest catch in terms of mass per setting (0.211 kg/setting).

The size group of *Oreochromis macrochir* most efficiently caught in the gilll nets was fish with body lengths between 9 and 20 cm. They were caught in gill net mesh sizes from 22 to 73/93 mm (**figure 5.4**).

Table 5.11. *Gill net selectivity for* Oreochromis macrochir *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	0	0	0	0
28	3	13.8	0.09	0.008
35	7	16.7	0.20	0.021
45	2	16.0	0.06	0.003
57	7	15.7	0.22	0.017
73	50	18.8	1.57	0.211
93	11	23.4	0.35	0.076
118	1	29.0	0.03	0.016
150	0	0	0	0
All mesh sizes	**81**	**18.8**	**0.28**	**0.039**

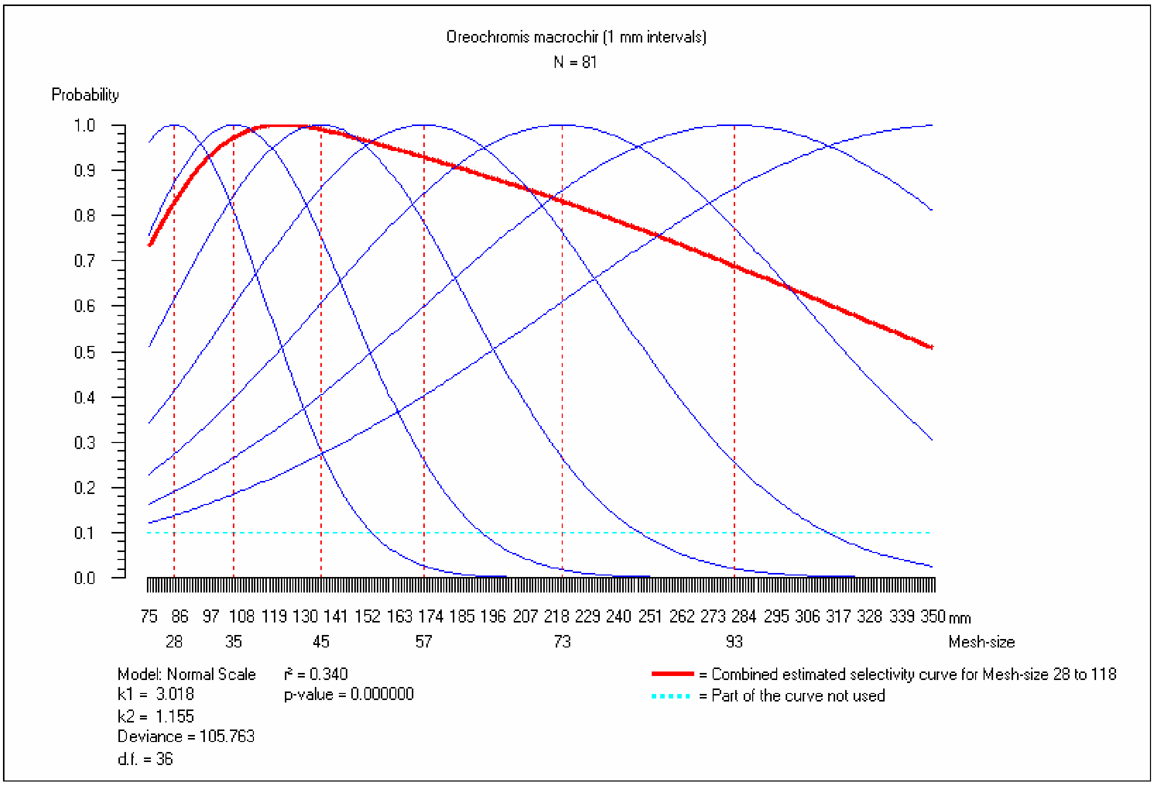

Figure 5.4. *Gill net selectivity for* Oreochromis macrochir *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Tilapia rendalli (Redbreast tilapia):
Overall IRI = 1.9%

Tilapia rendalli was the ninth most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 729, 4.2%), the twentyfirst most important species in the gill net catches (IRI = 0.1%), and the third most important in the catches with other gears (IRI = 12%). The minimum body length at maturity was 11.1 cm for males (21.0 cm in the gill net catches) and 10.0 cm for females (10.0 cm in the gill net catches).

A total of 23 individuals were caught in gill nets, with body lengths from 8.7 to 32.0 cm (mean 22.3 cm, modal length could not be calculated) (**figure 5.2**). A total of 706 individuals were caught by other gears, of which 635 individuals were length measured. Their body lengths varied from 0.7 to 30.0 cm (mean 5.0 cm, modal length 2.0-2.9 cm) (**figure 5.2**).

Tilapia rendalli was caught in mesh sizes 22 to 118 mm. The 93 mm mesh size had the highest catch in terms of number of fish per setting (0.27 fish/setting) (**table 5.12**). Fish caught with this mesh size had an average body length of 25.8 cm. The 93 mm mesh size also had the highest catch in terms of mass per setting (0.087 kg/setting).

The size group of *Tilapia rendalli* most efficiently caught in the gill nets was fish with body lengths between 9 and 29 cm. They were caught in gill net mesh sizes from 28 to 93 mm (**figure 5.5**).

Table 5.12. *Gill net selectivity for* Tilapia rendalli *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	1	10.0	0.03	0.000
28	0	0	0	0
35	1	8.7	0.03	0.000
45	2	16.0	0.06	0.006
57	1	16.0	0.03	0.003
73	6	20.6	0.17	0.029
93	10	25.8	0.27	0.087
118	2	31.6	0.06	0.036
150	0	0	0	0
All mesh sizes	**23**	**22.3**	**0.07**	**0.018**

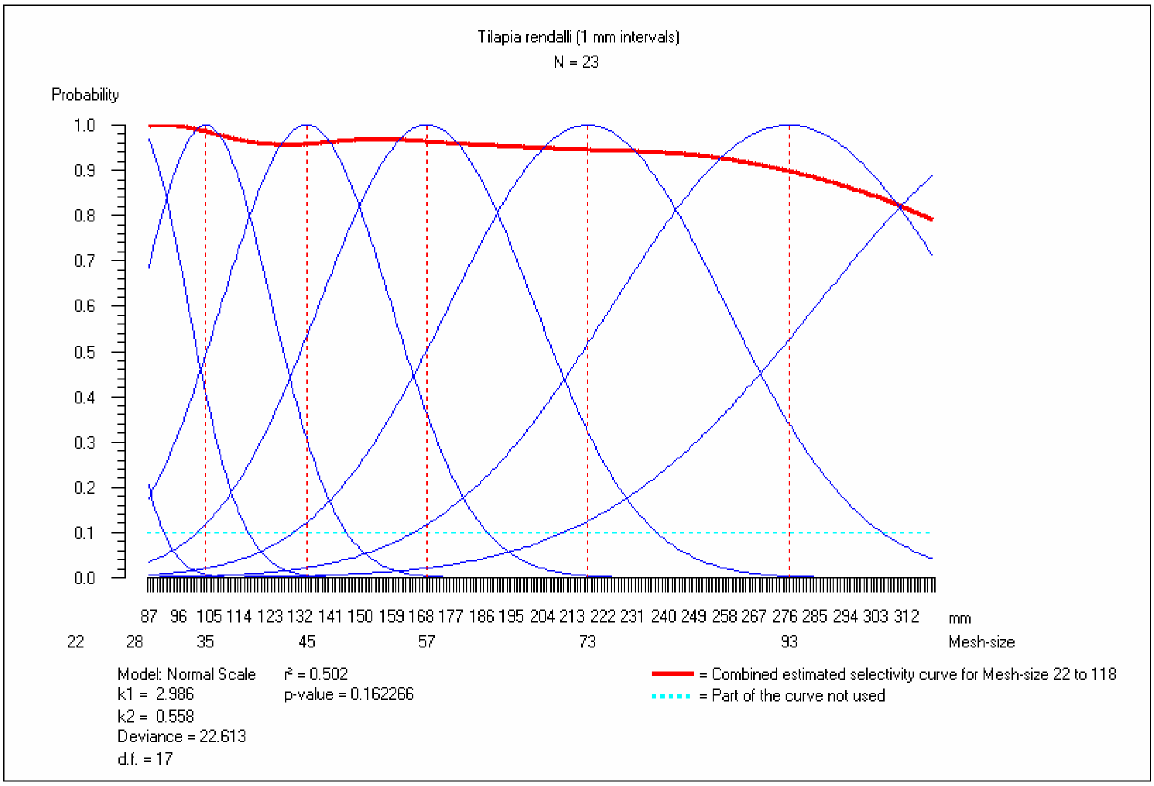

Figure 5.5. *Gill net selectivity for* Tilapia rendalli *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Serranochromis macrocephalus (Purpleface largemouth):
Overall IRI = 1.5%

Serranochromis macrocephalus was the sixteenth most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 244, 1.4%), the twelfth most important species in the gill net catches (IRI = 0.6%), and the eighth most important species in the catches with other gears (IRI = 2.5%). The minimum body length at maturity was 22.0 cm for males (32.0 cm in the gill net catches) and 20.0 cm for females (20.0 cm in the gill net catches).

A total of 68 individuals were caught in gill nets, with body lengths from 8.0 to 43.0 cm (mean 28.1 cm, modal length 25.0-25.9 cm) (**figure 5.2**). A total of 176 individuals were caught by other gears, of which all were length measured. Their body lengths varied from 2.5 cm to 30.0 cm (mean 7.2 cm, modal length 3.0-3.9 cm) (**figure 5.2**).

Serranochromis macrocephalus was caught in all mesh sizes (22-150 mm). The 93 mm mesh size had the highest catch in terms of number of fish per setting (0.66 fish/setting) (**table 5.13**). Fish caught with this mesh size had an average body length of 33.2 cm. The 93 mm size also had the highest catch in terms of mass per setting (0.308 kg/setting).

The size group of *Serranochromis macrocephalus* most efficiently caught in the gill nets was fish with body lengths between 10 and 40 cm. They were caught in gill net mesh sizes from 28 to 118 mm (**figure 5.6**).

Table 5.13. *Gill net selectivity for* Serranochromis macrocephalus *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	3	8.0	0.09	0.000
28	1	30.0	0.03	0.011
35	3	13.8	0.09	0.003
45	5	16.4	0.16	0.008
57	5	20.7	0.16	0.017
73	19	26.8	0.60	0.141
93	21	33.2	0.66	0.308
118	9	38.6	0.28	0.220
150	2	37.8	0.06	0.025
All mesh sizes	**68**	**28.1**	**0.24**	**0.081**

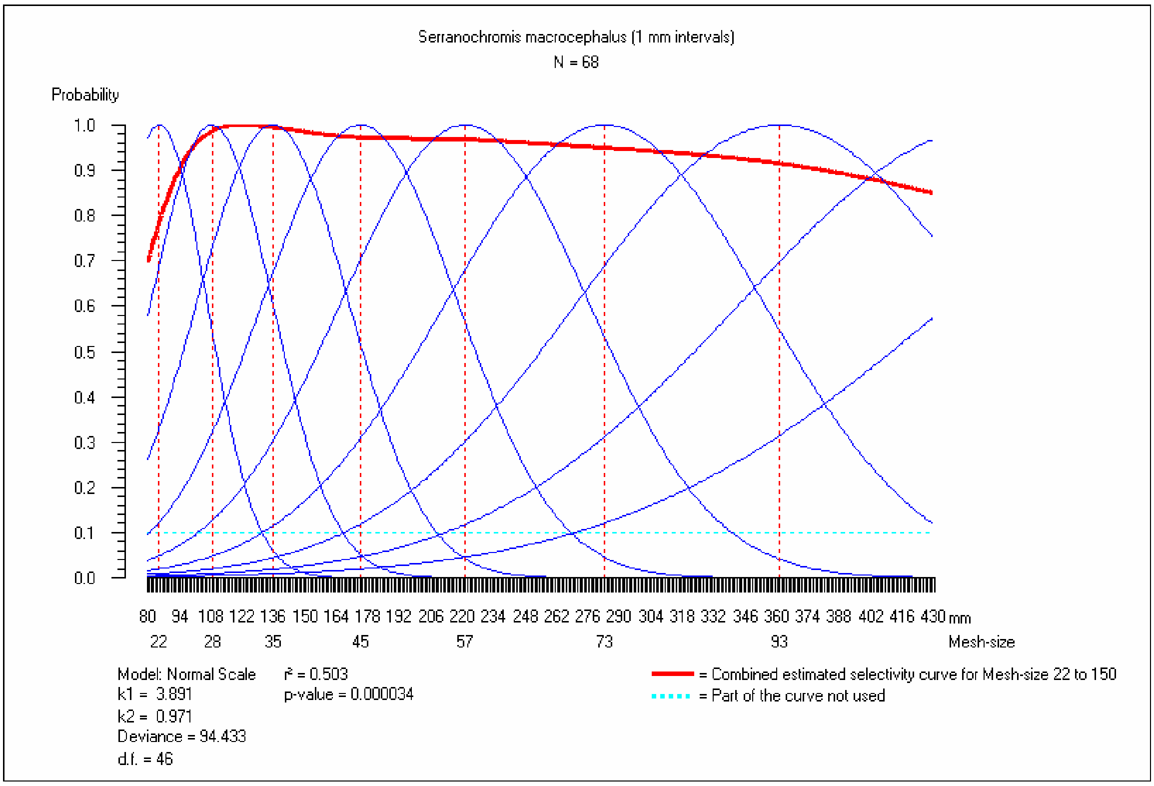

Figure 5.6. *Gill net selectivity for* Serranochromis macrocephalus *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Barbus mattozi (Papermouth):
Overall IRI = 12%

Barbus mattozi was the thirteenth most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 549, 3.2%), the third most important species in the gill net catches (IRI = 13%), and the thirteenth most important in the catches with other gears (IRI = 0.5%). The minimum body length at maturity was 12.0 cm for males (12.0 cm in the gill net catches) and 12.6 cm for females (12.6 cm in the gill net catches).

A total of 499 individuals were caught in gill nets, with body lengths from 7.5 to 39.0 cm (mean 20.7 cm, modal length 20.0-20.7 cm) (**figure 5.2**). A total of 50 individuals were caught by the other gears, of which all were length measured. Their body lengths varied from 2.5 to 26.5 cm (mean 13.1 cm, modal length 10.0-10.9 cm) (**figure 5.2**).

Barbus mattozi was caught in mesh sizes 22 to 118 mm. The 57 mm mesh size had the highest catch in terms of number of fish per setting (5.4 fish/setting) (**table 5.14**). Fish caught with this mesh size had an average body length of 21.0 cm. The 73 mm mesh size had the highest catch in terms of mass per setting (1.041 kg/setting). Fish caught with this mesh size had an average body length of 25.0 cm.

The size group of *Barbus mattozi* most efficiently caught in the gill nets was fish with body lengths between 9 and 36 cm. They were caught in gill net mesh sizes from 28 to 93 mm (**figure 5.7**).

Table 5.14. *Gill net selectivity for* Barbus mattozi *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	8	10.1	0.25	0.004
28	24	11.4	0.75	0.022
35	57	14.5	1.77	0.098
45	72	17.3	2.24	0.205
57	173	21.0	5.44	0.838
73	129	25.0	4.04	1.041
93	30	28.6	0.94	0.384
118	6	28.1	0.19	0.035
150	0	0	0	0
All mesh sizes	**499**	**20.7**	**1.74**	**0.292**

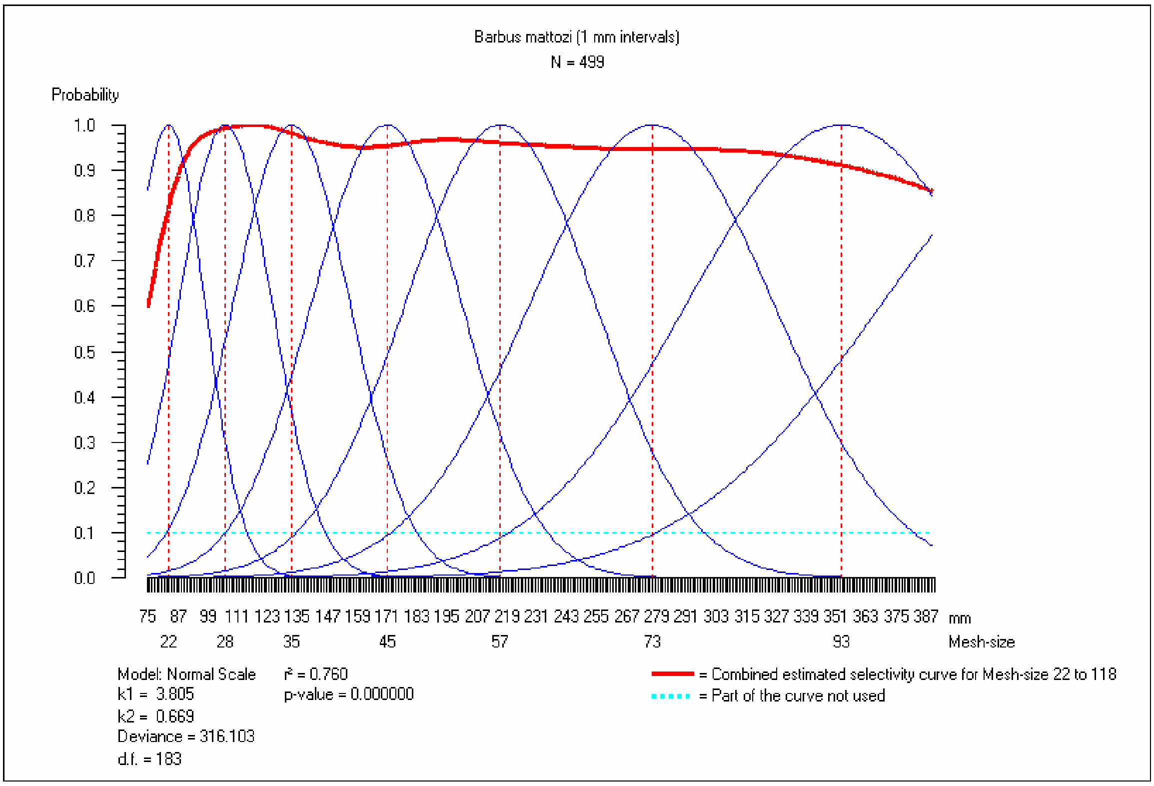

Figure 5.7. *Gill net selectivity for* Barbus mattozi *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Labeo ansorgii (Kunene labeo):
Overall IRI = 11%

Labeo ansorgii was the tenth most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 592, 3.4%), the fourth most important fish in the gill net catches (IRI = 11%), and the tenth most important in the catches with other gears (IRI = 1.0%). The minimum body length at maturity was 12.5 cm for males (12.5 cm in the gill net catches) and 14.0 cm for females (14.0 cm in the gill net catches).

A total of 504 individuals were caught in gill nets, with body lengths from 11.0 to 34.0 cm (mean 24.3 cm, modal length 26.0-26.9 cm) (**figure 5.2**). A total of 88 individuals were caught by the other gears, of which all were length measured. Their body lengths varied from 5.0 to 29.0 cm (mean 14.3 cm, modal length 15.0-15.9 cm) (**figure 5.2**).

Labeo ansorgii was caught in mesh sizes between 22 and 118 mm (**table 5.15**). The 57 mm mesh size had the highest catch in terms of number of fish per setting (6.1 fish/setting). Fish caught with this mesh size had an average body length of 24.7 cm. The 73 mm mesh had the highest catch in terms of mass per setting (1.464 kg/setting). Fish caught with this mesh size had an average body length of 27.7 cm.

The size group of *Labeo ansorgii* most efficiently caught in the gill nets was fish with body lengths between 11 and 33 cm. They were caught in gill net mesh sizes from 28 and 73 mm (**figure 5.8**).

Table 5.15. *Gill net selectivity for* Labeo ansorgii *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	1	28.0	0.03	0.012
28	14	15.1	0.44	0.030
35	43	20.4	1.35	0.196
45	102	21.2	3.19	0.477
57	194	24.7	6.06	1.405
73	140	27.7	4.40	1.464
93	8	27.6	0.25	0.110
118	2	29.8	0.04	0.013
150	0	0	0	0
All mesh sizes	**504**	**24.3**	**1.75**	**0.412**

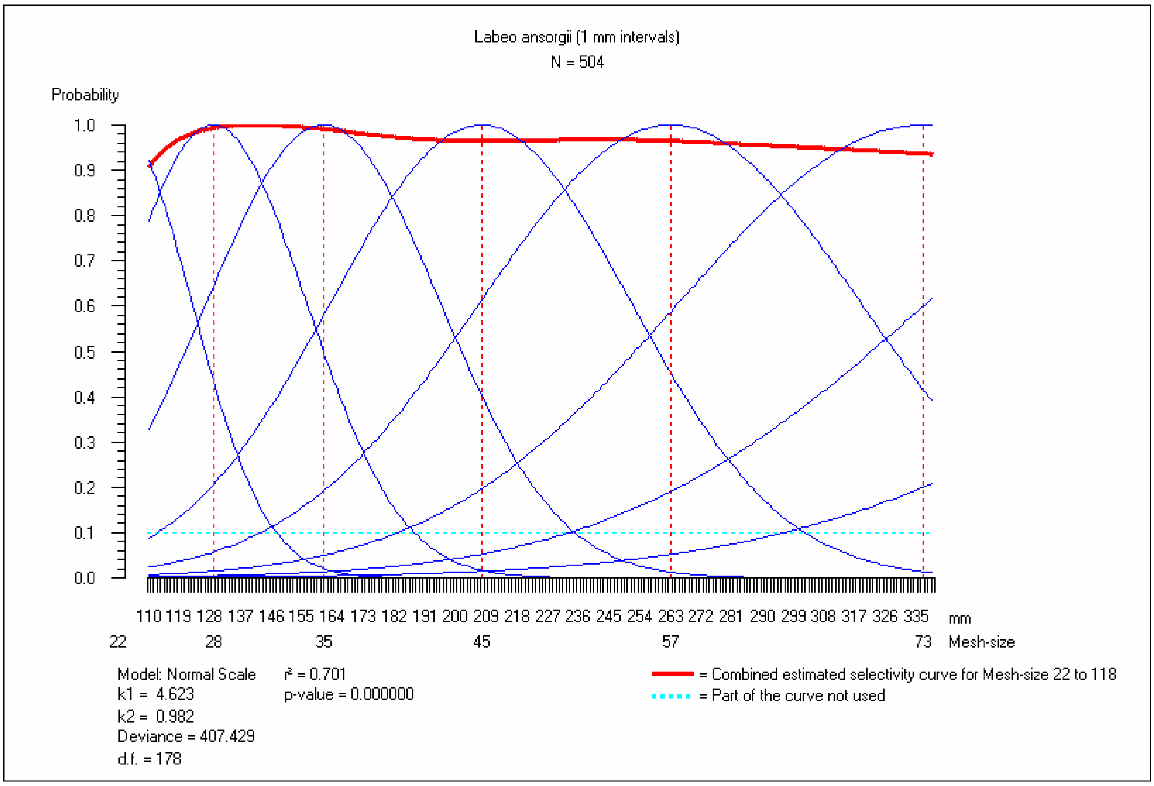

Figure 5.8. *Gill net selectivity for* Labeo ansorgii *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Labeo ruddi (Silver labeo):
Overall IRI = 1.0%

Labeo ruddi was the twentyfirst most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 151, 0.9%), the ninth most important species in the gill net catches (IRI = 1.2%), and the twentyeighth most important in the catches with other gears (IRI < 0.1%). The minimum body length at maturity was 14.0 cm for males (14.0 cm in the gill net catches) and 13.0 cm for females (23.5 cm in the gill net catches).

A total of 144 individuals were caught in gill nets with body lengths 13.0 to 38.0 cm (mean 26.0 cm, modal length 26.0-26.9 cm) (**figure 5.2**). Only seven individuals were caught by other gears, with body lengths from 4.0 to 23.0 cm (mean 11.3 cm, modal length could not be calculated) (**figure 5.2**).

Labeo ruddi was caught in mesh sizes 35 to 118 mm. The 57 mm mesh size had the highest catch in terms of number of fish per setting (2.3 fish/setting) (**table 5.16**). Fish caught with this mesh size had an average body length of 25.5 cm. The 57 mm mesh size also had the highest catch in terms of mass per setting (0.538 kg/setting).

The size group of *Labeo ruddi* most efficiently caught in the gill nets was fish with body lengths between 18 and 38 cm. They were caught in gill net mesh sizes from 35 to 73 mm (**figure 5.9**).

Table 5.16. *Gill net selectivity for* Labeo ruddi *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	0	0	0	0
28	0	0	0	0
35	20	20.8	0.63	0.081
45	4	23.8	0.13	0.023
57	74	25.5	2.33	0.538
73	39	28.9	1.23	0.441
93	5	28.4	0.16	0.053
118	2	35.0	0.06	0.015
150	0	0	0	0
All mesh sizes	**144**	**26.0**	**0.50**	**0.128**

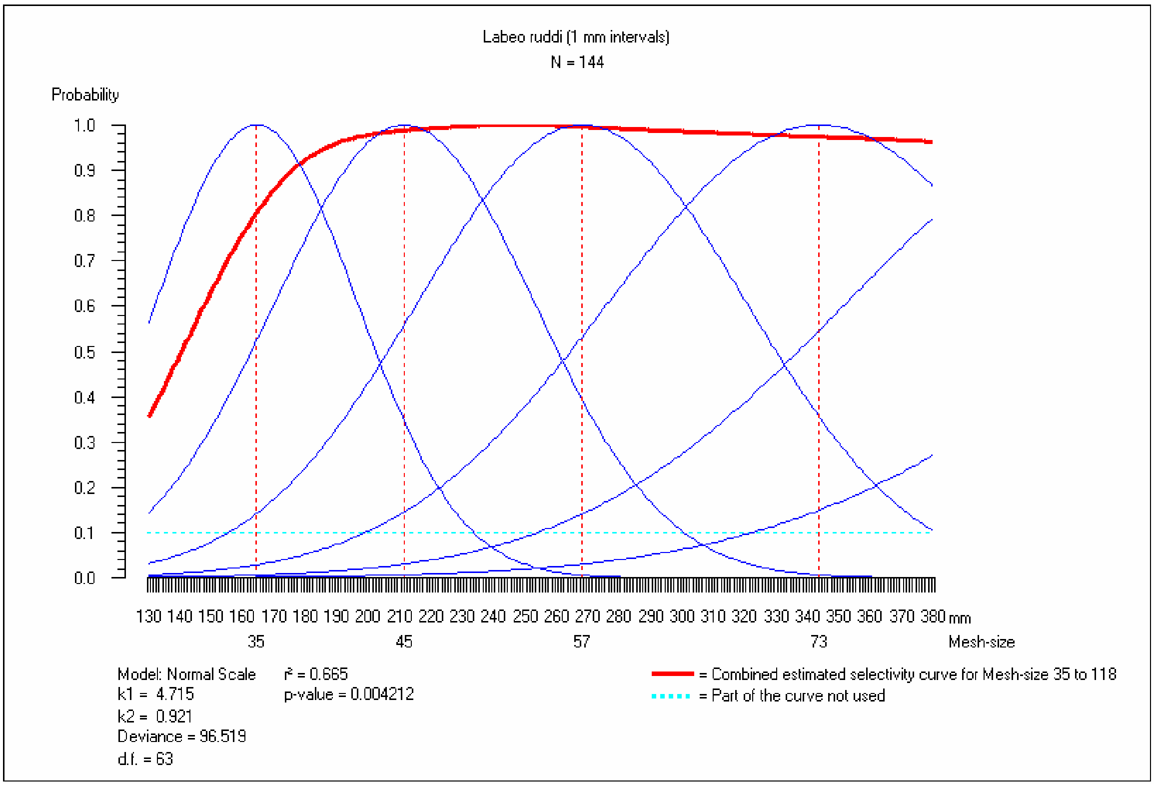

Figure 5.9. *Gill net selectivity for* Labeo ruddi *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Barbus trimaculatus (Threespot barb):
Overall IRI = 0.1%

Barbus trimaculatus was the twentysecond most important species with regard to numbers caught in the pooled catches in gill nets and other gears (n = 127, 0.7%). It was the sixteenth most important fish in the gill net catches (IRI = 0.1%), and the seventeenth most important in the catches with other gears (IRI = 0.2%). The minimum body length at maturity was 7.0 cm for males (9.0 cm in the gill net catches) and 7.5 cm for females (7.5 cm in the gill net catches).

A total of 62 individuals were caught with gill nets with body lengths from 7.5 to 14.0 cm (mean 10.3 cm, modal length 10.0-10.9 cm) (**figure 5.2**). A total of 65 individuals were caught by other gears, with body lengths from 4.2 to 12.0 cm (mean 8.7 cm, modal length 8.0-9.9 cm) (**figure 5.2**).

Barbus trimaculatus was caught in the 22 to 35 mm mesh sizes. The 28 mm mesh size had the highest catch in terms of number of fish per setting (1.1 fish/setting) (**table 5.17**). Fish caught with this mesh size had an average body length of 10.6 cm. The 28 mm mesh size also had the highest catch in terms of mass per setting (0.018 kg/setting).

The size group of *Barbus trimaculatus* most efficiently caught in the gill nets was fish with body lengths between 8 and 13 cm. They were caught in gill net mesh sizes from 22 to 35 mm (**figure 5.10**).

Table 5.17. *Gill net selectivity for* Barbus trimaculatus *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	18	8.8	0.57	0.005
28	35	10.6	1.10	0.018
35	9	12.2	0.28	0.009
45	0	0	0	0
57	0	0	0	0
73	0	0	0	0
93	0	0	0	0
118	0	0	0	0
150	0	0	0	0
All mesh sizes	**62**	**10.3**	**0.22**	**0.004**

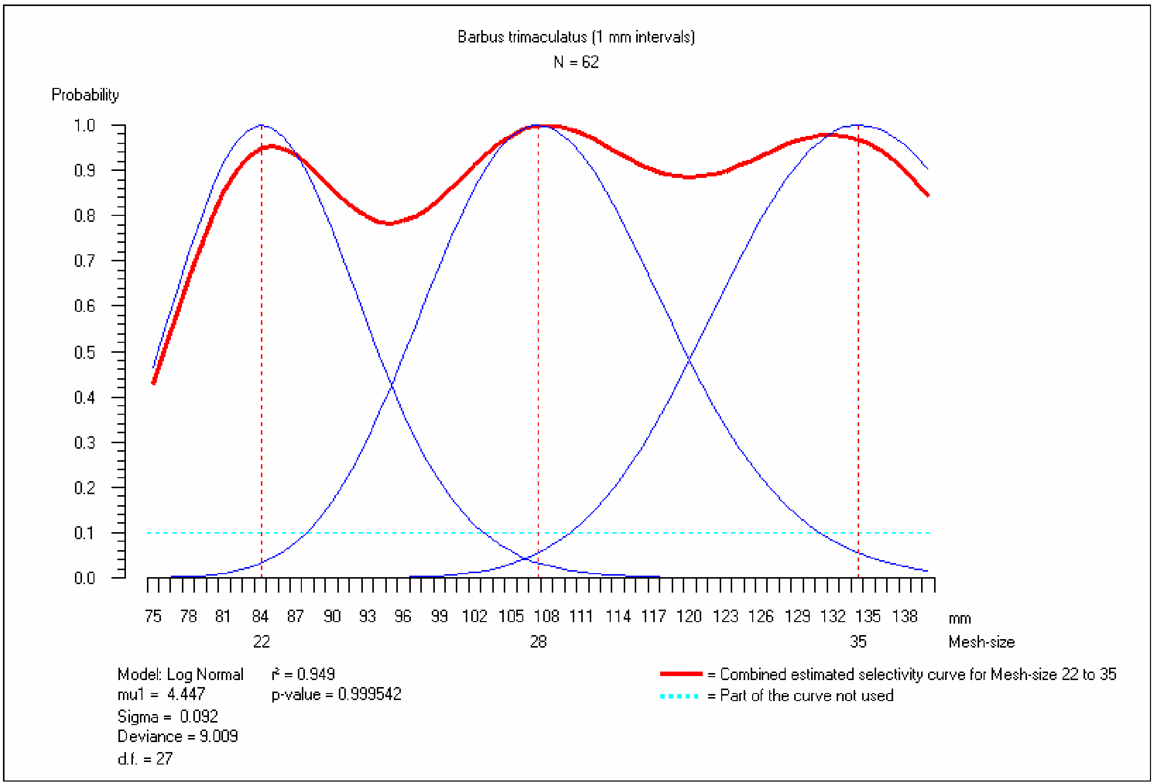

Figure 5.10. *Gill net selectivity for* Barbus trimaculatus *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Brycinus lateralis (Striped robber):
Overall IRI = 10%

Brycinus lateralis was the most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 1889, 11%), the second most important species in the gill net catches (IRI = 15%), and the twelfth most important in the catches with other gears (IRI = 0.6%). The minimum body length at maturity was 7.8 cm for males (7.8 cm in the gill net catches) and 7.6 cm for females (7.6 cm in the gill net catches).

A total of 1789 individuals were caught in gill nets, with body lengths from 2.5 to 18.0 cm (mean 10.1 cm, modal length 9.0-9.9 cm) (**figure 5.2**). A total of 100 individuals were caught by other gears. Their body lengths varied from 2.0 to 12.0 cm (mean 5.6 cm, modal length 3.0-3.9 cm) (**figure 5.2**).

Brycinus lateralis was caught in mesh sizes from 22 to 35 mm. The 22 mm mesh size had the highest catch in terms of number of fish per setting (34.5 fish/setting) (**table 5.18**). Fish caught with this mesh size had an average body length of 9.4 cm. The 28 mm mesh size had the highest catch in terms of mass per setting (0.347 kg/setting). Fish caught with this mesh size had an average body length of 11.1 cm.

The size group of *Brycinus lateralis* most efficiently caught in the gill nets was fish with body lengths between 9 and 15 cm. They were caught in gill net mesh sizes from 22 to 35 mm (**figure 5.11**).

Table 5.18. *Gill net selectivity for* Brycinus lateralis *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	1097	9.4	34.50	0.340
28	674	11.1	21.19	0.347
35	18	12.2	0.57	0.014
45	0	0	0	0
57	0	0	0	0
73	0	0	0	0
93	0	0	0	0
118	0	0	0	0
150	0	0	0	0
All mesh sizes	**1789**	**10.1**	**6.25**	**0.078**

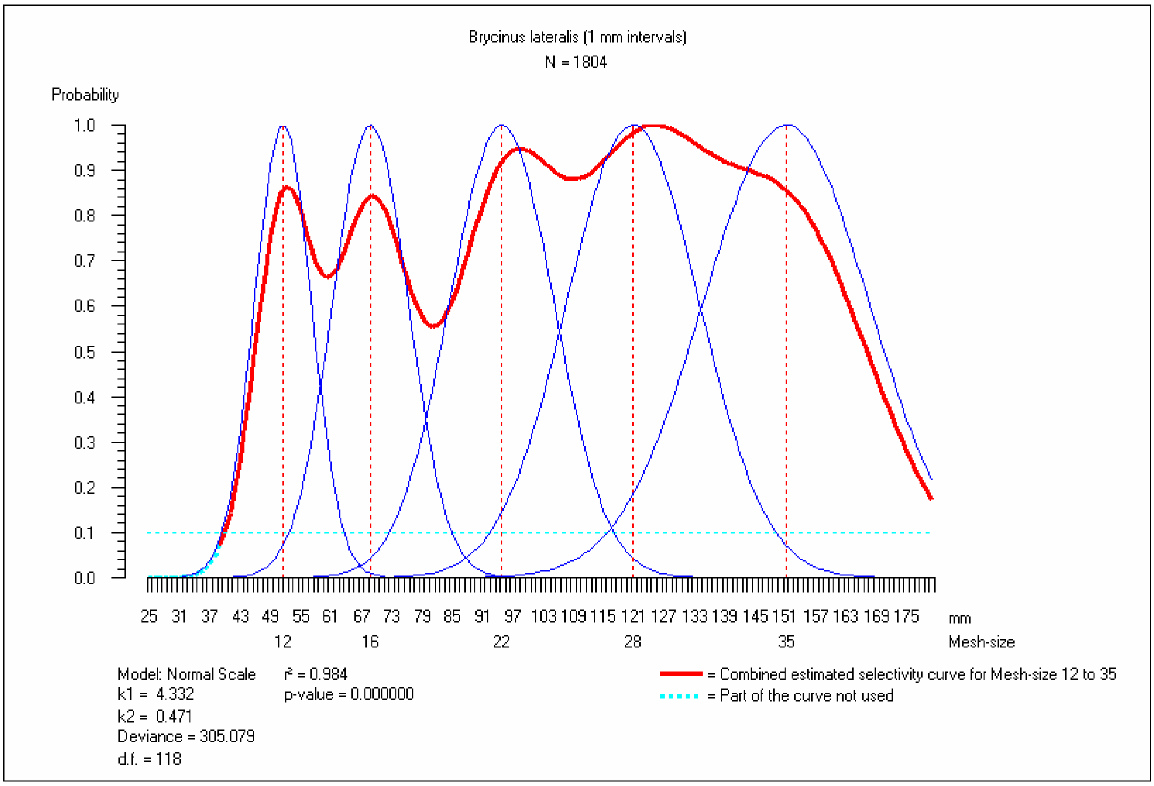

Figure 5.11. *Gill net selectivity for* Brycinus lateralis *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Micralestes acutidens (Silver robber):
Overall IRI = 3.1%

Micralestes acutidens was the fourth most important species with regard to numbers caught in the pooled catches in gill nets and other gears (n = 1074, 6.2%), the tenth most important species in the gill net catches (IRI = 1.1%), and the seventh most important in the catches with other gears (IRI = 7.4%). The minimum body length at maturity was 7.0 cm for males (7.0 cm in the gill net catches) and 6.5 cm for females (6.5 cm in the gill net catches).

A total of 367 individuals were caught in gill nets, with body lengths from 5.5 to 15.0 cm (mean 8.5 cm, modal length 8.0-8.9 cm) (**figure 5.2**). A total of 707 individuals were caught by other gears, of which 657 were length measured. Their body lengths varied from 0.5 to 13.4 cm (mean 4.7 cm, modal length 5.0-5.9 cm) (**figure 5.2**).

The 22 mm mesh size had the highest catch in terms of number of fish per setting (11.1 fish/setting) (**table 5.19**). Fish caught with this mesh size had an average body length of 8.4 cm. The 22 mm mesh size also had the highest catch in terms of mass per setting (0.083 kg/setting).

The size group of *Micralestes acutidens* most efficiently caught in the gill nets was fish with body lengths between 9 and 14 cm. They were caught in gill net mesh sizes from 22 to 28 mm (**figure 5.12**).

Table 5.19. *Gill net selectivity for* Micralestes acutidens *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	354	8.4	11.13	0.083
28	11	9.3	0.35	0.003
35	2	11.5	0.06	0.001
45	0	0	0	0
57	0	0	0	0
73	0	0	0	0
93	0	0	0	0
118	0	0	0	0
150	0	0	0	0
All mesh sizes	**367**	**8.5**	**1.28**	**0.010**

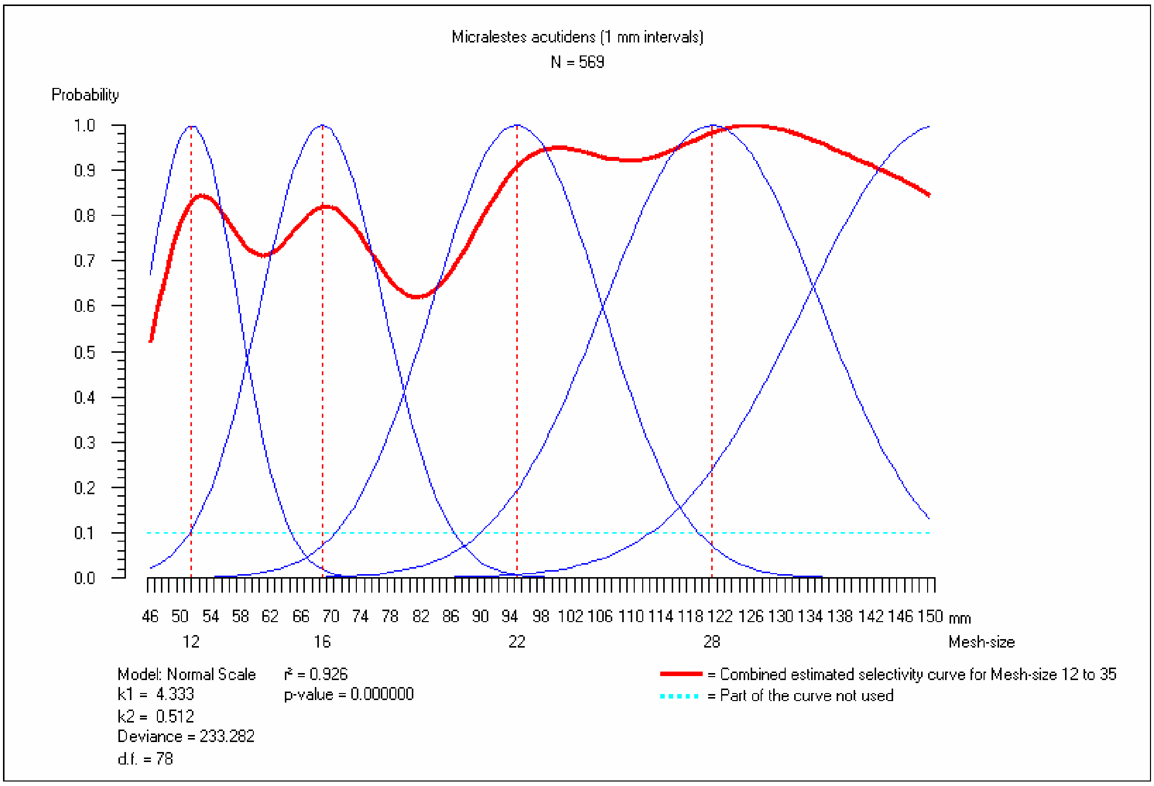

Figure 5.12. *Gill net selectivity for* Micralestes acutidens *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Marcusenius macrolepidotus (Bulldog):
Overall IRI = 4.2%

Marcusenius macrolepidotus was the eleventh most important species with regard to numbers in the pooled catches in gill nets and other gears (n = 577, 3.3%), the fifth most important species in the gill net catches (IRI = 6.3%), and the thirtyfirst most important in the catches with other gears (IRI < 0.1%). The minimum body length at maturity was 9.0 cm for males (9.0 cm in the gill net catches) and 9.5 cm for females (9.5 cm in the gill net catches).

A total of 569 individual were caught in gill nets, with body lengths from 7.7 to 26.0 cm (mean 15.6 cm, modal length 13.0-13.9 cm) (**figure 5.2**). Only eight individuals were caught by other gears. Their body lengths varied from 8.2 to 20.0 cm (mean 14.7 cm, modal length 16.0-16.9 cm) (**figure 5.2**).

Marcusenius macrolepidotus was caught in mesh sizes from 22 to 73 mm. The 35 mm mesh size had the highest catch in terms of number of fish per setting (7.6 fish/setting) (**table 5.20**). Fish caught with this mesh size had an average body length of 14.3 cm. The 45 mm mesh size had the highest catch in terms of mass per setting (0.353 kg/setting). Fish caught with this mesh size had an average body length of 17.2 cm.

The size group of *Marcusenius macrolepidotus* most efficiently caught in the gill nets was fish with body lengths between 9 and 25 cm. They were caught in gill net mesh sizes from 22 to 57/73 mm (**figure 5.13**).

Table 5.20. *Gill net selectivity for* Marcusenius macrolepidotus *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	20	8.7	0.63	0.004
28	53	11.6	1.56	0.028
35	242	14.3	7.59	0.268
45	187	17.2	5.88	0.353
57	59	20.9	1.86	0.191
73	8	18.1	0.25	0.017
93	0	0	0	0
118	0	0	0	0
150	0	0	0	0
All mesh sizes	**569**	**15.6**	**1.97**	**0.096**

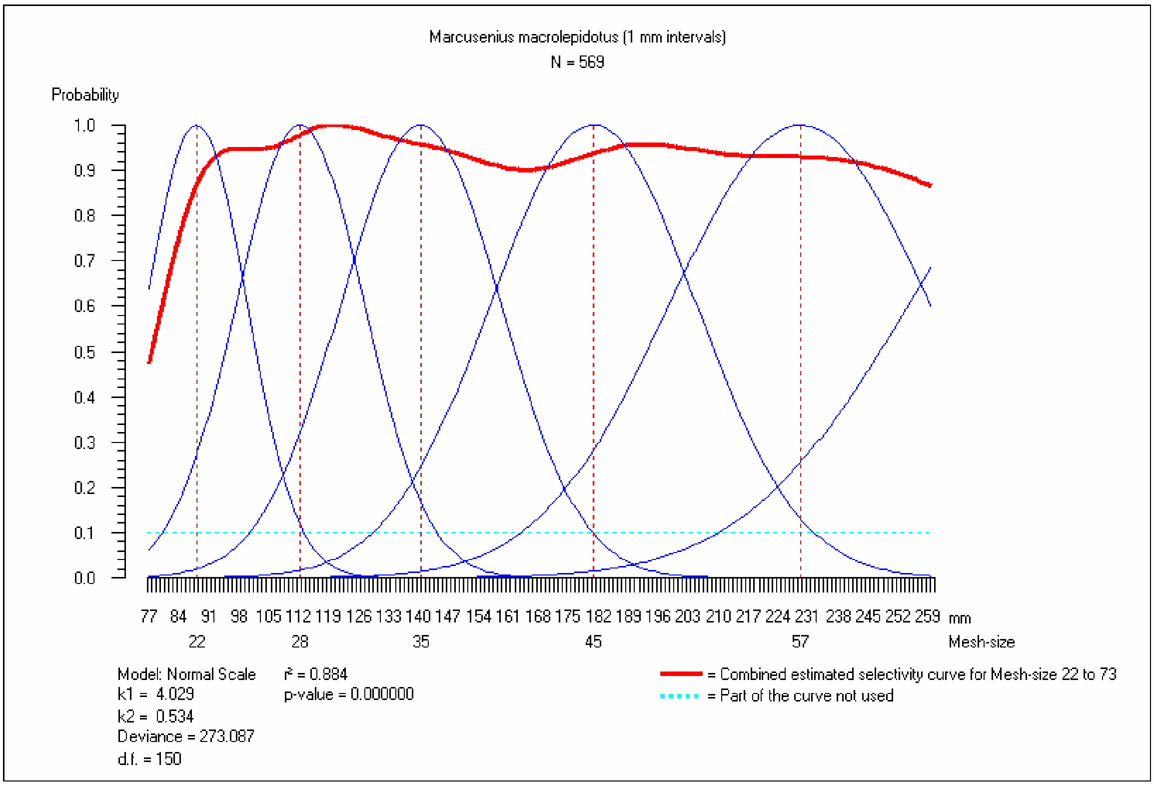

Figure 5.13. *Gill net selectivity for* Marcusenius macrolepidotus *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Mormyrus lacerda (Western bottlenose):
Overall IRI = 3.3%

Mormyrus lacerda was the sixteenth most important species in the pooled catches in gill nets and other gears with regard to numbers (n = 188, 1.1%), the seventh most important species in the gill net catches (IRI = 3.6%), and the thirtysixth most important species in the catches with other gears (IRI < 0.1%). The minimum body length at maturity was 23.9 cm for males (23.9 cm in the gill net catches) and 28.5 cm for females (30.7 cm in the gill net catches).

A total of 186 individuals were caught in gill nets, with body lengths from 13.0 to 47.0 cm (mean 37.6 cm, modal length 38.0-38.9 cm) (**figure 5.2**). Only two individuals were caught by other gears. Their body lengths were 28.5 and 31.5 cm, respectively.

Mormyrus lacerda was caught in the mesh sizes 22 to 118 mm. The 93 mm mesh size had the highest catch in terms of number of fish per setting (3.9 fish/setting) (**table 5.21**). Fish caught with this mesh size had an average body length of 39.1 cm. The 93 mm mesh size also had the highest catch in terms of mass per setting (2.346 kg/setting).

The size group of *Mormyrus lacerda* most efficiently caught in the gill nets was fish with body lengths between 13 and 35 cm. They were caught in gill net mesh sizes from 28 to 73 mm (**figure 5.14**).

Table 5.21. *Gill net selectivity for* Mormyrus lacerda *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	1	31.0	0.03	0.010
28	1	13.0	0.01	0.000
35	0	0	0	0
45	2	32.5	0.06	0.019
57	2	30.0	0.06	0.017
73	49	34.5	1.54	0.619
93	124	39.1	3.90	2.346
118	7	40.4	0.22	0.177
150	0	0	0	0
All mesh sizes	**186**	**37.6**	**0.65**	**0.354**

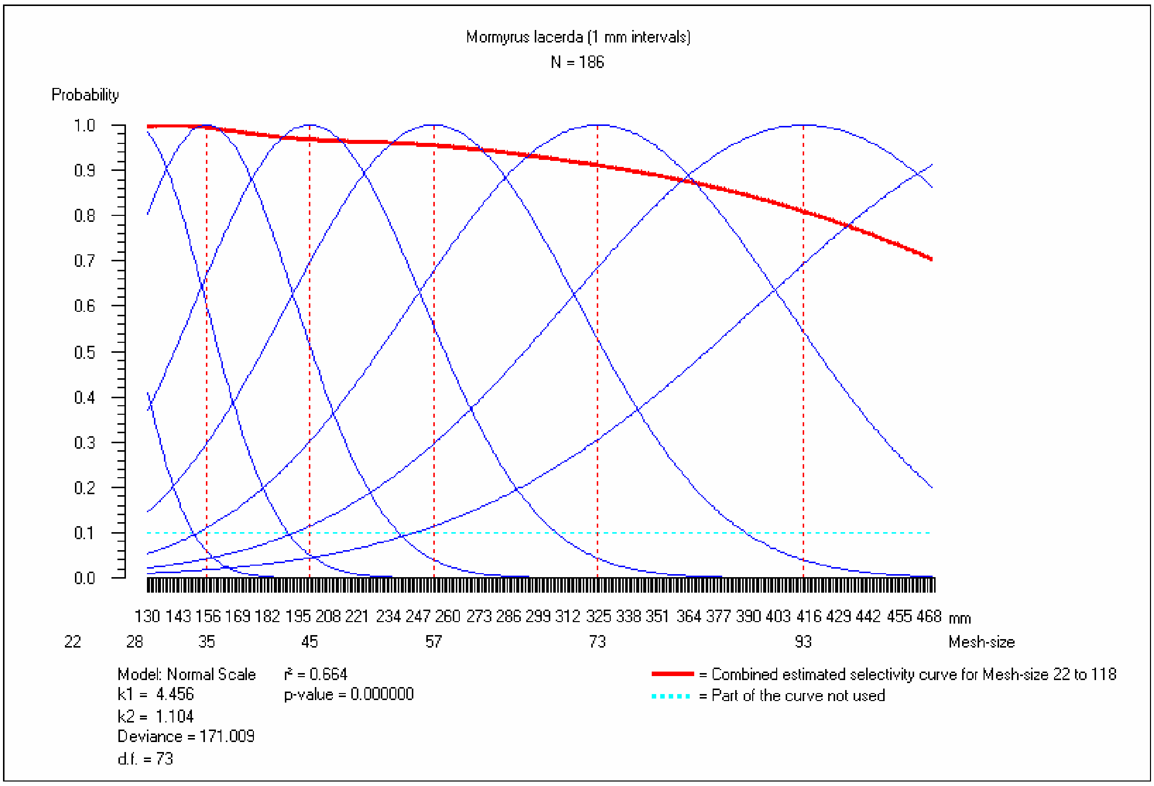

Figure 5.14. *Gill net selectivity for* Mormyrus lacerda *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Hepsetus odoe (African pike):
Overall = 3.7%

Hepsetus odoe was the nineteenth most important species in the pooled catches in gill nets and other gears with regard to numbers (n = 154, 0.9%), the sixth most important species in the gill net catches (IRI = 3.8%), and the nineteenth most important species in the catches with other gears (IRI = 0.1%). The minimum body length at maturity was 27.0 cm for males (27.0 cm in the gill net catches) and 28.0 cm for females (28.0 cm in the gill net catches).

A total of 145 individuals were caught in gill nets, with body lengths from 20.1 to 52.0 cm (mean 35.5 cm, modal length 35.0-35.9 cm) (**figure 5.2**). Only nine individuals were caught by other gears. The body lengths of these fish were between 6.0 and 36.7 cm (mean 14.1 cm, modal length 36.0-36.9 cm) (**figure 5.2**).

Hepsetus odoe was caught in the mesh sizes 22 to 118 mm, with exception of the 28 mm mesh size. The 73 mm mesh had the highest catch in terms of number of fish per setting (1.9 fish/setting) (**table 5.22**). Fish caught with this mesh size had an average body length of 35.7 cm. The 73 mm mesh size also had the highest catch in terms of mass per setting (1.092 kg/setting).

The size group of *Hepsetus odoe* most efficiently caught in the gill nets was fish with body lengths between 22 and 50 cm. They were caught in gill net mesh sizes from 22 to 118 mm (**figure 5.15**).

Table 5.22. *Gill net selectivity for* Hepsetus odoe *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	3	36.7	0.09	0.057
28	0	0	0	0
35	4	34.0	0.13	0.053
45	17	28.1	0.51	0.144
57	29	32.0	0.91	0.354
73	61	35.7	1.92	1.092
93	22	43.2	0.69	0.709
118	9	40.2	0.28	0.238
150	0	0	0	0
All mesh sizes	**145**	**35.5**	**0.50**	**0.294**

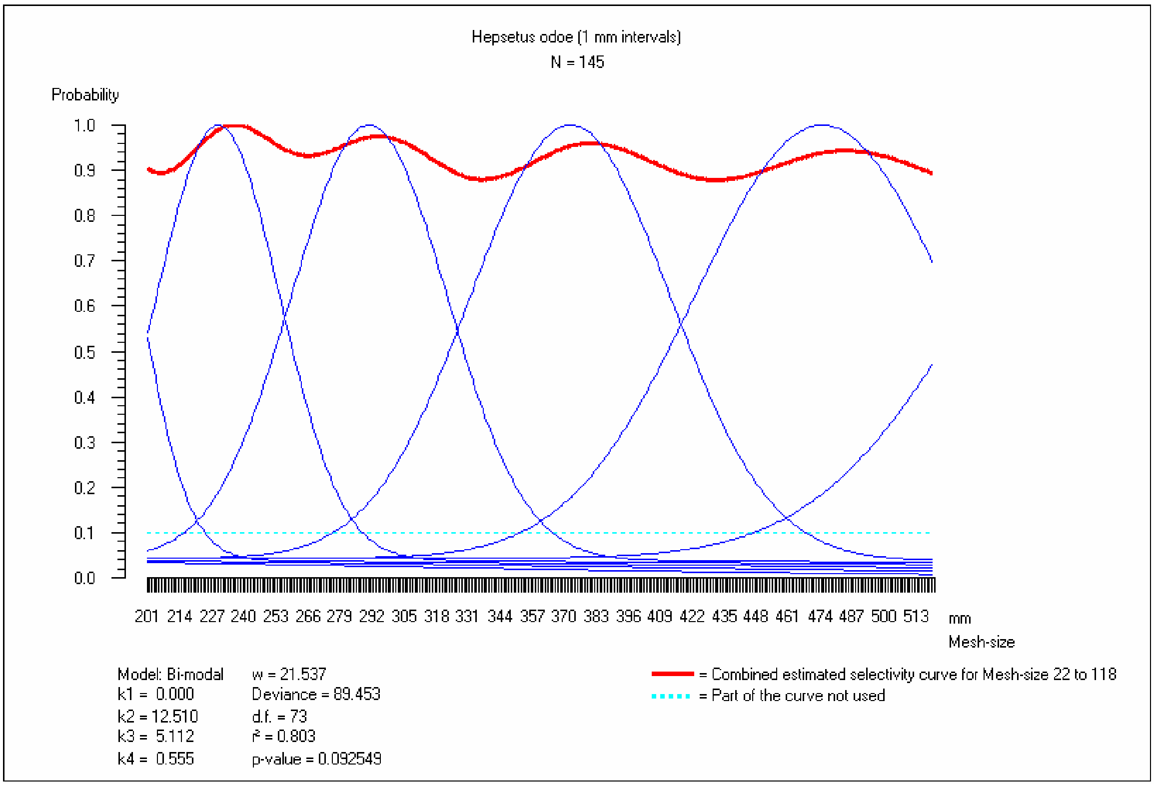

Figure 5.15. *Gill net selectivity for* Hepsetus odoe *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

Schilbe intermedius (Silver catfish):
Overall IRI = 24%

Schilbe intermedius was the seventh most important species in the pooled catches in gill nets and other gears with regard to numbers (n = 852, 4.9%), the most important species in the gill net catches (IRI = 30%), and the sixteenth most important in the catches with other gears (IRI = 0.2%). The minimum body length at maturity was 13.2 cm for males (13.2 cm in the gill net catches) and 14.0 cm for females (14.0 cm in the gill net catches).

A total of 840 individuals were caught in gill nets, with body lengths from 1.6 to 40.3 cm (mean 23.9 cm, modal length 23.0-23.9 cm) (**figure 5.2**). A total of 12 individuals were caught by other gears. The body lengths of these fish were between 19.0 and 35.0 cm (mean 26.6 cm, modal length 26.0-26.9 cm) (**figure 5.2**).

Schilbe intermedius was caught in mesh sizes 22 to 118 mm. The 57 mm mesh size had the highest catch in terms of number of fish per setting (7.3 fish/setting) (**table 5.23**). Fish caught with this mesh size had an average body length of 24.2 cm. The 73 mm mesh size had the highest catch in terms of mass per setting (1.439 kg/setting). Fish caught with this mesh size had an average body length of 28.4 cm.

The size group of *Schilbe intermedius* most efficiently caught in the gill nets was fish with body lengths between 9.0 and 39.0 cm. They were caught in gill net mesh sizes from 22 to 93 mm (**figure 5.16**).

Table 5.23. *Gill net selectivity for* Schilbe intermedius *caught during multi-filament gill net surveys in the Kunene River during 1994-2004. Number of fish caught (n), mean length of fish and mean standard catch per unit effort (CPUE) are given for each mesh size. Setting = 12 hours of fishing with one standard gill net (area = 50 m²).*

Mesh size (mm)	**Number of fish**	**Mean length** (cm)	**CPUE** (n per setting)	**CPUE** (kg per setting)
22	13	20.7	0.41	0.057
28	50	16.6	1.57	0.103
35	110	18.7	3.44	0.285
45	190	21.1	5.97	0.634
57	231	24.2	7.26	1.175
73	163	28.4	5.13	1.439
93	74	32.6	2.33	1.004
118	9	28.9	0.28	0.084
150	0	0	0	0
All mesh sizes	**840**	**23.9**	**2.93**	**0.531**

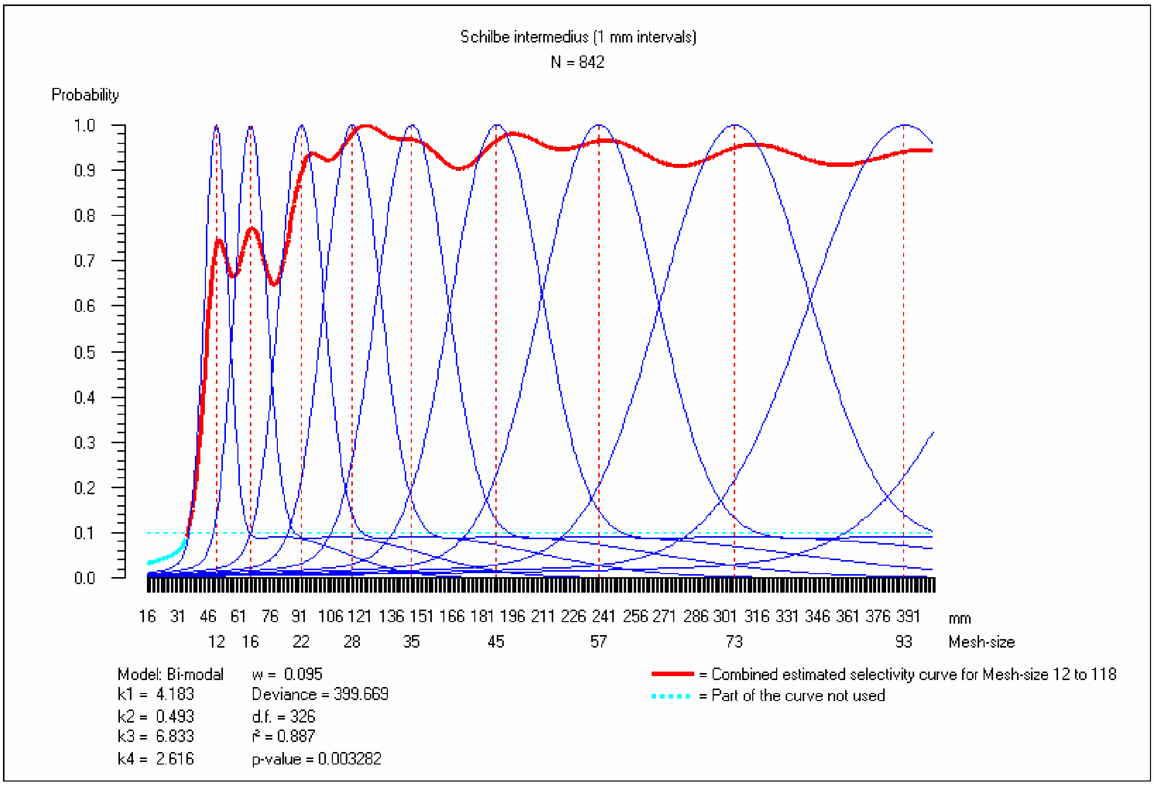

Figure 5.16. *Gill net selectivity for* Schilbe intermedius *for different mesh sizes from 22 mm to 150 mm (blue lines) and combined estimated selectivity curve for all mesh sizes (red line).*

5.4 Catch per unit effort (CPUE)

Catch per unit effort (CPUE) was estimated for the catches in the multi-filament gill nets in order to obtain a relative estimate of the fish densities at the sampling stations. The average CPUE in number of fish and mass were 23.8 fish and 3.1 kg per setting, respectively (**table 5.24**). As indicated by the large standard deviation (sd), there was a large variation in catches among settings.

Table 5.24. *Mean catch per unit effort (CPUE) given as number of fish and mass per setting in the total multi-filament gill net catches (22-150 mm mesh size) during the surveys in the Kunene River during 1994-2004. Setting = 12 hours of fishing with one standard gill net (area = 50 m). sd = standard deviation.*

Total number of settings	**Total number of fish caught**	**Total mass of fish caught** (kg)	**CPUE** (number of fish per setting ± sd)	**CPUE** (kg per setting ± sd)
1431	6862	896	23.8 ± 53.0	3.1 ± 6.3

5.4.1 Catch per unit effort in different mesh sizes

CPUE was estimated for each gill net mesh size (22-150 mm) (**figure 5.17, table 5.25**). Mean CPUE given as number of fish caught per setting decreased with increasing mesh size, from 55.2 fish/setting in the 22 mm mesh size to 0.8 fish/setting in the 150 mm mesh size (**figure 5.17, table 5.25**). For CPUE given as mass per setting, the opposite was found, as mean CPUE increased with increasing mesh sizes up to a maximum in the 73 and 93 mm mesh size, and thereafter decreasing again in the two largest mesh sizes (118 and 150 mm) (**figure 5.17, table 5.25**).

Table 5.25. *Mean catch per unit effort (CPUE) given as number of fish and mass (kg) per setting for total multi-filament gill net samples (22-150 mm mesh size) during surveys in the Kunene River during 1994-2004. Setting = 12 hours of fishing with one standard gill net (area = 50 m). SE = Standard error, sd = standard deviation.*

Mesh size	CPUE, number of fish (n)			CPUE, mass (kg)			Number of settings
	N per setting	SE	sd	Mass per setting	SE	sd	
22	55.2	7.8	98.1	0.6	0.1	1.4	159
28	42.4	6.0	75.2	0.8	0.1	1.4	159
35	29.7	4.7	59.5	1.5	0.2	2.6	159
45	22.9	3.0	38.1	2.1	0.3	3.8	159
57	27.6	3.1	39.3	4.8	0.5	6.6	159
73	22.0	2.2	27.7	6.9	0.7	8.6	159
93	11.4	1.2	15.6	6.3	0.7	9.4	159
118	2.5	0.5	6.2	2.5	0.5	5.8	159
150	0.8	0.2	2.2	2.4	0.5	7.3	159
Total	**23.8**	**1.4**	**53.0**	**3.1**	**0.2**	**6.3**	**1431**

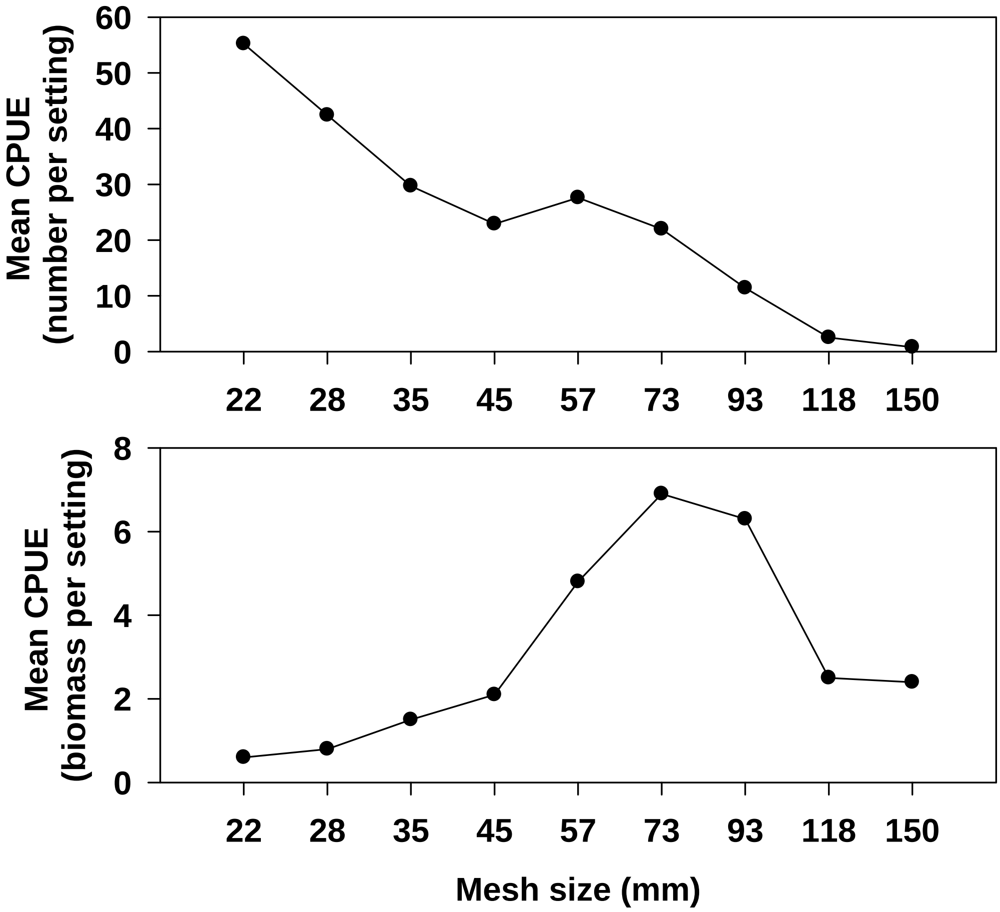

Figure 5.17. *Mean catch per unit effort (CPUE) given as number of fish (upper panel) and mass (kg) per setting (lower panel) for multi-filament gill net catches (22-150 mm mesh size) during surveys in the Kunene River during 1994-2004. Setting = 12 hours of fishing with one standard gill net (50 m²).*

5.4.2 Catch per unit effort at different stations

Average CPUE given as number of fish per setting varied between 3.8 and 56.0 fish/setting among the different sampling stations. The CPUE given as mass per setting varied between 0.9 and 6.2 kg/setting (**table 5.26**). The highest CPUE given as number of fish was recorded at Hippopool station (56.0 fish/setting) and Hartmanns station (32.8 fish/setting). The highest CPUE given as mass was recorded at Hartmanns station (6.2 kg/setting) and Hippopool station (5.7 kg/setting). The lowest CPUE given as number of fish was recorded at Foz do Kunene station (3.8 fish/setting) and Lagoon station (6.3 fish/setting). The lowest CPUE given as mass was recorded at Etemba station (0.9 kg/setting) and Lagoon station (1.0 kg/setting).

Table 5.26. *Total number and mass of fish caught, the percentage of the total catch and number of settings for all mesh sizes (22-150 mm mesh size) at the different sampling stations during multi-filament gill net surveys in the Kunene River during 1994-2004. Mean catch per unit effort (CPUE) given as number of fish and mass per setting is also given. Setting = 12 hours of fishing with one standard gill net (area = 50 m^2). sd = standard deviation.*

Station	**Total catch in number and mass**					**CPUE number**		**CPUE mass**	
	n	**%**	**kg**	**%**	**settings**	**n/setting**	**sd**	**kg/setting**	**sd**
Hippopool	4035	58.8	413.1	46.1	360	56.0	88.4	5.7	8.3
Ondorusu Falls	193	2.8	16.4	1.8	45	21.4	35.4	1.8	2.7
Swartbooisdrif	849	12.4	175.0	19.5	279	15.2	25.6	3.1	6.4
Otjimbundu	263	3.8	27.6	3.1	45	29.2	52.6	3.1	5.1
Etemba	30	0.4	3.2	0.4	18	8.3	9.7	0.9	1.4
Okandomba	47	0.7	5.5	0.6	9	6.1	27.4	3.1	5.6
Epupa	857	12.5	159.2	17.8	333	12.9	24.5	2.4	5.8
Otjinungwa	311	4.5	46.1	5.1	162	9.6	22.7	1.4	3.3
Hartmanns	59	0.8	11.2	1.2	9	32.8	22.4	6.2	11.9
Foz do Kunene	82	1.2	17.2	1.9	72	3.8	6.9	1.1	3.3
Lagoon	136	2.0	21.7	2.4	99	6.3	13.4	1.0	3.0
Total	**6862**	**100**	**896.2**	**100**	**1431**	**23.8**	**53.0**	**3.1**	**6.3**

Table 5.27. *Total number and mass of fish caught, the percentage of the total catch and number of settings for the smallest mesh sizes (22-35 mm mesh size) at the different sampling stations during multi-filament gill net surveys in the Kunene River during 1994-2004. Mean catch per unit effort (CPUE) given as number of fish and mass per setting is also given. Setting = 12 hours of fishing with one standard gill net (area = 50 m^2). sd = standard deviation.*

Station	Total catch in number and mass					CPUE number		CPUE mass	
	n	%	kg	%	settings	n/setting	sd	kg/setting	sd
Hippopool	2612	64.0	55.4	57.95	120	108.8	124.9	2.3	2.8
Ondorusu Falls	137	3.4	3.0	3.16	15	45.7	51.0	1.0	1.1
Swartbooisdrif	334	8.2	8.1	8.46	93	18.0	27.9	0.4	0.7
Otjimbundu	171	4.2	3.6	3.80	15	57.0	81.0	1.2	1.2
Etemba	14	0.3	0.5	0.54	6	11.7	10.3	0.4	0.8
Okandomba	18	0.4	0.38	0.40	3	30.0	10.0	0.6	0.4
Epupa	466	11.4	14.0	14.66	111	21.0	35.8	0.6	1.5
Otjinungwa	209	5.1	6.7	7.03	53	19.7	36.3	0.6	1.8
Hartmanns	32	0.8	0.6	0.60	3	53.3	10.4	1.0	0.5
Foz do Kunene	44	1.1	1.8	1.90	24	4.4	9.4	0.2	0.4
Lagoon	43	1.1	1.4	1.49	33	5.3	8.4	0.2	0.3
Total	**4080**	**100**	**95.6**	**100**	**476**	**42.5**	**79.8**	**1.0**	**1.9**

Table 5.28. *Total number and mass of fish caught, the percentage of the total catch and number of settings for the medium mesh sizes (45-73 mm mesh size) at the different sampling stations during multi-filament gill net surveys in the Kunene River during 1994-2004. Mean catch per unit effort (CPUE) given as number of fish and mass per setting is also given. Setting = 12 hours of fishing with one standard gill net (area = 50 m^2). sd = standard deviation.*

Station	Total catch in number and mass					CPUE number		CPUE mass	
	n	%	kg	%	settings	n/setting	sd	kg/setting	sd
Hippopool	1232	53.3	229.0	51.8	119	51.8	51.3	9.6	9.4
Ondorusu Falls	49	2.1	8.3	1.9	15	16.3	17.0	2.8	3.1
Swartbooisdrif	433	18.7	90.0	20.4	92	23.5	30.4	4.9	6.8
Otjimbundu	76	3.3	11.9	2.7	15	25.3	23.9	4.0	4.0
Etemba	12	0.5	1.1	0.3	6	10.0	11.8	0.9	0.8
Okandomba	29	1.2	5.2	1.2	3	48.3	33.3	8.6	7.7
Epupa	280	12.1	60.5	13.7	111	12.6	16.1	2.7	4.3
Otjinungwa	76	3.3	17.5	4.0	53	7.2	9.3	1.7	2.5
Hartmanns	18	0.7	3.4	0.8	3	30.0	10.0	5.7	5.4
Foz do Kunene	25	1.1	4.4	1.00	24	4.5	4.6	0.8	1.0
Lagoon	81	3.5	10.9	2.5	33	12.0	20.3	1.6	3.7
Total	**2311**	**100**	**442.2**	**100**	**474**	**24.3**	**35.5**	**4.7**	**6.9**

Table 5.29. *Total number and mass of fish caught, the percentage of the total catch and number of settings for the largest mesh sizes (93-150 mm mesh size) at the different sampling stations during multi-filament gill net surveys in the Kunene River during 1994-2004. Mean catch per unit effort (CPUE) given as number of fish and mass per setting is also given. Setting = 12 hours of fishing with one standard gill net (area = 50 m^2). sd = standard deviation.*

Station	**Total catch in number and mass**					**CPUE number**		**CPUE mass**	
	n	**%**	**kg**	**%**	**settings**	**n/setting**	**sd**	**kg/setting**	**sd**
Hippopool	191	40.5	128.7	35.90	120	8.0	13.8	5.4	9.0
Ondorusu Falls	7	1.5	5.1	1.42	15	2.3	3.7	1.7	3.2
Swartbooisdrif	82	17.4	76.8	21.44	92	4.5	10.0	4.2	8.1
Otjimbundu	16	3.4	12.1	3.37	15	5.3	10.3	4.0	7.6
Etemba	4	0.8	1.6	0.44	6	3.3	5.2	1.3	2.2
Okandomba	0	-	-	-	-	-	-	-	-
Epupa	111	23.6	84.7	23.62	111	5.0	12.0	3.8	8.6
Otjinungwa	26	5.5	21.9	6.10	54	2.4	5.0	2.0	4.8
Hartmanns	9	1.9	7.3	2.02	3	15.0	26.0	12.1	20.9
Foz do Kunene	13	2.7	11.0	3.07	24	2.6	5.9	2.2	5.6
Lagoon	12	2.5	9.3	2.61	33	1.6	3.6	1.3	3.7
Total	**471**	**100**	**358.5**	**100**	**476**	**4.9**	**10.8**	**3.8**	**7.8**

To study the gill net catches in various mesh sizes, the catches were divided into three mesh size intervals, 22-35 mm, 45-73 mm and 93-150 mm (**table 5.27, table 5.28, table 5.29**). The average catches in numbers of fish varied from 4.9 fish per setting in the 93-150 mm interval to 42.5 fish per setting in the 22-35 mm interval. The average catches in mass varied from 1.0 kg setting in the 22-35 mm interval to 4.7 kg per setting in the 45-73 mm interval.

In the 22-35 mm and 45-73 mm mesh intervals, average catches were highest at the Hippopool sStation, given in both number of fish and mass per setting (**table 5.27, table 5.28, table 5.29**). In the 93-150 mm mesh interval, the Hartmanns station had the highest average catch, given in both number of fish and mass per setting.

6 DISCUSSION

6.1 Species diversity

Comparable fish surveys to those reported here were conducted in the Okavango River during 1992-1999 (Hay *et al*. 2000), in the Zambezi and Chobe Rivers during 1997-2000 (Hay *et al*. 2002) and in the Kwando River during 1997-1999 (Næsje *et al*. 2004). The methodology was standardized to allow comparisons among the different river systems. The river systems of the Okavango, Zambezi, Chobe and Kwando, however, have large floodplains, differing from the Kunene River, where the channel-like formation dominates the Namibian section of the river.

6.1.1 All stations combined

6.1.1.1 Catches with all gear types

A total of 50 fish species were identified during the surveys, of which four species were marine species. In addition, *Synodontis* spp., an unknown freshwater species, an unknown marine species and Gobiidae spp. were recorded. Hay *et al*. (1997) and Hay *et al*. (1999) reported 69 and 65 species from the Kunene River, although this included the entire river system and not just the Namibian section as is the case in this report. The species diversity (freshwater species) is lower than in the Okavango River (Hay *et al*. 2000), Zambezi and Chobe Rivers (Hay *et al*. 2002), but higher than in the Kwando River (Næsje *et al*., 2004).

Hay *et al*. (1999) calculated the similarity indexes (SI) between the different river systems and found that the SI was the highest for the Okavango/Upper Zambezi comparison (0.86), followed by the Kunene/Okavango comparison (0.51) and then by the Kunene/Upper Zambezi comparison. There is a remarkable difference in species diversity if taken into account that, according to Hay *et al*. (1999), 49 species in the Kunene River are not shared with the Okavango River and 54 species are not shared with the Upper Zambezi River. Five species are listed as endemic to the Kunene River, which are *Kneria maydelli, Orthochromis machadoi, Sargochromis coulteri, Thoracochromis albolabris* and *Thoracochromis buysi*. The status of the undescribed *Clariallabes* sp. is not known. Other fresh water species present in the Kunene River but absent from the Okavango and Upper Zambezi River Systems are *Labeo ansorgii, Barbus mattozi, Aplocheilichthys macrurus, Labeo ruddi* and *Barbus trimaculatus*. Other anomalies are the absence of *Hydrocynus vittatus, Serranochromis robustus, Labeo cylindricus* and *Labeo lunatus* from the Kunene River as well as the families Anabantidae and Mastacembelidae.

The two most important species in the Kunene River, *Schilbe intermedius* and *Brycinus lateralis*, were also the two most important in the Zambezi/Chobe Rivers (Hay *et al*. 2002). Both these species were also very common in the Okavango River (Hay *et al*. 2000).

Several species in the Kunene River are considered to be habitat specialists and are confined to specific habitat types. These are *Clariallabes* sp., *Barbus breviceps, Kneria maydelli, Leptoglanis rotundiceps* and *Chiloglanis neumanni*. *The Clariallabes* sp. and

Chiloglanis neumanni are restricted to rapid habitats, *Barbus breviceps* and *Kneria maydelli* to fountains and *Leptoglanis rotundiceps* to sandy substrates with clear water currents. Despite being habitat specialists, *Chiloglanis neumanni* and *Clariallabes* sp. are not considered rare, mainly due to many rapid habitats present in the studied section of the river. *Barbus breviceps* and *Kneria maydelli* are considered threatened due to their restriction to fountains, of which only three have been found in the area. Although common in these fountains, any disturbance could lead to the disappearance of entire populations.

Low numbers of several species were recorded, which can be attributed to the absence of floodplains along the Namibian section of the river. It is expected that the floodplain species will be more common in the upper reaches of the river in Angola where floodplains are more frequently present. *Micralestes acutidens, Barbus eutaenia* and *Mesobola brevianalis* also prefer habitats with strong water currents and were commonly sampled mainly due to large sections of the river with these habitats. Low numbers of *Serranochromis altus* and *Serranochromis thumbergi* were recorded during this study. The reason for their low numbers is unknown.

The marine species were restricted to the river mouth, with the Mugilidae found up to approximately 10 kilometers from the mouth. It is expected that these species will migrate further upstream, but rapids prevented further sampling. This family was found more than 60 km from the river mouth in the Lower Orange River (Hay pers. obs).

6.1.1.2 Catches with gill nets

A total of 35 species were identified in the gill net cathes, of which two were marine species. In addition, *Synodontis* spp., Gobiidae spp., an unknown species and an unidentified marine species were recorded. Hence, 33 fresh water species were sampled, compared to 40 species during similar surveys in the Zambezi/Chobe Rivers (Hay *et al*. 2002), 41 species in the Okavango River (Hay *et al*. 2000) and 30 species in the Kwando River (Næsje *et al*. 2004).

Schilbe intermedius, Brycinus lateralis, Marcusenius macrolepidotus, Hepsetus odoe and *Clarias gariepinus* were all within the ten most important species sampled with the gill nets in the Kunene, Zambezi/Chobe, Kwando and Okavango Rivers. This, despite the difference in habitat types between the Kunene River and the other floodplain rivers. In all river systems, the ten most important species dominated the catches according to the total IRI. Species sampled with the gill nets in the Kunene River, but not in the other rivers, were *Labeo ansorgii, Labeo ruddi, Thoracochromis buysi, Barbus trimaculatus, Sargochromis coulteri, Orthochromis machadoi, Mugil cephalus* (marine species), *Thoracochromis albolabris, Pomadasys commersonii* (marine species), *Barbus eutaenia*, a marine species from the family Gobiidae and an unknown marine species.

The ten most important species in the gill net catches in the Kunene River comprised a larger proportion of the total fish caught (88%) than those in the Okavango River (84%), but less than those in the Zambezi/Chobe Rivers (96%) and in the Kwando River (98%) (Hay *et al*. 2000, Hay *et al*. 2002, Næsje *et al*. 2004). The two most important species contributed only 45% of the total IRI in the Kunene River compared to 73% in the Zambezi/Chobe River, 59% in the Kwando River and 58% in the Okavango River. *Brycinus* *lateralis* was similar to the Zambezi/Chobe River, the most abundant species sampled in the Kunene River, but not as frequently sampled as *Schilbe intermedius* in the Kunene, Zambezi/Chobe and Okavango Rivers.

The Characidae dominated the catches in the Zambezi/Chobe Rivers, whereas in the Okavango and Kunene Rivers their contributions were only 12% and 17%, respectively. Although high in species diversity, the Cichlidae constituted only 1% of the total IRI in the Kunene River, similar to the Zambezi/Chobe and Okavango Rivers. The Mormyridae had a similar contribution in the Kunene River (11%) as in the Zambezi/Chobe Rivers (10%), but was higher in the Okavango River (19%).

6.1.1.3 Catches by other gears

The number of species recorded with other gears than gill nets in the Kunene River (47) was lower than in the Zambezi/Chobe (67) and Okavango Rivers (70) (Hay *et al*. 2002, Hay *et al*. 2000). The absence of floodplains is most likely the reason for this lower diversity in the Kunene River. *Tilapia rendalli* is the only species listed among the ten most important species caught by other gears in the Kunene, Zambezi/Chobe, Okavango and Kwando Rivers (this study, Hay *et al*. 2002, Hay *et al*. 2000, Næsje *et al*. 2004).

Fifteen species were recorded only in the catches by other gears and not in the gill nets, which were *Aplocheilichthys macrurus, Chiloglanis neumanni, Barbus fasciolatus, Clariallabes sp., Barbus breviceps, Kneria maydelli, Mesobola brevianalis, Liza falcipinis, Hemigrammocharax multifasciatus, Lichia amia, Barbus barnardi, Serranochromis thumbergi, Leptoglanis rotundiceps, Barbus thamalakanensis* and *Clarias theodorae*. Some of these are mainly small species or species requiring specific habitats where gill nets could not be set. The difference in number of species between the gill nets catches and catches by other gears were much smaller in the Kunene River than in the Zambezi/Chobe and Okavango Rivers. The main reason is likely that the floodplains, absent from the Kunene River, accommodate large numbers of small sized species that are not targeted by the gill nets. A larger number of species would likely have been recorded by other gears if the floodplains of the Kunene River in Angola had been sampled.

6.1.2 River versus the river mouth

6.1.2.1 All gear types

A total of 46 species was sampled at the stations in the rest of the river compared to 23 species sampled in the river mouth. Another difference was the presence of four marine species sampled in the river mouth (excluding Gobiidae spp and an unknown marine species). The marine species *Mugil cephalus* dominated the catches in the river mouth, constituting 78% of the total IRI. The most important species in the rest of the river, *Schilbe intermedius*, constituted only 25% of the total IRI in the river mouth.

The species diversity was much higher in the rest of the river (Shannon index of 3.04) than in the river mouth (Shannon index of 1.39). This is attributed to the dominance of *Mugil cephalus* in the river mouth, reducing the species diversity at these stations. Seven of the ten most important species were present in the river mouth as well as in the rest of the river. These were *Marcusenius macrolepidotus, Mormyrus lacerda, Schilbe intermedius, Thoracochromis buysi, Clarias gariepinus*, *Micralestes acutidens* and *Labeo ansorgii*.

The families Cyprinidae and Cichlidae also had a higher diversity in the rest of the river (14 and 12 species, respectively) than in the river mouth (6 and 5 species, respectively). Also the families Schilbeidae and Characidae constituted 39% of the total IRI in the rest of the river compared to only 2% in the river mouth, again due to the high number of the family Mugilidae sampled at the river mouth stations.

The marine species in the river mouth play an important role when considering the number and abundance of species, as nearly 82% of the IRI comprised of marine species.

6.1.2.2 Catches with gill nets

The families Schilbeidae and Characidae dominated the gill net catches in the rest of the river, compared to the Mormyridae in the river mouth. Also fewer species (18 species) were recorded by gill nets in the river mouth, compared to in the rest of the river (33 species). The Shannon index was very similar between the two areas although very few fish were sampled in the river mouth with the gill nets. One reason for this is that sites where gill nets can be set are limited in the river mouth due to the influence of the sea, with currents changing continuously and the absence of vegetation that can be used as anchorage. This was also the reason why so few individuals of *Mugil cephalus* were sampled with gill nets compared to other gears. Six species, both at the stations in the rest of the river and in the river mouth, were listed among the ten most important species according to the IRI, which were *Schilbe intermedius, Labeo ansorgii, Barbus mattozi, Marcusenius macrolepidotus, Clarias gariepinus* and *Mormyrus lacerda*.

6.1.2.3 Catches by other gears

The Cichlidae dominated the catches by other gears in the rest of the river (IRI of 70%), whereas the Mugilidae dominated the catches in the river mouth (IRI of 97%). Fortyfour species were sampled by other gears in the rest of the river and only 16 species in the river mouth.

Six species, *Thoracochromis buysi, Oreochromis macrochir, Tilapia rendalli*, *Micralestes acutidens*, *Labeo ansorgii* and *Barbus mattozi* were all listed among the ten most important species in both areas. The species diversity was also much higher in the rest of the river than in the river mouth, again due to the dominance of *Mugil cephalus* in the river mouth.

6.2 Catch per unit effort (CPUE)

The catch per unit effort in the multi-filament gill nets was higher in mass (3.1 kg per setting) for the Kunene River than any of the other Namibian rivers surveyed with similar methods, except the Lower Orange River (3.9 kg per setting in the Lower Orange River, 1.87 kg per setting in the Zambezi/Chobe Rivers, 1.44 kg per setting in the Okavango

River and 1.23 kg per setting in the Kwando River; Hay *et al*. 2000, 2002, Næsje *et al*. 2004, 2007). In number of fish per setting, the catches in the Kunene River were higher (24 fish per setting) than in the Lower Orange River (17 fish per setting) and Kwando River (10 fish per setting), but lower than in the Okavango River (28 fish per setting) and Zambezi/Chobe Rivers (89 fish per setting) (Hay *et al*. 2000, 2002, Næsje *et al*. 2004, 2007).

6.2.1 Catch per unit effort in different mesh sizes

Mean CPUE given as number of fish caught per setting decreased with increasing mesh size. For CPUE given as mass per setting, the opposite was found, as mean CPUE increased with increasing mesh sizes up to a maximum in the 73 and 93 mm mesh size, and thereafter decreasing again in the two largest mesh sizes. A similar tendency was observed for the Orange River (Næsje *et al*. 2007).

6.2.2 Catch per unit effort at different stations

Similar to in the Orange, Okavango and Zambezi/Chobe Rivers (Hay *et al*. 2000, 2002, Næsje *et al*. 2007), the catch per unit effort in the Kunene River varied among stations. Hippopool had the highest CPUE of all stations in the Kunene River, both in number of fish as well as in mass. The lowest CPUE given as number of fish was recorded at Foz do Kunene and as mass at Etemba. The low number of settings at Etemba may have influenced the results.

6.3 Body length at maturity

Several species from the Kunene River had larger minimum lengths at maturity than those from the Zambezi/Chobe (Hay *et al*. 2002) and Okavango Rivers (Hay *et al*. 2000). These were *Schilbe intermedius, Brycinus lateralis, Marcusenius macrolepidotus, Hepsetus odoe, Serranochromis macrocephalus* and *Petrocephalus catostoma*. The minimum lengths at maturity, however, were very similar to those recorded from the Kwando River (Næsje *et al*. 2004). The larger maturity lengths in the Kunene River could be an indication of utilization of the resources in the Zambezi and Okavango Rivers, as very little harvesting has been observed in both the Kunene and Kwando Rivers over the last decade.

Oreochromis macrochir had smaller minimum lengths at maturity in the Kunene River than in the Zambezi/Chobe Rivers. Minimum lengths at maturity for *Tilapia rendalli* and *Clarias gariepinus* varied between the different river systems. *Clarias gariepinus* has a wide habitat tolerance and is an omnivore, which may enable this species to withstand high utilization pressure.

6.4 Life history and gill net selectivity for important species

The 14 species selected for detailed analyses contributed 56% of the total number and 64% of the total weight sampled. They were all important species sampled during the surveys between 1994 and 2004.

Thoracochromis buysi, a medium-sized species, was sampled with gill nets of smaller mesh sizes than 73 mm, with the majority of fish sampled with the 22, 28 and 35 mm mesh sizes. It was the most important species sampled with the other gears, mainly due to the high number caught and frequency of occurrence. The majority of the fish sampled with gill nets had body lengths between 50 and 130 mm, and those sampled with other gears between 30 and 130 mm. The mean and modal body lengths indicate that larger fish were recorded with the gill nets than with the other gear types.

Only fish sampled with the 35 mm to 57 mm mesh size were mature, with the majority of the fish sampled in gill nets and other gears being immature, according to the length frequencies. The maximum body length sampled was much larger than the length indicated by van Zyl (1992) and Skelton (2001), as well as larger than the holotype as stated by Penrith (1970). *Thoracochromis buysi* has also been found to be migrating into the Cuvelai System in Northern Namibia due to the artificial linkage between the Kunene and Cuvelai Systems (van der Waal 1991, Hay *et al*. 1997b).

Oreochromis macrochir was sampled with all the gill nets mesh sizes, except with the 22 and 150 mm mesh size. The body length range of fish sampled with gill nets was much larger than in the Zambezi/Chobe River (Hay *et al*. 2002). The mean and modal body length was also larger in the Kunene River than in the Zambezi/Chobe River. A similar length range was sampled in the Kwando River despite the fact that only six individuals were recorded with the gill nets in the Kwando River (Næsje *et al*. 2004). A higher number of individuals were sampled with other gears, and they were much smaller with smaller mean and modal body lengths. These body lengths were similar to the catches in the Zambezi/Chobe Rivers (Hay *et al*. 2002) and the Kwando River (Næsje *et al*. 2004). The maximum length was the largest in the Kunene River, but the mean lengths were similar in the different river systems. The maximum length recorded in Lake Liambezi was larger than the lengths recorded in the Kunene River (van der Waal 1985).

The 73 mm mesh size was the most effective, with the highest catch per unit effort in number of fish caught as well as in mass. The fish caught with this mesh size was mainly mature fish. Also in the Okavango River, the 73 mm mesh size was the most efficient (Hay *et al*. 2000). The mean body length of individuals caught in this mesh size was slightly smaller in the Kunene River than in the Okavango River. *Oreochromis macrochir* was important in the gill net subsistence fishery in the Zambezi/Chobe Rivers (van der Waal 1990, Hay pers. obs).

The minimum body length at maturity for both males and females was smaller in the Kunene River than in the Lake Liambezi (van der Waal 1985), the Zambezi/Chobe Rivers (Hay *et al*. 2002) and in the Kwando River (Næsje *et al*. 2004). Van Zyl (1992), however, reported slightly larger minimum lengths in the Kunene River, and with smaller lengths at 50% maturity than calculated in this study.

Tilapia rendalli was sampled with all mesh sizes except the 28 and 150 mm mesh size. Very few individuals were sampled with gill nets, with the majority of the fish sampled by other gears. This was similar to the surveys in the Okavango (Hay *et al*. 2000), Zambezi/Chobe (Hay *et al*. 2002) and Kwando Rivers (Næsje *et al*. 2004) as well as in Lake Liambezi (van der Waal 1985). The reason may be that *Tilapia rendalli* prefers vegetated habitats where it is sometimes difficult to set the gill nets with a motorized boat. In the subsistence fishery using traditional mokoro boats, large numbers of *Tilapia rendalli* are caught with gill nets. The fishers set their nets near or in vegetated habitats and use a wooden oar to hit the water surface to chase the fish into the gill nets. Large numbers of *Tilapia rendalli* are caught using this method. The body length range caught with the gill nets in the Kunene River was similar to in the Zambezi/Chobe Rivers (Hay *et al*. 2002). The maximum body length recorded in the Kunene River was smaller than the maximum body length recorded in the Zambezi/Chobe and Okavango Rivers, but similar to the maximum body length recorded in Lake Liambezi.

The 93 mm mesh size had the highest CPUE in number of fish caught as well as in mass. In comparison, the 35 mm mesh size had the highest CPUE in number of fish caught and the 73 mm mesh size in mass in the Zambezi/Chobe Rivers (Hay *et al*. 2002). In the Okavango River, the 73 mm mesh size had the highest catch in number of fish caught and the 118 mm mesh size the highest catch in mass (Hay *et al*. 2000). The mesh sizes 45 to 93 mm caught fish efficiently in the Kunene River, compared to the mesh sizes 57 to 118 mm in the Okavango River (Hay *et al*. 2000). The 45 mm and larger mesh sizes all caught mainly fish larger than the minimum length at maturity, and the 73 mm mesh size larger than the length at 50% maturity. The length frequency of the catches by other gears indicates that the majority of the fish sampled were immature, compared to mainly mature fish being recorded with the gill nets. Several length classes caught by other gears had not been sampled with the gill nets.

Serranochromis macrocephalus was sampled with all the different gill net mesh sizes, with the majority sampled with the 73 and 93 mm mesh size. The body length range of the individuals caught with the gill nets was larger than that of the catches in the Okavango River, with a much larger mean and modal length. This species was more numerous in the catches sampled with the other gears in the Okavango River than in the Kunene River, with a slightly larger mean and modal body length than in the catches in the Kunene River. The majority of the fish sampled with the gill nets were larger than 230 mm, whereas the majority of the individuals sampled with the other gears were smaller than 110 mm.

The larger mesh sizes were more effective for this species in the Kunene River than in the Okavango River (Hay *et al*. 2000), with the highest CPUE in number of fish caught with the 93 mm mesh size in the Kunene River and with the 45 mm mesh size in the Okavango River. The 150 mm mesh size also sampled this species in the Kunene River, but with no catches with this mesh size in the Okavango River. The mean body length of the individuals sampled in the Kunene River was smaller than those sampled in the Zambezi/Chobe Rivers (Hay *et al*. 2002), but larger than those sampled in the Okavango (Hay *et al*. 2000) and Kwando Rivers (Næsje *et al*. 2004). The Kunene River, however, had the largest individual fish sampled of all the rivers.

Barbus mattozi is present in the Kunene River, absent from the Okavango River and has not been recorded in the Zambezi/Chobe and Kwando Rivers although Skelton (2001) showed that it may be present in the Kwando-upper and Zambezi Rivers. This species was also recorded in the Limpopo and Incomati River System, but was not found to be abundant (Gaigher 1969). The preferred habitat was deep pools in perennial and non-perennial rivers. Preferred habitats in Zimbabwean rivers are quiet water areas with associated vegetation. It is also mentioned that the species was found in fast flowing rocky habitats (Bell-Cross & Minshull 1988).

Barbus mattozi was very common in the gill net catches, with much fewer individuals sampled by other gears. It seemed to be much more abundant in the Kunene River than in the Limpopo and Incomati River System (Gaigher 1969). It was, however, more common in irrigation dams in the Limpopo and Incomati System than in Zimbabwean rivers.

This species was sampled with all the gill net mesh sizes except for the 150 mm mesh size. The 57 mm mesh size had the highest CPUE in number of fish caught and the 73 mm mesh size in mass. The maximum body length recorded was 390 mm sampled with the gill nets. The majority of the fish sampled with the gill nets were mature according to the length frequencies, whereas mainly juveniles were caught by other gears. The gill nets were not very effective in sampling of juveniles, especially fish smaller than 110 mm.

Labeo ansorgii is present only in the Kunene River and in the Ouanza River in Angola. Very little is known about this species and all that is mentioned by Skelton (2001) is that it prefers flowing water in rocky habitats. This, despite the fact that it was the fourth most important species sampled with the gill nets during the surveys. It is also present throughout the river system from the upper reaches (Hay *et al*. 1997a) to down to the river mouth, although not as common in the river mouth as it was in the rest of the river. The high number sampled with gill nets may also be an indication that it is present in deep water habitats. Mainly mature fish were sampled with the gill nets, whereas mainly smaller fish were sampled by other gears, according to the length frequencies. The small fish sampled indicate successful recruitment during the survey period. The maximum length was slightly larger than reported by Skelton (2001). The high number sampled shows that this species, although having a restricted distribution, is not presently threatened in the surveyed section of the Kunene River, based on surveys carried out during 1994-2004.

Labeo ruddi is present in the Kunene River, but has not yet been collected in the Okavango or the Zambezi/Chobe Rivers. However, it is present in the Limpopo and Incomati System (Skelton 2001). It was sampled in the Kunene River during the surveys with the mesh sizes 35 to 118 mm, with the majority of the fish caught with the 57 and 73 mm mesh size. The mesh size with the highest CPUE both in number of fish caught and mass was the 57 mm. The body length range of individuals caught with gill nets was between 130 and 380 mm. The species was more commonly sampled with gill nets than with other gears. It was also found to be relatively common in the Limpopo River (Gaigher 1969) and in some rivers in Zimbabwe (Bell-Cross & Minshull 1988). It has not yet been recorded above the Ruacana Falls in the Kunene River (Hay *et al*. 1997a).

The maximum body length recorded was larger than the body length mentioned by Skelton (2001). The mean body length recorded for catches in the gill nets was larger than the maturity lengths calculated, but smaller for catches by other gears. Hence, according to the length frequency of the catches, the majority of the fish sampled with gill nets were mature and the majority of the fish sampled with other gears were juveniles.

Barbus trimaculatus was not very common in the gill net catches. It was relatively common in the Lower Orange River (Næsje et al. 2007). It is closely related to *Barbus poechii* from the Okavango and Zambezi/Chobe Rivers. The status of *Barbus trimaculatus* in the Kunene River is still under investigation. The body length range sampled in the Kunene River was larger than that recorded from the Lower Orange River (Næsje et al. 2007) with larger mean and modal lengths. The body length at maturity was also larger in the Kunene River.

Brycinus lateralis was very important in the gill net catches in the Kunene River, similar to all the other rivers in Namibia where it is present. It was the second most important species in the gill net catches in the Kunene River, the most important in the Zambezi/Chobe Rivers (Hay *et al*. 2002), the fifth most important (excluding the *Synodontis* spp.) in the Okavango River (Hay *et al*. 2000) and the eighth most important in the Kwando River (Næsje *et al*. 2004). It was also abundant in the smaller mesh sizes and in the commercial fishery in the Okavango Delta (Merron & Bruton 1988) and in Zimbabwean rivers (Bell-Cross & Minshull 1988). This species was only sampled with the smaller mesh sizes, with no fish collected with the 45 to 150 mm mesh sizes. In the other rivers, the 22 mm mesh had the highest catch rates in number of fish caught and the 28 mm mesh in mass. The mean body lengths per mesh size were larger in the Kunene River, although in the Zambezi/Chobe Rivers (Hay *et al*. 2002) individuals were also recorded with the 45 and 57 mm mesh size, which was not the case in the Kunene River. The mean body length of all fish caught in the Kunene River was larger than in the other rivers. The maximum body length recorded in the Kunene River was also the largest, except for in the Zambezi/Chobe Rivers (Hay *et al*. 2002), where it was slightly larger. According to Bell-Cross (1974), *Brycinus lateralis* does not enter the fishery due to the small size, although larger numbers have been found on the Katima Mulilo market (Hay pers. obs.).

According to the length frequency, the majority of the fish caught with gill nets in the Kunene River were already mature, which is similar to the other river systems in Namibia. The body lengths at maturity in the Kunene River were also slightly larger than in the Zambezi/Chobe Rivers (Hay *et al*. 2000) and the Okavango River (Hay *et al*. 2000), but similar to those calculated in the Kwando River (Næsje *et al*. 2004).

Micralestes acutidens was much more regularly sampled with others gears than gill nets. This was also the scenario for the other river systems. In the Kwando River, it was the third most important species sampled with other gears (Næsje *et al*. 2004). The main reason is that it is a small-sized species with a maximum length of 150 mm sampled in the Kunene River, which was much larger than in any of the other rivers. It was not sampled in the Lake Liambezi (van der Waal 1985), probably as this species prefers clear, flowing water habitats. This species was sampled only with the smaller mesh sizes, from the 22 mm to the 35 mm in the Kunene River. Only eight individuals were recorded with the gill nets in the Okavango River (Hay *et al*. 2000), and only with the 22 mm mesh. In the Zambezi/Chobe Rivers (Hay *et al*. 2002), catches of *Micralestes acutidens* were with the 22 and 28 mm mesh sizes, in addition to a few individuals with the 57 mm mesh size. It was not sampled with gill nets in the Kwando River (Næsje *et al*. 2004). Both in the Kunene and Zambezi/Chobe Rivers, the 22 mm mesh size had the highest CPUE in number of fish caught and mass. The body length range of individuals sampled with gill nets in the Kunene River was between 50 and 150 mm, compared to between 60 and 84 mm in the Zambezi/Chobe Rivers (Hay *et al*. 2002). The mean and modal body lengths were larger in the Kunene River than in the Zambezi/Chobe Rivers.

The larger body lengths at maturity in the Kunene River, together with the larger mean and modal body lengths, may also be an indication of very little utilization in this system. The catchability curve indicated that this species was not efficiently sampled with the gill nets for all length groups, especially those larger than 100 mm.

Marcusenius macrolepidotus was very common in the catches with gill nets, but not with other gears. This species was abundant also in other river systems such as the Okavango River (Hay *et al*. 2000), the Okavango Delta (Mosepele 2000, Merron & Bruton 1988), the Zambezi/Chobe Rivers (Hay *et al*. 2002), Lake Liambezi (van der Waal 1985), the Kwando River (Næsje *et al*. 2004), the Limpopo and Incomati System (Gaigher 1969) and in river systems in Zimbabwe (Bell-Cross & Minshull 1988).

It was only sampled with the mesh sizes 22 to 73 mm in the Kunene River. It is a medium-sized species and is unlikely to be sampled with large mesh sizes. The individuals caught with gill nets had body lengths between 70 and 260 mm, which is similar to the body lengths sampled in the Kwando River (Næsje *et al*. 2004), and slightly larger than in the Okavango River (Hay *et al*. 2000) and Zambezi/Chobe Rivers (Hay *et al*. 2002). The species was not very important in the commercial catches in the Okavango Delta, probably due to the large mesh sizes used (Mosepele 2000). At Impalila in the Caprivi, the two inch gill nets used by the subsistence fishers caught large numbers, with *Marcusenius macrolepidotus* being the second most abundant species sampled, but with very few individuals recorded with the larger mesh sizes (Hay pers. obs.). The 35 mm mesh size had the largest CPUE in number of fish caught and the 45 mm mesh size in mass in the Kunene River, which was the same as in the Okavango River (Hay *et al*. 2000) and the Kwando River (Næsje *et al*. 2004). In the Zambezi/Chobe Rivers, however, the 35 mm mesh size also had the highest CPUE in mass (Hay *et al*. 2002). The mean body length of individuals sampled in the Kunene River was larger than in the Okavango River (Hay *et al*. 2000), the Zambezi/Chobe Rivers (Hay *et al*. 2002) and in the Kwando River (Næsje *et al*. 2004). Also the maximum length recorded was larger in the Kunene River, except for in the Kwando River, where a slightly larger maximum length was recored. The maximum length was also larger in Lake Liambezi (van der Waal 1985).

Mainly mature fish were caught in the gill nets in the Kunene River according to body length frequencies, which is the opposite from the other rivers in Namibia. The modal length in the Kunene River was also larger than in the Okavango (Hay *et al*. 2000), Zambezi/Chobe Rivers (Hay *et al*. 2002) and in the Kwando River (Næsje *et al*. 2004). The modal length in Lake Liambezi was larger than that in the Kunene River, although this may be attributed to the larger mesh sizes used in the lake by van der Waal (1985).

The catchability of the gill nets for *Marcusenius macrolepidotus* was very similar between the different river systems, although gill nets were slightly more efficient for the smaller individuals in the Okavango (Hay *et al*. 2000) and the Zambezi/Chobe Rivers (Hay *et al*. 2002).

Mormyrus lacerda was important in the gill net catches at all stations, including the river mouth. Only two individuals were caught by other gears. This species was not abundantly sampled with the gill nets in the Okavango River, although several individuals were sampled with other gears (Hay *et al*. 2000). It was also not common in the Zambezi/Chobe (Hay *et al*. 2002) and Kwando Rivers (Næsje *et al*. 2004), which is difficult to explain as the preferred habitats such as slow flowing deep water areas and vegetated sites are present (van der Waal & Skelton 1984, Hay *et al*. 1997a, Skelton 2001). *Mormyrus lacerda* appears to be more active at night than during the day (Hay *et al*. 1997a).

This species was not caught with the 35 and 150 mm mesh sizes in the Kunene River. The body length range of the individuals caught with the gill nets was between 130 and 470 mm. The most effective mesh size was the 93 mm, both in number of fish caught as well as in mass, which coincides with the catches in the Okavango Delta, where Merron & Bruton (1988) mentioned that *Mormyrus lacerda* was mainly caught with the large mesh size gill nets. The mean and maximum body lengths recorded in the Kunene River were larger than those recorded in the Lake Liambezi (van der Waal 1985), the Okavango Delta (Merron & Bruton 1988), the Okavango River (Hay *et al*. 2000), the Zambezi/Chobe Rivers (Hay *et al*. 2002) and the Kwando River (Næsje *et al*. 2004). This could be due to no harvesting of the resource in the Kunene River, resulting in large individuals.

The length frequency indicates that the majority of the fish caught were mature, with very few juveniles sampled. The maturity lengths could not be calculated for the other rivers due to low numbers sampled.

Hepsetus odoe was abundantly sampled in the Kunene River with the gill nets, but not with other gears, which was similar to the situation in the other rivers. It was caught in all mesh sizes, except the 28 and 150 mm mesh size. This was similar to the Okavango and Zambezi/Chobe Rivers, except that the 118 mm mesh also did not record this species in those rivers. *Hepsetus odoe* was also abundantly sampled with the gill nets by the subsistence fishes in the Caprivi (Hay pers. obs.). The body length range of individuals caught in the Kunene River varied between 200 and 520 mm and differed from the Okavango, Zambezi/Chobe and Kwando Rivers, where mean and modal lengths were smaller than in the Kunene River. The 73 mm mesh size had the highest catch in number of fish caught and mass in the Kunene River, compared to the 57 mm mesh size in the other rivers. The maximum body length recorded in the Kunene River was 520 mm, which is very large compared to 360 mm in the Zambezi/Chobe Rivers (Hay et al. 2002) and 430 mm in the Okavango River (Hay et al. 2000). Van der Waal (1985) recorded a maximum length of 470 mm in Lake Liambezi.

The length at 50% maturity was much larger in the Kunene River than in any of the other river systems in Namibia, including the Okavango Delta (Merron 1991) and Lake Liambezi (van der Waal 1985). Bell-Cross (1974) mentioned that *Hepsetus odoe* may be restricted in the Upper Zambezi due to competition with *Hydrocynus vittatus*. In the Kafue River, where also *Hydrocynus vittatus* is absent, *Hepsetus odoe* is common in the open water similar to in the Kunene River. The large sizes recorded in the Kunene River may be attributed to the fact that it is replacing the habitats usually frequented by *Hydrocynus vittatus,* and also that it is not utilised in this system. Due to the large individuals recorded, the gill net catches were more effective for the larger sizes compared to the other rivers, where smaller fish were sampled in gill nets.

Schilbe intermedius was very common in the gill net catches in the Kunene River, including the river mouth. This was also the situation for all the other rivers in Namibia as well as in Lake Liambezi (van der Waal 1985), the Okavango Delta (Merron & Bruton 1988, Mosepele 2000), and the Kafue River and Lake Kariba in vegetated areas (Bell-Cross & Minshull 1988). It was sampled in all mesh sizes except the 150 mm mesh size. It is usually easily caught due to the serrated spines. It is a medium-sized species with the majority of the fish caught with the mesh sizes 35 to 73 mm. The 57 mm mesh size had the highest CPUE in number of fish caught, and the 73 mm mesh size in mass. In the other rivers, the smaller mesh sizes were more effective. *Schilbe intermedius* was also regularly sampled with gill nets by the subsistence fishermen in the Caprivi, mainly with the smaller mesh sizes (Hay pers. obs.). The mean and maximum body lengths recorded in the Kunene River were also larger than in the other rivers, also indicating that the absence of utilization of the fish resource in the Kunene River may have benefited this species in terms of growing to larger body sizes. The body length range of individuals caught in the gill nets in the Kunene River was between 10 and 400 mm, which is much larger than in any of the other rivers. The mean and modal body lengths were also much larger in the Kunene River.

The majority of the fish sampled with the gill nets were larger than the minimum maturity lengths calculated. It is apparent from the body length frequencies that the larger individuals were abundant in the Kunene River in comparison to Lake Liambezi (van der Waal 1985), the Okavango Delta (Merron & Bruton 1988), the Okavango River (Hay *et al*. 2000) and the Zambezi/Chobe Rivers (Hay *et al*. 2002).

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