Fish populations, gill net selectivity, and artisanal fisheries in the Okavango River, Namibia

Executive summary and recommendations

C.J. Hay, T.F. Næsje, J. Breistein, K. Hårsaker,
J. Kolding, O.T. Sandlund, and B. v. Zyl

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Executive Summary[1]

Objective:
The objective of this report is to produce guidelines for a sustainable management of the fisheries in the Okavango River, Namibia, based on fish survey data for the years 1992-1999. Data were also collected regarding the subsistence fishery in the river. The rationale for the report is the 1995 White Paper "Responsible Management of the Inland Fisheries of Namibia" and the draft bill on inland fisheries. These have the objectives of ensuring a sustainable and optimal utilisation of the freshwater resources, and to favour utilisation of fish resources by subsistence households over commercialisation. The stated policy takes into consideration the large differences among water systems in Namibia and proposes adoption of separate management regimes for the various river systems.

Material and study area:
Fish were collected in seven main areas (Matava, Musese, Bunya, Rundu, Cuito, Mbambi, and Kwetze) with survey gill nets (22–150 mm stretched mesh) and 16 other sampling methods, such as seine nets, mosquito nets, cast nets, angling, electrofishing apparatus, rotenone and different traditional gears. These are later collectively called "other gears". The stations were selected to include all main habitats present in the Okavango River. The gill nets were mainly used in relatively deep water, whereas the other gears were mainly used in shallow and vegetated habitats. All seven localities were sampled at least once a year between 1992 and 1999. A total of 47438 fishes were sampled, 13559 in gill nets, and 33879 in other gears.

The Okavango River originates in the central highlands of Angola at approx. 1700 m a.s.l. and enters Namibia at Katwitwi. The river forms the border between Namibia and Angola before turning south towards Botswana. Along the Namibian section of the river, there are large floodplains with sandy substrates and rocky outcrops, and abundant aquatic vegetation. After a distance of 460 km within Namibia, the river enters Botswana where it evaporates in the swamps of the Okavango Delta.

The annual flood in the Namibian portion of the Okavango starts during December reaches its peak in March-April and recedes during May. The annual discharge of the Okavango at Rundu is between 5,000 and 6,000 million m^3. Below the confluence with the Cuito River, the annual discharge nearly doubles to over 10,000 million m^3.

More than 136,000 people live in the Okavango region. An estimated 90 % of the population live within 10 km of the river, and many of the economic and social activities in the region are connected to the river. More than 50 % of the human population along the river do fish, both with traditional gears such as baskets, funnel traps and fences constructed of plant material, and with some modern gears such as gill nets, seines, hook and line, and mosquito-nets. For more than 90 % of the households fish is a source of subsistence, and sales of fish provide some income for approximately 45 % of the households. The highest population density is at Rundu, whereas no people live at Kwetze, which is within the Mahongo Game Park. It is assumed that the fishing pressure is correlated to the riparian population density.

Results:
Data on local fishing activities were collected through a survey of the gears (modern and traditional) used in the subsistence fishery and interviews with fisherfolk attending their gear in June 1994. This survey revealed that the peak fishing time is during the receding phase of the flood and during low water periods when the fish are concentrated, i.e. from May onwards. There is reduced fishing activity during the flood when large areas along the river become inaccessible for the subsistence fishers. A diversity of traditional gears include, e.g., baited traps, corral traps, fish fences, scoop baskets, fish funnel, bow and arrow, and fish spear. Modern gears are mainly restricted to gill nets, used most often by men, and mosquito nets, a method used by women. Casts nets were rarely used. A comparison with earlier surveys reveals that there is an overall decline in catches in subsistence fisheries from 1987 to 1992. A socio-economic survey in 1994 indicated that 56,000 people along the Namibian portion of the Okavango River were fishing an average of 60 days per year catching 1,045 tonnes.

In the survey catches in this investigation a total of 75 fish species were recorded. Gill nets caught 47 of these species, whereas all species were recorded in the other gears used mainly in shallow waters. These figures include seven *Synodontis* species which are not easily separated and therfore have been pooled in the results. In gill nets the ten most important species constituted between 70 and 80 % of the catches both by numbers and weight. The three most important species in gill net catches according to an index of relative importance (IRI) were silver catfish (*Schilbe*

[1] **The complete data report is available at:** Hay, C.J., Næsje, T.F., Breistein, J., Hårsaker, K., Kolding, J., Sandlund, O.T. & van Zyl, B. 2000. Fish populations, gill net selectivity, and artisanal fisheries in the Okavango River, Namibia. Recommendations for a sustainable fishery. NINA-NIKU Project Report 010.

intermedius), bulldog (*Marcusenius macrolepidotus*) and tigerfish (*Hydrocynus vittatus*). In the other gears, the ten most important species constituted approximately 54 % and 37 % of the total catch by numbers and weight, respectively. The lower proportion of the dominant species reflects the higher species diversity in catches with other gears. The three most important species in these gears, according to the IRI, were all cichlids; southern mouthbrooder (*Pseudocrenilabrus philander*), banded tilapia (*Tilapia sparrmanii*), and redbreast tilapia (*T. rendalli*). The *Synodontis* group of species was important both in gill nets and other gears.

The body length of fish caught in gill nets was generally larger than fish caught in other gears. This is evident both in the combined catches of all species and when comparing individual species. Fish caught in gill nets were between 4 and 79 cm in length, with fish between 7 and 17 cm constituting 82.9 % of the catches. Modal length was 9.0-9.9 cm. Fish caught in other gears were between 1 and 75 cm, with fish between 2 and 8 cm constituting 88.0 % of the catches. Modal length in this group was 4.0-4.9 cm.

The highest proportion of sexually mature fish was found during the period January-March, i.e. during the peak of the rainy season. This is before the main thrust of the local fisheries. Most of the important species (according to IRI) mature and spawn during this period. The smallest size of sexually mature fish varies among the different species. The overall smallest size at maturity was found in the cichlid southern mouthbrooder (*P. philander*), being a mature female of 3 cm. The largest size at maturity was found in sharptooth catfish (*C. gariepinus*), with minimum size of males and females at 40 and 38 cm, respectively.

Based on their importance according to number of fish caught and IRI in gill nets, other gears, and local subsistence fisheries, 21 species were selected for a closer description in terms of basic ecology and gill net selectivity. In addition, 16 species with the potential of being important for anglers are also described in these terms.

The results concerning gill net selectivity show that for most of the 21 important species (in local fisheries and in the survey fishing), the highest number of fish per setting were caught in small mesh sizes (22-45 mm, 15 species). Only two species are most efficiently caught in larger mesh sizes (73 and 93 mm). In terms of weight of fish per setting, 11 species were most efficiently caught in the 22-45 mm mesh sizes, two species in 57 mm, and four species in 93-118 mm. These results reflect that the fish community in the Okavango River is dominated by relatively small species and individuals. Among the species that are important in local fisheries or in our survey catches, only six out of 21 species have a minimum mature length above 10 cm or are on average above 15 cm in the gill net catches. Only two out of 21 species have mean lengths above 20 cm in our survey catches. Moreover, only seven out of the additional 16 species that are considered attractive angling species, have mean lengths above 20 cm in the gill net catches. This indicates that there presently is no firm basis for a commercial fishery for large fish in the Namibian part of the Okavango River.

Comparison of fish catches between the seven sampling localities revealed that there was a correlation between human population density and catches, both by weight and number of fish. The largest catches were taken in the areas with the lowest population densities. This correlation is highly significant for catches in kilograms. For catches in number of fish, the trend was similar, although not significant. The total gill net catches by weight at Kwetze (3.76 kg per setting) were nearly five times as high as at Rundu, Bunya and Musese (0.61-0.68 kg per setting). Catches at Cuito, Matava and Mbambi were intermediate, but considerably lower than at Kwetze (1.02-1.30 kg per setting). This indicates that the fish stocks at Kwetze are relatively unexploited. These differences between stations were more pronounced in the backwaters than in the main stream habitats. It is important to note, when evaluating the fish populations as a resource for subsistence fisheries, that the most important factor is the biomass (weight) of fish caught. In subsistence fisheries, the size of the individual fish is of less importance. In commercial or recreational fisheri-es, on the other hand, the size of the individual fish may be of great importance.

Between the different stations, differences were larger when comparing catches in the larger gill net mesh sizes than in the smaller ones. Catches in small mesh sizes (22 and 28 mm) at Kwetze (1.12 kg and 56.8 fish per setting) were not very different from the other stations (0.80-1.17 kg and 70.6-72.8 fish per setting). However, the mean weight of the fish caught in 22 and 28 mm mesh size at Kwetze were on average larger, 20 g compared with 10–13 g at the other stations. In the larger meshed gill nets (35-150 mm), differences were more pronounced. Kwetze had the highest catch both in weight and number of fish (4.35 kg and 39.9 fish per setting), whereas Rundu had the lowest catch (0.57 kg and 7.9 fish per setting).

Based on population densities, Rundu and Kwetze may represent the extremes in fishing intensity in the Okavango River, with close to no fishing at Kwetze and probably high exploitation rates at Rundu. These two sampling localities may therefore be used to exemplify possible differences in catches due to fishing intensity. In the smallest mesh sizes (22–28 mm) there were no significant differences in catches by weight between Rundu and Kwetze (0.8 and 1.1 kg, respectively). How-ever, in larger mesh sizes (35–150 mm) catches were several times higher at Kwetze than at

Rundu. In the largest mesh size (150 mm) there was no catch at all at Rundu, whereas the catch at Kwetze was 2.6 kg per setting.

Intensive fishing and exploitation of fish populations may reduce the overall number of individuals within a species. However, the result of selective fishing aiming at relatively large fish is often that the average size of species are reduced due to an increasing proportion of smaller fish. For most of the relatively large species in the Okavango River, catches in weight were largest at Kwetze compared with the other stations. No such tendency was observed for the small species. In terms of number of fish per setting, there was no systematic difference between Kwetze and the other stations, neither for large or small species. Thus, mean size of fish is larger at Kwetze than at the other stations.

The gill net mesh sizes used in this investigation were chosen to obtain a representative catch and size distribution of the fish populations. On average a larger proportion of large fish were caught in gill nets at Kwetze than at the other sampling localities. This was shown both in the total catches, and for many of the individual species sampled. Three examples are the common species silver catfish, bulldog and tigerfish. The largest fish were caught at Kwetze, where mean fish length in total gill net catches was 16.3 cm. The smallest fish were caught at Rundu, with a mean length of 10.7 cm. The two numerically dominant species in the gill net catches, silver catfish and bulldog, showed a similar pattern in length distribution among localities. Both species are largest at Kwetze and smallest at Rundu. These differences are reflected in the mean weight of fish, which was highest at Kwetze and lowest at Rundu (92 and 33 g respectively).

Two species, silver catfish and bulldog, are among the three most important species at all localities when ranging the ten most important species at each locality in terms of the index of relative importance (IRI) in gill net catches. Several species, which were important or common at the unexploited locality of Kwetze, were of little importance at the heavily fished locality of Rundu. These are in particular African pike (*Hepsetus odoe*), spotted squeaker (*Synodontis nigromaculatus*) and dashtail barb (*Barbus poechii*). One large cichlid species, threespot tilapia (*Oreocromis andersonii*) is only found in any significant number at Kwetze.

The recommended management actions are summarised as follows:

- The fish community consists of 75 species each with their specific ecology, forming an integral part of a complex and dynamic ecosystem. The exploitation of such a multi-species fish resource should preferably be performed non-selectively, i.e.; fish from all trophic levels should be caught in proportion to their occurrence in the aquatic ecosystem. This principle of proportional exploitation forms the basis of our management recommendations.
- The Okavango River is shared between Namibia, Angola and Botswana. The present collaboration with neighbouring countries on management issues is limited, and the available biological data from the sections of the river in Angola and Botswana is very restricted. The future aim should be to establish a management regime in close collaboration with neighbouring countries.
- Commercialisation of the fish resources in the Okavango is not an economically and ecologically viable option. The limited fish resource should be regarded strictly as a source for a sustainable subsistence fishery utilised by the population along the Okavango River. All traditional gears may be allowed. These gears are an important part of the tradi-tional life of local inhabitants. Gill nets and angling equipment (rods and reels) should be the only modern gear allowed.
- Regulation of the artisanal fishery by means of a quota system is logistically impractical. A more practical system based on effort restrictions by means of gear regulations is therefore recommended. Recrea-tional and trophy fishing, however, may be regulated through both quotas and gear restrictions.
- Our results clearly show the value of sanctuaries where fishing is prohibited. Depending on their size and position, sanctuaries may protect breeding and/or feeding habitats for different species. The protected areas may also serve as source areas, where fish production provides a surplus that migrat-es out of the protected area and reinforce the exploited fish populations. In addition, given the appropriate regulations, sanctuaries may provide excellent trophy fishing (e.g., catch-and-release) attracting exclusive fishing safaris creating economic activities to benefit local communities.
- No activities or gears should be allowed which may potentially pollute the environment. This includes also explosives, noxious substances, poison or electrical devices should be allowed. Artificial light during any fishing activities should not be allowed.
- The recreational fishery should be licensed, and specific regulations developed. Organisers of angling competitions must seek permission from the Ministry.

Management actions for future consideration, which may depend on further scientific research, and collaboration with local communities and neighbouring countries:

- The establishment of fish sanctuaries in addition to the Mahango Game Park should be considered. In this context, investigations about the habitat use and migration patterns of riverine fish species are needed. Fish sanctuaries could be included in the already present community conservancies.
- Closed fishing seasons could be implemented to protect the fish population during vulnerable periods, for example when fish are congregated during spawning at low water discharge or during seasonal migrations.
- Defined areas for specific activities, such as areas for fishing safaris and fishing competitions should be considered.
- The initiation of a community data collection programme should be considered to increase the fish database.
- Continuous international collaboration with neighbouring countries should be given high priority.

In future research programmes, the following is recommended:

- It is imperative that a modified monitoring pro-gramme of the river continues so that changes in the fish community may be identified and management actions taken to reverse possible future adverse effects.
- The collection of data by the community for research purposes have been done successfully elsewhere in Africa and should be considered in the Okavango to increase the database for future stock assessment studies.
- The knowledge of fish behaviour, migration, and area and habitat use, is limited. Resources should be allocated to conduct such studies. This is important for the establishment of fish sanctuaries and to dissolve conflicts between the recreational and sub-sistence fishermen.
- The socio-economic role of fish in the region should be subject to ongoing studies to complement the fishery and experimental data.
- Namibia has very little control over the management of the Okavango watershed as the catchment area falls within neighbouring countries. The Okavango River must be managed as an entity and collaboration with neighbouring countries is essential for further improved management of the fish resources.
- Where possible, comparable data sets from neighbouring countries should be included in future analysis.

Recommended management actions

Background

The White Paper "Responsible Management of the Inland Fisheries of Namibia" was finalised in December 1995, and forms the basis for a new law and regulations concerning fish resources management in the different freshwater systems in Namibia. The Okavango River is one of the most important of the perennial rivers, and freshwater fish are a very important food source for local inhabitants. Hence, the protection of this resource is of utmost importance to secure the future food availability of the riparian population in this region of Namibia. In this report management actions are recommended on the basis of eight years of biological studies in the river. Later reports will give recommendations for regulations of fisheries in the other perennial rivers in Namibia.

Our main objective has been to develop applicable guidelines for regulations of the inland fisheries in the Okavango River. This report will further enable the Ministry of Fisheries and Marine Resources to implement the proposed law and regulations necessary for sustainable management of the fish resources in the river.

In addition, a second goal of this report has been to identify critical aspects and needs for more knowledge that should be addressed in future studies, and give recommendations on how to obtain the necessary information needed for future management of the Okavango River.

Management regulations

The rationale for management regulations is to maintain and protect a sustainable subsistence fishery for the local population along the different river systems in Namibia, where fish have been and still is an important source of animal protein. Due to the diverse nature of the different water systems, separate management regimes are envisaged for each river system in Namibia.

The Okavango River enters Namibia from Angola and follows the border between Angola and Namibia before flowing south through Namibia and into Botswana. The present collaboration with neighbouring countries on management issues is limited, and the available biological data from the sections of the river in Angola and Botswana is very restricted. The fish populations in the river may be strongly influenced by fishing and other activities in the different countries. Therefore, if at all possible, the future aim should be to establish a management regime in close collaboration with neigh-bouring countries.

Commercialisation of the fish resources in the Okavango is not an economically and ecologically viable option. This conclusion is based on the present state of the fish resources in the river and the high human population densities along most of the river. The supply to local fish markets in the Okavango region consists mainly of marine fish (horse mackerel) and lately of a limited amount of fresh water fish imported from the Caprivi. Although people in the region may prefer freshwater fish, marine fish is accepted and more affordable. Locally, the riverine fish resource has always been considered a source of subsistence, and approximately 90 percent of the people utilising fish as a supplement to their daily diet. Presently the fish populations in large part of the river are impacted by human exploitation. Few large fish are present and the catch per unit effort is smaller than in areas where fishing activities are restricted. The fish resource should therefore be re-garded strictly as a source for a sustainable subsistence fishery utilised by the population along the Okavango River.

The fish community consists of more than 70 species each with their specific ecology, forming an integral part of a complex and dynamic ecosystem. Selective utilisation of the fish resources, for example catching mainly the large predatory species, may have a profound negative effect on the fish community structure. Therefore, any exploitation of such a multi-species fish resource should preferably be performed non-selectively, i.e., fish from all trophic levels should be caught in proportion to their occurrence in the aquatic ecosystem. This principle of proportional exploitation forms the basis of our management recommendations. As a consequence, regulations for the recreational fishery should be based on quotas and restriction of fishing effort rather than specific minimum sizes.

The fisheries in the Okavango River exploit a large number of species. Although some species may be preferred as food, the local fisheries spend more effort to increase the quantity of fish (and thereby food supply) rather than to catch specific species. Regulation of the artisanal fishery by means of a quota system thus becomes logistically impractical. A more practical system based on effort restrictions by means of gear regulations is therefore recommended. Recreational and trophy fishing, however, may be regulated through both quotas and gear restrictions.

Bological studies

The study presented in this report is based on a data series covering the period 1992 to 1999. This series constitutes good baseline data for future monitoringprogrammes. Earlier fish data from the Okavango River were mainly limited to species lists and systematic studies with very little ecological information collected. Some ecological studies were done in the 1980's, but these were short-term projects and no data series were collected. Data for the present study were collected at seven main stations along the Namibian part of the Okavango River. Fishing was done with experimental gill nets in the deeper parts of the water bodies, and several other gears including rotenone, seines and traditional gears in shallow waters. In addition, the areas between these stations were occasionally sampled. The data series form the basis for our management recommendations as well as for the discussions on future research programmes.

The results obtained in this study do indicate that the structure of the fish community has changed because of fishing activities. This is seen when comparing the fish community within the protected area (Mahango Game Park, with no fishing) with the other stations where fishing is continuously going on. In the fished areas, there are less large fish within species and overall in the catches. Fewer fish are caught in the large meshed gill nets, and the large, long-lived species are replaced by small, short-lived species. There is also a tendency that catch per unit effort (by weight) in gillnets is lower in the heavily fished areas. The effect of these changes is observed by the Okavango fisherwoman saying "I still catch enough fish for my family, but I need to catch more, as they are smaller".

The biological study also clearly indicates that the fish resource will not be able to sustain a commercial fishery economically, sociologically nor ecologically. The present catches by the local fisherfolk consist mainly of small species with a relatively low commercial value. These catches are utilised mainly for subsistence, but a limited surplus may be sold or exchanged for goods. A commercial fishery, for example with beach seine, as occasionally seen today, may deplete the fish resources drastically in some areas and thereby reduce the food supply for other fisherfolk. Women and children are particularly vulnerable as they are exploiting the same fish resources but with less effective traditional gears.

The Okavango River is easily accessible for fishing activities, especially during the low water period between September and December when fishing becomes intense. This is the period just before the start of the ploughing season. Other types of food are not readily available, and the low water level concentrates fish, making fisheries more effective. However, this is also the onset of the breeding season of most fish species. Therefore the brood stock more vulnerable to distur-bances and exploitation.

Our results clearly show the value of sanctuaries where fishing is prohibited. Catches at the study site within Mahango Game Park contained a higher number of large species, and within the same species, fish was larger than conspecifics caught in other areas. In gillnets, the catch per unit effort (by weight) was approximately 3-6 times higher within Mahango than at the other stations. The protected area protects the fish resource and its habitats as well as other aquatic organisms, maintaining a healthy aquatic ecosystem. Depending on their size and position, sanctuaries may protect breeding and/or feeding habitats for different species. The protected areas may also serve as source areas, where fish production provides a surplus that migrates out of the protected area and reinforce the exploited fish populations. Different fish species may have very different migration patterns, but very little is known about the migration patterns of the fish species found in the Okavango. However, it is reasonable to assume that sanctuaries may be an important manage-ment action to sustain the fishery in heavily exploited rivers such as the Okavango River. In addition, given the appropriate regulations, sanctuaries may provide excellent trophy fishing attracting exclusive fishing safaris creating economic activities to benefit local communities.

Management actions

The introduction of a proper management regime based on the new legislation should be done in two phases. The first phase would be the immediate implementation of actions based on present knowledge as soon as the bill is adopted by Parliament. These actions were identified through this study. The second phase should include issues that will need further research, considerations and deliberations with the local inhabitants. These actions may be included in future regulations as deemed necessary.

Management actions for immediate implementation

All traditional gears may be allowed. These gears are an important part of the traditional life of local inhabitants. The manufacturing of these gears are often time consuming, but they are mainly produced from local materials. Many of them are not very efficient, although they may catch enough fish for household supplies.

- Gill nets, and angling equipment (rods and reels) should be the only modern gear allowed.
  - ccordance with the proportional exploitation principle all mesh sizes of gill nets should be allowed to prevent selective fishing.
- Gill nets should be registered to prevent transboundary conflicts and to facilitate control of fishing effort.
  - people resident in the Okavango region should be allowed to register gill nets for use in the Okavango River. This is necessary to prevent an influx of people from other regions, which will put more strain on the already exploited fish resource.
  - ximum of two gill nets per fisherman with a maximum total length of 50 m may be allowed. Up to two nets per person may be advisable to secure the individual some catch even if a gill net is destroyed. Maximum depth of the gill nets should be 2 m.
- The regional council may restrict the number of gill nets per region. Presently it is not possible on the basis on available data to advice on the total number of nets that should be allowed in the Okavango River, or in any section of the river.
- No gill net should be set in such a way as to close off more than 50% of a water body, channel, or main stream.
- The dragging of any fishing device should be pro-hibited. The dragging of nets, mosquito nets, shade cloths, etc., are non-selective fishing methods, but often also the most destructive way to catch fish. The fish are especially vulnerable to this method during the low water period when migrating into shallow habitats for breeding. The fishing method may also destroy the habitat for fish and other aquatic organisms. In addition the use of dragging devices may spoil the water quality and its use for other purposes, for example watering household animals.
- No activities or gears should be allowed which may potentially pollute the environment.
- No explosives, noxious substances, poison or electri-cal devices should be allowed.
- No artificial light during any fishing activities should be allowed.
- The recreational fishery should be licensed.
  - ultaneous use of maximum two rods/lines per person should be allowed.
  - more than two hooks or baits per line should be permitted.
  - aglimit of not more than 10 fish per person per day should be set. A daily bag limit of two fish of selected trophy fishes (for example tiger fish and tilapia species) is also recommended.
  - catches by recreational anglers should be record-ed on a form to be provided with the licence. For each fish caught this form may include informa-tion on: Date of catch, place of catch, fish species caught, body length of fish kept by angler, and type of fishing tool. In addition information on total fishing effort as for example how many days of total fishing and average hours of fishing per day should be recorded. Failing to return this form may result in the refusal of obtaining a licence the next year.
- All motor powered boats used for fishing should be registered and licensed.
- Organisers of angling competitions must seek per-mission from the Ministry, who will eventually approve and control the event.

Management actions for future consideration

To implement the new legislation in practice, more precise information is needed on several aspects such as the type of gill nets used by fishermen, where they fish, the species composition of the catches, the abundance and size distribution of fish species and fish size at sexual maturity.

Several actions should be considered for the future, but for which more scientific research and collaboration with the communities and neighbouring countries are needed.

- The establishment of fish sanctuaries in addition to the Mahango Game Park should be considered. Sanctuaries are most often established to protect important breeding and/or feeding habitats or areas. For stationary species the sanctuary may include all areas or habitats used by the species. For migratory species the sanctuary may protect the species in certain phases of the life cycle. The purpose of the sanctuary may be to protect rare or endangered species, and it may also function as a source from which the surrounding waters can be restocked. Our knowledge about the habitat use and migration patterns of most of the species in the river is limited and should be further studied to establish the area, the management and the size of these sanctuaries. Sanctuaries may lead to an increase in the number of large individuals, which will be attractive to recrea-tional anglers. The community may generate revenue by allowing fishing safaris with strict bag limits to these areas. Fish sanctuaries could be included in the already present community conservancies.
- Closed fishing seasons could be implemented to protect the fish population during vulnerable periods, for example when fish are congregated during spawning at low water discharge or during seasonal migrations.
- Defined areas for specific activities, such as areas for fishing safaris and fishing competitions should be considered.
- The initiation of a community data collection programme should be considered to increase the fish database.

Continuous international collaboration with neighbouring countries should be given high priority.

Future research programmes

Future projects should be designed to ensure the availability of data needed for management purposes.

- The value of a continuous data series cannot be underestimated. Due to natural variasjons within fish stocks and ecosystems it is important to study long time trends in the populations. It is imperative that the monitoring of the river continues so that changes in the population structure may be identified and management actions taken to reverse possible future adverse effects. The emphasis of the monitoring, however, should be on fewer stations, but with an increased effort at each station. Stations should be sampled once a year, preferably in the spring before flooding. Smaller mesh size gill nets should be included in the surveys to sample the smaller individuals in the deeper, open water habitats.
- The collection of data by the community for research purposes have been done successfully elsewhere in Africa and should be considered in the Okavango to increase the database for future stock assessment studies. Data from the subsistence fishery should therefore be collected on a regular basis to more accurately assess the status of the fish resource. A community based data collection programme should be initiated which will increase the database as well as the frequency of data collection. The local involvement in community based data collection may also facilitate participation in any future management activities and raise local awareness about manage-ment and conservation issues.
- The knowledge of fish behaviour and migration, especially of potential angling species, is limited and resources should be allocated to conduct such studi-es. This is important for the establishment of fish sanctuaries and to dissolve conflicts between the recreational and subsistence fishermen.
- The socio-economic role of fish in the region should be subject to ongoing studies to complement the fishery and experimental data.
- Namibia has very little control over the management of the Okavango watershed as the catchment area falls within neighbouring countries. The Okavango River must be managed as an entity and regular collaboration with neighbouring countries is essential if the fish resource is to be managed properly.
- Where possible, comparable data sets from neigh-bouring countries should be included in future ana-lysis.