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# The Zambia-Zimbabwe SADC Fisheries Project on Lake Kariba: Report from a study trip

Trygve Hesthagen
Odd Terje Sandlund
Tor Fredrik Næsje

NINA

NORSK INSTITUTT FOR NATURFORSKNING

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This report outlines the information and experiences gained during a two weeks' visit to Lake Kariba Fisheries Research Institute (LKFRI) and the Zambia/Zimbabwe SADC Fisheries Project, in Kariba, Zimbabwe, in September 1993. Lake Kariba (surface area 5350 km$^2$) is one of the largest man-made reservoirs in the world. It is located on the Zambezi River on the border between Zambia and Zimbabwe. The fish community in the lake and the lower parts of the inflowing rivers consists of approximately 60 benthic fish species. Some 28 species were recorded in this section of the Zambezi before inundation, but this figure is probably too low. Three benthic species have been introduced, of which *Tilapia rendalli* has become significant in the benthic net catches. The dominant pelagic species, kapenta (*Limnothrissa miodon*), was also introduced. The inshore fishes are exploited through an artisanal fishery as well as through a recreational fishery. The artisanal fishery yields approximately 1200 metric tons on the Zimbabwean shore and some 2000 metric tons on the Zambian shore. Yields from the recreational fishery are not known. The kapenta is exploited through an industrial fishery yielding some 30000 metric tons annually. The SADC (Southern African Development Community) Fisheries project was started in 1989. It is funded mainly by Denmark (DANIDA) and Norway (NORAD). The aim of the project is to produce a scientific basis for a sustainable utilisation of the fish stocks of Lake Kariba, and to facilitate joint management of the fish resources, which are shared by Zambia and Zimbabwe.

Key words: Lake Kariba - Fisheries Prospect - study trip.

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# Contents

# Foreword

This report is based on our study trip in September 1993 to Lake Kariba Fisheries Research Insitute (LKFRI), and the Zambia/Zimbabwe SADC Fisheries Project, Kariba, Zimbabwe. The trip was supported by a grant from the Norwegian Ministry of Foreign Affairs' competence development programme related to environmental problems in developing countries. We want to express our sincere gratitude to Director Cecil Machena, Project coordinator Digby Lewis and Project scientist Jeppe Kolding for receiving us so well in the midst of a busy period, and arranging a very instructive programme during our stay in Kariba. Our thanks are also due to the LKFRI staff who assisted us in many different ways at the Institute and in the field. We are also grateful for the instructive discussions with Professor Brian Marshall and Dr. Jeremy Jackson, of the University of Zimbabwe. Our travel itinerary and the names of people met are given in **Annex 1**.

We also received essential assistance and information from Ms. Kirsten Bjøru, NORAD, Oslo, during the preparations for the trip.

Trondheim, March, 1994

Trygve Hesthagen
Odd Terje Sandlund
Tor Fredrik Næsje

# 1. Introduction

The demand for electricity and water supply have resulted in the creation of many reservoirs in Africa. Lake Kariba, on the border between Zimbabwe and Zambia, was at its completion the world's largest man-made lake (surface area 5350 km$^2$, Balon & Coche1974). The electricity production is 666 megawatts on the South Bank (Zimbabwe) and 600 megawatts on the North Bank (Zambia). Zimbabwe and Zambia are land-locked countries with few natural lakes (Allanson et al. 1990). In Zimbabawe, all stored surface water is held in reservoirs ranging from small farm dams to large reservoirs like Lake Kariba (Masundire 1992). The freshwater fish resources of Africa are generally of great local or regional importance as a supply of animal protein. Thus, a lake the size of Lake Kariba constitutes an important source of food both for local communities and for the rest of the two countries. The inland fisheries in Africa are usually small-scale and labour intensive. Fishing and related activities employ a total of some 10 million people on the African continent (Tvedten & Hersoug 1992). In Lake Kariba, both industrial and artisanal fisheries are operated. Over the last three decades, substantial information have been collected on the ecology of the lake, and the DANIDA/NORAD sponsored fisheries management project on the lake has been in operation for approximately three years.

Of special importance for the Lake Kariba fish community is the introduction of the Lake Tanganyika clupeid *Limnothrissa miodon* (Boulenger), locally called kapenta (Bell-Cross & Bell-Cross 1971). This species now supports the important commercial pelagic fishery on Lake Kariba (Machena & Kautsky 1991). In addition there is an inshore fishery along the shores of Lake Kariba, mainly exploiting species which occurred in the Zambezi before the inundation (Karenge & Kolding 1994, Machena & Moinuddin 1993). The catches from the inshore fishery is partly used in the subsistence economy and partly sold commercially. The tourist industry is of increasing importance in the area, and the recreational fishery, catching tigerfish, catfishes and tilapias, is among the major tourist attractions.

A proposal for a joint Zambia-Zimbabwe project to coordinate fisheries research and development was presented by SADCC (Southern Africa Development Coordination Conference, presently SADC, Southern Africa Development Community) at the SADCC Donor Conference in 1983. The revised project was adopted for funding by DANIDA and NORAD in 1989.

The main objective of this report is to summarize our experiences and impressions during a two weeks' visit in September 1993, to the Lake Kariba Fisheries

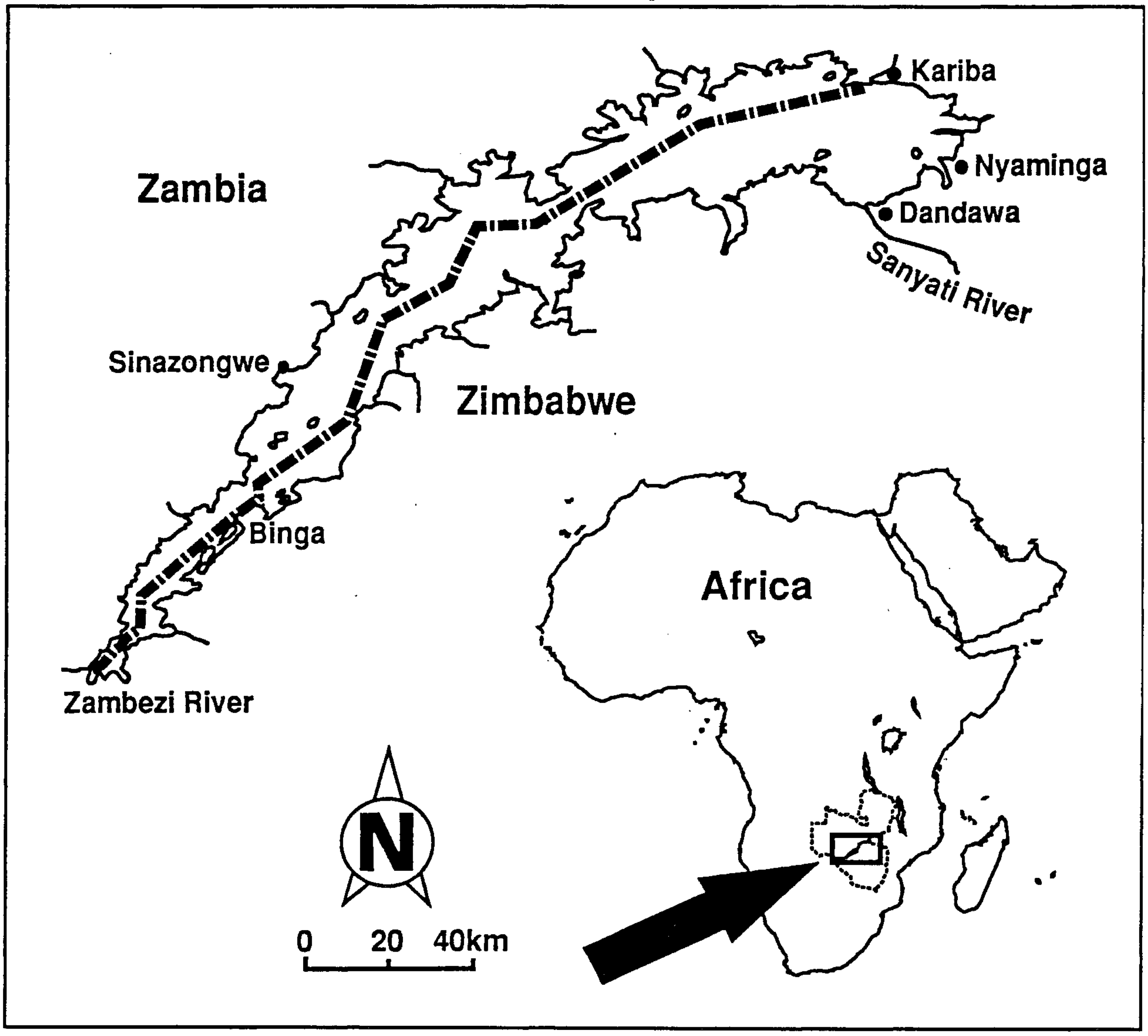
Research Institute and the SADC Fisheries Project. Our primary goal was to increase our own competence by studying the following themes:

- the fish ecology and stock assessment research
- the artisanal and commercial fishery
- the socio-economic conditions related to the fishery
- the project organisation and activities

Potential areas of collaboration between LKFRI and NINA are given in **Annex 2.**

# 2. Locality

Lake Kariba (16° 28' - 18° 04' S and 26° 42' - 29° 03' E) is located in the northwestern part of Zimbabwe on the Zambezi River, forming the border between Zambia and Zimbabwe (**Figure 1**). Most of the area around the lake have infertile soils and a hot and dry climate; annual rainfall is between 500 and 700 mm. The lake was formed when Zambezi was impounded




***Figur 1.** The location and outline of Lake Kariba.*

at Kariba Gorge in 1959, and the lake was filled by 1963. The lake is divided into five basins along its length axis (**Figure 1**). Some physical characteristics of Lake Kariba are given in **Table 1**. Due to the regulation, the littoral zone is subjected to annual water level fluctuations of about 3 m. The drawdown is, however, substantially increased during drought periods, which may last for several years.

Lake Kariba is a slightly alkaline and oligotroghic lake. Hence nitrogen and phosphorus supply is limiting to the primary production, and the potential fish production is relatively low. The major nutrient input to the lake depends on the inflowing rivers after the rainy season, which normally lasts from November to March (Marshall 1982, 1988a, Machena & Kautsky 1991). Zambezi contributes about 70 % of the inflow. The lake is monomictic. During turn-over in June-July nutrients from deep water are mixed with nutrient-poor surface waters. Talling & Talling (1965) grouped African lakes and reservoirs into three classes based on conductivity. Lake Kariba belongs to Class 1 which is characterized by conductivities below 600 µS $cm^{-1}$. Such reservoirs are fed by inflowing rivers of low nutrient content (cf. Coche 1974, Magadza et al. 1987).

The limnology of Lake Kariba has been fairly well investigated through activities conducted from the Lake Kariba Research Station of the University of Zimbabwe. This station was the base for a freshwater ecology project funded by the Swedish development research collaboration agency SAREC from 1984 (e.g. Ramberg et al. 1987, Magadza 1992). Several studies of zooplankton population density and dynamics have been carried out (e.g. Magadza 1980, Masundire 1989, 1992). The crustacean zooplankton is dominated by small species such as the cladoceran *Bosmina longirostris*, and the copepods *Thermocyclops* spp. and *Mesocyclops* spp. A bibliography on Lake Kariba is published in Anon. (1991).

According to Jackson (1961), the middle section of the Zambezi contained some 28 species of fish before the inundation. During the first decade after the inundation, approximately 40 species of fish were recorded in Lake Kariba (Balon & Coche 1974). Until now, 62 species have been recorded (Karenge & Kolding 1994). The increase in species number was explained by immigration from the upper Zambezi, but some introductions had also been made. The most important introduction was the kapenta, which was introduced from Lake Tanganyika in 1967-68 (Bell-Cross & Bell-Cross 1971).

***Table 1** Some physical data on Lake Kariba*

| | |
|---|---|
| Altitude | 488 m a.s.l. |
| Total length | 280 km |
| Shoreline length | 2164 km |
| Maximum breadth | 40.0 km |
| Mean breadth | 19.4 km |
| Surface area | 5350 $km^2$ |
| Maximum depth | 120 m |
| Mean depth | 29.2 m |
| Volume | 156.5 $km^3$ |
| Theoretical replacement time | 2.4 yrs |
| Surface temperature (annual range) | 20 - 33°C |
| Thermal stratification period | mid Sept. - late May |
| Thermal mixing period | June - August |
| Transparency (Secchi disc, annual range) | 3 - 6 m |

# 3. The Zambia-Zimbabwe SADC Fisheries Project

The aim of the fisheries project is to strengthen the research capabilities of the research institutions in Zambia and Zimbabwe, and to facilitate joint management of the shared fish resources in Lake Kariba. Due to political factors, research on the lake has been carried out separately by the two countries since 1966, and the management regimes for the joint fish resource have been different in the two countries.

The Fisheries Project was originally proposed at the SADCC Donor Conference in 1983. Due to the complexity and estimated cost of the proposed project, the donors considered feasible a pre-project phase of approximately one year. The pre-project involved work to further clarify the local conditions in the project area, discuss the mode of cooperation between Zambia and Zimbabwe, and prepare a detailed project description. During the pre-project phase in 1988-89, an acoustic survey of the pelagic fish stocks of the lake (Lindem 1988) and a limited socio-economic study (Murphree et al. 1989) were performed. A comprehensive project proposal was presented to NORAD and DANIDA in May 1989 (Lewis 1989). It was decided to split the project into two sub-projects. The Kapenta Fisheries Project deals with the pelagic fisheries and the ecology and dynamics of the kapenta stock. The Artisanal Fisheries Project deals with the inshore fisheries and the ecology and dynamics of the benthic fish community. During the initial stages of the project, two project planning workshops were held, to lay out the detailed work schedule for the two sub-projects: the kapenta fishery (Moinuddin 1990a), and the artisanal fishery (Moinuddin 1990b).

The Zimbabwean part of the project has been localized at the Lake Kariba Fisheries Research Institute (LKFRI), in Kariba town. The Zambian part of the project is based at the Lake Kariba Fisheries Research Unit in Sinazongwe. Due to various problems in Zambia, this part of the project did not appear to progress according to the plans, and is only recently beginning to function. According to the NORAD representative in Harare, the lack of parallel development in the Zambian and Zimbabwean parts of the project has been of some concern. These problems indicate that collaboration and coordination between two countries with different economies and political goals may create large problems for a development project. On the other hand, this aspect cannot be avoided in a project dealing with sustainable fisheries management in border lakes, i.e. resources shared by two or more countries.

The project activities have included e.g. monitoring of fish stocks through hydroacoustic surveys and gill netting, monitoring of catches, socio-economic studies of the artisanal fisheries, and economic analysis of the kapenta fishery. As the project activities have progressed, the results have been treated in project workshops. For example were workshops held on kapenta stock assessment in March 1992 (Anon. 1992), and on inshore fish stocks in September 1993 (Anon. 1993).

An important aspect of all development projects is the training and competence transfer. This occurs partly through the collaboration between expatriate experts and their counterparts. However, training and competence building are long-term activities. Thus to ensure a continuous activity, it is important to establish institutional collaboration. In the Lake Kariba SADC Fisheries Project, the local institutions LKFRI in Kariba and the Research Unit in Sinazongwe have been collaborating with the Danish Institute for Fisheries and Marine Research (DIFMAR). Several courses as well as on the job training have been provided for local staff. For formal education of project staff, the master's programme in fisheries management at the University of Bergen have been utilized. The Centre for Applied Social Sciences (CASS) at the University of Zimbabwe in Harare is working with socio-economic aspects of the fisheries, in collaboration with the project.

# 4. The fish community

## 4.1 The benthic (inshore) fish community

According to Karenge & Kolding (1994) a total of 64 fish species have been recorded in the Kariba area (**Annex 3**). Of these, six species are not native to the Zambezi. Test fishing with standard gill net series have been conducted close to Kariba town in the eastern basin (**Figure 1**) from 1969 until present (Karenge & Kolding 1994), catching a total of 27 species. The most important species in the survey net catches were tigerfish (*Hydrocynus vittatus*, Characidae), the cichlids green happy (*Serranochromis codringtoni*) and Kariba tilapia (*Oreochromis mortimeri*), and the mormyrid eastern bottlenose (*Mormyrus longirostris*). Of the three introduced benthic species, only *Tilapia rendalli* was of some significance in the survey net catches.The results show that there has been a continuous change in the species composition. Over the years, there has been an overall increase in species diversity, but with some variation from year to year. The fish production (as indicated by catch data) was fluctuating with the nutrient input to the lake system. The findings of Karenge & Kolding (1994) indicate that a stable low water level causes high fish species diversity, but low production. The main reasons are that a stable water level allows the development of a submerged vegetation creating many new niches. Due to low water influx to the lake, however, nutrient levels are low. Rising water levels, on the other hand, improves the nutrient levels, both because of river influx and leaching from the submerged land. This causes a decrease in fish species diversity, but an increase in production, which is the desirable situation from the fishermen's point of view,.

The tigerfish reaches a length (asymptotic length) of 58 cm, the corresponding lengths for the green happy and the Kariba tilapia are 39 and 48 cm, respectively (Kolding et al. 1992). The large catfishes (Clariidae), particularly the vundu (*Heterobranchus longifilis*, up to 55 kg) are attractive sport fishes, as are the tigerfish and some of the larger-bodied cichlids (Kenmuir 1983).

The tigerfish is a seasonal breeder, entering rivers to spawn. The seasonal recruitment makes cohort analysis based on length frequencies possible. The stock assessments made for the tigerfish indicates a fairly high mortality rate ($Z \approx 2$ based on material from a supposedly unfished area). This species is highly migratory, so that the estimated population parameters may not differ much between fished and unfished areas. The relatively high mortality may be due to the fact that this species is exploited by three different fisheries: the inshore (or artisanal) fisheries, the recreational fishery, and the commercial kapenta fishery (as a by-catch). A reliable stock assessment on the tigerfish is difficult due to the variety of exploitation methods. However, at present the tigerfish is probably exploited at a rate close to its maximum potential (Anon. 1993), at least if trophy specimens for the sports fishery are to be conserved (Machena et al. 1993).

The other main species are more or less continuous breeders. This complicates population analysis, as cohort analysis based on length distributions becomes nearly impossible, and ageing of the fish is difficult with presently known methods. It appears that age determination and verification of growth rates are important steps in the development of the knowledge base for the management of inshore fishes. Although fraught with uncertainities, the stock assessments performed for the two cichlids indicate a lower total mortality than for tigerfish (Anon. 1993). These species are, however, rather stationary, and the population parameters will probably vary significantly among areas in the lake, according to the level of exploitation. The exploitation rate (proportion of mortality caused by fishing) estimated for the major cichlids in the artisanal catches does not indicate overfishing.

The habitat utilised by the benthic fishes is mainly restricted to the 0-20 m depth zone (Machena & Kautsky 1991). In this part of the lake, only restricted areas were cleared of bush and tree vegetation before the lake was filled. The cleared zones were designated for gill net fishing, but time and money did not allow larger areas to be cleared. Today, however, the areas where the trees were left standing function as reserves protected against fishing, as the tree stumps make gillnet fishing difficult. This is probably one of the main reasons that the inshore fishes are not threatened to be overfished in Lake Kariba. Thus, the drowned forest, which usually is a result of the urge to save time and money, may have a positive conservation effect. Moreover, in most cases the drowned forest is considered an aestethic problem, but in Lake Kariba the areas with emerging dead trees seem to have become tourist attractions.

Crocodiles do not appear to be significant fish predators in Lake Kariba (Magazda 1992). Insects, small mammals, antelopes, and dead carcasses of various animals are more important as food. Fish only play a major part in the diet of sub-adult crocodiles. Although an observer gets the impression that the density of fish eating birds is fairly high along the lake margins, fish eating birds seem to play a minor role as fish predators (Magazda 1992). However, both crocodiles and hippos may be dangerous for the artisanal fishermen working from very small boats.

## 4.2 The pelagic community

The pelagic fish community in Lake Kariba is very simple, as it is totally dominated by kapenta. The tigerfish also occur in this zone as a pelagic predator.

Prior to the creation of the reservoir, it was suggested that none of the indigenous Zambezi river fish species would be able to colonize the pelagic zone of Lake Kariba (Jackson 1961). Therefore, it was recommended that a pelagic species from one of the great African lakes should be introduced. Consequently, the clupeid ("sardine") kapenta was introduced from Lake Tanganyika in 1967-68 (Bell-Cross & Bell-Cross 1971). Already by 1970, the species had colonised the entire lake and had established itself downstream in the Cahora Bassa reservoir (Junor & Begg 1971). Jackson's (1961) assumption that the riverine fishes of Zambezi would not be able to utilize the pelagic zooplankton may have been correct. However, the period from inundation until the introduction of kapenta was too short to be sure about this. For example, the small characid *Brycinus lateralis* seemed to be developing a planktivore behaviour when the kapenta was introduced (Balon & Coche 1974, Mitchell 1976, Balon & Bruton 1986).

The kapenta is a specialised planktivore, with adults feeding mainly on zooplankton such as crustaceans and rotifers (Cochrane 1984). The species breeds throughout the year, but catches of larvae indicate a higher breeding activity from September to March. The larvae are found mainly in littoral areas, and the fish migrates gradually into the pelagic zone as they grow larger. Most fish do not reach an age of one year, and the dominating length in the commercial catches is around 50 mm. Sexual maturity is reached at a length of approximately 35 mm and an age of 3-4 months (Marshall 1988b). According to the stock assessments of the kapenta, overfishing of the stock to the extent that the recruitment will be reduced is not likely (Anon. 1992). Before reaching a fishing level which may influence recruitment, the decrease in catch per unit effort will render the fishery unprofitable.

The impact of the introduced kapenta on the ecology of Lake Kariba has recently been evaluated (Marshall 1991). Usually, species introductions will have various negative effects on the environment (Balon & Bruton 1986). Concerning the kapenta, however, the conclusion is that although Lake Kariba itself constitutes a major environmental change with some negative effects, the kapenta has created a major fishery which is of great benefit to the people of the area.

# 5. The fisheries

## 5.1 Inshore fisheries

The inshore fishery in Lake Kariba is dependent on a simple technology and therefore demands small investments. Thus, it is easy for almost anyone to enter the fishery. Zimbabwe has for many years tried to control the access to the fishery through licensing, and there are restrictions on gear types. Presently only gillnets above 100 mm stretched mesh size are allowed, and each fisherman may only use five nets. The last frame survey showed that there are at least 1040 fishermen in action in 40 villages on the Zimbabwean side (Anon. 1993). In Zambia, at least 1700 fishermen in 246 villages are taking part in the inshore fishery, with no restrictions concerning number of nets. Presently, in Zambia minimum mesh size of gill nets is 75 mm (Machena & Moinuddin 1993).

The lakeshore of Lake Kariba is communally owned. Parts of the shoreline have been declared conservation areas, where fishing is not allowed. Some of the fishing villages are actually camps used only temporarily by people from villages in the hinterland. Some of the camps are easily moved, and there has been a tendency among fishermen to congregate in better fishing areas, which might cause local overfishing. The major problem is, however, that the population growth, unemployment and drought in the area cause an influx of people to take up fishing (Machena & Moinuddin 1993). In spite of indications of an increase in the number of fishermen, the annual inshore fish yields seem to have stabilized at 1200 to 1500 metric tons in Zimbabwe. To avoid a decrease in the profitability of the fishery, attempts should be made to limit access to the fishery. It has been recommended that fisheries communities take over the responsibilities to manage and control the fishery within defined exclusive zones along the lakeshore. The rationale for this is that the most efficient and cost-effective system of catch regulation is the local community's collective self-interest in sustainability. This is in parallel with the principles of the successful CAMPFIRE programme regarding management rights and responsibilities over local wildlife resources in Zimbabwe.

## 5.2 Impressions from a fishing camp

We were able to visit Dandawa fishing camp close to the Sanyati River (**Figure 1**). The camp has some 264 inhabitants, of which 40 are in posession of a fishing license. For each license holder two additional persons may take part in the fishing activity, although only one boat may be used. The fishing gear used was 45 m long gillnets with mesh size 100 mm stretched mesh. Present restrictions allow a maximum of 5 nets per license, and the annual fee is 80 Zimbabwean dollars. The maximum number of nets used to be 12 nets with an annual fee of 5 Z-dollars. The fishermen from Dandawa camp are operating in the immediate area of the lake, towards the Sanyati river. The major species in the catches was tigerfish, which is most easily marketed as well as the most preferred fish for food by the villagers themselves. The fish was sold either fresh or dried. The drying process includes salting the fish for 24 hrs before sundrying on open-air racks for 48 hrs. The dried fish was packed in bales and sold to local traders.

The home village of the people of Dandawa camp was located some 14 km from the lake shore, where it was relocated after the filling of Lake Kariba. Recent administrative changes in Zimbabwe have resulted in the village and the Dandawa camp being located in two different adminstrative areas (under two different District Councils). This has caused some conflicts, as the villagers feel that they are not able to make their opinions heard in the political bodies making important decisions. There is a plan to move the people of the fishing camps on this part of the Lake Kariba shoreline to a newly constructed village called Nyamunga (**Figure 1**), where infrastructure in terms of a clinic, primary school and freshwater supply should be available. When we visited Dandawa, this was a source of deep conflict between the camp dwellers and the political authorities.

The tigerfish enters the Sanyati River to spawn, and gillnet fishing is therefore prohibited in the lake close to the river. There is, however, quite a lot of poaching in the area. Some of the illegal fishing is done by fishermen from nearby camps, and some is done by people coming down to the river from the hinterland. The fish management authorities expect that the poaching problem would be reduced if the fishermen of the camps were moved to the Nyamunga village.

The visit to Dandawa clearly demonstrated the fact that factors of great consequence to the management of the fish resources are more political and social than biological, once the biological parameters have been established and the system understood. This is a very important aspect of the development of natural resource management in general.

## 5.3 The kapenta fishery

The kapenta fishery differs greatly from the inshore fisheries in the investment needs and the level of technology. It has therefore been possible for both Zimbabwe and Zambia to establish a fairly strict system of limited entry through licensing (Machena & Kautsky 1991).

The fishing is performed during night, with dipnets (8 m diameter, 10 mm mesh size) lowered from a rig into the water. Several strong lights were mounted on the rig as the light attracts the kapenta. A diesel engine on the rig operates the generator to produce light as well as the winch to pull the dip net. Two persons are generally working on each rig, from afternoon till morning. On average four hauls can be made per night.

Commerical sardine fishing began on Lake Kariba in 1973 and the fishery grew rapidly (Marshall 1991). At present there are 240 kapenta fishing licence in Zimbabwe and 200 in Zambia. The total annual yield of Lake Kariba currently exceeds 30.000 metric tonns (Anon. 1992). This amounts to several times the total yield from other species in the lake (Marshall 1987, Machena & Moihuddin 1993). The catches of kapenta show a distinct seasonal pattern with a peak in August and low catches in April and May. This pattern is related to physio-chemical changes in the lake created by the flood in the major river feeding the lake (Marshall 1982).

The majority of the kapenta is sundried before marketed. Several fairly large enterprises, both private and cooperative, operate the kapenta processing. This fishery have brought economic development and jobs to an area where none existed before (Marshall et al. 1982).

Fishing for kapenta is not allowed less than 5 km from shore, to protect rearing grounds for juvenile kapenta and avoid noise which might disturb tourists at the hotels on shore. Safety risks for the fishermen are mainly related to storms, in 1992 seven rigs were sunk.

## 5.4 The recreational fishery

Lake Kariba is a real tourist trap in this part of Africa, where open water is a scarcity. One of the main factors attracting tourists is the angling opportunities offered in the lake. As is commonly seen all over the world, there are some hints of conflict between the recreational fishery on one hand, and the artisanal fishery on the other. In many cases these conflicts are more based on psychology than on biological realities. Generally, the two fisheries may exploit different species. However, in Lake Kariba there is at present a lack of data regarding the actual impact of the recreational fishery on the fish stocks. As some of the most attractive sport fishes are also attractive for the artisanal fishermen, there may be some real conflicts. Presently, the large tigerfish, which is the most attractive sports fish in the lake, are becoming increasingly scarce due to artisanal gillnet fisheries. With the immense "dollar power" of tourism, the artisanal fisheries are probably bound to lose in this conflict. However, if the fishing communities are given the ownership rights and responsibilities (like the CAMPFIRE system), and are able to sell sports fishing rights, their economic benefits from the fisheries may improve. The gross values of the various ways of exploiting Lake Kariba are approximately 10 million Z-dollars from the inshore fishery, whereas the kapenta fishery and tourism earn more than 100 million Z-dollars each. An unknown part of tourism is based on sport fishing.

# 6. The political and social structure

In Zimbabwe, the management of the fisheries are under Department of National Parks and Wild Life Management, of the Ministry of Environment and Tourism. The Zimbawean waters of Lake Kariba have the status of recreational park, and the Ministry have granted the control over the fishing rights to the District Councils.

The construction of the Kariba Dam led to relocation of a number of people who previously lived along the shore of the Zambezi river which were to be inundated. The people were partly relocated in communal lands far from the lake, where it was assumed that they should reestablish farming. However, many of the relocated people rather wanted to continue fishing. They were granted fishing rights in Lake Kariba, but to utilise these rights, they had to erect fishing camps on the lake shore. The fishing camps are villages where the fishermen live for shorter or longer periods while fishing. Most of the fishermen have agricultural land tended by their families back in the hinterland villages. Over the years, many of the camps have developed into apparently permanent villages.

As is commonly seen in developing countries, the artisanal fishermen form one of the weakest groups in society. They are the least educated, have weak organisations, and form weak links with other groups and institutions. They are therefore easily deprived of the necessary authority to manage their own resources. Many of the problems described to us by the fishermen, and the information gained through the socio-economic work of Centre for Applied Social Sciences (CASS) in the area, indicate that also in the case of Lake Kariba, one of the major consequences of the hydropower development is related to social effects of relocation of people. This is in many ways the main lesson to be learned from large dam construction in the tropics (Balon 1978, FIVAS 1988, Pearce 1992).

# 7. Summary


- The fish species of Lake Kariba clearly belong to two separate habitats: the pelagic habitat, with mainly kapenta, and the benthic, or inshore habitat, with approximately 40 fish species. Including the lower parts of the inflowing rivers, a total of 60 fish species have been recorded. The riverine fishes which colonized the lake from Zambezi all live in the benthic habitat, whereas the pelagic species, kapenta, was introduced from Lake Tanganyika. The predatory tigerfish to some extent feed in both habitats.

- The fisheries of the lake reflect the two different fish communities. The inshore species are utilised by the artisanal fishermen, whereas the kapenta is exploited by an industrial fishery. Thus, there is no major conflict between the artisanal and industrial fishery. The recreational fishery, however, which increases with the growing tourist industry, exploits the inshore fishes. Consequently, there is ample potential for conflict between tourism and the artisanal fishery. It is a major task for any management plan to solve this conflict.

- Effective regulation of the artisanal fishery is difficult due to two major factors. The artisanal fishery demand small investments, and there is a considerable urge in the local population to join the fishery because of the high unemployment rate.

- The fact that the fish resource in Lake Kariba is shared by two countries with different political and economic conditions make an optimal management of the pelagic fish stock very difficult.

- Due to the continuous reproduction of most of the species taken in the fishery, it is a complicated matter to perform reliable stock assessments. However, good progress have been made by the project in this respect.

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# Annex 1

## Travel itinerary
## Study tour to Lake Kariba, September 1993

**20 September**
Arrival Kariba. Met by Mr. Jeppe Kolding, SADC Fisheries Project.

**21 September**
Discussions with participants at the Zambia/Zimbabwe SADC Fisheries Fisheries Project work shop.

**22 September**
Visit Dandawa fishing camp accompanied by Mr. Songore Newman. At Dandawa we met Dr. Jeremy Jackson, CASS, and several fishermen.

**23 September**
Meeting at the LKFRI

**24 September**
Accompanying LKFRI staff to pull the survey nets. Stayed at LKFRI in the afternoon.

**25 September**
We visited a kapenta drying factory in the morning. We spent the night on Lake Kariba to see the kapenta fishery.

**26 September**
Field trip at Lake Kariba with Newman Songore, LKFRI. Visited a tilapia fish farm which raised fish in floating net cages. Recreational/subsistence fishing with handheld tackle from the shore appears to be of importance for the local population.

**27 September**
O.T. Sandlund leaves Kariba for Harare.
T. Hesthagen and T.F. Næsje had meeting with Dr. C.H.D. Magadza and Dr. H.M. Masundire at the Research Station of University of Zimbabwe in Lake Kariba. At LKFRI in the afternoon compling literature.

**28 September**
O.T. Sandlund had meeting with Mr. Kjartan Stigen (NORAD) and Professor Brian Marshall, University of Zimbabwe.
T.Hesthagen and T.F. Næsje visted Andorra Kapenta Factory and Crocodile Farm before lunch. Stayed at LKFRI in the afternoon.

**29 September**
O.T. Sandlund leaves Harare for Windhoek, Namibia. T. Hesthagen and T.F. Næsje made a roundtrip on Lake Kariba and stayed at LKFRI in the afternoon.

**30 September**
T. Hesthagen and T.F. Næsje leaves Kariba for Harare

**2 October**
We left Harare

# Annex 2

## Potential collaboration between LKFRI, the SADC Fisheries Project and NINA

The potential areas of collaboration were also discussed during the visit by Dr. Cecil Machena (LKFRI) and Mr. Gordon Mudenda (Department of Fisheries, Zambia) to NINA, Trondheim in 1991.

### Aspects related to the tigerfish

The considerable sport fishery in Lake Kariba creates a need for better knowledge about the ecology of the most important sport fish, the tigerfish. This species is also one of the most attractive in the catches of the artisanal fishermen. One of the basic ecological questions is whether the tigerfish stock in Lake Kariba consists of several local stocks. Alternatively there may be a mixed stock migrating over large parts of the lake. This question may be answered through:

- Tagging/recapture and radiotelemetry experiments. NINA has a long tradition and a wide experiece of this type of research in large lake and fjord systems, e.g. with anadromous and freshwater resident salmonids.
- Electrophoretic analysis of spawning stock and of stocks in various parts of the lake outside the spawning season. NINA has an experienced laboratory working with enzyme electrophoresis on fish, insects, birds and mammals. Our laboratory is currently extending into biochemical methods for genetic analysis (DNA-analysis).
- Cantch statistics on the tigerfish from all three types of fisheries. Questionnaires may also be a useful method to evalutate changes in fish community status and abundance. NINA har relevant expertise from many years of using questionnaires to gain information for management purposes.

### Other aspects

NINA may also have expertise of relevance to the problems in Lake Kariba regarding themes like:

- Development of aquaculture methods for the production of fish for the aquarium trade to replace the exploitation of vulnerable wild stocks.
- Genetic studies of various species to facilitate local stock management.
- Pelagic ecosystem dynamics (the phytoplanton-zooplankton-kapenta interactions).
- Basic ecology of inshore fishes.

If needed, scientists at NINA are aslo available for supervision of students from the SADC Fisheries Project who would want to take their Master's or PhD degrees in Norway.

# Annex 3

**Fish species recorded in Lake Kariba area. (i) are introduced species. After Karenge & Kolding (1994).**

| Family | Genus | Species |
|---|---|---|
| Angulidae | *Anguilla* | *bengalensis* |
| | | *marmorata* |
| | | *mossambica* |
| Bagridae | *Leptoglanis* | *rotundiceps* |
| Centrarchidae | *Lepomis* | *macrochirus* |
| | *Micropterus* | *salmoides* |
| Characidae | *Brycinus* | *imberi* |
| | | *lateralis* |
| | *Hydrocynus* | *vittatus* |
| | *Micralestes* | *acutidens* |
| Cichlidae | *Oreochromis* | *macrochir*(i) |
| | | *andersonii* |
| | | *mortimeri* |
| | *Pharyngochromis* | *darlingi* |
| | *Pseudocrenilabrus* | *philander* |
| | *Serranochromis* | *carlottae* |
| | | *codringtonii* |
| | | *giardi* |
| | | *angusticeps* |
| | | *macrocephalus* |
| | | *robustus*(i) |
| | *Tilapia* | *rendalli*(i) |
| | | *sparmanii* |
| Clariidae | *Clarias* | *gariepinus* |
| | *Heterobranchus* | *longifilis* |
| Clupeidae | *Limnothrissa* | *miodon*(i) |
| Mormyridae | *Hippopotamyrus* | *discorhynchus* |
| | *Marcusenius* | *macrolepidotus* |
| | *Mormyrops* | *deliciosus* |
| | *Mormyrus* | *longirostris* |
| | *Petrocephalus* | *catostoma* |
| Cyprinidae | *Barbus* | *annectens* |
| | | *bifrenatus* |
| | | *fasciolatus* |
| | | *lineomaculatus* |
| | | *marequensis* |
| | | *mattozi* |
| | | *paludinosus* |
| | | *poechii* |
| | | *radiatus* |
| | | *trimaculatus* |
| | | *unitaeniatus* |
| | *Carassius* | *auratus* |
| | *Cyprinus* | *carpio* |
| | *Opsaridium* | *zambezense* |
| | *Labeo* | *altivelis* |
| | | *congoro* |
| | | *cylindricus* |
| | | *molybdinus* |
| | *Varicorhinus* | *nasutus* |
| Distichodontidae | *Distichodus* | *mossambicus* |
| | | *schenga* |
| Kneriidae | *Kneria* | *auriculata* |
| Malapteruridae | *Malapterus* | *electricus* |
| Mochokidae | *Chiloglanis* | *emarginatus* |
| | | *neumanii* |
| | | *pretoriae* |
| | *Synodontis* | *nebulosus* |
| | | *zambezensis* |
| Poeciliidae | *Aplocheilichthys* | *johnstonii* |
| | | *katangae* |
| | *Gambusia* | *affinis affinis* |
| Protopteridae | *Protopterus* | *annectus brieni* |
| Shilbidae | *Shilbe* | *mystus* |

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