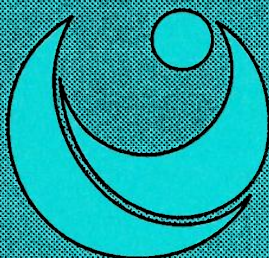
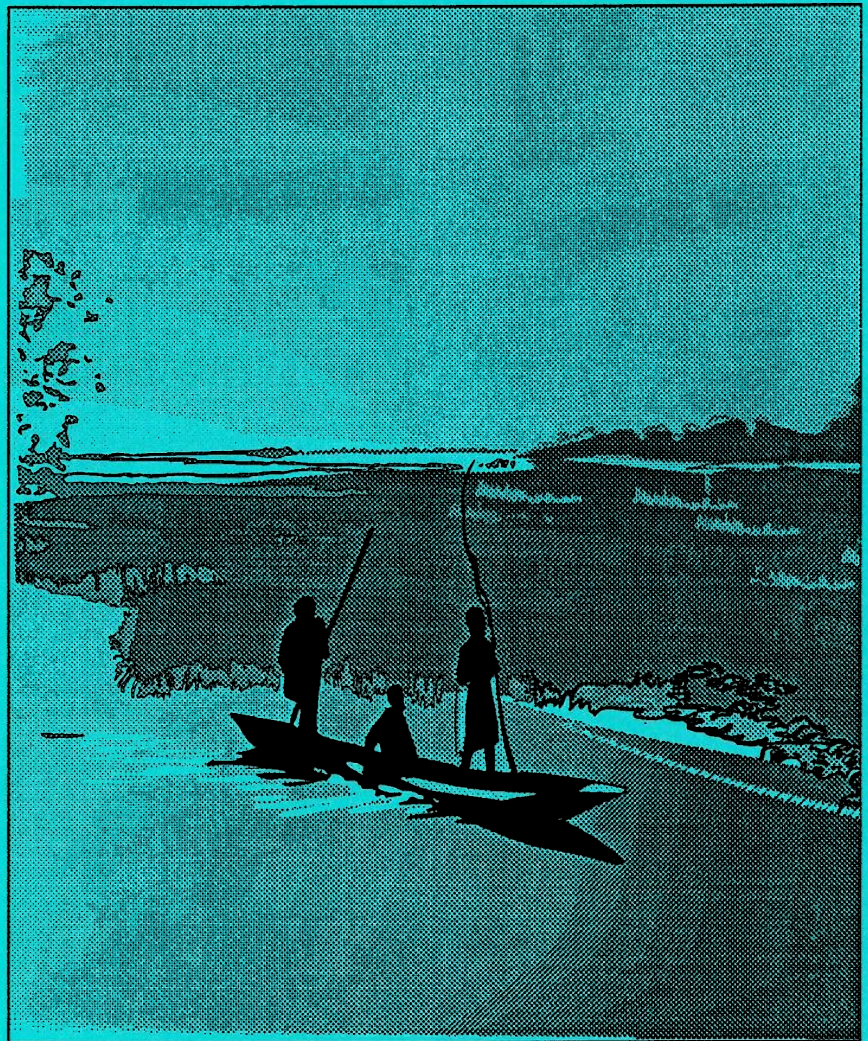


234

oppdragsmelding

Feasibility study of fish stock assessment programme in Okavango

Odd Terje Sandlund
Tor F. Næsje



NINA

NORSK INSTITUTT FOR NATURFORSKNING

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Kontaktadresse:

NINA

Tungasletta 2

7005 Trondheim

(07) 58 05 00

Preface

Norwegian Institute for Nature Research (NINA) was, in a letter dated 11 March 1993, requested by NORAD/Gaborone, Botswana, to review a project proposal entitled "Fisheries Development/Fish Stock Assessment" concerning the Okavango Delta. The project proposal was submitted by the Botswana Ministry of Agriculture in October 1992 for possible funding by NORAD.

The review team consisted of Dr. Odd Terje Sandlund (team leader) and Dr. Tor F. Næsje. The Terms of Reference for the feasibility study are given in Annex I. The field work in Botswana lasted from 4-19 September 1993, and included meetings with Botswana government officials, local Fisheries Unit personnel, NORAD officials, local fishermen and tourist lodge owners, in Gaborone, Maun, and in villages of Ngamiland. The travel itinerary and list of people met are given in Annex II.

The review team want to express their thanks for the assistance provided by NORAD/Gaborone, particularly by Deputy Resident Representative Harald Karlsnes. Representatives for the Ministry of Agriculture/Fisheries Section: Agricultural Economist/Planning Officer Beth Lemberg, Ass. Agric. Economist David Tibie, Regional Fisheries Officer Shaft Nengu, and Senior Fisheries Officer Trevor Mmopelwa had organised a very instructive and efficient programme. We also want to thank them and

their field colleagues of the Fisheries Section for enjoyable company during the field trip to the Delta.

Trondheim, October 1993

Odd Terje Sandlund
Tor F. Næsje

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1 Introduction

The Okavango Delta is one of the most famous natural wonders of the world, and attracts a large number of tourists to Botswana every year. The rich resources of fish, wildlife and water have created the basis of existence for the local communities for centuries. The importance of the Okavango Delta is also due to the fact that it is the only major source of surface water in the arid Kalahari area (Campbell 1990). The wildlife, natural scenery and sport fishing form the basis for the economically important tourist industry. The fish resources are presently exploited through subsistence fishery, commercial fishery, and through tourists' angling, but the level of exploitation is not known.

The large number of conflicting interests concerned with the utilisation at the Delta indicates that formulation of a plan for sustainable management of the area is a complex, but urgent task. The many aspects of management put an even higher demand on the necessary basis information. However, the fish stocks of the Okavango Delta have only been subject to sporadic research. None of the investigations have been planned and performed with the goal of producing the information needed by the Botswana authorities for the formulation of a management plan. The ecological knowledge base is therefore poor. In addition, the information concerning the level of exploitation and the present socio-economic importance of the fish resources is quite inadequate. Moreover, the research performed

has not contributed to developing Botswana's own competence in the field of fisheries and freshwater ecology.

The fish stock assessment programme in the Okavango Delta presented by the Botswana Ministry of Agriculture, Fisheries Section (Annex III), has two main goals. First, to improve the knowledge base for the development of a well founded plan for sustainable management of the fish resources. Second, to improve Botswana's competence in the field of fish ecology, aquatic ecology and socio-economy. This report reviews the background data and discusses the objectives and the components of the project, suggesting adjustments to the original proposal. Finally, recommendations regarding the feasibility of the project are given.

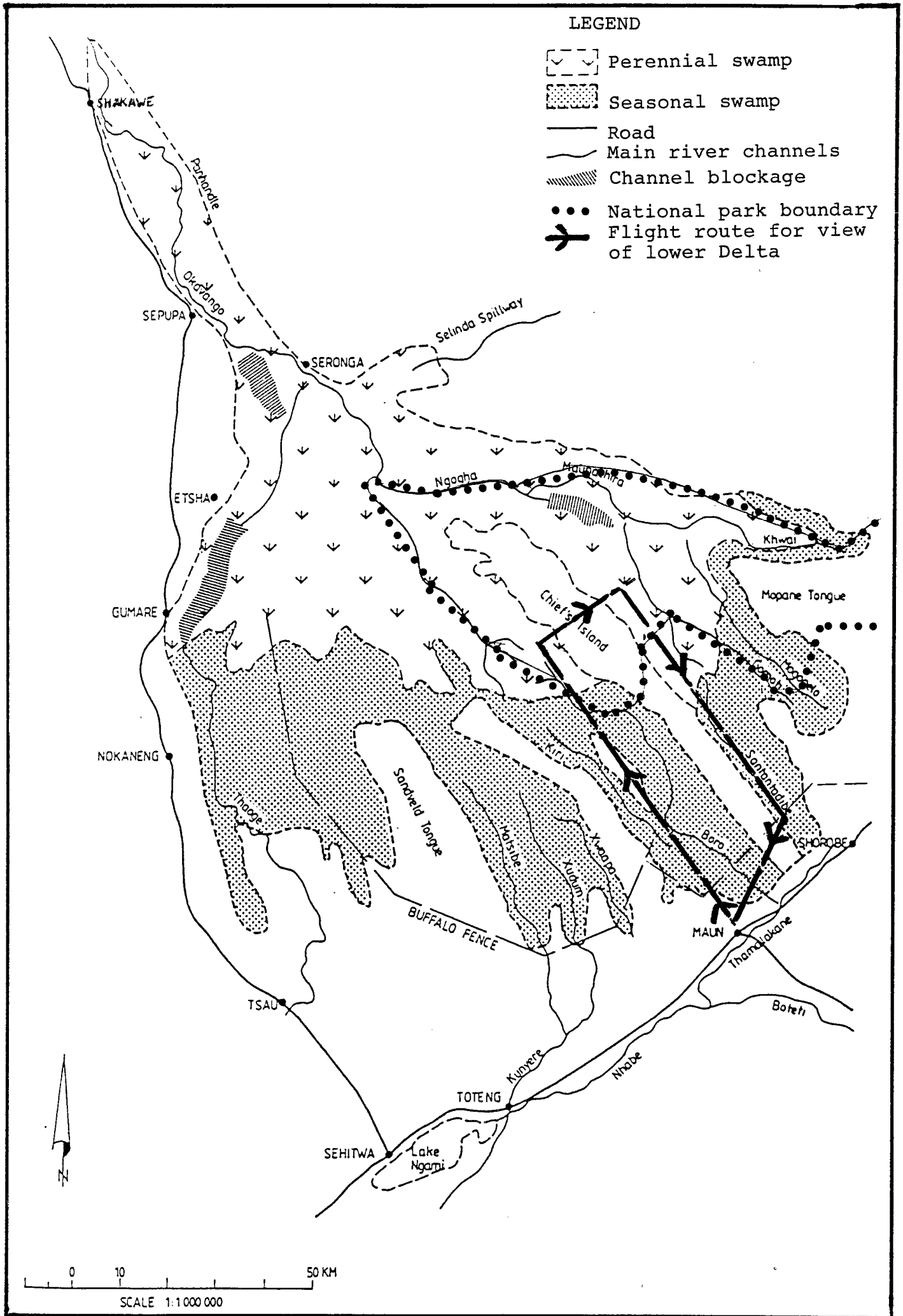


Fig. 1 The Okavango Delta, with the various ecotones, and the approximate outline of the Moremi National Park (Wildlife Reserve). The flight route taken by the review team to obtain an impression of the lower part of the Delta is also indicated.

2 Rationale for the development of a management plan

There are at least four major aspects of the present use of the Okavango delta that make the development of integrated management plans an urgent issue: the subsistence and commercial fishery; the tourist industry; the conservation of nature through protected areas; and the agricultural activity in the immediate catchment area.

The subsistence fishery in the Delta is undoubtedly essential for the nutritional status of the local human population. As many as 5000 persons may be involved in the fishing activity in the Delta (Skjønberg and Merafe 1987). Surplus production is sold at local markets, or even at other markets in Botswana. Some export to Namibia (Caprivi) has also been mentioned in our discussions, but no documentation has been available. The marketing of fish creates income opportunities, and indicates a possibility for economic development (e.g. Nylund et al. 1985). According to the information from the Fisheries Section, most fishermen are fishing only for two thirds of the year (8 months), and cultivating their land for one third (4 months). This diverse individual economy contributes to an increased food security for the families. However, according to information from the Fisheries Section, only approximately 10 persons are full time fishermen. A future development of a commercial fishery must be based on correct stock assessments. This is important both to ensure sustainability of the

fishery and to ensure that a possible reduction in the subsistence fishery does not cause a decreased nutritional standard for the local population. Thus, the socio-economic aspects of the subsistence and commercial fishery must be incorporated in all management plans. It should be noted that the present Fish Protection Act (Annex IV), has not been enforced due to lack of data on which to base management plans.

The tourist industry is growing steadily in northern Botswana. The Okavango Delta is a unique area by any standard, and in the arid south-western Africa, it has rightly been called the "Jewel of the Kalahari". In addition to the scenery and wildlife, one important reason for people choosing to travel to the Okavango Delta is the angling opportunities. There are at present some conflicts between the commercial/subsistence fishery and the tourist industry. The reasons behind the problem are similar to what is normally seen in similar conflict situations. Both parties claim that the other party is catching too much fish or are performing their activity in a way that is detrimental to their own interests or to the ecosystem. The realities behind this are not known, but the conflicts will certainly grow as both the local population and the number of tourists are increasing.

A substantial part of the lower and eastern part of the Okavango Delta has been protected in the Moremi Wildlife Reserve (Fig. 1), and fishing is prohibited within the Reserve borders. The area covered by the Reserve has

recently been enlarged by the Department of Wildlife and National Parks (Ministry of Commerce and Industry) without consultation with the Fisheries Section (Ministry of Agriculture). The effect for the local fishermen of this increase in the protected area is not known, but it is probable that some fishermen has had their opportunities reduced. On the other hand, an increased protected area means that the fish stocks have a larger refuge. This may help to sustain the fish stocks in case of overfishing in the exploited areas. The management of the wildlife resources is under reorganisation. The Department of Wildlife and National Parks have set up a system of concession areas, so called Controlled Hunting Areas (CHA). The various concession areas will be designated either community areas, multipurpose areas, photographic areas, or reserved areas. The position of the various ways of utilising the fish resources in this system appears to be undecided, or at least unclear.

In relation to nature conservation, the international fame of the Delta attracts the interest of several foreign NGOs and individuals. Consequently, any management action taken by Botswana authorities will be closely scrutinised by these outside interests, in addition to the various national groups. In addition these foreign NGOs often impose considerable pressure on the authorities in favour of specific management actions. The competence of the NGOs, however, may not always be adequate in the local socio-economic and political setting. This interest in the management of the area makes it even

more essential that the necessary biological, environmental and socio-economic information and competence is available to Botswana authorities.

Cattle ranching is one of the two major sources of income in Botswana. There is substantial cattle ranching in the parts of the Delta outside the veterinary cordon fence (Fig. 1). The veterinary fence was erected to keep cattle separated from wild ungulates in order to avoid the transfer of diseases (e.g. foot and mouth disease). Presently, the fence may also reduce the spreading of cattle ranching into the Delta, thus protecting the natural ecosystems. Even so, some cattle, sheep and donkeys are also found around villages inside the fence. The seasonally flooded areas ("molapos") are to some extent cultivated after the flood season (Tvedten 1985). Heavy grazing close to the river canals and lagoons must be expected to have a substantial effect on water runoff and erosion, and thereby on water quality and conditions for the fish population. In general, the unusually close connections between the aquatic and terrestrial parts of the Okavango Delta ecosystem indicate the importance of integrated management plans.

In view of this, the development of a management plan for the fisheries of the unique area of the Okavango Delta is certainly a feasible and important task.

3 Knowledge about Okavango fisheries

3.1 Ecology

The Okavango Delta is in principle a tropical floodplain ecosystem, characterised by fluctuations in water covered area, and with at least three types of aquatic habitats: the river channels, the lagoons and oxbow lakes, and the seasonally flooded areas (Welcomme 1979). However, the hydrology of the Okavango Delta makes this system more complicated than common floodplains. The high water level in the Okavango River is caused by rains in Angola, and reaches the northern end of the Delta in April. The maximum water level moves slowly through the Delta, reaching the southern end around Maun in August, approximately 4 months later (Scudder et al. 1992). As the water leaves the Delta mainly through evaporation (95%, Camphell 1990), the flood level is strongly reduced in the southern end. This north-south gradient is the reason that Merron and Bruton (1987) has defined four ecotones in the Delta: the riverine panhandle; the upper swamp; the lower swamp; and the drainage rivers.

A collaboration project between the Department of Water Affairs (Ministry of Mineral Resources and Water Affairs), the University of Botswana, and the University of Lund, Sweden, studying the hydrology and limnology of the Delta has been performed. No information from this project has been available so far, but these data will certainly be of great use for the proposed project.

A total of 86 fish species have been recorded in the Okavango Delta (Merron and Bruton 1987). A substantial number of these have a small adult size, and are of minor importance as food. In the fishermen's catches, 10-20 species are important. The smaller species may, however, have a commercial value in the aquarium trade.

Until now, the major ecological research on the fish stock in the Delta was performed by scientists from Rhodes University, South Africa, during 1982-86 (Merron and Bruton 1987, Merron 1991). The results from this project constitute a useful basis for the proposed management-oriented project as the environmental conditions in the Delta vary between years, and also over longer time periods. The data collected in 1982-86 are therefore valuable as they provide the first data points in a time series which will be necessary to develop a plan for sustainable management of the fish stocks. Research in the Namibian section of the Okavango River has also produced relevant information (see review in Sandlund and Tvedten 1992).

3.2 The present exploitation of the fish stocks

No proper programme for recording catches has been organised in the Okavango Delta. For a number of years, the Botswana Government operated programmes of buying fish from the Delta which was distributed to schools and other public institutions. The

quantity of fish handled through this system was recorded (Skjønberg and Merafe 1987), but fish caught for subsistence purposes or sold through ordinary marketing was not recorded. To develop a plan for sustainable management, catch statistics must be combined with biological data on the fish stocks.

3.3 Socio-economics

The social and economic aspects of the Delta fishery have been discussed in a report published in 1987 by Skjønberg and Merafe. The socio-economic conditions for farmers in the Delta have also been analysed (e.g. Tvedten 1985). However, several factors indicate that the conditions have changed since these investigations.

First, the human population in the area has been steadily growing. One may assume that this means that more people are involved in some form of subsistence fishery, and are dependent on fish for their nutritional status. It also means that the demand for fish in local markets has increased.

Second, fish trade is now totally dependent on free enterprise, although the Government may still assist local communities with cold store facilities to increase quantities sold fresh/frozen. Nothing is known, however, about the proportion of catches sold locally, to other markets in Botswana, or exported to neighbouring countries.

Third, the marine fisheries in neighbouring Namibia are developing quickly, providing cheap marine fish. A commercial artisanal inland fishery will most probably not be able to compete with the marine fisheries in terms of prices. The economic perspectives for the development of a commercial fishery in the Okavango Delta may therefore to a large extent depend on the supply of marine fish from Namibia.

Forth, the tourist industry is very important in earning foreign exchange for Botswana. The national income from this industry is expected to increase in the coming years. The Okavango Delta is also promoted as an angler's paradise, but the actual economic value of the angling opportunities is not known.

Solid information on these aspects is necessary to develop a management plan for the fisheries, and should form the basis for planning of any development of the fishery and the tourist industry. The importance of the various aspects also indicates the importance of formulating integrated management plans for the Delta.

4 Project components

4.1 Objectives

The project is ultimately aimed at sustainable utilisation of the fish resources in the Okavango Delta. A management plan for sustainable use and conservation of the

resources must take care of the different and partly conflicting interests in the area. To achieve this, a sound basis of ecological and socio-economic data are indispensable. The development of a management plan is the responsibility of the Botswana authorities. The Convention for Biological Diversity (UNEP 1992), to which Botswana is one of the signatories, states that the individual ".....States have sovereign rights over their own biological resources" and "also that States are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner". The principles of conservation and sustainable use are also stated in Botswana's National Conservation Strategy (1990, pp. 2-3).

According to Botswana's National Development Plan no 7, the political aim is to diversify production in the agricultural sector, through e.g. fisheries. To achieve sustainable development in this sector, better knowledge about the fish stocks and the ecological conditions of the surface water localities is needed.

For Botswana to be able to fulfil this task, and to take full responsibility for the management of their own resources, there is a need to train Botswana staff of the Ministry of Agriculture/Fisheries Section, and other natural resource management agencies, to sufficient academic levels. The Okavango Delta, being a unique natural area also in a global perspective, attracts the interest of various foreign or international interest groups and NGOs. To maintain its sovereignty in the

face of these external interests, it is necessary for Botswana to staff their natural resource management agencies with personnel of internationally accepted professional standard. The aim should therefore be to have key staff at Ph.D. level.

The objective of the programme is twofold:

- Develop a management plan for a sustainable utilisation of the fish resources in the Okavango Delta.
- Improve Botswana's competence and capability to monitor its freshwater ecosystems and fish resources, and to improve Botswana's competence in socio-economic analyses related to natural resource management.

Immediate objectives are to:

- Collect baseline data on the various habitat types in the Delta, and to evaluate whether the selected research sites are representative.
- Establish data collection systems regarding the ecology of fish stocks and selected environmental parameters.
- Establish data collection systems for recording the fish catches in the Delta, including commercial, subsistence and recreational fisheries.
- Investigate the socio-economic role of the fish resources for the local communities, as well as the importance of the fish stocks for the tourist industry.

4.2 Scope of work

The project's scope of work should include:

4.2.1 Ecological data

Data on ecological conditions regarding the fish stock and selected environmental parameters should be collected. At the start of the project, a survey of different localities (river sections and lagoons) should be performed to establish the importance of different habitats, and to obtain an indication of the variability among localities. In connection with management of the fisheries, it is essential to collect information on the variation in time and space in the major physical and chemical parameters of the water in the different parts of the Delta. Among parameters with relevance to fish productivity are:

- water depth and current velocity in the river channels,
- basin depth and form of the lagoons and oxbow lakes,
- water transparency,
- oxygen concentration ,
- water acidity (pH),
- contents of major nutrients.

In the fish research performed earlier, a description of the environmental parameters was omitted. Thus nothing is known about e.g. the morphometry of the lagoons, which is of great relevance for the biological production. In addition, an important limiting factor for fish production may be a lack of oxygen in the lagoons during parts of the year, but little or

nothing is known about this, or any of the other environmental factors.

The lack of basic knowledge makes it important to investigate the variation among different localities within each of the habitat types. These data will form the basis for selecting sampling localities which should be representative for larger areas of the Delta. This information will also be important as general baseline data, and for monitoring purposes.

The research sites should therefore be selected on the basis of data from the limnological and fish survey, as well as on criteria such as: sites used in earlier investigations, the extent of present fishing activity, representativeness of the various ecotones and habitat types. It is necessary to repeat the limnological survey of several localities to obtain a picture of the seasonal variations in oxygen levels and other relevant parameters.

At each site selected for fish ecology research, parameters such as the fish community structure, catch per unit of effort, habitat use by the various species will be recorded. In addition population dynamics and feeding habits will be studied for selected species. The data collection procedures should be designed so that a simplified monitoring programme can be continued after the termination of the project. It is well known that the environment of the Okavango Delta varies greatly over longer time periods. It is therefore important for an improved management of the area to

eventually have access to long time series of data.

4.2.2 Catch statistics

Comprehensive data on fish catches should be collected. A system should be designed so that total catch, catch composition, contribution to subsistence and commercial market, and catches in tourist fishing is recorded. The sampling programme has to be carefully designed to satisfy the need for reliable information even when only small samples of the catches can be recorded. A combination of common catch statistics methods and the methods of socio-economy may prove useful in such a complex small-scale fishery. Major parts of the field work to collect the catch statistics must be performed by the Field Officers of the Fisheries Section.

Catches by subsistence and commercial fishermen should also be sampled to provide data on the size and age composition in the catches of the various species. This will show the selectivity of this fishery on the fish stocks.

This data collection programme must be designed so that it constitutes the start of a long term monitoring programme.

4.2.3 Hydrology

Water discharge data and remote sensing information (e.g. satellite imagery) should be combined, with the aim of establishing a correlation between water inflow and fish production. There is a general relationship

between water covered area and fish yield in floodplain fisheries (Welcomme 1979). Long time series for water discharge in various sectors of the Delta have been collected by the Department of Water Affairs. It may be possible to combine these data with satellite images of water covered area in the Delta. These data would facilitate modelling of the relationship between water inflow, duration of the flood and fish yields.

4.2.4 Socio-economics

The socio-economic significance of the fish resources in the Okavango Delta should be investigated. Data on the importance of the fishery as a protein source for local communities, as a cash earner in commercial markets, and the value of angling in the tourist industry, will be of basic importance for Botswana authorities in developing a plan for sustainable management of the fish resources.

4.2.5 Training

Possibilities must be provided for training to at least M.Sc. level, and ultimately Ph.D. level, of Botswana counterpart staff of the Fisheries Section. An important criterion for a feasible Masters course is that the field work for the thesis is done in the Okavango project. Many courses available in Europe and North America are based on data collection through field work in these countries or laboratory experiments in a high-tech environment. This provides experiences which are of little or no relevance to the work the candidates are

expected to do in their home country after their education is completed.

However, there are a few relevant courses available. A good quality Master-level course in fisheries biology for students from developing countries is given at the University of Bergen. The study programme of this highly relevant course is given in Annex V. A Master's course with a wider scope towards tropical fish and freshwater ecology is planned to start at the University of Zimbabwe in 1994. The study programme for this course indicates that this also will be a highly relevant course for training of Botswana staff from an Okavango project (see Annex VI). The University of Wageningen, The Netherlands, is also giving a Master level course in fisheries. This course, however, is more directed towards aquaculture, which is not relevant for the Okavango project. At present there are various B.Sc. courses in ecology available at the University of Botswana. This University is in the process of hiring staff on aquatic ecology and fish ecology, planning to be able to offer Master's courses on these subjects within a few years.

In the socio-economic field, the University of Zimbabwe offers training at all levels. Collaboration with the Centre for Applied Social Sciences (CASS) would probably be a feasible solution for an Okavango project. CASS is presently taking part in the Zambia/Zimbabwe SADC Fisheries Project in Lake Kariba, and is developing their competence with regards to the socio-economics of fisheries. The universities of

Oslo, Bergen and Trondheim, Norway, may also give Masters courses relevant for this aspect of the project.

Training to B.Sc., M.Sc. and Ph.D. level of additional Botswana and Norwegian students would benefit both Botswana, Norway, and the project. Botswana is generally in need of competence in ecology and natural resources management. Education through participation in a fisheries project in the Okavango Delta would increase knowledge in the fields of aquatic ecology and socio-economics related to the utilisation of natural resources. A more generalised education in tropical aquatic ecology, as envisaged in the Master's course at the University of Harare (Annex VI) will also qualify for more general management of tropical natural resources. In Norway, there is generally a lack of competence in tropical ecology and the management of tropical natural resources. In recent years, Norwegian agencies of development collaboration, in particular NORAD, have expressed their interest in developing a stable Norwegian competence in tropical ecology. Major projects in this sector, like the one envisaged in the Okavango Delta, should be utilised to create this type of competence in Norway. We will suggest that two scholarships for Norwegian students are included in the project budget. This will also benefit the project, as these students will constitute an addition of motivated and enthusiastic participants, which will positively affect the project group.

At the technical level, Fisheries Section field officers will receive on-the-job training in the

project, but possibilities of formal training outside the project should also be pursued.

4.2.6 Project staff

The number of expatriate experts proposed in the original project proposal was one fish ecologist, one limnologist and one socio-economist. We will maintain three experts, but recommend that their tasks and qualifications will be somewhat different. The three experts should be one fisheries biologist, one freshwater ecologist, and one socio-economist. The proposed terms of reference for the three positions are given in Annex VII.

The fisheries biologist will be the team leader and work mainly on fish stock assessment, concentrating on the major species in the Okavango system. The freshwater ecologist will look further into the ecology of the main species, evaluating feeding ecology, competition among species, predator-prey relationships etc. The socio-economist will collect data on the socio-economic value of the fish resources in the subsistence, commercial and recreational fishery. It has been pointed out that it might be difficult to recruit a well qualified socio-economist for permanent residence in Maun. If this is the case, it may be feasible to find some arrangement where the expert spends a specified part of the year with the project team in Maun. The catch statistics programme need to be developed in collaboration between the three experts, as it may be productive to combine the methods of traditional fisheries statistics and socio-economic methods to

develop reliable methods for data collection in complicated systems like the Okavango fishery.

The expatriate project staff should be based in Maun.

Short-term consultancies will be necessary regarding various aspects of the project. At the start of the project consultants will be needed in the limnological and fisheries survey of the Delta. This survey will provide data necessary for deciding the permanent fish research sampling sites. By performing this with sufficient manpower at an early stage, the project will have a swift start. Other relevant themes for short-term consultants are the recording system for limnological data, and the development of a model combining hydrological data and remote sensing data from satellite. The detailed planning of the project will reveal further themes which will have to be analysed by short-term consultants. This will also to some extent depend on the actual qualifications of the permanent experts.

4.2.7 Students

All Botswana counterparts to the expatriate experts should be enrolled in education programmes aiming at a Master's degree. The ultimate aim should be to reach Ph.D. level in due course. Only university programmes based on field work in the project are recommended.

To increase the number of qualified ecologists in Botswana, additional students should be

given an opportunity to take part in the project work. Detailed contracts need to be signed with these additional students, specifying their rights and responsibilities in relation to the project and the collaborating institutions.

The project should also aim at engaging four Norwegian students, two at a Master's level and two at Ph.D. level. This would be an important contribution towards increasing Norwegian competence in the field of tropical aquatic ecology. If, for budgetary reasons, there is not room for this within the project, funding of the Norwegian students should be pursued from other sources in Norway.

4.2.8 Reference group

A Reference group should be established to lay out the strategies and the main lines of work for the project. The members of the group should act as advisers to the project team in any question regarding the activities of the project, and also act as ambassadors for the project in their daily work. Members of the group should be two representatives from the Ministry of Agriculture, two representatives from the Norwegian collaborating institution, one representative from the Ministry of Mineral Resources and Water Affairs, one representative from the Ministry of Commerce and Industry (Dept. of Wildlife and National Parks), one representative from one of the universities where project staff are enrolled as Master or Ph.D. students (a supervisor), and one representative from NORAD/Gaborone. The expatriate team leader will act as the Reference group secretary.

The professional responsibility for the project should rest with the Norwegian collaborating institution. The institution should inter alia. recruit qualified professional personnel, act as employer for the expatriate personnel, ensure project work progression according to plans, and ensure that the results from the project is published in adequate ways. One of the Norwegian institution's two representatives in the Reference group will be co-ordinator for the project in Norway.

4.2.9 Equipment

The necessary investments are listed in chapter 9 "Budget and staff proposal". Major investments has to be made at the Maun site of the Fisheries Section. There is a need for offices for expatriate and Botswana staff, students' offices, laboratories, computer rooms, storage rooms for equipment, cold storage for biological material etc. Rather than building field laboratories at various sites in the Delta, it is recommended that a 5-tonne truck is equipped with field laboratory facilities. Careful detailed planning of this and other equipment will facilitate efficient field work.

5 Time aspect

The proposed project period of 3 years will most probably be too short to reach the objectives. Particularly the training aspects of the project indicates this. Training to M.Sc. level will usually take a minimum of two to three years after B.Sc. For Botswana counterparts to assist in setting the project on

its tracks, to take M.Sc. degrees, and then gain sufficient experience to take over the project after 3 years seems unlikely.

The best procedure would be to evaluate the first phase of the project after two years, and plan for a follow up phase of at least two additional years. In this way adjustments taking care of questions which may turn up during the first phase are possible.

6 The project's relation to the policies of Botswana and NORAD

As shown earlier (chapter 4), the proposed project is in full accordance with Botswana's policies in the sector of natural resources management, as stated in the National Development Plan no 7, 1991-97, and in the National Conservation Strategy (1990).

In NORAD's principles for development collaboration "NORAD in the Nineties" it is stated that: "The objective of sustainable development in all countries should be the basis for NORAD's cooperation with developing countries". The need for sustainable management of natural resources is also emphasised in the Norwegian Government's White Paper on Norway's development collaboration (Stortingsmelding nr. 51, 1991-92). This is also a major subject in the new strategy for NORAD's bilateral collaboration with Botswana, where it is stated that environmental considerations should be an integrated part of the collaboration. Moreover, the need to perform surveys and

research regarding natural resources in general and fish resources in particular are emphasised.

7 Institutional collaboration

The tasks of the project, to collect ecological and socio-economic data with an applied purpose, and the training of staff to an academic level, indicate that collaboration between the responsible Botswana institution and a Norwegian institution experienced in similar work will be feasible. The aim would be to develop a long-term collaboration between the institutions. The project period should only constitute the first step in this collaboration. To achieve this, it is important that high quality research institutions are involved. It is also important that the institutions involved have stated as their long-term goal to be involved in this type of international collaboration. The universities involved through enrolment and supervision of students from the project will also be important partners in the collaboration.

Provided that adequate funding is available, Norwegian Institute for Nature Research (NINA) is interested in participating in the project as the main Norwegian institution in the project collaboration.

8 International resource management

The Okavango River is shared by Angola, Namibia and Botswana. Through the Selinda Spillway, the Okavango is also connected with the Kwando-Chobe-Linyanti-Zambezi system, involving both Zambia and Zimbabwe. Consequently, there is an obvious need for regional collaboration on the management of the river systems. The most immediate concern regarding the Okavango is a collaboration with Namibia, which is in the process of developing its legislation on inland fish resources. Namibian institutions have also started a monitoring programme of the fish stocks in their section of the Okavango River. A close collaboration between a project in the Okavango Delta and the Freshwater Fish Institute in Namibia would therefore be feasible.

9 Budget and staff proposal

The present budget proposal concerns the first three-year phase of the project (cf. chapter 5, Time aspect). All figures are in thousand Norwegian kroner (1000 NOK). One Botswana pula is assumed equal to three Norwegian kroner (P 1 = NOK 3). The budget does not take into consideration how the costs should be divided between NORAD and Botswana authorities.

The Fish ecologist and team leader holds a key position and should be appointed as soon as possible after the funding is established.

Appointment of the rest of the personnel may take some months after the start of the project. The first year cost of salaries may therefore be reduced accordingly. Fisheries Section staff are to be counterparts to the expatriate experts. In addition to the staff listed below, the project will be stingily dependent on help and assistance from the other staff of the Fisheries Unit in Maun and the extension officers in villages in the Okavango Delta.

SUMMARY BUDGET

	Yr 1	Yr 2	Yr 3
1 Expatriate staff	3020	2980	2980
2 Short term consultancies	1200	880	560
3 Students/training	275	2400	2400
4 Reference group	430	480	480
5 Investments	3070	560	375
6 Recurrent costs	551	551	551

Sum	8546	7851	7346
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	Yr 1	Yr 2	Yr 3
1 PERMANENT EXPATRIATE STAFF			
Fish biologist and team leader	980	980	980
Fish ecologist	900	900	900
Socio-economist	900	900	900
Travel and expenses	200	200	200
Expenses in connection with employment of staff (interviews, travel expenses etc.)	40		

Sum	3020	2980	2980
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Comments: The expatriate staff costs includes salaries, social insurances, post adjustments etc. The actual expenses during the first year (Yr 1) will depend on when the staff can be recruited and in function. If it is decided that the socio-economist's tasks can be completed by an expert staying for less than the full year in Maun, this will reduce the expenses.

2 SHORT TERM CONSULTANCIES	Yr 1	Yr 2	Yr 3
Limnologist/hydrologist (2 months)	180	150	120
Travel and expenses 100	80	50	
Remote sensing expert (1 months)	90	0	0
Travel and expenses (1 month)	50	0	0
Technical assistance (6 months) 540	450	270	
Travel and expenses (3x2 months)	240	200	120

Sum	1200	880	560
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Comments: The need for short term consultancies to cover various specific subjects will be fairly great during the first year, but is expected to decrease over the project period.

3 STUDENTS/TRAINING	Yr 1	Yr 2	Yr 3
NORWEGIAN			
2 cand. scient/master students (incl. travel and expenses)	50	200	200
2 Ph.D. students, scholarships	100	650	650
Travel and expenses	50	200	200
BOTSWANA			
4 Bachelor students	0	600	600
4 Master students	0	600	600
Other training	25	100	100
<u>Workshops</u>	<u>50</u>	<u>50</u>	<u>50</u>
Sum	275	2400	2400

Comments: To ensure that the project work gets properly started, the Botswana counterparts will have to stay in Maun for a minimum of 6 months after the arrival of the expatriate experts. Thus, their enrollment in Master's or Bachelor's courses will most probably occur at the beginning of the second year.

The cost for Norwegian students is based on standard Norwegian scholarship rates. These students may be able to join the project whenever this is found feasible by the project team. However, this will most probably only occur late in year 1 or in year 2. If there is no budgetary room for the Norwegian students, funding for these scholarships may be sought from other Norwegian sources.

4 REFERENCE GROUP

Norwegian Institution:

Scientific advisor and project co-ordinator 2.5 months	240	240	240
Travel and expenses (Norw.-Bot. 2x1 weeks)	50	50	50
Scientific advisor 1 month	90	90	90
Travel and expenses (Norw.-Bot. 2x1 weeks)	50	50	50

Ministry of Agriculture, Botswana:

2 members

Ministry of Mineral Resources and Water Affairs, Botswana:

1 member

Ministry of Commerce and Industry, Botswana:

1 member (Dept. of Wildlife and National Parks)

NORAD

1 member

University African/Norwegian:

1 member Travel and expenses (Norw.-Bot. 2x1 weeks)	(0	50	50)
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Sum	430	480	480
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Comments: The Norwegian members of the Reference group should act as scientific advisers to the project, and take active part in the various aspects of the work. The travel expenses for the Botswans members of the group has not been included.

5 INVESTMENTS

	Yr 1	Yr 2	Yr 3
Buildings:			
Buildings Maun 3 buildings each 30 m ²	500		
Storage buildings in Maun	100		
Office renovation in Maun	150		
Fencing Fisheries offices in Maun	30		
Vehicles:			
Mercedes 5-tonne truck	600		
Fitting up of truck (field laboratory)	200		
Toyota Landcruiser wagon	450		
18 ft. alum. boat	30		
12 ft. alum. boat	15		
50 hp. outboard motor	20		
Two 30 hp. outboard motors	25		
Field equipment:			
Gill nets	150	50	50
Electrofisher	45		
Beach seines and longlines	60		
Camping equipment	30	15	15
Plastic holding bins and cold boxes	15	10	10
Accessories	50	50	50
Research equipment:			
Laboratory equipment:			
Stereoscopic microscopes (3)	150		
Microfiche (2)	40		
Oxygen and temperature meters (3)	80		
pH and conductivity meters (3)	80		
Various lab. equipment	30	30	
Balances	15		
Computers (4) and software	75	75	
Furniture	75	50	
Freezers	15	15	
El.-aggregates	15		
Communication equipment (FM-radios)	25	15	
Satellite images		250	250
Sum	3070	560	375
6 RECURRENT COSTS:			
Petrol	120	120	120
Rotenone	6	6	6
Preservatives	10	10	10
Building maintenance			
Non electrified bldgs	75	75	75
Electrified buildings	150	150	150
Vehicle maintenance	90	90	90
Unexpected costs	100	100	100
Sum	551	551	551

10 Conclusions and recommendations

- The proposed project is feasible and should be taken up for funding by NORAD, with the modifications outlined in this report.
- The available information on the fish stocks and the fishery in the Okavango Delta is not adequate for enforcement of the existing Act on Fish Protection, or for the development of plans for sustainable management of the resources.
- The project proposal is in full accordance with the stated policies of Botswana in this sector.
- The project proposal is well in line with the general principles for Norwegian development collaboration, as well as with the newly revised principles for bilateral collaboration between Botswana and Norway.
- The scope of work of the project should comprise research and investigations on fish ecology, fish stock assessment, catch statistics, selected environmental parameters, and the socio-economic significance of the fish resources.
- Training of Botswana staff to Master's level and ultimately to Ph.D. level should be given the highest priority.
- Training of Norwegian students in tropical aquatic ecology should be included in the project activities.
- The proposed project is well suited for institutional collaboration between a Norwegian institution experienced in applied research regarding management of natural resources and the Botswana Fisheries Section (Ministry of Agriculture).
- Close collaboration regarding management and research on the Okavango River should be established between the Fisheries Section (Botswana) and the Freshwater Fish Institute of the Ministry of Fisheries and Marine Resources, Namibia.
- Better collaboration on the management of the Okavango Delta should be established between Ministry of Agriculture, Fisheries Section, and Ministry of Commerce and Industry, Dept. of Wildlife and National Parks.

11 Literature cited

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- Welcomme, R.L. 1979. Fisheries ecology of floodplain rivers. - Longman, London.

List of annexes

- Annex I Terms of Reference, Review team.
- Annex II Travel itinerary and list of people met.
- Annex III Original project proposal (budget adjusted to September 1993)
- Annex IV The Fish Protection Act.
- Annex V Study programme, M.Phil. course, fisheries biology, University of Bergen, Norway.
- Annex VI Study programme, M.Sc. course, tropical fish and freshwater ecology, University of Zimbabwe.
- Annex VII Proposed Terms of Reference for three expatriate experts.

TERMS OF REFERENCE

for

Feasibility study of Fish Stock Assessment Programme in Okavango

1. BACKGROUND

The Ministry of Finance and Development Planning requested NORAD in November 1992 to finance a fish stock assessment research project in the Okavango Delta based on a Project Memorandum from the Ministry of Agriculture for the project "Fisheries Development - Fish Stock Assessment" (Project No. AG 203 (51/203)).

The project is to be implemented by the Fisheries Section of the Ministry of Agriculture (MOA).

NORAD has found the project interesting for Norwegian funding. However, before a final decision is taken, it is agreed to be prudent by both Parties to have the project proposal and the draft terms of reference for the technical assistance personnel of the project to be closer examined by a team of experts experienced in such projects conducted elsewhere.

2. OBJECTIVES

The objective of the assignment is to discuss the proposal with the Ministry of Agriculture and thereafter come up with a recommendation to NORAD about Norwegian support to the project, and to discuss with the Ministry and appraise the possibility of an institutional cooperation between the Fisheries Section, MOA and a Norwegian institution.

3. SCOPE OF WORK

The work shall comprise, but not necessarily be limited to, the following tasks:

- 3.1 Go through relevant fisheries study reports and give a brief summary of their main conclusions and how the conclusions have been followed up by the authorities in Botswana.
- 3.2 Give an assessment of the project proposal regarding its objectives, scope of work, manning, equipment, time aspect, budget and funding.

- 3.3 Assess the project proposal with regard to the Botswana National Conservation Strategy (1990), the Botswana National Development Plan 7 and the NORAD Strategies for Development Cooperation/Strategies for Bilateral Development Cooperation.
- 3.4 Discuss the possibility of an institutional cooperation between the Fisheries Section MOA and a Norwegian institution, and present a proposal for such cooperation.
- 3.5 Look into a cooperation between Botswana and Namibia concerning the management and administration of the natural resources/fish resources in the Okavango area with reference to the ongoing Namibian work with a policy document for the Namibian freshwater sector.
- 3.6 Make recommendations to NORAD as to whether the project should proceed as in the proposal or with any modifications.

4. MODE OF WORK

4.1 Method of work

The work shall be based on a study of all relevant documents and on discussions with relevant personnel in institutions in Botswana and Norway.

- 4.2 The field work shall take place during the period 6 through 18 September 1993.

Before the consultants leave Botswana they shall give NORAD and the Fisheries Section, Ministry of Agriculture, a short oral brief of their impression of the programme.

4.3 Team composition

The team shall consist of the following persons:

- Dr. Odd Terje Sandlund (teamleader)
- Dr. Tor F. Næsje

Gaborone, 13 May 1993.



Terje Vigtel
Charge d'Affaires a.i.

ANNEX II

Travel itinerary and list of people met.

3 - 19 September 1993

Dr. O.T. Sandlund

Dr. T.F. Naesje

Norwegian Institute for Nature Research, Trondheim,
Norway

Friday, 3 Sept.

Departure Trondheim

Saturday, 4 Sept.

- Arrival in Gaborone, Botswana, and met by Deputy Resident Representative Mr. H. Karlsnes, NORAD; Agric. Economist/Planning Officer Ms. B. Lemberg; and Ass. Agric. Economist Mr. D. Tibie
- NORAD's activities in Botswana, orientation given by Mr. H. Karlsnes.
- Tour of Gaborone guided by Mr. H. Karlsnes.
- Literature study.

Sunday, 05. Sept.

- Tour of area around Gaborone guided by Mr. H. Karlsnes (Gaborone - Thamaga - Kanye - Lobatse - Gaborone).
- Lunch at Mr. H. Karlsnes' residence.
- Literature study.

Monday, 6 Sept.

- Presentation of the staff at the Norwegian Embassy and NORAD.
- Meetings with:
 - I) Ministry of Agriculture:
Agric. Economist/Planning Officer Ms. B. Lemberg
Senior Fisheries Officer Mr. T. Mmopelwa
Regional Fisheries Officer Mr. S. Nengu
Ass. Agric. Economist Mr. D. Tibie
 - II) Ministry of Agriculture:
Deputy Director Mr. H.L. Robertson
 - III) Ministry of Agriculture:
Chief Agric. Economist Mr. H.K. Sigwele
 - IV) Ministry of Agriculture:
Principal Agric. Economist (Planning) Mr. A.A. Mokgare
 - V) National Conservation Strategy (Co-ordinating Agency): Conservation Officer Mr. M. Sebina
- Literature study.

Tuesday, 7 Sept.

- Meetings with:
 - I) Ministry of Agriculture:
Director Dr. J. Diteko
 - II) Ministry of Agriculture:
Remote Sensing Officer Mr. M. Mulalu
- Literature study.

Wednesday, 8 Sept.

- Departure Gaborone for Maun, by air.
Travelling party:
Agric. Economist/Planning Officer Ms. B. Lemberg
Regional Fisheries Officer Mr. S. Nengu
Ass. Agric. Economist Mr. D. Tibie
Dr. O.T. Sandlund
Dr. T.F. Naesje
- Meeting with Fisheries Unit staff in Maun:
Fisheries Tech. Officer Mr. J.M. Manyemane

Chief Tech. Asst. Mr. E.K. Katsi

Senior Tech. Asst. Mr. D. Maphomo

Senior Tech. Asst. Mr. L. Mokunki

- Meeting with representatives for the University of Botswana:
Head of Biology Department Prof. Dr. Mpuchane
Physical Planner Mr. B. Barron
Registrar Mr. D. Mokgautsi
- Site appraisal of fisheries offices in Maun.

Thursday, 9 Sept.

- Deputy Resident Representative Mr. H. Karlsnes, NORAD, arrived in Maun.
- Meetings with:
 - I) Ministry of Agriculture:
Senior Veterinary Officer Dr. R. Payne
 - II) District Commissioner, Ngamiland, Mrs. K. Boepetwe.
 - III) Ministry of Commerce and Industry:
Senior Wildlife Officer Mr. Nkwane
Wildlife Scientist Dr. R. Bell

Friday, 10 Sept.

- Departure for the Okavango Delta.
- Visit and tour of Okavango bream hatchery and aquaculture operation, 3-spot tilapia (*Oreochromis andersonii*) at Guma Lagoon.
- Meetings with:
 - I) Field Ass. Mr. B. Haengora, Etsha 13
 - II) Field Ass. Mr. M. Keakabetse, Ikoga
 - III) Field Ass. Mr. K. Boi, Sepopa
 - IV) Tech. Ass. Mr. S. Khuting, Shakawe
- Setting up camp in Shakawe.

Saturday, 11 Sept.

- Tour of Shakawe.
- Tour of Samochima and visit proposed fish market site. Meeting with local fishermen.
- Meeting with owners of the two fishing lodges Drosky's Cabins Fishing Lodge and Shakawe Fishing Lodge.
- Boat tour of River Okavango, Shakawe - Ngarange (T/R).
- Meeting with fishermen and Tech. Ass. Mr. K. Kutoro and Field Ass. Mr. S. Kachere, Ngarange.
- Tour of fish marketing site in Ngarange.

Sunday, 12 Sept.

- Break camp in Shakawe. Departure for Seronga.
- Boat tour on River Okavango, Sepopa - Seronga.
- Setting up camp in Seronga.
- Meeting with Field Ass. Mr. S. Maeze.
- Tour on River Okavango and visit of different lagoons previously used as fish research sampling sites. Guided by Mr. S. Maeze.

Monday, 13 Sept.

- Visit of Dungu Lagoon, previously fish research sampling site.
- Meeting with local full time fisherman. View of different fish products sold locally.
- Tour on River Okavango, guided by Mr. S. Maeze. Angling for tigerfish (*Hydrocynus vittatus*), catching two!

Tuesday, 14 Sept.

- Breaking camp in Seronga.
- Departure by boat on River Okavango, Seronga - Sepopa.
- Visit and tour of Etsha 6.
- Arrival in Maun.

Wednesday, 15 Sept.

- Tour by air over lower parts of Okavango Delta. Maun - River Boro - Thokatseebe (fish research sampling site) - Moumo - Chiefs Island - River Guekha - River Santantadibe - Komoko - Maun. This part of the Delta was inaccessible by boat or vehicle.
- Visit to Chanoga Lagoon, previously fish research sampling site. Studying fresh fish caught by local fishermen in Chanoga Lagoon.
- Summary of collected information.

Thursday, 16 Sept.

- Meeting with:
 - I) Conservation International
Co-ordinator Okavango Program Dr. K. Ross
 - II) Dept. of Water Affairs
Hydrology and Water Resources Division
Mr. Bacapi
- Departure Maun for Gaborone by air.
- In Gaborone meeting with Ministry of Agriculture staff:
Agric. Economist/Planning Officer Ms. B. Lemberg
Senior Fisheries Officer Mr. T. Mmopelwa
Regional Fisheries Officer Mr. S. Nengu
Ass. Agric. Economist Mr. D. Tibie

Friday, 17 Sept.

- Study of collected information and preparation of preliminary conclusions.
- Summary discussion with Resident Representative Mr. T. Vigtel and Deputy Resident Representative Mr. H. Karlsnes, NORAD

Saturday, 18 Sept.

- Summary meeting with presentation of preliminary conclusion in the Norwegian Embassy with:
NORAD:
Deputy Resident Representative Mr. H. Karlsnes
Ministry of Agriculture:
Director Dr. J. Diteko
Chief Animal Production Officer Mr. J. Masokwane
Agric. Economist/Planning Officer Ms. B. Lemberg
Senior Fisheries Officer Mr. T. Mmopelwa
Regional Fisheries Officer Mr. S. Nengu
Ass. Agric. Economist Mr. D. Tibie

Sunday, 19. Sept.

- Departure Gaborone and Botswana.

ANNEX III

MINISTRY OF AGRICULTURE

PROJECT MEMORANDUM

PROJECT TITLE: Fisheries Development
(Subtitle: Fish Stock Assessment)

PROJECT NUMBER: AG 203 (51/203)

TOTAL ESTIMATED COST: P 1 200 000

FUNDS ALREADY APPROVED: none

FUNDS REQUESTED: P 2 479 000

PROPOSED SOURCE OF FUNDING: NORAD

PROPOSED START DATE: June 1994

This memorandum prepared by Beth Lemberg.

September 1993

SYNOPSIS

This is a request for funding for a fish stock assessment research project in the Okavango Delta, to be implemented by the Fisheries Section of the Botswana Ministry of Agriculture. A data collection system will be introduced, with the help of technical assistance, which will be used to assess the fish populations of the Delta. Baseline ecological information will be collected, from which a comprehensive management plan will be devised for the Okavango Fishery. Funds will also be used for training of Botswana staff, and to set up a small laboratory in Maun, purchase laboratory and sampling equipment, acquire 2 boats and 2 off-road vehicles to carry out research at sites around the Delta. Development funds of P2 479 000 are required for this three-year project.

PROJECT DESCRIPTION

Background

Fisheries has been an expanding sector in recent years, especially in the Ngamiland and Chobe Districts. The rural poor in these areas have traditionally been dependent on fish hunting for subsistence, gaining valuable protein for their diets, as well as a tradable commodity, from their fishing efforts. It has been estimated that there are approximately 5000 fishermen among the local population in Ngamiland (Merron 1989). The majority of these can be categorised as seasonal fishermen, splitting their yearly activities between fishing and arable agriculture. The fish resource is also utilised by sport fishermen based at camps throughout the Okavango Delta. Sport fishing is a significant tourist draw in Botswana.

While the Okavango Fishery is presently being utilised by numerous people, no comprehensive fisheries management plan exists for this resource as yet. To a large extent this can be attributed to the limited amount of information available regarding the Fishery's ecology. A study conducted in 1965 by Marr produced a crude estimate of fish biomass in the Okavango Delta at 10 000 tonnes per year. However, this figure is questionable, as it was based mainly on the size of the delta during the limited study period, and neglects the complex nature of the riverine, swamp, and floodplain systems making up the delta, which are variable from year to year. A more recent study by Merron was published in 1988, based on research done in the delta over the previous five years. This report included investigations of species diversity and distribution, habitat preferences, and feeding and reproductive biology of certain commercially important species. Merron estimates the standing stock at between 5000 and 7000 tonnes, which differs from Marr, possibly due to the drought that was in effect during the course of Merron's research. While drought-induced reductions in flood levels may have caused fewer fish to be in the Okavango system during Merron's study, the effects of drought are still unclear

with respect to fish breeding patterns. There is great need to understand the relationship between changing flood levels and the dynamics of the Okavango fish population. At present no data is available to project fish population levels in any given year.

It is also unclear as to what the present offtake of fish is in the Delta. Users are numerous, and catches are generally not recorded. When the Government's fish buying program was in effect, sales of fish to the Food Resources Department were recorded. From this, extrapolations were attempted for the entire Delta, although the accuracy of the figures obtained is questionable. Using this method, in 1989, the Fisheries Section estimated annual offtake from the Okavango at 1200 metric tonnes. In some instances drought conditions could give higher yields in riverine systems because fish get concentrated in the smaller amount of water. The type of nets used may also effect yields. The widespread use of gill nets, with their high catch rating, may have certain implications for the life of the Fishery.

Obviously, management of the Fishery is severely hampered by lack of baseline ecological information from which to predict effects of any natural event or human intervention.

Technical Description

Technical assistance is proposed for three years, during which time technical assistance staff will have fulfilled their terms of reference, and their counterparts completed academic training, so as to take over permanent responsibilities for the ecological monitoring of the Okavango Fishery. Temporary extension of the technical assistance staff may be necessary for a smooth transition to local management, since some of the Batswana counterparts will just be completing formal training after three years, and may not have the opportunity for sufficient on-the-job training with the technical assistance staff.

The immediate objective of the proposed research project is to set up a data collection system that will allow the Fisheries Section to determine:

- fish species composition in the Okavango
- species habitat preferences
- species feeding habits
- fish population dynamics (including reproductive and migratory patterns, growth rates, and natural mortality rates)
- the effects of flood level changes on population dynamics
- annual levels of fish harvests
- catch per unit effort for commercial species
- limnological parameters for the various zones of the Okavango
- estimates of total ichthyomass during the Delta's two annual hydrological regimes (i.e., the high water of May to July, and low water of October to December)
- safe exploitation rates (maximum sustainable yields) of commercial species for a complete hydrological cycle

Predictive models will be devised utilising the above information, to investigate the outcome of various management options. The long term objective is to formulate a comprehensive plan that will reconcile economic uses of the fish resource with ecological limits, to produce a sustainably managed fishery that maximises benefits to the people of Ngamiland.

A 30m² laboratory is proposed for the Maun office site which will enable researchers to conduct analysis of fish and water samples. Two computers and other equipment for measurement and analysis will be installed in the laboratory. Existing offices will also be expanded by 64m² at Maun to accomodate the technical assistance personnel and their counterparts.

Recruitment for the following positions will take place:

1. Team Leader / Stock Assessment Biologist
2. Hydrologist / Limnologist
3. Fisheries or Resource Economist

The Stock Assessment Biologist will act as Team Leader, coordinating the study in collaboration with the Head of Fisheries Section, and directing the sampling effort. The Hydrologist/Limnologist will monitor and assess the dynamic physical, chemical, and biological conditions of the Delta waters. The Fisheries Economist will establish and implement a data collection system, in order to estimate the value of fish to the local communities, assess the socio-economic significance of the Fishery to Ngamiland, and determine sustainable exploitation rates for important species.

Information collected from all researchers will be used to design a model integrating physical, biological, and economic constraints, to allow prediction of seasonal stock levels and optimum sustainable exploitation rates under varying conditions. Results from this model will be used to formulate a Management Plan for the Okavango Fishery - the most important outcome expected from this project. Annual reports will be expected from the project team, detailing works undertaken and information/results obtained by team members.

Diploma level training in Aquatic Ecology will also be required to create two more posts for research assistants.

Plan Of Operation

The project will be based in Maun, and administered by the Fisheries Section of the Ministry of Agriculture. A Stock Monitoring and Evaluation Unit will be established for the Section, from which the research described will be conducted - at first with temporary technical assistance described herein, and thereafter on a continuous basis by the Unit's permanent staff. Some facilities already existing in Maun, such as stores, offices, and equipment, can be utilised for the project, although they will be inadequate if left unimproved. Office space must be expanded and laboratory facilities provided, for analysis and

storage of samples. Technical Assistance (TA) staff will be accommodated in BHC houses in Maun where they will be based. Most construction is hoped to be accomplished before technical assistance personnel arrive at the job, although equipping of the laboratory can be carried out with advice of the specialists. Department of Architecture and Building Services will begin tendering procedures for the laboratory and offices once funds are made available.

In order to build on past work done by Merron, the same research sites will be used as those used in his studies. These are: Ngarange, Seronga, Xakaniga, Nxaraga, Thokatsebee, Thamalakane, and Chanoga Lagoon. Vehicles will be necessary to transport researchers to these remote locations. Two four-wheel-drive vehicles and two motor boats are considered necessary for this purpose.

The recruitment process for the Technical Assistance researchers will start once project funding is secured. They will be matched with Batswana counterparts who will undergo training in the beginning of the program and work with the specialists upon their return from degree programs in Fisheries Biology, Hydrology, and Fisheries/Resource Economics. As research counterparts return from training they will assume full time duties with the project, taking over responsibilities from the TA staff. When the TA contracts finish, the counterparts will be set to run the Stock Monitoring and Evaluation Unit of the Section. Two staff members will also be sent for Diploma training in Aquatic Ecology at Lake Kariba (Zimbabwe), or another institute in the region, in order to acquire skills necessary to assume the responsibilities of Research Assistants for the technical team. Field operations will be conducted by the TA researchers initially in cooperation with existing MoA Fisheries staff when necessary and possible, until the return of the trained Batswana Fisheries researchers.

Financial Analysis

Capital costs (See Appendix 1 for phasing of capital costs.):

a) Technical assistance:		
Team leader/Stock Assessment Biologist		
(3 yrs. @ P120 000/yr.)		P360 000
Fisheries/Resource Economist		
(3 yrs. @ P100 000/yr.)		P300 000
Hydrologist/Limnologist		
(3 yrs. @ P100 000/yr.)		P300 000
Subtotal "a"		P960 000
b) Buildings:		
i) laboratory bldg. (30m2, @ P1350/m2)		P 40 500
(+ 40% location factor)		P 16 200
ii) office renovation (64m2, @ 1200/m2)		P 76 800

(+ 40% location factor)	P 30 720
iii) fencing of Maun offices	P 9 000
Subtotal "b"	P173 220
c) Research equipment:	
aquaria/tanks	P 30 000
compressor for aquaria	P 1 000
laboratory equipt.	P 75 500
sampling and preservation equipt.	P 71 800
Subtotal "c"	P178 300
d) Vehicles:	
5-ton Mercedes 4x4 truck	P180 000
Landcruiser station wagon	P148 000
18 ft. aluminum boat	P 8 600
12 ft. aluminum boat	P 4 800
50 hp outboard motor	P 6 900
30 hp outboard motor (2)	P 8 400
Subtotal "d"	P356 700
e) Camping equipment	P 5 000
f) Training:	
(1) 2-yr. M.S. program - Fisheries Biology (@ P50 000/yr.)	P100 000
(1) 2-yr. B.S. program - Biophysics PLUS (@ P50 000/yr.)	P100 000
(1) 2-yr. M.S. program - Limnology/Hydrology	P100 000
(1) 2-yr. B.S. program - Agric. Econ. PLUS	P100 000
(1) 2-yr. M.S. program - Fisheries Economics	P100 000
(2) 2-yr. Diploma program - Aquatic Ecology @P25 000/program	P 50 000
(3) In-service workshops @P10 000/workshop	P 30 000
Subtotal "f"	P580 000
SUBTOTAL a+b+c+d+e+f	P2 253 220
10% Price contingency	P 225 322
SUBTOTAL	P2 478 542
TOTAL	P2 478 542
(SAY)	P2 479 000

Recurrent costs:

petrol	P 40 000
rotenone	P 3 000
preservatives	P 2 000
labels, tags, recording stationary	P 1 500
waders, life jackets, gloves, protective clothing	P 1 500
building maintenance (15.5%)	P 25 450
vehicle maintenance	P 27 250
TOTAL PER YEAR	P100 700

Socio-Economic Analysis

This project is aimed ultimately at sustainable utilization of the Okavango Fishery - a national resource. Without adequate ecological knowledge there is no sensible way to manage the fishery, or work toward its conservation. The danger of not having this knowledge is that the resource could be overexploited through ignorance and accompanying lack of management.

Currently, the only management tool open to Government is the Fisheries Act, written in 1975. This legislation has been shown to be largely impotent because it depends on presently unavailable biological information in order to be used.

Based on the information collected through this project, the Government of Botswana will be able to make informed management decisions for the fishery. Once baseline ecological data exists, controls can be instituted over fisheries. The management plan to be formulated under this project is expected to help preserve the fishing activities for Ngamiland's 5000 fishermen, approximately 300 of whom are considered to be commercial. Maximum sustainable yield levels can be determined for the safe exploitation of the resource by those who derive their livelihoods from it. Conservation regulations such as minimum mesh size and closed seasons can be put in place once their scientific basis is known. In this way the present and future integrity of the resource will be ensured for fishermen, tourists, and the nation as a whole.

With adequate ecological information, it will be possible to integrate tourism and other economic activities in the region (i.e., fishing) with environmental conservation. It may even be possible for fishing activities to undergo expansion when more is known about lesser utilised species. This could lead to job creation and income generation among the residents of Ngamiland.

At the moment, overall development designs for the Okavango do not give much notice to fisheries, due to the fact that only a minimum amount is known about it scientifically. With the dissemination of findings from this research, it is expected that fisheries will then be included in earnest in development plans targetted for the region. In particular, information on ecology of the Delta's fishery would be highly important in the event

that any water diversion scheme is considered for the region, as has occurred recently.

From an international perspective, the implementation of this project would contribute significantly to the body of knowledge on floodwater systems in the world. The information produced could assist in the preservation of similar ecosystems in Africa and other continents. In particular, Namibia and Angola, who share the Okavango system with Botswana, could benefit from the knowledge gained here. Current world concern over environmental degradation has focused attention on the Okavango Delta as a unique and relatively pristine ecosystem, with a high level of biodiversity to be found amongst its resident species. This project is a necessary measure in any serious effort to conserve the Delta. The fish population not only makes up a major share of the species to be found there, it also forms a large part of the food resources in the system, sustaining many of the species higher up the food chain, including man.

The implementation of this project will demonstrate the Government of Botswana's commitment to the development and conservation of its natural resources, as laid out in its 1990 National Conservation Strategy, and NDP7.

APPENDIX 1: Phasing of Project Cost.

Fish Stock Assessment (Fisheries Development: 51/203)

Year:	1	2	3
Technical Assistance			
Biologist (Team Leader)	120000	120000	120000
Economist	100000	100000	100000
Limnologist	100000	100000	100000
Training			
MS, Fisheries Biology	50000	50000	
MS, Limnology/Hydrology		50000	50000
MS, Fisheries Economics		50000	50000
BS, Bio/Physics	50000	50000	
BS, Agric. Economics	50000	50000	
Diplomas, Aqua. Ecology		25000	25000
Workshops	10000	10000	10000
Research Equipment			
Aquaria, tanks	30000		
Compressor for aquaria	1000		
laboratory equipment	35000	40500	
sampl. and preserv. equipt.	35000	36800	
Buildings			
laboratory	56700		
office renovation	50000	57520	
fencing	9000		
Vehicles			
5-tonne truck		180000	
Landcruiser wagon	148000		
18 ft. alum. boat	8600		
12 ft. alum. boat	4800		
50 hp outboard motor	6900		
30 hp outboard motor	8400		
Camping Equipment			
tents, misc.	5000		
Contingency	87840	91982	45500
TOTAL per year	966240	1011802	500500

Overall project TOTAL 2478542

APPENDIX 2: DETAILED EQUIPMENT COST BREAKDOWN

aquaria/tanks	P 30 000
compressor for aquaria	P 1 000
laboratory equipt.:	
oxygen meters	P 12 000
conductivity meter	P 2 000
temperature probe	P 2 500
pH meters	P 2 100
trays, dissection kits, glassware	P 5 000
maps, films, cartographic supplies	P 3 900
computers (2)	P 20 000
microscopes (2)	P 18 000
digital balances (3)	P 10 000
sampling and preservation equipt.:	
monofilament and nylon gillnets	P 9 000
seine nets and longlines	P 20 000
electrofisher	P 15 000
spring and digital balances	P 13 640
measuring board	P 800
plastic holding bins and cold boxes	P 5 300
deep freezers (2)	P 8 000
Camping equipment:	
cottage tents (4)	P 2 200
camp beds (7)	P 1 120
mosquito netting	P 200
other camping equipment	P 800
TOTAL EQUIPMENT COST:	P182 560

I. STOCK ASSESSMENT BIOLOGIST

The Stock Assessment Biologist will act as Team Leader, coordinating the study in collaboration with the Head of Fisheries Section. He/She will direct the sampling effort, and will have the following responsibilities:

- choice of sampling sites (starting with those used by Merron, and adding/substituting from there)
- design of the sampling program. This will include deciding on frequency of sampling, a rotational sampling schedule for different ecological zones, methods of sampling (incorporating a variety of catching equipment), choice of testing parameters, etc.
- oversee laboratory analysis of stock and water samples
- supervise production of reports
- act as administrative coordinator for the project
- act as liaison between project staff and Fisheries Section

II. HYDROLOGIST/LIMNOLOGIST

The Hydrologist/Limnologist will monitor and assess the dynamic physical, chemical, and biological conditions of the Delta waters. This will be accomplished through:

- sampling and measurement of dissolved solids, dissolved oxygen, levels of Ca, K, Fe, N, etc., Biological Oxygen Demand, pH levels, salinity, turbidity, transparency, current, discharge, etc.
- measurement of the seasonal changes that occur in these parameters throughout the Delta ecosystem
- working closely with the Department of Water Affairs and other related agencies to assist in compiling pertinent information

III. FISHERIES ECONOMIST

The Fisheries Economist will establish and implement a system to collect economic data. This will include:

- mounting frame surveys to estimate annual production levels
- identifying the users and beneficiaries of the Okavango fish resource
- assessing the number of people employed in the Fishery
- determining the efficiency of different gear types
- investigating potential markets for underutilised species of fish

With this information, the Economist will estimate the economic value of fish to the local communities, assess the socio-economic significance of the Fishery to Ngamiland, and determine sustainable exploitation rates for economically important species.

-
- (i) boat, explosive, poisonous or noxious substance, net, instrument, rod, line or any other appliance or article which he has reasonable cause to believe is being or has been used in contravention of this Act or any regulation made thereunder, or
 - (ii) fish which he has reasonable cause to believe was captured in contravention of this Act or any regulations made thereunder; or
- (c) without warrant, arrest and search any person whom he may find committing, or whom he reasonably suspects of having committed, an offence under this Act or any regulations made thereunder.

7. Any person who wilfully obstructs, hinders, assaults or resists an authorized officer or a police officer in the exercise of his powers under this Act or any regulations made thereunder shall be guilty of an offence and liable to a fine not exceeding P500 or to imprisonment for a term not exceeding 12 months, or to both.

Obstructing
officers

8. On the conviction of any person for an offence under this Act or any regulations made thereunder, the court before which such person was convicted may order any articles in respect of which the offence was committed, and any vehicle or vessel which, with the consent or connivance of the owner thereof, was used in the commission of the offence, to be forfeited, and to be destroyed, sold or otherwise disposed of.

Disposal of
articles after
conviction

nets to be used in fishing and the size of the meshes thereof, or the prohibiting of any special description of nets or meshes or any tackle, instrument or appliance whatsoever tending to impede the lawful taking of fish or being in any manner detrimental to the preservation or increase of fish;

- (g) prohibiting, restricting or regulating the bringing into Botswana of any live fish;
- (h) prohibiting, restricting or regulating the transfer within Botswana of any live fish;
- (i) prohibiting, restricting or regulating the sale of any fish.

(2) Regulations made under subsection (1) may require acts or things to be performed or done to the satisfaction of an authorized officer and may empower such officer to issue orders requiring acts or things to be performed or done or prohibiting acts or things from being performed or done, and may prescribe periods or dates upon, within or before such acts or things are to be performed or done.

(3) The Minister may, in regulations made under subsection (1), fix such penalties for the breach or non-observance of any regulation or any order issued under or by virtue of such regulation as he may think fit but no such penalty shall exceed, in the case of a first conviction, a fine of P200 and imprisonment for three months, and in the case of a second or subsequent conviction a fine of P500 and imprisonment for 12 months, and where no penalty is fixed the breach or non-observance of any regulation or order shall be punishable to the extent aforesaid.

Prohibition of
use of explosive,
poisonous or
noxious
substances

4. Any person who uses or permits to be used any explosive, poisonous or noxious substance for the purpose of killing, stunning or disabling fish or in any way rendering fish more easily caught shall be guilty of an offence and liable to a fine not exceeding P500, or to imprisonment for a term not exceeding 12 months, or to both.

Exemptions

5. The Minister may, in the interests of science or for any other reason that to him may seem fit, exempt in writing any person from the provisions of section 4 or of any regulations made under section 3.

Powers of entry,
seizure and
arrest

6. Any authorized officer or police officer not below the rank of assistant inspector may—

- (a) at all reasonable times enter into and upon any land or premises, or stop and enter upon any boat, for the purpose of preventing or detecting offences under this Act or any regulations made thereunder;
- (b) seize any—

CHAPTER 38:05

FISH PROTECTION

ARRANGEMENT OF SECTIONS

SECTION

1. Short title
2. Interpretation
3. Regulations
4. Prohibition of use of explosive, poisonous or noxious substances
5. Exemptions
6. Powers of entry, seizure and arrest
7. Obstructing officers
8. Disposal of articles after conviction

An Act to provide for the more effectual regulation, control, protection and improvement of fish and fishing in Botswana

Act 42, 1975.

[Date of Commencement: 31st December, 1975]

1. This Act may be cited as the Fish Protection Act. Short title
2. In this Act, unless the context otherwise requires— Interpretation

“authorized officer” means a person authorized by the Minister for the purposes of this Act;

“fish” includes all vertebrate fishes, and the spat, brood, fry, spawn, ova and young thereof.
3. (1) The Minister may make regulations which shall apply Regulations

to such areas as are specified therein, providing for the more effectual control, protection and improvement of fish, and the government and management of any specified area in which fishing may be carried on, and without prejudice to the generality of the foregoing for all or any part of the following purposes—

 - (a) imposing and prescribing conditions for the regulation of fishing;
 - (b) registering all boats employed in fishing;
 - (c) determining the times and seasons at which the taking of any species of fish shall commence and cease;
 - (d) the issuing of licences and certificates of registration to persons authorized to take any species of fish;
 - (e) prescribing the fees to be paid for or in respect of any licence or registration issued or made;
 - (f) providing for and regulating the description and form of

ANNEX V

STUDY PROGRAMME

NORAD INTERNATIONAL DIPLOMA/MPHIL COURSE IN FISHERIES BIOLOGY AND FISHERIES MANAGEMENT

The Department of Fisheries and Marine Biology at the University of Bergen is every second year offering a Diploma/MPhil course in Fisheries Biology and Fisheries Management under the NORAD (the Norwegian Agency for Developing Countries) fellowship programme.

The course which leads to an MPhil degree comprises two parts. The first part (10 months) consists of a Diploma course. Entrance to the second part (18 months) is restricted and admission is depending on satisfactory completion of courses and examinations in the Diploma course.

The participants must have a good BSc degree in biology with special knowledge in aquatic biology. A strong background in mathematics and statistics is necessary as well as some field practice. All lectures are given in English. A good working knowledge of English is therefore essential.

The course is aimed at young scientists in fisheries biology requiring graduate level training for careers in research, teaching, management and development.

A more detailed description of the courses is given below:

Diploma Course:

COURSE SECTION I BASIC SUBJECTS

- 1.1 Marine Biology
 - food chains, marine ecosystems
- 1.2 Ichthyology
 - taxonomy, marine research, fresh water fish
- 1.3 Fish Biology, general
 - anatomy, physiology, reproduction, life history
- 1.4 Oceanography
 - physical and chemical properties and processes, upwellings, major current systems, methodology
- 1.5 Limnology
 - physical and chemical environment, nutrient cycles, biological interactions
- 1.6 Mathematics
 - function theory, differential and intergral calculus
- 1.7 Statistics
 - descriptive statistics, simple hypothesis-testing
- 1.8 Introductory course in the use of microcomputers

COURSE SECTION II SPECIALIZED SUBJECTS

- 2.1. Fishing Technology
 - passive and active fishing gears; design and operation
 - gear selectivity and fish behaviour
 - fishing vessels
 - practical onboard demonstrations
- 2.2 Fishery Economics
 - introduction to economics
 - the economic theory of fisheries
 - applied bioeconomic models
 - fluctuations of fish stocks and catches
 - methods of fisheries management

2.3 Social, Economic and Political Contexts of Fisheries Development

- development economics
- development sociology
- social anthropology

2.4 Fisheries and Fisheries Management

- world fisheries
- law of the sea
- management policies

2.5 Fisheries Stock Assessment

- behaviour of exploited populations
- dynamics of fishing fleets
- models and parametre estimation
- harvest strategies

2.6 Methods of Resource Evaluation

- egg and larval surveys
- tagging/recapture methods
- catch and effort data
- hydroacoustics in biomass estimation
- virtual population analysis (VPA)
- bottom trawl surveys
- selected case studies

2.7 Aquaculture

- culture of seaweed
- culture of marine organisms
- culture of freshwater organisms
- fish diseases
- excursion to an aquaculture research station

2.9 Term Paper

During the second semester the students will have to write a Diploma thesis. It is desirable that the students in their practical training are working on problems related to their own regions. The candidates are therefore strongly recommended to bring data.

MPhil programme (18 months extension)

The MPhil degree consists of:

- a) 5 oral exams (minimum 10 credits altogether)
- b) a scientific study (preferably based on their own field or laboratory data) presented as a thesis written in English

Examination

The MPhil degree requires satisfactory completion of the following subject:

Fisheries Stock Assessment	3 credits
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In addition you can choose among the following subjects so that you have at least 7 more credits:

Social, Economic and Political Contexts of Fisheries Development	2 credits
Resource Evaluation	2 credits
Fisheries and Fisheries Management	2 credits
Fishing Technology	1 credit
Inland Fisheries/Aquaculture	2 credits
Special reading list	1-3 credits

A minimum of 5 credits must enter into a final oral examination after the thesis has been submitted and approved of.

Grade scale

A	2.20 and higher
B	2.21 - 2.80
C	2.81 - 3.40
D	3.41 - 4.00
F	4.01 and lower

The degree Master of Philosophy (MPhil) is equivalent to the degree Candidatus Scientiarum (cand. scient.) awarded by the Faculty of Mathematics and Natural Science, University of Bergen.

UNIVERSITY OF ZIMBABWE

DEPARTMENT OF BIOLOGICAL SCIENCES

PROPOSED MASTERS DEGREE IN TROPICAL HYDROBIOLOGY AND FISHERIES

1. Introduction

This Department has, for a considerable length of time, been considering the introduction of an M.Sc. in Tropical Hydrobiology and Fisheries. This programme has been included as one of the components of the SADC Regional Fisheries Training Programme and we have had extensive discussions with the programme coordinator who is based in Malawi. Donor agencies are being approached for support but support is unlikely to be forthcoming until we have the degree regulations in place.

2. The need for an M.Sc. in Tropical Hydrobiology and Fisheries

The recent droughts have demonstrated to everyone the importance of water. The continuing growth of the human population means that water will begin to limit development in many areas. This process has already begun and major projects that will radically alter river flow patterns, such as the Zambezi pipeline, have already been proposed. Other human activities, such as the disposal of waste products or land degradation have already had a major impact on aquatic ecosystems. These impacts will become increasingly severe as the demand for water grows.

Management of our water resources requires personnel with a good basic training in tropical ecology with a specialisation in hydrobiology. The need to increase fish production in the region will become more urgent as terrestrial ecosystems become less able to produce animal protein and an understanding of the tropical limnology is essential in fisheries management. This is because the productivity of freshwater fish is very closely linked to environmental factors.

The objective of this programme is to produce graduates with a sound understanding of tropical aquatic ecology and the scientific skills to deal with any management problems that might confront them.

3. Entry Requirements

A good Honours degree in Biological Sciences would normally be required.

4. Degree Structure and Duration

The degree will be offered on a full-time basis and run for two years. The first year would be the coursework component whilst the second would be the research component. The coursework component will consist of six courses.

5. Financial Implications

5.1. Staff.

The Department of Biological Sciences has adequate staff to mount this course. There are two members of staff with appropriate expertise currently in post we have a vacancy for a third. Some courses can be taught concurrently with the M.Sc. (Tropical Resource Ecology) which means that three to four extra staff members will be available for teaching purposes.

Additional input should be available through specialised contributions from the University Lake Kariba Research Station and the Department of National Parks and Wildlife Management. This programme is a component of the SADC Regional Fisheries Training Project who will attempt to find funds to provide other specialists for short contributions if they are required.

5.2. Equipment.

The Department has adequate resources for mounting this programme. Some items are antiquated (e.g. our boat and engine is about 25 years old) and will eventually have to be replaced. Donor agencies will be approached, through the SADC regional programme, for the necessary funds.

5.3. Accommodation.

The Department has adequate laboratory and lecture facilities.

REGULATIONS FOR THE MASTER OF SCIENCE DEGREE IN
TROPICAL HYDROBIOLOGY AND FISHERIES

1. PREAMBLE

These regulations should be read in conjunction with the General Academic Regulations for Masters Degrees by Coursework and the Faculty of science Regulations for Master of Science Degrees.

2. DURATION OF THE PROGRAMME

The programme is offered on a full-time basis and will run for two years.

3. STRUCTURE OF THE PROGRAMME

- 3.1. The programme will consist of two parts. Part I will be the coursework component and Part II will be the research component.
- 3.2. The programme will normally commence on or about 1 March.
- 3.3. Students are required to take all six courses.
- 3.4. Formal examinations in Part I will normally be held in November of the first year.
- 3.5. Part II will normally commence in December.
- 3.6. The dissertation must normally be submitted by 31 October of the second year.

4. SCHEME OF EXAMINATION

Part I and Part II will be weighted equally in the final assessment.

PROGRAMME; MASTER OF SCIENCE IN TROPICAL HYDROBIOLOGY AND FISHERIES (MTFH 5)

Part I

<u>Code</u>	<u>Description</u>	<u>Duration</u>
MTFH 501.	Introduction to Tropical Ecosystems	2 hrs
MTFH 502.	Research Methodology	2 hrs
MTFH 503.	Tropical Limnology	2 hrs
MTFH 504.	Fish Biology	2 hrs
MTFH 505.	Applied Aquatic Ecology	2 hrs
MTFH 506.	Conservation of Tropical Resources.	2 hrs

PROGRAMME; MASTER OF SCIENCE IN TROPICAL HYDROBIOLOGY AND FISHERIES (MTFH 5)

Part II

<u>Code</u>	<u>Description</u>	<u>Weighting</u>
MTFH 551.	Research Seminar	10
MTFH 570.	Research Dissertation	90
MTFH 590.	Oral Examination	(see note 3)

Notes

1. The marks for each course in Part I will consist of the marks for continuous Assessment and the formal examination in that course in the ratio 50:50.
2. Students are required to take all the courses in Part I. All courses carry the same weighting.
3. The oral examination will normally be conducted in the presence of the external examiner within one month of the thesis submission date. A separate mark will not be awarded for the oral examination. Instead, performance in the oral examination will be used to confirm or adjust the mark awarded for the research dissertation.
4. In some instances the laboratory or field work, or both, of the research project may be conducted at an institution approved by the Department. In making such arrangements the Department will take into account the extent of technical assistance available to the student.

PROPOSED COURSE OUTLINE

* **MTFH 501 Introduction to Tropical Ecosystems**
 Determinants, dynamics and distribution of tropical aquatic ecosystems; latitudinal gradients in ecological diversity; human social ecology and society/environment interactions; resource utilisation and development in the tropics; environmental degradation. A field trip will form part of this course.

* **MTFH 502 Research Methodology**
 Review of basic statistics; use of computers in data management and analysis; experimental design; data presentation; overviews of ecological modelling; univariate and multivariate statistics and GIS; sociological survey methods; research paradigms of the social and natural sciences.

MTFH 503 Tropical Limnology
 The properties, physics and chemistry of water; aquatic ecosystems in the tropics; biological communities in running and standing water; productivity and energy flow. Water resources and catchment management; waste water and sewage disposal; pollution and ecotoxicology.

MTFH 504 Fish Biology
 Taxonomy, zoogeography and evolution of African fish. Tropical fish communities; nature and ecological relationships; population dynamics; stock assessment. Parasites and diseases. The ecological principles of aquaculture.

MTFH 505 Applied Aquatic Ecology
 Catchment management and planning; multi-purpose use of water resources; stream and lake management and reclamation. Fishery management and economics; aquaculture practices, pond management, artificial propagation, disease control, economics. Resource allocation; involvement of people in resource management; policy formulation and project management; the role and financing of state agencies; resources and the law; organisational structures and relationships.

* **MTFH 506 Conservation of Aquatic Resources**
 Conservation biology including the biodiversity issue, minimum population size, population vulnerability analysis and conservation genetics; sustainable utilisation; national park planning; environmental and social impact analysis; regional and international cooperation.

* Taught jointly with M.Sc. (Tropical Resources Ecology)
 Dept. of Biological Sciences
 Centre for Applied Social Sciences

ANNEX VII

The ToR are proposals for the scope of work of the three expatriate experts. The final assignments of tasks should be decided after the experts are appointed.

TERMS OF REFERENCE: FISHERIES BIOLOGIST

The Fisheries Biologist will act as team leader, and be the liaison officer between the reference group, project staff and the Fisheries administrative authorities (i.e., Senior Fisheries Officer in Gaborone, and Regional Fisheries Officer in Maun).

Responsibilities:

- Co-ordinate the study in collaboration with the head of the Fisheries Section and the head of the field office in Maun.
- Become versed in available literature on local fish biology and ecology, particularly the 1988 report by Merron on Okavango fish species, and the four NORAD consultancy reports.
- Design sampling frames with sufficient sampling frequency to ensure sample representation from all seasons and all ecological zones, and which employ a variety of sampling techniques and gear.
- Evaluate how fishermen's catch data could be utilised to benefit the research programme, and where possible, implement any suggestions resulting from such evaluation.
- Determine the catch efficiency of different gear types.
- Oversee laboratory analysis of fish samples.
- Supervise field, laboratory, and office activities of support staff working with the officer.
- Co-ordinate the production of reports from field expeditions, workshops, or conferences, as well as annual reports and scientific publications.
- Relate overall juvenile fish recruitment to variations in floods received.
- Establish, in collaboration with other team members and senior Fisheries staff, a permanent data collection and analysis system for ecological monitoring of the Okavango fish populations.
- Estimate, based on collected data, a maximum sustainable yields for economically important fish species in the Okavango.
- Formulate, in collaboration with other project team members, a computer model to be used to predict the effects of changing environmental and economic parameters on fish populations.
- Utilising input from all project team members, make recommendations on management of the fishery, based on data collected and analysed throughout the project regarding ecology and usage of the fishery. Formally submit such recommendations to Fisheries administrative authorities in the Ministry of Agriculture.
- Work closely with designated counterpart and other local fisheries staff so as to impart expertise and prepare them for eventual local take-over of the duties of this position.
- Co-ordinate and participate in periodic workshops and/or seminars for Fisheries staff and other interested parties, to review progress to the research program.
- Act as secretary for the reference group.
- Supervise students working in the project according to responsibilities determined by the reference group.

Qualifications:

The successful candidate should be professionally trained in fisheries biology and management to at least the Master's level (preferably PhD level), with emphasis on predictive fish yield modelling. Substantial experience from tropical freshwater environment will also be required for qualification.

TERMS OF REFERENCE: FRESHWATER ECOLOGIST

The Freshwater ecologist will assess and monitor ecological parameters as feeding ecology and habitat use of the major fish species in the Okavango. Responsibilities will also include the routine collection and assessment of environmental data.

Responsibilities:

- Oversee the sampling of fish for recording of habitat use and diet. Assess the results and produce reports in collaboration with the other team members.
- Establish and maintain a sampling programme for environmental parameters.
- Conduct laboratory and field analysis of water samples.
- Work closely with the Fisheries Biologist to determine any relationships between fish population dynamics, ecology and environmental factors.
- Take immediate steps to measure and monitor water quality factors at sites where sudden fishkills have occurred, and carry out tests and analysis to determine possible causes for such occurrences.
- Become knowledgeable on existing information about Okavango Delta water quality and hydrology, including data available from the Department of Water Affairs and their various metre stations.
- Establish, in collaboration with other team members and senior Fisheries staff, a permanent data collection and analysis system for ecological monitoring of the Okavango fish populations.
- Collaborate with other project team members to formulate a computer model to predict the effects of changing environmental and economic parameters on fish populations.
- Work closely with designated counterpart and other local fisheries staff so as to impart expertise and prepare them for local take-over of the duties of this position.
- Supervise support staff who are working on fish sampling and limnological measurements, tests and analysis for the project.
- Participate in periodic workshops and/or seminars for Fisheries staff and other interested parties to review progress of the research program.
- Supervise students working in the project according to responsibilities determined by the team leader and reference group.

Qualifications:

The successful candidate should be professionally trained to at least Master's level in freshwater ecology, with emphasis on fish ecology. Working experience will also be required, preferably in a tropical freshwater situation.

ANNEX VII

The ToR are proposals for the scope of work of the three expatriate experts. The final assignments of tasks should be decided after the experts are appointed.

TERMS OF REFERENCE: FISHERIES BIOLOGIST

The Fisheries Biologist will act as team leader and be the liaison officer between the reference group, project staff and the Fisheries administrative authorities (i.e., Senior Fisheries Officer in Gaborone, and Regional Fisheries Officer in Maun).

Responsibilities:

- Co-ordinate the study in collaboration with the head of the Fisheries Section and the head of the field office in Maun.
- Become versed in available literature on local fish biology and ecology, particularly the 1988 report by Merron on Okavango fish species, and the four NORAD consultancy reports.
- Design sampling frames with sufficient sampling frequency to ensure sample representation from all seasons and all ecological zones.
- Evaluate how fishermen's catch data could be utilised to benefit the research programme, and where possible, implement any suggestions resulting from such evaluation.
- Determine the catch efficiency of different gear types.
- Oversee laboratory analysis of fish samples.
- Supervise field, laboratory, and office activities of support staff working with the officer.
- Co-ordinate the production of reports from field expeditions, workshops, or conferences, as well as annual reports and scientific publications.
- Relate overall fish recruitment to variations in floods received.
- Establish, in collaboration with other team members and senior Fisheries staff, a permanent data collection and analysis system for ecological monitoring of the Okavango fish populations.
- Estimate, based on collected data, sustainable yields for economically important fish species in the Okavango.
- Formulate, in collaboration with other project team members, a computer model to be used to predict the effects of changing environmental and economic parameters on fish populations.
- Utilising input from all project team members, make recommendations on management of the fishery, based on data collected and analysed throughout the project regarding ecology and usage of the fishery. Formally submit such recommendations to Fisheries administrative authorities in the Ministry of Agriculture.
- Work closely with designated counterpart and other local fisheries staff so as to impart expertise and prepare them for eventual local take-over of the duties of this position.
- Co-ordinate and participate in periodic workshops and/or seminars for Fisheries staff and other interested parties, to review progress to the research program.
- Act as secretary for the reference group.
- Supervise students working in the project according to responsibilities determined by the reference group.

Qualifications:

The successful candidate should be professionally trained in fisheries biology and management to at least the Master's level (preferably Ph.D. level), with emphasis on predictive fish yield modelling. Substantial experience from tropical freshwater environment will also be required for qualification.

TERMS OF REFERENCE: FRESHWATER ECOLOGIST

The Freshwater ecologist will assess and monitor ecological parameters as feeding ecology and habitat use of the major fish species in the Okavango. Responsibilities will also include the routine collection and assessment of environmental data.

Responsibilities:

- Oversee the sampling of fish for recording of habitat use and diet. Assess the results and produce reports in collaboration with the other team members.
- Establish and maintain a sampling programme for environmental parameters.
- Conduct laboratory and field analysis of water samples.
- Work closely with the Fisheries Biologist to determine any relationships between fish population dynamics, ecology and environmental factors.
- Take immediate steps to measure and monitor water quality factors at sites where sudden fishkills have occurred, and carry out tests and analysis to determine possible causes for such occurrences.
- Become knowledgeable on existing information about Okavango Delta water quality and hydrology, including data available from the Department of Water Affairs and their various metre stations.
- Establish, in collaboration with other team members and senior Fisheries staff, a permanent data collection and analysis system for ecological monitoring of the Okavango fish populations.
- Collaborate with other project team members to formulate a computer model to predict the effects of changing environmental and economic parameters on fish populations.
- Work closely with designated counterpart and other local fisheries staff so as to impart expertise and prepare them for local take-over of the duties of this position.
- Supervise support staff who are working on fish sampling and limnological measurements, tests and analysis for the project.
- Participate in periodic workshops and/or seminars for Fisheries staff and other interested parties to review progress of the research program.
- Supervise students working in the project according to responsibilities determined by the team leader and reference group.

Qualifications:

The successful candidate should be professionally trained to at least Master's level in freshwater ecology, with emphasis on fish ecology. Working experience will also be required, preferably in a tropical freshwater situation.

TERMS OF REFERENCE: SOCIO-ECONOMIST

The Socio-Economist will analyse the relationships between the Okavango fishery resource and its users, covering subsistence, commercial and recreational utilisation.

Responsibilities:

- Familiarise oneself with available information on socio-economic aspects of the Okavango Fishery, including the NORAD consultancy reports, and Ministry of Agriculture documents.
- Mount frame surveys to determine the exact number of fishermen in the Okavango Delta, and other occupations they are engaged in.
- Estimate annual fish production in the Delta, and further specify estimates of harvest, home consumption, barter, and sales.
- Collect pricing data from around the Delta in regard to fish sales.
- Assess the present economic value of the fish resource to the fishing communities as determined through all its uses.
- Assess the present economic value of the fish resource to those involved in recreation or tourism.
- Evaluate the current fish marketing system and if possible, suggest ways in which it can be improved, in terms of generating more income for the local citizens, while maintaining sustainable utilisation of the resource.
- Evaluate the effect on fish marketing from potential imports of marine fish species.
- Establish a permanent data collection system for fisheries statistics (i.e., annual catch, value, location, etc.) in collaboration with the other team members and short term consultants in this field.
- Investigate possible markets for lesser-valued species and/or secondary (by-product) uses for species already considered commercially important.
- Review the 1975 Fish Protection Act, and assess its value to the Okavango community and the nation (i.e.: does it achieve its original purpose? Is further legislation necessary?).
- Suggest fishery management approaches which will ensure community participation and understanding of management tools so as to safeguard the sustainable utilisation of the resource, and fair allocation of its benefits.
- Supervise support staff who are working on economic data collection, compilation, and analysis for the project.
- Collaborate with other project team members to formulate a computer model to predict the effects of changing environmental and economic parameters on fish populations.
- Participate in periodic workshops and/or seminars for Fisheries staff and other interested parties, to review progress of the research program.
- Work closely with designated counterpart and other Fisheries staff so as to impart expertise and prepare them for local take-over of the duties of this position.
- Supervise students in socio-economy working in the project.

Qualifications:

The successful candidate should be professionally trained in resource socio-economics or related fields to at least the Master's level. Substantial experience from work on artisanal (small-scale) fisheries will also be necessary, preferably in a developing country.

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Norsk institutt for
naturforskning
Tungasletta 2
7005 Trondheim
Tel. (07) 58 05 00