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JESS REPORT ON FISHERIES

Prepared by:

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CONTENTS

ABBREVIATIONS AND ACRONYMS

A	area
AID	U.S. Agency for International Development
ARD	Associates in Rural Development, Inc.
BuRec	U.S. Bureau of Reclamation
C	catch
CAS	catch assessment survey
cm	centimeter
CPUE	catch per unit of (fishing) effort
CV	coefficient of variation
d	desired confidence level
E	effort
FAO	Food and Agriculture Organization of the United Nations
FBS	fish biology sampling
FSP	fish sampling program
gm	gram
gn	gill net
GSDR	Government of the Somali Democratic Republic
ha	hectare
hl	hook line
hn	hoop net
ICA	International Center for Aquaculture
JESS	Jubba Environmental and Socioeconomic Studies
JuDAS	Jubba Development Analytical Studies
kg	kilogram
km	kilometer
maxcpue	maximum catch per set
mcpue	mean catch per set
mincpue	minimum catch per set
MEI	morphoredaphic index
MFMR	Ministry of Fisheries and Marine Resources
mg	milligram
mm	millimeter
MNPJVD	Ministry of National Planning and Jubba Valley Development
MSY	maximum sustainable yield
N	number
ppm	parts per million
SEBS	socioeconomic baseline survey
SSh	Somali shillings
SMP	Somali Marine Products
spp	species (plural)
TARDA	Tana and Athi River Development Authority
TDS	total dissolved solids
wt	weight

PREFACE

The Jubba Environmental and Socioeconomic Studies (JESS) project is a three-year program of river basin investigations in Somalia. The project is part of a larger project, Jubba Development Analytical Studies (JuDAS), a cooperative effort between the U.S. Agency for International Development (AID) and the Ministry of National Planning and Jubba Valley Development (MNPJVD) of the Government of the Somali Democratic Republic (GSDR). Associates in Rural Development, Inc. (ARD) was contracted to provide technical assistance and project management for JESS.

The long-range goals of JESS and JuDAS are to provide MNPJVD with needed information on soils/land use, natural resource utilization, social and environmental issues, staff training, and technical support.

Under a consultancy contract with ARD, Mr. Earl Meredith studied the fishery resources in the Jubba Valley during 2 field trips, October-November 1986 and March-May 1987. Mr. Mohamad Hassan Aden of MNPJVD assisted Mr. Meredith with the frame survey during the first consultancy. Further assistance was provided by Mr. Ahmed Abdulaahi Yassin of the Ministry of Fisheries and Marine Rescurces (MFMR).

I. EXECUTIVE SUMMARY

This report details the results of a consultancy to assess the potential impacts of construction of the Baardheere Dam on downstream fish populations and fisheries development in the Jubba Valley. The goals of this fishery assessment were to describe the status of the fisheries in the Jubba Valley, identify effects of the proposed dam on the fish populations in the Jubba River, and discuss fishery development and management issues relevant to the Jubba Valley.

The preliminary consultancy consisted of 2 field trips. The first, from the mouth of the Jubba River to the Faanoole Barrage, took place from 6 to 20 October 1986. The second, from Saakow to Luuq, was conducted from 30 October to 17 November 1986. Field notes from the first trip are included in Appendix A of this report.

A second consultancy was completed between 22 March and 17 May 1987. Five field trips were conducted during this period. Three of these trips sampled fish populations in the Jubba Valley. The other 2 assessed fishery potential and observed fishing activities at the Johar Reservoir on the Shabeelle River. A Somali fishery biologist was trained in rotenone chemofishing during these trips.

Ichthyomass (fish biomass) was estimated to be 350 to 1,250 kilograms per hectare, using an 80 percent confidence interval. Approximately 20 fish species were collected during the study. Based on predictive models, the annual sustained harvest could be 1,600 metric tons, with a potential value of US$900,000.

II. INTRODUCTION

The Jubba River flows south from the highlands of south-central Ethiopia and the northeastern corner of Kenya. The headwaters of the Jubba River are formed by the confluence of the Gestro, the Genale, and the Dawa rivers, as they flow into Somalia at Dolow (Figure 1). Daget and Iltis (1965) and Welcomme (1985) would classify the Jubba River as a Sudanian floodplain river, flowing through a semi-arid savanna region, with associated Nilotic fish fauna.

The hydrological cycle of the Jubba River, shown in Figure 2, is bimodal. Three levels of discharge correspond to the maximum, average, and minimum flow regimes at Luuq from 1951 to 1982. The early flood occurs from April to June each year; the second flood, the major high-water period, is from September to November.

The primary development effort at this time is the construction of a mainstream dam on the Jubba River, approximately 35 kilometers upstream from Baardheere Town, or 400 kilometers from the mouth of the river at the port town of Kismaayo (Figure 1).

Specific objectives of the fishery assessment were to:

- describe the fish community in the Jubba River;
- determine present fishing activities and fish consumption by local communities along the river;
- estimate the present economic value of the Jubba River fishery;
- forecast downstream effects of the proposed Baardheere Dam on fish populations;
- estimate potential fish production in the reservoir of the proposed dam; and
- discuss development and management issues relevant to fish resources in the Jubba River.

Area of the Baardheere Dam Project and the Jubba Valley Development

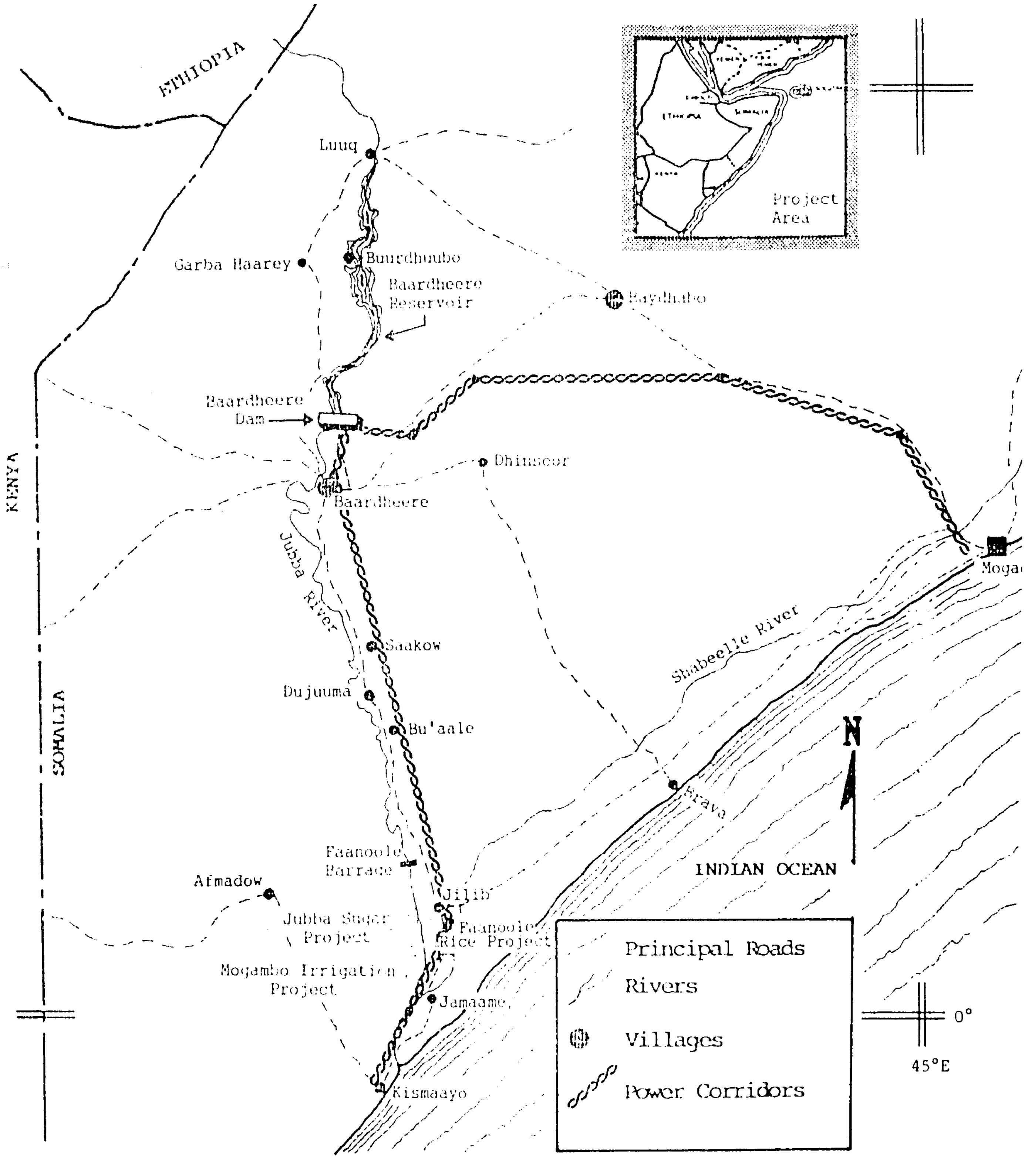
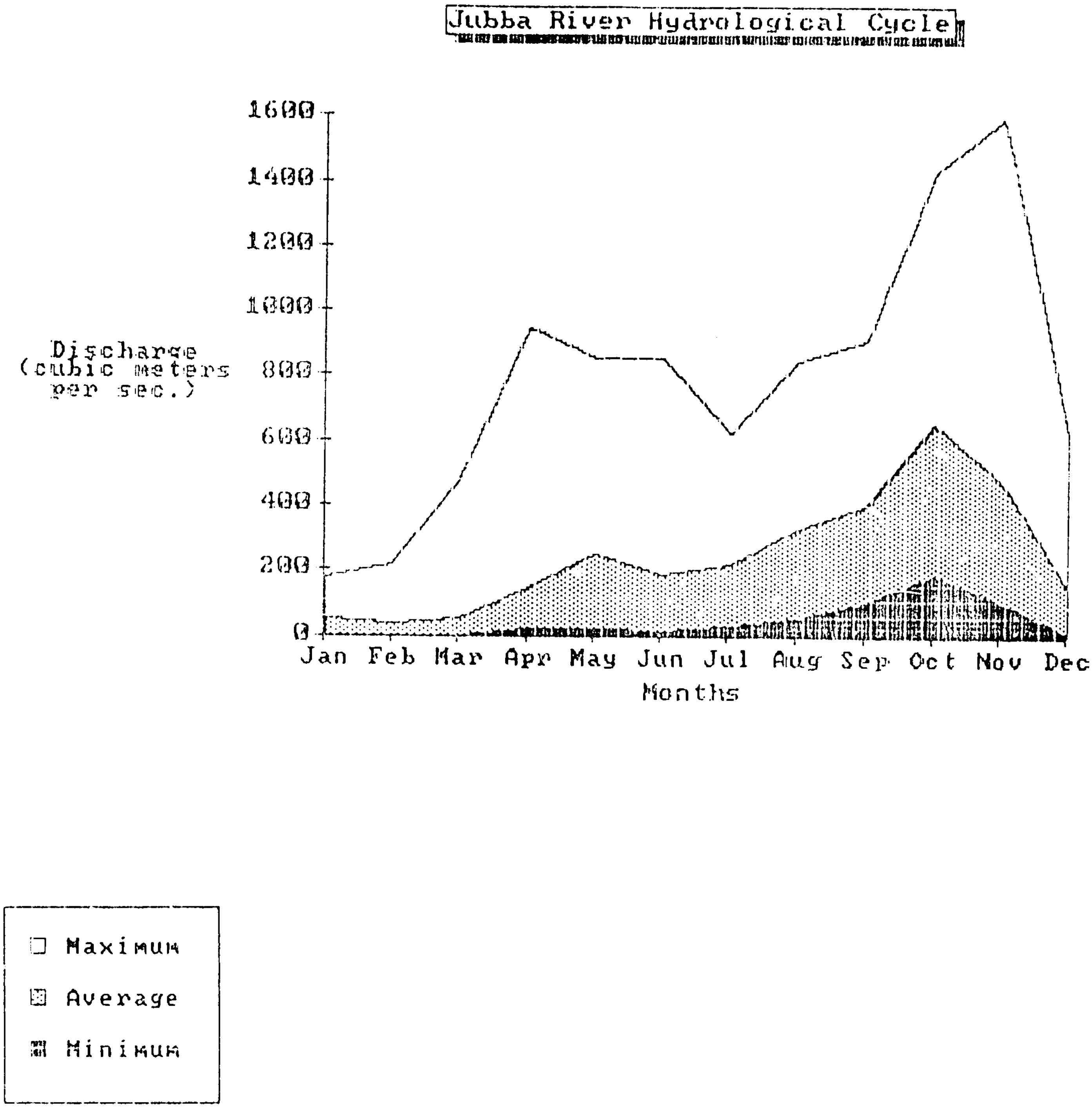


Figure 2.



Jubba River Hydrological Cycle
1600
1400
1200
1000
800
600
400
200
0
Discharge (cubic meters per sec.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
Maximum
Average
Minimum

III. GENERAL RIVER CONCEPTS AND PREDICTIVE MODELS

Rivers and floodplains provide water for households, livestock, industrial use, transportation, irrigation, and hydroelectric power generation. A major use of African rivers is fishing, and most African river fisheries are local or regional. These small-scale, artisanal fisheries provide a source of income and valuable protein-rich food for families living along the river. Fishing usually is not a full-time activity, but is integrated into household, agricultural, and pastoral customs, which change with the hydrological cycle. On a continental basis, African rivers provide 40 to 50 percent of the total fish harvest (Welcomme 1985) and 25 percent of the total animal protein consumed by African peoples (Shell 1986).

Fisheries biologists in Africa have directed their efforts primarily toward assessing the status and potential of marine and lake fisheries. Until recently, rivers have received little attention, as is the case on a worldwide basis. One reason for this is that rivers are very complex ecosystems. They are open-ended, with potentially large variations in environments caused by seasonal changes in hydrological cycles and fluctuations in flow regimes. This diversity of habitats makes sampling, characterizing, assessing, and managing riverine fisheries very difficult. The sheer size of these systems, which sometimes cross international boundaries, compounds the management and development problems.

The necessity for comprehensive preimpoundment studies of African reservoir projects has been clearly recognized and discussed. Thorton (1980), Adenifi et al. (1981), and Marshall (1984) have offered predictive models of primary production and fish yields from African reservoirs using available preimpoundment information. Welcomme (1985) discussed the effects of river management and floodplain development practices on fish populations and river-basin ecosystems. His summary of the effects of hydraulic works on river fish communities is presented in Table 1.

Table 1. Summary of the Effects of Hydraulic Works on River Fish Communities

Changes in Flow	
Temporal changes	**Effects**
Disruption of spawning patterns through inappropriate stimuli or unnatural short-term flows	Changes in community structure from seasonal spawners to species with more flexible spawning
Shift from pulse-regulated to stable-system dynamics	Diminished productivity at community level
Increase in flow rate (usually due to channelization)	Young fish in drift swept past appropriate sites for colonization
	Local shifts in species composition in tail race with accumulation of rheophilic (preferring flowing water) predators
Decrease in flow rate	Shifts from rheophilic to lentic communities in reservoir upstream and in controlled reaches downstream
	Changes in flushing rate resulting in accumulation or low dilution of toxic wastes or anoxic conditions leading to fish mortalities
Loss of Habitat	
Prevention of flooding by dams and levees	Loss of floodplain area available for spawning growth; loss of habitat diversity; change in species composition with loss of obligate flood-plain spawners
	General diminution in productivity of whole system

Drowning of spawning substrates upstream of dams or in channelized reaches	Variable effects usually involving decline of lithophils or psammophils, although new wave-washed shore or riprap may simulate rhithronic habitats

Blocking of Channel

Interruption of migratory pathways by dam walls or by the creation of conditions unsuitable for passage	Elimination of diadromous or obligate migrants by preventing movement to upstream breeding sites by adults and slowing downstream movements of juveniles

Changes in Silt Load

Changes in channel form (due to channelization or to changes in deposition/erosion process)	Reduction of habitat and community diversity: loss of species
Increased rate of silt deposition (usually upstream of dams but also in newly cut-off portions of channel or channelized reaches downstream)	Choking of substrates for reproduction in lithophils/psammophils (species that prefer rock or sand habitats, respectively)
	Changes in density of vegetation, usually in favor of phytophils (vegetation-preferring species)
	Changes in quantity and type of food available and in the benthos (bottom substrate), leading to restructuring of the fish community toward illiophages
Decrease in suspended silt load	Changes in fish community, reduction in number of non-visual predators and omnivores
Lack of sediment (downstream from the dam)	Changes in nutrient cycle and in the nature of the benthos, leading to loss of illiophages and increase in benthic limnivores

Changes in Plankton Abundance	
Increase in phytoplankton in reservoir or downstream due to slower flow and higher water transparency	Increase in abundance of planktivorous fish
Changes in Temperature	
Changes in mean temperature caused by low-flow regimes	Increasing temperature variation can cause shifts in success of spawning due to adverse temperatures for cold- or warm-water spawners
Stratification in reservoirs	Difficulties of passage for migrant species
	Elimination of fish in the deoxygenated hypolimnion
	Fish mortalities downstream of dams due to emission of anoxic waters and H_2S
Uptake of Water	
Induction of water into power stations or through pumps or irrigation canals	Entrainment of fish into currents diverting them; impingement of fish on turbines and pumps resulting in loss of fish, particularly juveniles
Water transfers between river systems	Transfer of species and disease organisms from one system to another

Source: Welcomme 1985.

Welcomme (1976) pointed out that, despite serious inadequacies in available catch data for African rivers, analysis of fish-yield patterns gives a fairly coherent picture of factors that can be used to determine the catch expected from a particular river system. Welcomme (1985) presented predictive models for annual fish catch for African rivers, using total basin area and main channel length. These models were applied to 20 African rivers and the results are presented in Table 2.

Table 2. Main Channel Length, Basin Area, and Catch from African Rivers

River	Channel Length (kilometers)	Basin Area (square kilometers)	Annual Catch (tons)
Nile	6,669	3,000,000	40,840
Zaire	4,700	4,014,500	82,000
Ubangi	1,060	772,800	4,670
Kasai	1,735	342,116	7,750
Niger	4,183	1,125,000	30,000
Benue	1,400	219,964	12,570
Zambezi	2,574	1,300,000	21,000
Senegal	1,641	335,000	16,000
Gambia	1,120	77,000	3,000
Volta B.	650	45,324	1,560
Volta R.	260	6,871	370
Volta W.	255	6,602	70
Pendjari	330	11,226	140
Oueme	700	40,150	646
Mono	360	22,000	533
Tana	600	38,000	500
Bandama	950	97,000	3,408
Sassandra	650	75,000	1,518
Comoe	1,160	78,000	2,142
Rufigi/Ruaha	750	17,700	3,600

Source: Welcomme 1985.

Excluding catches from exceptionally large flooded areas, the sample conformed to the following relationship:

$$C = 0.03A_C^{0.97} \quad (r=0.91)$$

C and A_C are equal to annual catch (tons per year) and river basin area (square kilometers), respectively. Welcomme pointed out that, because river-basin area and total length of the longest channel (L) are correlated, fish catch can be depicted as a function of L (kilometers):

$$C = 0.0032L^{1.98} \quad (r=0.90)$$

Thus, catch is approximately equal to $L^2/300$.

These models should only be used as tools to give fishery managers or resource administrators an estimate of potential harvest for riverine fisheries.

Marshall (1984) discussed using physical, hydrological, and chemical data to predict ecological parameters and fish yields i preimpoundment river-basin studies. Henderson and Welcomme (1974) pioneered the use of the morphoredaphic index (MEI) to predict fish yields in African reservoirs with the following relationship:

$$Y = 14.3136 \text{ MEI}^{0.4681}$$

Y equals the fish yield in kilograms per hectare and MEI the total dissolved solids (TDS) or conductivity divided by mean reservoir depth. This relationship was modified by Toews and Griffith (1979) to predict total catch (Y_T) from any particular system by adding lake surface area (A_o) in square kilometers to produce the following equation:

$$\text{Log } Y_T = 1.4071 + 0.3697 \log \text{MEI} - 0.00004565 \, A_o$$

Marshall (1984) discussed the use of preimpoundment physio-chemical data to predict fish yields in African reservoirs. These data include:

- physical data -- reservoir shoreline length (L_o) in kilometers; reservoir surface area (A_o) in square kilometers; mean depth (z) in meters; volume (V) in meters cubed x 10^6; catchment area (A_c) in square kilometers; and

- chemical data -- conductivity in μS cm^{-1}; TDS in mg l^{-1}.

By using this information, it is possible to predict yields from simple, readily available morphometric data. Youngs and Heimbugh (1982) showed that lake area alone is a powerful predictor of fish yields in African reservoirs. They derived the following model to predict total yield (Y = total yield in tons) using lake area:

$$\text{Log}_e \, Y = 3.57 + 0.76 \log_e A_o \quad (r=0.858)$$

A second approach uses a more detailed morphometry technique. Two concepts form the basis of this model--a dendritic (many coves and arms) reservoir would be more productive than a non-dendritic one and a shallow reservoir more productive than a deep one. Lake shoreline development (D_1), calculated using the following formula, indicates how dendritic a reservoir is:

$$D_1 = L_0 \left(2\sqrt{\pi} A_0\right)^{-1}$$

Fish yields were plotted against D_1/z for 7 African reservoirs, resulting in the following model, which nad a good correlation:

$$Y \text{ (kg/ha)} = 19.996 + 32.038 \, (D_1/z)$$

Estimates of potential fish yield in the proposed Baardheere Reservoir can be made when the above physical and chemical data become available.

IV. METHODS

The assessment of the fisheries of the Jubba Valley was based on a fish biology sampling (FBS) program and a catch assessment survey (CAS). The CAS was conducted to determine the levels of fishing and the extent to which the resource is being exploited. In addition, fishery-related questions were added to the socioeconomic baseline survey (SEBS) to determine the amount of fish being sold in the marketplace and the role fishing and fish consumption play in the households of Jubba Valley villagers.

A. Fish Biology Sampling

The objectives of the FBS program were to:

- identify species present in the river;
- determine relative abundance of each species;
- establish length-frequency distributions for each species caught;
- begin providing data which will be useful in establishing weight-length relationships and condition factors for each species;
- determine length at maturity and seasonality of spawning for valuable commercial species;
- attempt to identify fish migrations; and
- establish baseline catch per unit of fishing effort (CPUE) measures for experimental fishing gears for future comparisons of relative stock density.

The FBS was conducted using experimental gill nets, hoop nets, hook lines, and rotenone chemofishing techniques. Fish captured were weighed, measured, and identified by taxa. Sex and maturity were determined by visual observation of the gonads and ranked according to the following scale:

- sex not visually discernable;
- immature--sex discernable, but gonads translucent;
- developing gonads--maturing testis creamy white, ovaries with eggs that are colored and lightly granulated to fully developed;

- mature and in spawning condition--running eggs or milt either by stripping or upon handling of the fish; and

- mature and spent--gonads well developed but empty and flaccid, much vascularization;

The adult stock of a particular species was considered to all individuals equal to, or larger than, the smallest fish collected at Maturity Stage 4.

1. Experimental Gill Net Sampling

Experimental gill nets were monofilament and multifilament each with 7 panels, 50 feet long and 8 feet deep. Mesh sizes f both types of gill nets, in both inch and millimeter bar measur twine sizes, mounting ratios, and net depths measured in number of meshes, are shown in Table 3.

Table 3. Gill Net Specifications Used During the Fishery Investigations in the Jubba River

Monofilament Experimental Gill Nets

Mesh Size (inch)	Mesh Size (mm)	Twine Size	Mounting Ratio	Number of Meshes (in depth of net)
1.0	22	69	12/12	54
1.5	35	69	8/12	36
2.0	47	104	8/14	27
2.5	60	139	6/15	21
3.0	73	139	5/15	18
3.5	86	208	5/17.5	15
4.0	98	208	5/20	13

Multifilament Experimental Gill Nets

Mesh Size (inch)	Mesh Size (mm)	Twine Size	Mounting Ratio	Number of Meshes (in depth of net)
1.0	22	104	12/12	54
1.5	35	104	8/12	36
2.0	47	139	8/14	27
2.5	60	139	6/15	21
3.0	73	139	5/15	18
3.5	86	208	5/17.5	15
4.0	98	208	5/20	13

The monofilament gill nets had a one-ounce lead on every other tie along the bottom line, and a #125 float every 60 inches along the top line. The top and bottom lines were #6 braided poly-nylon lines. Multifilament gill nets were mounted with float-core top lines and lead-core bottom lines. All nets were constructed by Memphis Net and Twine of Memphis, Tennessee, USA.

Experimental gill nets were set in the main channel and along the shoreline. During high-water season, nets were set at varying depths from the bottom to the surface; during low-water season, they usually filled the entire water column. The nets were generally set in the afternoon and fish were removed the following morning.

2. Hoop Net Sampling

The hoop nets, a design proposed by Ahmed Yassin, were the type used extensively by the MFMR freshwater research group. They were constructed locally, using steel reinforcing bar and fishing net of 2 different multifilament nylon mesh sizes, 0.5-inch stretch mesh for the cod end, and 2-inch stretch mesh for the remainder. Hoop nets were installed on the bottom of the river in several locations and in various depths of water. The openings were set facing downstream to trap fish swimming upstream. Traps were baited with fish and fish trimmings and most were set to a maximum depth of about 6 feet. The majority of hoop net sampling was done during the low- and rising-water seasons.

3. Rotenone Chemofishing

The rotenone sampling technique allows standing crops (numbers or kilograms per hectare) of fish to be estimated with relative nonselectivity for species and sizes of fish. Fish toxicants have been used worldwide for sampling fish populations. In the United States, rotenone, which inhibits respiration in gill-breathing organisms, has been most widely used for chemofishing sampling programs. Rotenone is an extract of the roots of plants of the family *Leguminosae*. *Derris*, a native of Australia, Oceania, and Southern Asia, is the most common genus. The crystalline forms of this substance ($C_{23}H_{22}O_6$) are insoluble in water, but soluble in organic solvents. Emulsified liquid formulations are most frequently used for fishery biology. The chemical is relatively safe, effective, and available.

Numerous fishery biologists in Africa have used this technique to classify fish populations in lakes and rivers. Toews and Griffith (1979) used chemofishing to estimate the ichthyomass (in kilograms per hectare) and potential yield for the Lake Bangweulu system in Zambia, Central Africa, and Kapet (1974) used this technique to determine ichthyomass and fish production in the Kafue River floodplain there.

Chemofishing was conducted in the Jubba River during low-water season, from 31 March to 2 April 1987 in the Baardheere area, and from 23 to 24 April 1987 in the Jilib area. One rotenone sampling was conducted in the Johar Reservoir on the Shabeelle River between 4 and 6 May 1987.

The objectives of the rotenone sampling program were to:

- estimate ichthyomass in the Jubba River and Johar Reservoir to compare fish populations and estimate potential fish populations in the proposed Baardheere Reservoir;
- describe fish species compositions in the Jubba River and Johar Reservoir;
- develop length-frequency distributions for each species; and
- train a Somali fishery biologist in chemofishing techniques.

Materials used for rotenone sampling included:

- 5 percent liquid emulsified rotenone;
- one block net 12' X 100' X 1/8" (ace mesh);
- one block net 10' X 150' X 1/4" (knotted mesh);
- boat and outboard motor with necessary gear;
- dip nets, buckets, measuring boards, and weighing scales
- survey equipment (tripod, survey level, Philadelphia rod, data book, etc.);
- crystalline potassium permanganate ($KMnO_4$) used for detoxification of rotenone; and
- miscellaneous materials, including rope, anchors, floats, water jugs, cameras, knives, calculator, and fish collection jars with formalin.

Holder and Crochet (1984) described methods of setting up stream sampling sites and application of rotenone. These method are more applicable to the United States, where proper equipment and logistical support are available. They were adapted to local conditions for use in the Jubba River.

Most river ichthyomass estimates are based on low-water sampling programs, since flows are too swift for rotenone sampling during the flood or high-water season. Small floodplain or riverbed pools created by exposed sandbars provide dess assumed that, during floods, the ichthyomass in the river would not differ significantly from that of the open water areas of the floodplain. On the basis of repeated rotenone and seine sampling in open-water floodplain, the estimated ichthyomass was 337 kilograms per hectare. Samples taken during low water were less, 204 kilograms per hectare, but it was shown that the dry-season estimate was low due to fishing pressure and variability in sampling.

Sample sites were chosen based on the absence of current and the ease of closing off the area with block nets. These nets were relatively small, thus restricting the choice of sampling sites. No main-channel sampling was possible because the potassium permanganate, used to detoxify the rotenone downstream from the sample site, did not arrive until the water level increased and flows were too fast. Welcomme (1983) described several rotenone-sampling methods used by fishery workers on large rivers. He pointed out that rotenone sampling, and indeed any fish sampling in the main channel, is difficult due to strong currents, channel width, and labor force requirements.

For this reason, sampling in the Jubba River was done in small pools, ranging in size from .006 to .20 hectares, created by exposed or deposited sandbars and connected to the main channel. The 2 pool habitats can best be described as "dead-arm" and "slack-arm" pools (Figures 3 and 4). Welcomme (personal communication) described the interactions between these pools and the main channel of the river.

In a dead-arm pool, the sandbar is located on the outside of the river bend and has created a small island with a narrow arm separating it from the main bank. As the water level recedes and sand is deposited at the upper end, the upstream inlet closes and the small channel is blocked at the upper end. The downstream outlet remains open, but very little water exchange or interaction between the dead-arm pool and main river channel occurs (Figure 3).

Figure 3. Dead-Arm Pool

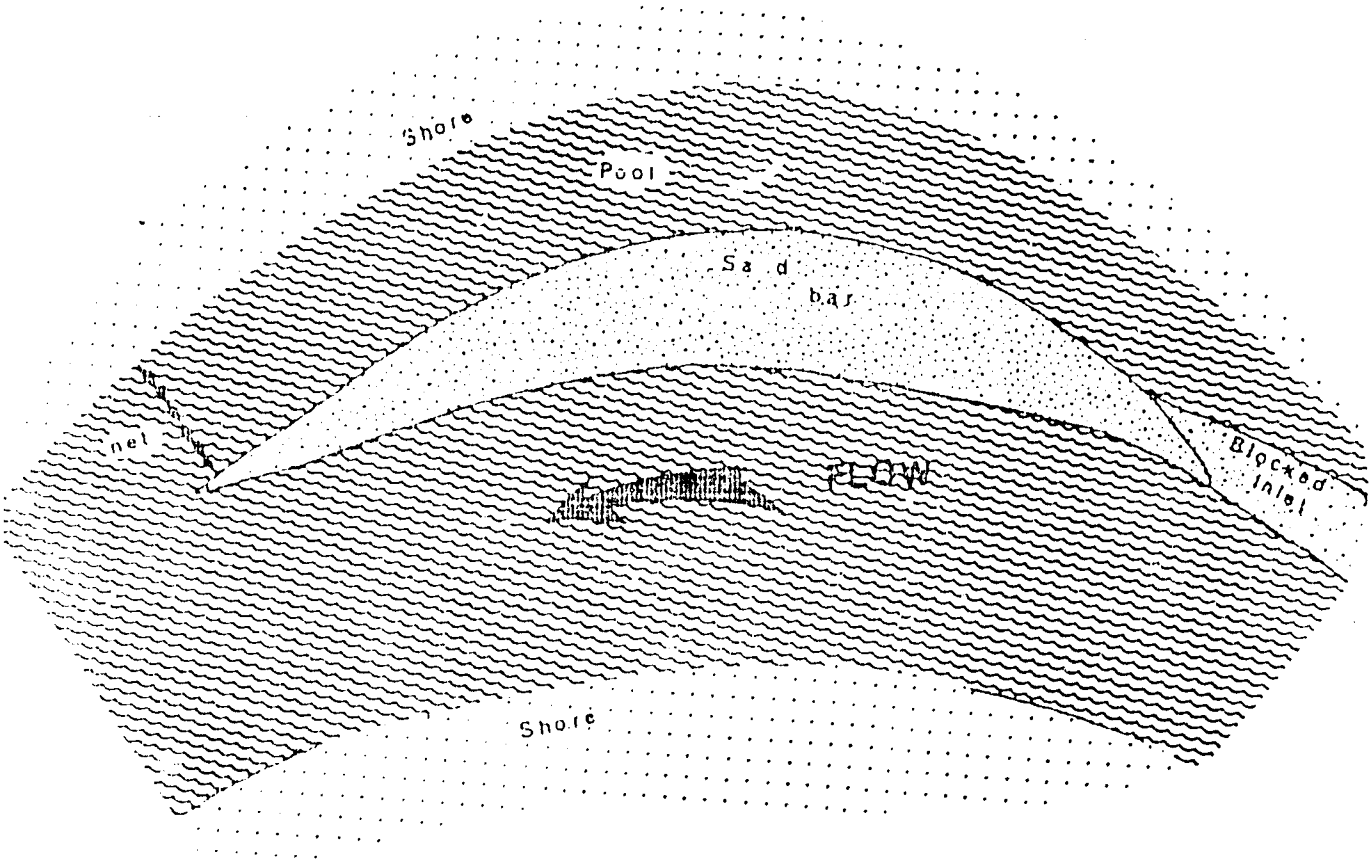
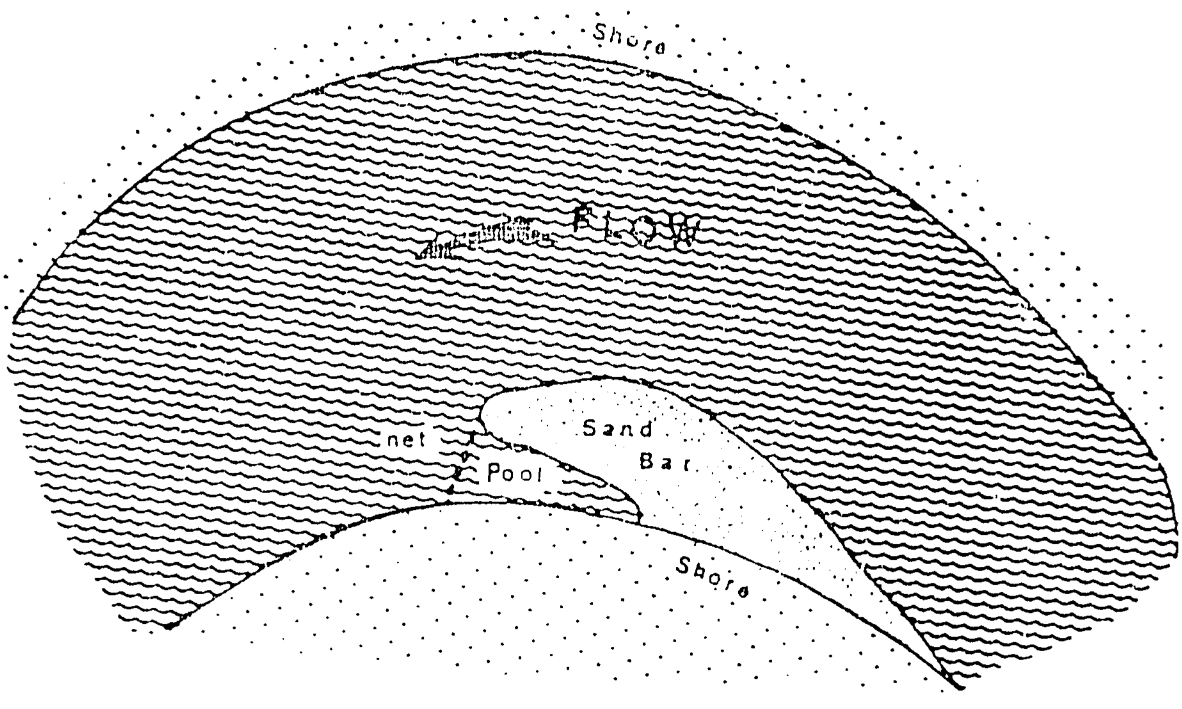


Figure 4. Slack-Arm Pool



A slack-arm pool is created on the inside of the river bend and by exposed sandbars, but the upstream portion of the bar is not isolated from the main bank. The slack-arm pool is usually smaller than the dead-arm pool. There is much more water exchange due to eddy turbulence created by the strong current close to the pool entrance (Figure 4). The small size of the pool contributes to interaction and water exchange with the main channel.

During rotenone sampling, the block net was placed in the water at the downstream end, completely blocking off the pool from the rest of the river, and the sink line was checked to make sure it was lying along the bottom so the net blocked the entire water column. The sample site was surveyed to determine surface area, mean depth was estimated, and enough 5 percent rotenone was applied to the area to insure a 1 to 2 parts per million (ppm) concentration. All fish were collected, identified, measured, and weighed. Sometimes, because of a large number of fish and lack of trained manpower, a 10 percent subsample was taken, and individual weights were not taken.

Ichthyomass was calculated by dividing the number of kilograms of fish collected by the area sampled (in hectares). Fish biomasses were estimated for these small-pool habitats and do not necessarily reflect the entire river. However, the information collected will give first-order estimates of the fish population biomass, species composition, and length frequencies. These data, combined with the other stock assessment methods, will provide a valuable data base for fishery administrators.

B. Catch Assessment Survey

For less exploited river systems, or for very dispersed fisheries, data collection is more difficult. Landings are not centralized or well defined, and few, if any, fish markets exist, making it difficult to sample fishermen to determine effort and catch. The sheer size of some river systems and the extremely low water conditions that can exist during dry periods also contribute to sampling problems. In these situations, other sampling methods, incorporating fish transportation and consumption surveys, have proven valuable.

Statistical sampling designs are varied and depend on the complexity of the system. Gulland (1972) described several sampling and statistical methods used by fishery biologists. In many designs, it is desirable to stratify the river system into relatively homogeneous spatial and temporal units to reduce variability and increase the effectiveness of sampling. It is also necessary to randomize sampling to reduce potential bias. Stratified random sampling is a common sampling method when physical and logistical conditions are favorable.

Basic estimates needed for fisheries assessment, monitoring, and subsequent management are:

- effort (E) -- the number of fishing units operating on the system, i.e., individual fishermen operating out of small dugout canoes or walking along the bank, or groups of fishermen operating out of larger boats;

- catch (C) -- an estimate of total harvest; and

- CPUE -- a measure of fishing success, dependent on catchability and relative abundance of fish. CPUE can also be a measure of the profitability for an individual fishing unit. Malvestuto and Meredith (in press) used the distribution of individual CPUEs on the Niger River in Niger, West Africa, to determine the percentage of no-profit days that fishermen experienced on that system.

After completing a preliminary fisheries survey in the Jubba Valley during the first consultancy, a stratified random sampling program was designed and implemented. This program proved to be difficult for the fishery technician to conduct, and manpower was very limited. During the second consultancy, the sampling design was modified so one person could collect as much data as possible. The fishery technician has begun to interview fishing households on a random basis in villages adjacent to FBS sampling locations. This information is not available yet, but the data probably will be scant and marginally valuable. Detailed analysis of the fish-related questions from SEBS should provide more detailed information.

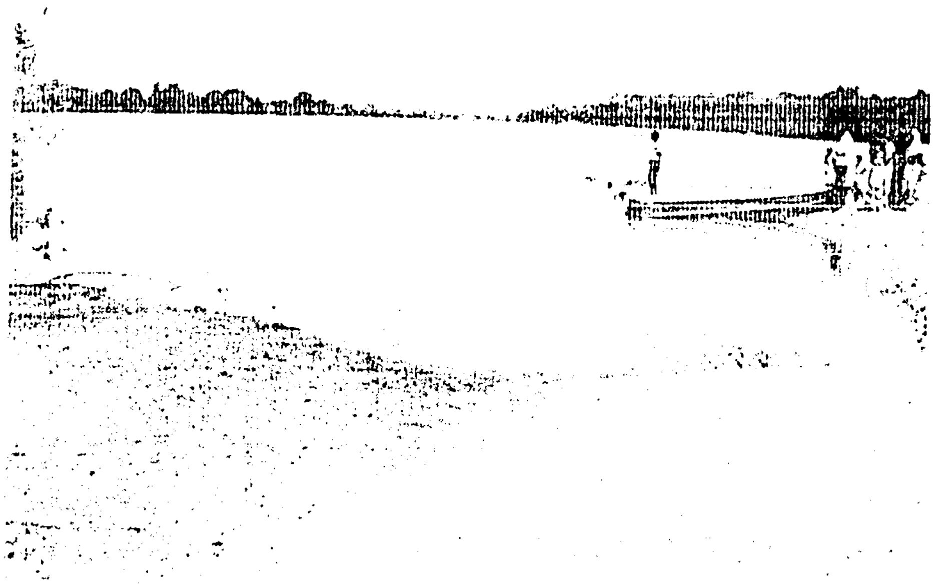


Photo 1. Selection of "slack-arm pool" for rotenone sampling in the Jubba River, 10 kilometers downstream from Baardheere, 15 April 1987.

Photo 2. Setting net at mouth of "dead-arm pool" for rotenone sampling in the Jubba Valley.

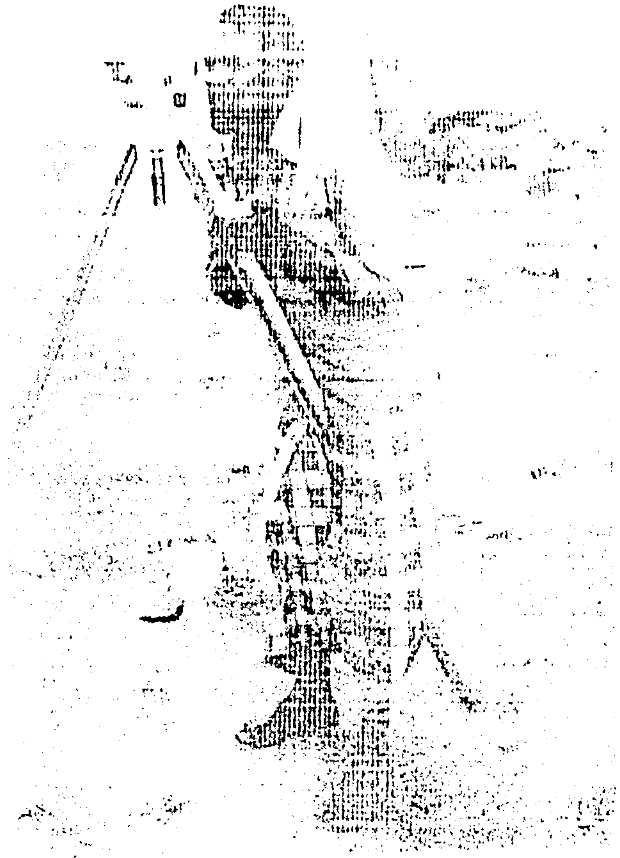


Photo 3. Ahmed Abdulaahi Yassin surveying rotenone sampling site, 15 April 1987.

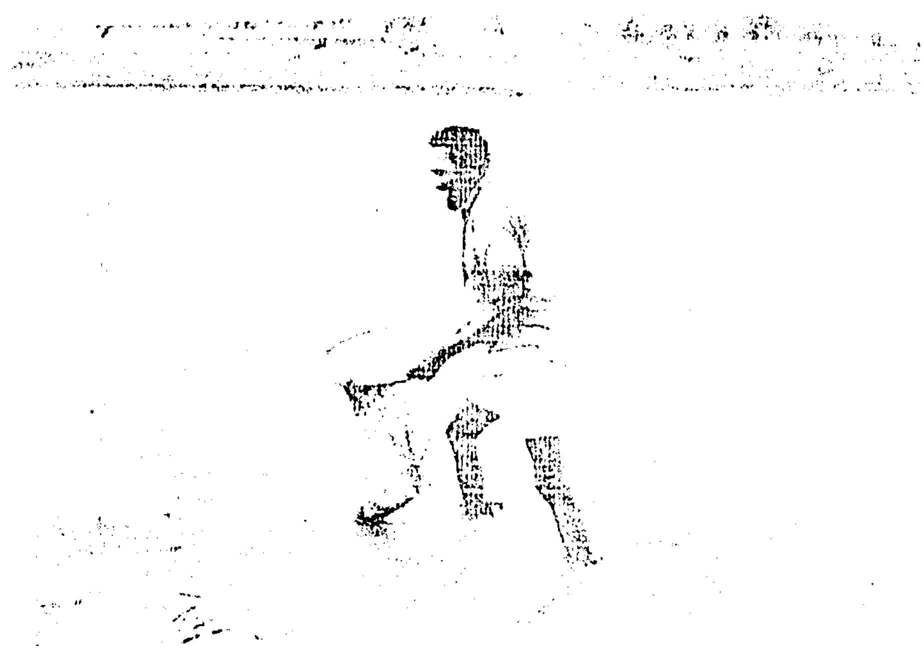


Photo 4. Ahmed Abdulaahi Yassin collecting fish during Johar rotenone sampling.

Photo 5. Ahmed Abdulaahi Yassin packing large *Clarias gariepinus* and *Bagrus* spp collected during rotenone sampling in the Jubba River, 15 April 1987.

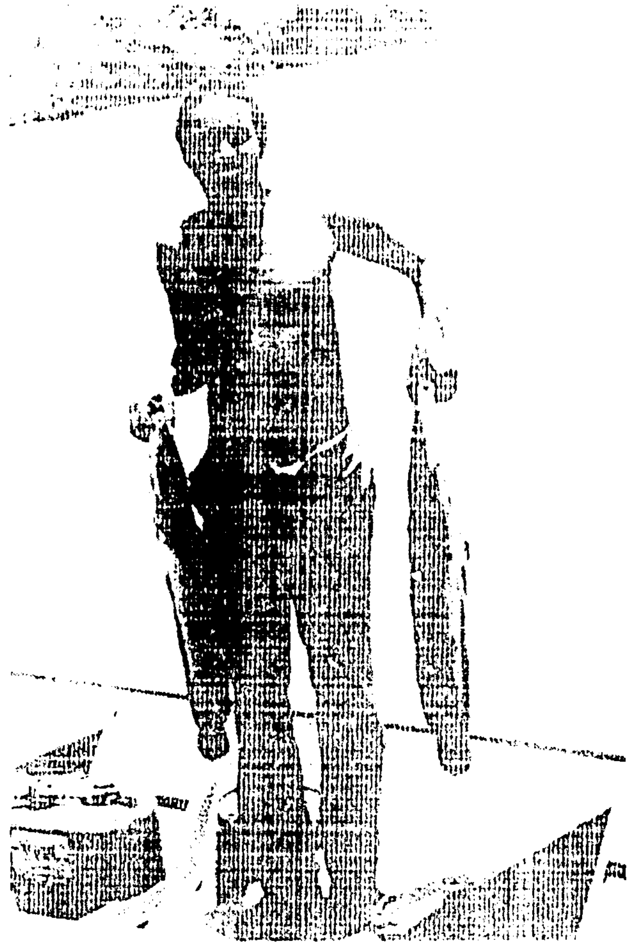


Photo 6. Ahmed Abdulaahi Yassin with large *Clarias gariepinus* collected from the Jubba River rotenone sample.

Photo 7. Earl Meredith collecting fish in "dead-arm pool" of the Jubba River.

Photo 8. Basins of *Barbus* spp collected during rotenone sampling in the Jubba River.

Photo 9. Gonadal inspection of large *Clarias gariepinus* captured in the Jubba River. The tip of the knife points to the ripe ovary.

V. STUDY RESULTS

Preliminary results of the FBS and CAS are presented in this section. Further analysis will take place upon receipt of the data presently being collected by Mr. Yassin. It is strongly recommended that sampling programs continue in a standardized fashion in order to monitor pre- to post-impoundment changes in the fish populations. Further data collection will improve the statistical validity of the assessment presented here.

The current sample sizes for each gear used are as follows:

gill net (gn)	20 sets
hoop net (hn)	9 sets
hook line (hl)	3 sets
rotenone	6 samples

A. Catch Per Unit of Effort

Calculation of CPUE, frequently used as an index of fish abundance, will allow comparisons of fish abundance before and after impoundment of the Jubba River. The CPUE for each experimental fishing gear type and size is presented in Table 4.

Number of samples taken (sample freq.), mean catch per set (mcpue), minimum catch per set (mincpue), and maximum catch per set (maxcpue) for each gear type and gear size by strata are shown. Gear types are abbreviated as gill net (gn), hook line (hl) and hoop net (hn). Gear sizes are in inch bar mesh.

Table 4. Stratum 1 (Northern Region)

gear type	gear size	sample freq.	mcpue (gm)	mincpue (gm)	maxcpue (gm)
gn	1.0	8	725	50	1600
gn	1.5	12	3063	200	18180
gn	2.0	9	6027	670	14730
gn	2.5	7	5139	400	15100
gn	3.0	7	5051	1460	12200
gn	3.5	7	2157	600	4700
gn	4.0	4	7468	870	10500
hl	*	3	5633	2000	10000
hn	*	9	1513	40	9650

Table 4. <u>Stratum 2 (Southern Region)</u>

gear type	gear size	sample freq.	mcpue (gm)	mincpue (gm)	maxcpue (gm)
gn	1.0	4	2540	570	4830
gn	1.5	8	2481	220	8725
gn	2.0	6	3293	700	6200
gn	2.5	5	2770	700	6500
gn	3.0	4	3752	2200	5500
gn	3.5	4	9000	2400	18500
gn	4.0	3	3367	590	6000

*Hoop nets and hook lines are of one size only.

By analyzing CPUE for gill net mesh sizes combined into a single fleet, rather than by individual mesh sizes, it is more practical to determine the number of sets needed to accurately estimate CPUE within a certain percentage confidence limit. The following formula was used to calculate the number of samples needed to obtain 80 percent confidence intervals of ±25 percent and ± 30 percent:

$$n=(t^2)(CV^2)/d^2$$

where: n = necessary sample size;
t = student's t value at n-1 degrees of freedom and at alpha=.20;
CV = coefficient of variation; and
d = desired confidence level.

CV and d are expressed as percentages. The resulting information is given in Table 5.

Table 5.

Gear type	Mean CPUE (gm)	Minimum CPUE (gm)	Maximum CPUE (gm)	CV (%)	Sample size at d = 25%	30%
gill net	3800	50	18500	105	29	20
hook line	5633	2000	10000	72	13	9
hoop net	1513	40	9650	202	107	74

B. Species Composition

1. Experimental Gill Net Sampling

The species composition by percent weight and number from experimental gill net sampling on each stratum of the Jubba River is shown in Table 6. Eleven positively identified species, and 3 species that could be identified to genus only, were captured in Stratum 1 (northern region). Six positively identified species and 3 species identified to genus only were caught in Stratum 2 (southern region).

Table 6. Percent Species Composition by Number and Weight in Each Geographical Stratum

Genus and Species Groups	Northern Region		Southern Region	
	% wt	% N	% wt	% N
Mormyrops deliciosus	0.39	0.67	0	0
Petrocephalus gliroides	0.02	0.34	0	0
Mormyrus kannume	2.85	3.69	0	0
Alestes affinis	0.02	0.34	0	0
Labeo spp	2.37	3.69	5.98	7.19
Labeo bottegi	10.30	14.43	22.51	12.50
Bagrus urostigma	3.32	2.35	2.64	0.63
B. bayad macropterus	0	0	0.28	0.31
Clarotes spp	25.62	14.43	3.11	1.56
C. laticeps	9.01	7.38	35.67	24.69
Malapterurus electricus	0.90	0.34	0	0
Eutropius depressirostris	35.17	32.55	16.50	28.13
Clarias gariepinus	3.90	1.68	0	0
Synodontis spp (schall)	6.11	17.79	11.77	21.88
Oreochromis niloticus	0.02	0.34	1.55	3.13

In Stratum 1, the following 4 genera made up 88.6 percent of the catch by weight: *Eutropius depressirostris* (35.17%); *Clarotes* spp (34.63%); *Labeo* spp (12.67%); and *Synodontis* spp (6.11 %). In Stratum 2, 95.5 percent of the experimental gill net catch in weight was composed of *Clarotes* spp (38.8%), *Labeo* spp (28.6%), *Eutropius depressirostris* (16.5%), and *Synodontis* spp (11.8%).

Eutropius depressirostris was approximately twice as abundant in the northern stratum as in the southern stratum, *Labeo* spp were approximately twice as abundant in the southern region as in the northern region, *Synodontis* spp were about twice as abundant in the south, and *Clarotes* spp were about equally abundant in both strata.

In Stratum 1, 90.3 percent of the species captured was composed of *Eutropius depressirostris* (32.6%), *Clarotes* spp (21.8%), *Labeo* spp (18.1%), and *Synodontis* spp (17.7%). In Stratum 2, 95.6 percent of the catch was composed of *Eutropius depressirostris* (28.1%), *Clarotes* spp (26.3%), *Synodontis* spp (21.9%), and *Labeo* spp (19.7%).

2. Hoop Net Sampling

The hoop net sampling program provided much fewer data than the other stock assessment survey methods. This was primarily because turtles caught in the opening of the funnel entrance prevented fish from entering and being trapped. Modifications did not improve the performance of these nets and further work is under way to improve the design. More sampling with this type of gear is necessary before data analysis would be warranted.

3. Rotenone Chemofishing

Five rotenone samples were taken in the Jubba River and one in the Johar Reservoir on the Shabeelle River. The samples were taken from relatively small areas, particularly Sample #4. It will be necessary to take more rotenone samples to validate the current results, although the kilograms per hectare expansions seem reasonable in magnitude and exhibit the normal range of variability for data of this nature (Tables 7 through 12). A fishery technician has been trained to conduct rotenone sampling for future monitoring purposes.

Table 7. Rotenone Data for Sample #1*

Species	Number	Wt (gms)	N (%)	Wt (%)	kg/ha
Alestes affinis	10	140	27.8	2.3	7.0
Eutropius depressirostris	1	30	2.8	0.5	1.5
Oreochromis niloticus	2	100	5.6	1.7	5.0
Eleotris spp	12	150	33.3	2.5	7.5
Synodontis spp	4	490	11.0	8.0	24.5
Clarias gariepinus	1	2500	2.8	41.2	125.0
Labeo spp & Barbus spp	6	2660	16.7	43.8	133.0
Total	36	6070	100	100	303.5

*Sample taken 31 March 1987. The area of this sample was .02 hectare, 10 kilometers south of Baardheere.

Table 8. Rotenone Data for Sample #2*

Species	Number	Wt (gms)	N (%)	Wt (%)	kg/ha
Alestes affinis	8	90	4.6	0.2	2.25
Eutropius depressirostris	4	770	2.3	1.5	19.25
Oreochromis niloticus	6	220	3.5	0.4	5.5
Eleotris spp	5	70	2.9	0.2	1.75
Synodontis schall	7	560	4.1	1.1	14.0
Synodontis spp	2	670	1.2	1.3	16.75
Clarias gariepinus	7	14800	4.0	29.1	370.0
Labeo spp & Barbus spp	127	30940	73.4	60.9	773.5
Clarotes laticeps	7	2700	4.0	5.3	67.5
Total	173	50820	100	100	1270.5

*Sample taken 1 April 1987. The area of this sample was .04 hectare, 10 kilometers north of Baardheere.

Table 9. Rotenone Data for Sample #3*

Species	Number	Wt (gm)	N (%)	Wt (%)	kg/ha
Alestes affinis	35	320	12.2	0.3	2.7
Eutropius depressirostris	33	870	11.5	0.9	7.3
Oreochromis niloticus	5	120	1.8	0.1	1.0
Eleotris spp	2	100	0.7	0.1	0.8
Synodontis schall	18	1364	6.3	1.4	11.4
Physailia somalensis	6	70	2.1	0.1	0.6
Clarias gariepinus	17	34800	5.9	36.2	290.0
Labeo spp & Barbus spp	148	43690	51.7	45.4	364.1
Clarotes laticeps	15	3410	5.3	3.5	28.4
Bagrus urostigma	4	9260	1.4	9.7	77.2
Malapterurus electricus	1	1700	0.4	1.8	14.2
Mormyrops deliciosus	2	510	0.7	0.5	4.3
Total	286	96214	100	100	801.8

*Sample taken 2 April 1987. The area of this sample was .12 hectare, 10 kilometers south of Baardheere.

Table 10. Rotenone Data for Sample #4*

Species	Number	Wt (gms)	N (%)	Wt (%)	kg/ha
Alestes affinis	35	460	52.2	18.3	76.7
Eutropius depressirostris	7	100	10.4	4.0	16.7
Oreochromis niloticus	3	600	4.5	23.9	100.0
Eleotris spp	0	0	0	0	0
Synodontis schall	0	0	0	0	0
Physailia somalensis	0	0	0	0	0
Clarias gariepinus	1	600	1.5	23.9	100.0
Labeo spp & Barbus spp	8	620	12.0	24.7	103.3
Clarotes laticeps	8	110	11.9	4.4	18.3
Bagrus urostigma	0	0	0	0	0
Malapterurus electricus	0	0	0	0	0
Mormyrops deliciosus	0	0	0	0	0
Glossogobius giurus	5	20	7.5	0.8	3.33
Total	67	2510	100	100	418.3

*23 April 1987. The area of this sample was .006 hectare, 5 kilometers upstream from Jilib.

Table 11. Rotenone Data for Sample #5**

Species	Number	Wt (gms)	N (%)	Wt (%)	kg/ha
Alestes affinis	188	1400	13.9	1.8	21.5
Eutropius depressirostris	45	1600	3.3	2.0	24.6
Oreochromis niloticus	30	1200	2.2	1.5	18.5
Eleotris spp	0	0	0	0	0
Synodontis schall	0	0	0	0	0
Physailia somalensis	4	200	0.3	0.3	3.0
Clarias gariepinus	2	1330	0.2	1.7	20.5
Labeo spp & Barbus spp	968	70900	71.4	90.0	1090.8
Clarotes laticeps	116	2000	8.7	2.5	20.8
Bagrus urostigma	0	0	0	0	0
Malapterurus electricus	0	0	0	0	0
Mormyrops deliciosus	1	70	*	*	1.1
Glossogobius giurus	0	0	0	0	0
Mugil spp	1	60	*	*	0.92
Total	1355	78760	99.9	99.9	1211.7

*Denotes values below .1 percent.

**Sample taken 24 April 1987. The area of this sample was .065 hectare, 5 kilometers downstream from Jilib.

Table 12. Rotenone Data for Sample #6*

Species	Number	Wt (gms)	N (%)	Wt (%)	kg/ha
Alestes affinis	0	0	0	0	0
Eutropius depressirostris	0	0	0	0	0
Oreochromis niloticus	398	149600	64.0	43.0	748.0
Eleotris spp	0	0	0	0	0
Synodontis schall	0	0	0	0	0
Physailia somalensis	0	0	0	0	0
Clarias gariepinus	41	145200	6.6	41.8	726.0
Labeo spp & Barbus spp	183	52800	29.4	15.2	262.5
Clarotes laticeps	0	0	0	0	0
Bagrus urostigma	0	0	0	0	0
Malapterurus electricus	0	0	0	0	0
Mormyrops deliciosus	0	0	0	0	0
Glossogobius giurus	0	0	0	0	0
Mugil spp	0	0	0	0	0
Total	622	347600	100	100	1736.5

*Sample taken 5 May 1987. Main pool at drain of Johar Reservoir. The area of this sample was .20 hectare.

VI. DISCUSSION OF STUDY RESULTS

A. Preliminary Predictions of Yield from the Jubba River

The World Concern project has predicted potential annual catch for the Jubba River at 2,407 metric tons, using Welcomme's basin area (A) model, with A equal to 98,000 square kilometers. More up-to-date estimates of basin area for each of the 3 countries sharing the Jubba Valley drainage basin are shown in Table 13.

Table 13. Drainage Basin Areas for the Jubba River System*

Country	Area (A) in Square Kilometers
Ethiopia	134,000
Somalia	76,000
Kenya	10,000
Total	220,000

*Data provided by the MNPJVD-Baardheere Dam Project.

The estimated annual sustainable yield for the Jubba River fishery in Somalia is 1,600 metric tons, using A equal to 76,000 square kilometers (Table 13) in Welcomme's basin area model. Expanding this to a U.S. dollar value, using 50 Somali shillings (SSh) per kilogram of fish and 100 SSh per dollar, gives an estimated potential annual economic yield of US$800,000, or 80 million SSh.

Using Welcomme's main channel length model, the estimated annual catch could be approximately 1,800 metric tons. This expands to an estimated value of approximately US$900,000, or 90 million SSh.

It must be emphasized that these values are based on general river-fishery predictive models, which allow for general estimates of fishery potentials for resource managers. Local environmental or socioeconomic conditions can cause variations in these figures.

B. Biomass Estimation from Rotenone Sampling

The mean estimated fish biomass based on the rotenone samples taken in the Jubba River was 801 kilograms per hectare with a coefficient of variation (CV) of 55 percent. CVs associated with cove rotenone sampling programs conducted in

Alabama reservoirs are usually between 50 and 100 percent. The 80 percent confidence limits around the mean are 350 to 1,250 kilograms per hectare.

The fish biomass of the Johar Reservoir on the Shabeelle River was estimated at 1,736 kilograms per hectare, based on one sample. This was about twice the estimate for the Jubba River and 3 to 4 times the fish biomass reported for Lake Kariba (Kapetsky and Petr 1984, quoting Balon 1973; Mitchell 1976; and Longerman, unpublished). Welcomme (personal communication) stated that the habitat sampled was not representative of the entire Johar Reservoir because fish are attracted to drainage dams and canals. Further sampling is highly recommended by the author and fishery biologists from the Food and Agriculture Organization of the United Nations (FAO). More reasonable estimates of potential fish biomass for the Johar Reservoir would be from 500 to 1000 kilograms per hectare.

C. Species Composition

Previous fishery investigations by colonial scientists have indicated that approximately 50 fish species would be expected to occur in the Jubba Valley. Welcomme (1985) discussed the differences in number of fish species between river systems and presented the following model that can be used to estimate the number of species (N) to be expected in any given African river, correlated against total basin area (A) in square kilometers:

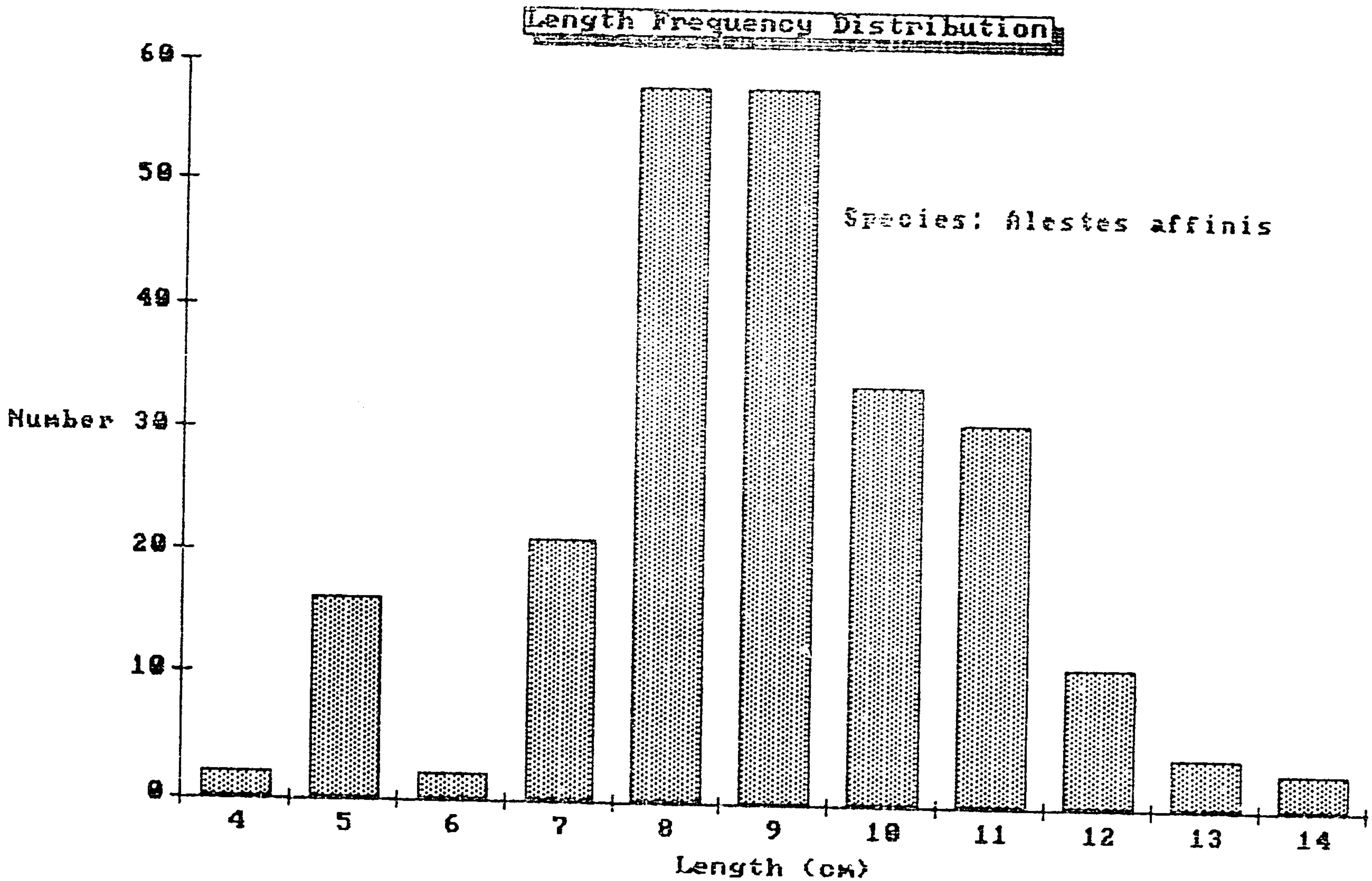
$$N = 0.449A^{0.434} \quad (n=25;\ r=0.91)$$

Using 220,000 square kilometers for the entire Jubba River drainage basin, 93 species are estimated to occur. Excluding the Ethiopia and Kenya drainage areas, an estimated 58 species should occur. Approximately 20 freshwater species were collected during this study. Several marine and estuarine species from the families *Sciaenidae, Carangidae, Arriidae, Clupeidae*, and *Mugilidae* were collected at the mouth of the river.

The number of species in the 2 geostrata appear to be equal. Approximately 20 species were collected in both the northern and southern strata. The only 3 species that did not occur in the sample from the northern stratum were *Eleotris* spp, *Glossogobius giurus* and *Mugil* spp. The absence of these species might be attributable to the Faanoole hydroelectric facility, which may have cut off upstream fish movement from the marine and estuarine environments. The Faanoole facility could possibly have contributed to the elimination of several obligate migratory species, resulting in a smaller number of fish species than expected.

The species diversity of the Johar Reservoir was smaller than that measured in the Jubba River. This is based on one sample and is not necessarily representative of the entire reservoir. In impounded rivers, the lotic (riverine) fish fauna is usually more diverse than the lentic (reservoir) fish fauna. Typically, the riverine genera which tend to thrive, or whose populations expand, in reservoirs are *Tilapia, Oreochromis, Labeo, Barbus, Clarias,* and *Clarotes.* The *Clarias* species contributed 43 percent and *Oreochromis* 42 percent by weight to the sample catch in Johar Reservoir. The percent contribution to weight of the *Clarias* catfish in the Jubba River was variable, with estimates ranging from 1.7 to 41.2 percent. *Labeo* and *Barbus* spp contributed 15 percent by weight to the fish biomass in Johar Reservoir, but 25 to 90 percent in the Jubba River.

Length-frequency distributions for rotenone sampling are shown in Figures 5 through 13.


Length Frequency Distribution
Species: Alestes affinis
Number
0
10
20
30
40
50
60
4
5
6
7
8
9
10
11
12
13
14
Length (cm)

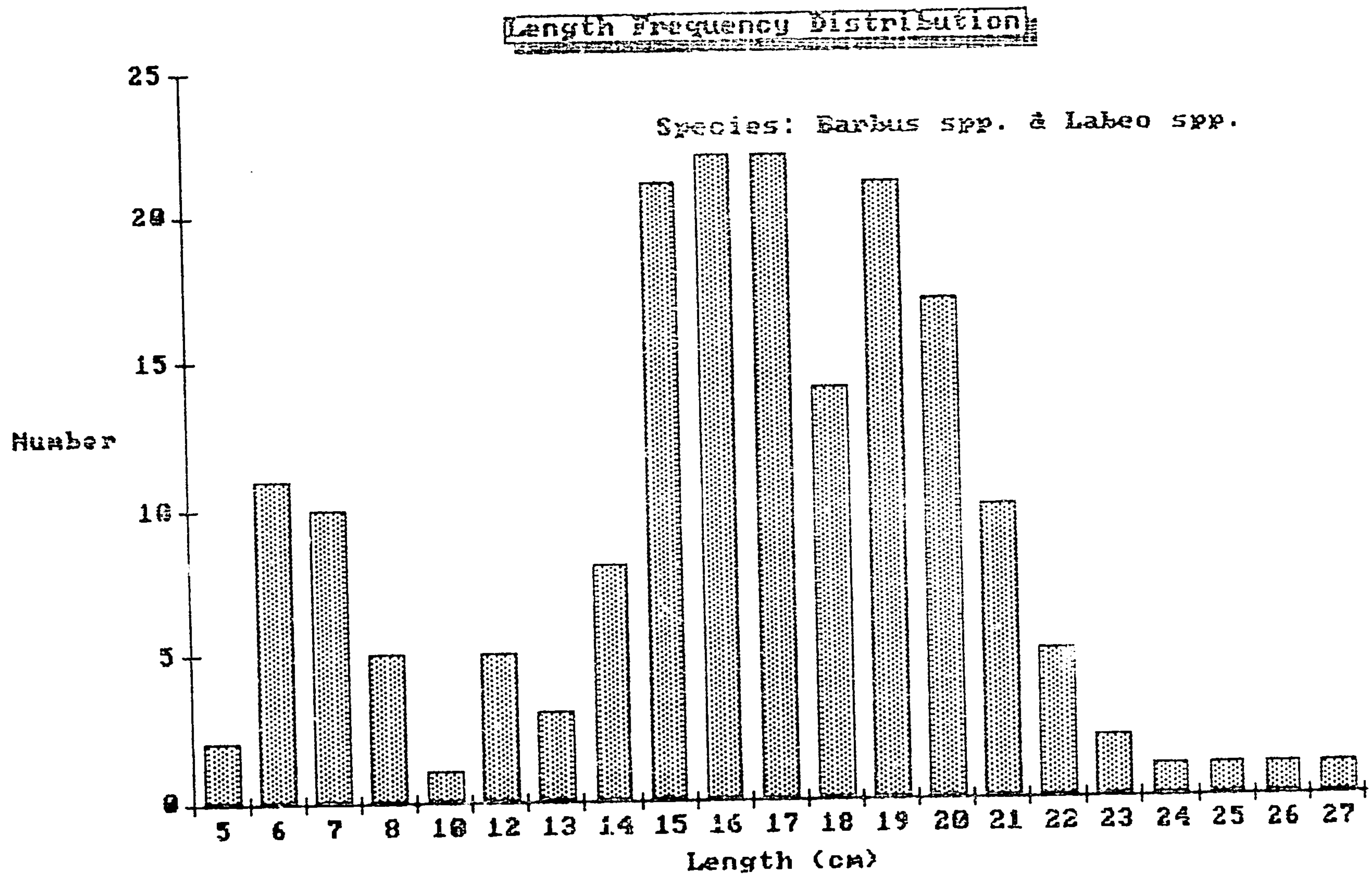

Length Frequency Distribution
Species: Barbus spp. & Labeo spp.
Number
25
20
15
10
5
0
5 6 7 8 10 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Length (cm)

Figure 6.

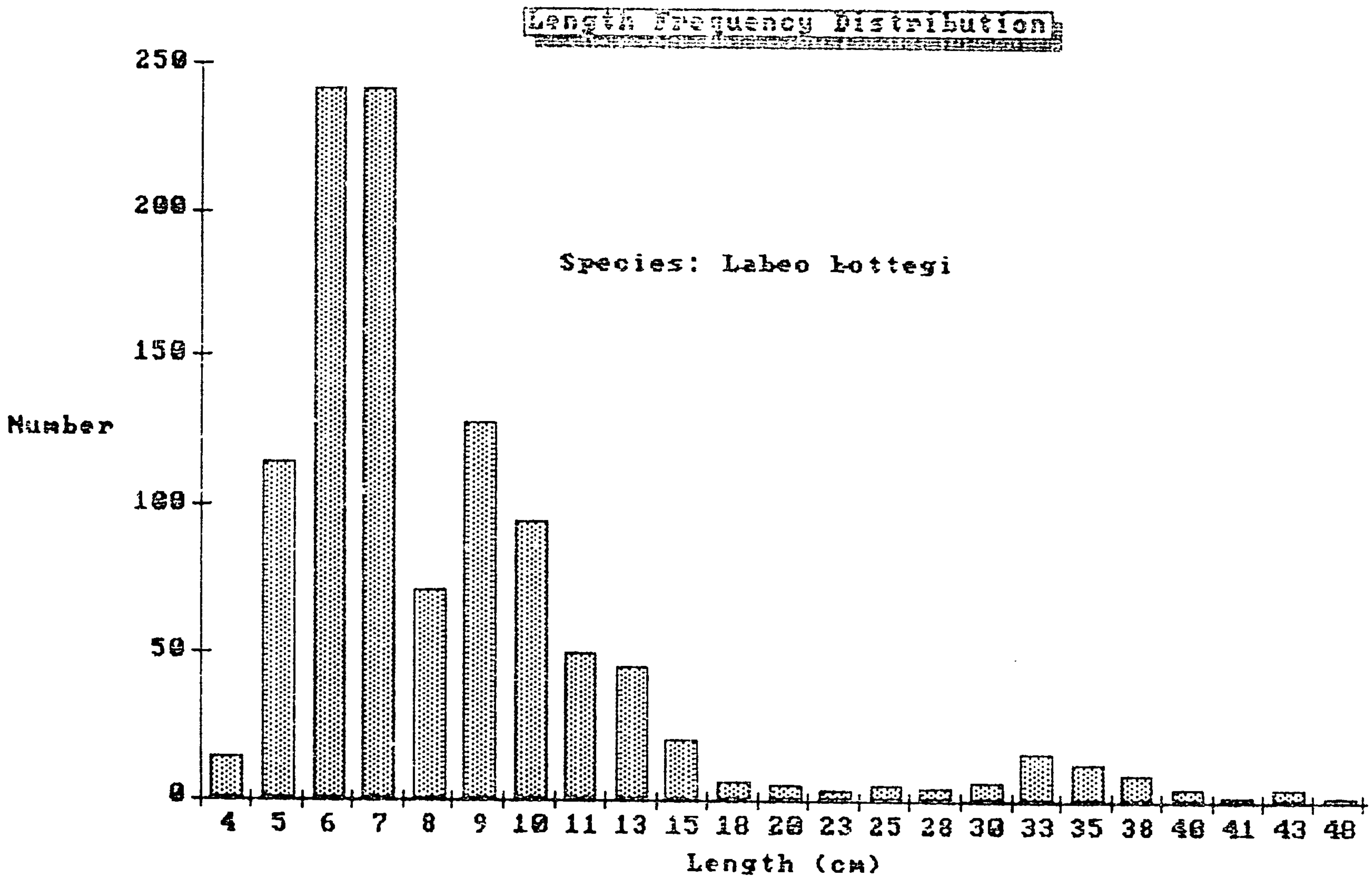

Length Frequency Distribution
Species: Labeo bottegi
Number
250
200
150
100
50
0
4 5 6 7 8 9 10 11 13 15 18 20 23 25 28 30 33 35 38 40 41 43 48
Length (cm)

Figure 7.

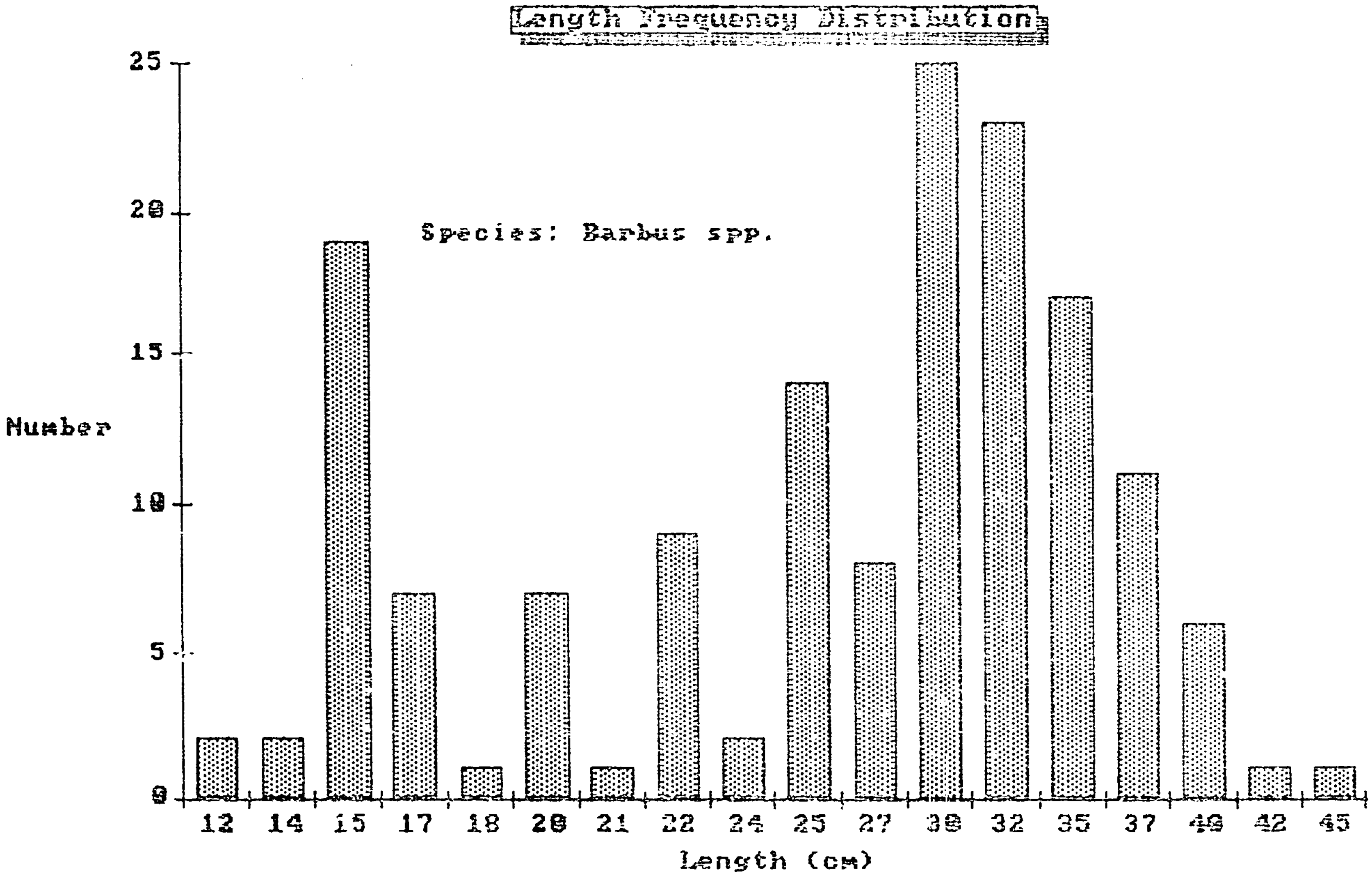

Length Frequency Distribution
Species: Barbus spp.
Number
25
20
15
10
5
0
12 14 15 17 18 20 21 22 24 25 27 30 32 35 37 40 42 45
Length (cm)

Figure 8.

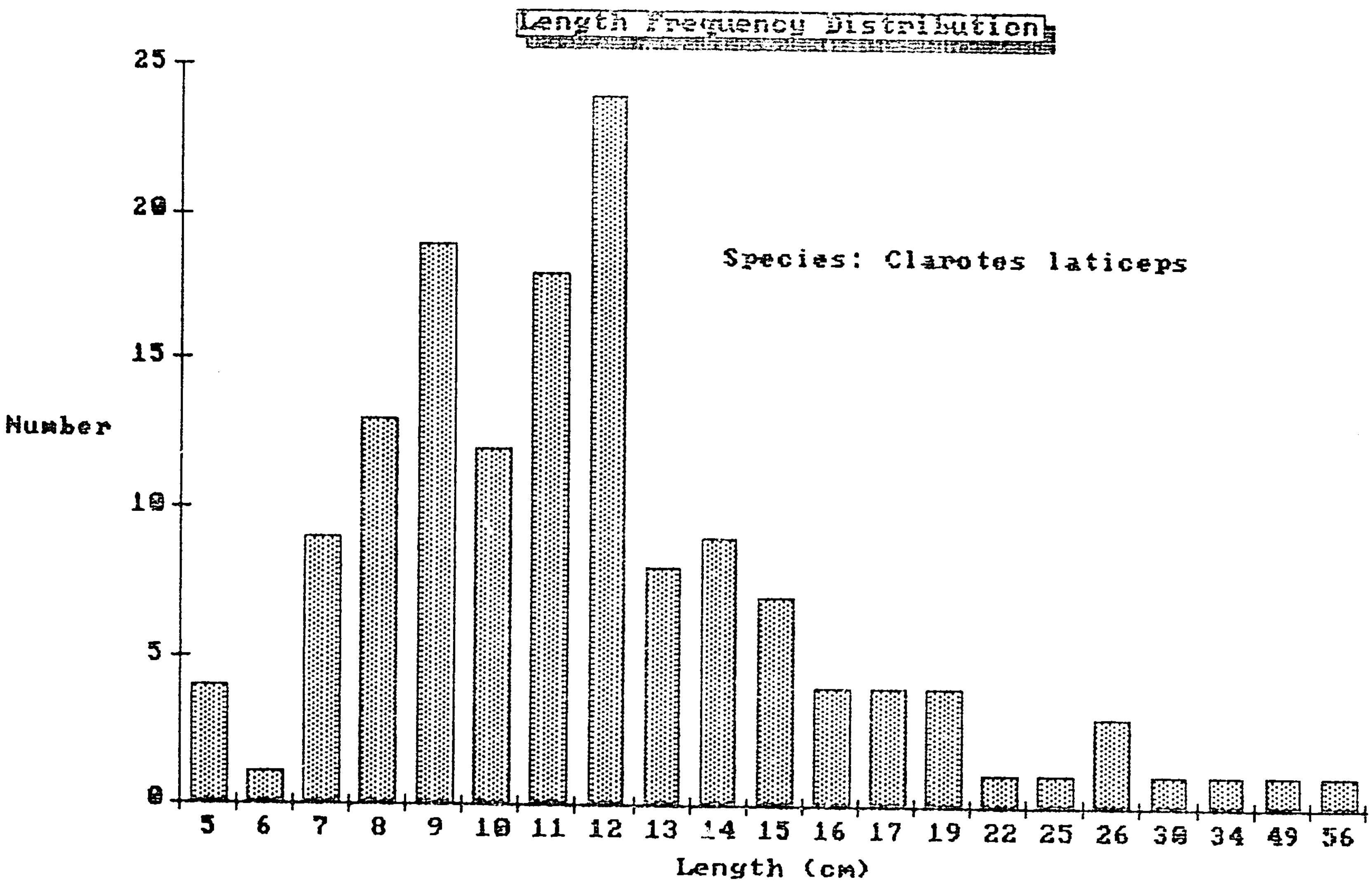

Length Frequency Distribution
Species: Clarotes laticeps
Number
0
5
10
15
20
25
5
6
7
8
9
10
11
12
13
14
15
16
17
19
22
25
26
30
34
49
56
Length (cm)

Figure 9.

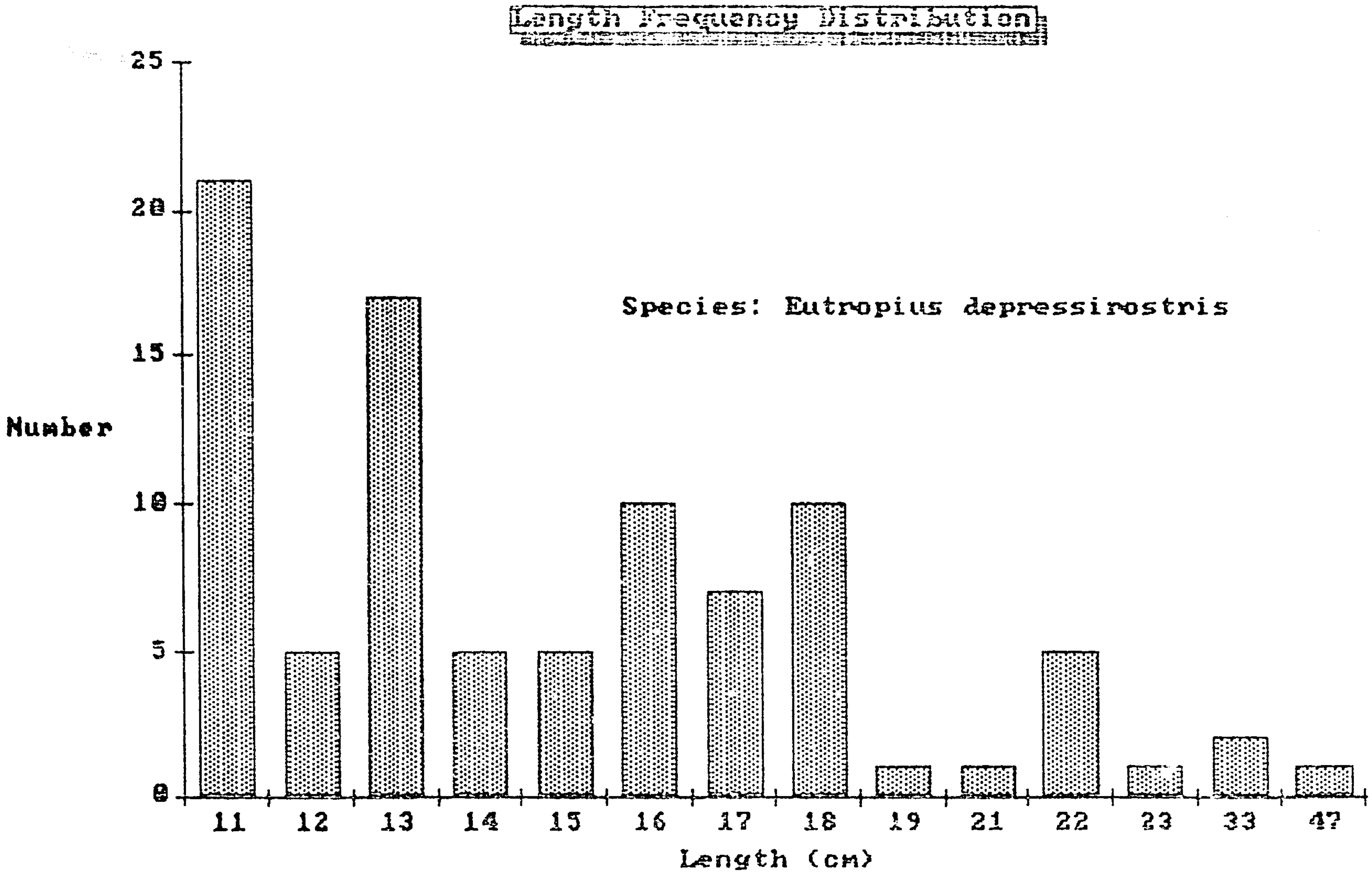

Length Frequency Distribution
Species: Eutropius depressirostris
Number
25
20
15
10
5
0
11
12
13
14
15
16
17
18
19
21
22
23
33
47
Length (cm)

Figure 10

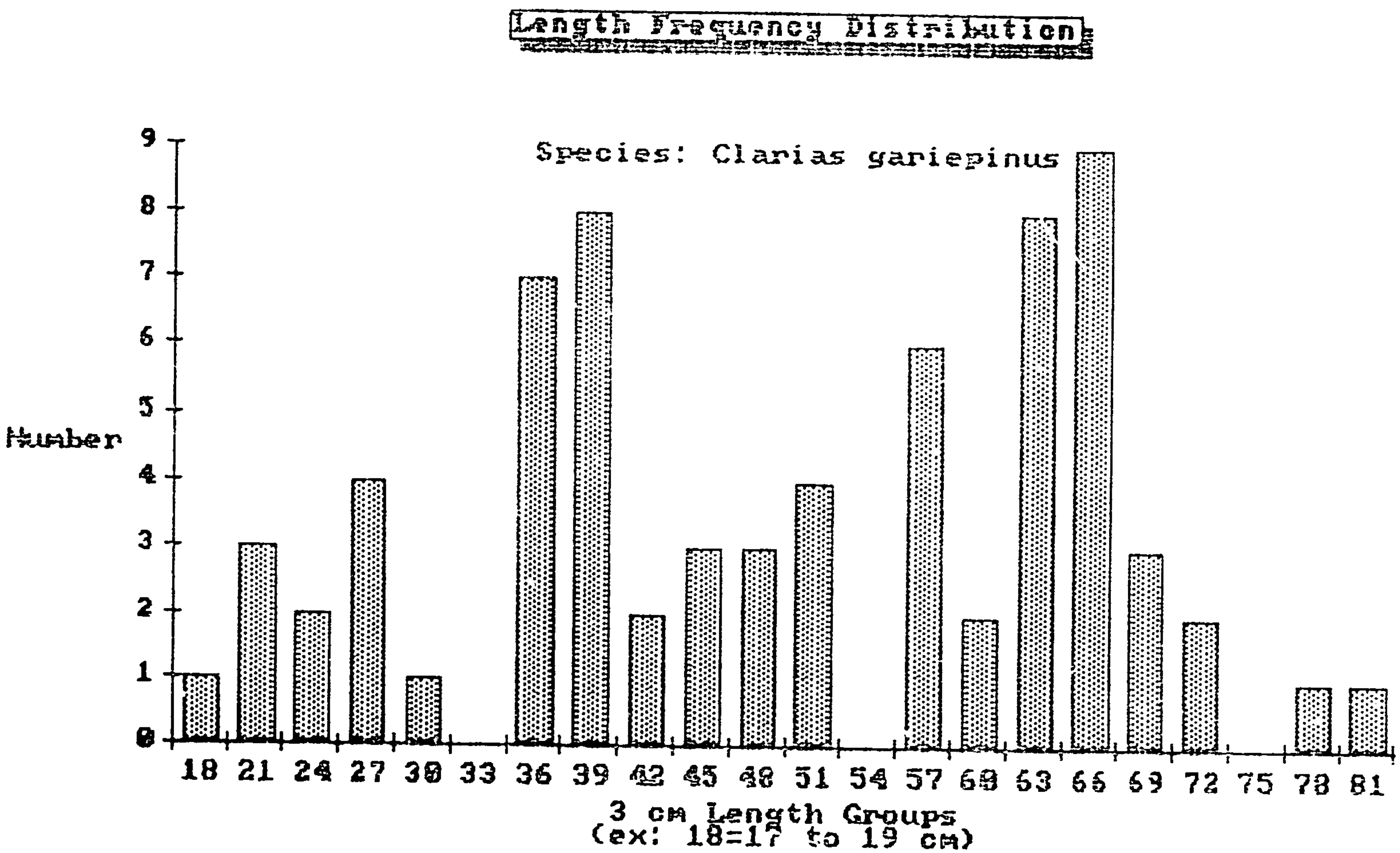

Length Frequency Distribution
Species: Clarias gariepinus
Number
0 1 2 3 4 5 6 7 8 9
18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81
3 cm Length Groups
(ex: 18=17 to 19 cm)

Figure 11.

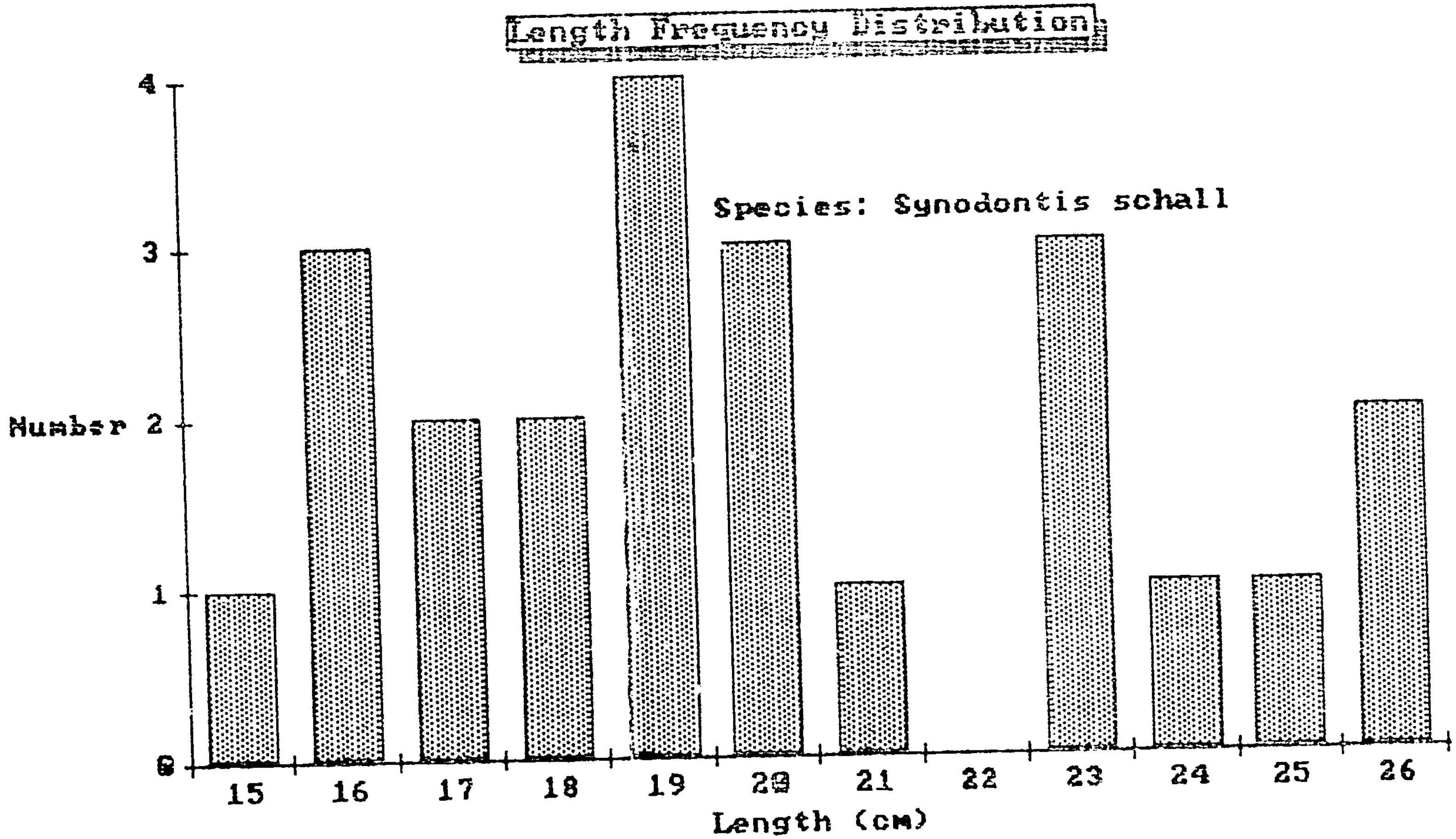

Length Frequency Distribution
Species: Synodontis schall
Number
0
1
2
3
4
15
16
17
18
19
20
21
22
23
24
25
26
Length (cm)

Figure 12.

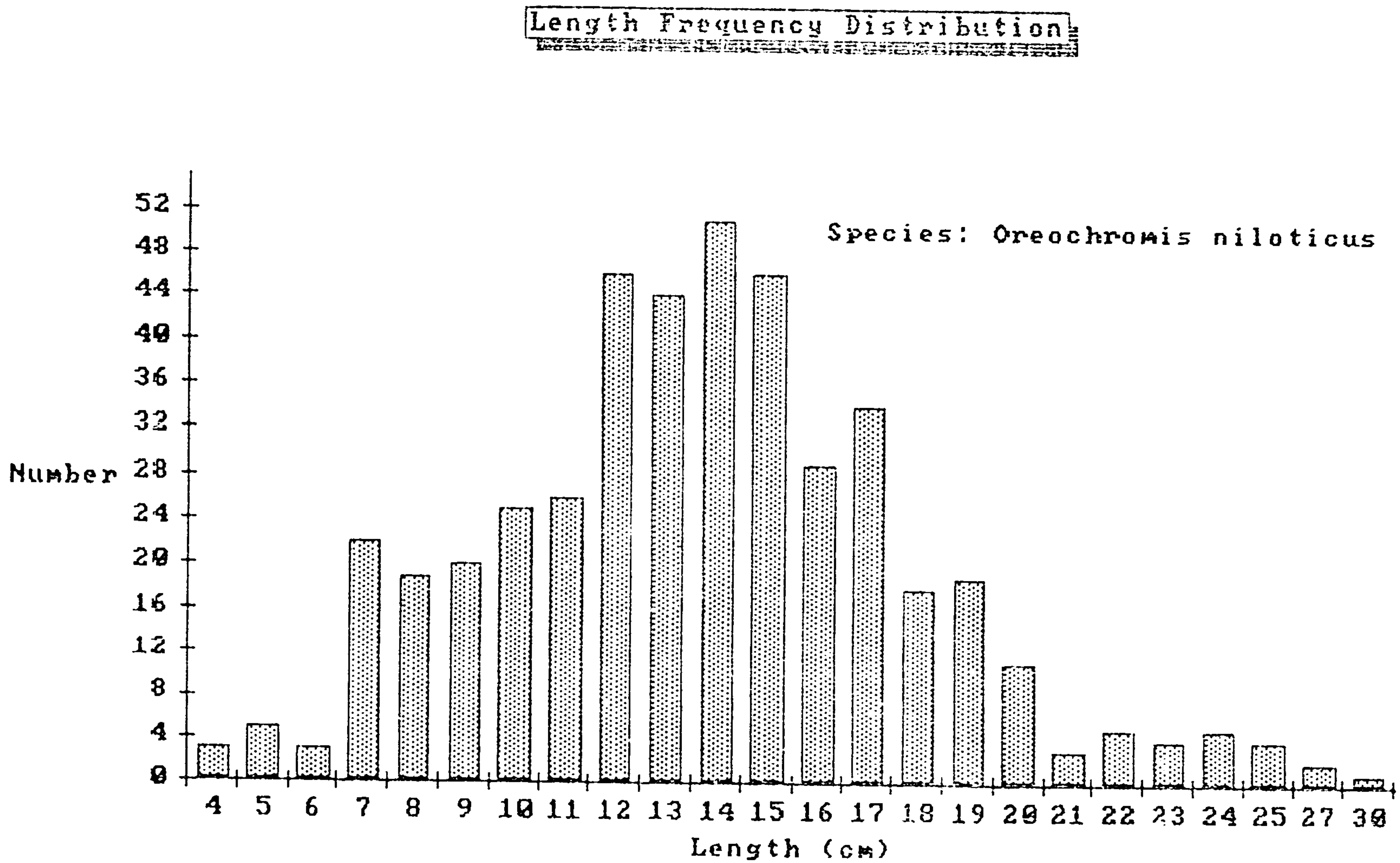

Length Frequency Distribution
Species: Oreochromis niloticus
Number
52
48
44
40
36
32
28
24
20
16
12
8
4
0
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 27 30
Length (cm)

Figure 13.

VII. PROJECTIONS OF DOWNSTREAM IMPACTS ON FISH POPULATIONS ASSOCIATED WITH THE PROPOSED BAARDHEERE RESERVOIR

The impacts on fish populations after closure of mainstream dams in Africa are not well documented. Welcomme (1985) discussed the effects of various uses of river systems on fish populations, including changes in flow rates, silt load, water quality, habitat, plankton abundance, and temperature. (See Table 1, Section III, for a list of the major effects of dams on river ecosystems.)

This section focuses on potential impacts of the Baardheere Dam on the fish populations downstream. These could include the interruption of fish migrations, the disruption of normal annual hydrological cycles (reduced flows and restriction of the flood), and changes in temperature and water chemistry.

There are 2 types of fish migrations in river systems, as discussed by Daget (1960). Longitudinal migrations take place in the main channel of the river and are upstream or downstream movements. Lateral migrations take place between the main channel and the floodplain. Welcomme (1985) quoted Blache et al. (1964) and Williams (1971), who studied fish migrations on the Chari and Kafue rivers, respectively, and found 4 phases of fish movements. The following 6 main phases associated with various groups of fish emerge after combining these classifications:

- longitudinal upstream migrations within the main channel;
- longitudinal downstream migrations within the main channel;
- lateral migrations onto the floodplain;
- local movements on the floodplain and distribution among flood season habitats;
- lateral migration from the floodplain towards the main channel; and
- local movements within the dry-season habitat--this may be the river, adjacent lakes, or the sea.

Some species of African fish have movements that fall into one, or a combination, of the above categories, while others have distinct habitat preferences, or are confined to one specific area. These fish move only if they are put under stress due to changes in the environment, such as low dissolved oxygen, receding water levels, or chemical contaminants. Three groups of freshwater African species that display movements can be identified.

The first category, "blackfish," represents genera such as *Clarias* and *Clarotes*. These fish migrate laterally between the fringes of the main channel and the floodplain and are typically found in the dhesheegs (lagoons and residual pools on the floodplains of the Jubba Valley). These areas sustain the most important commercial fishery in the Jubba Valley, and the fish resources are dependent on the flood cycle to replenish the water supply and flush out nutrient-bearing silt.

A second group consists of species that undertake more modest movements between the main channel and the floodplain. These fish probably reproduce in the pools or lagoons and return to the main channel to avoid unfavorable conditions on the floodplain that the blackfish can survive. The Mochocids, Schilbeids, Cyprinids, and Mormyrids are likely to be included in this group.

The third group, "whitefish," migrate upstream during the early rainy or late dry season to avoid harsh low-water conditions downstream and to reproduce. This group includes Mormyrids, Characids, Cyprinids, Schilbeids, Gobiids, and Eleotrids.

The Gobiids, Ariids, Muguliids, and Anguilids are the only fish families that are potentially anadromous (migrating from the sea to the river for breeding purposes). Several *Arius* spp were captured in gill nets installed in the Goob Weyn estuary area; gobies and mullet were captured here and in the Jilib area. No gobies, *Arius*, or mullet were collected above the Faanoole hydroelectric facility. This indicates migration of these species has been curtailed by the dam.

The effects of Faanoole Dam on the movements of other longitudinal species, such as Characins and Siluroids, are not known. Welcomme (1985) stated that the African Characins and Siluroids are conspicuous among the migratory species; Cyprinids also exhibit this behavior. Due to lack of manpower and the short time allocated for fishery assessment in the Jubba Valley, it was decided that a fish migration sampling program was too ambitious and would result in very marginal data for the high cost involved.

It is probable that the construction of the Baardheere Dam will stop movements of the Siluroids, Cyprinids, Mormyrids, and Characins from the middle Jubba Valley (above Faanoole and in the Saakow region where several dhesheegs are located) up to the 3 main headwater drainages. As stated in the first report, many large *Eutropius depressirostris* were caught in gill nets in the Baardheere to Luuq region. These fish were all in nuptial (breeding) condition with ripe gonads and were probably migrating for spawning purposes.

Since the construction of a mainstream dam in the Jubba Valley will disrupt the normal hydrological cycle and flooding, discharge regulations and policies should be defined early in the planning process. It should be understood that the impounded river channel is as much an artificial, man-made and man-controlled freshwater ecosystem as the reservoir upstream.

Bernacsek (1984) discussed dam design and operation to optimize fish production in impounded river basins. He stated that the most extreme effect on downstream aquatic environments can occur soon after the closure of the dam because initial filling can reduce flows to virtually zero, resulting in fish kills. During the initial filling of the Cahora Bassa Reservoir on the Zambezi River, flows were reduced from normal dry-season flows of 2,000 to 3,000 cubic meters per second to 60 cubic meters per second, against the advice of ecologists who recommended no less than 400 to 500 cubic meters per second. This caused large fish kills and stranding of breeding fish. Initial testing of hydroelectric equipment can create erratic flows, which have adverse effects on downstream environments.

Subsequent to initial filling of a river impoundment, downstream flow tends to become more constant, with smaller fluctuations and reduced flooding. This causes a change from a lentic to a more lotic fish species composition. Malvestuto and Meredith (in press) showed that during the Sahelian drought, low-flow regimes on the Niger River in Niger contributed substantially to the decline of the fishery; species composition of the harvest became less diverse with higher contributions by lentic species.

During drought years, reduced flows decrease the productivity of river fisheries by decreasing the amount of inundated floodplain. Welcomme (1986a) correlated a 20-year series of discharge data for the Niger River with fish landings at Mopti in Mali. The resulting multiple-regression equation had a high degree of predictability (R^2=0.87) when the catch from one year was regressed against hydrological indices for the 2 previous years. Catches were positively correlated with flows, implying that higher flows inundated more floodplain area, which enhanced reproductive success and survival of young fish. Thus, under the low-flow regime of the drought, or with reduced flows due to impoundment, it is certain that the carrying capacity of the river will be reduced.

Large dams also have a substantial impact on water quality downstream. Hydroelectric turbine intakes usually draw water from the hypolimnion or metalimnion water layer in the reservoir. The resulting discharge is much cooler, with lower or depleted dissolved oxygen, and sometimes contains hydrogen sulfide. Fish mortalities caused by oxygen depletion are common in large tailraces below dams.

Bernascek (1984) presented various options for reoxygenation of discharge water.

First, discharges through floodgates or overflow spillways can create tremendous turbulence as the water jet strikes the stilling pool below the dam and mixes with turbinated discharge water. This is often sufficient to effect reoxygenation. Unfortunately, not all dams have such discharge structures. For those that do, the reoxygenation benefit can be variable, since it will be realized only when the discharge structure is in actual use. Increasing the hydroelectric capacity of a dam's power station (a fairly common practice) results in more turbinated and less floodgate and spillway flow, thus further reducing the reoxygenation benefit.

Second, "natural" reoxygenation occurs mainly by diffusion from the atmosphere and by photosynthesis by phytoplankton and submerged macrophytes, whose growth is favored by the increased transparency of the water. These processes are, however, more gradual and the latter can be slowed considerably by the presence of toxic hydrogen sulfide.

Third, some rivers possess waterfalls or cataracts downstream from the dam, with resulting water turbulence responsible for reoxygenation. This, however, is not the case in the Jubba Valley.

None of the processes available for artificially improving the oxygen content of water discharged from dams, including aeration of the hypolimnion or the tailrace, is installed on African dams. In view of the magnitude of mechanical, hydraulic, and electrical power developed at multipurpose dams, artificial reoxygenation should not be expensive. Because of the drawbacks of the 3 reoxygenation processes discussed above, none can be relied on to rapidly restore oxygen to biologically nonstressful levels and to ensure complete protection against hydrogen sulfide throughout the year. There would appear to be no alternative to the use of artificial reoxygenation processes. It is strongly recommended that such processes be considered for incorporation into the design of the Baardheere Dam.

VIII. FISHERIES DEVELOPMENT AND MANAGEMENT ISSUES FOR THE PROPOSED BAARDHEERE RESERVOIR

The contribution of riverine fisheries in meeting the economic, social, and nutritional needs of African countries has been poorly understood or played down in the past. River and floodplain fisheries contribute substantially to household food and financial budgets in many riverside villages across Africa. Malvestuto and Meredith (in press) show that on the Niger River in West Africa, 20 percent of the catch is consumed by fishing households and 80 percent of the catch is sold for income.

In the Jubba Valley, the "Maley Madow" (Somali for "blackfish"), *Clarias gariepinus*, is believed to be valuable as a treatment for malaria. This is an example of a social value associated with the fishery which should be considered in evaluation of "yield" from the fish resource. Though most of the population of Somalia is traditionally nomadic and non-fish-consuming, there seems to be a substantial number of villagers along the Jubba River who are fish consumers. More information on this will be available from the SEBS.

Development and management of the river fish resources and the potential fishery created by the Baardheere Dam should be an integral part of the overall Jubba Valley development strategy. In the FAO (1986) strategies for the development and management of fisheries, it was stated that, "while acknowledging the specific circumstances of each country, the following guidelines should be taken into account when examining the contribution that fisheries can make to the achievement of national economic, social and nutritional objectives." Those guidelines are repeated here with modification and elaboration with regard to specific circumstances in Somalia.

A. General Development Guidelines

1. Fisheries comprise complex human and intersectoral activities in the overall national economy and within society in general. Therefore, fishery development plans should be an integral part of national economic development and food security plans and in accord with social and nutritional goals and established priorities. The formulation of medium- and long-term plans, as central elements of fishery development, should be considered in planning river basin development.

2. Objectives should be based on an assessment of the fishery resources available, existing technology, markets to be served, social and economic conditions, and the potential impact

of other economic activities and relevant factors, including foreign operations, where applicable.

3. Fisheries development is often planned to meet several complementary objectives, but multiple objectives are not always compatible. Where compromises have to be made, objectives should be explicit, comparative advantages indicated, and priorities made clear.

4. Since the conditions within which fisheries are conducted are highly dynamic, objectives appropriate at one time may not be appropriate at another. Therefore, periodic evaluation of objectives is necessary.

5. There is a need for governments to establish mechanisms and develop skills for fisheries planning, involving all relevant disciplines.

6. Careful management and investment planning are necessary to achieve optimum utilization of resources. Countries should introduce appropriate conservation and management measures based on scientific evidence. Where there is little information on the resources and potential yields, expansion or investment should be undertaken carefully and continually monitored to allow detection of declining returns.

7. Reliable, timely data and statistics on all aspects of fisheries are needed for planning, implementation, and subsequent monitoring of fishery management and development. The national capability to collect data and information should be developed. Regional and subregional cooperation on collection and dissemination of data should be encouraged wherever necessary. (It should also be noted that intergovernmental agencies must, by necessity, cooperate and share responsibility in management and development of resources.)

8. It is essential to enhance the stock assessment capability of coastal states so that they can determine the allowable catch of living resources in the areas where they exercise sovereign rights. This point applies to marine fisheries and inland freshwater fisheries where expatriate, migratory fishermen are exploiting fish resources and exporting the products. This is the case on the Niger River in West Africa where Malian and Nigerian fishermen migrate to Niger to fish and export the smoked fish to neighboring countries. In Somalia, fishery exploitation by foreign fishermen is quite likely. These fishermen could be encouraged to exploit the potential fishery created by the Baardheere Dam. Export of the fishery products would help generate foreign currency. Local consumption could be encouraged also.

9. Development plans should take into account all aspects of the fisheries sector, not only harvesting, processing, marketing, servicing, and material supply, but also the development of the infrastructure, technology, and human resources to enable better use of fishery resources. This will increase the value added to the economy and improve employment opportunities. It is essential to make all those involved understand the social value of fisheries as a source of food, employment, and profit, hence the need and the desirability of using fishing methods and processes which do not jeopardize economic viability by exhausting resources.

10. The formulation and execution of fisheries management and development plans require close consultation and collaboration among administrators, scientists, and those involved in fish production and marketing. Agencies and organizations such as MNPJVD, MFMR, SMP, FAO, and AID need to form an alliance for fishery development and management in Somalia. Allocation of responsibilities can be distributed among these agencies and overseen by a single governing body, such as a Somali Fishery Development Authority.

11. Legal frameworks and institutional structures are essential if the objectives of fisheries management and development are to be achieved. This applies to marine fisheries as well as to inland fisheries and aquaculture and is of particular importance where there is competition among commercial fishermen and among commercial, artisanal, and recreational fisheries, and where there is intense competition from other land and water uses. For example, regulations or laws governing minimum flow rates or simulated flood in accordance with preimpoundment standards could be developed for the Jubba Valley.

12. Small-scale fisheries development requires special support from governments. An integrated approach with participation of fishing communities is often the best way of channeling technical, financial, and other assistance, since it is important to design and adopt technologies appropriate to local conditions.

13. Support from government could range from financing schemes for the implementation and expansion of fishing groups to extension activities for small-scale artisanal or medium-scale pelagic commercial fishing operations. Extension activities could encompass such topics as improvements and modifications to fishing gear, preservation of the catch via drying and smoking techniques, use of fishery products by the local non-fish-consuming segment of the population, and management inputs for self-managed community fishing organizations.

14. Development and management plans should consider the need to protect aquatic habitats from the effects of pollution and other forms of environmental degradation, e.g., desiccation of the floodplain pools, chemical pollution from agriculture, deoxygenation or high sulfur dioxide content from dam discharges, and fisheries themselves, since aquaculture water released from installations is sometimes a source of pollution.

15. When planning the development of new fisheries, attention should be given to production and promotion of products which are low-cost and acceptable for local consumption. Early emphasis should be directed towards study and development of a fishery product that is acceptable to the local non-fish-eating population.

16. In formulating price policies, the interests of producers and consumers should be taken into consideration. Fishermen should be encouraged to increase their production after the fisheries are developed.

17. Finally, the potential of sport fisheries can be taken into account.

B. Management Strategies for the Baardheere Reservoir

Kapetsky (1986) discussed the management of fisheries on large African reservoirs. He stated that classical management methods have not been practiced, mainly because regulations, such as limits on number of fishermen or amount of fishing gear, gear characteristics and sizes, closed areas or closed seasons, are usually politically and economically unacceptable. Many African countries suffer from high rates of unemployment. Reservoir fisheries provide rural employment, and it is not acceptable to restrict this source. Most African fishery agencies operate under severe funding and trained manpower constraints, so they find it extremely difficult to adequately enforce fishing regulations or implement management schemes.

African reservoir fisheries appear to be underharvested and relatively unaffected by overfishing (Kapetsky 1986), with changes in species composition but little change in total fishery output. Therefore, management schemes advocating limited entry or gear restrictions seem unnecessary, especially in the early stages of development. Most African reservoirs need fishery expansion or development, rather than strict controls.

C. Considerations for Introductions of Non-Native Species

Fish communities in rivers usually have few species that are adapted to fill new niches created by impoundment. Management strategies that may be practical for the Baardheere Reservoir include introduction of non-indigenous species to take advantage of the new habitat and control of disease vectors. Non-native fish species introductions should be carried out only after exhaustive research, since the vast majority of fish introductions have had detrimental environmental or economic consequences.

Kapetsky and Petr (1984) and Kapestsky (1986) discussed the results of introduction of non-indigenous fish species into reservoirs where preimpoundment studies showed no indigenous species in the rivers that would take advantage of the new open-water pelagic zones in the reservoir. The most successful introduction has been that of the sardine, *Limnothrissa miodon*, into Lake Kariba (Zambia/Zimbabwe) in 1967 and 1968.

The inadvertent introduction of common carp, *Cyprinus carpio*, into the Masinga Reservoir in central Kenya has had a detrimental economic effect on the fishery. During visits to fishing villages and fish regulatory agencies in the Tana River Reservoir area, it was found that the local fish-consuming population prefers the Tilapia fishes, and the carp are not as valuable. The carp population has increased to 50 to 60 percent of the harvest. In early years of development of this fishery, the Tilapia comprised over 80 percent of the harvest. Thus, the economic value of the Masinga fishery has declined subsequent to the inadvertent introduction of the carp.

With the creation of the Baardheere Reservoir, habitats favorable to the snail vector of bilharzia will be created. Numerous experiments have been conducted on biological control of this vector. Welcomme (1981), quoting Jhingran and Gopalakrishnan (1974), stated that the introduction of *Astatoreochromis alluaudi* (Pellegrin, an East African fish in the family Cichlidae) into Cameroon, Central African Republic, Congo, and Zaire fresh waters was successful in reducing snail populations 64 to 98 percent.

IX. RECOMMENDATIONS

Due to the lack of adequately trained fishery personnel within MNPJVD and restrictions on time available for fisheries surveys during the consultancies, the assessment program reported here was the most ambitious possible. Results from this survey are limited, but provide a better understanding of existing fish resources and fishery potential in the Jubba River Valley and should be useful for planning purposes. More trained personnel and more time for fisheries monitoring would result in larger sample sizes, improving the value of the FBS and CAS data. The optimum number of field personnel for fisheries work on the Jubba River system would be 3 in each of the 2 geostrata. These persons should take at least 20 samples per gear type per hydrological season.

More extensive training for selected field personnel in fisheries and aquatic ecology is highly recommended. The AID-supported aquaculture training program of the International Center for Aquaculture (ICA) at Auburn University is a good hands-on training course in aquaculture and fisheries management. MNPJVD desperately needs to develop technical expertise within its staff. The Auburn program offers an excellent opportunity to begin this development. There are a number of international training facilities in Africa and numerous fishery consulting firms that can provide in-country training programs as well. At the very minimum, MNPJVD should provide fishery administrative training to one of the present staff members, enabling logical interactions with associated government ministries (MFMR) for planning of fisheries development and management in the Jubba Valley.

A serious problem identified in the Tana River Basin development in Kenya is the lack of coordination and cooperation among concerned agencies within the government structure. There is very little interaction between the Ministry of Tourism and Wildlife (the Fisheries Department is within this Ministry) and the Tana and Athi River Development Authority (TARDA), with resulting duplication of fishery research and contradictory management policies. MNPJVD and MFMR should develop a cooperative infrastructure for development and management of the Jubba Valley to avoid the problems associated with the Tana River.

Another problem identified in the Tana River Basin is lack of availability of information from TARDA. Scientific research and project information must be available for review by scientists and project administrators at all times to help avoid duplicating costly mistakes.

The potential for freshwater fisheries development on the Jubba and Shabeelle rivers is evident. Ongoing assessment surveys and short-term fishery development programs with extension activities are recommended. Predictions of maximum sustainable yield (MSY) can be fine-tuned for management purposes by creating ongoing monitoring programs, which will establish relationships among E, C, and CPUE. Welcomme (1980b) discussed these relationships for African rivers. Government agencies involved in fisheries management and development in the Jubba Valley will then be able to assess fishery development and encourage appropriate expansions, or implement necessary restrictions, to insure the viability of the resource.

Development and extension programs should include encouragement of fish consumption by local villagers, development of local and international freshwater fish markets, and creation of community fishing centers that could provide low-cost fishing gear on a revolving-credit basis. These centers might implement extension efforts concerning fishing techniques, fish preservation, and formation of professional fishermen organizations.

Ben-Yami and Anderson (1985) discussed the guidelines for establishment and operation of community fishing centers. Several of these small fishery centers can be established around the reservoir and along the river to assist in development of the fishery resources in the Jubba Valley.

In Cameroon, West Africa, the ice plant built and operated for the construction of Lagdo Dam on the Benue River is now providing ice for preservation and shipping of fish from the reservoir to all parts of the country. Other infrastructure improvements made for the construction of the dam can benefit the fishery development process. Improved access roads and availability of electric power will encourage private-sector enterprises such as fish transporters, fish merchants, and fishing gear distributors.

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APPENDIX A

Field Notes for Fisheries Frame Survey--Trip 1

6-17 October 1986

Monday, 6 October and Tuesday, 7 October, mouth of river to Faanoole Dam.

Made final preparations for field trip and travel to Qorioli, where we stayed the night in the Save the Children compound. This is a convenient stopoff if a team gets a late start from Mogadishu on the way to Jilib and needs a comfortable place to stay about 3 hours from Mogadishu. This stop allowed us to check the boat and trailer for any modifications or adjustments that needed to be made after assembling in Mogadishu. On Tuesday, we drove as far as Jilib and stayed the night in the JESS/U.S. Bureau of Reclamation (BuRec) compound. We met with the mayor, Mr. Djamma, as the DC was out of his office and busy with other matters. The mayor answered many of our questions and gave us his impressions of the value of fishery resources in this region. His impression is that fish is consumed quite a lot here. He said that there is no set price on fish, but it is based on supply and demand. He told me that there is no central fish market in Jilib. When people want to buy fish they go to a fisherman's house to see if he has caught any that day. I later found that there is a special location in the market where dried and fresh fish are sold. The majority of the fish consumed in Jilib is from the local dhesheegs. He said that people even go out to the dhesheegs to buy fish. I found that there is a vehicle which goes out to the dhesheegs on a daily basis and distributes fish to villages along the road from Yontooy to Jilib. He indicated that there are a few people who are more or less occasional fishermen and fish in the river with hook and line. Occasionally there are deliveries of frozen fish from Kismaayo marine fishery which are sold in the market place in Jilib and distributed to other villages in the district. We saw a broken-down refrigerator truck that Mohamad Hassan told me was once used by a private merchant to haul frozen fish from Kismaayo.

Wednesday, 8 October.

We drove to Kismaayo and met with the DC and local authorities to inform them of our intentions and work schedule. We also met with Captain J. R. Christensen of Somali Marine Products (SMP) to discuss trawl design and marine fishery systems in this area. Two trawl designs were discussed. Plans were made to build these nets and other necessary equipment to facilitate fish sampling along the coastal area outside the mouth of the Jubba River. We also discussed the possibility of hiring a trawl vessel from SMP to conduct these trawls, but J.R. said that he had no vessel available and didn't want to commit himself to this type of activity. We discussed using our boat for this type of sampling and I expressed doubt as to the applicability and safety of using this boat in the ocean. Two trawl nets were designed and begun. One is a tri-net to be used with two 15-kilogram trawl doors and towed behind the boat along the coast. The second net is a 2-meter beam net that is to be used in the river for sampling deep mid-river habitat. The mesh size of this net (2-inch stretch) will allow sampling of adult fish. A special bag of 1/4-inch woven mesh can be inserted into the large mesh, allowing larval or juvenile fish studies. J.R. told us that there had been a man from upriver (Malenda, a village north of Jilib, just downriver from the Faanoole Dam) who wanted to establish freshwater fish sales to SMP. He claimed he would organize a group of fishermen in that area and could supply SMP with 3 tons of fresh fish per day from the river. This never materialized, however. J.R. asked him to bring in a 20-kilogram sample but never saw the man again. J.R. also told us of an organization (PRODMA, a subsidiary of Kellogg Seafoods) that did experimental trawls off the Kismaayo coast in the late 1960s. Perhaps this information can be found and comparisons drawn from pre- and post-impoundment sampling to determine changes in the coastal-estuarine fish communities. J.R. told us that some river fishermen buy fishing nets or hooks from the SMP stores and some build seines, called Yashi (small beach seines 50 to 60 feet long) and Yuma, (100 to 150 feet long and most commonly used in the marine fishery). These nets are also purchased in the store in Mogadishu. He didn't know the prices. Hooks can be purchased in most towns or villages.

Thursday, 9 October, Goob Weyn to mouth of river (on-water work).

This was the first on-water reconnaissance. We launched the boat at the old ferry site, where there is an old concrete ramp. It is easier to launch the boat during high tide as there are many large rocks in the water at the foot of the ramp which have a tendency to eat props. This is a difficult location to land the boat because the current is very swift just as you line the boat up for pulling onto the trailer. You must have a lot of experience in boat loading in order to drive right up onto the trailer. I showed Mohamad Hassan how to do this and he tried it a couple of times. I think he needs more practice and experience in boat handling but he learns very fast and will pick it up soon.

We found one hippo near the mouth and the fishermen we hired to help us said they smelled crocodiles. I entered the water near the mouth to see if the current was too fast for a 50-foot beach seine trial. The fishermen started yelling for me to get out of the water and not go in again as the current would carry me out to sea and the crocodile would eat me. We saw many ducks and various other water birds along this section of the river. A trial seine sample using the 150-foot seine was attempted and was partially successful. The water was very shallow, which made maneuvering the boat very difficult, and the current was very strong. We did, however, catch 3 fish in the family Cyprinidae. I gave Mohamid Hassan some training in boat handling and launching. The trial seine haul was also intended as a training experience and proved to be valuable, as it was marginally successful and very difficult, demonstrating the difficulty of fish sampling in flowing-water environments.

Friday, 10 October, Yontooy.

Location: on the main road from Jilib to Kismaayo, about 10 to 12 kilometers north of Goob Weyn.

Upon arriving at Yontooy we found a fisherman checking his gill net and we interviewed him before he took his fish into town for marketing. His name is Mohamad Awes Hadji and he works at the agricultural project there. He was fishing out of a small fiberglass boat, which belongs to the agricultural project and is used for repairs. He was fishing just downstream from the pump station for that project. He caught one *Clarotes laticeps*, weighing about 1.5 kilos. We didn't have the scales with us so we had to estimate the weight of this fish. He was using a 4-finger (40-millimeter stretch mesh) gill net, 15 fathoms long and 35 meshes deep, which he bought in Kismaayo last year for 900 SSh. He set this net yesterday evening at about 5:00 p.m. and harvested at about 8:00 a.m. this morning. He also fishes with hook and line when the river is low Hooks are purchased in Kismaayo for 10 shillings each and line costs about 100 shillings. He sells fish in Yontooy for about 50 shillings per kilo. I don't know how he weighs his fish. He said he cuts the fish up and sells it to people who come to his house. He fishes in the early morning and evening and works for the irrigation project during the day. Problems that he has with fishing include the crocodiles eating the fish out of his net and the hippos knocking his boat. During the high-water seasons, he has problems with debris caught in his net. When asked if he ever caught Lates niloticus he said yes, but mostly during the low-water season. We showed him several fish drawings and asked him to give us their local names. The following is a list of species or species groups and local Somali names:

Species group (spp), Somali Name

Lates niloticus, Abungishar
Protopterus annectens, Mayumbe
Polypterus spp., Mayumbe
Heterotis niloticus, Gomia
Mormyridae family, Ballan
Hydrocunys spp., Abusef
Alestes spp., Gishar
Alestes brevis, Tewa
Citharinus spp., Mashirfato
Bagrus spp., Sharib
Clarotes laticeps, Lubi
Clarias or *Heterobranchus*, Malay Madow
Synodontis spp., Kurtay
Chiloglanis micropogon, Fumi

Crustacea

Atya gabonensis, Kambo Kambo

This list of names was compiled by showing the fisherman the pictures in Reed (1967), so it might not reflect the actual fish species or crustacea present in the Jubba River. More work needs to be done on this matter. It is interesting to note that in less developed fisheries there is not as well-developed a local or traditional naming system for individual fish species as is found in more developed fisheries. For example, in Niger there are names for almost every species of fish. We also recorded the local names of the fishing gear most commonly used in this area. The following is a list of these gear types and Somali names:

Gear Type	Somali Name
fish trap	Sab or Irman
hook	Makalin
hook and line	Hadak makalin
gill net	Shabak
small seine	Yashi
large seine	Yuwa

The site where we found this fisherman is also a major watering site and an excellent launching ramp for the boat. We decided to return tomorrow to launch the boat here and go downriver on-water to Goob Weyn for some trial fishing and to interview more fishermen along the way.

Friday, 10 October, Mokomane.

Location: from Yontooy we drove down a dirt road about 3 to 5 kilometers along the river.

This village has up to 40 families, and people indicated almost every family has a hook and line that they use to fish. The fish are for their own consumption. Three other adjacent villages of significance for fishing are Yontooy, Wirkoy, and Bouloguduud. The people told us that they fish in the river near the village during low-water season, using hook and lines. They do the majority of their fishing during the early morning or late afternoon hours. They told us they only fish for personal consumption and, if they catch enough fish, they dry the leftover fish for future consumption. They never sell fish in their village or other villages.

Discussed with JESS team leader the possibilities of sampling along the river and the dhesheegs. He indicated that one 16-day sampling trip could be organized during a 3-month period that would correspond to the phases of water level in the river. These phases are as follows: mid- to low-water dry season (August-October), high-water rain season (mid-October or early November-December to mid-January), low-water dry season (January -March), and high-water rainy season (April-July). These are approximate dates and seasons, and further research will be needed to temporally stratify for sampling purposes. These sampling trips could be made in conjunction with other sampling being carried out in the river basin. For example, trips could be coordinated with water-quality sampling teams or other socioeconomic sampling trips. More of this will be discussed in the final report and proposal for the CAS, FSP, and SEBS.

Saturday, 11 October, Yontooy to Goob Weyn.

On-water reconnaissance survey for fishing villages and fishing trails.

We hired one fisherman to work with us and guide us down the river. We saw about 5 cable ferries along the section of river that we traversed. We stopped at the largest of these and interviewed an old man who was running the ferry, Haji Mohamad Moussa. The cable ties 2 villages together, Mokomane and Hadja Ali. There are approximately 100 families here. The old man told us that his people fish with hook and line for their own consumption. He really likes fish and said that he values them very much. He told us that when he was young he was in a local market one day and someone told him that he had fish to sell. He went to see the fish and the man didn't have fish, but fish oil, which he claimed to have made from fish caught from Dhesheeg

Waamo. It was at that point that the old man said that he learned to eat fish and learned of their value.

He told us that during the <u>Jiilaal</u> (low-water) season, salt intrusion is very high and they have to dig shallow wells to get drinking water for themselves and their livestock. He also said that the women have to walk into the bush to find water. He told us they only eat fish during the low-water season.

We did some drift gill netting and a mini-rotenone sample. The catch from the gill net was very interesting, as there were several large *Synodontis* spp and *Siluridae* spp that are the largest specimens I've ever seen. They were caught in the 1.5- and 2-inch bar mesh nets. The drift gill net samples were rather difficult as we got hung up in the bottom about 10 minutes after we put the net in. The result was a very short sample and a couple of holes in the larger mesh panels. We are in need of mending line and net needles and I need to teach Mohamad and the other fishery personnel how to mend torn nets. I think it will also be valuable to purchase some locally available nylon net materials and teach Mohamad Hassan how to build his own experimental gill nets, thus eliminating the need to import expensive nets and increasing our units of experimental fishing. I will check this out when we return to Mogadishu.

I want to have a meeting with the MFMR personnel to discuss the possibility of integrating them into the freshwater fisheries evaluation and training since they are mostly concerned with the development of their extensive coastal marine fishery resource. They should also have some participation in the evaluation and development of their inland riverine and reservoir fisheries.

We did one trial mini-rotenone that was partially successful in that we caught several Silurides, Labeo, and an interesting Gobie that skips along the shore and can leave the water in pursuit of cover in the grass and reeds. The bottom was very muddy and made it very difficult to move around in the water. I don't think we should do any more of this kind of sampling until the low-water season, or we should at least stay in the boat and use dipnets to retrieve dead fish. It is also probably very dangerous to be in the water like that. The threat of crocodile attack is something we need to be very aware of. We need to have some form of security, like a police with a gun or someone in the team armed.

We saw 6 to 10 hippos and 2 crocodiles at an island located about the point in the river where Luglouw is. The hippos were at the head of the island. The crocodiles were at the foot of the island on the perimeter of a small sand bar with grass and reeds. This seems to be a habitat type they prefer. So far I have heard many stories of villagers along the river being eaten or taken away by the crocodiles. They also seem to cause a lot of trouble in the few fishing nets that we have seen along the river.

The Blazer broke down due to 2 bad batteries, so we had to tow it back to Kismaayo with the Jeep and deposit it at the local garage for repair.

Sunday, 12 October, Dhesheeg Waamo.

Location: Dhesheeg Waamo is a large (approximately 72 square kilometers) lowland area located from about the town of Gaduub to Baar, west of the Jubba River (Figure 1). We traveled 10 kilometers on the Jilib road past Gaduub and turned west on a pretty rough dirt road. The dhesheeg is approximately 30 kilometers down this road, but the many branches are very confusing. I recommend that future teams either take along a guide who is very familiar with Waamo or take the transport vehicle which travels this road almost daily to buy fish from the fishermen and transport goods and people from the dhesheeg. You can find this vehicle in Kamsuuma by inquiring at the taxi stop or talking with Mohamad Ali Aden (the village chairman) or Abdulkadir Hassan Ali (the fishing organizer and transport coordinator).

Dhesheeg Waamo is inundated periodically by rains and river floodings that are controlled by opening flood control gates located along the dyke which parallels the river. This dyke was built by the Italians and a canal was dug from the river to the dhesheeg. I was told that the Ministry of Agriculture authorizes the opening of these gates whenever the river is high enough.

We found that there is a large component of fishermen operating here and a very large amount of fish harvested. There were 2 fishermen walking with bundles of dried *Clarias* spp (probably *C. gariepinus*). These fishermen were from Jamaame and come here to fish for 4 to 5 days at a time. They said they are part of an organization of about 20 people who trade off fishing shifts of 4 days to one week. They are organized by a coordinator in the village who goes out to Waamo and sends out the transport vehicle to pick up the dried fish and change groups of fishermen. The fishermen were on their way to meet the vehicle, so they were in a hurry. I did get to ask them several questions concerning their fish. They told me that one bundle of fish would be sold for about 1,000 SSh (86 SSh equals US$1.00). This bundle of dried fish weighed about 10 to 15 kilograms and contained about 30 to 35 dried Clarias.

We found 2 other fishermen and interviewed them much more extensively. These men were from Kamsuuma and were part of a kind of coop of about 50 people who come here for a few days to work and then return to their village. They indicated that there is a coordinator (probably Mr. Abdulkadir Hassan Ali, mentioned earlier) who hires people or sends his sons to fish using his nets. They said it is common for several people to purchase a net or 2, and for a cooperative fishing group to operate in this fashion. These fishermen indicated that a vehicle comes 3 times a week to pick up their fish and change fishermen.

These fishermen were using gill nets which were 4 and 8 fingers (one finger equals 10 millimeters stretch mesh), 30 double-arm lengths (2 outstretched arms are equal to one fathom or 1.9 meters) and about 2 meters deep. They learned to make and set these nets from the ocean fishermen in Kismaayo. They bought the line to make these nets in Kismaayo or Mogadishu for about 2,600 SSh. It required 1.5 kilograms of cotton line to make these nets. One fisherman told us that they sometimes buy premade nets made of "plastic," meaning nylon, and they cost about the same. The lifetime of one of the cotton nets is about 3 to 4 years if they repair them periodically. The lifetime of the premade nylon nets is 6 months.

They indicated that they do not use hook and line or long lines in their fishing here in Waamo. During high-water seasons they use canoes, which they rent or borrow from someone on the other side of the dhesheeg. Usually there are 3 to 4 fishermen per canoe and they set one or 2 nets per fisherman.

They told us that the price of their fish is the same for dried or fresh. One fish would sell here for about 35 SSh and 100 to 135 SSh in their village. They had one very large *Clarias* sp, which measured about one meter long, maybe longer, and probably weighed 10 to 15 kilograms. They cut the fish up into strips and hang them in trees or racks to dry.

They indicated that there are problems with hippos getting into their nets and sometimes crocodiles (in the high-water season). They fish in the river only when the dhesheeg is too high or during low-water season in the river. They use hook and line when they fish in the river. When asked if their catches have changed in the past few years, they indicated that the number of fish has increased and the size distribution has not changed.

<u>Monday</u>, 13 October, Kismaayo and Goob Weyn.

This was a relatively down day as the Blazer and the trawl nets were not yet fixed. We decided to run several errands and try a dormant-set gill net overnight at Goob Weyn. This was also a very good opportunity to conduct some training for Mohamad Hassan Aden and give him some experience in boat handling. In the afternoon we went up to Goob Weyn and practiced launching and landing the boat. The gill net was set at 5:30 p.m., just upriver from Goob Weyn in a fairly shallow area on the edge of the left bank of the river.

The gill net is a Memphis Net and Twine product with 7 panels of 50-foot length. The mesh sizes and twine sizes are given in the following table:

Panel no.	Mesh Size (bar in inches)	Monofil Size
1	1	69
2	1.5	69
3	2	104
4	2.5	139
5	3	139
6	3.5	208
7	4	208

The experimental gill nets are built with 2 inch hollow plastic floats and 1 inch lead sinkers, enough to give it neutral buoyancy. This should be a standard unit of effort in the future so as to enable comparisons between CPUEs in subsequent fish sampling surveys.

Tuesday, 14 October, Goob Weyn.

We got a late start and ended up harvesting the gill net later than I had planned. It was 11:00 a.m. when we finally pulled in the net. The data from the catch are listed below:

Mesh	Species Group	Length (cm)	weight (gm)
4	Clarotes spp.	36	1,000
4	"	55	1,600
4	Eutropius	..	910
1.5	Synodontis spp.	41	700
1.5	Eutropius	29	150

This was a very small catch for this kind of net, but it was improperly set and had 2 holes in it from the drifting gill net trials that we conducted the other day. The fish, however, are very la_ge specimens; in fact, the largest of these species I've ever seen. This is an indication of little or no exploitation.

I suspect that larger catches will be obtained if the net is set properly and we harvest at proper times. We should try setting the net in the morning and checking it both in the evening and morning. This will give us a better idea of nighttime vs. daytime catchabilities. I'm very surprised at the lack of diversity of species in the catch.

Tuesday, 14 October, Bangeeni.

We moved on upriver and set up camp in Jamaame. From there we covered the section of river between Jamaame and Bangeeni to look for fishermen and fishing villages. We found that Bangeeni is composed of 2 villages, one on each side of the river. There is a cable ferry between the villages. This is the next village downriver from Jamaame, (see map of Dhesheeg Waamo). We talked to several people there and it was indicated that there are 2 or 3 people who fish, but because there is no market for fish, and plenty of meat, they don't fish for commercial reasons. They fish strictly for personal consumption.

At the ferry we found a gill net installed in the water and searched out the owner. He is the operator of the ferry and answered all our questions. He lives in Bangeeni on the left side. He set this net yesterday and told us that the crocodiles have eaten the lower halves of all the fish in the net. This net is 12 fathoms long and 1.5 deep. He said he made this net himself and that the mesh sizes vary from 4 to 8 fingers. He purchased the cotton line to build this net in Kismaayo. His uncle taught him how to make and set nets. He told us that he fishes in the dhesheegs during the Gu season. His views are the opposite of the other fishermen we have interviewed so far. He said he catches more fish when the river is in flood stages, as opposed to low-water stages. During the low-water stages he prefers to fish in the dhesheegs. Later on in the interview he confessed he does fish in the pools left in the river during the low-water period. He said there is no market where he sells his catch, but that people come to his house when they know he has fish for sale.

Wednesday, 15 October.

Location: All of the villages visited on 15 October (except Mogambo) are located close to the river on the opposite side from Jamaame. There is a turnoff about 3 to 4 kilometers past the turnoff to cross the bridge for Jamaame. The road starts out paved and turns to dirt after about a kilometer. This road eventually goes back to the Jilib road.

Wednesday, 15 October, Sunguuni.

The people that we talked to said there are many fishermen here, but they were all out fishing at the dhesheeg. Ten fishermen were out at Dhesheeg Waamo. They indicated that 100 percent of the population in this village eats fish on a somewhat regular basis. They told us that during low water the men use nets in the river and that there is a problem with crocodiles here. During the high water several people use hook and line in the river to catch fish for personal consumption.

Wednesday, 15 October, Kobon.

There are no commercial fishermen here but many people use hook and line to catch fish for personal consumption. They indicated that a merchant does bring fish from Waamo to sell here and occasionally they jump on the vehicle that goes to Waamo to buy fish. They indicated that there are problems with the crocodiles in the river.

Wednesday, 15 October, Aboro.

There are about 40 families living in this village. At the present time, the 4 fishermen who live here are out at Waamo. During the low-water season they use gill nets in the river. They sell fish to people in other villages along the river as far up as Jamaame. They said everyone in this village eats fish on a regular basis. Many young people fish in the river during the high-water season with hook and line. Their catch is for personal consumption.

Wednesday, 15 October, Balad Raxan.

We found that there are 2 fishermen who fish here on a regular basis. These fishermen own nets, which are 7- and 8-finger mesh sizes, 41 to 32 fathoms in length and 2.5 fathoms deep. These nets were purchased ready-made in the Mogambo market. The fishermen mounted them on float and bottom lead lines. The 41-fathom net cost 1,500 SSh and the 32-fathom net cost 950 SSh. These nets have lasted for 2 years and 3 months. If the nets are properly mended they can last up to 3.5 years. They are presently being used at Dhesheeg Waamo.

The fisherman we talked to told us that his nets are being used by 2 young men from this village. He pays them 10 SSh per fish. He transports these fish back from Waamo and sells them from his house. The price is from 70 to 100 SSh per fish. He gets fresh fish on occasion and sells them at the same price. Fishing and sales of fish from Waamo are carried out all year. He does not fish in the river because he is afraid of the crocodiles. The villagers told us that there was a crocodile fatality just 2 nights ago.

Most families in this village have someone in the family, usually small children, who fishes in the river. The main type of fishing gear used is hook and lines, which are baited and placed in the river from the bank.

For monitoring the catch from the dhesheeg, there is a young man, Abdulkadir Ibrahim Abcou, who speaks English and could possibly measure and weigh the fish as they are brought to the village.

<u>Wednesday</u>, 15 October, Mana Moofi.

The estimated population of this village is 3,570. Villagers told us of a group of Americans who came through here several years ago in an attempt to eradicate the crocodiles. A man related a story of one woman who was eaten last Saturday, and told of several other attacks in the last few months.

We found that there are about 20 fishermen living here. One fisherman uses a net and the others use hook lines. They fish for personal consumption only but sell fish if they have surplus. The villagers usually buy fish from Dhesheeg Waamo. They told us of a daily supply of fresh fish from Waamo that is sold along the road from a transporter going to Jilib. This vehicle usually comes by here around 3 to 5 p.m. The villagers prefer fresh fish and pay from 80 to 100 SSh per fish. They usually consume one fish per family per day.

<u>Wednesday</u>, 15 October, Fagan.

The people of this village do not eat fish and gave us displeasing looks and scrunched noses when we asked them about fish. They told us that the people who live next to the river eat fish.

Mogambo

We visited this village; however, no field notes were taken.

<u>Thursday</u>, 16 October, Jilib to Faanoole.

We drove up to the Faanoole Barrage and searched for a location to launch the boat. After looking around on the east side of the river with no luck, I walked across the barrage and found a suitable launch site. However, the guard at the electric facility would not move the tractor blocking the road.

We turned around and drove downriver to a small village where I was determined to launch. The name of this village is Nasib and it is located approximately 3 to 5 kilometers from the barrage. We launched the boat over a 12-foot-high cliff, which was a monumental task. Launching this boat will require great skill and care. After launching the boat we motored upstream to the barrage and counted about 5 crocodiles. We set the gill nets and attempted 3 trials with the beam trawl. All 3 trials were unsuccessful because the beam is made of wood and did not sink to an adequate depth for sampling fish on the bottom.

We harvested the nets and drove back to Jilib the next day.

<u>Saturday</u>, 18 October, Qalaaliyo.

This village is 4 kilometers south of Jilib. We found that there are 12 fishermen living in this village. We talked to 2 of these fishermen and they told us that they own gill nets. One fisherman has 4 nets and the other has one net. They are presently fishing at a local dhesheeg called Harnaca. This dhesheeg is probably from the Shabeelle River and is located on the road to Mogadishu. Most of the fish from that dhesheeg are sold in the Jilib market. They told us there are a lot of fish sold here and that they like to eat fish, one man even prefers it over meat. The fishermen bring dried fish, which has been stored for 10 to 14 days, from the dhesheeg. All 12 fishermen come and go as one group and they hire a vehicle to transport themselves and their fish.

The villagers told us of another dhesheeg called Shatole. This dhesheeg is farther up the road to Mogadishu (approximately 12 to 15 kilometers).

The fishermen told us that they have small plots (approximately 1 to 2 hectares) of land they cultivate, growing corn, sesame, and some millet.

One fisherman told us that he uses one hook and line in the river during the high-water season. During the low-water season he used several hooks and he indicated that there are a lot more fish and more fishing during this season. During the low-water season, they use nets in the dhesheegs and during the high-water season they use hooks. They sell these fish for 60 to 100 SSh per fish, no matter what size. They hire a truck from Jilib to transport their catch to that market. He told us that there are some people who use canoes that are rented from villagers in surrounding villages, but that there are no canoes in this village. A canoe rents for about 120 SSh per day. Most fishermen don't like to fish in the river because they are afraid of the crocodiles and hippos.

APPENDIX B

Revised Data Form for Fisheries Survey

Ministry of Jubba Valley Development
Jubba Evnironmental and Socioeconomic Studies
Fisher Household Interview Questionnaire

Date:__________ Strata:____ Village:______________

Number of fisher households in village:______

Number of interviews:______

Family name:______________
list of fishing gear and cost:

Gear	Cost	Age of this gear

list of family members involved in fishing:

Member	relationship	activity (fishing or sales)

1.
2.
3.
4.
5.

Seasons of fishing in river?:____________________
Seasons of fishing in Dhesheeqs?:________________

Estimated amounts of fish captured daily in previous week:_______kg Number of days fished:__________

any comments on local indigenous fishery or water management structures or historical accounts of such organizations in this area: