A Comparison of Fishing Strategies in the Bangweulu Swamps

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ABSTRACT The fishing strategies in the Bangweulu Swamps, Northern Zambia, are described and analysed based on the data obtained from a three month field study in 1983. At the Muilika fishing camp, situated in the center of the Swamps, six fishing methods were employed by a total of 19 fishing units consisting of 27 fishermen. A comparison was made of the fishing effort allocated to the six fishing methods by these 19 units. In spite of a difference found in the allocation pattern of fishing effort, no significant difference in fishing efficiency was found among the fishing units . For *ukusakila* (fish-driving method), comparisons of efficiencies were made between the two variations of *ukusakila* method, among various sizes of co-fishing group, and among fishing units, none of which showed a significant difference. It is suggested that overall fishing efficiencies are levelled out in the long run by the fishermen who disperse their effort to different strategies and cooperate in using a small fishing ground so as not to reduce efficiencies. In group fishing, a social factor based on kinship ties is also important, although it may not be directly relevant to the optimization of fishing efficiency.

INTRODUCTION

The Bangweulu Swamp in Luapula Province, Zambia, is one of the largest swamps in Africa, extending over a vast area of approximately 5,000km^2(Fig. 1). It consists of floodplain grasslands, swamps with dense reeds and papyrus clumps, shallow lakes and lily lagoons varying in size and shape, winding rivers and channels, and has rich ichthyofauna of more than 80 species (Tait, 1965). Fishing has been one of the major subsistence activities of the swamp people for a long time. In the early 20th century when copper-mining began in the area along the present Zambia-Zaire border, the fishermen in the Bangweulu were first brought into contact with fish traders. They transported the fish from the swamp to the copper-belt to supply protein food to the mine laborers. According to Brelsford (1946), the Bangweulu fishery had been involved in commercial trade since the early 1940's. He estimated the annual catch of the Bangweulu at about 4,000 tons (fresh weight), equivalent to a £100,000 money value at the time. Today, the Bangweulu fishery is the largest of the six major fisheries in Zambia, yielding almost one-fourth of the total catch of Zambia (Central Statistical Office, 1971). The importance of Bangweulu fishery will increase even more in the near future, as the road directly connecting Samfya with the copper-belt towns has now been almost completed.

In spite of such importance, fishing in the Bangweulu has not been well studied from a human ecological viewpoint. The only substantial work on the fishing in this area is an ethnographical monograph published nearly 40 years ago (Brelsford, 1946). While this work is indispensable to understanding the fishing life in historical and ethnographical contexts, it does not contain enough data on fishing activities to make any quantitative analysis possible. This lack of data is specially important when we consider the fact that fishing in this area is mainly carried out by small-scale fishing units with dugout canoes

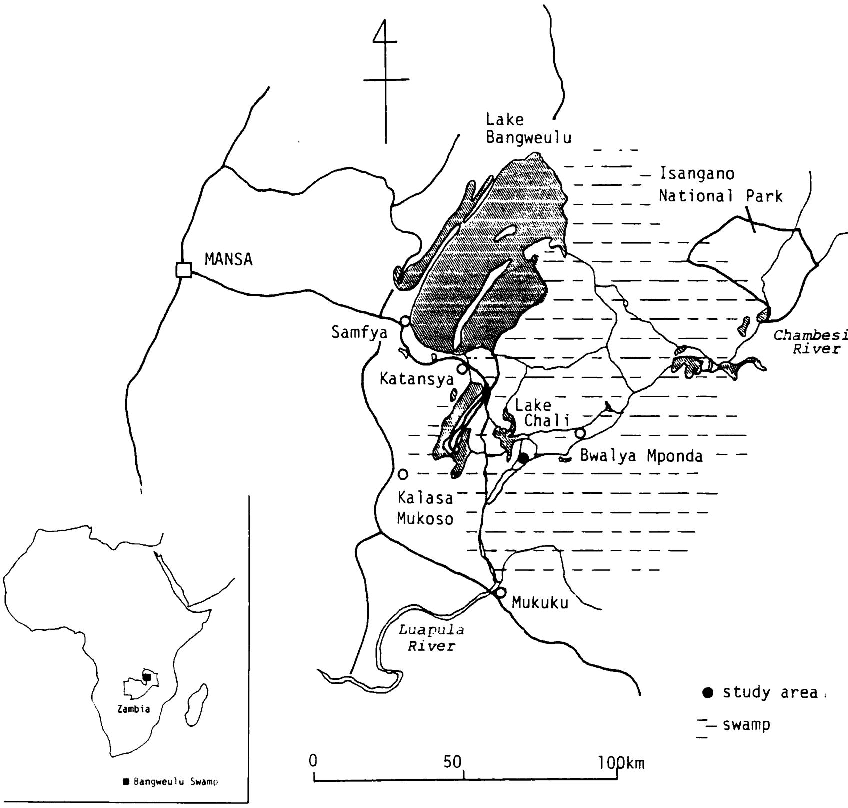

Fig. 1. Study area.

and small nets. In order to understand such artisanal fishing (Hayward, 1981) properly, an analysis of fisheries statistics on the catch, numbers of fishermen, canoes, nets, etc. is not sufficient. We must also examine the activities of the fishermen; how they arrange their fishing activities according to various natural, economic and social conditions, and what the results of their arrangement are.

The purpose of this report is to present the data necessary to make such an analysis of fishing in the Bangweulu Swamps. In particular, the focus is put on a comparison of efficiency in terms of effort-return ratio among various fishing methods and among individuals who adopt different fishing strategies. It also aims at presenting some basic data on the fishing activities so that comparisons may be made in future among various fisheries in Zambia.

SEASONALITY IN THE BANGWEULU SWAMP FISHING

Lake Bangweulu is a shallow lake. Even in the deepest part it is less than 6 meters. Most of the other lakes and lagoons are less than 4 meters deep. The swamp areas rarely exceed 3 meters even in the high-water season. In such a flat and shallow area, the environmental conditions change radically with the changes in rainfall and water level, which in turn causes clear seasonal changes in the distribution of ichthyofauna and human fishing activities.

The Bangweulu system is fed by the Chambesi river, one of the headwaters of the great Zaire river system, and other rivers flowing in from the north and the east. The outlet river is the Luapula flowing out from the south of the swamp. The water level in the swamp is thus largely affected by the flow in and out through these rivers, as well as precipitation and evaporation within the area.

The mean annual rainfall is 1380 mm with considerable annual fluctuation (Department of Meteorology, 1972). A year is clearly divided into wet (*amainsa*) and dry seasons. The latter is further divided into dry and cold season (*umupepo*, which literally means the wind) from May to July and dry and hot season (*ulusuba*, literally meaning the sun) from August to October. There is almost no rain during the six month dry season. The first rain comes usually in the middle of October. Rainfall increases as the wet season proceeds reaching its peak between January and March when it sometimes exceeds 400 mm per month with more than 20 rainy days.

The change in water level in the swamp follows the change in the rainfall. According to the data of the Department of Water Affairs, Samfya, the lowest water level occurs in October or November when the rain has begun to fall, but not so much as to affect the water level. From January it gradually rises to reach its highest point in May or June. The difference between the lowest and highest water levels in Lake Bangweulu is 1.2 to 1.5m. In some part of the swamp and floodplain along the Luapula, the difference may be even greater. Estimating from the distribution of earth weirs in the floodplains along the Luapula in the southern part of the Bangweulu, the difference in this area may be as much as 3 to 4 m.

When the water rises in the wet season, swamps and grasslands are flooded and the habitat of the fish extends to a vast area. On the contrary, when the water recedes, swamps get shallow and isolated from major streams. As the water becomes stagnant with little or no oxygen, the fish move to deeper lagoons and lakes, or to swamps with fresh water supply from major rivers. Thus, the fish are scattered in the high-water season and concentrated in the low-water season. Since efficiency of fishing generally depends on the density of the fish, the best fishing season usually corresponds to the season of the lowest water level.

In fact, there is a marked seasonality in the catch, which clearly shows negative corelation with water level, as shown in Fig. 2. The amount of smoked and sun-dried fish weighed at Katansya Check Post is used here as the indicator of the catch of the Bangweulu. There is one exception to the negative corelationship between the catch and the water level. In December and January when the water level is not high, there is not much catch. This is because of the rainfall. The fishermen do not like to work in the rain. Moreover, most of the fishermen from the mainland usually return to their home villages to hoe the fields and plant the crops during the early period of the wet season.

Although they have been involved in commercial fishing for many years, most of the Bangweulu fishermen are part-time fishermen who also cultivate the fields. Some practice large-scale maize and sorghum cultivation in slash-and-burn fields (*citemene*, here called *umunda*), and others only small-scale cassava cultivation in mud mounds. The extent to which they depend on agricIture also varies. However, there is one common feature shared by all the fishermen in the Bangweulu. That is, they have their home villages where they cultivate the fields or take rest, and migrate seasonally from their home villges to fishing camps and *vice versa*. By the time hoeing and planting is finished, they are into the worst season for fishing with high-water and much rainfall. When the rain stops in April or May, some begin to move to fishing camps. As the whole swamp area is flooded and no land is

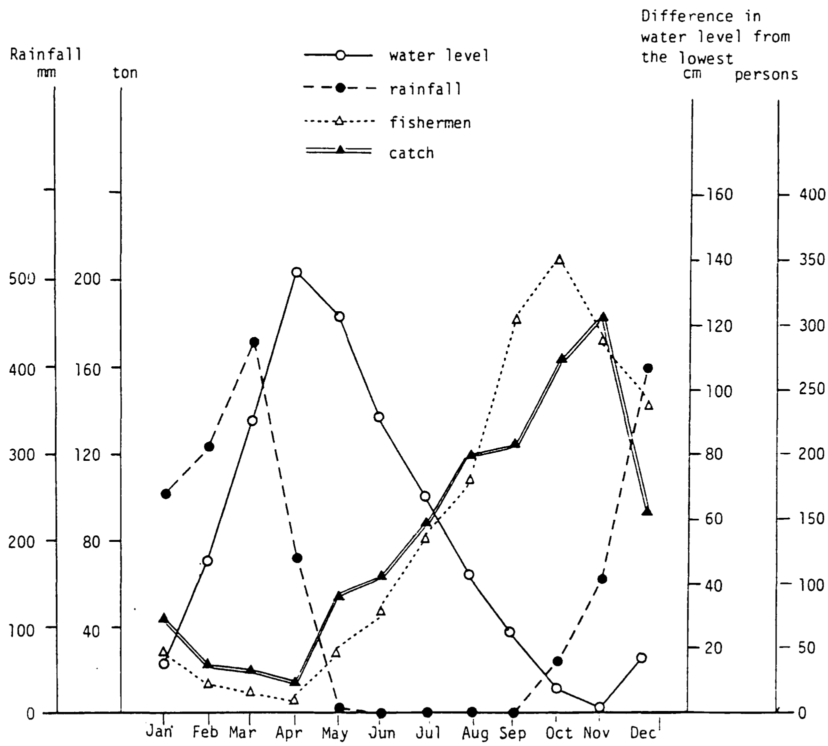

Fig. 2. Seasonal changes in rainfall, water level, catch and No. of fishermen in Bangweulu Swamps. For rainfall and water level, averages for three years from 1978 to 1980 are given. For catch, average weight (tons) of dried fish passed Katansya Check Post for three years from 1978 to 180. For the number of fishermen, information was obtained from the fishermen observed on Lake Chali in September, 1983.

available above water at the time, they build their huts on floating island (*ulufunsu*). As the water recedes from July to August, some slightly elevated land, such as sand banks of rivers or banks of artificial channels, emerge above the water. At this time, many fishermen move to the fishing camps. The change in the number of fishermen staying in lake Chali is shown in Fig. 2. The numbers are calculated from the time of migration of the fishermen observed in September, 1983, who only account for a part of the total fishermen on lake Chali. The change in the number of fishermen corresponds fairly well with the change in catch size. This means that the change in the catch is caused not only by the change in fishing efficiency, but also by the change in fishing effort, *i.e.*, the number of fishermen.

The migration pattern of the inhabitants on the swamp islands differs somewhat from that of the fishermen from the mainland. The Unga people living on the swamp islands usually make mud mounds to grow cassava in August through September after the water recedes and before the rain comes. Therefore, most of them migrate from villages to fishing camps in September and October and stay there until later than those from the mainland.

STUDY AREA AND METHOD

After a preliminary survey in August, 1982 (Kakeya and Ichikawa, 1983), an intensive field research was carried out in Muilika fishing camp in the central part of the Bangweulu Swamps for a total of 63 days from September 22 to Octorber 19 and from November 2 to December 6, 1983.

Muilika camp is situated 7km to the south of lake Chali. It is built on a sand bank of one of the Luapula rivers flowing southward from lake Chali (Fig. 3 and 4). This sand bank is submerged in water during the high-water period and emerges in the low-water period when fishing is intensively carried out. Some fishermen of this camp moved as early as April from their home villages this year. First, they built a camp on a floating island about 1 km to the west of Muilika camp, and then moved here in early August when the water receded. Other fishermen joined the camp directly from home villages in August.

There are a number of lagoons (*icisiba*) varing in size and shape around the camp. Most of them are connected either directly or indirectly through natural channels (*mulonga*) with the major streams, and are not isolated even in the driest season. With continuous supply of fresh water rich in oxygen and nutrients from Luapula river, these lagoons provide the fish, especially Cichlids, with a favorable habitat. The three major lagoons are of special importance; Ngandua to the west of the camp, Muilika to the east and Chamasipi to the south. Fishing is mainly done in these three lagoons and along

Fig. 3. Aerial photo of the study area. The location of Muilika fishing camp is indicated by an arrow.

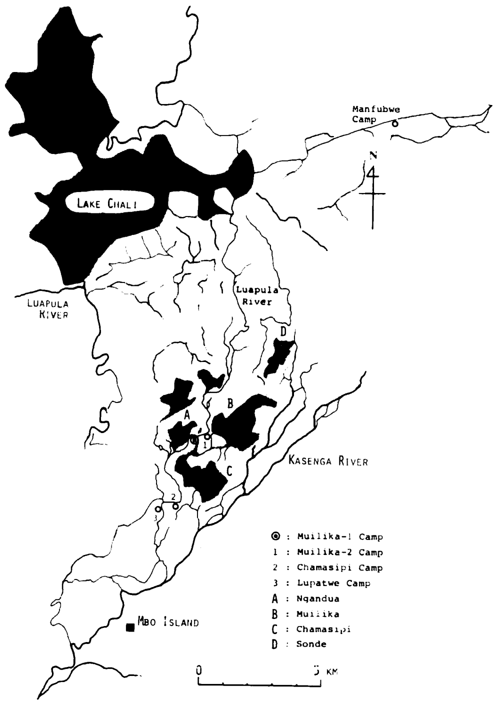

Fig. 4. Fishing grounds around Muilika camp.

Luapula and Kasenga rivers (Fig. 4). The depth of lagoons were from 0.7 to 1.5 m in September, 1983, that of channels reaching as much as 2 m and that of the Luapula river exceeding 3 m in some parts.

As shown in Fig. 4 there are four fishing camps of which the members use the lagoons mentioned above. In September, 1983, 65 huts and about 50 canoes were counted. In addition to these, fishermen of Mutapwe camp on the southern side of lake Chali also came to fish in this area, althorgh the frequency was not high.

During 63 days of intensive survey, data was collected on the following points: 1) Composition of the fishing camp, 2) fishing gear used, 3) fishing methods employed, 4) fishing activities, including actual procedure and time schedule of each fishing method, 5) effort allocation to each fishing method in terms of number of fishing attempts and hours spent in fishing, and 6) species composition in number and weight and the total catch from each fishing attempt.

A fishing unit is here defined as the minimum working unit with net(s) and a canoe, and a fishing attempt as a unit fishing effort which consists of a series of activities made by one fishing unit from starting from the camp with net(s) to returning to the camp with the catch. Thus, as will be seen later, in stationary gillnet fising (*malalikisha*), one attempt usually consists of two round trips to a netting ground. One is for setting nets and the other for removing the fish and nets. For each fishing attempt, as far as possible, fishing hours were recorded, and the catch was first sorted into species, then counted and weighed with spring balances.

FISHING UNITS, FISHING METHODS AND THE CATCH

1) Composition of the camp

In the research period, Muilika camp consisted of 27 adult and young fishermen, 13 married women and 15 infants who lived in 21 huts arranged in a line on the narrow sand bank of 10 m wide and 100m long. They are related to one another through various kinship ties as shown in Fig. 5. Most of the women and infants and some fishermen stayed only for a part of the resarch period and had returned to their home villages before the rain became severe in December. The fishermen went to the villages once for a week to ten days to bring firewood and maize meal. Sometimes they returned to the villages to take a rest for several days. Apart from this, the composition of the camp did not change much during the research period. There are examples, in the Bangweulu Swamps, of fishermen, especially those specializing in *ukusakila*, who shift their fishing camps and fishing grounds according to the change in water level. In the early fishing season, they fish in shallow swamps far from major lakes and lagoons, to which they move when the water recedes and the fish disappear in the shallow swamps. However, most fishermen of Muilika camp, except No. 15 through 17 who specialized in *ukusakila*, stayed there or on the nearby floating island throughout the fishing season.

The home villages, clans and kinship relations of the fishermen are shown in Table 1. The majority came from the villages in Kapata peninsula under Chief Mulakwa. The distance from these villages to the fishing camp is a one to one and a half day paddle by canoe. Of the three fishermen from the Kalasa Mukoso location, No. 15 began to fish here from the 1980 season, and the other two came this year with No. 15 for the first time. Nos. 2, 16 and 17 fished here this year also for the first time. All other fishermen have been fishing here for at least 6 to 7 years.

In Bangweulu, there is no fishing right with regard to netting grounds, as mentioned

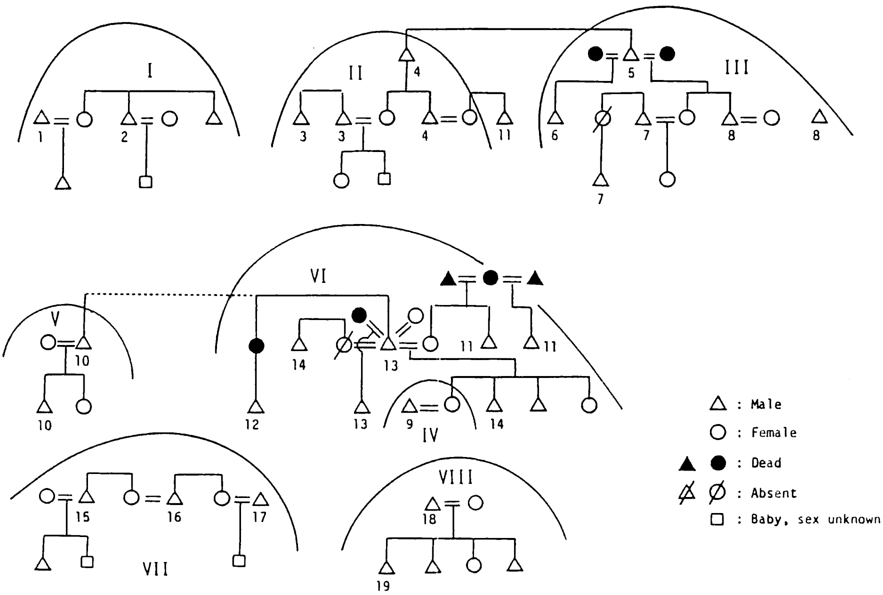

Fig. 5. Composition of Muilika camp. The numbers from 1 to 19 indicate the fishing units and I to VIII the commensal units.

by Brelsford (1946). A fisherman can fish anywhere on the conditions that he pays the administration of Samfya for the fishing license, and that he is requested, at least in principle, to pay a tribute to the local chief to whom the fishing ground belongs. Most fishermen, however, fish at the same camp every year, and a camp is mainly composed of the fishermen from one or a few neighboring villages. This general tendency was also observed in Muilika camp as well as other camps in Bangweulu.

Not all fishermen possess a canoe and nets of their own. A fisherman without a canoe and net(s) fishes as workmate (*umusua*) of another fisherman who owns them. The owner provides his workmate with a canoe and net(s), meals, firewood and other necessities, and shares a part of the money obtained from selling the catch. At Muilika camp, a workmate is usually paid about 30% of the money from his catch, if he fishes as an independent fishing unit. Fishing gear, their owner and his workmate(s) thus comprise a production unit in fishing, which in this area is called "company". There are 14 such "companies" in Muilika camp, as shown in Table 1.

Number of canoes and length of nets used by each production unit is shown in Table 2. A production unit with more than one canoe is further divided into working units. Here, a minimum working unit with a canoe and net(s) is called a fishing unit. There are 19 such units in the camp (Table 1).

The 14 production units are grouped into 8 commensal units within which food is shared. Members of the same commensal are closely related through kinship ties. As shown in Table 1 and Figure 4, patrilateral, matrilateral and affinal ties are almost equally important in forming commensal and other units in the fishing camp. This is in contrast to the village custom in which matrilateral principle is predominant. This difference is partly due to the fact that fishing is essentially a male activity which requires and facilitates

Table 1. Fishing unit, "company" and commensal unit in the Muilika fishing camp.

Fishermen	Village	Chief	Clan	Fishing unit	"Company"	Commensal	Kinship and other relationship
No. 1	Mansagwengu	Mulakua	Benaluo	1	a	I	
2	=	=	?	2	a	I	No. 1's wife's brother
3	Mwaba	=	Benambwili	3	b	II	
4	=	=	=	3	b	II	No. 3's brother
5	=	=	Benaluo	4	b'	II	No. 3's wife's father
6	=	=	Benachulu	4	b'	II	No. 5's son
7	Katie	=	Benaluo	5	c	III	No. 5's brother
8	=	=	?	6	c	III	No. 7's son
9	=	=	Benachulu	7	d	III	No. 7's daughter's husband
10	?	=	Benachulu	7	d	III	No. 9's sister's son
11	Katie	=	Benakasya	8	e	III	No. 7's son
12	Mwaba	=	Benachulu	8	e	III	No. 11's friend
13	=	=	Benangoma	9	f	VI	No. 19's daughter's husband
14	Chileya	=	Benangoma	10	g	V	
15	=	=	Benachulu	10	g	V	No. 14's son
16	=	=	Benamuti	11	h	VI	No. 19's wife's brother
17	=	=	Benamuti	11	h	VI	No. 16's half-brother
18	=	=	Benangoma	12	i	VI	No. 19's sister's son
19	=	=	Benangoma	13	i	VI	
20	?	=	?	14	i	VI	No. 19's wife's brother
21	Chileya	=	Benamuti	13 or 14	i	VI	No. 19's son
22	Bwalya Mponda	Bwalya Mponda	?	13 or 14	i	VI	No. 19's son
23	Mabo Kunda	Kalasa Mukoso	Benangoma	15	j	VII	No. 24's sister's husband
24	=	=	Benaluo	16	k	VII	No. 24's sister's husband
25	?	=	Benangoma	17	l	VII	
26	Sondasi	Mulakua	Benamumba	18	m	VIII	
27	=	=	Benangoma	18	m	VIII	No. 26's son

bonding between brothers, affines, a father and his son, as well as between mother's brother and sister's son.

2) Fishing methods, work input and the catch

1. Fishing gear and methods

There are at Muilika camp 51 gillnets with sinkers (*isumbu*), approximately 3550 yards in total, and 5 gillnets without sinkers (*kacala*), 500 yards in total, and 2 small-sized drawnets. The gillnets are made of size No. 2 nylon twine and are of either 50 or 100 yards (streched length) when bought from traders. The price is 10 to 11 kwacha (equivalent to US$ 10) per 50 yards. Net length becomes about a half of the streched length when hung in water. The streched mesh size is from 1 to 3 inches and the depth is 26 meshes regardless of the mesh size. When used in deeper lagoons, two small-sized mesh nets are mounted together to make a deep net of 52 meshes. At Muilika camp, nets of large-sized mesh over 4 inches, *mutobi*, are not used in the research period, since the lagoons were shallow. Nets with mesh size smaller than 2 inches are illegal, but widely used for stationary gillnet fishing.

According to Brelsford (1946), there were 17 types of fishing methods in the Bangweulu. We recorded as many as 14 methods still employed in the research area. However, only 6 of these were of any importance in the commercial fishing at Muilika camp. The details of the fishing methods are given in Imai (this volume). Here, a brief account on the 6 major methods is given.

ukusakila (fish driving)

Gillnets are set in a shallow lagoon or swamp, and fishes are driven toward the nets by

Table 2. Length of nets and number of canoes per "company".

"company"	isumbu*						kacala*	mkwao**	canoe**
	1"	1.5"	1.75"	2"	2.5"	3"			
a	–	100	100	200	100	100	–	–	2
b	–	–	–	–	–	100	–	1	1
b'	–	–	–	100	–	100	–	–	1
c	–	–	–	450	150	200	–	–	2
d	–	100	–	100	–	200	–	–	1
e	100***	–	–	150	–	200	–	–	1
f	–	150	–	350	–	100	–	–	1
g	–	–	–	–	–	250	–	–	1
h	–	150	–	200	–	100	–	–	1
i	–	–	–	200	100	200	–	1	3
j	–	–	–	–	–	–	100	–	1
k	–	–	–	–	–	–	100	–	1
l	–	200	–	–	–	–	100	–	1
m	–	–	–	–	100	100	200	–	2
Total	100	700	100	1750	450	1650	500	2	19

* Length of nets in yards; ** Number of net or canoe; *** *mkwenba* net with 52 meshes in depth.

beating the water with a special type of pole (*akatule*) until they gill themselves in the nets. In this method, only one 100 yard net of 2.5 or 3 inch mesh size is used by a fishing unit. Fishing is carried out either by a single fishing unit or by a group of more than ten units. Two types of net are used; one (*isumbu*) is with sinkers and the other (*kacala*) without sinkers. The latter is specially devised for *ukusakila* fishing which is carried out in a muddy shallow lagoon and swamp. The two types of net involve different fishing strategies, as will be discussed later. One round of netting consists of a series of activities; setting a net, driving the fish, removing the net and fish and moving to the next netting place. It takes about 40 minutes for one round with *isumbu* and 80 minutes with *kacala*, and usually sevaral to ten rounds are repeated in a day. Fishing is made both in the daytime and at night.

ukusakila lupata (*lupata* driving)

When a fisherman sees a school of *Schilbe mystus* in a pool along streams (*mumbali ya mulonga*), he sets one or two nets and drives the fish toward them. The principle of this method is the same as that of *ukusakila* mentioned above, except that in *lupata* fishing, a net is set only when a school of fish is located and that the net is of smaller mesh size, 1 to 1.5 inches. It takes about an hour for one netting. As the fish are frightend and scatter away after a drive, netting is not repeated unless the fisherman finds another school of fish nearby.

malalikisha (stationary gillnet fishing)

Gillnets are set in the evening in a shallow lagoon or a pool with little or no current along a major stream , and the catch is collected the next morning. If the catch is good, the nets are left for a few days in the same place, but usually they are removed and reset at a different place everyday or every other day. It takes about 2 to 3 hours for one attempt of *malalikisha*; one hour for two round trips to a netting place, and 30 to 45 minutes each for setting nets and removing them. In addition, one to two hours are spent in removing the fish from the nets.

mapila (stationary gillnet fishing in the daytime)

This is also a type of stationary gillnet fishing. The difference from *malalikisha* is that the catch is collected the same day, usually several hours after setting the nets. As the fish can see the nets in the daytime, the catch from this method is not large.

ukusebesha (stationary gillnet fishing at a floating island)

The fish in the swamp, especially nocturnal Mormyrids, hide themselves under floating islands. Mormyrid fish come out from a floating island to forage after sunset and return there before dawn. Fishermen set nets along the floating island around sunset and dawn so as to catch the fish as they move in and out. After setting nets, they wait there for 1 to 2 hours and then remove the nets to bring them to the camp. It takes about 3 to 4 hours to make one *ukusebesha* attempt. In addition, 1 to 2 hours are necessary to remove the fish from the nets.

mkwao (drawnet)

Two small drawnets were used at Muilika camp. One was 200 yard long and 192 meshes in the deepest part (*udumba*, bag), and another was of 150 yards. A fishing ground for *mkwao* is sought in a smooth-bottomed lagoon, or along major streams where there are few weeds. A net is hauled from a small beach emerged above water. *Mkwao* fishing is not carried out during the high-water period, because there is no adequate beach from which to haul the net. In deep lagoons and lakes, another type of net, *kapopela*, is used. It has tiny sinkers less than 100 g each, so that it can be hauled from a canoe. Some fishing grounds for *mkwao* are weeded and exclusively used by specific people. Usually fishing is done by four fishermen in two canoes. It takes 40 to 50 minutes for a haul, and several to ten hauls are repeated in one attempt. Fishing is done both in the daytime and at night.

2. Fishing effort and return

Preferably, the amount of fishing effort should be recorded in terms of hours spent in fishing. However, hours could not be recorded for all fishing attemps made during the research period. Here, the number of fishing attempts is used for a comparison of fishing effort allocated to various methods. As mentioned above, it takes 2 to 3 hours for a *malalikisha*, *mapila*, or *ukusakila lupata* attempt, 3 to 4 for a *ukusebesha* attempt, and several to ten for a *ukusakila* or *mkwao* attempt.

During the research period, a total of 1115 attempts were recorded, of which *ukusakila* accounted for more than a half, and *malalikisha* nearly one-fourth (Table 3). The total catch was 7388.9 kg, of which 56% were from *ukusakila* and 20% from *malalikisha*. Namely, in the research period, *ukusakila* and *malalikisha* were the most important fishing methods in terms of both effort and return.

Species composition of the catch varies from method to method, as shown in Table 4. In *ukusakila*, two Cichlid species, *Tilapia rendali* and *Sarotherodon macrochir* accounted for more than 80% in weight of the total catch. Nearly 70% of the catch from *ukusebesha* belonged to Mormyrids. *Schilbe mystus* was the single most important species in *ukusakila lupata*.

An index of species diversity is used here to express the diversity of fish species caught by each method. This was originally devised by Simpson (1949) for expressing the species diversity of a plant community, and is calculated from the following formula:

Table 3. Effort and return for each fishing method.

Method	No. of attemps	Catch in kg	Catch per attempt	Species diversity*
ukusakila	563 (50.6)	4165.5 (56.4)	7.4	2.47
ukusakila lupata	30 (2.7)	176.2 (2.4)	5.9	2.24
malalikisha	276 (24.7)	1488.2 (20.1)	5.4	7.15
mapila	51 (4.5)	91.2 (1.2)	1.8	3.06
ukusebesha	65 (5.8)	472.7 (6.4)	7.3	5.41
mkwao	130 (11.7)	995.1 (13.5)	7.7	9.84
Total	1115 (100.0)	7388.9 (100.0)	6.6	5.46

*Species diversity is calculated from the following formula: Species Diversity = $\frac{1}{\Sigma(p_i)^2}$, where p_i indicates the proportion of i species to the total catch for each fishing method.

$$\text{Index of Diversity} = \frac{1}{\sum_{i=1}^{n} (Pi)^2}$$

where p_i indicates the proportion of i species to the total catch, and n the number of species caught by each method. If the species are of equal importance in the catch, the index will be n. The smaller the index, the more selective a fishing method is to the ichthyofauna. In *ukusakila* and *ukusakila lupata*, the indices are smaller than 3. On the contrary, the index is larger in *malalikisha*, which is not very selective of the species caught. In *mkwao* fishing, the catch from day fishing mainly consist of Cichlids, and that from night fising of Mormyrids (Imai, this volume), but as a whole this method is not very selective, as the index shows (Table 3).

The index is not very large, 5.46, for the total catch by all the 6 fishing methods, of which Cichlid is the most important group, accounting for nearly 80% of the total catch. This means that fishing in this area and this season depends on a very small number of species, although more than 80 species had been recorded in the swamps.

FISHING STRATEGIES

1) Allocation of effort to various fishing methods

In Table 5, a comparison is made among 6 fishing methods mentioned above. Each method differs from others in at least one of the three points compared; types of net used, fishing grounds and fishing time. This restricts the possibility of methods employed by the fishermen in a day, either singly or in connection with other methods. For example, those without *mkwao* can not do drawnet fishing. One can not perform both *ukusakila* and *mkwao* on the same day, as these require a similar time schedule but different types of net and fishing ground. Those engaged in *ukusebesha* at both sunset and dawn can not spare much time for other methods, as they must rest in the daytime. On the contrary, not a few fishermen do both *malalikisha* and *ukusakila* on the same day; they first go to collect the catch and nets of *malalikisha* early in the morning, then start for *ukusakila*, and after

Table 4. Species composition of the catch from each fishing method.

Species (Latin)	*ukusakila* kg (p_i)	*ukusakila lupata* kg (p_i)	*malalikisha* kg (p_i)	*mapila* kg (p_i)	*ukusebesha* kg (p_i)	*mkwao*	Total kg (p_i)	rank
Sarotherodon machrochir Boulenger	876.6(0.211)	0.2(0.001)	62.6(0.042)	5.6(0.061)	2.7(0.006)	160.4(0.161)	1108.1(0.150)	2
Tilapia rendalli Domeril	2455.2(0.590)	0.1(0.001)	46.7(0.031)	2.0(0.022)	1.7(0.004)	201.5(0.202)	2702.2(0.366)	1
T. sparmanii Smith	26.1(0.006)	28.9(0.174)	485.0(0.326)	49.5(0.543)	48.1(0.102)	113.2(0.114)	750.9(0.102)	3
Serranochromis angusticeps (Boulenger)	441.3(0.106)	1.9(0.011)	144.6(0.097)	11.5(0.130)	4.2(0.009)	102.2(0.103)	706.1(0.096)	4
S. robustus (Gunther)	66.1(0.016)	0 (0)	20.7(0.014)	0.5(0.006)	0 (0)	25.5(0.026)	112.8(0.015)	
S. thumbergi (Castelnau)	126.3(0.030)	0.1(0.001)	25.5(0.017)	1.3(0.014)	1.4(0.003)	22.8(0.023)	177.4(0.024)	9
Haplochromis mellandi (Boulenger)	34.2(0.008)	2.7(0.016)	126.4(0.085)	6.1(0.067)	10.0(0.021)	37.3(0.037)	216.7(0.029)	7
Tylochromis bangwelensis Regan	47.1(0.011)	0.3(0.003)	6.7(0.005)	0.8(0.009)	0.9(0.002)	9.2(0.009)	65.0(0.009)	
Mormyrus longirostris Boulenger	1.6(0.000)	0 (0)	9.6(0.006)	0 (0)	3.8(0.008)	13.8(0.014)	28.8(0.004)	
Mormyrops deliciosus (Leach)	0 (0)	0 (0)	4.3(0.003)	0 (0)	4.7(0.010)	109.2(0.110)	118.2(0.016)	
Marcusenius monteirii (Gunther)	7.7(0.002)	0.2(0.001)	60.2(0.040)	0.2(0.003)	46.7(0.099)	62.9(0.063)	177.9(0.024)	8
M. macrolepidotus (Peters)	2.0(0.001)	18.9(0.114)	138.4(0.093)	4.6(0.050)	169.6(0.359)	20.2(0.020)	353.9)0.048)	5
Petrosephalus simus Sauvage	0 (0)	0.6(0.004)	2.3(0.002)	0.5(0.006)	23.3(0.049)	0.6(0.001)	27.3(0.004)	
P. catostoma (Peters)	0 (0)	0 (0)	4.9(0.003)	0 (0)	74.1(0.157)	9.9(0.010)	88.9(0.012)	
Hydrocyon vittatus Castelnau	31.3(0.008)	3.4(0.020)	15.7(0.011)	0 (0)	9.6(0.020)	34.0(0.034)	94.0(0.013)	
Alestes macropthalmus Gunther	0.5(0.000)	0 (0)	2.4(0.002)	0 (0)	3.3(0.007)	31.9(0.032)	38.1(0.005)	
A. imberi Peter	0.1(0.000)	0 (0)	3.9(0.003)	0 (0)	1.1(0.002)	4.0(0.004)	9.1(0.001)	
A. grandisquamis Boulenger	2.0(0.001)	0.3(0.000)	0 (0)	0 (0)	0 (0)	0 (0)	2.5(0.000)	
Distichodus maculatus Boulenger	0 (0)	0.2(0.001)	2.7(0.002)	0 (0)	5.3(0.011)	4.8(0:005)	13.0(0.002)	
Barbus sp.	0 (0)	2.1(0.013)	3.0(0.002)	0 (0)	0.4(0.001)	0.1(0.000)	5.6(0.000)	
Labeo altivelis Peters	0 (0)	0 (0)	0.1(0.000)	0 (0)	0 (0)	0 (0)	0.1(0.000)	
Schilbe mystus (Linneaus)	4.9(0.001)	106.0(0.636)	63.0(0.042)	2.4(0.026)	33.4(0.071)	14.2(0.014)	223.9(0.030)	6
Clarias gariepinus Peters	16.1(0.004)	0 (0)	66.7(0.045)	1.0(0.011)	1.1(0.002)	2.7(0.003)	87.6(0.012)	
C. ngamensis Castelnau	21.9(0.005)	0 (0)	116.1(0.078)	4.4(0.048)	0.8(0.002)	2.1(0.002)	145.3(0.020)	10
C. buthupogon Sauvage	0.9(0.000)	0 (0)	17.4(0.012)	0 (0)	0.7(0.001)	0.9(0.001)	19.9(0.003)	
Heterobranchus longifilis Valanciennes	0 (0)	0 (0)	0.5(0.000)	0 (0)	0.1(0.000)	1.5(0.002)	2.1(0.000)	
Synodontis nigromaculatus	0.3(0.000)	0.7(0.004)	36.0(0.024)	0 (0)	24.5(0.052)	4.4(0.004)	65.9(0.009)	
Auchenoglanis occidentalis C. & V.	0.5(0.000)	0 (0)	21.0(0.014)	0.4(0.004)	0.5(0.001)	3.8(0.004)	26.2(0.004)	
Chrysichthys mabusi Boulenger	0 (0)	0 (0)	1.5(0.001)	0 (0)	0.7(0.001)	2.0(0.002)	4.2(0.001)	
Ctenopoma multispinis Peters	0 (0)	0 (0)	0.1(0.000)	0 (0)	0 (0)	0 (0)	0.1(0.000)	
Species unidentified	(2.8)	(9.7)						
Total	4162.7(1.000)	166.5(1.000)	1488.2(1.000)	91.2(1.000)	472.7(1.000)	995.1(1.000)	7376.4(1.000)	

Table 5. Comparison of fishing methods.

Fishing method	Type of net	Fishing ground	Major target	Time of work	Hours spent in one attempt
ukusakila	2.5 or 3" *Kacala* or *isumbu*	swamp and shallow lagoon	*Tilapia* and *Sarotherodon*	day and night	several to ten hours
ukusakila lupata	1 or 1.5" *isumbu*	water pool along the river	*Shilbe mystus*	daytime	2–3 hours
malalikisha	1.5 to 3" *isumbu*	swamp and shallow lagoon	not specified	before sunset after dawn	2–3 hours
mapila	1.5 to 3" *isumbu*	swamp and shallow lagoon	not specified	daytime	2 hours
ukusebesha	1.5 to 2" *isumbu*	floating island	*Marcusenius* and other Mormyrids	around sunset and dawn	3–4 hours
mkwao (*ukukula*)	*mkwao*	lagoon and river	not specified	day and night	several to ten hours

returning to the camp from *ukusakila*, they again go out to set nets for *malalikisha*. How they choose among several alternatives the fishing methods to employ on a given day is a complicated matter influenced by various factors, such as distribution of the fish, water level, rainfall, wind, phase of the moon, and change in the efficiency of each fishing method, etc. It is necessary to examine carefully the individual choices in order to understand such a decision-making process. Such a detailed analysis can not be made here. Instead, an analysis is made on how the fishermen allocated their effort to various fishing methods and what the results of their strategies of effort allocation were.

For each fishing unit, the number of fishing days and attempts allocated to each fishing method are shown in Table 6. *Mkwao* and *ukusebesha* were carried out only by a few fishing units, whereas *ukusakila* was done by most of the units at Muilika camp. Number of fishing methods employed by each unit varies from 1 to 5 and the index of diversity in fishing method from 1 to 4.1. There was a clear difference in the degree of specialization in fishing method. Nos. 2, 15, 16 and 19 specialized in *ukusakila*, No. 1 in *malalikisha* and No. 14 in *mkwao*, whereas others employed more or less diverse methods. There existed two distinct strategies in Muilika camp; the first can be called a specialist strategy in which fishing effort is focused on one fishing method, and the second a generalist strategy in which effort is dispersed to various methods. By adopting these two strategies, the fishermen at Muilika camp as a whole dispersed their effort in environmental utilization to a certain extent. For each fishing unit total catches and catches from each fishing method are shown in Table 7.

2) Comparison of efficiency among fishing units.

In spite of the difference in the pattern of effort allocation among the fishing units, there was no significant difference in efficiency among them. There was, of course, a differnce in the total catch of each unit. But the difference in the catch per fishing day was very slight, and there existed a strong corelation between the number of fishing days and the total individual catches (see Fig. 6, $r=0.92$, $p<0.001$, $N=17$). This implies that the total catch can generally be estimated from the number of fishing days. The relationship can be expressed in the following formula:

$$y=-20.3+10.4x$$

where x indicates the number of fishing days and y the total catch of a fishing unit. It should be noted that this relationship can be applied only when the total fishing days are long enough. Efficiency may also change considerably according to the fishing season, for which data is not available at present.

Table 6. Individual variation in fishing attempts recorded from Sep. 22 to Dec. 6, 1983.

Fishing unit	No. of days spent fishing	No. of fishing attempts						No. of fishing method	Total No. of fishing attempts	Method* diversity
		ukusakila	*ukusakila lupata*	*malalikisha*	*mapila*	*ukusebesha*	*mkwao*			
1	29	0	0	29	5	0	0	2	34	1.33
2	20	20	0	4	1	0	0	3	25	1.50
3	55	50	0	0	0	0	28	2	78	1.60
4	61	50	1	14	1	0	28	4	94	3.28
5	14	10	0	11	6	0	0	3	27	2.84
6	39	33	0	32	5	0	0	3	70	2.29
7	49	54	0	33	4	0	0	3	91	2.06
8	53	37	7	32	6	0	0	4	82	2.71
9	43	14	6	16	4	34	0	5	74	3.25
10	37	39	0	12	1	0	0	2	52	1.62
11	53	32	12	20	8	30	0	5	102	4.11
12	41	40	2	34	8	0	0	4	84	2.50
13	44	18	0	6	0	1	37	4	62	2.27
14	38	2	2	0	0	0	37	3	41	1.22
15	11	11	0	0	0	0	0	1	11	1.00
16	36	36	0	0	0	0	0	1	36	1.00
17	47	46	0	9	0	0	0	2	55	1.38
18	38	35	0	22	2	0	0	2	59	2.30
19	36	36	0	2	0	0	0	2	38	1.11
Total	744	563	30	276	51	65	130	6	1115	2.98

*Diversity of method employed calculated from the formula : $\frac{1}{\Sigma (p_i)^2}$, where p_i indicates the proportion of method i attempts to the total fishing attempts.

Table 7. Total weight (kgs) of each fishing unit for each fishing unit.

Fishing unit (No. of fishing days)	*ukusakila*	*ukusakila lupata*	*malalikisha*	*mapila*	*ukusebesha*	*mkwao*	Total	Catch per fishing day
1 (29)	0	0	266.1	8.8	0	0	274.9	9.5
2 (20)	147.4	0	13.0	2.1	0	0	162.5	8.1
3 (55)	429.4	0	0	0	0	214.7	536.8	9.7
4 (61)	283.5	5.8	6.5	0.7	0		403.9	6.6
5 (14)	80.9	0	63.8	9.3	0	0	154.0	11.0
6 (39)	179.1	0	194.2	11.6	0	0	384.9	9.7
7 (49)	434.0	0	159.0	3.4	0	0	596.4	11.2
8 (53)	208.7	49.0	157.7	9.2	0	0	424.6	8.0
9 (43)	49.0	32.8	131.9	10.7	262.1	0	486.5	11.3
10 (37)	224.6	0	19.8	0.9	0	0	245.3	6.6
11 (53)	210.7	61.2	82.8	17.9	208.3	0	580.9	11.0
12 (41)	293.7	10.1	179.5	13.6	0	0	496.9	12.1
13 (44)] 14 (38)	103.1	17.3	42.8	0	2.3	781.4	946.8	11.5
15 (11)	94.2	0	0	0	0	0	94.2	8.3
16 (36)	357.3	0	0	0	0	0	357.3	9.9
17 (47)	499.1	0	38.7	0	0	0	537.8	11.4
18 (38)] 19 (36)	570.8	0	132.4	3.0		0	706.2	9.5
Total (744)	4165.5	176.2	1488.2	91.2	472.7	995.1	7388.9	9.9

Note: Correlation between the number of fishing days and the catch is significant; $r = 0.92$ ($p < 0.001$, N=17).

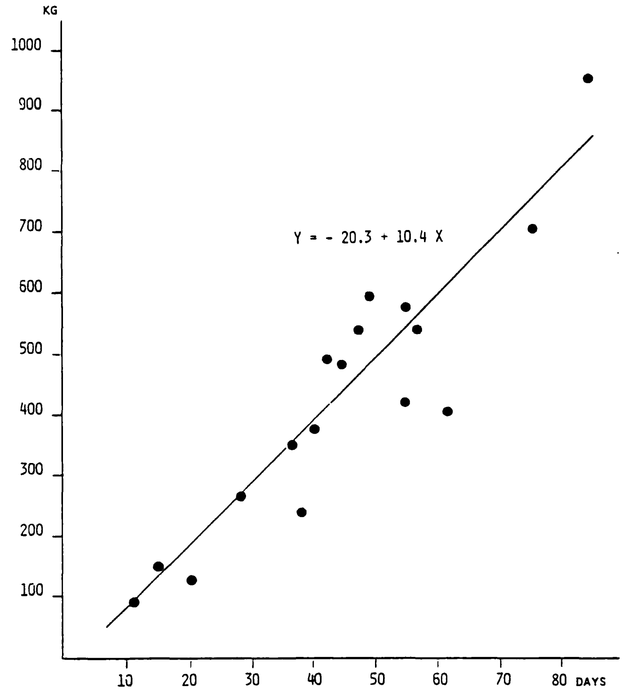

Fig. 6. Relationship between the number of fishing days and the catch (kgs).

The efficiencies of the fishing methods in terms of the catch per attempt are given in Table 3. The efficiency of *malalikisha* in terms of the catch per attempt per net (equivalent to catch per unit effort in Everett, 1974) is given in Table 8. There is little difference among *ukusakila*, *ukusebesha* and *mkwao*. The efficiency is slightly lower in *malalikisha* and *ukusakila lupata*, in which less time, only 2 to 3 hours, is spent for one attempt. The efficiency of *mapila* is exceptionally low. For this reason it is carried out only when the nets and manpower are not used for other more productive methods, and when the fishermen want to maximize the total catch, regardless of the efficiency.

3) Strategies for *ukusakila* fishing

1. *isumbu* and *kacala*

There are two types of gillnets used for *ukusakila*; one is *isumbu* with sinkers and the other is *kacala* without sinkers. While the fundamental principle is the same, there is a difference in actual procedures between fishing with these two types of net.

An *isumbu* can be easily hung in water, bacause it has sinkers and large floats. In order to set *kacala*, a fisherman must at first remove the weeds from a netting place. They might otherwise entangle in the net and make it rise with the slightest wind or water current. Then, he pushes the lower end of the net into the muddy bottom with a pole so that it may not rise to the surface. To hang *kacala* is thus troublesome work requiring nearly an hour which is more than three times as much as that for setting *isumbu* (Table 9). Time spent in driving the fish is nearly the same, but that in removing the fish and a net is slightly longer for *kacala* than for *isumbu*. This is because the former catches more fish in one netting.

Table 8. Efficiency of *malalikisha* fishing.

Fishing unit	No. of attempts	Length of nets used	Catch (kgs)	Catch per attempt	Catch per attempt per 100 yard net
1+2	33	500	279.1	8.5	1.7
4	14	100	6.5	0.5	0.5
5+6	43	600	258.0	6.6	1.0
7	33	300	159.0	4.8	1.6
8	32	350	157.7	4.9	1.4
9	16	500	131.9	8.2	1.6
10	12	150	19.8	1.7	1.1
11	20	350	82.8	4.1	1.2
12+13+14	40	300	222.3	5.6	1.9
16	9	200	38.7	4.3	2.2
18+19	24	200	132.4	5.5	2.8
Total	276	3550	1488.2	5.4*	1.6**

* : Average; ** : Average catch per attempt per 100 yard net calculated from;

$$(\text{Average catch per attempt}) \div \frac{\sum_{i=1}^{19} (A_i B_i)}{(\text{Total No. of attempts})} \times 100,$$ where A_i indicates the length of nets used by i fishing unit and B_i the number of fishing attempts of i.

According to the fishermen, fish gill themselves more easily in *kacala* which is very loosely hung with mud and small floats and moves together with the fish rushing into it. Fish may sometimes hit against and back away from *isumbu* which is tightly hung with sinkers and large floats. Time for moving between the netting places is approximately the same, several to ten minutes. The time for one netting round is 80 minutes for *kacala* and about 40 minutes for *isumbu* (Table 9 and 10).

Fishing with *kacala* takes more time for one netting round and yields more catch per netting than that with *isumbu*, whereas more netting can be made in a day in the fishing with the latter. It should be noted that although there exists such a difference in fishing strategy, there is no difference in efficiency (catch per fishing hour) between the two strategies using different types of net. The catch per attempt is more for *kacala*. This is only because the fishermen using *kacala* spent more time in one fishing attempt (Table 10).

2. Day fishing and night fishing

There is a marked difference in efficiency between day fishing and night fishing. The catch per hour in night fishing is almost two times as much as that in day fishing (Table 11). In spite of higher efficiency in night fishing, only a few people fish at night. The reasons for this are that it is more difficult to handle a net in the darkness, that they may suffer from severe mosquito bites at night and that it is more dangerous to fish at night in the place where there are plenty of hippos and crocodiles. In night fishing, they do not use *kacala* which requires elaborate work to hang.

Table 9. Minutes spent in each activity; *kacala* and *isumbu*.

	Net setting	Fish driving	Removing fish and net	Moving	one netting cycle
kacala (N=5)	52.0 ± 7.9	6.0 ± 1.0	15.3 ± 3.8	6.5 ± 1.5	79.8 ± 10.9
isumbu (N=5)	16.3 ± 2.9	6.5 ± 1.5	8.5 ± 1.7	6.3 ± 0.8	37.5 ± 4.5

Table 10. Comparison between *kacala* and *isumbu*.

	kacala	*isumbu*
sinker	no	yes
float	small	big
Minutes for one netting	80	38
No. of nettings per day	few	many
Night fishing	no	yes
No. of fishing attempts	162	392
Hours spent	1197:00	2011:20
Catch	1509.1	2643.1
Catch per attempt	9.3	6.7
Catch per hour	1.3	1.3

Table 11. Comparison of night fishing with day fishing.

	Night fishing	Day fishing
No. of fishing attempts	32	360
Hours spent	95:30	1915:50
Catch (kg)	237.5	2405.6
Catch per attempt	6.7	7.4
Catch per hour	2.5	1.3

3. Group size

In Table 12, the frequencies are shown with which each fishing unit participated in fishing groups of various sizes. For all fishing units, the frequencies were high for smaller group sizes of 1 to 4 units. Except for solitary fishing, the freqeuncies are not significantly different form those expected from a random distribution. A closer examination on each fishing unit, however, shows that there were some units like Nos. 2, 7, 11, 15 and 17 which prefered to fish alone, and others which most of the time fished in groups of various size.

According to those who prefered to fish in groups, they can catch more in group fishing than in solitary fishing. But this is not true as far as the data shows. In Table 13, the effeciencies for various group sizes are compared, from which it is concluded that, contrary to some fishermen's view, there was no significant difference in the efficiency. The reason for forming a fishing group is probably not that it improves the efficiency.

Table 12. Number of *ukusakila* attempts observed for each group size.

Group size / Fishing unit	1	2	3	4	5	6	7	8	11	13	night fighing	Total
2	15	1	2	0	1	0	0	0	0	0	1	20
3	4	9	11	7	3	1	1	1	0	0	13	50
4	2	16 (1)	8 (1)	11	5	2	2	1	0	0	1	48 (2)
5	0	3	1	1	2	2	1	0	0	0	0	10
6	2	5	6	9	6	2	2	1	0	0	0	33
7	20	5	5	9	4	1	2	1	0	0	7	54
8	7 (1)	5	6	10	5	2	1	0	0	2	0	36 (1)
9	2	4	0	4	3	0	0	1	0	0	0	14
10	5 (1)	6 (1)	3	11	2	2	1 (1)	1	0 (1)	0	4	35 (4)
11	14	7	4	3	1	0	0	1	0	0	2	32
12	7	14	5	6	4	0	1	1	0	0	2	40
13	4	6	2	2	1	0	1	0	0	0	2	18
14	0	1	0	0	0	0	1	0	0	0	0	2
15	9	1	1	0	0	0	0	0	0	0	0	11
16	3	18 (1)	9	1	3	1	0	0	0	0	0	35 (1)
17	16	16	6	2	4	2	0	0	0	0	0	46
18	5	3	8	3	9	5	0	0	1	1	0	35
19	1	2 (1)	10	2	13	5	0	0	1	1	0	35 (1)
Total	116 (2)	122 (4)	87 (1)	81	66	25	13 (1)	8	2 (1)	2	32	554 (9)

( ) : Fishing hours not recorded.

Table 13. Comparison of efficiency among various group sizes in *ukusakila* fishing.*

Group size	1	2	3	4	5	6	7	8	11	13	Total
No. of fishing attempts	116	122	87	81	66	25	13	8	2	2	522
Hours spent fishing	695:20	749:15	557:25	432:40	385:50	149:15	72:35	39:40	15:35	15:30	3113:05
Catch (kg)	827.1	963.1	722.8	530.3	479.6	205.4	95.6	54.6	16.9	21.7	3917.1
Efficiency (kg/hour)	1.2	1.3	1.3	1.2	1.2	1.4	1.3	1.4	1.1	1.4	1.3
Correlation** coefficient	0.56	0.65	0.35	0.54	0.56	0.51	0.24	0.52	–	–	–

* Night fishing excluded.

** Correlation between fishing hours and catch for each group size.

Theoretically speaking, they might expect more catch per fishing unit in group fishing, as they drive the fish from a more distant point in group fishing than in solitary fishing, and the driving area per fishing unit increases. The matter is, however, complicated, because in group fishing, it takes more time for one netting round.

4. Individual variation in the catch and efficiency

According to some fishermen, a great difference may occur in the catch of *ukusakila* due to the difference in fishing skill. Here, it is examined whether or not, such a difference in the skill really exists. In Table 14, number of attempts, hours spent, and the catch per fishing hour are shown for each unit. The catch of each unit varies from 50.7 to 499.2 kg. There is also a differnce in the catch per attempt. However, average catch per fishing hour is from 0.8 to 1.7 kg which does not show a significant difference. In other words, there is a linear corelation between the total catch of a fishing unit and the total hours spent in fishing ($r=0.96$, $p<0.001$, $N=16$), which can be expressed in the following formula:

$$y=-18.1+1.35x$$

where x indicates the hours spent in fishing and y the total catch of each unit (Fig. 7). This formula can be applicable only when x is large enough.

A closer examination reveals that within each fishing unit the corelation between the catch and fishing hours is not strong, ranging from 0.78 to 0.25 (Table 14). This means that, although there is a strong corelation between the overall catch and effort in the long run, the daily catches of individual units show greater fluctuations, which are not simply determined by the fishing hours spent.

5. Association pattern in group fishing

Group *ukusakila* fishing facilitates social relationship among the people staying in the same camp. Such a sociological aspect is also important in understanding group fishing.

In Table 15, the frequencies with which each fishing unit associated with various other units are shown. From these data, indices of association are calculated between each pair of fishing units using the following formula:

$$\text{Index }(i,\ j)\ =\ \frac{N(i \cap j)}{N(i \cup j)}$$

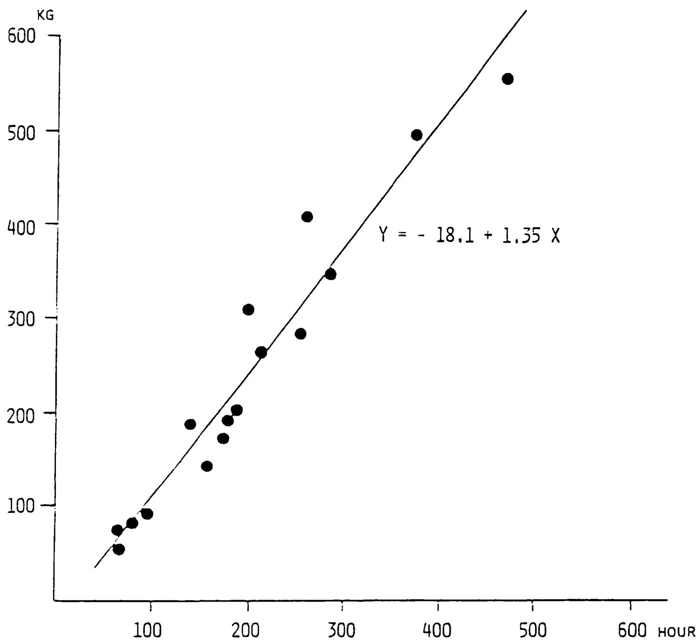

Fig. 7 Relationship between the fishing hours and the catch (kgs).

Table 14. Efficiency of *ukusakila* for each fishing unit.

Fishing unit	No. of attempts	Hours	Catch (kg)	Efficiency (kg/hour)	r*
2	19	155:00	141.9	0.9	$0.56, p < 0.05$
3	37	192:35	316.7	1.6	$0.46, p < 0.01$
4	47	244:50	282.0	1.2	$0.50, p < 0.001$
5	10	60:30	73.7	1.2	$0.62, p > 0.05$
6	33	173:45	175.7	1.0	$0.78, p > 0.001$
7	47	248:10	412.3	1.7	$0.62, p > 0.001$
8	36	184:00	202.7	1.1	$0.55, p < 0.001$
9	14	61:15	50.5	0.8	$0.75, p < 0.01$
10	31	179:10	194.4	1.1	$0.57, p < 0.001$
11	30	132:30	195.5	1.5	$0.30, p > 0.1$
12	38	208:50	276.7	1.3	$0.25, p > 0.1$
13	18	75:35	83.5	1.1	$0.58, p < 0.05$
15	11	93:15	94.2	1.0	$0.74, p < 0.01$
16	35	274:35	346.2	1.3	$0.39, p < 0.05$
17	46	368:25	499.2	1.4	$0.64, p < 0.001$
18 & 19	70	460:45	566.7	1.2	–
Total	522	3113:05	3917.1	1.3	–

Note: Correlation between fishing hours and catch for all fishing units is high; $r = 0.96$, $p < 0.001$ (N = 16).

* : Correlation coefficient between fishing hours and catch for each fishing unit.

Table 15. Matrix of association in *ukusakila* fishing.

Fishing unit	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	18	19	No. of *ukusakila* attempts
2	16	3	3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	20
3		17	30	3	10	10	6	1	10	2	5	2	0	0	0	0	0	50
4			8	7	14	15	9	2	13	3	8	3	0	0	0	0	0	50
5				0	6	5	6	0	3	0	0	1	0	0	0	0	0	10
6					2	14	24	6	8	3	4	3	0	0	0	0	0	33
7						27	11	5	10	2	6	2	0	0	0	0	0	54
8							7	4	8	3	2	2	0	0	0	0	0	37
9								2	5	5	5	1	0	0	0	0	0	14
10									5	5	15	8	0	0	0	1	0	39
11										14	12	4	0	0	0	0	0	32
12											8	12	0	0	0	0	0	40
13												4	0	0	0	0	0	18
15													9	2	1	0	0	11
16														3	25	1	4	35
17															16	6	7	46
18																5	25	35
19																	0	36

where N ($i \cap j$) indicates the number of fishing attempts in which both i and j participated, and N ($i \cup j$) the number of attempts in which either i or j participated (excluding the cases in which both participated). A sociogram of association drawn from the indices is given in Fig. 8 in which the thickness of the lines are proportionate to the index values in Table 16. It is easily understood that the fishing units of Muilika camp are clearly divided into two clusters. One is compsed of 12 units from No. 2 to No. 13, and the other of 5 units from No. 15 to No. 19. The division into these two clusters is quite natural, since all units of the former cluster use *isumbu*, and those of the latter *kacala*, each of which requires a different strategy as already mentioned. Those units connected by thick lines are related through close kinship ties; No. 3 and No, 4, and No. 16 and No. 17 are affines to each other, No. 6 and No. 8 half-brothers from a common mother, No. 18 and No. 19 a father and his son, and No. 13 is the maternal uncle of No. 12. All the pairs with an index larger than 0.2 belong to the same commensal units which are in themselves composed of the fishermen related through variuos close kinship ties. The association pattern in *ukusakila* fishing thus reflects the kinship relationship among the fishermen.

DISCUSSION AND CONCLUSION

Through a comparison of the fishing effort allocated to the six major fishing methods by 19 fishing units of the Muilika camp, a difference was found in the allocation pattern of fishing effort. In spite of this difference, no significant difference was found among the 19

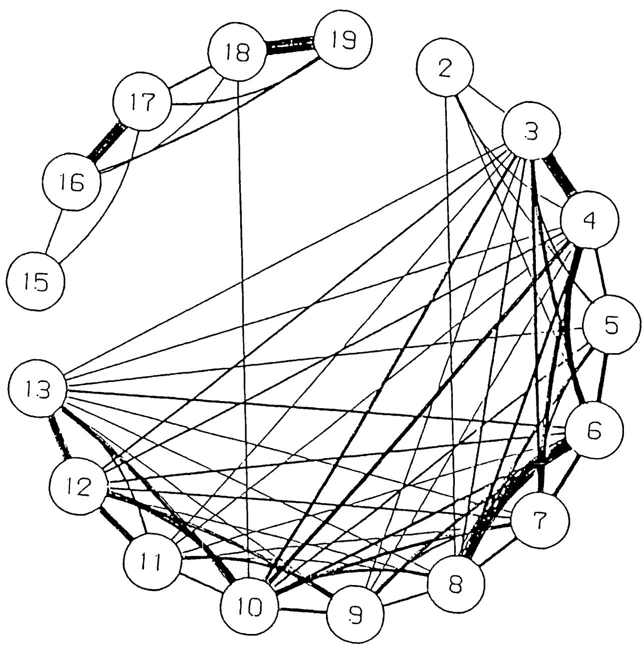

Fig. 8. Sociogram of association in group *ukusakila* fishing. The thickness of the lines is proportionate to the index in Table 16.

Table 16. Index of association in *ukusakila* fishing.

Fishing unit	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	18	19
2		0.045	0.045	0.034	0.019	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3			0.429	0.053	0.137	0.106	0.074	0.016	0.127	0.025	0.059	0.030	0.000	0.000	0.000	0.000	0.000
4				0.132	0.203	0.169	0.115	0.032	0.171	0.038	0.098	0.046	0.000	0.000	0.000	0.000	0.000
5					0.162	0.085	0.146	0.000	0.065	0.000	0.000	0.037	0.000	0.000	0.000	0.000	0.000
6						0.192	0.522	0.146	0.125	0.048	0.058	0.063	0.000	0.000	0.000	0.000	0.000
7							0.138	0.079	0.120	0.024	0.068	0.029	0.000	0.000	0.000	0.000	0.000
8								0.085	0.118	0.045	0.027	0.038	0.000	0.000	0.000	0.000	0.000
9									0.104	0.122	0.102	0.032	0.000	0.000	0.000	0.000	0.000
10										0.076	0.234	0.163	0.000	0.000	0.000	0.014	0.000
11											0.200	0.087	0.000	0.000	0.000	0.000	0.000
12												0.261	0.000	0.000	0.000	0.000	0.000
13													0.000	0.000	0.000	0.000	0.000
15														0.045	0.018	0.000	0.000
16															0.446	0.014	0.060
17																0.080	0.093
18																	0.543
19																	

Note: Index of association between i and j fishing unit is calculated from; index $(i, j) = \frac{N(i \cap j)}{N(i \cup j)}$, where $N(i \cap j)$ represents the number of attempts in which i associated with j, and $N(i \cup j)$ the total number of attempts in which either i or j participated.

units in fishing efficiency in terms of catch per fishing day. It might be concluded that there will be no significant difference in the efficiencies in the long run among the fishing units as well as among the fishing methods. However, this does not necessarily mean that there may be no difference at all, whatever strategies the fishermen may adopt. The number of floating islands for *ukusebesha* fishing is limited around the camp. There are not many good fishing grounds for *mkwao* in the nearby lagoons. If more effort had been spent on these methods, the efficiencies would have probably declined. Therefore, it seems more appropriate to say that the efficiencies were levelled out by the fishermen who adopted different fishing strategies and dispersed their effort to various fishing methods which involved different types of net, fishing ground, time schedule, and target fish.

For *ukusakila* fishing, comparisons of efficiencies were made between the two variations of *ukusakila* method, between day fishing and night fishing, among various sizes of fishing groups and among fishing units. None of these, except between day fishing and night fishing, showed a significant difference. The reason for forming a fishing group is probably not that it may improve the fishing efficiency. Fishing group size is actually determined as a result of the choice of a fishing ground. The fishermen usually talk early in the morning or on the previous night about where to fish. After this talk, those going to the same fishing ground may join to do group fishing. Sometimes, they join on their way to a fishing ground, or even after arriving there.

Those who fish in the same lagoon may disturb one another's work. While setting a net, they must keep silent so as not to frighten away the already nervous fish. If others beat the water nearby, the fish may be altogether frightened away. Such a situation might well occur in a small lagoon of 1 to 2 km^2 at the largest. Fishing groups may be formed, thus, not because they may improve the efficiency, but because they may reduce the disadvantage deriving from simultaneous independent fishing in a small lagoon, hence maintain the efficiency at the same level with that in solitary fishing. This also seems to explain well the low frequencies for large-scale group fishing in the research area.

An examination of the association pattern in group fishing showed the importance of kinship relationship in forming a fishing group. It can be concluded that, in order to understand properly the fishing activities of the Bangweulu fishermen, it is necessary to pay attention also to social aspects not directly relavant to the optimization of fishing efficiency.

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Appendix. Vernacular names of the fish in the Bangweulu Swamps.

Scientific name	Commonly used vernacular	Other vernaculars	For small type	For large type
Cichlidae				
Haplochromis philander Weber	*cikundu*	–	–	–
H. mellandi (Boulenger)	*mbilia*	–	–	–
Sarotherodon macrochir Boulenger	*inkamba*	*matuba*	–	*icilelya, soto*
Serranochromis angusticeps (Boulenger)	*polwe*	–	–	–
S. robustus (Gunther)	*nsuku*	*umliba*	*kamuliba*	*ibimba, ibukula*
S. thumbergi (Castelnau)	*ntasa*	*saungolole*	–	–
Tilapia rendalli Domeril	*mpende*	–	*kapende*	*ilindakatondo*
T. sparmanii (Smith)	*ituku*	*ipilibu*	–	–
Tylochromis bangwelensis (Boulenger)	*nsangula*	*ntembwa*	*kamumbala*	*lyongo*
Mormiridae				
Marcusenius macrolepidotus (Peters)	*muntesa*	*muncebwe*	–	*cilupande*
M. monteirii (Gunther)	*lucesu*	*lukupe*	*kalucesu*	–
Mormyrops deliciosus (Leach)	*lombo*	*munene*	*ntongo, mulobe*	–
Mormyrus longorostris Boulenger	*lububu*	*ilusa*	*mansanbubu*	*muenda-ulutalala*
Petrocephalus catostoma Peters	*cipumamabwe*	–	–	–
P. simus (Sauvage)	*cise*	–	–	–
Characidae				
Alestes grandisquamis Boulenger	*mutula*	*citololo*	–	–
A. imberi Peter	*lusaku*	*ilundacupo, ulumene cendapampumbu*	–	–
A. macropthalmus Gunther	*manse*	*mutuku*	*talamanse*	*mutobola*
Hydrocyon vittatus Castelnau	*nsanga*	*ncene*	*ibwilu*	*cikapala*
Citharinidae				
Distichodus maculatus Boulenger	*lubala*	*cikama, mukakabala*	–	–
Cyprinidae				
Barbus sp.	*mumbuluwe*	–	–	–
Labeo altivelis Peters	*mpumbu*	–	*inanga*	–
Schilbeidae				
Shilbe mystus (Linneaus)	*lupata*	*lupatapaba*	*kalolo*	–
Clariidae				
Clarias buthupogon Sauvage	*mbomba*	*cineke*	*kabomba*	–
C. gariepinus Peters	*muta*	*ngenda, ngola*	*kangola*	–
C. ngamensis Castelnau	*muta*	*nkose, ngola*	*kangola*	–
C. sp.	*mulonge*	*mulonfi, utelemuka-pawabune*		
Heterobranchus longifilis Valenciennes	*sampa*	*kapetangele, sampa-wa-lwaongo*	–	–
Bagridae				
Auchenoglanis occidentalis (C. & V.)	*mbowa*	*mbowa-lupenbe*	–	–
Chrysichthys mabusi Boulenger	*mfusu*	–	*kabonbola*	*mabuli*
Mochokidae				
Synodontis nigromaculatus Boulenger	*cinyimba*	*mbongo, cinkuesu kalakue, fikofiko cingongo*	–	–
Anabantidae				
Ctenopoma multispinis Peters	*ulukomo*	*ilanga*	*kalukomo*	–