THE DEVELOPMENT OF THE TANZANIAN SARDINE FISHERY ON LAKE TANGANYIKA

by

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ABSTRACT

THE DEVELOPMENT OF THE TANZANIAN SARDINE FISHERY
ON LAKE TANGANYIKA

Lake Tanganyika is an international lake shared by the Republics of Tanzania, Zaire, Burundi and Zambia. By far the most important fishery on the lake is the sardine fishery. The underutilized stocks of sardines offer excellent prospects for further development.

This thesis deals with the sardine fishery in the Tanzania portion of the lake. It aims to outline the structure of the fishery in terms of production, marketing, distribution and management of the fishery, to analyse the problems of the fishery and to draw conclusions regarding further development prospects. A linear programming model is used as an aid in determining an optimum development pattern for the fishery.

The thesis concludes that further development requires particularly improvements in fish processing, marketing and distribution. Improvement of the infrastructure on the lake is also required. Joint management of the fish stock by the four countries bordering the lake is desirable.

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CHAPTER 1: INTRODUCTION

Lake Tanganyika, located in the Western Rift Valley of East Africa has an area of 31,000 km^2 with a length of 600 miles and a depth of 750 fathoms. It is an international lake shared by the Republics of Tanzania, Zambia, Zaire and Burundi. Tanzania territorial waters include approximately 13,500 km^2 or about 41% of the lake's total area.

The lake has large underutilized stocks of fish and offers excellent prospects for future development of this resource. A standing stock of 2.5 million metric tons of all species of tropical fish is available (Johannesson, 1974). The present total annual harvest by the four countries bordering it amounts to 2-3% of the standing stock (see page 6).

The Lake Tanganyika fishery contributes one third of Tanzania's annual total output of all fish of about 165,000 metric tons[1]. Total employment for the fisheries is at about 34,813 fishermen generating agross revenue of about Tshs. 403,604,700[1], including home consumption (Bazigos, 1975).

Fish from the freshwater lakes of the country are playing an important role in supplementing the protein deficient diet of the people and in contributing to the economy of the country. Development of fisheries is an important objective, for several reasons. Increased incomes in the fisheries sector can stimulate the demand for domestic industrial products as well as provide funds for investments in other sectors of the economy. The fishing sector can be an important source of scarce foreign exchange because of its potential for export of staple fish products to neighbouring countries.

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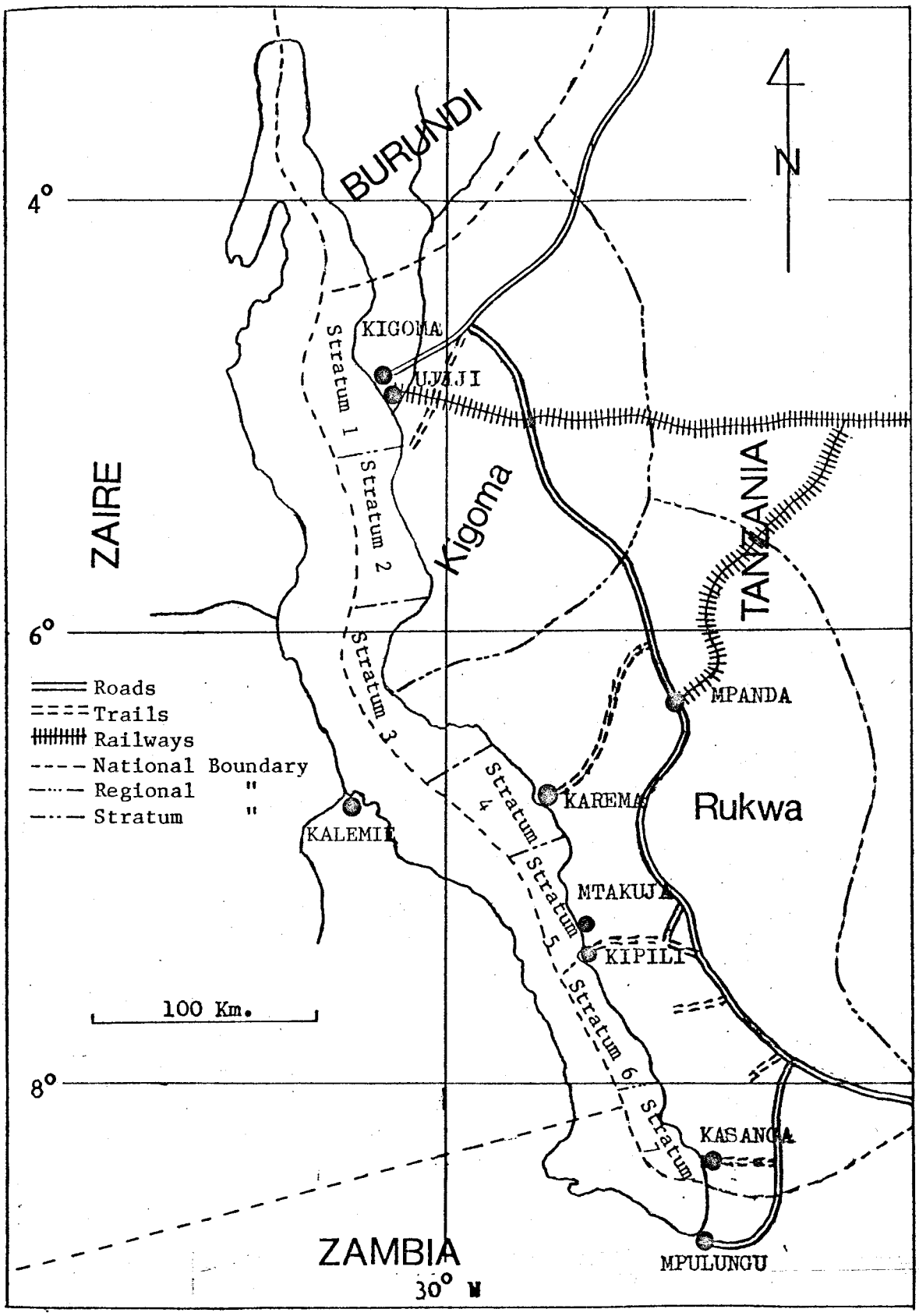
1 See Table I, page 6.

1 1978 Report on Production Figures for Major Freshwater Lakes of Tanzania, Fisheries Division, Ministry of Natural Resources and Tourism, Dar es Salaam.

Figure I: Map of Lake Tanganyika



Expansion of the fisheries sector could reduce the growing unemployment problems experienced in the country as well as meet increased domestic and external demand for fish. The official fisheries development policy in Tanzania is stated as the "development of a higher standard of living for the fishermen and the nation as a whole through increased fish production and improved fish marketing, processing and distribution." (Tanzania Five Year Development Plan 1969-1974)

Serious constraints hinder the development of the fisheries sector in Tanzania. Most fishermen live in small villages, but towns and cities remain the main potential markets for fish. Lack of storage facilities as well as inadequate methods of processing and marketing contribute to low prices for fish. Prices are also depressed by the low incomes and consequent low purchasing power of consumers.

The sardine fishery is by far the most important fishery on the lake in Tanzania. It contributes about 80% of the total catch. It is because of this importance that this thesis is undertaken to outline the structure of the sardine fishery of Lake Tanganyika in terms of production, marketing, distribution and management of the fishery, to analyse the problems of the fishery and to draw conclusions regarding further development of the fishery. A linear programming model is formulated as an aid in determining an optimum development pattern for the sardine fishery of Lake Tanganyika.

This thesis will deal principally with the sardine fishery because it is the most important fishery but will also deal with other species where it is necessary to explain the overall situation in the fishery and the overall potential for economic development in the fishery.

Following this introductory chapter, the study continues with a chapter on the present state of the fishery on Lake Tanganyika. It deals with fishing

operations, fishermen and social organization, markets and distribution.

The fishery potential of the lake is discussed in Chapter 3. It starts with a section on biological factors of the lake and further analyses the harvesting, processing, marketing and international aspects of fisheries expansion.

Fisheries economics in the context of Lake Tanganyika is the subject of Chapter 4 and Chapter 5 contains an outline of a linear programming model for the fishery as well as a development design for the fishery. The discussion in Chapter 6 deals with policy considerations by analysing a cooperative village structure (Ujamaa) as a possible vehicle for improving markets, distribution and re-investment.

An analyses of the stage of full exploitation of the fishery is contained in Chapter 7 and set out in Chapter 8 are the conclusions of the thesis.

CHAPTER 2: THE STATE OF THE FISHERY ON LAKE TANGANYIKA

The Fish Stocks

Biological surveys carried out on Lake Tanganyika indicate a standing stock (pelagic ichthyomass) of 2.5 million metric tons. The results of the accoustic surveys suggest that the potential maximum sustainable yield of the whole lake is about 500,000 metric tons of fish per annum (Chapman, 1976).

Detailed biological analysis of the lake's stock indicates that six species make up practically all of the pelagic ichthyomass in the lake (Chapman, 1976). The stock consists of two clupeid planktivores (Limnothrissa miodon and Stolothrissa tanganicae) and four predators (Lates angustifrons, L. marie, L. microlepis, and luciolates stappersie). The two clupeid planktivores are sardines. They account for 80% of the total stock. The sardines of Lake Tanganyika are the only fresh water herring of commercial importance in Africa. The sardines in catches are about 4.0 inches long. In the open lake they remain at depths around 35 fathoms during the day and migrate up to the surface at night (Coulter, 1963).

Fishing Operations

On the Tanzania section of the lake, there are two sectors of the fishery. First, there is the inshore traditional fishery which is characterized by small scale fishing units operated by labour-intensive techniques. Second, there is the industrial fishery, which is off-shore and capital intensive.

The industrial fishery has four medium sized purse seine units which operate from Kigoma. Two of these are owned by Uvuvi Kigoma Limited, which is a government owned company. Another purse seining unit is operated by the FAO/UNDP Project and the fourth is operated by a Greek fisherman. These units land substantial catches of sardines, luciolates and lates species. The units sell fish themselves. The larger fish are usually sold either

through small wholesalers or direct to the retailers who later sell at the retail markets in Kigoma district. Sardines, dried on their own drying racks are usually sold to government institutions such as the National Milling Corporation which produces fish meal out of the dried sardines for human and animal consumption to meet domestic requirements. When large catches are landed, fresh sardines are sold sometimes to small private traders to dry and resell to the traders in Kigoma/Ujiji.

The distinction between the two sectors of the fishery rests definitionally on the type of fishing vessels and the relative amount of capital employed. The Tanzania portion of the lake contributes more than 50% of the lake's total catch. The total catch on the lake is estimated to be less than 100,000 metric tons per annum (Smart, 1976). The catch from Lake Tanganyika contributes one-third of Tanzania's annual total output of all fish (Midtgaard 1975) as shown in the table below.

Table 1: Approximate Output of All Fish per Annum in Tanzania in 1974.

Source:	Output in Metric Tons:
Lake Tanganyika	52,000
Lake Victoria	45,000
Indian Ocean	30,000
Lake Nyasa	10,000
Other Inland Lakes, Rivers and Ponds	28,000
Total	165,000

Source: (Annual Report of the Fisheries Division, Ministry of Natural Resources and Tourism, Tanzania, 1975).

Of the two sectors on the lake, the traditional fishery is by far the more important. In 1974, it took 89% of the catch (47,453 metric tons) and the industrial fishery took the rest. The vessel used in the traditional fishery is the canoe. A total of 5,233 canoes operate in Tanzania waters on Lake Tanganyika (Bazigos, 1975).

The traditional fishery is confined to a short range of operation from the beaches. The duration of the trips undertaken by the fishermen is only a few hours. The traditional fishery is divided into six techniques of fishing. These are hand lining, beach fish seining, beach dagaa seining, gill netting, lift netting and lusenga. Some of the techniques such as beach fish are for luciolates species though most techniques produce mostly sardines.

The lusenga fishery is by far the most important one along the lake. According to the frame survey of August 1975 undertaken on the Tanzania shoreline of the lake, about 72% of the fishing canoes on the lake were engaged in the lusenga fishery. They contributed 88.7% of the total catch of all species while lift nets contributed 0.5%, handlines 0.5%, beach fish 0.8%, beach dagaa 6.6% and gill net 2.9%.[1] Catches from the industrial sector were excluded from the survey.

The lusenga is a hand held scoop net with an eliptical mouth attached to a handle of about 4.0 to 4.5 metres long (see Figure II, page 8). Depth of the net is between eight and ten metres. It is used by canoes that are paddle-powered and normally carry a crew of two fishermen.

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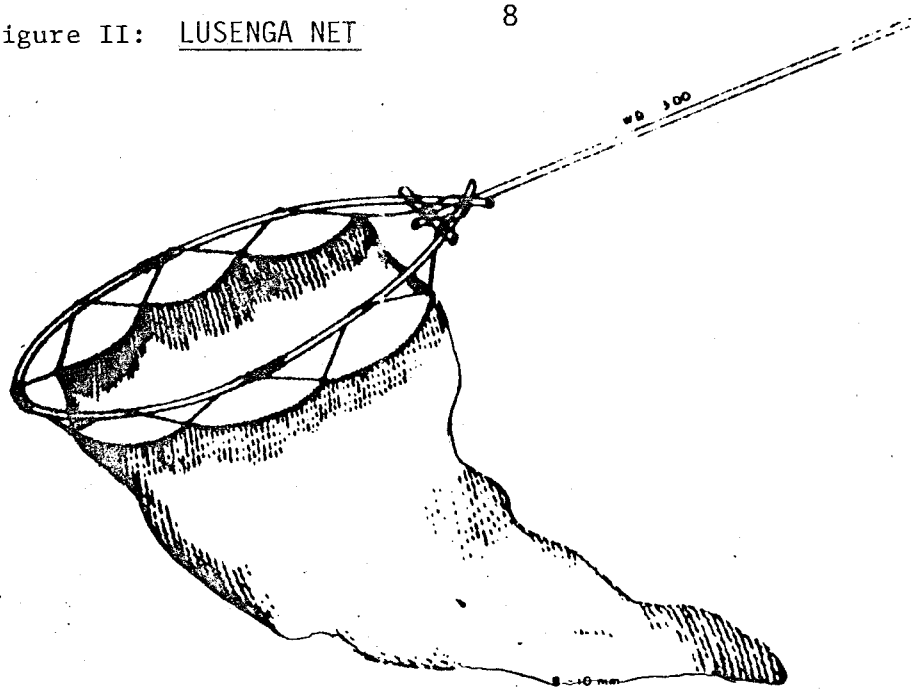
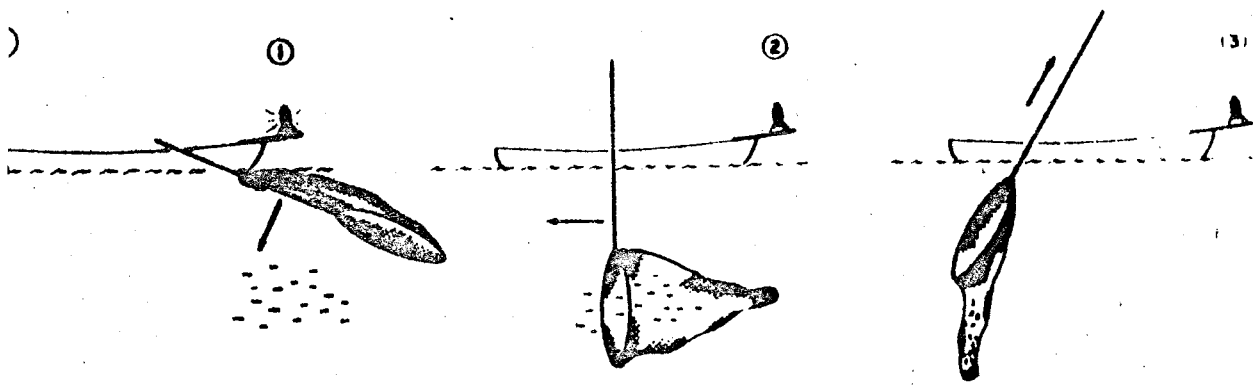
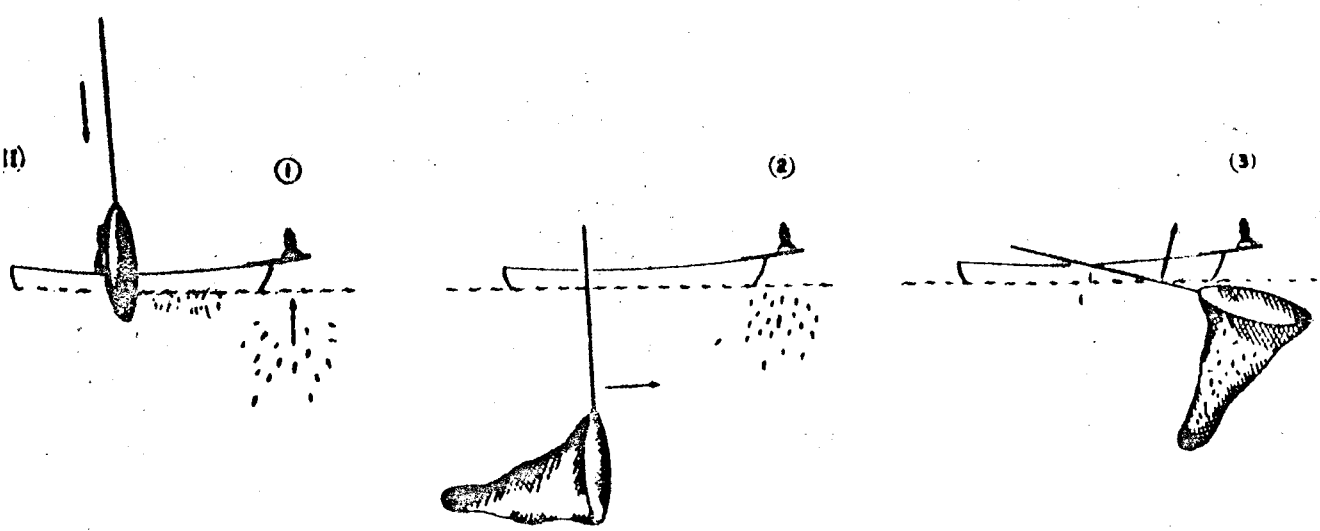
1 The frame survey involved a complete enumeration and assessment of all the inputs and outputs of the fishing industry. It was carried out prior to initiation of a catch assessment system based on sampling surveys in order to provide data on the characteristics of the traditional canoe fishing industry.

Figure II: LUSENGA NET



USE OF LUSENGA NET





The lusenga fishery is conducted at night by a system of light attraction. Two pressure (kerosene) lamps with top shades are attached to a protruding frame usually from the rear of the canoe for attracting the fish. When the fish are concentrated around the lamps or in the "light attraction area" one of the crew operates the net (scoops) while the other manoeuvres the canoe. The process is repeated several times until all the fish are depleted in the light attraction area (Sasidharan, 1976).

Catches from the traditional fishery as well as the industrial fishery consist of about 80% sardines and 20% larger species, lates and luciolates (Smart, 1976). The fishery operates from open beaches, generally where it is both sheltered from the weather and has some flat ground for drying sardines. Very few of the fishing villages have access to roads. Communication is mostly by boats (water taxis).

The canoe fishery is basically subsistence in character and the productivity of fishermen tends to be low. This is caused in part by an inadequate marketing and distribution structure that has tended to discourage fishermen from increasing their catches. Hence, for the most part, fishermen produce just enough to provide for their own needs.

The following table shows an estimated total fish catch and monthly average total fish catch on a stratum basis. In the context of Lake Tanganyika fishery, a stratum is an area for catch assessment survey. The Tanzanian shoreline of Lake Tanganyika is divided into seven major catch assessment areas called strata by taking into account geographical and biological criteria of stratification.

Table II. Estimated Total Fish Catch and Monthly Average Total Fish Catch on a Stratum Basis for the Traditional Fishery in 1974

(metric tons)

	Fishing Year		SP-1		SP-2		Total fish catch (%)		
	Total	Monthly Average	Total	Monthly Average	Total	Monthly Average	Fishing Year	SP-1	SP-2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total	53,476	4 456	29 125	4 160	24 351	4 870	100	100	100
Stratum 1	28 280	2 357	16 087	2 298	12 193	2 439	52.9	55.3	50.1
Stratum 2	13 883	1 157	6 912	987	6 971	1 394	26.0	23.7	28.6
Stratum 3	1 904	159	409	58	1 495	300	3.6	1.4	6.1
Stratum 4	2 617	218	1 783	255	834	167	4.9	6.1	3.4
Stratum 5	4 555	380	2 531	362	2 024	405	8.5	8.7	8.3
Stratum 6	1 789	149	1 078	154	711	142	3.3	3.7	2.9
Stratum 7	448	37	325	46	123	24	0.8	1.1	0.6

Source: G.P. Bazigos, The Present State of the Traditional Fishery of Lake Tanganyika.

SP-1: Refers to the period of the fishery (March 1974 to September 1974)

SP-2: Refers to the period of the fishery (October 1974 to February 1975)

Stratum one and two account for 80% of the catch. Kigoma, located near the northern end of the lake is a railway terminal and is also the largest town along the lake. It is the main collection and distribution centre for fish. Therefore, stratum one and two that are located near to Kigoma have lower transport costs and stratums located further away from Kigoma have higher transport costs.

As a result, prices of fish in the stratums that are further away from Kigoma tend to be depressed because of the long distances that buyers have to travel and also the high transport costs involved in getting fish from these regions. It is probable that catches could be improved in these distant stratums if marketing channels were improved so that fishermen could be offered better prices.

At the present, the prices are probably realistic from the standpoint of buyers because they have high transportation costs. If transportation, marketing and distribution systems are improved, it may be possible to lower transportation costs so that the margin paid to fishermen can be increased.

Besides estimating the total fish catch on a stratum basis, the Lake Tanganyika fisheries research and development project also analysed the cost structure in the fishing industry. Table III below shows an estimated cost structure by fishery per fisherman per active fishing day and per fishing economic unit per month. A fishing economic unit consists of the fishermen, the canoes and gear used in the fishing operation. The costs in table II include operating costs for repairs, labour costs and maintenance and exclude the interest paid on the capital invested.[1]

Table III. Estimated Total Cost per Fisherman per Active Fishing Day and per Fishing Economic Unit per Month by Gear Type for the Traditional Fishery in 1974

(Tanzania shillings)

Gear Type	Cost per fishing Economic Unit per Month	Cost per fisherman per active fishing day
1. Lusenga	542.4	33
2. Gill net	123	8.88
3. Beach dagaa	255.6	38.1
4. Beach fish	270	5.46
5. Liftnet	176.4	23.4
6. Handlines	74	13.8

Source: Costs and Earnings Survey, Lake Tanganyika Fisheries Research and Development Project.

1 Labour costs in this context include only the share of the catch paid to crew members.

The above table indicates a higher cost for Lusenga economic units. This is due to high material cost, eg. kerosene lamps, nets, net repairs and canoe maintenance. The high costs of fishing units for beach dagaa and beach fish are attributed to high total crew wages because of the large numbers of men used for each fishing unit.

The lusenga fishery is also by far the most important fishery on the lake in terms of revenue. Both the total revenue per fishing economic unit per month, total revenue per fisherman per month and the total revenue per fisherman per active fishing day is higher for the lusenga fishery in the two periods SP-1 and SP-2 as shown in Table IV below. The table also shows that total revenue was increased in SP-2 due to a decrease in supply of fish in SP-2 caused by the movements of fishermen into concentrated cooperative villages (Ujamaa). This in turn led to higher prices for fish in SP-2.

Table IV. Estimated Economic Secondary Magnitudes by Gear Type and for SP-1 and SP-2 for the Traditional Fishery in 1974

(shillings)

Gear Type	SP-1				SP-2			
	X1	X2	X3	X4	X1	X2	X3	X4
1. Lusenga	904	457	90.4	45.7	1339	669	111.6	55.8
2. Gill net	205	123	15.8	9.5	239	133	26.6	14.8
3. Beach dagaa	426	72	71	12	2239	381	373.2	63.5
4. Beach fish	450	93	90	18.6	499	100	45.4	9.1
5. Lift nets	294	57	32.7	6.3	2032	429	184.7	39
6. Handlines	124	83	20.7	13.8	132	92	33	23

Source: G.P. Bazigos, The Present State of the Traditional Fishery of Lake Tanganyika.

X1: Total revenue per fishing economic unit per month
X2: Total revenue per fisherman per month
X3: Total revenue per fishing economic unit per active fishing day
X4: Total revenue per fisherman per active fishing day

Source: Bazigos, 1975.

In addition to the traditional fishery there is an industrial fishery. It uses larger vessels with purseining gear. The vessels are either government owned or company owned. On the whole, this industrial fishery is rather localizedin Lake Tanganyika. At present, there are less than 40 industrial purse seiners operating in the four countries. A general survey made by the Lake Tanganyika Fisheries Research and Development Project at Kigoma indicates that there are 23 purse seiners in Burundi; seven in Kalemie (Zaire) and four in Mpulungu (Zambia).

There are four such vessels in Kigoma (Tanzania). They operate up to 10 miles out of Kigoma home port. The industrial techniques are also based on the attraction of sardines to artificial light at night, causing an aggregation of big shoals near the surface. The fishing operations in this sector are based on specialization of labour, with each crew member on board being assigned a particular task for the month.

Catches realized by the individual purse seining units are high and total cost per individual unit is also high. The following table shows the cost structure for one purse seining unit in Kigoma for one year.

Table V: Cost Structure for a Purse Seine Unit

	(T. shillings)
Total Annual catch (metric tons)	800
Value (in Tanzania shillings)	794,897
Operating Costs (boat, engine, light boats, nets)	110,000
Variable costs (Fuel, net and engine repairs, boat maintenance	150,000
Crew wages	300,000
Total cost	560,000
Cost per metric ton	700
Profit (Interest on capital inclusive)	234,897

NB. T shs. 8 = $1 U.S.

Source: Studies on Estimated Economics of Purse Seining Unit, by Lake Tanganyika Fisheries Research and Development Project.

Fishermen

The high catches realized by the industrial units are due to increased productivity of the fishermen through specialization. The majority of the fishermen in an industrial unit do fairly simple jobs over and over again. By developing particular skills and working with specialized equipment, these coordinated groups of fishermen can turn out far larger catches per man than units in the traditional fishery.

The industrial units are large-scale units of production involving great numbers of crew members (30). They also employ 20 other crew members for unloading fish and drying sardines on racks and using large amounts of capital per worker. This has tended to increase efficiency and productivity in terms of catch per fisherman.

On the whole, the fishery is the second largest economic sector in the regions of Kigoma and Rukwa.[1] It is significant, in the first place, for the large sector of the labour force it employs. About one fifth of all persons occupied in the two regions work in the fishing industry (1971 Census Survey for Kigoma and Rukwa regions).

The table below gives the area distribution of the fishing manpower of the industry in the two sub-periods, SP-1 and SP-2.

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1 See map page 2. Kigoma Region comprises of strata one to three and Rukwa Region has strata four to seven.

Table VI: Estimated Monthly Average Total Number of Fishermen by Stratum and by Sub-period, 1974.

	Monthly average total number of fishermen	
	SP-1	SP-2
Total	16,557	12,369
Stratum 1	5 608	4 460
Stratum 2	3 386	3 144
Stratum 3	974	733
Stratum 4	360	284
Stratum 5	2 323	2 098
Stratum 6	2 066	762
Stratum 7	1 840	888

Source: Analysis of the Results of Catch Assessment Survey of Lake Tanganyika, (Bazigos, 1975).

Most fishermen are concentrated in stratum one and two in Kigoma region near the railway town of Kigoma. Except in the railhead town of Kigoma, accessibility to the lake shore is rather poor. There are no all weather roads along the lake. Only two dry season roads from the east join the lake shore at Kipili and Karema. Apart from these two points, the rest of the lakeshore is inaccessible except on foot or by boat. As a result, most of the fishermen are to be found in stratum one and two which are close to the railhead town of Kigoma.

Table VI also shows a decline in the number of fishermen in SP-2. This is to be attributed to the process of re-organizing the traditional fishing villages into cooperative villages (Ujamaa) that led to the migration of some fishermen opposed to the policy (Zaire nationals) to neighbouring countries.

The fishery sector is underdeveloped in terms of its potential. A much higher sustainable yield of fish could be taken from the lake than is

now obtained. But at the present stage of the fishery there is no need for improved gear as the traditional vessels and gear are effective enough for taking current catches as well as for expanding the catch. The traditional gear can take a much larger catch if it were more fully employed or if additional units of traditional gear were employed.

The underdeveloped state of the fish processing, marketing and distribution structure has aggravated the underdevelopment of the fishery sector. Also, the fishermen are engaged in other economic activities such as subsistence farming to supplement their meagre fishing incomes. This practise and the lack of developed infrastructure, has led to the inadequate development of specialization and exchange between the fishery sector and other sectors in the economy. As such, the fishery sector has remained incapable of attaining high levels of productivity.

The following Table VII shows some supplementary village economic activities in some three Ujamaa fishing villages in Kigoma Region.

Table VII: Supplementary Economic Activities in three Ujamaa Fishing villages, 1975.

Name of Ujamaa Village	Estimated total Income from fishing (Tanzania shillings)	Supplementary economic activities	Estimated income from supplementary economic activities (Tanzania shillings)
Mtanga	3,126,000	shop hotel farming	1,000 500 400
Zashe	1,152,000	shop farming	2,000 -
Kibirizi	1,566,000	shop hotel farming	3,000 2,000 -

Source: Costs and Earnings Survey in Five Ujamaa Fishing Villages on Lake Tanganyika, X. Mapunda.

As shown by Table VII, supplementary incomes in these villages is negligible. All villages along the lake undertake both activities, subsistence fishing and farming. In some villages, farming is only for the production of food crops for consumption in the village. In others, farming is undertaken as a source of income. Hence fishing remains a part time job and the main source of income for all the villages.

The Traditional Social Structure

In order to understand the economic structure of the traditional fishing industry, one has to understand the social structure of the villages in which the fishing operations are carried out.

Historically, the hereditary political systems in most parts of Tanzania vested authority in the chief, who was the absolute owner of all land.[1] Normally, the chief would appoint his sons as headmen in villages wherein they would exercise subordinate judicial and executive powers delegated to them by him. They would exercise these powers in collaboration with village elders. Figure III below shows the administrative structure under the traditional system. Thus the rights of the village headman in relation to land allocation or the hearing of cases were derived from the chief whose representative he was and by whom he could be appointed or dismissed.

Below the chief were 'councils of states', comprising elders whose duties were to select new chiefs following deaths of chiefs and advise them on matters of security, economics and social welfare of the chiefdoms.

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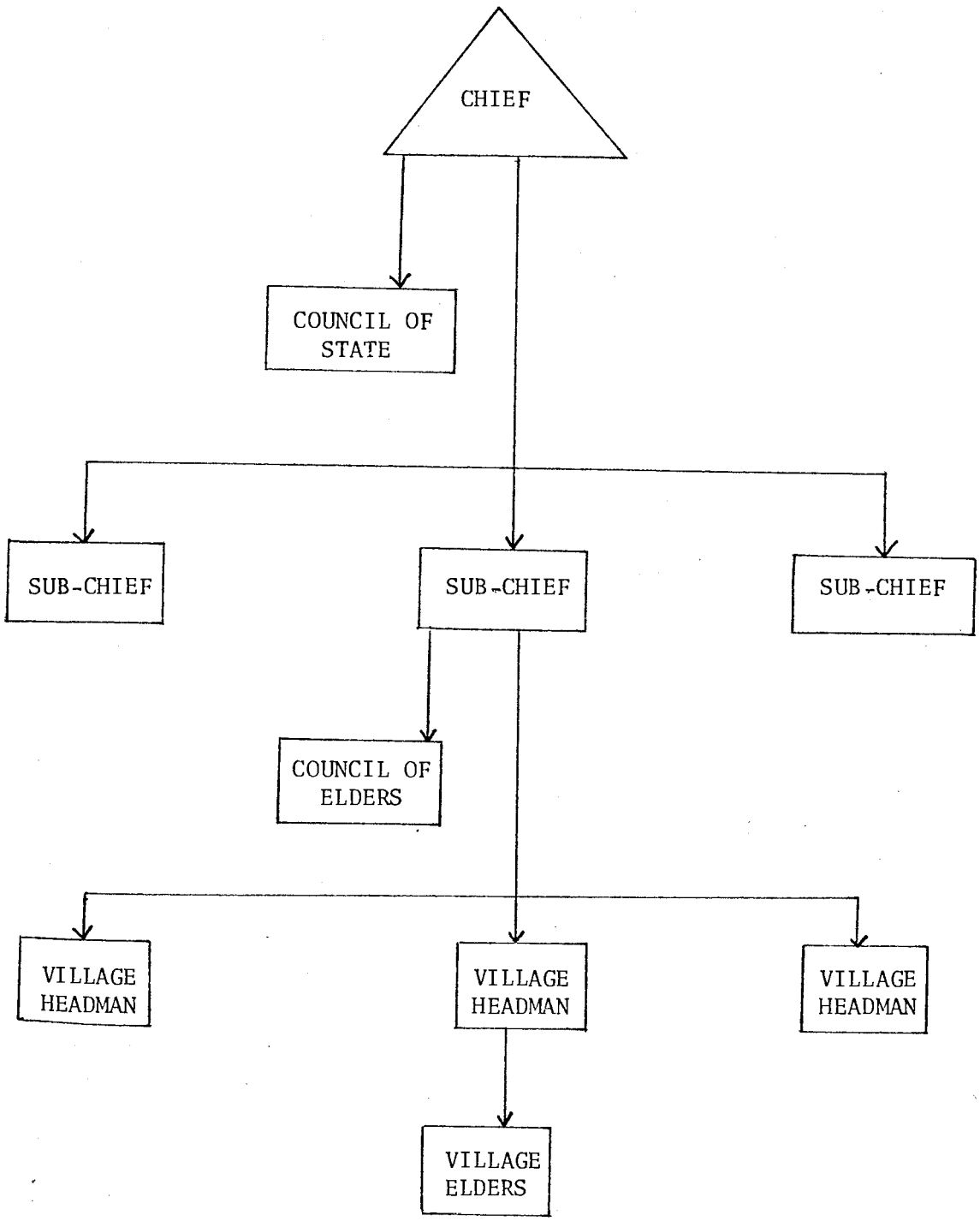
1. See Malcolm (1965, 20-32). The description applies to most areas of Tanzania.

Figure III: The Administrative Structure under the Traditional System



As population grew, the administrative chain containing only two links, the chief and the village headmen, became too short and a chief's son, instead of becoming a village headman, was sometimes given a block of country of which he became the 'small chief', under the paramount authority of the parent chiefdom.[1] The rights of cultivation, control and disposal attaching to the position of the chief were delegated to the village headman. There were some exceptions such as the right of eviction which remained in the hands of the chief himself.

To maintain the chiefdom, dues were collected from individual households. Tribute varied with the harvest, but in normal years it amounted to a basketful of grain. Along the shores of Lake Tanganyika, dried or smoked fish was also accepted as dues. The supplies served to replenish the chief's stores from which his household and retainers were fed. Also, the chief would make contracts for cultivation with the village societies.[2] Along Lake Tanganyika, it is told by elders, that fishing contracts were also made as described later in this section.

"The villages were usually small, the needs of mutual assistance were met by personal arrangement. The village headman and the elders helped with such small matters of organization as did arise. If the village was considerable and the population increased to a number sufficient to preclude the possiblity of making all arrangements for mutual assistance by personal contact, some organization became necessary. To meet this need some village

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1 See Figure III page 18.

2 These were work agreements between the chief and the villagers, or between a villager and the rest of the people in the village. At the time of hoeing, for example, someone may require assistance. He could inform the village work leader that he has a sheet or goat with which he is willing to pay for cultivation in a certain field. The village work leader would settle the contract and call the members of the village to work on the field.

associations were formed for security and defense of the village, health etc. But the most important one was the "work association". This consisted of young men of the working age group and elders as advisers (Malcolm, 1965, 33-61). The actual number of associations within a village depended on the size of a village. The associations had leaders whose primary function was to organize collective work. Besides agricultural work, the associations constructed the majority of new houses. Some materials may be collected by the man for whom the house is to be built, but usually he would receive considerable assistance with the collection of poles, grass, string and the like, as well as with building. In fishing, assistance would be provided in net construction and mending of a new beach seine net as well as in its operations.

The typical pattern of groups to be found in the villages consisted of a man with two to four wives and their children. When the children are full grown they seldom remained at home long after marriage. The new families would usually move to found new homesteads elsewhere unless there was abundant land in the village.

The Lake Tanganyika villages operated with the structure described. They were scattered settlements where a number of fishing families lived in close proximity to each other. They were small and their size depended on the number of persons in the extended family unit or lineage that constituted the village. An extended family consists of a nuclear family plus other members from outside like nieces, nephews, uncles, etc. each of whom cares for the others.

The villages were located close to the beaches and adjacent to or in close proximity to their farmland (Georgulas, 1962, 8-16). There were no formal surveyed or registered boundaries that defined the extent of the

scattered traditional villages. The internal economy of each village varied from season to season, according in part to the extent of cultivation and fishing during a particular season, the weather and the resulting harvest.

Fishing was usually carried out on an individual or family basis rather than on a communal basis. Members of the same family would use equipment in common. On some occasions, communal fishery operations would be carried out. This was the case if one family owned a beach seine net that required many men to operate.

During the colonial period, the traditional administrative powers changed. Authority was no longer vested in the chief. Chiefs worked for the colonial government. However, the traditional administrative structure remained much the same with more or less the same administrative functions. The main difference was that the chiefs, sub-chiefs and headmen could only be appointed with the approval of the district colonial administrative officers.

Colonialism introduced into the villages and in the whole of Tanzanian society a system of production for cash. Thus modern relations of production became associated with the traditional economic and social forms of relations. The villages were small and remained scattered settlements with fishing being carried out mostly on individual basis rather than on a communal basis (Szentes, 1971). More fish was sold for cash than barter and fishermen produced more of a surplus of fish for trading than before. The colonial period witnessed a greater cash economy and a greater trading surplus.

The Ujamaa System

Involvement in the cash economy during the colonial period (1884-1961) led to a progressive dissolution of the bonds of solidarity that constituted

the substance of traditional Tanzanian society. It was against this background that in 1967 the Tanzanian government introduced with the Arusha declaration Ujamaa villages, using forces outside the traditional social structure. The Arusha declaration was a policy declared by the ruling party (TANU - Tanganyika African National Union) that was designed to enhance political, social and economic development of the country. It has since then become the cornerstone of Tanzania's development policies.

Ujamaa villages literally means villages based on community living. They are meant to be self-reliant, socialistic and democratic institutions.

The major objective of the Ujamaa policy is to promote a rapid development in agricultural production to secure for the rural population clearly visible gains in material well-being (Svendsen, 1969, 273). This implies more and better food, housing, clothing and dispensaries. It also means the development of a new social life for rural communities using Ujamaa villages as institutions to effect the transformation. The villages on Lake Tanganyika were intended to operate as democratic fishing institutions. Starting from 1967 up to 1974 the process of establishing Ujamaa villages was gradual. In 1975, there was a movement of the whole population of Tanzania into concentrated Ujamaa villages by government directive.

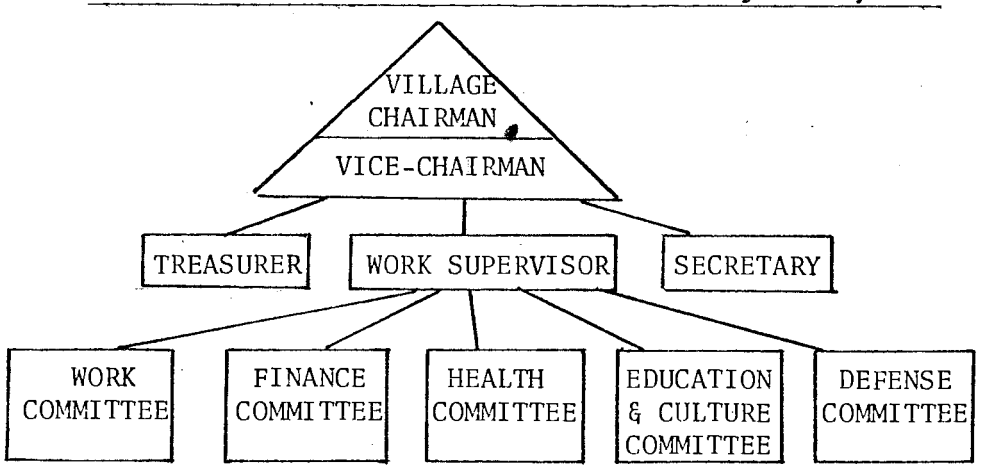
In the process of moving the Ujamaa organization the number of villages was greatly reduced. Over 1000 traditional villages on the Tanzanian lakeshore were reduced to about 100 villages. All of these carry out activities in the manner described in this section.

The purpose of the resettlement was to get a smaller number of larger villages that would act as future poles of economic growth and hence accelerate rural economic development. Under the Ujamaa structure, the village is governed by an elected chairman, secretary-treasurer and an

appointed work supervisor. The latter in conjunction with committees, each of which is charged with responsibility for a particular aspect of village affairs, ranging from work to education and health. The committees are run entirely by the villagers. Arrangements vary widely from village to village. Many villages do not have a complicated committee structure. Instead they rely on frequent general meetings to supervise the management of village affairs (Svendsen, 1969). Figure IV below shows the administrative structure under the Ujamaa system.

A particularly crucial aspect of Ujamaa village life is work organization. In most Ujamaa villages, almost all work from cultivation to building is done communally. Fishing is still being conducted on an individual basis, and government policy is to develop communal fishing in the villages. However, there is no single system of organization. In some villages all villagers work together at the task of the moment. In some they work in teams, each of which has a particular responsibility.

Figure IV: The Administrative Structure Under the Ujamaa System



NB: The administrative structure may vary from village to village. Usually the Work Supervisor would be an educated person who is capable of advising and implementing the various committee programs in the village.

In others they retain a piece work system. This means that everyone gets the same amount of work to be done. If anybody finishes up faster than others he has more time off to attend to personal matters.

Ujamaa is thus a break with the old traditional village system that was characterized by family groupings rather than planned gathered settlements. Even in agricultural Ujamaa villages, the subsistence farmers retain individual plots for farming. In some villages, farmers use the produce that goes to them directly from their plots for household consumption as well as for selling them to the market. In others, the crops grown are only for household consumption while fishing remains the sole source of income. The same applies to the crops grown communally. They may be sold either communally to the market or distributed to the villagers in kind depending on the village needs of the time. Fish caught in lusenga nets is owned individually and sold directly to traders by fishermen themselves. With colonialism, the traditional forms of fishing were transformed by the cash economy. There was a greater cash economy and trading during the colonial period. What Ujamaa has done is to maintain the old forms of traditional society such as communal farming while still leaving fishing to be carried out mainly on individual basis.

In most of the villages under Ujamaa, most of the gear is owned individually and some communally. Fishermen have tended to put more effort in fishing for themselves using their individual gear than in fishing communally. This is because fishermen benefit themselves by spending more time on the fishery for which they get the entire catch for themselves.

The present traditional fishing techniques which are mostly based on two-men canoes, are suited to individual fishing rather than to collective fishing. Ujamaa policy encourages collective fishing by emphasizing beach

seine fishing both for sardines and big fish in order to employ as many of the fishermen as possible together, while the remaining fishermen work with their own gear. Although beach seining is a labour intensive fishing technique that can employ most of the fishermen at this stage of the fishery, some of the figures that are available tend to suggest that productivity of beach seine is low and is therefore unwise to move to it (refer Table XII page 54).

The implementation of the Ujamaa policy has encountered many problems. Apart from the social dislocation from which many families had suffered in the process of consolidating the villages, the most serious problem was the reduction in the total number of fishermen from 16,557 in 1974 to 12,369 in 1975. This resulted from the departure of non-Tanzanian fishermen. One major effect of Ujamaa with regard to collective fishing has been the initial reduction in output in most of the villages as shown on Table VIII of this chapter. Fishermen who for a long time had fished for themselves found it hard to accept the idea of collective fishing which the Ujamaa policy puts emphasis on.

Table VIII: Lake Tanganyika - Annual Fish Catch in Seven Sampled Consolidated Old Ujamaa Villages (in metric tons)

Village	1968	1969	1970	1971	1972	1973	1974	1975
Kagunga	1758	574		3950	7303	4880	5999	3966
Mwamgongo	158	324		11693	4276	3354	6566	2769
Ilagala	7137	258		1432	5038	10636	2638	2408
Mgondozi	4178	1842		12536	16752	9573	16845	12674
Kala	1063	523		1101	1101	2613	10126	5677
Kasanga	114	73		209	209	1946	1904	1432
Karema	5208	545		203	308	455	370	275
Total	20616	4139		31124	34987	33457	44448	29201

Source: Annual Report of Fisheries Division 1975 - Dar es Salaam

* Data for 1970 is not available.

1974 was characterized by fall in production in every sector of the economy due to resettlement into Ujamaa villages. Zaire nationals who had been moved into villages left the industry for Zaire in protest against the policy. It should be noted that 1974 was the year for mass resettlement into Ujamaa villages. Prior to 1974 less than ten villages along the lake operated on Ujamaa principles as described previously.

The belief and hope of Tanzanians in introducing the Ujamaa system is that productivity can be increased because of the following reasons. The improved education facilities, social ammenities and constant contacts with towns has begun giving the villagers a much better chance to acquire skills, attitudes and experience that could help them to increase productivity in the future.

On the whole, to most Tanzanians, Ujamaa village life is a new and complicated experience as it differs from the traditional system. The web of social relations and contacts in which the Ujamaa village places them is an intricate one. It has generated stresses and strains. This is particularly true, since in an Ujamaa village, fishermen not only fish together, but live together as well, practising a form of cooperation more intimate than the traditional forms.

Markets and Distribution

The total amount of fish that is marketed from Kigoma Region is estimated to be 38,104 metric tons. This excludes the amount consumed by crews and boat owners (Refer to Table IX). An amount of 2,500 metric tons is kept by crews for consumption and another 2,396 metric tons by boat owners for consumption in their households. About 15,500 metric tons are sold locally and 17,500 metric tons are sold to other regions in Tanzania. An estimated amount of 10,000 metric tons is sold in illegal trade in other countries (Midtgaard, 1975).

Close to 80% of the fish is sold as dried fish and close to 20% as fresh fish and smaller amounts are smoked (Smart, 1975). More of the fish sold consist of sardines (32,000 metric tons) and less of other species. Sardines are sold in other regions and in the illegal trade with neighbouring countries as dried fish. Fresh fish and smoked fish are sold locally along the lakeshore.

Information provided by a pilot survey conducted in Kigoma Region by the Lake Tanganyika Fisheries Research and Development Project shows that the coastal belt, limited to some 10 kilometres belt from the lakeshore inland, has a relatively high consumption of all fish. This is estimated to be about 12% of the total output from the Tanzanian portion of the lake. The following Table IX shows the estimated catch from Kigoma, values and per capita consumption in 1975. The survey was carried out in Kigoma district alone of Kigoma Region.

Table IX: Estimated Catch and Distribution of Fish from Kigoma Region including Estimated Values and Per Capita Consumption, 1975 (Wet Weight in Metric Tons)

	Dagaa	Other Species	Total
Total Catch in Kigoma Region	40,000	3,000	43,000
Consumption in Kigoma District, 10km. belt along lakeshore, 83,000 people at rate of 57 kg.	4,200	800	5,000
20 km. belt along railway, 32,000 people at rate of 30 kg.	800	200	1,000
Rest of the District, 41,000 people at rate of 30 kg.	1,400	100	1,500
Total for Kigoma District, 156,000 people	6,400	1,100	7,500
Consumption, rest of Kigoma Region, 377,000 persons at rate of 20 kg.	7,300	700	8,000

	Dagaa	Other Species	Total
Total Consumption Kigoma Region, 533,000 people	13,700	1,800	15,500
Distribution to other regions	16,800	700	17,500
Illegal Export	9,500	500	10,000
Total Catch on Lake Tanganyika, Kigoma Region	40,000	3,000	43,000

Value of fish sold, excluding crew consumption of 2,500 metric tons is Tshi	32,562,000
4/5 to 2,396 boat owners at the average of Tsh. 10,900	26,562,000
1/5 to 7,244 crew members at the average of Tsh. 900	6,520,000

At estimated wholesale price of . . .	Tsh. 1.50	Tsh. 3.39	
The wholesale value is Tsh.	60,480,000	9,153,000	69,633,000
Less payment to fishermen, Tsh.	26,460,000	6,102,000	32,562,000
Gross profit, Tsh.	34,020,000	3,051,000	37,071,000

Estimated transportation costs, Tsh.		22,325,000
Estimated loss, 10% of wholesale value, Tsh.	6,963,000	29,288,000
Net profits Tsh.		7,783,000

Source: Midtgaard, 1975. Marketing of Fish from Lake Tanganyika.

The annual consumption of all fish estimated by Midtgaard is 57 kilograms per capita in the coastal belt and is about 20 kilograms per capita in the hinterland. The villages close to the Central railway line and those close to Kigoma town have an estimated consumption of about 30 kilograms per capita. Areas of the hinterland receive small quantities only due to the poor communications and lack of purchasing power.

The trading centres of Kigoma and Kipili receive at present most of the

fish caught, mostly in the form of dried sardines. The sardines are transported to these centres by water taxis from the various fishing villages along the lakeshore by the traders. The traders visit the fishing villages most of the times and buy the fish. They buy the fish mostly from individual fishermen, but also from the Ujamaa villages. At times, some Ujamaa villages and individual fishermen undertake the task of transporting fish to Kigoma and Kipili.

At present there is no established central marketing agency for the villages. Traders buy fish at a low price. Nearby all traders move along the lake by boats (water taxis), with very limited movements by vehicles or on foot. Their visits range from daily to irregularly depending on the demand for fish and distances of the villages from the railway terminal of Kigoma which tend to determine the costs of transportation.

The price for a kilogram of dried sardines that a trader pays a fisherman ranges from Tsh. 6.0 in Kigoma (Stratum 1) to Tsh. 1.50 in (Stratum 7). This is attributed to the variable costs of transporting sardines to the principal trading centre of Kigoma/Ujiji. The cost of transportation for dried sardines by water taxi is Tsh. 0.40 per metric ton per kilometre. Transportation charges must be subtracted from the buying price in Kigoma to determine prices offered to fishermen. This explains the point that prices for fishermen are lower the further from Kigoma. The only exception is at Kipili which is another collection centre for fish on the lake. The traders in the collection centres have for a long time been operating in a kind of a cartel whereby protecting their interests and have managed over a long time to keep competition at a very low level hence operating as a monopsony capable of depressing prices of fishermen's catches.

Although very little detailed information is at present available regarding prices and trade routes of the fish from the traditional fishery, some information is available on the prices for the industrial fishery from the records of Uvuvi Kigoma Company Limited which is a government owned company operating from Kigoma. The landed price of fish in 1975 tended to vary considerably according to supply. Tables IX and X below show the catch composition and the landed price of fish from the industrial purse units.

The tables clearly show that purse seiners catch relatively little dagaa (20%). This is because they use larger mesh size nets which tend to catch sardines of large sizes only while the smaller ones escape easily. Secondly, if they used nets with smaller meshes they would be heavy and occupy more space on the deck and there would be less room left for the crew as well as for storing other equipment on board such as fish bones. The purse seining units are, however, suitable for sardine fishing. This is particularly evident from the figures in Table XI. Out of the total catch by the Greek Purse Seiner 44% consist of sardines. The reported results of the Greek Purse Seiner are unexplained.

The fish products for consumption in Kigoma District are sold by many small retailers in several permanent markets in the railway terminal twin towns of Kigoma and Ujiji. These markets operate throughout the year and have many stalls used exclusively for fish. On the other hand, the village markets are more gatherings of traders on open ground without shelter. The sardines are usually sold in small heaps in such markets ranging from 20 to 250 grams (Midtgaard, 1975).

The domestic demand for fish could increase if supply could extend to the hinterland, inland towns and rural areas of the other regions throughout

Table X: Catch Records and Prices obtained for One to Two Purse Seine Units each towing Five Light Boats (Canoes) for Uvuvi Kigoma Company Ltd, January to July 1975.

	Number of Fishing Days	Stolothrissa & Limnothrissa (dried dagaa)		Limnothrissa & Stolothrissa converted into wet weight		Limnothrissa & Stolothrissa (fresh dagaa)		Luciolates		Lates		Total		Average Catch/Day
1975 January pr. kg.	21	472	2,014 4.27	2,360	2,014 0.86	856	1,139 1.33	17,568	38.935 2.22	2,779	10,190 3.67	23,563	52,278	1,222
February pr. kg.	21	474	1,896 4.00	2,370	1,896 0.80	339	366 1.08	20,320	48,664 2.39	2,930	7,647 2.61	25,959	58,573	1,236
March pr. kg.	22	481	1,368 2.84	2,405	1,368 0.57	127	213 1.68	32,453	69,970 1.97	2,641	9,635 3.65	37,626	75,186	1,710
April pr. kg.	16	247	626 2.53	1,235	626 0.51	--	--	19,170	32,459 1.69	1,992	7,360 3.69	22,397	40,445	1,400
May pr. kg.	17	2,853	10,129 3.55	14,265	10,129 0.71	112	164 1.46	28,017	55,284 1.97	9,063	17,112 1.89	51,457	82,689	3,026
June pr. kg.	16	810	2,876 3.55	4,050	2,876 0.71	2,042	3,805 1.86	8,161	29,647 3.63	4,947	17,203 3.48	19,200	53,351	1,200
July pr. kg.	21	284	1,126 3.96	1,420	1,126 0.79	9,358	13,247 1.42	6,153	25,597 4.16	10,190	35,131 3.45	27,121	75,101	1,291
						40,939		131,842		34,542		207,323	437,803	
						20%		63%		17%		100%		

Source: Midtgaard, 1975. Marketing of Fish from Lake Tanganyika.

Table XI: Catch Records and Prices Obtained for One Greek Style Purse Seine Unit Operated by Master fisherman, E.D. Andrianos, July 1974 to April 1975.

	Number of Fishing Days	Number of Fishing Hours	Stolothrissa and Limnothrissa		Luciolates		L. Microlepis		L. Marie		Other Species		Total		Average Catch/Day
			Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.	Kg.	Tsh.	Kg.
1974 July	23	350	37,940	35,536	5,085	14,116	11,960	18,056	3,926	5,700	70	270	58,981	73,678	2,564
pr. kg.				0.94		2.78		1.51		1.45		3.86		1.25	
August	22	358	54,660	40,678	9,535	16,158	8,671	20,668	2,114	6,525	320	309	75,300	84,338	3,422
pr. kg.				0.74		1.69		2.38		3.09		0.97		1.12	
September	21	326	54,943	32,998	10,518	18,572	5,770	13,828	1,692	5,284	250	419	73,173	71,101	3,484
pr. kg.				0.60		1.77		2.40		3.12		1.68		0.97	
October	21	342	8,014	4,185	8,820	3,884	6,775	6,561	211	6,414	325	660	26,052	21,704	--
pr. kg.				0.52		0.44		0.97		3.03		2.03		0.83	
November	22	327	17,400	9,823	22,397	37,858	3,000	7,101	4,256	12,775	460	1,240	47,513	68,797	2,160
pr. kg.				0.56		1.62		2.37		3.00		2.70		1.45	
December	21	321	32,480	13,379	44,410	45,988	4,240	5,825	6,326	14,399	490	569	87,946	80,160	4,188
pr. kg.				0.41		1.04		1.37		2.28		1.16		0.91	
1975 Jan.	21	299	30,380	12,311	16,150	28,126	1,426	3,312	3,566	10,162	305	402	51,827	54,313	2,468
pr. kg.				0.41		1.74		2.32		2.85		1.32		1.05	
February	21	325	9,860	5,608	46,030	59,155	2,107	4,786	6,314	16,254	180	699	64,491	86,502	3,071
pr. kg.				0.57		1.29		2.27		2.57		3.88		1.34	
March	17	242	6,020	2,708	45,150	50,408	2,295	5,083	3,224	8,421	40	393	56,729	67,013	3,337
pr. kg.				0.45		1.12		2.21		2.61		9.83		1.18	
April	16	221	1,240	766	25,315	41,974	2,790	6,707	1,628	5,131	90	231	31,063	54,809	1,941
pr. kg.				0.62		1.66		2.40		3.15		2.57		1.76	
Total			252,937		233,410		49,034		35,164		2,530		573,075	662,415	
			44%		41%		9%		6%				100%		

Source: Midtgaard, 1975. Marketing of Fish from Lake Tanganyika

Tanzania where potential demand is estimated to be 10 times that of Kigoma district (Marketing Research by the Lake Tanganyika Fisheries Research and Development Project). The traders ability to develop these distant markets is limited, mainly due to lack of an adequate transport network. The traders only purchase fish in accordance with the local demand to meet orders they receive from the inland buyers and to maintain a reasonable stock. If there was proper communication with both near and distant markets they would be able to absorb increased catches.

The inadequate communication and lack of transport facilities has tended to create a sensitive market for the fishermen with a low price elasticity of demand as prices fluctuate with the level of daily catches. When catches exceed immediate demand traders increase their stocks. This tends to depress future prices until a period of low landings is reached. As such, fishermen's attempts to increase catches are discouraged as this often leads to fishermen obtaining low prices.

The demand for dried sardines in Tanzania is substantial at the moment. At the same time, there is undoubtedly a lot of additional potential demand in industrial areas, towns and cities as well as in government institutions. (Marketing Research by Lake Tanganyika Fisheries Project). These need only be identified and exploited by maximum utilization of sales possibilities in the areas with sufficient purchasing power at prices ensuring a fair return to fishermen. The quantity of dried sardines sold in international markets, mainly in Zaire and Zambia, is estimated to be 10,000 metric tons per annum.[1] About 1,000 metric tons per annum of dried sardines has been

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1 See Midtgaard, 1975. The official figures 1968 to 1973 report an estimated export of about 5,000 metric tons per year.

shipped by water taxis to Burundi in past years. Official records now show a decline of exports to Burundi as the country has become self-sufficient for dried sardines. Much of the exports are in the form of an illegal trade.[1] Some of the trade with Zaire for example is on a barter basis whereby bags of dried sardines from the Tanzanian portion of the lake are exchanged for textile materials imported into Zaire from France and Belgium. Most traders avoid the red tape of custom formalities and exposure to taxes that they are likely to face if their trade is conducted through the proper legal channels.

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1 Implies the export of dried sardines without a valid official trading licence.

CHAPTER 3: THE FISHERY POTENTIAL OF THE LAKE

Biological Potential

Biological research carried out on Lake Tanganyika indicates a standing stock of 2.5 million metric tons. About 50% of this total is in Tanzania waters and the four countries bordering the lake harvest an amount less than 100,000 metric tons per annum (Johannesson, 1974).

A brief description by Chapman on the limnology of the lake points out that most of the bottom of the lake lies deeper than 500 metres and maximum depth is 1470 metres. He further points out that only the surface up to 200 metres contains oxygen depending on area and season. Internal waves are a lakewide phenomenon (Ferro, 1975). These are important for the nutrient cycle and in influencing fishing behaviour and productivity. Productivity of phytoplankton tends to be associated with seasonal winds, internal waves and upwelling. An annual peak in productivity develops earlier in the southern end of the lake (August) and progresses northwards attaining a maximum in the northern end of the lake in October. This tends to be related to the onset of strong winds earlier in the southern part of the lake.

Sardines in catches are about four inches long and their predators (Luciolates and Lates) 20" to 30" long. As for the sardines, fish of a probable five to six months of age make up the bulk of the catch. At between 7-12 months any given cohort declines to zero. Thus, life span appears to be under a year (Chapman, 1976).

The results of biological sampling programs designed to assess the distribution and abundance of exploitable fish stock in Tanzania waters indicates that exploitable stocks exist throughout the Tanzania waters. Because of the upwelling brought on by monsoon winds, the high level of

organic material accumulated and the extreme depth and volume of the lake (second deepest lake in the world), biological productivity tends to be high. Because of the very steep slope and the virtual absence of shelf, most of the fish found in the lake are pelagic or surface associated.

Of the two sardine species (See Chapter 2 on fish stocks) the more important one is Stolothrissa. This species cycles in abundance from a low in April-May to a high in November-December. This cycle occurs in Zambia, Burundi and Tanzania at the same time. Stolothrissa has a maximum length of 89mm. and an annual mortality rate of 99.5%. Its spawning period is January to April and recruitment to the fishery begins at the age 2-3 months or when about 50mm. Chapman and Van Well, point out that the stock turns over rapidly and can stand a very heavy exploitation rate of 50-60% of the biomass per year. This suggests that the MSY for Stolothrissa is 50-60% of the biomass.

The other sardine species is Limnothrissa. Limnothrissa sardines tend to live in shore when under 60mm. The territorial waters of Burundi and Zambia provide excellent rearing habitat for the young fish (Coulter, 1968). Spawning takes place twice a year in the Tanzania waters (December-February and August-September). The mean length of this species in catches is 116mm. Limnothrissa species do not contribute heavily to the total catch of sardines in Tanzania waters although they make up 40% of chupeid catches in Burundi.

Luciolates species make up about 15% of the catch of the traditional fishery and about 50% of the industrial fishery (Tables X and XI). They move shoreward in October-November from the offshore nursery areas. Recruitment of this fish species is at 1.5 years when they are about 18cm. long. When about two years they have a mean length of 27cm. and at this size, they start spawning.

Lates species have a period of maximum abundance in February to April when spawning occurs for L. marie and L. microlepis. Maximum size is about 74 cm. for L. marie, 85 cm. for L. microlepis and over 100 cm. for L. angustifrons. Larvae of all the three species appear to leave pelagic life at 1-2 cm., moving to shoreline areas where they remain until they reach 18-20 cm, then return to pelagic life. These lates species have been fished to a low abundance in Zambia and Burundi but are under exploited in the Tanzania waters (Chapman, 1976).

Big Nile Perch over 100 lb. and up to 150 lb. are occasionally caught. Most of the larger fish caught are consumed locally.

Fishing Capacity

To utilize the available fish stocks more fully it is necessary to improve conditions both with respect to supply and with respect to demand for fish so that a greater volume of catch can be achieved. In this section, the discussion is on what is necessary to improve supply conditions.

There are a number of ways of increasing the fish supply. Fishermen could fish larger number of days with existing boats or could go fishing on more productive fishing grounds. Fishermen could move to more productive techniques e.g. purse seiners. Also, the fishery could employ larger numbers of fishermen and boats. The order aspect of increasing supply is to give fishermen an incentive to fish for the market rather than primarily for subsistence, supplementing their catches by cereals grown on their small plots of land around their homes. Fishermen at the present time spend only a small part of their time as fishermen and a substantial part of their time as subsistence farmers, so they have a subsistence income of some fish and cereals for themselves. In order to become more productive, it is necessary that fishermen spend a larger part of their time fishing, specialize and

increase their fishing productivity. This could mean they would have less time to work as farmers and this could mean that they would have to use some of the cash they would have earned from their larger sales of fish to buy agricultural produce for themselves.

An incentive for the fishermen can be achieved in two ways. By offering fishermen higher prices for larger amounts of fish so that they can sell more fish. The only way to offer higher price to fishermen and the way to offer to buy more fish from them is to improve markets so that they can absorb more fish. Also to improve distributional efficiency so that there is more money left over for the fishermen.

In order for fishermen to get more fish for the market they have to increase the catch with existing equipment. This is by increasing the number of fishing days. At present, an average canoe fishes for 14 nights of the month. This is partly due to fish migrations and moonlight nights when the fishing is poor. But it is also partly due to the fishermen adjusting their landings to the traditional market requirement in order to avoid low prices when the demand for fish is low. In periods of over supply traders don't want any more fish and pay a low price to fishermen. Hence more fish would be caught and made available if fishermen were able to sell all the fish caught at good prices.

Fuller exploitation of the stocks in order to increase catches and revenue could possibly be achieved by fishermen exploiting the most productive fishing grounds even if such grounds are known to exist in places distant from their homes. This means fishermen have to take the trouble of travelling back and forth and spending part of the fishing days in the distant productive fishing grounds. They may find it advantageous to do so although this may mean that they won't be able to see their families for a few days

during which they are away. Putting outboard engines on canoes would enable fishermen to get to these distant fishing grounds in good time for fishing and return home in time after fishing.

For future expansion of the fishery there may be many difficulties in harvesting and utilizing the considerable stocks of fish. These might include the limitation of funds for investment in efficient fishing boats, gear, landing facilities such as piers, fish receiving stations, processing plants, transport facilities such as insulated railway wagons, fish carrier boats and lorries. Difficulties might also arise in raising output of the less productive strata 3-7 whose output of fish is costly to transport to Kigoma because of the long distances involved.

Processing

If increased harvests of fish are to be marketed effectively they would have to be appropriately processed. The better the product after processing and the lower the cost of processing the easier it would be to sell the product. Then, what has to be done is to improve the processing sector to make a better product and to do so at a low cost.

The traditional method of processing involves the drying of sardines on either the beach or flat ground near the shore. When the dried product is gathered from the ground and packed a high percentage of sand and stones get mixed with the product. During the rainy seasons drying of sardines becomes very difficult. Catches landed can take several days to dry, and consequently the product is inferior. The problem has been tackled in the industrial sector, where they have used drying racks. However, they have run into marketing problems. This is assumed to be due to the improved product not having a distinctive packer, which precludes any regular increment in price over the traditional product. The solution is for the

government to introduce a grading system that is well recognized with a government stamp of approval. This would involve checking on quality and would require government inspection system and only if the product measures up to quality would the inspectors allow them to be packed with a distinctive label. There ought to be an information or advertising campaign to inform consumers that a product with a particular kind of packaging with a government stamp is of first quality.

Since the intensity of fishing is reduced in the traditional sector during the rainy season because of the difficulty of drying sardines, it appears that introduction of drying racks with portable covers using local materials, e.g. timber poles, would reduce the costs in processing relative to the present use of imported drying racks.

Small quantities of larger fish including lates and luciolates are smoked over fires before transport to market. Most are sold out immediately after catch without any preservation. That limits the market to local communities. In order to expand the market a different marketing technique that will use some form of preservation will have to be employed. These could include smoking, icing and freezing. But icing of fish would give limited preservation and no ice is presently available for marketing fish except in Kigoma and there only in limited quantities.

Freezing is an expensive technique to undertake at this stage of the fishery, and there are no freezing facilities along the lake except at the fish receiving station at Kigoma. Some canning trials for Lake Tanganyika fish were conducted in 1962 (Bencjon, 1963). Taste panels gave a general preference for luciolates and lates fillets, canned sardines (in tomato sauce) was not favoured to the same extent. Investigations into the economics of the canning operation in 1964 showed that there was insufficient

demand in Tanzania and other parts of East Africa for canned sardines costing over 2,000 % more than the price paid to the fishermen. Considering the fact that sardines are relatively low value fish species, the prospects of commercially profitable canning operations adding a considerable amount to the price of the initial product is highly unlikely to be bright.

Marketing

Marketing is important to allow for greater utilization of the available resources. It is the key factor at this present stage in expanding the fishing industry.

Several constraints hinder the utilization of the available resources. One of them is the limited purchasing power of the rural population which creates difficulties in obtaining prices for fish high enough for the fishermen and the traders. Hence full utilization of the resources cannot be realized unless it is proved to the fishermen that it can pay them to increase catches.

In view of this situation, it is logical to point out that a fish marketing board could be an appropriate body to provide guaranteed prices and improve fish trade for the fishery industry as the estimated reserve catch capacity could indeed be sufficient to fulfill domestic and export market demands if a proper marketing infrastructure is established. This implies improvement of lake transport and marketing facilities from the villages in order to exploit the potential demand in the domestic and international markets. Such marketing boards tend to be effective in so far as they can hold over surplus catches from some periods and make them available at some other periods. Also, such boards would expand markets so that the overall output of fish can be increased.

The marketing system which includes the processing (drying of sardines)

and distribution of sardines in the fishing villages and the transportation of surplus to distribution centres as well as the handling and processing in the distribution centres could be restructured further. The second part of the marketing system, the trade and distribution centres which consists of the wholesale system (private wholesalers) and operates by the principle of profit maximization could operate with a parallel system of marketing by a government parastatal organization like TAFICO.[1] This would give competition to the private wholesalers and retailers and might encourage them to be more efficient or else they would lose trade to the government agency. Tafico (Tanzania Fishing Corporation) whose role is to exploit and market the fishing resources from all Tanzania waters. At present Tafico operates jointly with the other industrial purse seining units in the country by owning some shares in such companies. Tafico's other main objective is to promote and increase fishing activities in Tanzania waters in order to exploit the potential demand in domestic and international markets.

For Tafico's efforts to be a success, requires an improvement in the marketing structure. To do so, TAFICO and the two district development corporations along the lake (Mpanda and Kigoma district corporations) should see to it that demand and supply both are increased. Balancing of supply and demand at a higher volume of production and sales. The strategy of achieving this is to concentrate on the demand side as the supply of fish can be increased easily if there is an effective demand for additional fish.

Prices are at present set in the towns and villages by the Price Commissioners rather arbitrarily. Under the free market system, the price

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1 Tanzania Fishing Corporation is a government parastatal body responsible for exploiting the fishery resources in all Tanzania waters in cooperation with district development corporations.

mechanism sees to it that supply and demand are balanced. In a situation where prices are fixed there is a tendency for the price to be above or under the market level. If the price is set below the market price, one finds the demand at the low price exceeding what suppliers are prepared to make available at such low prices. However, in some cases a reduction in prices by the Price Commissioner may be beneficial and workable. The Tanzanian situation is that the market is often fragmented and that traders in particular areas tend to have local control of the market and therefore act as monopolists and hence get a higher price than would prevail in a market where there are many sellers in competition with one another. Reducing the price to the level that would prevail under competition would seem in order. This might even increase supplies in response to the higher demand that would come with a lower price.

In order to realize greater utilization of the lake's potential, storage facilities would be required so that an adequate stock of fish can always be kept near the market, so that supply needs of the market can be taken care of effectively. The marketing situation could be improved if depots could be built up throughout the country that would partially eliminate price fluctuation problem. Depots could hold stocks so that there would be a constant market supply instead of periodically running out of fish because of lack of storage capacity to hold enough fish. Although this would require additional capital investment, the provision of a smaller number of strategically sited fish depots with a comprehensive communication system linking them to the fish markets (lakeshore) would be an alternative to an extensive system of fish depots throughout the country. The advantage of smaller numbers of depots that would require lower capital and operating costs to take care of a smaller number of depots than that would take for a large

number of depots. This would also require a proper system of communication and exchange of information in order to keep the depots stocked. This would lead to the development of increased fish consumption. This is especially so in view of the fact that as the catches change daily, it becomes difficult without a proper information system to know to what extent the demands in the consuming areas are satisfied. This results in the demand for fish very often not being satisfied and the consumers often having to buy substitute commodities, e.g. meat. In general, the real problem is that not enough protein is being obtained and therefore both more meat and fish is called for at costs that are reflected in prices that Tanzanians can afford to pay.

The present use of water taxis to transport fish from villages to collection centres could be further improved by installing in them inboard engines in order to enable fishermen to move faster and make more trips per month and therefore be able to move more goods. Tug boats and barges could be introduced for shipping dried sardines to the collection centres and for bringing supplies to the fishing villages. These modes of transport could help to improve the marketing structure along the lake.

The steamer Liemba, responsible for transporting passengers and supplies to various villages on the Tanzanian shoreline of the lake should be utilized for transporting dried sardines as well as fresh fish if cold and freezing chambers are installed. The carrying capacity on the lake could be increased by increasing the number of water taxis and barges if success is achieved in expanding market for fish, Because fresh fish is expensive to transport, more expensive than dried fish , then what is needed is to keep the distance of transporting fresh fish to a minimum. Because Kigoma is the main market and distribution centre, the need for transportation of fresh

fish will be reduced if the fresh fish is produced directly in Kigoma area. Therefore the fresh fish need not be transported from the outlying areas to Kigoma. This then will cut down on fresh fish transportation cost.

Furthermore, greater utilization of the potential of Lake Tanganyika could be achieved if export of fish to international markets (Zaire and Zambia) is encouraged. This is so because of the fact that even though the trade at the present time is not expanded it is economically profitable enough for traders to engage it. This could be done without restricting the domestic supply. This is because both the stocks and the fishing capacity are so underutilized. Total fishing output could be greatly increased to supply both domestic and foreign markets.

Supplies of sardines for example from Stratums 3-7 could be marketed in Zambia and Zaire as they are close to these countries while Stratums 1-2 could supply the domestic market. The demand for fish in Zaire and Zambia is believed to be very high (Beatty, D. 1969) and a substantial surplus from the Tanzania portion of the lake could easily be absorbed if proper marketing is accomplished, the communication system e.g. roads and water transport are improved and extended to these neighbouring countries. The cheapest means would be water transport across the lake. A few more steamers on the lake like the Liemba would improve the carrying capacity.

The export trade is carried out at two levels. First by traders who export sardines to Zambia and possess valid export licenses from the Fisheries department. These traders undertake the trouble of going through custom formalities. Having delivered their sardines to their agents in Zambia they are paid in hard currency (US dollar cheques) which they have to surrender to any bank branch on arrival in Tanzania. Traders who follow this procedure are subjected to income tax and are said to be engaged in a

legal trade as their sales records can be easily traced by the government.

The second level of the export trade is carried out by traders who do not possess valid licenses. These export sardines as well and get paid in kind mainly on a barter basis. Such traders may evade income tax as their sales records are hard to find. This kind of trade is discouraged by the government and is termed 'illegal trade'.

Considerable quantities of dried sardines have been exported illegally over many years from the Tanzania sector of the lake to neighbouring countries. The main trade has been to Mpulungu in Zambia where imports from Tanzania supplements the local catches of the same specie locally known as (kapenta). Such trade was carried out using locally made water taxis. The bulk of the legal fish trade from Tanzania was landed from the S.S. Liemba, until it ceased trading in 1972 due to mechanical breakdown. A Zambian report of this trade in 1969 states "Much of the kapenta imported into Zambia was of a very poor quality, being on occasions insufficiently dired and infested with insects, often it was full of sand and on many occasions it had been been dried after the fish had gone bad, poor quality kapenta has a bitter taste". Although buyers in Zambia demanded that high quality kapenta be sold, yet poor quality fish continued to be exported. This made sense because kapenta in Zimbabwe (Rhodesia) exported through Zambia, for instance, was sold to Boer farmers at a more or less fixed price of one US dollar per pound and they gave it to their employees as rations. The Boer farmers were not concerned with quality as long as the product had no bad smell (Smart, 1976 and Beatty, 1969). It is worth pointing out that the poor quality kapenta was exported because the trading system in Tanzania is not yet capable of distinguishing and paying for different grades of fish. If good quality kapenta was produced in Tanzania there would be an additional market

to supply in Zambia itself because of the demand for better quality kapenta and therefore total exports could be increased. There has been a considerable increase of such exports. The trade is conducted on a barter basis. Reliable information indicates that the price per pound of dried sardines in Zaire is about one US dollar, (Marketing research by Lake Tanganyika Fisheries Research and Development Project).

A level of about 1,000 tons per annum of dried sardines has been shipped by water taxis to Burundi in the past ten years although such records now show a decline of exports to Burundi (Custom records in Bujumbura, Burundi). This is because Burundi fishermen have come to fish in the good fishing areas of Tanzania in the northern part of the lake because of the dense stocks in Tanzania waters and hence catch per unit of effort is high in Tanzania. This has tended to reduce the dependence on imports of sardines from Tanzania. However, increased fishing in Tanzania waters and improvements in the Burundi fisheries have almost made the country self-sufficient in the cheaper varieties of fish. Burundi is now looking for export markets for dried sardines in Ruanda and northern Zaire in order to market the expected 40% increase in production during the next five years.

International Aspects

The level of fisheries development differs among the four countries on Lake Tanganyika. The Republic of Burundi; possesses important fisheries in her sector of Lake Tanganyika and smaller fisheries in interior lakes. By early 1970's her fishing effort and landings had reached approximately 1459 canoes producing an estimated 5,966 tons per annum (fresh landed weight), 516 catamarans yielding 4,876 tons per annum and 15 purse seiners landing 4,540 tons per annum. Annual yields amount to 15,382 tons.

Current production of fish of the Tanzanian portion of the lake is about 53,000 metric tons (Bazigos, 1975). This is thought to be the major part of the lake's total catch.

The Zaire sector is the largest sector of the lake. The fishery is generally very underdeveloped except around Kalemie, a railhead, where about 10 purse seiners operate. Zaire has no priority to develop the fisheries sector and total fish production on the Zaire zone of the lake is unknown but could be below that of Burundi.

In Zambia, the UNDP/FAO fisheries project at Chilanga is the responsible body for all the waters of the country. Little indeed of this project's effort has been geared directly to Lake Tanganyika where research and development programs have been under government supervision since 1960. About 80% of the 6,000 metric tons harvest recorded annually for the Zambian portion of the lake consists of sardines (locally called kapenta-dagaa) half of which is caught by the traditional lusenga fishery. It is clear from the above summary of activities on the lake that the four regions of the lake are being exploited in different ways and at different levels. While at the present time there is no danger of over exploitation and no great need for conservation, there are reasons for the four countries to work together. The reasons are that in the future when stocks are more fully exploited they will have to consider conservation and they will have to consider limiting fishing effort.

For future utilization of the lake when the stocks will become more utilized, then, competition among the four countries for the available stocks will appear. Each of them will try to increase its catch by taking fish away from the others and eventually fishermen will get lower catches per unit of effort. Improvements can be made by way of limitation of effort

in the case of over-exploitation. Conservation measures need biological research to get a better idea of how conservation can be carried out. Biological research would require cooperation between the four countries and would save costs in doing it as a joint team rather than have all the work done four times by four different countries acting on their own.

Research could be carried out by the formation of a regional project for the four countries, while development could be carried out separately by the four countries because of the differences in economic development policies in the four countries as well as differences in the level of resources for investment into the fishery. A research project would absorb a large part of the present country project research activities, while limiting much of the development work on the individual countries although it would be essential that there be close coordination between the regional research project and development programmes in each nation. The establishment of a regional project for the four countries would have numerous technical advantages over the current separate national efforts in the same fields.

First, in the stock assessment and biology field, uniformity of data collection methods would be maintained together with the standardization and integration of fishery statistics on a lakewide basis for stock assessment. Such a programme would facilitate the identification of different substocks and evaluation of their interactions and would also result in coordinated research on physical and chemical parameters of the lake environment as it pertains to the fish stocks.

In gear technology, such a project would indeed bring the pooling of more knowledge and the economics of non duplication of effort. Incorporated would be the investigation and improvement of transport and marketing on a lakewide basis to develop trade and trading facilities involving for example

trading vessels and port facilities. If there is to be trade among the four countries then there must be cooperation and coordination in preparing the infrastructure for this trade because it involves more than one country and the countries must agree.

Cost advantages would also be realized. These would include coordination of training programmes through movement and exchange of personnel and facilities. This could further be developed by the establishment of a regional fisheries training centre for the four zones. Undoubtedly economics could be achieved by avoiding duplication of expensive equipment. Other cost advantages would include improved information flow and understanding of ongoing development work in the different national sectors, and the facilitation of movement of research personnel between nation sectors on the lake.

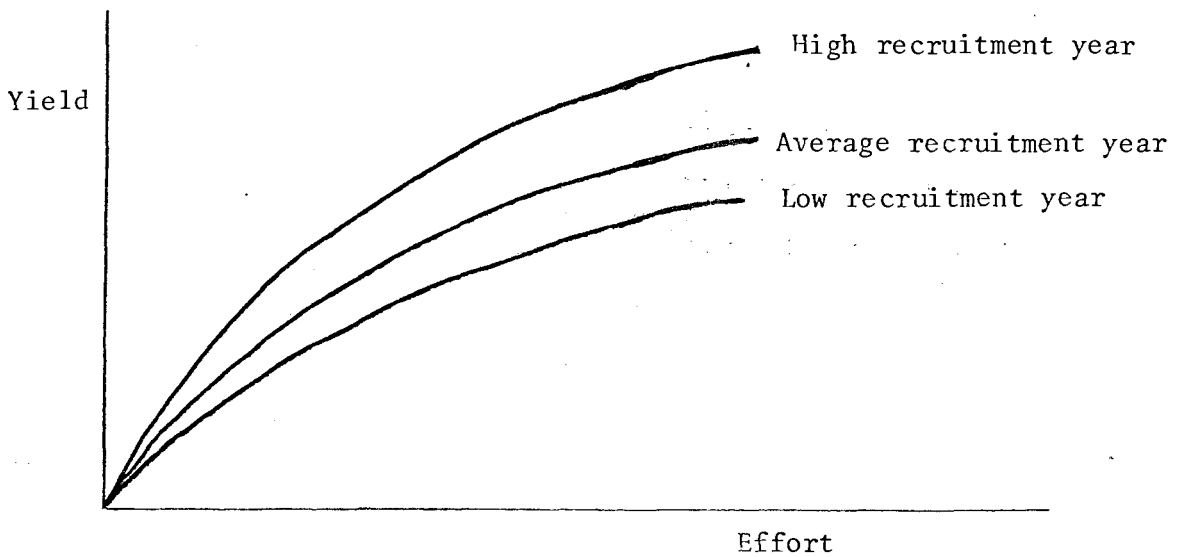
Although the idea of a regional project for the lake would result in financial and manpower economics, the main advantages of such a project would come through greater comprehensiveness of the work that would be undertaken on the lake and undoubtedly, such a project could lead to better management of the fisheries of Lake Tanganyika for the benefit of the four nations in the long run. It is worthwhile noting here that Burundi and Tanzania are the two countries that have shown the greatest interest in developing their fisheries sectors while Zaire and Zambia have so far indicated little interest. This is so partly because they are pre-occupied with mining development (Mapunda, 1973).

CHAPTER 4: FISHERIES ECONOMICS IN THE CONTEXT OF LAKE TANGANYIKA

Yield Curves for the Fishery

The sardines of Lake Tanganyika are a non-self regulating stock. Recuitment which is the accession of juveniles to a fishable stock is dependent primarily on food supply. The population of sardines in any one year bears little relation to the size of the parent stock in the previous year.[1] The sardines are a very short lived species. The stocks turn over very quickly so that their recruitment becomes a very important factor in the biomass size at any one time. In view of that, long run yield curves do not apply. In some years recruitment is higher than other years. Hence it is necessary to consider variations in the level of annual yield curves as shown in Figure V below.

Figure V: Yield Curves for a Non-Self Regulating Stock



1 Anderson (1977, 103-104) describes the fishery based on this type of stock.

A yield curve is the relationship between catch and level of fishing effort, The mortality due to fishing simply is the same as yield or catch and is a function of effort given the population size of a particular year of recruitment. This is why different levels of recruitment give different yield curves as shown in Figure V.

Biomass is the total amount of fish that is available in a lake at any one particular time. The estimated total biomass in Lake Tanganyika in an average year is 2.5 million metric tons. The biomass in the Tanzania section of the lake is half the lake's total biomass which in this case is 1.25 million metric tons on the average. (Refer to Chapter 3). About 80% of the biomass consists of sardines. Therefore, the average biomass for sardines on the Tanzania portion of the lake is 1,000,000 metric tons.

The maximum sustainable yield for a stock (MSY) is the maximum amount that can be taken out of a lake over a particular period of time, usually a year, while maintaining an equilibrium in the biomass from year to year. The current estimates of the MSY for the entire lake and for all species of fish is 500,000 metric tons per annum (Johannesson, 1974). The MSY for the sardines is estimated to be about 50% of the sardine biomass (Chapman, 1976). Therefore the MSY for the sardines of the Tanzania portion of the lake is 500,000 metric tons.

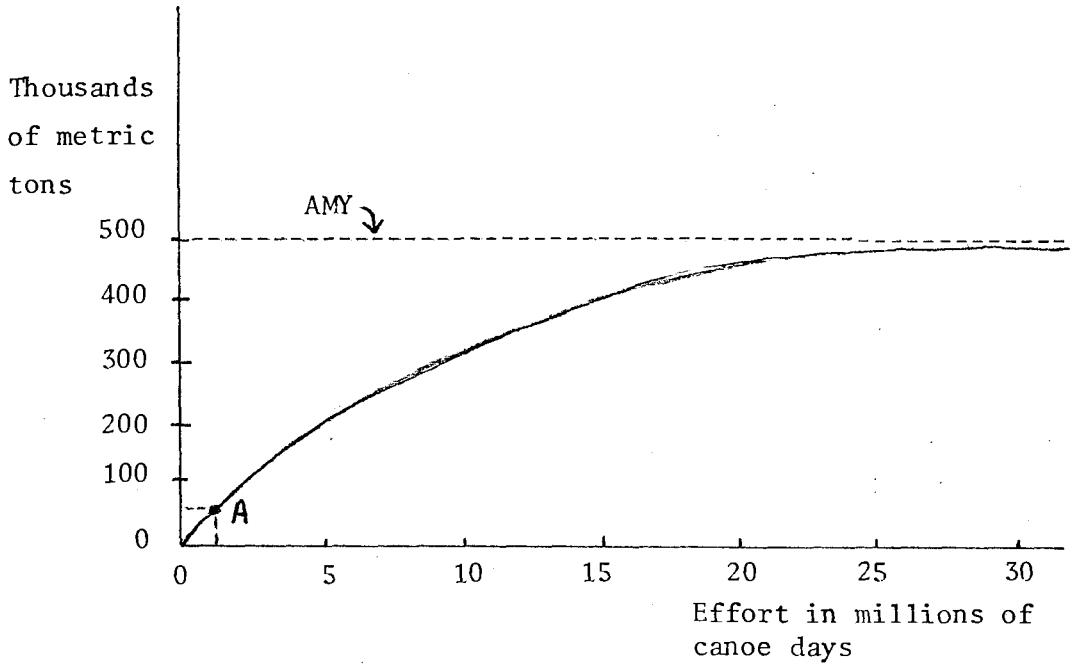
MSY is a concept that is most appropriate to long run yield curves. Because we are here dealing with a stock of a short lived species with a very rapid turn over, environmental conditions make for variations in the biomass from one year to another. Hence a long run yield curve can't be obtained; only a short run curve.

It is more appropriate in this case to talk about average maximum yield (AMY) instead of maximum sustainable yield. The AMY is the maximum

yield for the average yield curve. The average annual yield curve of the sardine stocks for the Tanzania portion of the lake is as presented in the following Figure VI.

In Figure V yield curves were drawn for different years according to the size of the biomass in each year. On the basis of long term observations, the average recruitment level can be established and the yield curve that goes with the average recruitment and the maximum yield for that curve would be the average maximum yield (AMY).

Figure VI: Average Annual Yield Curve for Sardine Stocks of the Tanzania Portion of Lake Tanganyika.



The actual shape and position of the yield curve in Figure VI is a matter of speculation because few actual data are available as confirmation of this curve. A few points are available in the left hand bottom corner, which are shown in Figure VII. Also it may be assumed that the yield curve is asymptotic to the horizontal line at approximately the 500,000 metric tons level. The latter we know about from the estimates of the AMY for the

sardine fishery of the Tanzania portion of the lake. Apart from the bottom left corner of the curve and the horizontal line we don't know how the yield curve runs. The configuration of the available data suggests that effort could be expanded three or four times while still achieving relatively high catches per unit of effort. In Figure VI, point A represents the current low level of effort (see Table XIII).

In the context of the Lake Tanganyika fishery, effort may be measured in terms of canoe days. That is the total number of standard canoes times the average number of fishing days per canoe in the year. A standard canoe would be operated by two men and would be about 12 ft. in length. Only the number of canoes that are actually existing are taken because they in fact, average out to standard canoes. Canoes may be of plank or dugout design. Both types have the same fishing capacity. Table XII below gives the monthly total number of fishing units using dug-out and plank type canoes by fishery and average monthly total fish catch by lusenga and beach seine for the sardine fishery.

Table XII: Average Monthly Total Number of Fishing Units using Dug-out Canoes, Plank Canoes and the Average Monthly Total Fish Catch by Lusenga and Beach Seine (in metric tons)

Fishery	Fishing Units using Dug-out Canoes	Fishing Units using Plank Canoes	Total Fishing Units	Fish Catch by fishery (in metric tons)	Total number equivalent Lusenga Units
Lusenga	2,166	3,018	5,184	3,954	5,184
Beach Seine	9	514	523	293	418
All Fisheries				4,247	5,602

Source: Results of the Catch Assessment Survey of 1975 on Lake Tanganyika, Tanzania.

From Table XII, one beach seine is equal to 0.75 lusenga nets in terms of productivity and therefore the 523 beach seine units are equivalent in productivity to .75 x 523 = 392 lusenga units.

Current statistics have not shown any significant variations in the catch per unit of effort for the time period and range of effort over which statistics are available. The table below shows the production figures for sardines for Lake Tanganyika for the period 1975-77.

Table XIII: Estimated Production Figures for Sardines for Lake Tanganyika 1975-77

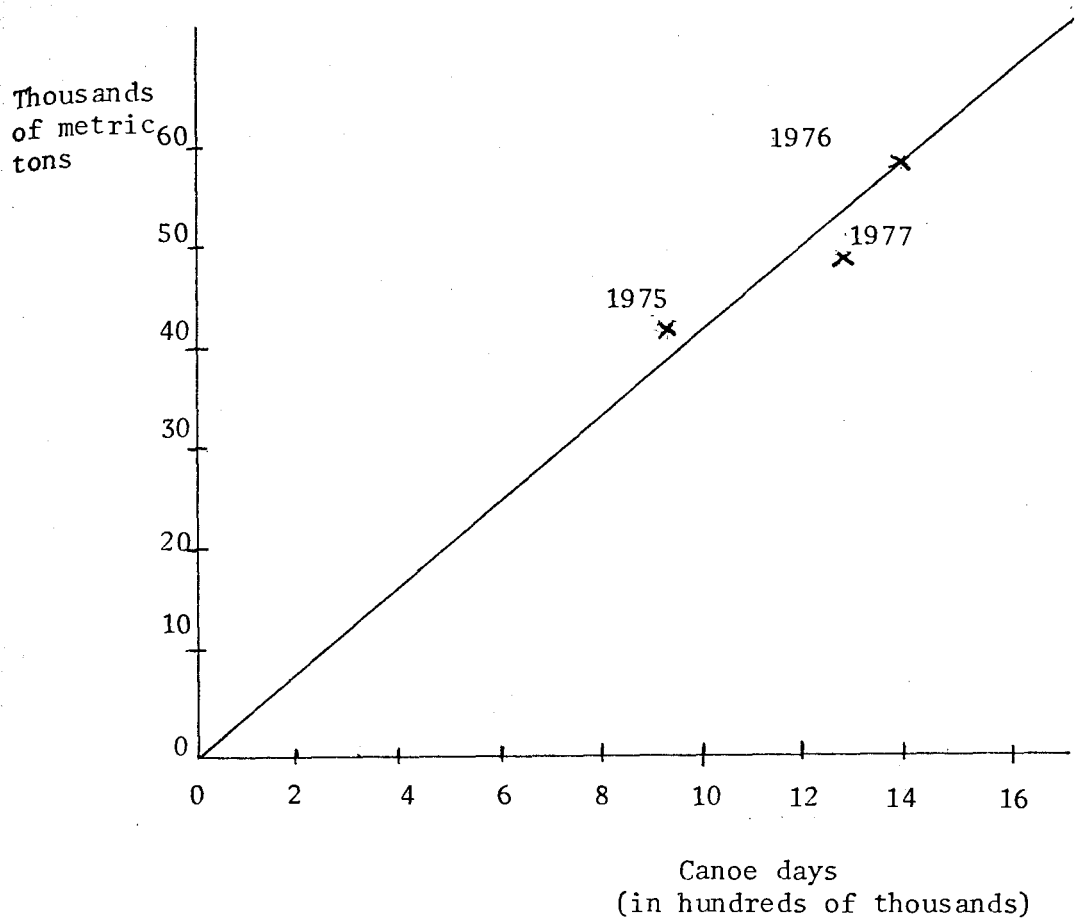
Year	Number of Canoe Days	Catch in Metric Tons	Catch per Unit of Effort
1975	956,256	41,600	0.044
1976	1,412,544	58,845	0.042
1977	1,285,872	49,510	0.039

Source: Fisheries Division Annual Report, Tanzania, 1978.

From Table XIII it is clear that the catch per canoe day is indeed very low. From Table XIII, the average catch per canoe day is only 0.041. In the case of the Tanzania sardine fishery effort is low in relation to the available stock. Hence, here we are dealing with only the first part of the yield curve (Refer to Figure VI). We are dealing here with the lower left hand corner of the diagram. At such a low level of exploitation catch tends to be nearly proportional to effort. This part of the yield curve is almost a straight line as shown on Figure VII below.

In Figure VII below there are points lying close to the yield curve and one either side of it. Points that measure the actual relationship between effort and yield are not likely to be precisely on the average

Figure VII: A Straight Line Yield Curve at Low Level of Effort



yield curve becaus of actual circumstances and recruitment will vary from year to year and accordingly these points in most instances will lie off the average yield curve to a greater or lesser extent depending on how close circumstances in any one year are to the average. The straight line yield curve drawn reflects a catch per unit effort of 0.041. This is derived by taking the average of the catch per unit of effort for the three years 1975-1977.

It is usually assumed that in the case of a non-self regulating stock, recruitment is not related to the size of the parent stock and therefore not related to previous fishing effort. In an extreme situation of heavy

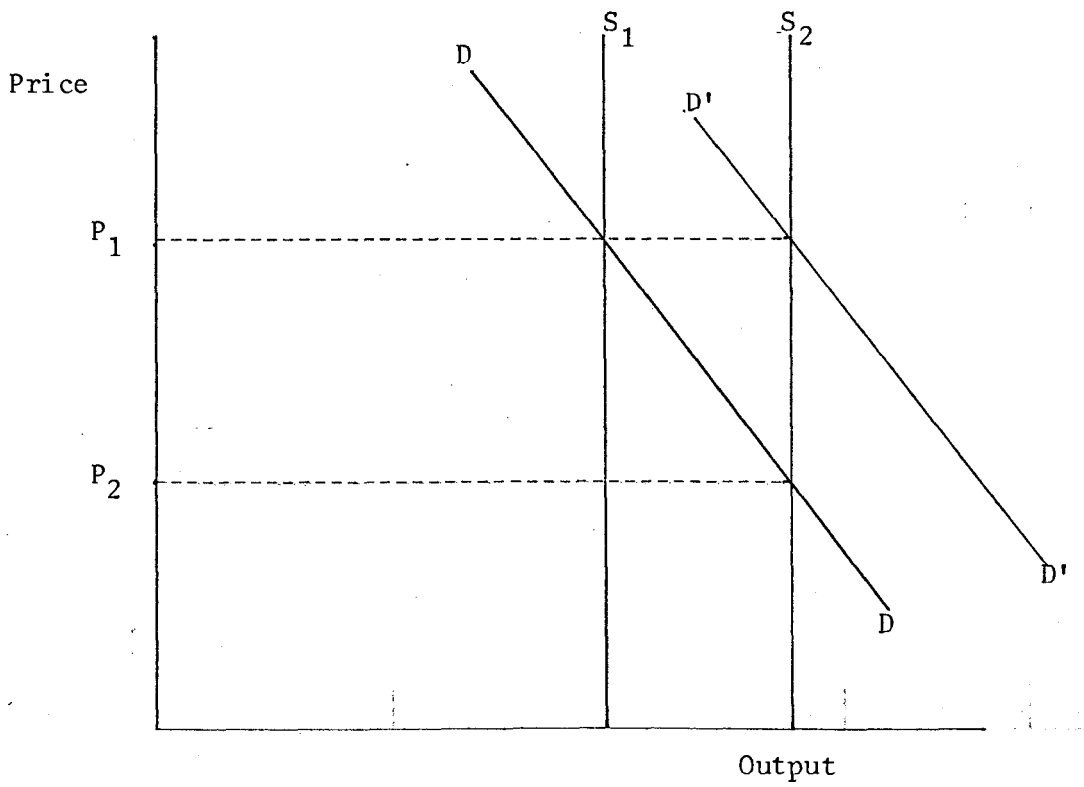
exploitation it is conceivable that the stock would collapse. This is because too much of the spawning stock would be removed so that recruitment would not be sufficient to fill the ecological niche available. Selective fishing could help in this situation to safeguard the fishery. By using gear of larger mesh sizes smaller fish of spawning age could escape. But the present situation on Lake Tanganyika does not call for selective fishing because fishing effort is so low as to constitute no danger to continued recruitment at the highest level.

Demand and Supply

The fishermen of Lake Tanganyika face a relatively inelastic demand curve. The established markets can absorb only a relatively fixed amount of fish. The immediately available market in the fishing villages and adjacent communities is rather small because there is a relatively small population there. Also, the fish traders who buy fish trade in a well defined and limited market because of the inadequacy of transportation networks. They also have access to a narrowly defined market that requires a certain amount of fish which does not vary much. If the amount of fish that is caught is in excess of what the local market and the market of the fish traders can readily absorb then the fish traders will find that they can get easily as much fish as they need for their markets and they will therefore offer a lower price. They will take some additional fish to put in inventories when prices are low, as it is advantageous for traders to do that when they can get fish cheaply. However, the consequence of this is that the fish traders build up their inventories and therefore will not need much additional fish for some time to come. This keeps the price for fish that they are willing to pay depressed until the inventories have been used up. Such a situation is demonstrated by Figure VIII below whereby,

normal variations in daily fish landings create large price fluctuations. Low catches (S_1) create high prices (P_1) and moderately larger catches (S_2) immediately lead to much lower prices (P_2) not only for the excess quantity but for the total amount of fish landed. Such a marketing situation is discouraging to the fishermen, as any attempt to increase catches leads to a lower price. This situation is demonstrated by the price/output diagram as shown in Figure VIII below. In order for fishermen to be able to sell larger catches at reasonable prices the demand for fish has to be increased. This can be shown in Figure VIII by a shift in the demand curve from DD to D'D' which allows a larger catch, the catch of S_2 to be sold at the same price (P_1) that supply S_1 achieves for the demand of DD. The key strategy in Tanzania to achieve greater output in the fishing industry, obviously rests on increasing the demand for fish.

Figure VIII: Supply and Demand Diagram



CHAPTER 5: LINEAR PROGRAMMING ANALYSIS FOR DEVELOPMENT

Background Information

The objective of this part of the thesis is to analyse further the structure of the fishing industry of the Tanzanian Sector of Lake Tanganyika in the fields of production, marketing and distribution. A linear programming model is formulated to aid such analysis.

Data for the estimated annual average totals of fish production the number of fishermen, canoes and revenues for the fishery in 1974 are shown in Table XIV below.

As pointed out in Chapters 2 and 3 little information is available in the areas of fish marketing and distribution. Some information was obtained by the Lake Tanganyika Fisheries Research and Development Project at Kigoma from the railway head station master on the quantities of dried sardines leaving the station by rail to various parts of the country. Table XV illustrates the output of fish and distances from the supply areas (seven regions)[1] to the central town of Kigoma and the associated costs of transportation from the supply areas as well as the prices charged in the urban areas. It is estimated that the output of fish delivered to Kigoma represents 60% and that the remaining 40% is consumed locally and exported to Zambia and Zaire (Midtgaard, 1975). The estimated 40% of local consumption and export to neighbouring countries illustrates the greater dependency on fish by the lake communities. This is because of the unavailability of other protein subsitutes such as meat except in the town of Kigoma.

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1 For statistical catch assessment surveys, the lake is divided into seven areas called strata by taking into account geographical and biological criteria of stratification. In the context of the present section of this thesis, the strata are referred to as regions of production (see map on page 2).

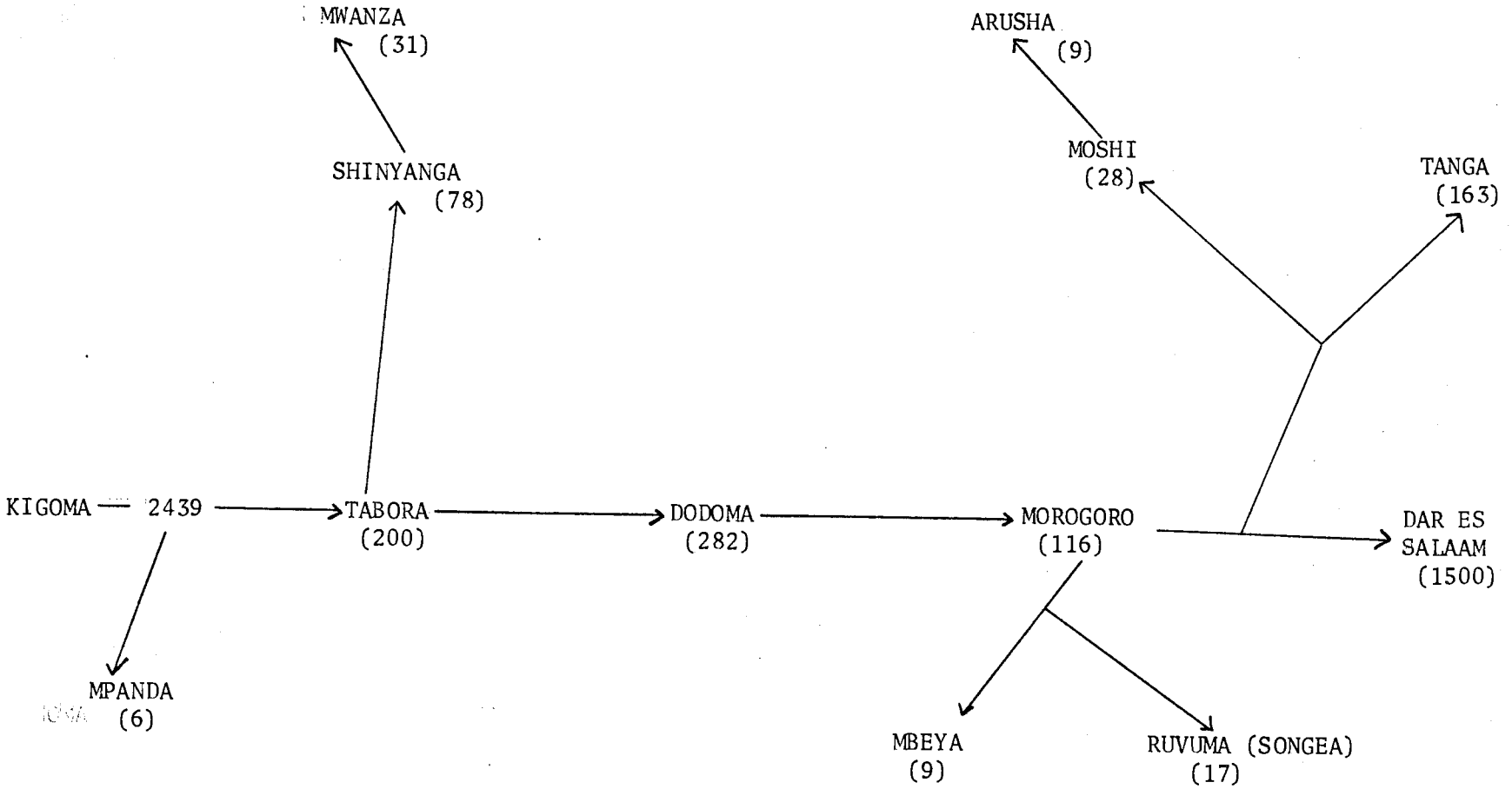
Table XIV: Estimated Totals of Fish Production, Number of Fishermen, Canoes and Revenue for Lake Tanganyika for the Year 1974

Symbol	Variable	STRATUM							Total
		1	2	3	4	5	6	7	
Fm	Total number of fishermen	5,034	3,265	854	322	2,221	1,414	1,364	14,464
C	Total number of canoes	2,805	1,937	258	140	1,005	556	675	7,376
O	Total Output in met. tons	28,280	13,883	1,904	2,617	4,555	1,789	448	53,461
R	Total Revenues in US$	4,590,250	2,226,250	348,250	426,750	745,625	312,875	84,875	8,778,875
I	Income per fisherman in US$	913	694	408	1,325	337	221	62	
O/F	Output per fisherman (in metric tons)	6	4	2	8	2	1	.3	
O/C	Output per canoe (in metric tons)	10	7	7	19	5	3	.7	
R/C	Revenue per canoe US$	1,638	1,170	1,350	3,048	742	563	126	

1 US$ = 8 Tsh. S.

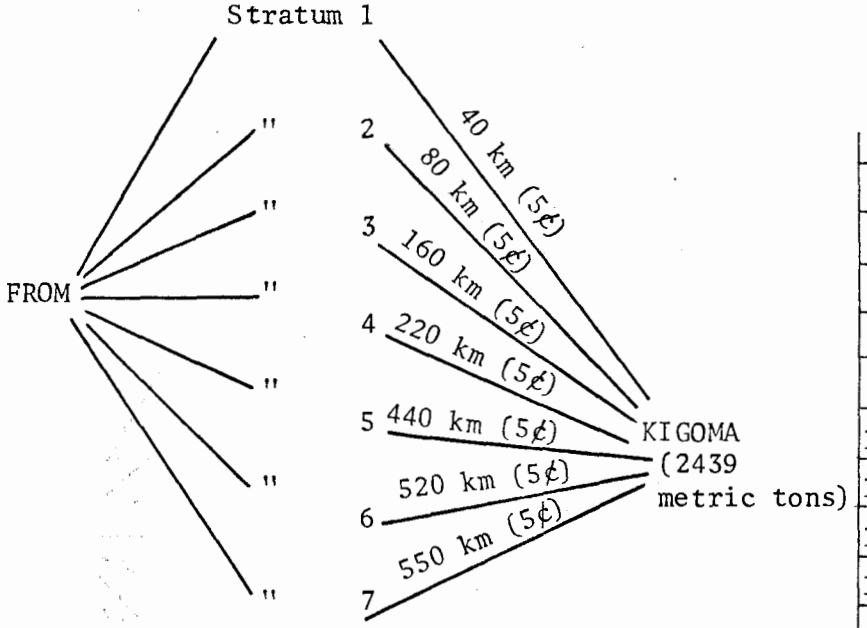
Source: Catch Assessment Survey on Lake Tanganyika 1974/75.

Figure IX: Distribution of Dried Sardines from Kigoma by Rail in 1974 (in metric tons)



Source: Results of marketing research by the Lake Tanganyika Fisheries Research and Development Project.

Table XV: Flow Diagram of Fish for Lake Tanganyika, Distance and Cost of Transportation per Metric Ton per Kilometre, 1974



TO SECOND DESTINATION	Towns	Present Supply m. tons	Present Demand m. tons	Present Prices $/kg.
250km (10¢) →	1 Tabora	200	2000	.90
450km (10¢) →	2 Shinyanga	78	780	.90
600km (10¢) →	3 Mwanza	31	310	.90
350km (10¢) →	4 Mpanda	6	60	.50
450km (10¢) →	5 Dodoma	282	2820	.90
550km (10¢) →	6 Morogoro	116	1160	.80
1000km (10¢) →	7 Mbeya	9	90	.80
1500km (10¢) →	8 Songea	17	170	1.00
1100km (10¢) →	9 Arusha	9	90	1.00
1000km (10¢) →	10 Moshi	28	280	.80
900km (10¢) →	11 Tanga	163	1630	.80
700km (10¢) →	12 DSM	1500	15000	1.20
	Total	2439	24390	

1 US$ = 8 Tshs.

Source: Results of marketing research by the Lake Tanganyika Fisheries Research and Development Project.

The linear programming model presented in this thesis deals with two separate but interrelated programming problems. The first is the problem of transporting fish from the seven regions of production to Kigoma each with a different set of prices for fish and transportation costs. The second problem is that of transporting fish from Kigoma to the 12 major demand areas of the country with another set of prices and transportation costs.

The data for the model are spatially distributed demands for fish, the production capabilities by the seven regions of the lake, the unit cost of dried fish deliveries from the seven regions to the central town of Kigoma and from Kigoma to the 12 demand locations in the country. The levels of the deliveries are some of the variables of the programming problem (See Model page 66). They are the levels of activities in terms of the amounts of fish taken from the regions and delivered to Kigoma and the amounts of fish deliveries from Kigoma to each of the demand locations. For example, the activity of producing fish in region one by one fishermen is denoted by the variable FISH and the activity of fish transferred to Kigoma from region one is denoted by the variable TFISHI in the model.

Fish stocks can be exploited to yield a flow or primary output of fish. Whilst fish stocks are a gift of nature the flow of fish is a result of economic activity. The prices of fish in the 12 delivery destinations are fixed arbitrarily by the regional price commissioners. Hence prices are different from region to region and have to be followed by consumers and traders.

Total transportation costs to the various delivery centres varies with distance. The cost of transportation for one ton of sardines per one kilometre by a water taxi to Kigoma is US $0.05. Similarly, the cost of transportation by rail from Kigoma to the 12 demand areas for one ton of

dried sardines per kilometre is US $ 0.10. Thus deliveries from the seven strata to the central town of Kigoma have identical transport rates per unit distance. The total cost associated with the deliveries of the fish is a function of distance and quantity of deliveries.

In each of the seven regions of the lake, there is a given set of resources. Technology is the same in all the regions. The dried sardines from the seven regions are purchased by traders from the fishermen, stored in their godowns and transported by water taxis to the railway terminal station in Kigoma.

Data from the supply area used in the formulation of this model originate from the 1974/75 statistical catch assessment survey on the Tanzania portion of the lake carried out on a lunar month basis by the Lake Tanganyika Fisheries Research and Development Project with the primary objectives of obtaining reliable estimates on a regional basis, of the total quantity of sardines harvested by the fishermen and of the fishing effort involved in obtaining the catch. Also, information regarding the distribution of dried sardines from Kigoma to the 12 demand areas was collected at the central railway station in Kigoma by the Lake Tanganyika Fisheries Research and Development Project. The railroad transport costs were also calculated on the basis of information provided by the railway terminal station office in Kigoma.

It is hard to estimate the total cost of fish production so the model will be dealing with gross revenue to fishermen rather than net revenue. Because the model did not take into account the production costs of fishermen the only costs recognized by the model are transportation costs. It is assumed that production costs are the same in all regions. Therefore, transportation costs are the only ones used in calculating optimum patterns of production and distribution. The solution to this model was obtained using the MPSX program and the model only deals with the supply of dried sardines

from the seven regions to the 12 final demand destinations, with no provision for exports.

The Model

The summary of the model can be presented as follows:

Max C'X

Subject to $Ax \leq B$

$Xi \geq 0$

C' = retail prices in consumption regions
A = Matrix of technical coefficients
B = Set of Resource constraint
X = The set of activities
i = 1 ... n

The inputs of the model include calculated coefficients of fish production per fisherman, the ratio of canoes to fishermen, consumption of fish in metric tons per fisherman, the coefficient of the transfer of fish to Kigoma per ton and the total cost of transportation per ton. The coefficients are calculated per region and the 12 final demand areas as shown below. There is no provision for exports.

TREV	- Total Revenue
TCostT	- Total Cost of Transportation from Kigoma to 12 demand areas
TCost	- Total Cost of Transportation to Kigoma from seven regions
RFISH	- Revenue of fish
MANi	- One fisherman in region i
CANOEi	- Number of canoes per fisherman in region i
FISHi	- Tons of fish produced by one fisherman in region i
MANFi	- Number of fishermen in region i

The columns include coefficients of fish production per fisherman per region, consumption per region, fish transfer and total cost of transportation per ton from the seven regions to Kigoma and from Kigoma to the 12 demand destinations. The constraints in the model are in terms of the number of fishermen and canoes available in the regions and the demand constraints in the 12 towns. This is all summarized as shown below.

The full model is as presented below:

Max: TREV

(1) TREV = 1000 RFISH - 1000 TCOSTT - 1000 TCOST

Equation (1) states the objective function which is to be maximized. This is the difference between total revenue obtained from selling the fish minus the costs of transporting the fish.

(2) 1000 TCOSTT = 25 Tab + 45 Shiny + 60 Mwanza
+ 35 Mpanda + 45 Dodoma + 55 Moro + 100 Mbeya
+150 Songea + 110 Arusha + 100 Moshi + 90 Tanga
+ 70 Dar es Salaam

Equation (2) states the total cost of transportion of fish from Kigoma to the 12 demand areas i.e. TcostT = 25 Tab + 45 Shiny + ... 70 Dar es Salaam. Where amount of fish is measured in metric tons.

(3) $1000\ TCOST = 2T_1 + 4T_2 + 8T_3 + 11T_4 + 22T_5 + 26T_6 + 27.5T_7$

Where TCOST is the cost of transporting fish from the regions to Kigoma.

Ti = number of metric tons exported from region k.

(4) 1000 RFISH = 900 Tab + 900 Shiny + 900 Mwanza + 500 Mpanda
+ 900 Dodoma + 800 Moro + 800 Mbeya + 1000 Songea + 1000 Arusha
+ 800 Moshi + 800 Tanga + 1200 DSM

Equation (4) shows price per 1000 kilograms in the 12 demand areas.

In each of the seven regions of production there are two main constraints. One is the number of fishermen and the other is the number of canoes. For example, in region one, the number of fishermen employed must be equal or less than the number available. The same constraint applies to the number of canoes.

(5) $R_1 \leq 5034$ where R_1 = Number of fishermen employed

(6) $.5572R_1 \leq 2805$

Equation (6) states that in region one there are .5572 canoes per fishermen.

(7) $6R_1 + 2.2471\ C_1 + T_1 \leq 0$ where C_1 = Number of fishermen working

(8) $C_1 = 5034$ (equality constraint)

Equations (7) and (8) state that the amount of fish exported from a region cannot exceed the amount caught minus the amount consumed in the region. The amount consumed locally is assumed to be 40% of the catch. Other six regions have similar constraints.

Interpretation of the Model Results

The model only allows for calculation of one cost item and that is transportation costs. So what is maximized in the model is total revenues of fishermen and traders net of transportation costs. Hence the amount that would maximize total revenues of the fishermen and traders net of transportation costs is US $24,448,984.19.

Furthermore, the model reveals underemployment in the industry. This is reflected by the fact that a relatively large number of fishermen are employed in regions two to seven where the production of fish is also low. This tends to suggest that a lesser number of fishermen and canoes could be employed and produce the same amount of fish in regions two to seven. If some of the fishermen and canoes were transferred to region one more output of fish would be realized. This also implies that the units in regions two to seven are not utilized to the same capacity as those in region one. Such a situation is revealed by Table XVI below.

In the context of fish marketing, the model shows how the fish might be distributed. On the basis of the existing price structure, it indicates that fish should be sold in all the 12 demand locations except Mbeya as demonstrated by Table XVII which shows the revenue accruing to the fishery industry for every tone of fish sold in each of the 11 demand locations.

Table XVI: Unused Capacity and Shadow Prices

Row	Activity	Slack Activity (Unused capacity)	Dual Activity (Shadow prices)
MANI	5034	--	12
$CANOE_1$	2804	0,05	--
$FISH_1$	--	--	2
MANFI	5034	--	4,49
KIGOMA	--	--	4
MAN_2	2740.25	524.74	
$CANOE_2$	1625.79	311.2	
MAN_3	380.79	473.2	
$CANOE_3$	115.03	142.96	
MAN_4	130.84	191.15	
$CANOE_4$	56.89	83.1	
MAN_5	911.04	1299.95	
$CANOE_5$	414.06	590.93	
MAN_6	715.62	698.37	
$CANOE_6$	281.38	274.61	
MAN_7	596.97	767.02	
$CANOE_7$	295.44	379.55	

Fish should not be sold in Mbeya because of the low price which seems to have discouraged traders from delivering larger quantities of fish. Table XVII shows the revenue which the model indicates as to what is achieved on the basis of the present fixed prices and transportation costs to the 12 demand locations.

Table XVII: Revenue of Fish per Ton sold in the 11 Demand Areas

Town	Revenue in US ($)
Tabora	871
Shinyanga	851
Mwanza	836
Mpanda	461
Dodoma	851
Morogoro	741
Mbeya	---
Songea	846
Arusha	886
Moshi	696
Tanga	706
Dar es Salaam	1126

NB The revenue figures are net of transportation costs and prices are assumed constant.

As shown in the above table, it is clear that the most profitable market for the fish is in Dar es Salaam (the capital city) followed by Arusha, Tabora, Shinyanga, Dodoma, Songea and Mwanza. This is because of the relatively higher prices of fish in these urban areas and the low transportation costs for some of the centres such as Tabora, Dodoma, Mwanza, Arusha, Dar es Salaam which are connected by rail.

From the above analysis it logically follows that prices of fish in Mbeya should be raised up in order to make shipments profitable as there is a demand of fish in Mbeya that can be met at some price.

The program tends to suggest that the total revenue could be increased if fishermen were reorganized with some transferred to region one. Hence a subsidy to relocate could be provided to fishermen by government to encourage them to move to region one. Alternatively, output in the Kigoma area could be increased by utilizing the available fishermen and canoes to the fullest extent possible. The strategy should be to increase output in the areas around Kigoma to serve the internal markets by the railway system while production from the areas further removed from Kigoma could be focused on supplying Zaire and Zambia.

The program also reveals that the current fixed prices i.e. US $500 per ton in Kigoma, together with the high transport cost, it is uneconomical to transport fish from regions three to seven to Kigoma. This is due to the fact that for every ton of fish shifted from region three reduces the total profit by $4, region four $7, region five $18, region six $22 and region seven $23.5 as shown on table XVIII below.

These results clearly suggest that the alternative would be to encourage and to strengthen export trade with Zaire and Zambia. Dried sardines could be sold in these countries with profit because of the high prices for the

Table XIX: Summary of Utilization and Transportation of Fish from Regions of Production to Regions of Consumption

Fish Production Region One (FISH1)

Local Consumption

	1	2	3	4	5	6	7	Total Weight
Total Production	28,280	13,883	1,904	2,617	4,555	1,789	448	53,476
Local Consumption	5,034	3,265	854	324	2,211	1,414	1,364	14,466
Transfer to Kigoma	18,892	5,407						24,299
" Tabora								2,000
" Shinyanga								780
" Mwanza								310
" Mpanda								60
" Dodoma								2,820
" Moro								1,160
" Mbeya								0
" Songea								170
" Arusha								90
" Moshi								280
" Tanga								1,630
" DSM								15,000

product in these countries and low transportation costs as the distances are short between regions three to seven and the two countries. On the other hand, increased fishing in the Kigoma region (region one) could serve the Tanzania market.

Table XVIII: Cost of Fish Transportation to Kigoma

Column	Reduced Cost
TFISH3	4
TFISH4	7
TFISH5	18
TFISH6	22
TFISH7	23.5
MBEYA	204

The program further points out that it is uneconomical to transport fish to Mbeya as doing so would reduce the total profit by $204 because of the high transportation factor and the low price presently prevailing in Mbeya a situation that calls for the setting up of realistic price level that would encourage traders to deliver larger quantities of fish.

In concluding this chapter of the thesis it is worth pointing out that the actual policy should not be based on the limitation of the model. The model should only be used as an aid in tracing some of the relationships.

The following limitations of the model are acknowledged. First, the model does not use realistic prices as a base but prices set by price commissioners rather arbitrarily. Secondly, the model maximizes gross revenue minus transportation costs and other costs are ignoredso that the solutions reached do not take into account possible variations in total cost levels and therefore in net revenue levels.

The usefulness of the model lies in the fact that it points out production regions three to seven are not suited to supply the inland areas through Kigoma and therefore the logic is to use production capacity in these

areas to supply Ziare and Zambia. Third, the model points out the consequences of setting out officially low prices in places like Mbeya which makes it difficult to supply realistically these areas.

Recommendations for Future Research

The model used in this study should be considered as a first approximation to a model representing the production - processing - transportation - marketing of the Tanzanian development of the Lake Tanganyika Fishery. As the fishery develops it would be necessary to further modify the model to reflect Tanzanian and Multiple country management of the fishery. However, at this point it would be possible, based principally on secondary sources of data referenced in preceeding chapters, to obtain technical coefficients for a more comprehensive specification of the fishery model. Specifically the following alternative sets of technology should be analyzed; (a) method of fishing; (b) methods of processing; and (c) methods of marketing. In this study one off-shore capital intensive method of fishing is described and six labor intensive inshore methods of fishing are described. If these methods were modelled showing all activity resource requirements by time period (for example monthly) then the model could be used to evaluate the relative efficiency of the various fishing techniques. To facilitate this it would also be necessary to estimate the available supply of fish by type and time period available for catching by the different methods (including any interactions). Further, depending upon the extent of fishing and the success rate in fishing it would be necessary to construct a set of activities for each fishing method to reflect the decreasing marginal physical product as any particular fishing method was increased (eg. due to more boats and/or longer hours).

The inclusion of time periods in the fishing activities would result in the need to analyze the time dimensions of marketing. The question of market development, (i.e. from the demand side), storage facilities to "modify" the flow of fish into the market, and the development of transportation and marketing infrastructure could all be modelled to analyze the impact of changes in this component of the fishery.

The consideration of time periods may also focus attention on the technology of processing. In the study various processing techniques have been directly or indirectly mentioned. Since some processing may be capital intensive and difficult to finance, the alternative which may hold the greatest possibility may be supplemental drying facilities to assist the traditional drying techniques used by the fishing communities.

There are three major reasons for building a more realistic model of the Tanzanian Lake Tanganyika Fishery. First, the collection of data for the model is a useful exercise because it facilitates a greater understanding of the fisheries system i.e. of the interdependencies of the production, processing, transportation and marketing. This greater knowledge may facilitate (a) the determination of relevant opportunities and (b) the selection of "better" solutions for these opportunities, even if the model itself were not used. Second, the more "relatistic" model would facilitate the selection of better alternatives to production, marketing, etc. problems because the interdependencies of the system have formally been identified and their effect upon the system can be determined. Thirdly, when the Tanganyika Fishery is better developed Tanzania will need a formal "fisheries position paper" for negotiating with other countries which have an interest in the Lake Tanganyika Fishery. The development of an adequate model would enable Tanzania to evaluate alternative policy positions regarding the fishery.

Based upon the above discussion it is important that the modelling component of the Tanzanian Lake Tanganyika Fisheries studies be given high priority. This observation is true both from the point of view of Tanzanian fishermen and of the Tanzanian Government. If the government wished to consider the impact on social welfare rather than net returns to fishermen then the objective function may be formulated to maximize consumer surplus.

The importance of an "adequate" model of the fishery must also be self-evident to external funding agencies who are concerned about financing or assisting the capital development of Tanzania.

CHAPTER 6: UJAMAA STRUCTURE AS A POLICY VEHICLE

The Place of Ujamaa in Development

The present Tanzanian five year development plan puts emphasis on the development of Ujamaa villages. The policy has required the concentration of population in a smaller number of villages. A strategic advantage of Ujamaa villages is that by having a smaller number of larger communities the government is able to provide better facilities for the population e.g. more effective educational, medical and cultural facilities because of the scale economics that can be obtained from these larger communities. Hence, there are then potentially considerable benefits. Also, these larger communities can be organized for cooperative work allowing larger economically more advanced activities to take place and ensuring that the benefits of cooperation are equitably distributed amongst the populations of the villages. This could be achieved if much effort is made to create and maintain an efficient economic system in the villages to ensure the highest possible economic output of the village activities.

Most Ujamaa villages are usually provided with a special transportation system to take care of transportation of commodities to and from the villages, the system could be further improved and considered as an important part of the future collection and distribution system for fish and fish products.

Disadvantages of Intial Ujamaa Applications

The implementation of the Ujamaa policy has had some disadvantages as well. The concentration of fishermen in a smaller number of villages has meant that more often they are not as close to their fishing grounds as they used to be. This has led to lower productivity while the fishery is still at subsistence level.

The rapid introduction of Ujamaa led to many disaffected fishermen leaving altogether, going back to Zaire resulting in a considerable reduction in the output of fish which has meant less vital protein for Tanzanians.

Under Ujamaa efforts have been made to shift fishing activity to group fishing techniques such as beach seining. But the most efficient technique for sardine fishing on Lake Tanganyika has proved to be the lusenga fishery because it is labour intensive and yet yields larger amounts of fish. In the present stage of scarcity of capital resources in Tanzania it is essential that no capital be wasted. There is no need to go into more capital intensive techniques when there is plenty of labour to engage in a very effective lusenga fishery. The lusenga fishery is typically undertaken by a two man operation. The incentive to carry out a two man operation well lies in the fishermen in this operation working for themselves. Therefore, any attempt to force or to introduce a communal operation directly on the lusenga fishery is likely to result in lower productivity and lower incentive to fishermen to work well.

However, some experiements in beach seining could be undertaken to see if productivity can be increased to the extent to see whether it will exceed or be equal to the productivity of the lusenga fishery, taking into consideration that with beach seining only a small part of the stock can be exploited. Hence, it is not a good technique to use to exploit the fishery fully. It can only be a supplementary technique. It is the lusenga fishery that should be improved and encouraged.

Adaptation of Ujamaa to the Fishery

The fishermen could continue to be left free in the Ujamaa villages to fish for themselves in the lusenga fishery hence having a maximum incentive to fish well because they will be rewarded with the catch they take.

The cooperative principle could be applied at the level of selling the catch cooperatively hence cutting out the traders who may be in a position to exploit the fishermen whereas if the fishermen jointly through their Ujamaa village cooperation sell their catch they can get the full value for it. In turn, the Ujamaa cooperative could be used to bring in supplies for the village on a cooperative basis again minimizing the cost of distribution of goods in the community.

In view of the large fishery resources in Lake Tanganyika, Tanzania has sought a loan from the World Bank for expoiting and developing its fishery sector of the lake through the Ujamaa village programme. The programme aims at introducing small purse seining units in the villages capable of being handled and managed by the villagers. The programme has been initiated in a few villages near Kigoma and is expected to expand to other villages as experience is gained. Although this proposed fishing method appears simple, and the existing fish drying methods are traditional, combining and managing the element of catching, processing, transportation and marketing may prove to be complex in the village context. At this stage of the fishery, expansion of the fishery through the introduction of new fishing techniques could be carried out by merely upgrading the present canoe fleet rather than the introduction of purse seining units.

As many of the Ujamaa fishing villages along the lakeshore are not served by roads because of the precipitous cliffs and extensive mountains and as the roads to many others are extremely poor, the World Bank program could include the provision of necessary lake transport facilities to allow the Ujamaa villages to transport dried sardines to the collection centres if fishing experience proves satisfactory and isolated villages demonstrate the capacity to organize fishing and processing activities and produce dried

sardines in large quantities. The same transport facilities could be used to distribute basic supplies to the villages. This would help strengthen the inadequate transport facilities. Improved transport facilities could include barges and tugs which can be brought up to the shoreline without any short facilities except wooden planks to facilitate loading.

The Lake Tanganyika fisheries research and development project whose head office is in Kigoma town could perform its development and training activities in the areas of fish processing and training in close cooperation with the Ujamaa villages. Such cooperation would provide the best possibilities and certainty for repayment of loans for investment in fishing boats and gear in order to secure the most efficient utilization of fishing equipment.

Future prospects

When the market for fish in Tanzania is adequately expanded both by better distribution system within the country and by better trading opportunities to Zaire and Zambia, it will be necessary to expand the fishery considerably to meet the additional effective demand. Also, if the country moves to a more advanced economic stage of higher productivity where labour becomes relatively more scarce and underemployment and unemployment are no longer a factor, it will be necessary to look for more capital intensive techniques of fishing. Here Ujamaa villages may run larger scale fishing oeprations. Hence at such a stage, purse seining may be introduced into the villages.

For future increase in productivity in the Ujamaa villages, there is need for a wide diffusion of practical fisheries education which has been so far exclusively the responsibility of fisheries extension officers, many of whom, with no transport must serve three to four villages. Since under the

Ujamaa policy settlement is nucleated, and since almost all work is done communally except for fishing operations an Ujamaa village could easily serve as a year round fisheries school for its members. In every village of about 100 - 500 fishermen, there are at least a few who are more knowledgeable than the rest. It could be the responsibility of such men to educate their fellows. If possible, they too could be given special training in one of the three fisheries training institutes of the country. In the Ujamaa villages each day's work could begin with practical fisheries lessons. Such teaching for productivity could put emphasis in the areas of fish processing so that a better quality product is turned out. The Ujamaa village, by pooling resources can make investments in productivity that an individual fisherman could not afford to make.

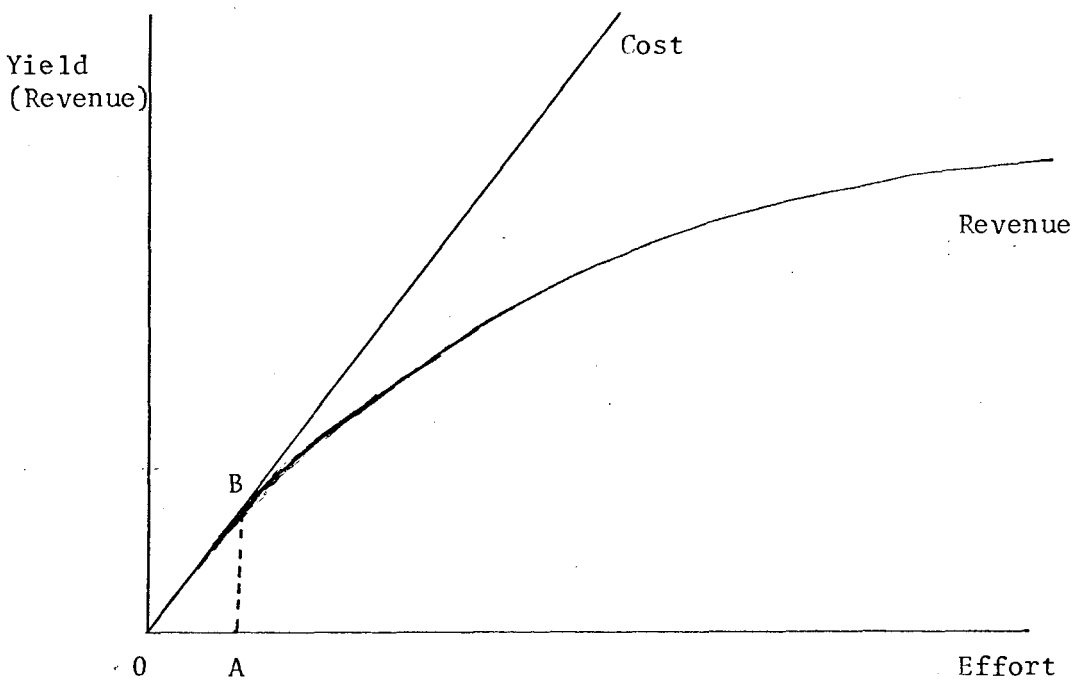
For the Ujamaa policy to become a possible vehicle for improving markets, distribution and re-investment, it is essential that the Ujamaa fishing villages progress slowly, mastering simple techniques before they attempt to employ complicated ones, practising labour intensive fishing such as beach seining before proceeding to capital intensive fishing.

CHAPTER 7: THE STAGE OF FULL EXPLOITATION

At the present time there is only a low level of exploitation of the stocks on Lake Tanganyika. This situation is demonstraded theoretically by Figure X below.

Fugure X is on the present stage of the fishery. The cost curve may be expected to be a straight line from the origin because cost is assumed to be proportional to effort (Anderson, 1977 p. 30-32). The present stage of the fishery is indicated by an effort level of OA which is a very low level of effort. The revenue (yield) curve may therefore be expected to be a straight line, because diminishing returns have not yet set in when the stock is plentiful. As the fishery is in equilibrium at point B corresponding to effort level OA and both curves pass through the origin and point B, they must coincide.

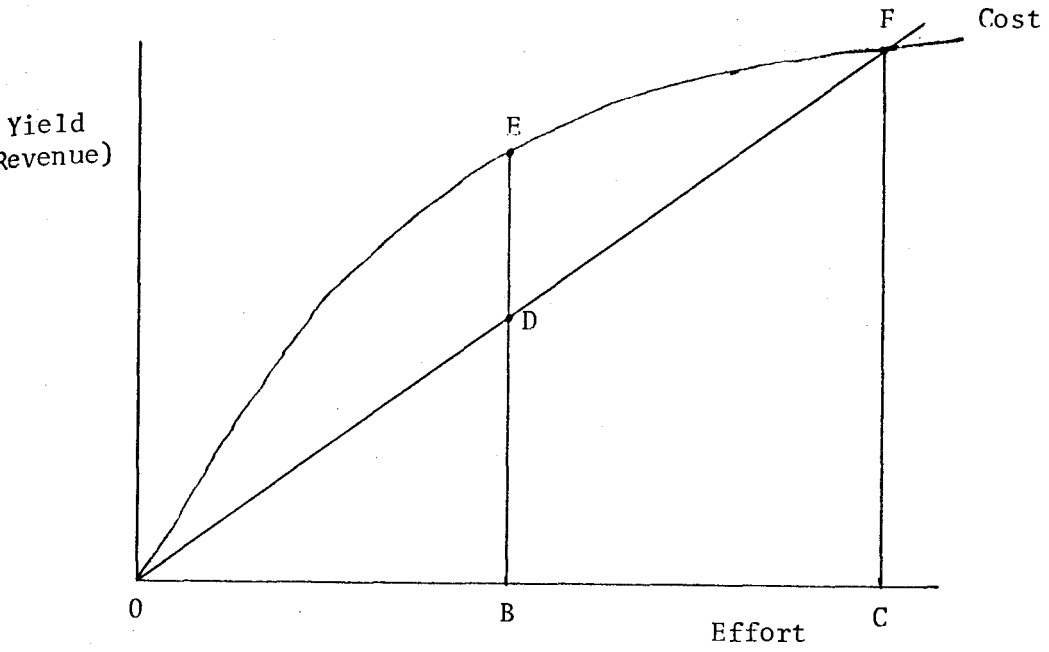
Figure X: The Present Stage of the Fishery



For fisheries development to succeed, costs will have to be reduced relative to revenue or revenue will have to be increased relative to cost. This will lead to a situation of Figure XI below, where the cost curve has dropped

below the revenue curve. In terms of fisheries economics theory, the equilibrium level of output is going to be given by an effort level of OC where revenue and cost break even (Anderson, 1977, p. 31).

Figure XI: The Stage of Full Fisheries Development



The revenue curve is simply the yield curve translated from quantities like metric tons into the revenue from these quantities which is in dollars or some other currency. The revenue curve will have the same shape as the yield curve if there is a constant price by which quantity of landings is converted to amount of revenue.The equilibrium is explained by the Gordon (1954) analysis that shows that in an open access fishery additional operators will be attracted until there is no profit left in the fishery and cost and revenue are equal. Hence, the equilibrium resulting from uncontrolled competitve fishing, where the rent is dissipated is where cost is equal to revenue from landings. This is at point F with effort OC. The more efficient exploitation of the fishery will take place at an effort level of OB where a net return in the fishery, or a rent, of ED may be obtained. This rent can either go to

fishermen as an extra income or it can go to the government in terms of licence fees or taxes. It thus represents a net economic gain from the fishery because total revenues exceed total costs. The maximum rent is obtained at an effort OB where rent of ED may be earned. OB then gives the optimum intensity of fishing effort that maximizes total net revenue (or rent). This is a social surplus yielded by the resource. The yield at this level is referred to as maximum economic yield (MEY). Gordon points out that economic over fishing will take place at a level of effort larger than OB. This will result in a higher expenditure of effort, higher fish landings, and a lower continuing fish population than the optimum equilibrium.

The sardine fishery of Lake Tanganyika is being exploited under conditions of unrestricted access. Because of the common property nature of the fishery, there is no motivation for any fisherman to conserve the resource. Copes (1980) points out that "What is everybody's resource in general, is nobody's property in particular. No one fisherman is personally motivated to conserve the resource. For any fish he would return to the water to grow to larger size will likely end up in the nets of a rival fisherman. Each fisherman will be induced to take as much fish as quickly as he can before others beat him to it."

Competition for the fish stocks may lead to externalities within the fishery. These may be at two levels. First, externalities may arise because of competition among individual fishermen for shares of the stock. Secondly, externalities may arise because of competition amongst countries for shares of the stock. These apply to Lake Tanganyika as the fish stocks move across international boundaries between the four countries bordering the lake.

The four countries should monitor progress in expanding the fishery and take preventive action to make sure that over exploitation does not take

place. The four countries bordering Lake Tanganyika have ample warning that this is the normal state of events in common property fisheries when they approach full exploitation. Therefore, they have time to take preventive action and make sure that over exploitation does not take place by imposing limited entry regimes in time. There have been countries that have successfully done this when they had new fisheries and they had closed entry in time. For instance both South Australia and Western Australia closed entry to the rock lobster and prawn fisheries before over exploitation took place. As a result they have maintained high levels of income and high levels of output in those fisheries.

It would be appropriate when the stocks become more fully exploited for a regional management program to be established for rational resource use. This should be a program in which all four countries participate. A limitation on catching capacity and entry for the double purpose of safe-guarding the stocks against physical over fishing and safeguarding fishermen against economic over fishing which can happen when there are too many fishermen sharing the catch (Copes, 1980).

Some additional measures that can be taken to improve the returns in the fishery would include an agreement by the four countries on the question of selective fishing. Selective fishing can be secured by a better choice of mesh sizes. This means choosing a mesh size that is large enough to let small fish escape so that they may be taken at a greater size and may continue to spawn before then. To come to the right mesh size to be used would require some experiments to determine them. Other measure could include the limiting of entry into the fishery either by banning additional entry or reducing the catching capacity of the vessels in order to prevent the erosion of net benefits in the fishery.

The stage of full exploitation is normally accompanied by technological advances in fishing. There are two kinds of technological improvements in a mature fishery. Those that are cost reducing and those that are capacity increasing. It is the capacity increasing technological improvements that should be reduced and keep those of cost reducing technological improvements. A lot of technological changes do both at the same time. They increase the capacity of fishing units and they also reduce the cost. What could be done in this case ideally is to allow the technological improvements to be introduced because of the cost reducing effects but at the same time ensuring that the total number of fishing units is reduced to overcome the capacity increasing effect. Hence a balance will have to be maintained between restriction for maintaining the fishery resource at a productive level while at the same time being flexible in encouraging innovation. There is no over capacity yet on Lake Tanganyika at present. The job of the four governments should be to prevent it from taking place.

The most important policy measure that will have to be implemented when a stage of full exploitation is reached is the introduction of quantitative regulation of fishing such as quotas. These could be introduced at three levels. First, quotas could be introduced for the four nations bordering the lake so that the quotas should make up the maximum economic yield. The maximum economic yield is the level of effort that will bring maximum net returns to the fishery. The way to divide the fishery logically would be in relation to the fisheries potential of the four parts of the lake. The reason to introduce quotas will be to overcome the common property aspect among the countries. If no agreement is made on quotas each country may try to fish as hard and as fast as possible in order to get a larger share of the catch before the other countries get it and as

a result, with this competition among the four countries they may end up with far too large a fishing capacity, a great excess of investment in fisheries and a poor return for every fisherman. So it is important that the countries agree on the amount of the catch each is allowed to take so that each country in turn then having a guaranteed share of the catch will take that share of the catch in the most economical fashion possible using no more manpower and equipment than is necessary.

The same applies at the lower levels as between Ujamaa villages within Tanzania. There has to be agreement among the Ujamaa villages along the Tanzanian shore of the lake so that each one gets an allocated share, for example, in proportion to the population in the Ujamaa villages. Hence no Ujamaa village will try to build too many vessels in order to out fish the other villages. As for the Ujamaa villages, instead of allocating quotas to each one of them, there can be an allocation of the number of vessles each village is allowed to operate.

Quotas could be made transferable. If for example, an Ujamaa village is unable to fish to the level of the allocated amount of fish the excess in the quota could be allocated to other villages. This quota system would require government enforcement e.g. cutting of fishing by time, area or even species when any evidence of over fishing develops. Quotas will give villagers control over the management of their resource. They could for example, carry out other measures within the villages such as the elimination of part time fishermen. The Ujamaa villages, having exhausted their quotas could as well formulate a working schedule that would combine fishing with complementary seasonal activities in agriculture.

All or some of the aforesaid measures will have to be put into force at the stage of full exploitation in order to meet the objective of management

of the fishery which in the Tanzanian context is stated as the "obtaining from exploitation of the fishery the greatest possible benefits to society as a whole, and in particular, to assure the economic welfare of fishermen in Ujamaa villages.

At the stage of full exploitation of the fishery there will necessarily be a trade off between increasing consumers' surplus on the one hand resource rent and producers' surplus on the other. If the fishery is controlled by the government there may be a larger total net social benefit by maximizing the combined total of consumers' surplus, resource rent and producers' surplus. If the fishery is controlled by fishermen through a cooperative marketing association they are in a position to maximize the resource rent and producers' surplus for their own benefit. They could act as a producers' monopoly (Copes, 1972b), charging relatively higher prices and thereby reducing total output and diminishing consumers' surplus.

CHAPTER 8: CONCLUSIONS

From the discussion on development prospects in this thesis the following conclusions emerge. The sardine stocks of Lake Tanganyika are underutilized and therefore there is an opportunity to expand the fishery. Expansion of the fishery could lead to increased protein supply, increased income and increased foreign exchange earnings.

The obstacles to expanding the fishery are on the demand side because the present capacity of the fishing fleet is underutilized and it would be easy to expand the fishery using the present techniques. The most immediate problem in the fishing industry is one of developing more effective markets so that more fish can be disposed off. The present situation requires a marketing policy that would lead to the creation of a marketing system capable of covering important and potential domestic and export markets. As such, marketing effort could be directed towards maximum utilization of fish sales possibilities in domestic markets with sufficient purchasing power at prices that would enable a return on the investment.

The fishermen have had discouraging experiences regarding prices for increased catches, hence they have to be convinced that an extension of fishing effort will result in higher incomes. This could be done by the government or traders guaranteeing stable prices for their catches. This would encourage fishermen to make full use of the existing fishing fleet and doing so would require the erection of fish receiving stations and processing plants in Kigoma and Kipili which are the main collection centres along the lake.

Therefore the marketing efforts could be directed towards finding the potential domestic buyers and fulfill their requirements. To meet these objectives requires development of the infrastructure, better

processing methods, transportation and storage facilities. At present, there is undoubtedly a lot of untapped purchasing power in smaller towns and rural areas both in Tanzania and in neighbouring countries. These future market prospects could be identified and their requirements fulfilled. Information concerning studies of consumption patterns on a monthly basis could be collected from these markets in order to make plans for new fish products development by fish processing technologists. This could enable any new fish products thought suitable for specific markets to be tested and marketed in the same area before any commercial mass production of new products is made.

At this stage of the fishery, the export of fish is very limited. If developed it may be noted that this would help compensate for the foreign exchange used for the fishing industry. Development of export trade (exports to Zambia and Zaire) could support and expand the possibilities for meeting the demand for fish products from the domestic low income areas. This implies that development of the export trade would successfully develop new attitudes in the fishing industry and new incentives if good rising incomes are to be obtained by fishermen by engaging larger scale fishing operations and the fishermen as a result would always look for opportunities to expand their production so that additional output would be available for the domestic market as well as for the export market.

Joint fishing ventures among the various districts in the country could be undertaken in order to increase the supply of fish for the export market and provide export earnings. This would bring about transformation of the fishing industry.

Government guarantee of higher and stable prices for fishermen's catches could help reduce illegal export trade. This would further provide more

export earnings. The implementation of the Ujamaa policy has led to lower productivity. But Ujamaa organization has many basic advantages that could be applied realistically but should not interfere with the most effect means of fishing (the lusenga). Ujamaa could be organized for cooperative work and could remove obstancles to trade and improve infrastructure.

The process of determining the optimum development of the fishery may be aided by a realistic linear programming model that will reflect the Tanzanian and multiple counting management of the fishery. A realistic model would facilitate the selection of better alternative in production, marketing, processing and distribution, because the interdependencies of the system would be formally identified and their effect upon the system would be determined.

In order to manage the fishery for future benefit of all the countries bordering the lake, it is important that a regional project be established by the four nations. This is needed not only for effective biological research and collection of economic data but also in the promotion of trade, development of gear and technology etc. Eventually, when the stocks become more fully exploited it will become particularly important in terms of joint research management and allocation of catch quotas amongst the four countries. Limited entry and quota regulation measures to prevent over exploitation will have to be introduced.

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