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Report on the

# SECOND FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION

## PART 2

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1972

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# R E P O R T

on the

# SECOND FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION

## SEMINAR FOR FISHERIES OFFICERS WORKING PAPERS AND DISCUSSION

Held at Entebbe, Uganda
22-27 February 1971

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1972

FAO. Report on the Seminar for Fisheries Officers, working papers and discussion at the Second FAO/Swedish Training Centre on Small Fishing Boat Design and Construction, held at Entebbe, Uganda, 22-27 February 1971, sponsored by the Swedish International Development Authority. Rome, 1972, 208 p. FAO/SWE/TF 84

ABSTRACT

This document is the Report on the working papers and discussions presented at the Seminar for Fisheries Officers, which was held at Entebbe, Uganda, 22-27 February 1971 in connexion with the Second FAO/Swedish Training Centre on Small Fishing Boat Design and Construction, from 11 February to 6 March 1971, sponsored by the Swedish International Development Authority.

The Seminar for Fisheries Officers was held at the Fisheries Training Institute, Entebbe, with 37 participants from Kenya, Nigeria, Sudan, Uganda, FAO and Industry. (The names of participants are given in Appendix I).

The objective was to bring together fishery officers and people from the industry on a regional basis, to discuss mutual problems in small boat development and mechanization. Eighteen papers on various aspects of fishing boat development in the Lake Victoria region were presented. The discussions were recorded.

The present edited version of the working papers and discussions contains sixteen papers under these headings.

| | |
|---|---|
| Session I | Economic and social factors in boat development |
| Session II | Materials for boat construction |
| Session III | Engines for small fishing craft |
| Session IV | Boatyards and boatbuilding |
| Session V | Financing boat development |
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## ACKNOWLEDGEMENTS

The Swedish International Development Authority (SIDA) made the organization of this Training Centre and the Seminar for Fisheries Officers possible through its financial contribution to the FAO/SIDA Cooperative Programme.

The Government of Uganda wholeheartedly supported the Training Centre and made available excellent facilities at the Fisheries Training Centre in Entebbe, including the boatyard belonging to the Fisheries Department.

Thanks are due to the persons who in a private or official capacity contributed with papers to the Seminar. The views expressed and techniques explained may be of great value, particularly for the Lake Victoria region, but also for other parts of the world with similar problems.

In the same manner the comments offered in the oral and written discussion are highly valuable and should be of interest to all persons dealing with fisheries development.

Special thanks are due to the Chief Fisheries Officer in Uganda, Mr. S. Semakula who, most efficiently, acted as Director of the Training Centre and the Seminar. Thanks should also be addressed to Mr. A Biribonwoha, Principal of the Fisheries Training Institute, Entebbe, who provided the staff and the participants with invaluable assistance.

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Session I ECONOMIC AND SOCIAL FACTORS IN BOAT DEVELOPMENT

Paper I/1

# Evolution of fishing boats in the Lake Victoria region

by

S.N. SEMAKULA

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

ME/05117/1

## INTRODUCTION

The need for water-borne transport among people who live on the shore areas and islands of major lakes has been recognized for a very long time, and various craft have been developed to carry people and their farm produce from one area to another and also to assist the fishermen to set their fish traps and baskets.

## PRIMITIVE RAFTS AND LOG BOATS

Perhaps the most primitive type of boat that has existed in the Lake Victoria region was the papyrus raft on which people could sit astride and paddle with their hands or flat pieces of wood. The type of craft depended on the type of flora in the area which the inhabitants could find, the most important consideration being that the materials used should be capable of floating. Flat rafts were made of bundles of papyrus tied together with fibre. The log 'boats' were often found to be made from the Ambatch tree, commonly found in the lake shore areas, the wood of which was light in texture and, consequently, very buoyant. The only disadvantage of using the Ambatch wood was that it was found to absorb a great deal of water, and dry logs were essential for long journeys.

## DUGOUT CANOES

From this very primitive type of boat, the next development took the form of a dugout canoe, and apparently this arose through the need for more space and carrying capacity. The dugout canoe consisted of a heavy trunk of wood with a long, narrow hollow gouged out from the centre to enable the paddlers to sit in the boat together with their belongings, none of which would get wet. In selecting a log for a dugout canoe, care was taken to choose a straight well rounded tree. The stability of these canoes has always left much to be desired, and they have been responsible for a large number of deaths in the water through overturning.

The various canoes built within the Lake Victoria region have tended to vary in shape, materials and size from one tribe to another; it is an interesting fact that many canoes of the Baganda tribe reached sizes of up to 75 ft in length in the past although such sizes are nowhere to be seen on Lake Victoria today. Those on Lake Kyoga, however, were often so small as to be sufficient to accommodate only one man and his goods, and many canoes on Lake Kyoga today are still very small.

The most obvious disadvantage of the dugout canoe is the wastage of timber. In the process of its construction, large volumes of wood have to be chiselled out from the trunk in the making of the hollow, most of which cannot be put to any good use. Today, when the use of timber is restricted and when there is greater demand for it to be put to other uses such as buildings and furniture, this method of construction becomes both undesirable and uneconomic.

## SESSE CANOES

Various types of dugout canoes have been constructed in the Lake Victoria region, and from these has emerged a canoe which was developed in the Sesse Islands which has become well known as the Sesse canoe. In its original form, the Sesse canoe was a mere modification of the old traditional dugout, intended to improve on stability and to save on the wastage of timber. This was done by cutting away the parallel sides of the dugout canoe, reducing it to the keel only. Two planks were then built on either side of the keel, one on top of the other, and these were joined in between by a round piece of wood and eventually sewn together with strong fibres of the Raphia Palm, passed through holes which were drilled through the sides of the boat with hot metal spikes.

Again, the Sesse canoe varied in size from area to area, and the shape is slightly different in each part of the Lake Victoria region. For example, a boat built in the Sesse Islands is slightly different from the boats that have been constructed in the Nyanza Gulf by the Jaluos of Kenya, which are again different from those that have been made by the fishermen from the eastern region of Lake Victoria.

The Sesse canoe has undergone various types of modification. What is probably unique about it, and what has caused much speculation, is the long false prow which is found to project beyond the keel in front of the boat. Some people have considered this false prow to be of no value, while others have felt it to be purely ornamental. However, another school of thought is that the prow is of assistance in increasing the seaworthiness of the craft in that it breaks the waves before they hit the actual body of the boat. It would seem that this assumption is accurate, as this type of prow is found only on boats that operate on Lake Victoria, where the waves are considered to be higher than on any other lakes in East Africa. The false prow is still to be observed in the present day in many canoes on Lake Victoria, but with improvements in construction it is not considered so essential.

The traditional Sesse canoe is pointed at both ends and, although the originals might not have had thwarts, most of the modern canoes now have thwarts which may or may not penetrate the sides of the boat. These act as seats for passengers and also give more rigidity to the craft. With the introduction of outboard motors, attempts were made to propel the Sesse canoes using such motors. Earliest attempts were to cut a well in the stern to provide an attachment for the motor, but this did not prove to be particularly successful. It was found more practical to provide an attachment for the outboard motor by cutting off one of the pointed ends of the canoe to form a transom. However, the greatest constructional change was the replacement of fibre with nails. The keel still remains basically a modified dugout canoe in most cases, to which the planks are now fastened by means of wire nails.

The Sesse canoe, in its present form, is a suitable type of boat for fishing and has been the main type of craft used in the exploitation of the fishery resources of Lake Victoria. It has also been used extensively for the ferrying of people and farm produce from the main islands of Lake Victoria to the mainland. The usual size of the Sesse canoe is about 28 ft.

## KABALEGA CANOES

The most recent modification of the Sesse craft is the Kabalega canoe which was developed at the Kabalega Technical School, Masindi, by the boatbuilders there. This boat is of double-chine form, with a carrying capacity of approximately 1½ tons. For the first time, frames were introduced into the construction of craft with copper rivets, a proper chine-batten, gunwales, seam battens on the inside of the joints of each plank, while the centre-line was modified to include a keel and a hog.

The original Kabalega canoes were built of mahogany using longitudinal planking, designed for use with 15 hp outboard engines. The boat proved to be successful in fishing and in transportation of goods across lakes. However, mahogany timber proved not to be the best type of wood for this boat, and more recently the canoes have been constructed from Muvule (*Chlorophora excelsa*), although this has meant an increase in the cost of production. This has meant that the boat is somewhat difficult for fishermen to obtain except when provided under the subsidy scheme, which scheme has enabled more than 40 boats of this type to be built in the Lake Albert region alone in one year.

Although these boats are now very popular among fishermen, the traditional dugout canoe is still much in evidence and contributes a great deal of the catch landed in all fishing areas of Uganda. In fact, on the Albert Nile, this is perhaps the only type of fishing boat other than the primitive rafts. Kabalega canoes are the largest fishing vessels in Uganda which Ugandan fishermen now operate.

## 32-FT TRAWLERS

Recent developments include a 32-ft boat that will be adaptable for trawling. Although not in general use by fishermen at the moment, it is hoped that with changing methods of fishing and the need for the exploitation of the distant waters of major fishing grounds in East Africa, this type of boat, powered by a 70 hp inboard engine with a hydraulic winch, may form an important feature of the fishing fleet in East Africa in the future.

## REFERENCES

Gooding, B.T., 1969 Development of Design and Construction of Fishing Boats in Uganda. Uganda Fisheries Department Occasional Papers, 1969. No. 2: 22-24

Worthington, S. and E.B., 1933 Inland Waters of Africa. Macmillan

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Session I ECONOMIC AND SOCIAL FACTORS IN BOAT DEVELOPMENT

Paper I/2

# Social and economic problems in relation to fishing boat development

by

J. STONEMAN

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

## INTRODUCTION

The policy of all East African Governments, implemented by their fisheries departments, is to maximize economic production of the lake fisheries. A vital part of development is the provision of fishing boats and gear. However, selection of boats cannot be decided in isolation, and many factors control the possibility of introducing new fishing boats, however desirable these may be from the standpoint of fishing efficiency.

## PRESENT POSITION

The present situation in the Lake Victoria area is that new boats and methods are on the threshold of utilization. It is, however, essential to consider how the present craft have evolved and the socio-economic pressures at work, as these also determine the approach to and the success of the new boats.

Throughout the Lake Victoria basin, the very valuable fishery is entirely in the hands of small-scale indigenous operatives, using open wooden boats and canoes of up to 30 ft long and propelled by paddles, sails or outboard motors. The evolution of these craft and the present types available have been amply documented and discussed (see References). The gillnet is the basic fishing unit, and up to 100 x 50 metre gillnets may be set from the current fishing vessels which are, in many ways, well adapted to this particular technique but which are not suited to other fishing methods.

There has been a noticeable lack of social and anthropological research into the lives of fishermen in the Lake Victoria basin, their earning powers, and into the cost-benefit analyses of their fishing operations. A good number of subjective impressions are available, and it is generally assumed that the availability of capital to fishermen is restricted, that their earning power is relatively low, and that in times of poor catches they turn to other occupations as they do not generally make a full-time career of fishing. It is also thought that if labour and other costs were fully worked out, their operations would not be commercially viable by normal business standards. It is widely assumed that the opportunity cost of labour available to fishermen is very low, and this alone makes the operation successful. Some research by officers of the United Nations Development Programme/ Special Fund Project in Lake Victoria has given figures for costs and earnings of dugout canoes and the improved planked canoes with outboard motors. Records in the fisheries department also show a similar picture, and it is clear that many African fishermen in the Lake Victoria basin can find up to sh. 10 000/- in capital to establish themselves and monthly operating costs of approximately sh. 1 000/- are common, and that this outlay is met by fish sales and obviously some profit is made. It has been interesting to observe the steady change in fishermen's lives following the introduction of outboard-powered and improved boats dating from approximately 1955. Leading fishermen now operate private motorcars and pick-ups, and are often land and cattle owners of some importance, with housing standards distinctly better than average. They may well maintain a separate establishment on the lakeshore and employ labour for the actual fishing and fish-curing operations. Of interest is the evolution of the specialised fishing operative and the outboard-engine driver/mechanic.

This improvement in the social standing of fishermen is real, even when allowance is made for the general rise in living standards in East Africa. Much of it is due to the greater catching power of the improved outboard powered boat. This fact is recognised by fishermen in general. As a consequence of the economic success of fishermen, there has been a considerably increased pressure on the fishery. Where fishing licences are restricted in number there is now greatly increased poaching and pressure on the authorities to increase the number of licences. When a new fishery becomes established, as on Lake Wamala or at Ntoroko on Lake Albert, there is an immediate influx of fishermen from other areas, and on the long-standing, unrestricted fisheries such as Lake Victoria itself, there is a steady and continual rise in canoe numbers. With a population growth of over 3 percent per annum and no obvious attempt by the Government to control this, demand for fish will evidently increase and profitability of fishing operations will remain good.

NEXT STEPS IN FISHING BOAT DEVELOPMENT

Research and development in the fisheries of Lake Victoria for some years has concentrated on mechanized, active techniques, particularly trawling. One reason for this was a desire not to conflict with the traditional gillnet fishery to the detriment of the existing fishermen. There was also a definite aim to reduce labour needs, both on the grounds of cost and non-availability of people prepared to carry out arduous, wet, dirty work for low salaries (this is, of course, a worldwide tendency, observed in the tuna longliners and, more domestically, responsible for the virtual cessation of beach seining on Lake Albert). Governmental policy also stresses the value and importance of human dignity and the need to lessen the drudgery of the common man.

It appears that trawling will be an extremely successful fishing method on Lake Victoria and may well tap fish stocks at present unutilized. There is some controversy about the optimum type of vessel to be used, which will be discussed during this seminar, but it is perfectly clear that we shall have to take a considerable step forward and that the boats must be inboard-powered decked craft with insulated fish storage and at least minimal accommodation. These will entail initial capital investment in the order of sh. 100 000/-, and operating costs of sh. 15 000/- per month. It is presumed that three men will operate one such trawler which will land possibly 500 tons of fish a year, which is equivalent to a catch by 25 of the present fishing vessels which would employ 75 people. The new boats will land fish in bulk as opposed to the present small scattered quantities, and it may be assumed that bulk marketing methods will require an equivalent increase in capital investment and an equivalent decrease in labour requirements.

REQUIREMENTS AND SOCIO-ECONOMIC IMPLICATIONS OF THE NEW CRAFT

It is clear, too, that the new vessels will require much more highly trained crews and that they will need harbours, piers, slipways, etc. It is already evident that the Governments of Kenya, Tanzania and Uganda will proceed with the introduction of these improved craft, and it is necessary to fully comprehend the steps required by the introduction and its effect on the community.

(1) Finance

The capital required will be beyond the ability of all but a few individual fishermen. We shall, therefore, expect to see Government-sponsored cooperative fishing enterprises, the entry into the fishing industry of businessmen and firms with the required capital but without previous experience of the fishery and increases in Government subsidy and credit schemes to provide the necessary capital. In view of the potential profits and the larger boats, capital should be easy to obtain, but unless great care is taken, the existing fishermen may not have a share in the new mechanized fisheries.

(2) Provision of Boats

From the proceedings of this seminar, it is clear that suitable craft can be produced locally quite satisfactorily.

(3) Training of Crews

As has been stated, this will be essential but all three countries concerned have established schemes and plans to produce the required men.

(4) Wholesale Markets, Bulk Sales and Shore Facilities

These must be provided concurrent with the introduction of the new boats. The Government will almost certainly provide some facilities either as a direct development item or as a cooperative profit-sharing measure. If Government policies permit, there is no reason why a commercial firm with the necessary vision and finance should not install facilities at some points on the lakeshore. Where national plans are in operation, this will depend on the amount of development allocated to the private sector.

(5) Business Management

Control of fishing operations on this scale, even only one trawler, will require management of an order and magnitude greater than existing fishing operations and, initially, managerial executives must be brought in from other larger-scale enterprises - either from public or private sectors.

(6) Effect on the Fishermen

Already a small number of the more successful fishermen are in a position to negotiate the capital required for the new larger boats, and will certainly do so. With proper safeguards by the Government, more fishermen should be able to enjoy the fruits of the larger boats, and it is obvious that, exactly as happened with the first generation improved fishing vessels, some fishermen's incomes and standards of living will rise disproportionately to the general level of the economy. However, there can be no doubt that the larger boats will land fish in a better condition and at a lower cost than the present fishery. This will undoubtedly benefit the consumer and help to delay inevitable price increases as unrestricted population growth outstrips the biological potential of the industry. Thus, cheaper bulk fish must also compete in the markets with the product of the existing fishery even though attempts are made to protect this by restricting trawling to certain areas. The impact of the trawling fishery, therefore, is bound to weaken the existing canoe fishery.

Some idea has been given above on the considerable labour savings, both in the catching and distributive trades attendant upon larger mechanized craft. This is a disturbing factor as shortage of employment is already a major concern with East African Governments, the Kenya Government's second tripartite agreement with employers to engage 10 percent extra staff being only one manifestation of this. However, while no clear-cut policy decision has been made or at least publicized, it certainly seems the intention of all three territories (a) not to control population increase and (b) to encourage mechanization and reduce labour intensive industries. This is certain to aggravate the employment problem, but without directives on this point from the policy-making bodies the technical and professional departments can only implement the projects approved and let the consequences look after themselves. It is relevant to consider what may happen in the future. The major consideration in the minds of those responsible for fixing the size of the new generation of boats was to have the minimum size and cost compatible with profitable operation. Below certain sizes, the trawlers cannot land enough fish to make a profit, yet the size must be as low as possible to reduce the costs to a level where individual fishermen or cooperatives may hope to acquire them. It is, however, obvious that within reason an upper limit of size is controlled only by first cost considerations and presumably, as one of our proposed boats will replace 25 canoes, a 200-ft stern trawler might replace 25 of the second generation trawlers. This would show savings and increased profits, considered purely as a financial exercise, from economies of scale alone.

The implications of this kind of progress in socio-economic terms should be obvious from the bulk of what has been already said. The same problems arise, of course, with all similar moves from labour intensive to capital intensive forms of primary production. It would, however, appear imperative for policy-making bodies to decide quite clearly what level of mechanization and labour replacement is to be aimed at, how many people will therefore require training, resettlement and re-employment, and how this will be done.

It is worthy of note that in developing countries, the criterion for investment and success of most projects and all fisheries projects is ultimately profitability, and the ultimate aim of research, training and expenditure by government is profit. This is not, of course, the case in other departments of government, particularly health, education and the maintenance of law and order, although it may be argued in the long term that these developments produce "profit" to the economy, though it may not be a direct cash profit. It could be argued that in certain cases, insistence on direct cash profit on investments for fisheries projects is not necessary and is, in fact, hampering the optimum development of the nation.

SUMMARY

It is clear from the foregoing that it is relatively simple for the professional and technical fisheries experts to design and introduce improved fishing craft that will be economically successful and suitable tools for the rational exploitation of the Lake Victoria area. It is also clear that the financial and physical requirements of all types required for this introduction can and will be provided. As professional fisheries officers, we can only point out the possible social and economic consequences of these developments as they will affect individual fishermen and, indeed, the population as a whole. We would be failing in our duty if we did not attempt to emphasize the far-reaching nature of these social and economic consequences to those authorities whose function it is to deal with them.

REFERENCES

1. Harris, C.M. 1946 Sesse Canoes, Uganda Journal, X. Uganda Society, Kampala

2. Stoneman, J. 1966 Fishing Boats of the World (Volume 3). FAO, Rome

3. Gulbrandsen, Ø. and Lundberg. 1967 FAO Fisheries Travel Report and Aide Mémoire, No. 78. FAO, Rome (Restricted)

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Session I ECONOMIC AND SOCIAL FACTORS IN BOAT DEVELOPMENT

Paper I/3

# Evaluation of fishing boat investments

by
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Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

## INTRODUCTION

The growing need to economize on capital and skilled manpower resources has led to more careful consideration of the economic aspects of fishing vessel construction and during the last few years several contributions have been made in this field. Most of the methods developed refer to large fishing vessels and imply the use of systems analysis techniques and computers. This paper will, while adhering to the generally accepted criteria, try to recognize the essential need for tools suitable for small craft development.

### (1) Purpose and limitation

The purpose of this paper is to present and discuss two methods, one a shortcut and the other more elaborate, which may be used for evaluating investments in fishing boats. It is assumed that the evaluations will be made from the point of view of a commercial enterprise and no costs and benefits not directly associated with its operation will be considered.

### (2) The problem

An investment may be conceived as a commitment of resources made in the hope of realizing benefits that are expected to occur over a reasonably long future period of time (Bierman, 1967). In this respect an investment in a fishing boat does not differ from other investments.

Of the specific problems facing an investor in a fishing craft, the following are likely to be of particular interest.

(a) Why invest at all?
(b) What type of boat?
(c) What size of boat?
(d) What ancillary equipment to boat?

### (3) Evaluation criteria

In order to decide whether an investment should be undertaken or whether one particular investment should be preferred to another, one needs to have some kind of tool or measure for evaluation. In the literature on investment theory, one finds several tools for decision-making on investments. The choice of the tool to use will depend on what the investor's main concern in the investment is. In cases where the main objective is to recover the invested capital in the shortest possible time, the so-called pay-back period is used as a tool for decision. In other cases the object is to get the maximum return on owned invested capital. For this paper it is assumed that the capital available for the financing or investments is limited and that the aim is, therefore, to maximize the return on the total capital invested regardless of whether it be owned or borrowed capital. Two different measures which may be considered to satisfy this goal will be described and discussed below.

## ACCOUNTING RATE OF RETURN

The first measure is the accounting rate of return (here called ARR) which is the percentage ratio of average annual net profit to investment cost. This is a method that employs the normal accounting and budgeting techniques to measure the profits expected to result from a new investment.

In order to explain the ARR method let us consider the following practical case (Table 1) regarding an investment in a boat that is expected to last for four years.

Table 1

Calculation of accounting rate of return
(in shillings)

| Boat A | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|---|
| Investment cost | 10 000 | - | - | - | - |
| Cash revenues | - | 9 000 | 9 000 | 9 000 | 9 000 |
| Cash outlays | - | 5 000 | 5 000 | 5 000 | 5 000 |
| Depreciation | - | 2 500 | 2 500 | 2 500 | 2 500 |
| Net profit | - | 1 500 | 1 500 | 1 500 | 1 500 |

As the average annual net profit is Sh. 1 500 and the investment cost is Sh. 10 000 the accounting rate of return for boat A is 15%.

The ARR method is applied without difficulty and is readily understood by people used to handling accounting data. It is widely used by banking people and businessmen. From a theoretical point of view, however, ARR suffers from at least two important disadvantages.

1. It fails to take the duration of the investments into proper consideration.

2. It does not take proper account of the time value of money.

With regard to the first objection, an investment that yields, for example, 15% for four years may ostensibly be considered superior to another investment that yields 14% for ten years. The second objection is particularly serious when a comparison is made between projects that have a varying cash flow pattern. A project for which the major parts of the profits arise at the end of the service period may wrongly be considered superior to a project where the profits, on balance, come much earlier.

One effect of the ARR method's failure to take the time factor into consideration is that one must be cautious when comparing ARR rate with the costs of financing the investment. For example, the fact that the average net profit of a project is 15% of the capital invested does not necessarily mean that one can borrow all the capital needed to cover investment cost at 15% and just break even.

To sum up the discussion on the ARR method, one may say that it is a quick and simple way of finding out whether an investment is profitable or not (which answers the first question in the "Problem" section) but for ranking purposes it is a satisfactory measure only when the duration and the cash flow pattern of the various possible choices are similar.

PRESENT VALUE INDEX

The other evaluation tool which will be discussed is the so-called present value index (here called PVI) which is the ratio of present value of future cash flow to investment cost. This tool is more complicated than the ARR and it may therefore be useful to explain briefly its components, some of which have already been mentioned.

(1) Estimated service life

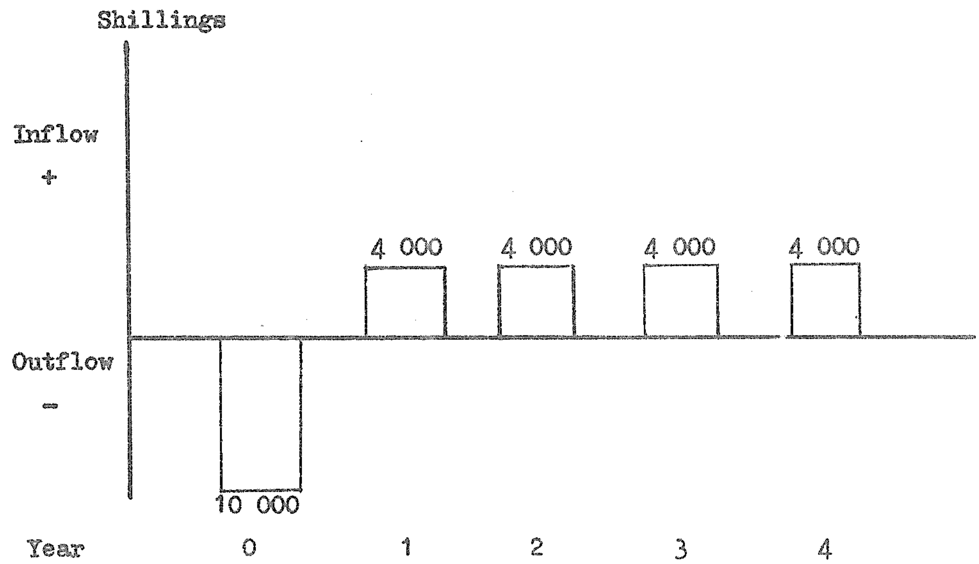
In order to calculate future benefits and costs of a project one needs to know how long it will last. In the case of fishing boats one may arrive at a fairly good idea of the estimated life by looking at fisheries of similar character. However, one should also pay attention to the specific conditions facing the particular boat investment. For instance, inadequate opportunities for maintenance and repair are likely to reduce the service life. If one expects that the boat in question will be replaced before it has become unserviceable, this should also be taken into consideration. The sales value received at the end of the estimated service life is usually called residual value.

(2) Investment cash flow

The outlays and the revenues that are measurable in monetary units and that are associated with a particular investment may well be illustrated in a so-called cash flow diagram. Let us consider the previous case of boat A again.

Table 2

Cash flow diagram




The negative column in year 0 represents the investment cost of the fishing boat. Each positive column represents an annual net cash flow, the difference between the yearly cash revenues and the yearly cash outlays. It should be noted that "annual net cash flow" is larger than "net profit" shown in Table 1. The difference is made up by "depreciation", which although being a cost in the bookkeeping sense, does not represent an actual cash outlay.

(3) Present value concept

As has already been indicated, according to the ARR method, time has no money value, i.e., one shilling obtained in year 1 is equal to one shilling in year 4. According to the PVI method which is based on the concept of the present value, one shilling some time in the future is worth less than one shilling today. The basic reason underlying the present value concept is that money has an earning capacity. The earning capacity varies according to how the money is used. Money may be deposited with banks, loaned, used to buy shares, etc. In most cases the owner of the money expects to receive a return (e.g. in the form of interest or dividends) varying with the time that he does not dispose of the money.

(4) Appropriate rate of interest

In order to calculate the present value of money to be received in the future, it is necessary to determine the "appropriate rate of interest" (here called ARI). This is not a fixed common rate but is rather a subjective rate that will vary with the circumstances under which an investment is planned. One may say that if the investor borrows most of the money for investing in, for example, a boat, then the ARI should not be lower than the interest he has to pay on the loan. If the investor is planning to use his own capital, the ARI should not be lower than what his money could earn in alternative uses ("opportunity costs") with about the same risk involved.

(5) Discounting of future cash flows

The procedure that is used to calculate the present value of future amounts of money is called discounting. Let us assume that we want to discount sh. 100 that we expect to receive in two years from now. Let us also assume that ARI is 10%. To solve this problem of converting future values to present values it is convenient to start out with the relationship between present and future values as is done in Table 3.

Table 3

Relationship between present and future values
(in shillings)

| | | Year 0 | | Year 1 | | Year 2 |
|---|---|---|---|---|---|---|
| (a) | | 1 | ⟶ | 1.10 | ⟶ | 1.21 |
| (b) | | 1 | ⟵ | | ⟵ | 1.21 |
| (c) | 0.826 ⟵ | $\frac{1}{1.21}$ | ⟵ | | ⟵ | 1 |
| (d) | 83 ⟵ | 100 x 0.826 | ⟵ | | ⟵ | 100 |

It can be seen (a) that in two years the value of sh. 1 will grow to sh. 1.21 which, in addition to two years interest on the original capital, includes interest on the interest accumulated after the first year. Thus, sh. 1.21 receivable in two years time will have a present value of sh. 1/1.21 which equals sh. 0.83 (c). The present value of sh. 100 receivable in two years will be sh. 83 (d). It should be pointed out that the discounting procedure only takes into account the time value of money. It does not take into account inflationary trends in money values.

The way of discounting future values presented in Table 3 is rather tedious and is therefore not widely used. In practice the present value factor (0.826 in the example) can be found in discount tables that have been prepared for various combinations of interest rates and time periods. In Annex 1 the present value factors for interest rates up to 30% for periods up to 15 years are shown. It can be seen that at 10% interest the present value of sh. 1 obtained in ten years (a "normal" service period for a fishing boat) is only sh. 0.39. This shows how important it is that the fishing boat - or any other investment - is operating efficiently in the early years.

(6) Practical application

We can now return to the data in Table 1 and see how the present value index method may be applied. The calculations are shown in the following Table 4.

Table 4

Calculation of present value index
(in shillings)

| Boat A | Cash flow | Present value factor (at 6% rate of interest) | Present value |
|---|---|---|---|
| Year 0 | - 10 000 (investment cost) | | |
| Year 1 | 4 000 | 0.94 | 3 760 |
| Year 2 | 4 000 | 0.89 | 3 560 |
| Year 3 | 4 000 | 0.84 | 3 360 |
| Year 4 | 4 000 | 0.79 | 3 160 |
| Total Year 1 - Year 4 | | | 13 840 |
| Present value index = $\frac{13\ 840}{10\ 000}$ = 1.38 | | | |

In Table 4 the various cash flows have been given a common denominator, i.e., the value of money in Year 0, through the discounting procedure. The Table shows that the present value of the future cash flows is greater than the cost of the investment and that, therefore, the present value index is greater than unity, 1.0. This indicates that the particular investment is profitable even if all the capital needed is borrowed at 6% interest. In fact, the present value index 1.38 in the example indicates that the investment is profitable at much higher rates of interest. By trial and error it may be found that at about 22% rate of interest the index will be 1.00. This rate, for which the present value of future returns is equal to the investment, is called "internal rate of return".

We have seen that the present value index may be used to find out whether an investment is profitable or not. The main advantage of the this method in comparison with most other methods (including the "internal rate of return" method) is, however, that it is immediately suitable for ranking different investment proposals. This means that if more than one project has a present value index over 1.0 the project with the highest index should be chosen before the others.

COMPARISON BETWEEN ARR AND PVI

In Table 5 another investment (boat B) costing sh. 50 000 is presented. Both PVI and ARR are calculated. The estimated service life for boat B is ten years. In year 4 there is a drop in the cash flow due to an assumed major repair. From year 5 to year 10 the efficiency is assumed to fall off successively. The residual value of the boat is supposed to be sh. 10 000.

Table 5

Comparison between ARR and PVI

| Boat B | Cash flow | Present value index: Present value factor (at 6% interest) | Present value index: Present value | Accounting rate of return Net Profit |
|---|---|---|---|---|
| Year 0 | - 50 000 (investment cost) | | | |
| Year 1 | 12 000 | 0.94 | 11 280 | 8 000[a] |
| Year 2 | 12 000 | 0.89 | 10 680 | 8 000 |
| Year 3 | 12 000 | 0.84 | 10 080 | 8 000 |
| Year 4 | 7 000 | 0.79 | 5 530 | 3 000 |
| Year 5 | 12 000 | 0.75 | 9 000 | 8 000 |
| Year 6 | 10 000 | 0.71 | 7 100 | 6 000 |
| Year 7 | 8 000 | 0.67 | 5 360 | 4 000 |
| Year 8 | 6 000 | 0.63 | 3 780 | 2 000 |
| Year 9 | 4 000 | 0.59 | 2 360 | - |
| Year 10 | 12 000 (10 000 residual value) | 0.56 | 6 720 | - 2 000 |
| Total Year 1 - Year 10 | | | 70 890 | 45 000 |
| Average annual net profit | | | | 4 500 |

Present value index = $\frac{70\ 890}{50\ 000}$ = 1.42

Accounting rate of return = $\frac{4\ 500}{50\ 000}$ = 9%

(Internal rate of return = 16%)

a/ Cash flow 12 000 less annual depreciation 4 000 $\left(\frac{50,000 - 10\ 000}{10}\right)$

From Tables 4 and 5 it can be seen that both boat A and boat B are profitable investments if the cost of capital is 6%. When it comes to ranking the two boats the accounting rate of return (and also the internal rate of return) indicates that boat A (15%) is a more favourable investment than boat B (9%). The present value index, however, shows that boat B is somewhat more profitable than boat A (1.42 against 1.38). This difference in ranking arises, as already mentioned, because duration and the pattern of the future cash flows are taken into account under the PVI method. As the basic assumptions of the present value index undoubtedly are more realistic than those of the accounting rate of return, boat B should be preferred to boat A. Since the investment cost for boat B is five times greater than that for boat A, an investment in boat B should be compared with five boats of type A[1]. The net present value (present value of future cash flows less investment cost) for boat B is sh. 20 890 and for five boats of type A is sh. 19 200 (5 x 3 840).

1/ Assuming that we want to maximize the return from a given amount of capital (in this case at least sh. 50 000 - the cost of the most expensive alternative)

## CASH FLOW ESTIMATES FOR FISHING BOATS

So far, the examples that have been used have been based upon given cash flows. In practice, one of the most difficult parts in investment analysis is in calculating the cash flows themselves. Some of the factors that influence the determination of cash flows for fishing boats will be described below.

### (1) Investment cost

In the case of fishing boats the concept of investment cost is fairly clear. Practically all outlays of investment type are made before the start of the operations. The total amount of the investment outlays will depend upon a number of technical factors of which the size (in gross tons, cubic metres or some other measure) and engine power are likely to be the most important ones. Other determinants are deck equipment such as winches and fish finding instruments such as echosounders. The gear costs may often be expressed as a function of boat size or engine power.

### (2) Annual revenues

Annual revenues from a fishing operation will depend upon the composition of species and catch volume, and ex-vessel price of each species. Fishing differs from most other industrial activities in the sense that output is very unpredictable. An investor in fishing boats will often have to rely on rough estimates regarding future abundance of fish. The degree of competition from other boats may be hard to foresee. Nevertheless, in most fisheries the output will depend to a fairly large extent on the type and size of the boat (and the gear) - factors which may be influenced by the investor. In existing fisheries and for existing boats, fairly good catch/boat relationships may be determined on the basis of available catch statistics. For new fisheries or new gear, however, a great deal of uncertainty will remain.

### (3) Annual operating outlays

Annual operating outlays are generally more easily foreseen than the revenues. Crew shares, which are usually the biggest single operating outlay, may often be projected as a certain percentage on the estimated sales revenues. Costs of provisions may be expressed as a function of crew size and time out of port. Fuel costs are dependent upon engine power and time spent fishing (including steaming). According to empirical studies, insurance costs and repair costs tend to vary with the capital costs. The latter costs tend to increase with the age of the fishing craft (Green, 1965; Proskie, 1963). As has already been indicated, annual depreciation and interest on own capital do not represent outlays for the investor and should therefore not be included in the annual cash flow estimates.

## OPTIMUM FISHING BOAT

In the following it will be shown how changes in one of the technical variables of a fishing boat may affect the cash flow projections. It will also be indicated how the described evaluation methods may be used to find the optimum combination of various technical variables, i.e., to find the answers to questions 2(a) to (d) mentioned in Introduction.

Let us assume that we want to know what engine power is most economical for a certain size of trawler in Lake Victoria. Let us also assume that a trawler (A), which is about 12 m long and which has a 90 hp engine, costs sh. 140 000 and has an annual cash flow of sh. 25 000. The estimated cash flow is based upon a catch rate of 200 kg/h trawling.

For two other vessels of the same length, one (B) with a 180 hp engine and another (C) with a 45 hp engine, the catch rates have been estimated at 280 kg and 100 kg/h respectively. In Annex 2 the cash flow breakdown of each vessel is shown. It can be seen that apart from fish revenues, crew share and ice costs, which are assumed to vary with the catch volume, initial boat costs and fuel costs are the main differing cash flow items for the three boats. Regarding profitability, it can be seen that the ranking is the same (first A, second B and third C) for the three different investment criteria used. In Annex 3 the PVI for the three boats has been plotted in a diagram. The curve combining the three points indicates that - under the given assumptions - the optimum size of the engine is around 120 hp1/.

In the above case it was assumed that the size of the boats was the same for engines varying between 45 and 180 hp. This assumption is probably not very realistic. In practice there is usually a correlation between the two variables, i.e., when the engine power is reduced boat size will be smaller and vice versa. Changes in overall boat size and in engine power may be combined with changes in other variables, as for example hold capacity, fuel capacity, size of gear and size of deck equipment. In order to evaulate a large number of theoretical investment possibilities, the use of computers may be required. At the end of this paper are listed a few studies concerned with computer systems for the optimization of fishing boats (Doust, FAO, 1965; Engvall and Engström, FAO, 1969; Haywood, FAO, 1969).

## ACCOUNTING FOR RISK AND UNCERTAINTY

All investments are to some extent subject to the elements of risk and uncertainty. For investments where costs and revenues are specified in size and time under contractual agreements the unknowns may be reduced to a minimum. For fishing boat investments the cash outflows, particularly the investment cost, can generally be predicted with a fair degree of certainty. The inflows, however, are highly unpredictable.

There are different ways of coping with risks and uncertainty in investment analysis. One way is to use a criterion (e.g. "pay-back period") which favours fast recovery of invested capital. Another way is to make "pessimistic" estimates of each revenue item and "optimistic", i.e., inflated, estimates of each cost item. Still another way, which is favoured in this paper, is to make the estimates as "realistic" as possible for the calculation of the present value (or the average net profit in the case of the ARR method) and leave the risk and uncertainty to the final analysis of the investment. Here two different techniques of measuring the "sensitivity" of investments to changes in various variables will be described.

### (1) Internal rate of return

The "internal rate of return" (IRR) has already been described as the rate at which the present value of future cash flows equals the cost (at present) of the investment. As has been seen from the examples given, a good way to find out how much "elbow room" there is in an investment proposal, is to compare the IRR rate with the cost of capital rate. If, as in the case of Table 5, after a realistic calculation of the cash flow, a boat appears to have an IRR of 16% and the cost of capital is 6%, one would have a fairly good margin for unexpected events.

Although it is a good measure for comparing single investments with the costs of capital, IRR is not considered ideal for ranking purposes2/. That is why PVI is preferred

1/ It should be emphasized that although some of the cost and earnings data are based on a preliminary investment proposal by the UNDP(SF) Lake Victoria Fisheries Research Project, the data are not intended to represent actual conditions but are merely hypothetical assumptions by the author to demonstrate a technique.

2/ The main objections being that it is not realistic to assume that future cash flows can continuously be reinvested at the IRR rate (Savage, 1967).

to IRR as a measure for determining the desirability of fishing boat investments. One practical disadvantage of the IRR method is the rather tedious trial and error procedure needed to arrive at the exact rate. As a practical rule-of-thumb measure - for investments with fairly even cash flow patterns - the IRR rate can be estimated to be about 50% higher than the ARR rate (see Tables 4 and 5).

(2) Break-even analysis

Another way of finding out how much room an investment may have to counter unexpected events is by application of the so-called break-even analysis. Instead of trying to quantify in money terms the risk embodied in, for example, the fish revenue factor, the potential investor may ask the question: what is the minimum catch needed, other factors unchanged, for a given fishing boat to break even? Or if the price of fish is considered the factor most in doubt, the investor may ask what is the minimum price needed, with the given catch rate, cost of capital, crew share, etc., not to incur a loss? After having calculated the various minimum values the investor will generally be in a position to judge whether the "safety margin" (the difference between the assumed realistic catch and the minimum catch) is large enough to make the investment worthwhile.

In the case of the boats presented in Annex 2 it can be seen that the safety margins with respect to the catch rates are not very large. For boat C, which shows a negative PVI, there is of course no margin at all. For boat A, it is found that the margin is only 10 kg/h (200 kg vs. 190 kg) and for boat B it is even less. The margin may be found by trial and error calculations. It may also be found directly via the calculation of the required reduction in annual cash flow[1/] which will move PVI to 1.0.

In virgin fisheries where catch statistics are not available, the break-even technique may be used to get a "reference frame" for the decision on what fishing boats should be employed initially. Provided that reasonable estimates of investment cost, operating costs and price of fish can be made, a calculation of the minimum catches needed to break even (or to arrive at a certain rate of return) for a number of hypothetical fishing boats may give some useful indication as to the most economical type and size of vessel. With such calculations and with comparisons with similar fisheries from other regions, it should at least be possible to point out those types and sizes of boats that are most unlikely to be good investments.

## EVALUATION FROM THE NATIONAL ECONOMIC POINT OF VIEW

The previous discussion has been concerned with evaluation methods applicable to commercial entrepreneurs. In view of the fact that in many countries a large portion of the investments in fisheries are made by the public, it has been considered appropriate to include in this paper also a brief discussion on the evaluation of public investments. Since a government must seek to avoid mis-allocation of the scarce capital resources, it has to have appropriate tools for investment analysis. One tool which is widely used among government bodies, is the so-called benefit/cost ratio $\left(\frac{\text{present value of cash inflows}}{\text{present value of cash outflows}}\right)$ which is very similar to the present value index described previously $\left(\frac{\text{present value of net cash flows}}{\text{initial investment cost}}\right)$. In general, one may say that a public evaluation needs to cover more aspects than a commercial evaluation of the same type of project. Furthermore, for certain benefit/cost items, the two methods of evaluation may employ different measures.

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1/ For boat A: $\frac{185\ 000 - 140\ 000}{7.40}$ = sh. 6 000

(1) "Direct" effects

In a public evaluation of an investment, the best way is to start out with the so-called direct benefits and costs which are easy to quantify. For fishing boat investments, these benefits and costs would probably coincide to a large extent with those of a private entrepreneur. For such items as costs of boat, gear and fuel which may be subject to taxation, the public costs are, however, likely to be less than commercial costs1/. The pricing of labour may also pose some problems in a public evaluation. Many economists argue that for areas with wide unemployment the true costs ("opportunity costs") of labour to the economy as a whole are smaller than the actual wages paid in the market (Bryce, 1960).

In a commercial investment calculation it is often implied that the public will provide certain services ("infrastructure") free of charge or at low charges. In the fishing sector such services may include harbours and various related shore facilities (such as wharfs, ice plants and auction halls). If public funds are to be invested in fishing boats and if these boats require additional investments in shore facilities, the latter costs also have to be included in the benefit/cost analysis.

(2) "Indirect" effects

Often some of the most significant effects resulting from a project, especially in the long run, are difficult to measure in money terms. For this reason, a public evaluation which only includes direct measurable benefits and cost is not a complete evaluation. Some of the "indirect" effects of an investment in fisheries may include the following.

i) Net foreign exchange effect - This item will be the difference between the "positive effect" which is the amount of foreign currency freed by import substitution or increased exports and the "negative effect" which is the quantity of foreign exchange required for installing, operating and maintaining the project.

ii) The stimulating effect on investments - This effect may include an investment's ability to generate savings (via profits) which may be used for new investments of a similar type. It may also include the ability to induce investments in related fields, for example, investments in boats may stimulate investments in repair yards, processing plants, insulated trucks, etc.

iii) Employment effect - One way of measuring the employment effect is to calculate the "employment coefficient" which is obtained by dividing the number of persons to be employed in the project by the latter's capital requirements (UN,1958). For countries with an abundance of labour it is generally argued that projects employing many men per unit of capital should have higher priority than projects with few men per unit of capital. According to this criterion a developing country may be better off with many small fishing boats employing many fishermen than with a few large, highly mechanized fishing vessels. It should, however, be mentioned that in fisheries technological requirements often determine the balance between labour and capital. For example, for certain types of fishing one must use certain types or sizes of equipment to be able to fish at all.

iv) Other social factors which may have to be taken into account are the impact on nutrition, on health and on skill formation.

It is apparent that public investment evaluation in general gives more room for arbitrary judgement than commercial evaluation. It is believed, however, that systematic use of sound investment criteria such as the benefit/cost ratio will limit the area for subjective analysis and will serve as a reasonable first approximation in making wise public decisions.

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1/ This refers to those frequent cases where the local currency - according to the official exchange rate - is overvalued in relation to other currencies.

**REFERENCES**

Bierman, H. and S. Smidt, The Capital Budgeting Decision. The Macmillan Company,
1966 New York

Bryce, M., Industrial Development. McGraw-Hill Book Company, New York
1960

Chaplin, P.D. and K.H. Haywood, Operational Research Applied to Stern Freezer
1968 Trawler Design. The Institute of Marine Engineers, London

FAO, Report of the Meeting on Business Decisions in the Fishery Industries. Edited
1965 by R. Hamlisch and A.A. Kerr. FAO Fisheries Reports No.22, Vol.1, Rome

FAO, International Conference on Investment in Fisheries. Edited by R. Hamlisch,
1969 FAO Fisheries Reports No.83, Vol.2, Rome

Goss, R.O., Economic Criteria for Optimal Ship Design. Quarterly Transactions of
1965 the Royal Institute of Naval Architects, London

Green, R.E. and G.C. Broadhead, Cost and Earnings of Tropical Tuna Vessels based
1965 in California. FIR Reprint 31. Bureau of Commercial Fisheries, Washington

Proskie, J., Cost and Earnings of Selected Fishery Enterprises - Atlantic Provinces.
1968 Department of Fisheries, Ottawa

Savage, C.I. and J. Small, Introduction to Managerial Economics. Hutchinson
1967 University Library, London

UN, Manual on Economic Development Projects. UN Publication No.58.II.G.5, New York
1958

## Annex 1

### Present value of 1 shilling receivable at the end of each period

Percentages

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.99 | 0.98 | 0.97 | 0.96 | 0.95 | 0.94 | 0.94 | 0.93 | 0.92 | 0.91 | 0.90 | 0.89 | 0.89 | 0.88 | 0.87 | 0.83 | 0.80 | 0.76 |
| 2 | 0.98 | 0.96 | 0.94 | 0.93 | 0.91 | 0.89 | 0.87 | 0.86 | 0.84 | 0.83 | 0.81 | 0.80 | 0.78 | 0.77 | 0.76 | 0.69 | 0.64 | 0.59 |
| 3 | 0.97 | 0.94 | 0.92 | 0.89 | 0.86 | 0.84 | 0.82 | 0.79 | 0.77 | 0.75 | 0.73 | 0.71 | 0.69 | 0.68 | 0.66 | 0.58 | 0.51 | 0.46 |
| 4 | 0.96 | 0.92 | 0.89 | 0.86 | 0.82 | 0.79 | 0.76 | 0.74 | 0.71 | 0.68 | 0.66 | 0.64 | 0.61 | 0.59 | 0.57 | 0.48 | 0.41 | 0.35 |
| 5 | 0.95 | 0.91 | 0.86 | 0.82 | 0.78 | 0.75 | 0.71 | 0.68 | 0.65 | 0.62 | 0.59 | 0.57 | 0.54 | 0.52 | 0.50 | 0.40 | 0.33 | 0.27 |
| 6 | 0.94 | 0.89 | 0.84 | 0.79 | 0.75 | 0.71 | 0.67 | 0.63 | 0.60 | 0.56 | 0.54 | 0.51 | 0.48 | 0.46 | 0.43 | 0.34 | 0.26 | 0.21 |
| 7 | 0.93 | 0.87 | 0.81 | 0.76 | 0.71 | 0.67 | 0.62 | 0.58 | 0.55 | 0.51 | 0.48 | 0.45 | 0.43 | 0.40 | 0.38 | 0.28 | 0.21 | 0.16 |
| 8 | 0.92 | 0.85 | 0.79 | 0.73 | 0.68 | 0.63 | 0.58 | 0.54 | 0.50 | 0.47 | 0.43 | 0.40 | 0.38 | 0.35 | 0.33 | 0.23 | 0.17 | 0.12 |
| 9 | 0.91 | 0.84 | 0.77 | 0.70 | 0.65 | 0.59 | 0.54 | 0.50 | 0.46 | 0.42 | 0.39 | 0.36 | 0.33 | 0.31 | 0.28 | 0.19 | 0.13 | 0.09 |
| 10 | 0.91 | 0.82 | 0.74 | 0.68 | 0.61 | 0.56 | 0.51 | 0.46 | 0.42 | 0.39 | 0.35 | 0.32 | 0.30 | 0.27 | 0.25 | 0.16 | 0.11 | 0.07 |
| 11 | 0.90 | 0.80 | 0.72 | 0.65 | 0.59 | 0.53 | 0.48 | 0.43 | 0.39 | 0.35 | 0.32 | 0.29 | 0.26 | 0.24 | 0.22 | 0.14 | 0.09 | 0.06 |
| 12 | 0.89 | 0.79 | 0.70 | 0.63 | 0.56 | 0.50 | 0.44 | 0.40 | 0.36 | 0.32 | 0.29 | 0.26 | 0.23 | 0.21 | 0.19 | 0.11 | 0.07 | - |
| 13 | 0.88 | 0.77 | 0.68 | 0.60 | 0.53 | 0.47 | 0.42 | 0.37 | 0.33 | 0.29 | 0.26 | 0.23 | 0.20 | 0.18 | 0.16 | 0.09 | 0.06 | - |
| 14 | 0.87 | 0.76 | 0.66 | 0.58 | 0.51 | 0.44 | 0.39 | 0.34 | 0.30 | 0.26 | 0.23 | 0.21 | 0.18 | 0.16 | 0.14 | 0.08 | - | - |
| 15 | 0.86 | 0.74 | 0.64 | 0.56 | 0.48 | 0.42 | 0.36 | 0.32 | 0.28 | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.12 | 0.07 | - | - |

Annex 2

**Trawler fishery in Lake Victoria - a hypothetical case**
(in 1 000 shillings)

| Boat | A | | B | | C | |
|---|---|---|---|---|---|---|
| Length | 12 m | | 12 m | | 12 m | |
| Engine power | 90 hp | | 180 hp | | 45 hp | |
| Service life | 10 years | | 10 years | | 10 years | |
| Investment cost | 140 | | 170 | | 120 | |
| **Annual cash flow** | | | | | | |
| **Revenues** | 180 | | 252 | | 90 | |

A 220 days x 8 hours x 200 kg/hour = 352 tons x 575 1/ = 200
B " x 280 kg/hour = 493 " = 280
C " x 100 kg/hour = 176 " = 100

less 10% market costs

| **Outlays** | A | | B | | C | |
|---|---|---|---|---|---|---|
| Crew share - 30% of revenue | 54 | | 76 | | 27 | |
| Fuel - 4.32 sh/gall | 35 | | 70 | | 18 | |
| Ice - 50% of catch x 140 sh/ton | 25 | | 35 | | 13 | |
| Repair vessel - 8% on cost | 11 | | 13 | | 10 | |
| Repair gear - 200% on cost | 8 | | 12 | | 5 | |
| Insurance - 5% on cost | 7 | | 9 | | 6 | |
| Administration, etc. | 15 | 155 | 15 | 230 | 15 | 94 |
| | | 25 | | 22 | | -4 |
| Present value factor (total for all ten years - at 6% interest) | | 7.40 | | 7.40 | | 7.40 |
| Present value of annual cash flows | | 185 | | 163 | | - 30 |
| Present value index | | 1.30 2/ | | 0.96 | | - 0.25 |
| Accounting rate of return | | 7% 3/ | | 3% | | - 13% |
| Internal rate of return | | 12% | | 5% | | - |

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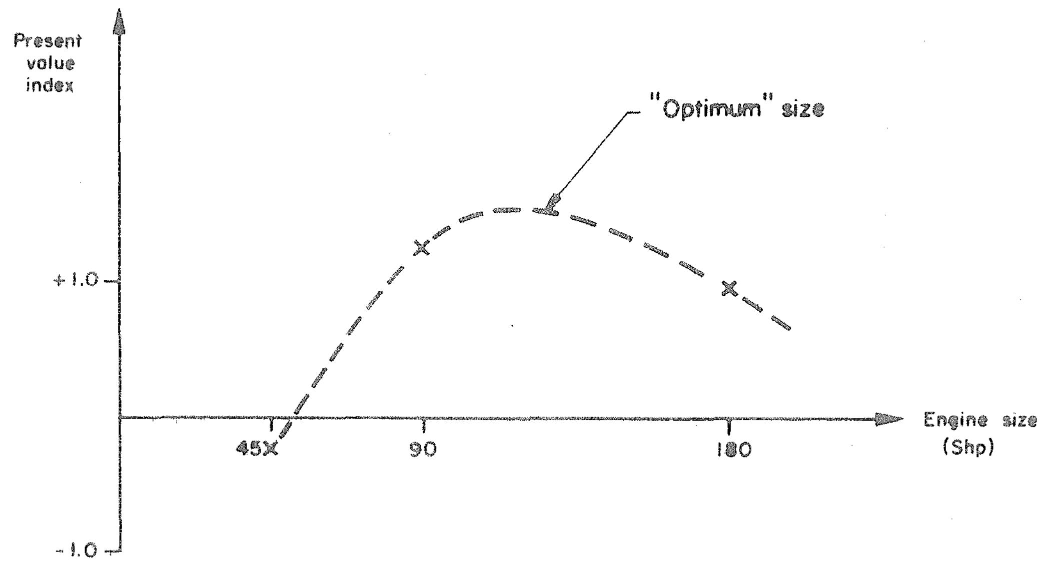
1/ 50% Haplochromis at 250 sh/ton
50% Other at 900 sh/ton

2/ $\frac{185}{140} = 1.30$

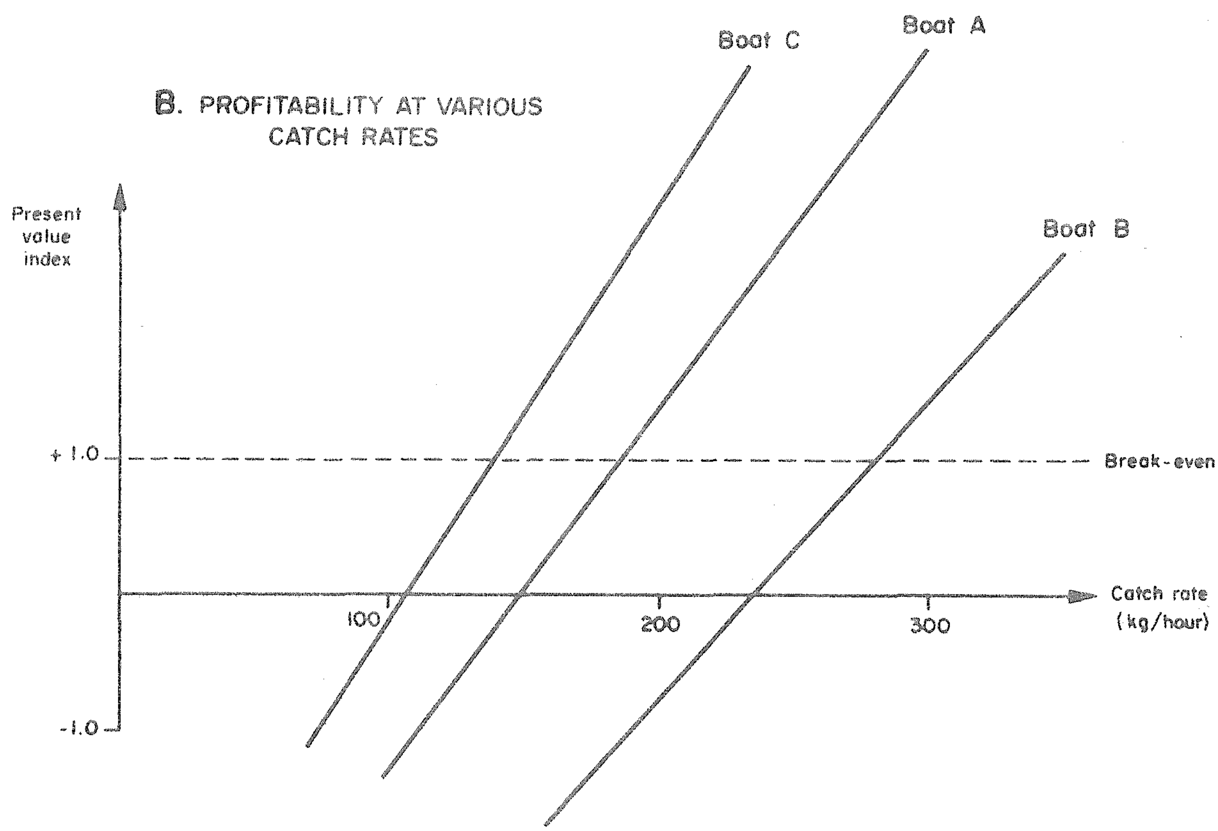
3/ $\frac{25 - 14 \text{ (depreciation)}}{140} = 7\%$

Annex 3 - continued Lake Victoria Case

A. PROFITABILITY FOR DIFFERENT SIZES OF ENGINES




B. PROFITABILITY AT VARIOUS CATCH RATES



SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session I ECONOMIC AND SOCIAL FACTORS IN BOAT DEVELOPMENT

Paper I/D

# Discussion

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

## 1. THE ROLE OF TRADITIONAL FISHING CRAFT

**S.N. SEMAKULA:** The survey carried out two years ago showed that in the Lake Victoria region 2 400 canoes were used in fisheries. It is difficult to know exactly how many of these were powered with outboard motors because some of the boats seen on the lake shores might have had engines which were stored away. The poor maintenance of the outboard motors accounted for a large number of engines being out of action. Information from the dealers shows that over the last three years they have sold more than 2 000 of these motors, but it is quite impossible to say how many of them are replacements of worn-out engines. However, one can reckon that in Ugandan waters approximately 2 000 canoes are operating with outboard motors. In addition to this number, a large amount of outboard engines could be introduced if proper maintenance facilities were available and trained mechanics were established at the main fish landing centres. On Lake Kyoga, there are approximately 2 000 fishing craft. A large number of these are dugout canoes and only about 20 percent are planked canoes, mainly Sesse-type canoes or flat-bottom canoes.

On Lake George, simple-type planked canoes are made, costing approximately sh. 350/- each. The construction of these canoes takes only two days.

On Lake Albert, there are mainly dugout canoes and kabalega-type boats. A type of flat-bottom boat called "Congo Barque" is also used.

Improved boats have been introduced but fishermen still stick to their dugout canoes. Although the construction of dugout canoes is laborious they may, in fact, spend no money on it. The tradition here is that a man can obtain a tree from the forest at no cost, so he goes to the forest together with some of his friends and keeps them in food and drink during construction, which may take up to two months, but he does not spend any cash. This explains why dugout canoes are still being made.

In Uganda there is a total of 5 000-6 000 fishing craft and a large number are dugout canoes.

**N. ODERO:** The type and size of fishing craft utilised in Kenya is determined by the type of fishing performed. In many places the fishing gear is very simple and is operated very close to the shore, so that sophisticated fishing craft are not needed. The simple dugout canoe does its job satisfactorily and the fishermen will be reluctant to change to new types of fishing craft.

On the Kenya side of Lake Victoria there are approximately 4 000 fishing craft of which I do not think more than 60 have been powered with outboard motors. In fact, a large number of these boats are of such construction that it would be difficult, if not impossible, to motorize them.

N. ODERO: (continued)

In Lake Naivasha, fishermen are earning more money than in the Lake Victoria region and the possibility here for motorization should be good.

In Lake Rudolf, fishing is in the early stages but at present there are very few motorized fishing craft operating there.

On the sea coast there are approximately 50 inboard-powered fishing craft.

It is estimated that for the whole country there are approximately 6 000 fishing craft, around 200 of them mechanized.

The present type of fishing craft is only used for day fishing. In the gillnet fishery, fast craft have become popular since they enable the fishermen to get out to the fishing grounds, which might be situated five miles away, and back to the fishing village in a short time. Undoubtedly, in the future there will be a need for vessels that can stay out fishing for more than a day.

P.B.N. JACKSON:

Nobody should underestimate the efficiency of the dugout canoe. The dugout canoe and the Sesse-type canoe have developed into very efficient fishing vessels for inshore use in this region. Some of the dugout canoes have a rather refined construction. The bottom is thicker than the sides at the chines which gives it some degree of stability.

## 2. IMPACT OF TRAWLER DEVELOPMENT ON LAKE VICTORIA

J.A. CRUTCHFIELD:

I think the main point in Mr. Stoneman's paper is that development of a fishery, in terms of efficiency and productivity, cannot be determined purely on the grounds of economic efficiency. The fishery depends, to a greater or lesser extent, on people. It involves the training of people, the moving of people and, in some cases, relocating whole communities so that any introduction of new techniques must somehow take these factors into consideration.

The second point which Mr. Stoneman makes is that, while we have a good deal of folklore, we do not have many hard facts about the sociology of African fishermen. There is also a large gap of knowledge regarding the economics of the various fishing methods now being utilized. Even though the fishing equipment might be very simple, this does not imply that from an economic and social point of view, this is an inefficient operation.

A third point is that in view of the increase in population and the higher income levels there will be an increased need for fish which, over a period of time, might not be covered by the available resources which again will lead to a rise in the price of fish.

**J.A. CRUTCHFIELD: (continued)**

We might be moving away more rapidly than we realize from development as the sole object, toward controlled development and a programme of controlled fishing effort which will improve rather than decrease the efficiency of the fishing operation.

A serious point which has been raised is the effect on the operation of the traditional inshore fishery due to the introduction of bigger trawlers on Lake Victoria. The question is: how can we provide an increased supply of protein food with minimal disruption to the people whose livelihood depends on the traditional fishery? The most important problem to solve is the marketing of the fish from these trawlers which should be done in such a way that it creates minimal interference with the existing market of the small boat fishermen. It is my opinion that this problem can be solved.

The major difficulty lies in the fact that these trawlers will require landing and marketing facilities which will involve a large amount of investment, probably by the government concerned in cooperation with private industry.

I think there is room for institutional research into the marketing of Haplochromis, which can be converted into fish meal or other processed products. This is probably the largest single problem facing the development of the fishery on Lake Victoria.

My own country and a number of countries with which I am familiar have suffered constantly and continue to suffer from attempts to develop on a national basis a fishery in international waters. The problems, but also the opportunities, are very great here in East Africa. We are now beginning to take the first steps toward full development of the waters of Lake Victoria. It seems to me that if the project to develop this fishery is going to succeed it will have to be a multilateral project.

**S.N. SEMAKULA:**

Trawl fishery does not contradict the traditional canoe fishery since the sale of fish will be carried out on two different markets. I do not believe that the canoe fisherman will develop into a trawl fisherman; rather, we have to train a completely new type of fisherman to operate the bigger and more sophisticated boats.

**N. ODERO:**

If the new trawlers are going to dump a large amount of fish on the same markets as the traditional fishermen, it is undoubtedly going to influence the price of the fish and the life of the traditional fishermen. The species caught by the new trawlers will also be the same as those caught in the gillnet fishery, such as Tilapia, Haplochromis and Clarias, so that there is bound to be some interference between the existing gillnet fishery and the new trawl fishery.

P.B.N. JACKSON: Trawl fishing will probably not be done by the traditional fishermen. I can see a possible problem arising when the trawl fishery gets started. The gillnets of the traditional fishermen are normally not very well marked. There might be a small stick or something at the end of the net which is not visible from any distance, and trawlers, even though they try to avoid these gillnets, might accidentally run into them. The shallower grounds are rich in Tilapia so there is a temptation for the trawler to go on the same grounds which are now fished by the traditional fishermen. What do we do? We must harvest the resources of this lake with the new trawlers and, at the same time, we must cause as little harm as possible to the inshore fishermen. One way is to prohibit trawling in shallow water, and this might be the best way. On the other hand, human nature being what it is, there is a temptation for the trawl skipper operating say in the vicinity of the Sesse Islands to fish in the shallower waters when he knows that there is little risk of being caught. This is the problem we are faced with: how can we get the maximum amount of fish out of this lake and get proteins to the population without seriously upsetting in any way the traditional fishermen?

J.A. CRUTCHFIELD: Nobody wishes to introduce a highly efficient fishing method that will wreck the grounds of the small fishermen or seriously depress the price of fish on the market. It is very easy to slip from this into a fishery policy that tries to maximize the number of people that can be supported on the fishery, endangering in the long run the total contribution the fishery can make to the country's economy. I think it is very easy to take a legitimate concern about the traditional fishermen and turn it into a prohibition of any real economic progress.

One cannot load all the problems of economic development on to the fishery itself. Sooner or later one will get a drain of what is now unutilized labour in the local fishery into more profitable occupations. To a large extent the health and welfare of the local fishery is geared to the economic development of the country as a whole.

I would like to ask Mr. P.B.N. Jackson the question which is intimately tied up with the problem of the traditional fishermen versus the new industrial fishery: what has been the result of the investigation carried out by the Lake Victoria Fisheries Research Project in this field?

P.B.N. JACKSON: Our investigations show that there are very large resources of fish in Lake Victoria which are not sufficiently exploited. However, a large amount of this is Haplochromis. The Haplochromis is mostly caught by a trawl in depths of around 20 m. The most valuable fish caught by the inshore fishermen is the Tilapia, which is rarely caught in water deeper than 6-7 m. At a depth of 20 m, the trawl catches other species of fish like Bagrus and Clarias. Our present plan is to propose a minimum fishing depth of 20 m for the trawlers and they will then mainly catch Haplochromis and not interfere with the Tilapia fishery of the

P.B.N. JACKSON: (continued)

local fishermen. It is estimated that at the present time there is a standing stock of about 18 000 tons of Tilapia in Lake Victoria. These trawlers must be fairly big vessels operating from well equipped shore bases and their catch of Haplochromis may probably mainly be converted into fish meal.

At the present time, East African countries are importing fish meal for livestock feeding and a local production of fish meal will save valuable foreign exchange. The project we have in mind will consist of creating trawler fleets and the required shore facilities. These shore facilities can, of course, also be utilized by the small boats. This will be a completely different type of operation compared with the existing canoe fishery which land their catches on open beaches. Furthermore, the trawlers will utilize resources of Lake Victoria that, at present, are unobtainable by their local canoes. The interference between these two types of fishing should, therefore, be minimal.

A.P.G. HOLNESS:

The new trawl fishery will have to be done the whole year round and the crew on these boats will have to be full-time fishermen. A large part of the traditional fishermen are only doing fishing part of the year and they have to take care of their crops and their property for the rest of the year. For a long time to come, this situation will persist simply because we cannot construct fish landing facilities in every village along the coast.

D. MUKIBI:

I do not think that there will be any likelihood of a collision between the fish marketed by the local fishermen and that marketed by the trawlers. The man operating the trawlers will not be interested in selling the fish on the spot; he will organize transport and bring it, for example, from Musaka to Kampala, or even to the Congo while the simple fisherman will, as he has always done, sell his fish on landing to the fishmongers.

J.A. CRUTCHFIELD:

While taking into account a 3 percent yearly increase in the population, even if we visualize no real increase in the income per caput it does not take many years before the need for fish is increased two or three times more than the present level. There is no foreseeable possibility of over-production of fish in the East African countries. On the contrary, I think even in our lifetime we will see considerable imports of fish.

## 3. AN INTERMEDIATE STEP BETWEEN TRADITIONAL CRAFT AND TRAWLERS

J.E. ENGSTRÖM:

I have two questions:

(1) Are there any alternatives between the traditional canoe fishery and the trawl fishery?

(2) Is it possible to give the traditional fisherman compensation in the form of a credit scheme that will allow him to modernize his equipment?

A.S. OBURU: Onthe coast of Mombasa, experiments have been carried out with a small boat equipped with a 12 hp inboard diesel engine and fitted out for trawling. These experiments have been conducted by a Japanese fisherman and the results are encouraging. Whatever new type of fishing boat or new fishing gear is introduced, it is important to clarify the economic aspects before introducing it to the fishermen. We have to know the possible improvements that can be made with new types of gear and boats and then balance these against the possible social consequences.

J.A. CRUTCHFIELD: There is one point that has been previously mentioned in the discussions specifically in connexion with bigger vessels and trawling, and I think it also applies to the inshore fishery, that is, the changing nature of the market. There will be an increasing market for fast boats which can move around rapidly and meet the need for fresh fish.

C.C. TAIT: For an intermediate fishing boat, it might be difficult to introduce any fishing method other than gillnetting which is being utilized at the present time. However, on the other hand, it should be possible to increase the catch even further by improving on the type of gillnets utilized by the local fishermen. I think this is an area which is worth more experimental and extension work.

J.A. CRUTCHFIELD: The success of the Kabalega boat on Lake Albert might possibly be explained by the fact that this boat makes it possible to handle a larger amount of gillnets than in the traditional Sesse canoes.

E.S. KANYIKE: As we are trying to develop the fishing industry there will be a need for more competitive fishermen and we might need a man who was not born in a fishing village and brought up doing fishing, but more an investor type, a man who is able to locate a business opportunity and can judge whether it is worth while investing his money. The two small trawlers which we have developed, the 32 ft MULULU and the MUVULE have been seen in various parts of Lake Victoria and have caused great interest. We have had people coming to our office asking for information about these boats and wanting to invest their money with or without a subsidy. The local fishermen will be content with their boats costing sh. 400-500 but the new men investing in the trawlers will come from a completely different background with sufficient financial resources.

S.N. SEMAKULA: In Uganda, we have a system which permits the traditional fishermen to obtain vessels and equipment with a one-third subsidy from the Government and we intend to establish a similar system for assisting the trawl fishery. They will get the Government's support whether they are working inshore or offshore.

Ø. GULBRANDSEN: There is a big step up in investment, going from a Sesse canoe, costing sh. 400-500 and possibly equipped with an outboard engine costing sh. 3 000, to an inboard-powered boat, say around 25 ft, with a 7-8 hp engine costing around sh. 12 000. It should be evident that the latter boat cannot fish with the same amount of gear as the Sesse canoe. It will simply not be possible to cover the increased cost of the new boat without increasing considerably the catches by utilizing a greater quantity of fishing gear or more efficient gear. The introduction of new boat types here in East Africa must be linked with the introduction of newer or better fishing gear. There have been many cases where a new type of fishing boat has been introduced, which was considerably more expensive than the local type of boat without, at the same time, investigating what type of gear the new boat had to utilize in order to catch enough fish to cover the increased costs.

J.A. CRUTCHFIELD: There is a danger of generalization regarding the bad economic status of the inshore fishermen. There are areas in Uganda, for example Lake Albert, where the inshore fisherman has an income which is superior to other groups in the same community. These people have been able to create impressive increases in the fish production which in the case of East Africa is three-fold. Most of this increase in production has been entirely financed by the fishermen themselves. Canoe fishery and inefficient fishery are definitely two different things.

## 4. EXPERIENCE FROM OTHER COUNTRIES

N. FUJINAMI: The Japanese fishing industry had 400 000 unpowered fishing vessels half a century ago. Now there is the same number of vessels but half of them are powered. This is a tremendous number compared with the fishing vessels owned by European countries.

If the total catch of the Japanese fishing industry is divided by the number of vessels we will get a very low figure and from that standpoint the Japanese fishing industry is not necessarily efficient. For a long time the Japanese Government was faced with a social problem concerning the small fishermen. From a purely production point of view most of the coastal fishermen were probably not required but these fishermen had no other means of subsistence. Regulations were, therefore, introduced to protect the small-scale fishermen and, for example, the use of otter boards has been forbidden on the inshore trawlers because they are too efficient. Big trawlers are kept out of coastal waters and to enforce these regulations the Government has more than 100 patrol boats.

Fortunately, the coastal fishermen have a different market from the high-seas fishermen. The per caput annual consumption of fish in Japan is 70 kg and fresh fish is preferred and, therefore, fish brought in by the inshore fishing boats is very much appreciated. This is why coastal fishermen can still survive in

N. FUJINAMI: (continued)

competition with deep-sea fishermen. The Government encouraged the expansion of the deep-sea fishery by giving a subsidy to owners of boats over a certain size built according to Government regulations. Now the deep-sea fishing fleets are facing trouble because of increasing labour costs and restricted areas of fishing, while the coastal fishing fleet is still operating profitably.

D.G.L. RIGBY:

In Ceylon a mechanized fishery has developed, parallel to the traditional canoe fishery, over the last 10 years. The mechanized boats have left the grounds that are fished by the traditional boats and are fishing further offshore, so the small-scale fisherman is still surviving while, at the same time, the owners of the mechanized boats are becoming more prosperous.

J.A. CRUTCHFIELD:

In Nigeria we have an example of a really spectacular development in a fishery, partly sponsored by production by Nigerian vessels and partly by imported frozen fish, which has gone from something like 300 tons in 1963 to around 40 000 tons in a matter of 4-5 years. The fish is moved directly from the cold stores in the major receiving areas up country to refrigerated stores for distribution on the local market. At the same time as this development was going on the price of fish from the inshore fishery continued to rise at a very satisfactory rate. I think that much the same thing has happened in Ghana. The markets were so strong that they could absorb the fish both from the inshore fishermen and from the long-distance freezer trawlers.

## 5. ECONOMIC ANALYSIS AND PILOT PROJECTS

Ø. GULBRANDSEN:

Economic analyses might seem dry and uninteresting to laymen. As a naval architect working in the small boat field for a number of years I have become convinced that the type of economic analyses as presented in the paper by Mr. Engström will become more and more important in the future. We can design a beautiful fishing boat, minimum resistance, excellent stability and it is of no use if that fishing boat is not making money for its owner. Mr. Engström's paper shows how the profitability of various alternatives in boat sizes can be calculated.

However, any economic analysis depends on the availability of data - you have to know something about the cost of the boat, the running expenses, crew expenses and what is most important, the expected catches. In places where one is faced with new development these data are not available, and it is then imperative to obtain data through pilot operations before a large-scale expansion of the fishing fleet is envisaged. Often several different sizes of fishing boats will have to be built and tried out over an extended period in order to obtain the required data. I believe that in future the two main tools in fishing boat development will be pilot projects and economic analysis.

J.A. CRUTCHFIELD: I think you have all run into problems with budgeting in competition with other government agencies and the private sector. The fact that you might find it difficult to forecast the effect of fish development should not prevent you from somehow trying to justify, by economic analysis, a better rate of return plus or minus social consideration than another government agency. The process is difficult and complex, but it is simply something that has to be done if you want to obtain a legitimate claim on a restricted government budget.

P. PROUDE: In connexion with the proposal of operating pilot projects to obtain more specific data, it is important to realise that a government agency is not very well adapted to these kinds of projects. A pilot project must be run as closely as possible to a commercial operation and a government agency with staff on fixed working hours and a fixed salary will find it difficult to run a pilot project as a private commercial firm would do. You might need very special type of staff to perform this kind of operation. If not, the results you get out of them might not be applicable to a development that will later have to be done by commercial firms.

J.E. ENGSTROM: Economic analysis is not only useful for evaluating various alternatives before making an investment. After a project has started it will be necessary to provide some control of the operation and the fact that you have forced yourself to put up a budget before the operations started, will make it possible for you to measure the achievement in relation to planned values and enable you to make corrections in time, if necessary. You have the possibility of having a continuous follow-up of an investment.

J.A. CRUTCHFIELD: The American tuna fleet uses a standard accounting technique for a large number of its vessels, and this has provided the type of data which is essential to achieve control of a development. It is possible to develop fleet accounting systems that will give you a fairly decent check on how close your estimates are and will indicate in which direction you are heading.

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session II MATERIALS FOR BOAT CONSTRUCTION
Paper II/1

# Progress of boatbuilding in Kenya

by

A.P.J. HOLNESS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

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As far back as 1912-18, the people who lived on the shores of Lake Victoria laid the foundation for the fishing industries of today. Very primitive rafts, dugouts and stitched plank Sesse canoes were used, without aid or advice from the outside fishing world. It was probably this lack of contact that built the foundation of the famous Luo fishermen, who migrated to every little village on Lake Victoria and even trekked down into Tanzania to other smaller lakes.

The Lake Victoria fishermen took with them traditions which remain to this day and may take years to change, if indeed a change is necessary.

One of their traditions was the type of boat suitable for their kind of work - a craft that could be moved easily through narrow channels in papyrus or thick reeds - a craft that could be used by one man or four, so as to enable families to work in the field as well as on the water. The craft had to be light enough in weight to be dragged out of the water by four people.

One reason why the Kenya fishermen of Lake Victoria were backward in the development of fishing craft was their difficulty in obtaining suitable timber for boats and the know-how of cutting the few trees which were available, hence the large numbers of dugouts which were used.

In Uganda, however, timber industries started at a very early stage, and on most of the shoreline of the Uganda Lake Victoria waters, large forests gave the local people there a great advantage in obtaining knowledge in the timber field.

This advantage became very noticeable when the original Sesse canoe came into being. The canoe was built of "pit sawed" one-inch planks, stitched together with a special fibre, and further strengthened by seats placed across the structure.

These boats were the backbone of the Uganda fishery and even though outwardly appearing flimsy and unstable, were good sea boats and became the traditional boat for progressive fishermen.

It was from these original Sesse canoes that the Uganda Fisheries Department began their campaign to improve the basic design without altering the traditional image.

Efforts to introduce other designs, such as beach "cobbles" and well constructed clinker boats, even conventionally designed fibreglass boats, were unsuccessful. The main reasons for the fishermen's rejection of these new ideas were as under:

i) Too clumsy for one man to operate on his own.

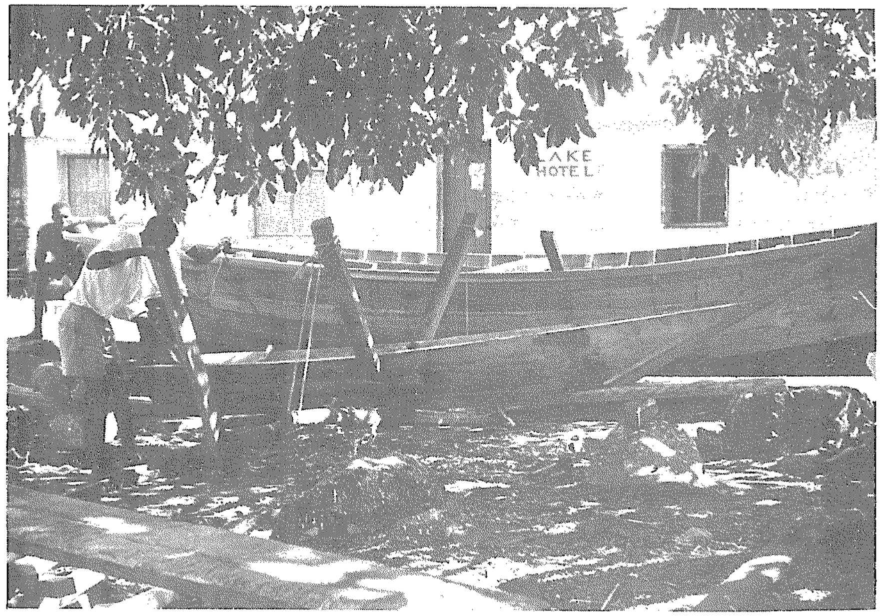
ii) One man would be unable to paddle such boats with a conventional paddle. (Oars were out of the question owing to the need to operate in weed or narrow channels.)

iii) Repairs to such boats would be costly.

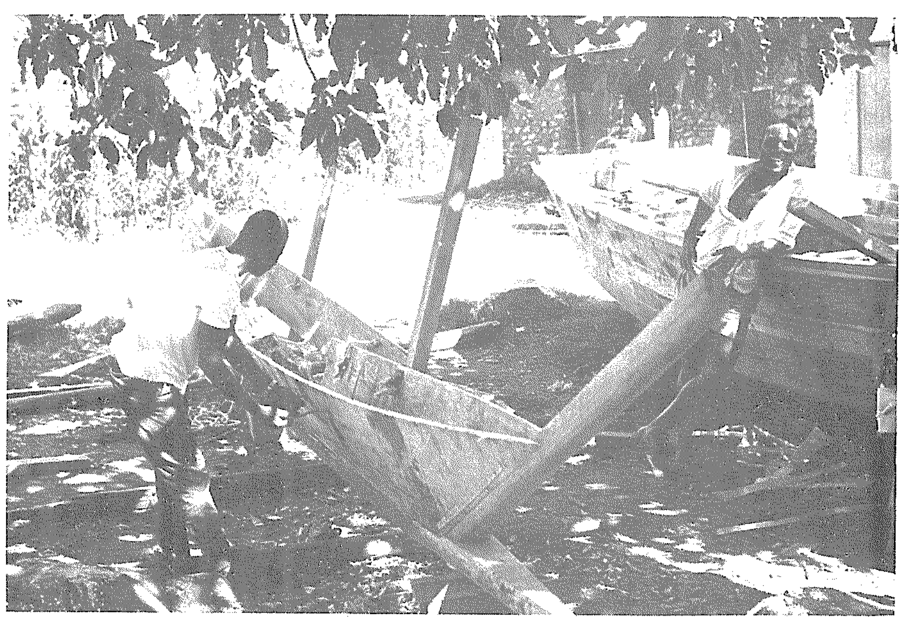
iv) They were considered clumsy and difficult to operate in high winds.

Rather than continue with the battle to change the fishermen's ideas and force them to accept a new boat, the Sesse canoe was put on the drawing board and a campaign was begun to improve the basic design which the people had already accepted.

Sesse canoes were made with proper frames, seats and designed with a square stern to take outboard engines. Local boatbuilders in Uganda began to improve their canoes in their own way, by using nails and metal strips to turn their craft into a more rigid type of boat.




Beach boatbuilding - preparing to bend boards



Beach boatbuilding

It was not long before the Sesse canoe was the accepted boat for all fishermen; their use slowly spread down into the Kenya waters of Lake Victoria and a variation of the Sesse canoe also came into being in Tanzania.

Later Uganda, once again with timber resources at their disposal, began properly organized boatbuilding training courses, firstly at Kichwamba Technical School, near Fort Portal, and eventually at Entebbe. Here the students were trained to build and improve on the old design of Sesse canoe, and eventually these trainees left to begin their own boatbuilding businesses.

The present-day Sesse canoe is of a very simple design, with good sea-keeping qualities, easy to repair and cheap to buy. It requires a small outboard engine to drive it at high speeds and can carry a load which more than meets the requirements of the ordinary fisherman.

The average length of the Sesse is 8 m (26 ft) with a mean of 1.4 m (4 ft 8 inches) but draws only 12 cm (5 inches) of water, carrying four fishermen and 25 cm (10 inches) loaded. This canoe will also sail with the wind and can be poled very easily.

The author, who has been involved in the advancement of boatbuilding both in Uganda and Kenya, recently introduced the Sesse to a local boatbuilding firm in Kenya, and they have since produced sixteen fibreglass versions of the canoe. The first seven which came off the line were bought by the Kenya Fisheries Department to demonstrate to fishermen on Lake Victoria, Lake Rudolph, Lake Naivasha, Lake Baringo and at the coast. It was found necessary to make a few modifications to the seats, and special wooden runners were fitted to protect the keel. The price, at present £175, compares favourably with the present price of wooden versions, and is, in fact, lower than some.

The average weight of the fibreglass canoe is only 250 kg (500 lb) making it fairly easy to transport, and this also enables the fisherman to step down on his outboard engine power. He can obtain a speed of over one knot per horse power, and can fit anything up to a 20 hp engine.

A ten-day course has been arranged in order to teach two fisheries scouts to carry out running repairs to fibreglass craft. The builder pointed out that it was a simple matter to carry out repairs on such canoes; similar repair jobs on wooden canoes would require the attention of a fully trained carpenter boatbuilder.

One very important additional advantage of the fibreglass Sesse is that built-in buoyancy sections under each seat have been incorporated in the design, making the craft virtually unsinkable.

This fibreglass version of the Sesse canoe is, in the author's opinion, the present-day answer for the middle-class fisherman.

When the future of boatbuilding is to be considered, a number of factors must be placed in order of importance:

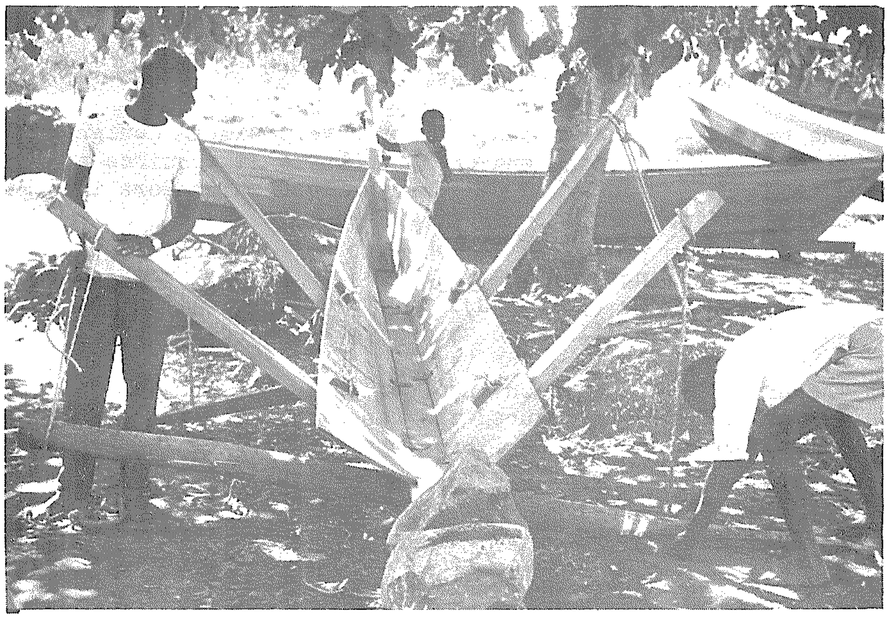
i) Are there always going to be adequate supplies of timber?

ii) What will be the cost of transporting such timber?

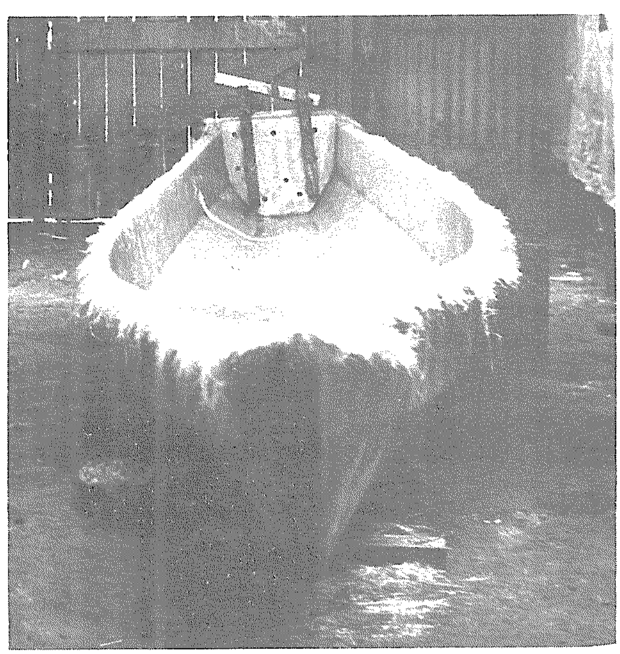
iii) What will be the future cost of other items required for wooden boatbuilding?

iv) What will be the labour costs?

v) What is likely to be the average cost of repairs and maintenance of a wooden boat?



Beach boatbuilding - arranging rope springs



Fibreglass canoe in mould

With fibreglass boats, however, we have a virtually maintenance-free boat. Running repairs are cheap and simple to carry out. The raw materials required are easily obtained, and as markets improve will become cheaper to buy.

The greatest expense involved in fibreglass boatbuilding is the original mould. This, however, could be easily overcome if the Government held moulds in stock, which could be made readily available to any local boatbuilder who wished to take up fibreglass construction.

At present in Kenya we have two companies building such boats in fibreglass, and their products have proved very acceptable. The author has tested a number of these boats and found them more than satisfactory.

At an earlier stage in the Kenya boatbuilding industry, experiments were carried out in building Sesse canoes from marine plywood. This was an attempt to see how a plywood boat would stand up to rough treatment without maintenance.

The results of this experiment varied considerably. One boat was maintained and lasted for three years; the other broke up after six months, although this was mainly owing to local heat conditions, as average temperatures in this part of Kenya (Lake Rudolph), range from 27°C to 50°C.

These experiments were later discontinued and it was found uneconomical to purchase plywood sheets for repairs.

Kenya has, at present, a number of first-class boatbuilding yards. There are four situated on inland lakes and four serving the coastal area. There is also a large boatbuilder outside Nairobi engaged in building boats for the coast.

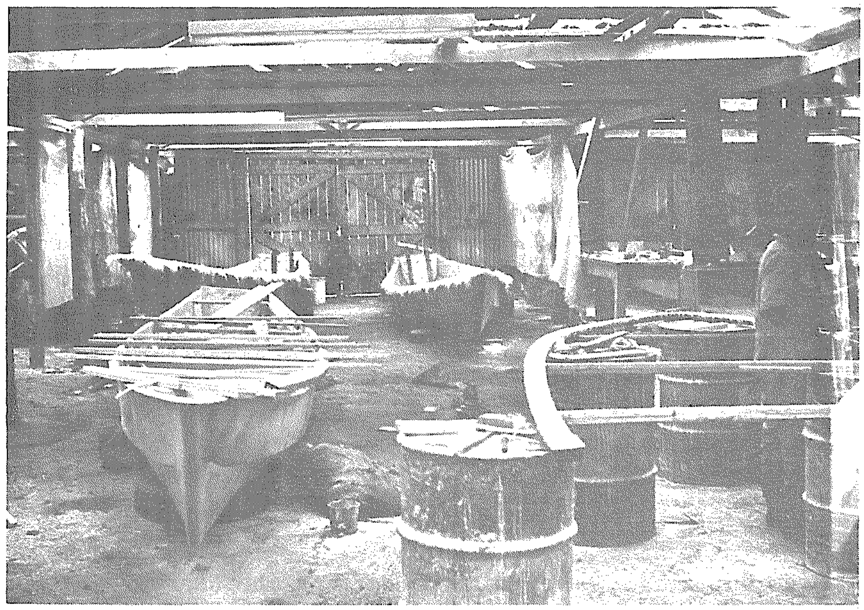
Boatbuilders currently established in Kenya are able to cope with present demands, but with the rapid growth of the fishing industry as a whole, the Fisheries Department is well aware of the urgent necessity of training local staff in boatbuilding crafts.

To this end, a Uganda boatbuilder has been recently engaged in training a few Turkana fishermen on Lake Rudolph to carry out simple repair work, and a Danish volunteer carpenter/boatbuilder has now arrived to extend this programme further. Additional Danish assistance will arrive shortly.

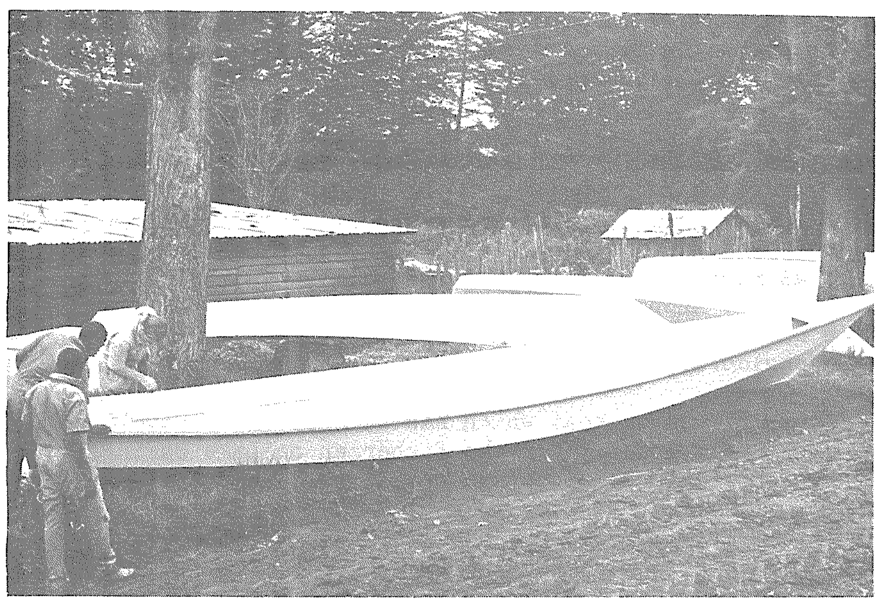
In Mombasa, a great many local people are employed by the larger boatbuilding organizations and receiving valuable training.

A further important factor in the training of local people is the need to urge the necessity of keeping costs of fishing boats as low as possible and within the money bracket of local fishermen. As stated before, Uganda is in a far better position than Kenya, as far as local supplies of timber are concerned. Kenya has to import her timber, and the price naturally increases with the distance it has to travel, and this must also be taken into consideration.

Another popular boat which has been recently developed is the "Baringo Sesse". This was designed specially for the fishermen on Lake Baringo, who found that the cost of the larger Lake Victoria Sesse was beyond their pockets (EA sh. 3 500), and a smaller version, 6 m (20 ft) with a beam of 1.10 m (3 ft 8 inches) has been introduced. This craft is stable, and will carry three men with ten to 15 nets. It performs well with a 6 hp engine. Similar construction methods are employed, i.e. 3/4-inch planks, and the cost is EA sh. 1 900.



Fibreglass canoes under construction



Preparing fibreglass canoe for transporting

Planning of Boatbuilding

The Kenya Fisheries Department appreciate very much the help and advice given by FAO on boatbuilding and all the effort involved in the training of local boatbuilders. This is a great step forward.

We have been approached on a number of occasions by overseas experts, shown new plans, and given information on many other different boats. This advice has always been gratefully received and the plans have been extensively studied, but when it came to putting the plans into practice, the costs have been high, and in most cases the plans too complicated for local boatbuilders to adapt. The entire process of introducing new craft to local fishermen takes time and tact, as they will not accept a boat unless they can be convinced that it suits their requirements in every way and are reluctant to give up well proved designs.

It is necessary, politically and economically, to encourage as many lake-shore dwellers as possible to participate in the fishing industry, even in a small way. This is essential to keep homes going and enable children to be educated. There will always be the "beach" fisherman who cannot afford, or does not wish, to expand to deeper waters. These masses must not be passed over just to improve a more distant and ambitious fishery.

The necessity of developing untouched waters is obvious, and boats required for this work will, of necessity, differ from those used by the average beach or village fisherman. Experienced men will be required, and ideally there should be a boat for each such fishery, whether close inshore, offshore, and even a collection service for distant offshore fishing.

The boat which has recently been designed for the Uganda Fisheries Deep Water Exploitation experiments (UGA-1) would be ideal for this purpose, and possibly more progressive fishermen could use such a boat. If too expensive for an individual to operate, it could possible be shared by a company or group.

The author has spent considerable time with the beach boatbuilders on the shores of Lake Victoria. These people are experts in their own line, and should not be overlooked. It was interesting to see that they used cedar on the Maziwa or small dhow, and on inspecting a craft which was said to be three years old, the cedar wood was found to be in excellent condition. Cedar was only used on the dhows as the curves were gradual.

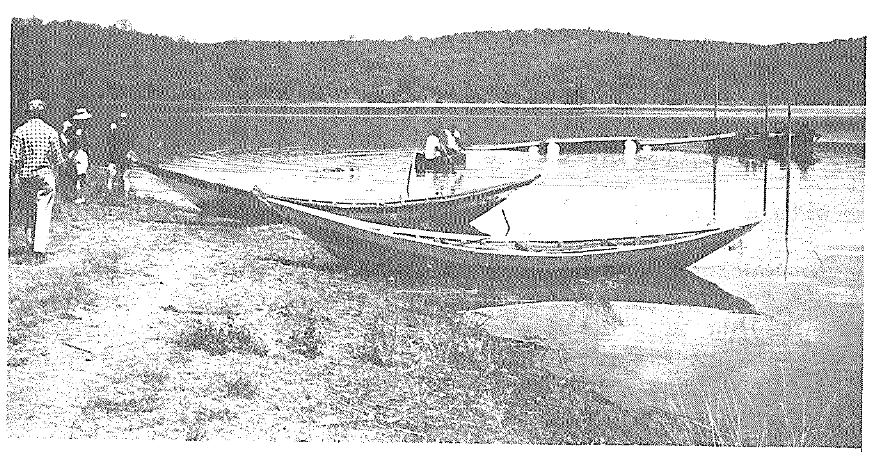
A larger Maziwa, 11.5 m (38 ft) long with a 4 m (13 ft) beam, was built with cedar and camphor wood. The keel of the "Mutungi" (the local Sesse), was also cedar, and the planks were camphor.

It was extremely interesting to watch the way in which the planking of the boats was carried out. Special stakes were used with rope springs which are twisted until the correct angle is reached. The seaworthiness and strength of these locally produced craft should not be underestimated.

Another important aspect is the low cost of the craft which are being produced. The cost of the big dhow is only £400, complete with sail. The smaller dhow 8.2 m (27 ft) long with a 2.4 m (8 ft) beam, is £100, and the "Mutungi Sesse" is £30.

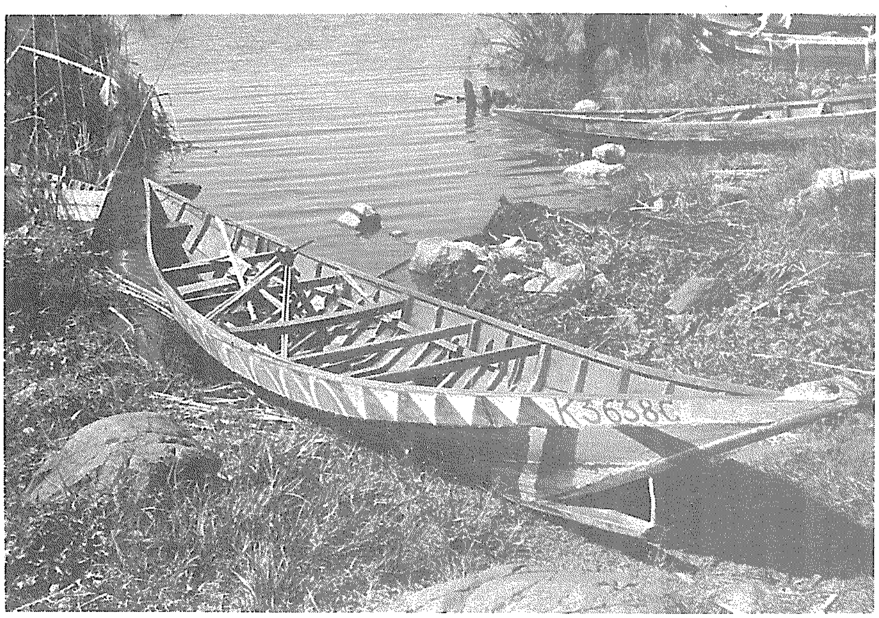
In conclusion it is felt that, while there is an obvious need to produce new designs of craft to cope with more complicated and advanced fishing gear in order to exploit waters further afield, we should not "bulldoze" the present modified traditional craft aside, as these are more than satisfying the moderate fisherman at present.

A Victoria "Maziwa" (small dhow), built of cedar

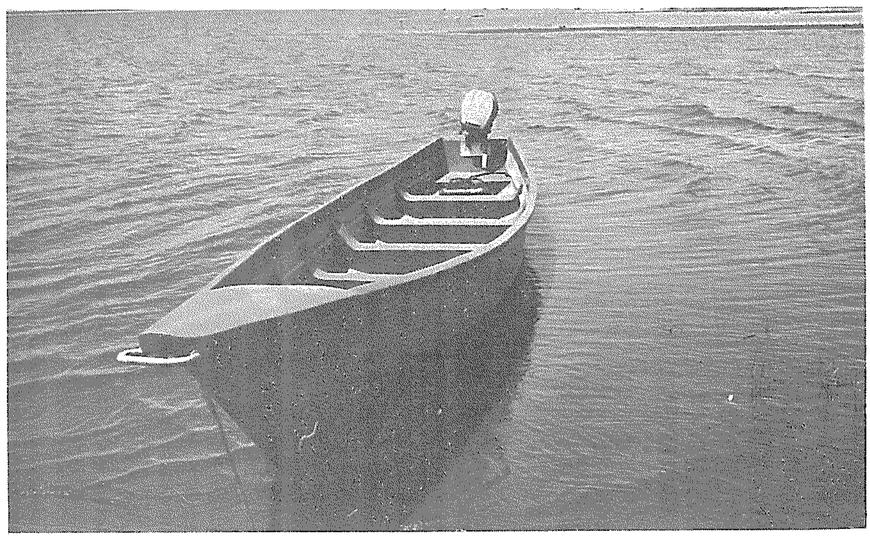


Mwanza canoe


A large "Maziwa" (dhow). Dunga landing




A typical "Mutungi" used on Lake Victoria



Fibreglass Sesse canoe - Lake Rudolph

Fibreglass Sesse (left), with 6 hp engine.
(second left) 20 ft Sesse canoe - Lake Baringo

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session II MATERIALS FOR BOAT CONSTRUCTION
Paper II/2

# Selection of construction material for small fishing boats

by

Ø. GULBRANDSEN

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

## INTRODUCTION

The following "case history" will illustrate the problems involved in the selection of construction material for small fishing vessels.

The UNDP Special Fund Fisheries Research Project in Lake Victoria has, through its trawl surveys, determined large stocks of fish not extensively fished so far. The exploitation of this untapped resource will require a sizable investment in boats, gear, shore and marketing facilities. All these elements must be developed together but we are, in this paper, concerned only with the boats, which, in magnitude of investment, are the most important.

Work done by the various members of the UNDP project has determined that the trawler should satisfy the following criteria:

| | |
|---|---|
| Maximum fish hold capacity | 6 tons of fish, 2 tons of ice |
| Engine power | 90 hp |
| Crew | 5 men |
| Trip duration | 2½ days maximum |

Six tons of fish will require approximately 7.5 $m^3$ and 2 tons of ice approximately 3.0 $m^3$ fish hold capacity. The total fish hold capacity should therefore be around 10.5-11 $m^3$. A vessel approximately 12 m length overall will satisfy this requirement.

The type and size of boat are therefore fairly well defined and we are now faced with the problem: what construction material?

## CRITERION FOR COMPARISON

There is a wide choice: wood, steel, fibreglass reinforced plastic (FRP), ferro-cement and aluminium. Anybody who has participated in a discussion about boatbuilding materials knows how coloured with subjective feelings the arguments become; some "like" wood, others think that there is nothing to beat steel. It is therefore essential to define a rational criterion for comparing the different materials. As a starting point take the following definitions: the best material is the one giving the boatowner the lowest yearly cost, expressed as:

$$\frac{\text{Initial investment}}{\text{Economic lifetime}} + \text{Interest on initial investment} + \text{Maintenance cost}$$

This criterion is based on the assumption that the type of construction material has no influence on the catch. A boat made of wood will catch as much as a boat made of FRP or steel, provided that the fishing gear and equipment are the same. The profit of the boatowner will therefore depend on the total yearly costs as expressed above.

The main problem in calculating the yearly costs lies in determining the economic lifetime and the maintenance cost of various materials. We are here in an area with very little dependable data and there is therefore a lot of guesswork involved. One detailed investigation of operating costs of fishing boats on the east coast of Canada revealed that, against expectations, wooden boats had less maintenance costs than steel boats. This conclusion cannot, however, be taken as universally valid. The number of years of service life and the yearly maintenance cost depend on many factors, such as workmanship of the builders, quality of materials, preventive maintenance done by the crew, salt or fresh water, climate, etc.

The conclusion is, therefore, that without any dependable data from vessels operating in the same area, it is very difficult to stipulate the exact economic lifetime in years and the maintenance cost of different boatbuilding materials. We are obliged to use the initial investment as our main criterion.

INITIAL INVESTMENT

The initial cost of a fishing vessel can be broken down to:

1. Hull, including bulkheads and deck
2. Superstructure, fish hold and outfit
3. Main engine
4. Fishing gear, including winches

One will note that points 2, 3 and 4 are not, to any great extent, dependent on the type of construction material. We will therefore mainly be concerned with point 1, which can be further divided into: Materials and Labour.

(1) Cost of Materials

The amount of material required will depend on the area of the surface to be covered and the amount of material per surface unit.

Fig. 2 gives the approximate surface area for a given cubic number. The cubic number is a commonly utilised measure for the size of a vessel. It consists of the product of the length overall (Loa), maximum beam (Boa) and depth measured midships (Dm). Cubic number (CUNO) = Loa x Boa x Dm.

Another method of calculating the hull area is to take the full girth midship, multiply it by length overall (Loa) and a factor k. The factor k can be taken as 0.93 for fishing boats of normal proportions. Therefore:

Hull area = 0.93 x full girth midship x Loa

The amount of material per surface unit, in this case using a square metre equal to 10.8 $ft^2$, will vary with the size of the vessel. The weights per square metre shown in Fig. 3 cover the weight of the skin or the planking, including the required framing. The curves shown are based on specific scantling rules. For FRP boats Lloyd's rules (Ref. 1) are used, for wooden boats "Scantlings for Small Wooden Fishing Vessels" by Rajendran and Choudhury (Ref. 2). Steel boat scantlings are according to Hanson's paper on "Fishing Boats of the World", Vol. 2 (Ref. 3) and ferro-cement boats according to regulations by the Marine Department of New Zealand (Ref. 4). For wooden boats one will find a fairly large variation in scantlings and the line represents the regulations having relatively light scantlings. Scantlings, according to other rules, might therefore be considerably heavier. Boats built of plywood would, on the other hand, be considerably lighter and approach FRP in weight. Where data are not available, as with new construction methods or materials, one can get a fairly good estimate of the amount of material per square metre of hull area by calculating the weight of the basic shell panel as shown in Table 1.

Additions must be made for weight of keel and deadwood, bulkheads, engine beds, stringers and other local stiffening. This can be taken as a percentage of the shell weight excluding deck. Available data indicate that the following percentages are appropriate:

| | | |
|---|---|---|
| Wood, steel, FRP | - | 50% |
| Ferro-cement | - | 30% |

The lower percentage applicable for ferro-cement is due to the increased stiffness in the shell which necessitates less internal stiffening.

Adding up the weight of the shell with the additions mentioned above and the deck will give the total hull weight. This weight can be used as a basis for calculating the cost of materials by using the basic cost of the materials per kg (or per ton) and by adding allowance for wastage, fastenings and parcel. The basic cost of materials will vary from country to country depending on import duties, sales taxes, etc.

(2) Cost of Labour

The number of man-hours required to build the hull varies considerably from one country to another. Generally, where the wages are low the number of man-hours is high, and vice versa. The amount of man-hours required to build the hull will therefore have to be considered separately for each case. For steel boats and FRP boats the number of man-hours is often calculated on the basis of structural hull weights and might vary between 150-350 man-hours/ton. For wooden boats, available data show a variation of between 200-550 man-hours/ton. The lower figures apply for efficient well equipped boatyards with skilled workers while the higher figure is more appropriate for countries in the starting-up phase of a boatbuilding industry.

(3) Cost of Outfit

In addition to the cost of the hull comes the cost of the outfit including super-structure, fish hold, insulation, joinery, rigging, navigation lights, electric installations, life-saving equipment, fuel tanks, steering system, anchor, chain and ropes. These items will cost the same, regardless of construction material.

The weight of the outfit can be calculated on the basis of the cubic number. For decked boats it will vary from between 35-45 kg/$m^3$, the lower figure for smaller boats with simple equipment. A boat with a cubic number of 100 will, for example, have an outfit weight of approximately 4 000 kg or 4 tons.

As a rough indication of the cost of the outfit one can calculate a figure of U.S.$ 800/ton (Sh 6 000/ton). This figure does not include main engines, fishing equipment, echosounders, radiotelephones and freezing machinery but covers all other items in the outfit mentioned above. For the installation of the outfit a figure of 300-800 man-hours/ton can be reckoned with.

Summing up the various cost figures, with addition of overheads and profit, gives an estimate for the cost of the completed boat.

## EVALUATION

Returning now to the trawler for Lake Victoria; after preparing several general arrangement drawings, a boat of 12.6 m Loa was arrived at, satisfying the requirements previously formulated.

Weight. Based on the previously mentioned diagrams, a weight calculation was made in Table 2. An FRP boat will be considerably lighter than a boat built with other materials. It is not yet clear to what extent this saving in weight can be beneficially utilized in the design of fishing vessels. A boat with relatively high displacement gives slower movements in a seaway than a boat with light displacement. So far it has been common to add considerable amounts of ballast to FRP fishing boats, in order to get the hull down in the water. A recently built 16 m FRP fishing boat carries 9 tons of ballast in the keel. Without ballast, the 12.6 m FRP trawler would, with an 80 hp/1 800 rpm engine, achieve a free-running speed in still water of approximately 9.2 knots. The ferro-cement boat, with almost 6 tons greater displacement would, with the same engine, reach a speed of around 8.5 knots. However, since in this case the boat spends 80 percent of the time trawling at a speed of 2.5 knots and the difference in free-running speed is in this case of relatively little economic importance.

Cost. Table 3 gives the cost calculation of the 12.6 m trawler. The calculation is based on actual prices of materials in Uganda. The figures for man-hours required for building the various hulls are necessarily an estimate and have intentionally been put fairly high.

The cost summary shows that there will be relatively small difference in the cost between the wood, steel and ferro-cement boats while the FRP boat will be approximately Sh 20 000 more expensive than the others. This is based on the assumption that five FRP hulls are produced from the same mould. If a large series of identical boats can be built, mould cost is distributed over a greater number of hulls and the total cost comes down to approximately the same cost as the other boats. The selection of FRP is therefore dependent on a prospective market for identical hulls.

In the case of Lake Victoria, the trawl fishery is at the starting-up phase and the first trawlers built will necessarily be prototypes that have to be tried out before a series of boats are envisaged.

For this initial period, FRP is therefore not attractive from a cost point of view. After extensive fishing experiments, the specification of an optimum fishing vessel can be determined and, if financing is secured for a series of identical hulls, FRP might come strongly into the picture.

Ferro-cement, with its low initial cost, was in this case selected for the construction of prototype trawlers. The hull construction can be done with fairly unskilled workers provided the foreman has previous wide experience in ferro-cement construction. The installation of the engine and equipment, of course, require experienced mechanics. Steel would also be an attractive material for fishing vessels in Lake Victoria. Experience with steel vessels in freshwater lakes in Africa is generally good. Steel can stand up to a lot of rough handling and the maintenance costs are low. This is in constrast to tropical salt-water conditions where rust becomes a major problem. The operation of this trawler will give sufficient experience before a large programme of construction is envisaged.

GENERAL CONSIDERATIONS

On a world basis, wood is still by far the most extensively utilized construction material for fishing vessels below 30 m (90 ft). However, the situation is not stable; steel is gradually replacing wood for boats of more than 20 m (60 ft) while FRP in some countries is increasing its part of the market for boats below 10 m (30 ft). We are in a situation where we can no longer depend on what has been traditionally accepted as the "best" material for smaller fishing vessels.

The present situation regarding fishing boats in East Africa is characterized by the large number of planked canoes and some dugout canoes, produced at a very low cost by local boatbuilders. These traditional types of craft, which land 90 percent of the catch, evolved without any interference from naval architects or fisheries officers. Yet, the sheer number of them demonstrates beyond doubt that the types are well suited to the present fishing techniques and economic level of the fishermen. It is realized more and more that these same craft, for a long time to come, will continue to make up the bulk of the fishing fleet.

In a country with little or no timber for boatbuilding within its borders and with a potential for fishery development, the import of boatbuilding materials is justified. Zambia is such a case where an increased fish production was essential for ensuring the food supply of the population. An FRP boatbuilding yard was established for mass-production of a 23 ft canoe. After some years, it was found that the canoe was too lightly constructed and was easily damaged. More than 800 canoes had by then been produced and the credit organization suffered a financial loss since the fishermen refused to reimburse. This case shows the need for proper design and testing-out of prototypes before they are mass-produced.

The introduction of new boat types and new construction materials should be directed toward new development rather than replacing traditional types of craft. New types of fishing gear and newly discovered fishing grounds further away will create a need for new boat types. This is the field where the efforts will give the greatest benefits in the future. A new type of boat should be introduced for a specific purpose, not just because it looks more "modern", in our eyes, than the traditional type. It has been a common error in the past to introduce European types of small fishing boats of complicated construction which has led to unnecessarily expensive wooden boats. The simplicity of the flat-bottom and the hard chine hull should make it the natural choice where trained boatbuilders are not available. In the lofting of the V-bottom hull only three points will determine the shape of the frame - rabbet, chine and sheer. Frame construction is quick with straight timbers, and galvanized bolts are used for fastenings. The planking can be cross-wise on the bottom, while the top-sides are planked with equal width to keep the wastage down and avoid the time-consuming spiling of the planks.

Fastenings should be galvanized boat-nails; with the relatively short life of wooden boats in tropical areas there is little sense in using copper or bronze fastenings.

The use of pressure-impregnated timber seems to be the only way to extend the service life of wooden boats in Africa. It is important, however, to select a type of timber that satisfies the following requirements:

(i) easily pressure treated
(ii) low shrinkage
(iii) good strength properties
(iv) relatively cheap

The forestry departments will be able to give advice on local types of timber satisfying these requirements.

An evaluation of the different construction materials will, in the future, have to be made on the basis of yearly costs, as previously mentioned. To make this criterion meaningful, far more data are required in order to determine the economic lifetime and yearly maintenance costs with sufficient accuracy.

## REFERENCES

(1) Lloyd's Register of Shipping: Provisional Rules for the Application of Glass Reinforced Plastics to Fishing Crafts

(2) Rajendran, R. and R.L. Choudhury, 1969 Scantlings for Small Wooden Fishing Vessels. Fishery Technology, Vol. VI, No. 2

(3) Hanson, H.C., 1960 Steel and Wood Scantling Tables, Fishing Boats of the World, Vol. II, Fishing News (Books) Ltd., London

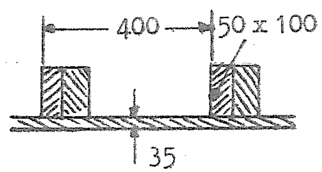
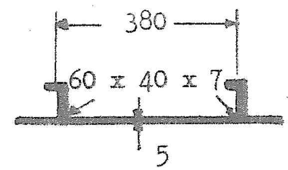
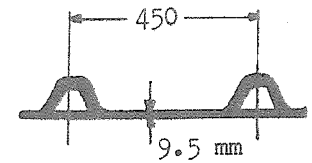
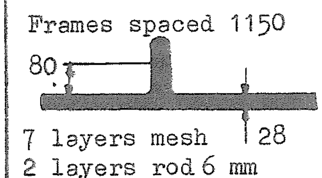
(4) New Zealand Marine Department, Provisional Requirements for the Construction of Ferro-Cement Boats

(5) Benford, H. and Kossa Miklos, 1960 An analysis of U.S. Fishing Boats - Dimensions, Weights and Costs, Fishing Boats of the World, Vol. II, Fishing News (Books) Ltd., London

(6) Proceedings Conference on Fishing Vessel Construction Materials, Canadian Fisheries Report No. 12, June 1969

Table 1

CALCULATION OF WEIGHT PER $m^2$

| | Mvule (Iroko) Sawn Frame Construction | Steel | FRP | Ferro-Cement |
|---|---|---|---|---|
| |   |   |   |   |
| Specific gravity | 0.75 | 7.8 | 1.5 | 2.6 |
| Weight of skin per $m^2$ | 26 kg | 39 kg | 14 kg | 70 kg |
| Weight of frame per $m^2$ | 19 kg | 17 kg | 6 kg | 6 kg |
| Weight of parcel per $m^2$ | 45 kg | 56 kg | 20 kg | 76 kg |

## Table 2

### WEIGHT CALCULATION 12.6 m (41 ft) TRAWLER

Basic data: = 12.6 m, B = 4.03 m, D = 1.85 m
Cubic number 94
Area of hull (Fig. 2): 90 $m^2$
Area of deck: 31 $m^2$

| | Wood Mvule (Iroko) | Steel Chine Construction | FRP | Ferro-Cement |
|---|---|---|---|---|
| Weight per $m^2$ $kg/m^2$ (Fig. 3) | 43 | 56 | 20 | 70 |
| Weight, shell (90 $m^2$ x $kg/m^2$) | 3 900 | 5 000 | 1 800 | 6 300 |
| + Weight keel, bulkheads, stringers | 50% = 2 000 | 50% = 2 500 | 50% = 900 | 30% = 1 900 |
| + Weight deck (31 $m^2$ x $kg/m^2$) | 1 300 | 1 700 | 600 | 2 200 |
| Weight, hull + deck (kg) | 7 200 | 9 200 | 3 300 | 10 400 |
| Weight, outfit 94 $m^3$ x 40 $kg/m^3$ | 3 800 | 3 800 | 3 800 | 3 800 |
| Weight, engine | 700 | 700 | 700 | 700 |
| Weight, winch, fishing gear | 800 | 800 | 800 | 800 |
| Weight, light ship (kg) | 12 500 | 14 500 | 8 700 | 15 700 |

Table 3

COST CALCULATION 12.6 m (41 ft) TRAWLER

| | Wood Mvule (Iroko) | Steel Chine Construction | FRP Minimum 5 Hulls | Ferro-Cement |
|---|---|---|---|---|
| | Sh 950 per $m^3$ | | | |
| Cost basic materials per ton | Sh 1 200 | Sh 1 650 | Sh 7 000 | Sh 1 100 |
| Addition for wastage | 30%=Sh 400 | 20%=Sh 330 | 15%=Sh 1 000 | 15%=Sh 170 |
| Addition for paint, fastenings | 15%=Sh 200 | 10%=Sh 170 | 0 | 10%= 110 |
| Total cost per ton | Sh 1 800 | Sh 2 150 | Sh 8 000 | Sh 1 380 |
| Weight hull + deck (Table 2) tons | 7.2 | 9.2 | 3.3 | 10.4 |
| Cost materials, hull + deck | Sh 13 700 | Sh 19 800 | Sh 26 400 | Sh 14 400 |
| Labour - hull, deck, man-hour/ton | 550 | 350 | 350 | 350 |
| Man-hours - hull, deck | 4 000 | 3 200 | 1 200 | 3 600 |
| Man-hours outfit | 3 000 | 3 000 | 3 000 | 3 000 |
| Total man-hours | 7 000 | 6 200 | 4 200 | 6 600 |
| Cost labour (Sh 2.70 per h) | 19 000 | 16 000 | 11 000 | 17 500 |
| COST SUMMARY | | | | |
| Materials | 13 700 | 19 800 | 26 400 | 14 400 |
| Labour | 19 000 | 16 000 | 11 000 | 17 500 |
| Outfit (Sh 6 000/ton) | 23 000 | 23 000 | 23 000 | 23 000 |
| Overheads | 15 000 | 15 000 | 15 000 | 15 000 |
| Subtotal hull and outfit | 70 700 | 73 800 | 90 400 | 69 900 |
| Engine 80hp/1 800 rpm | 45 000 | 45 000 | 45 000 | 45 000 |
| Winch with transmission | 10 000 | 10 000 | 10 000 | 10 000 |
| Echosounder | 5 000 | 5 000 | 5 000 | 5 000 |
| Subtotal completed boat | 130 700 | 133 800 | 150 400 | 129 900 |
| 10% profit | 13 000 | 13 300 | 15 000 | 13 000 |
| Total completed boat | 143 700 | 147 100 | 165 400 | 142 900 |
| Percent of lowest cost | 101% | 103% | 115% | 100% |

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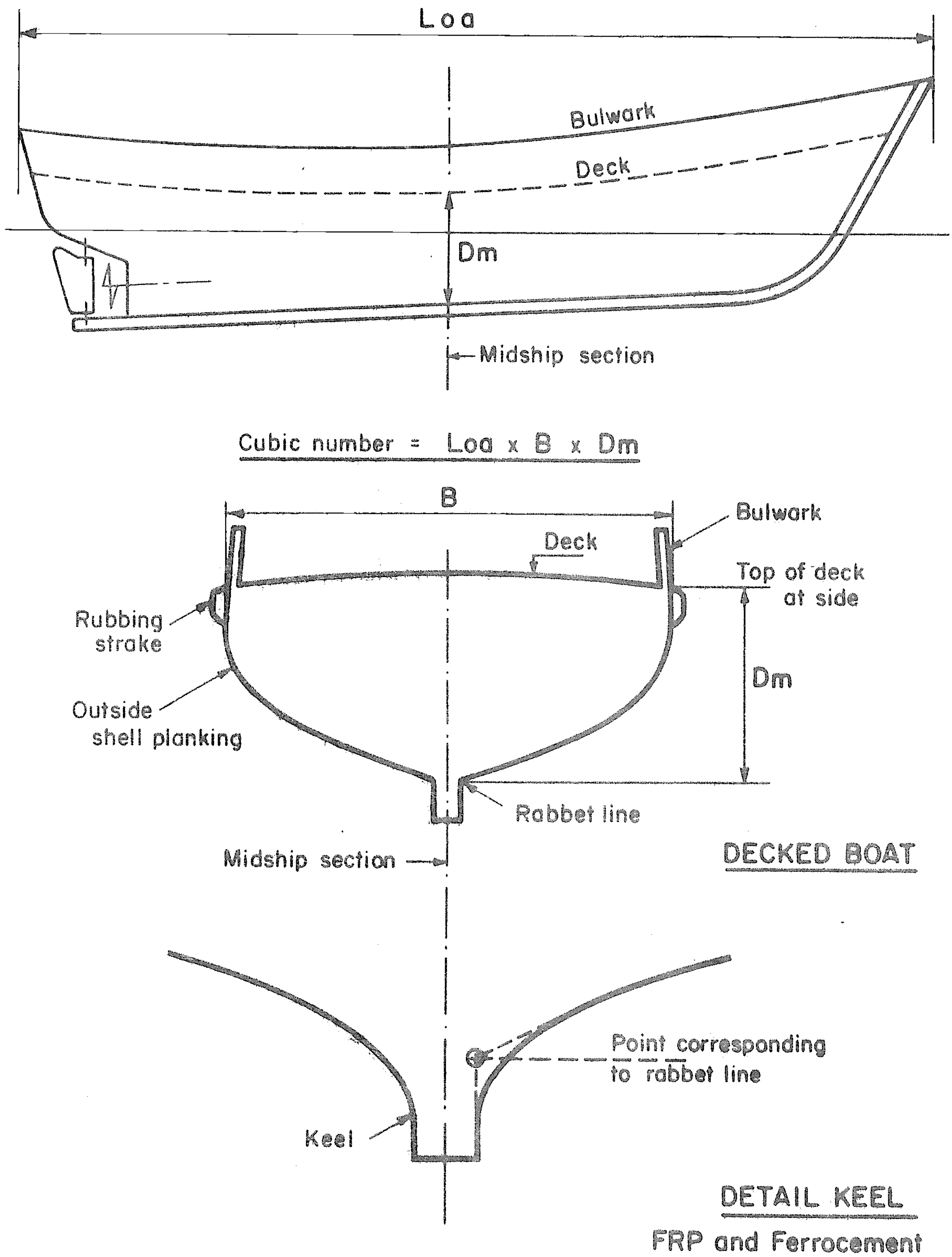



Fig. 1 - Definition of cubic number.

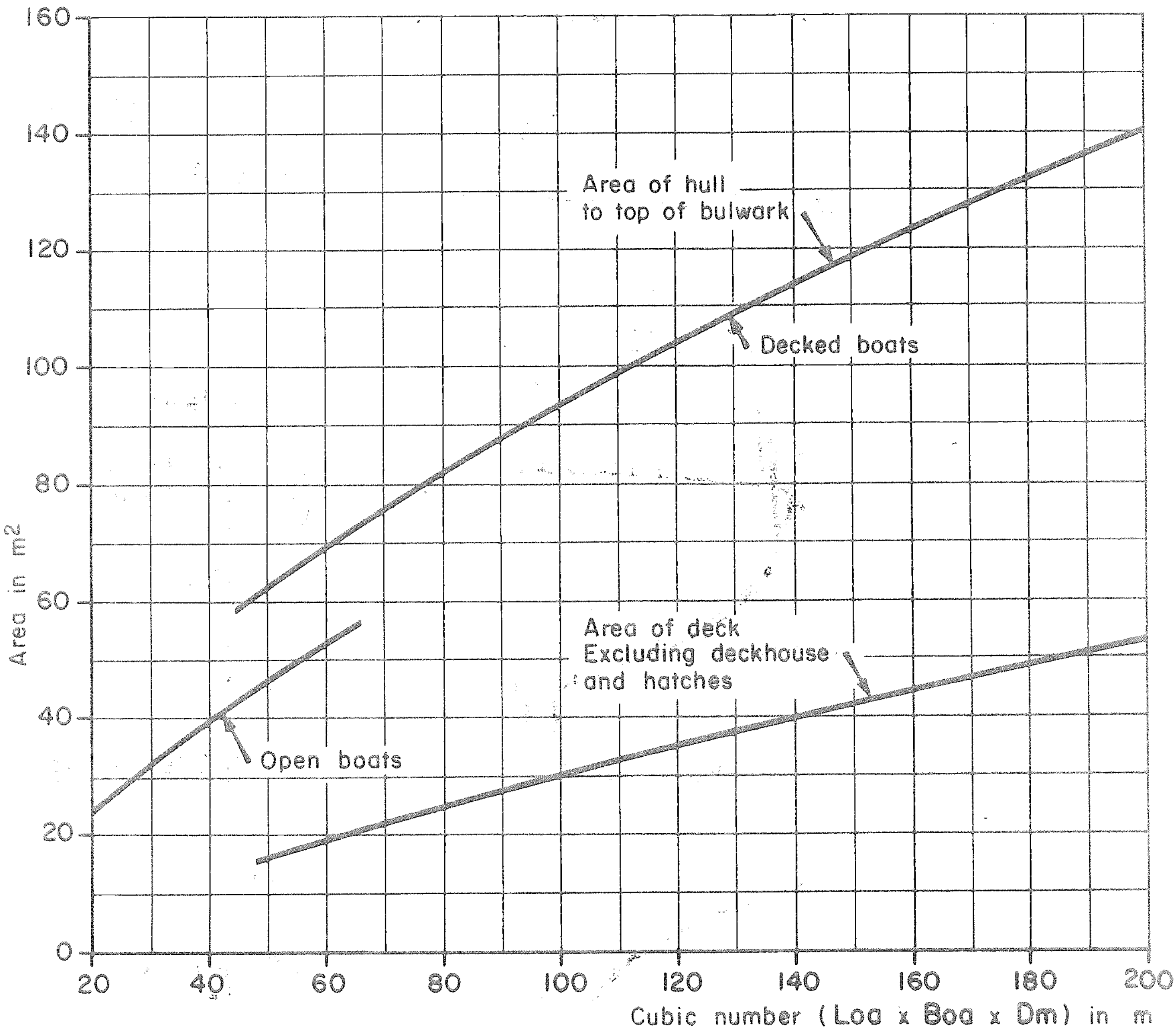



Fig. 2 - Area of hull and deck.

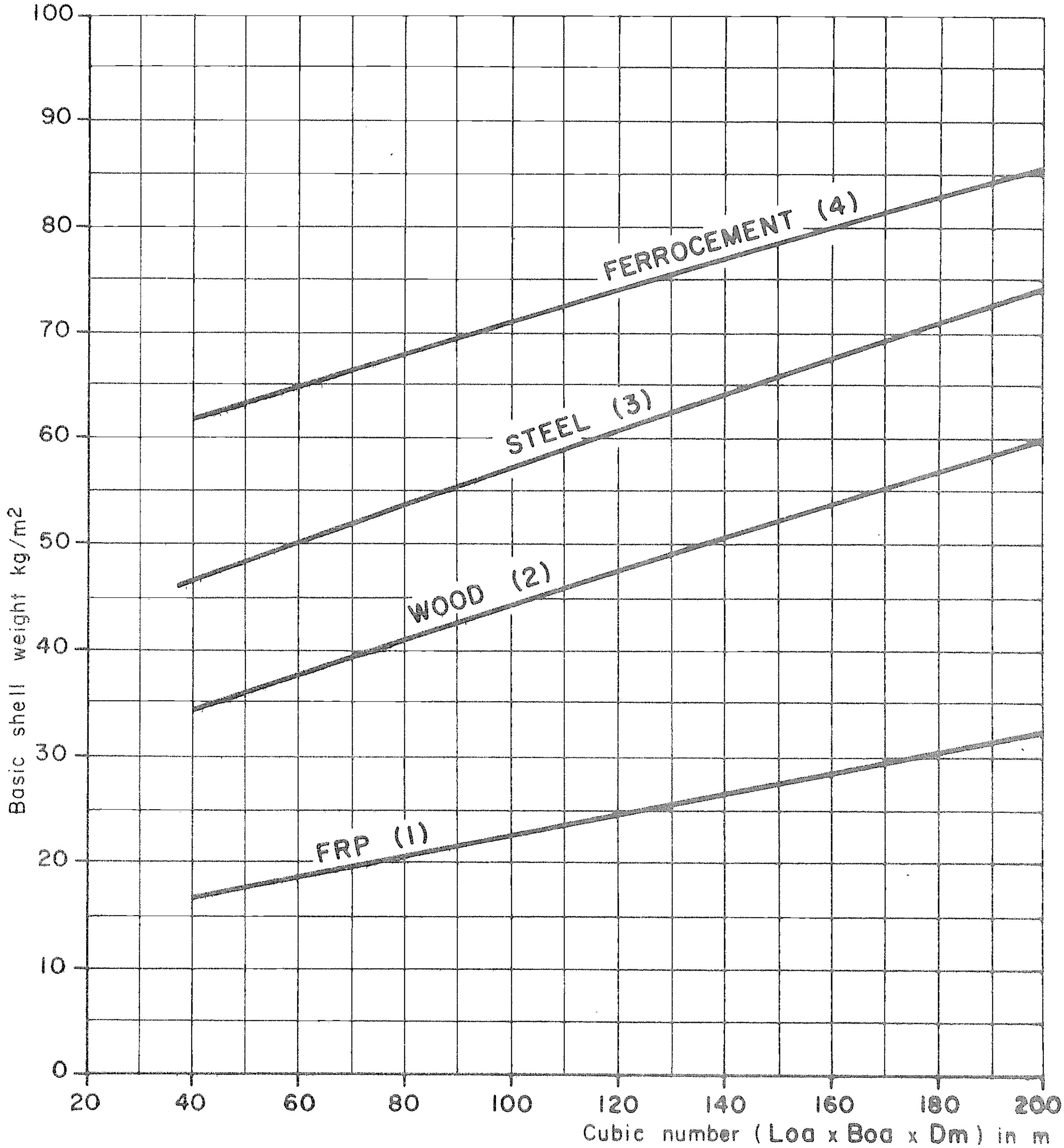
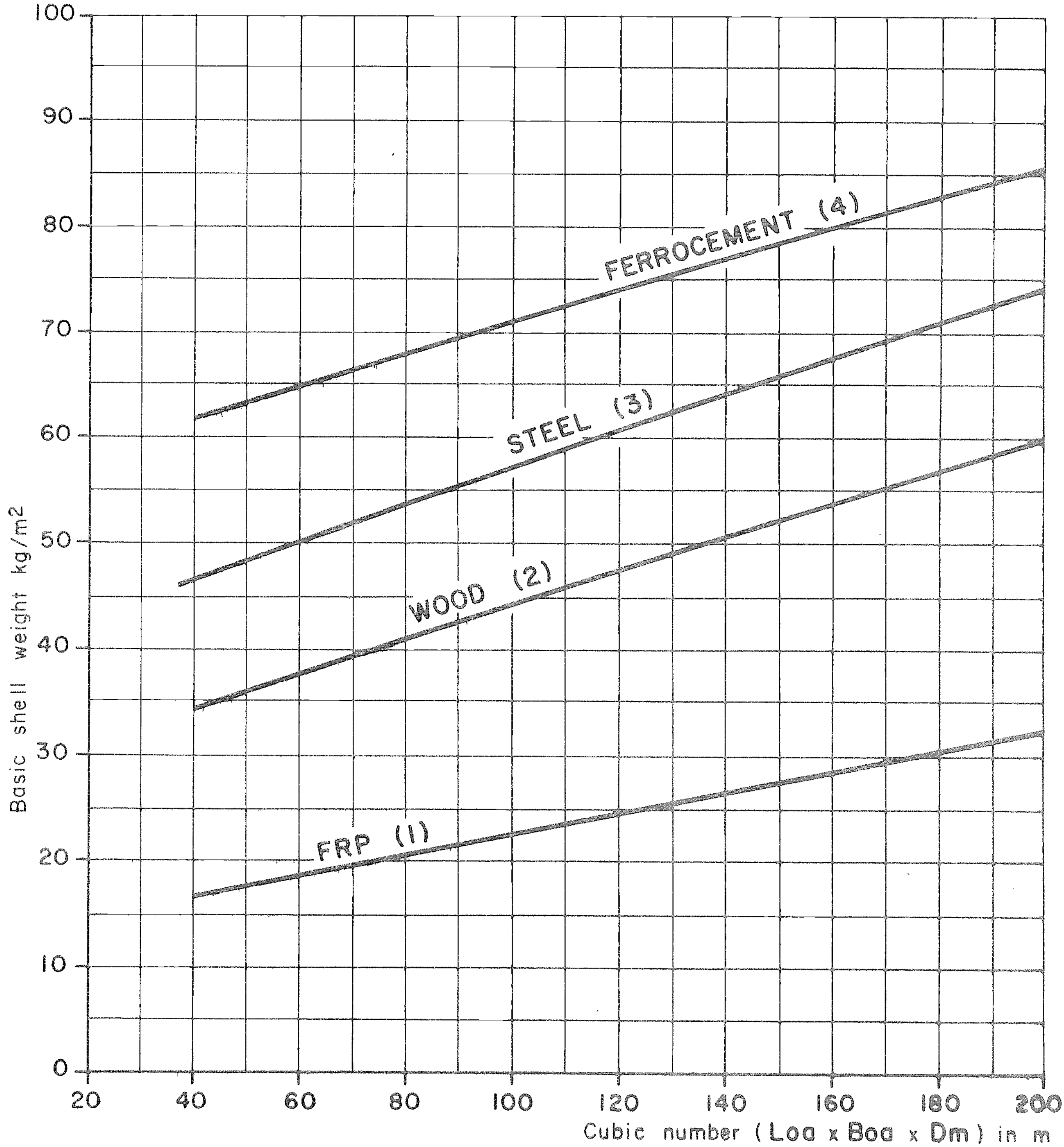



Fig. 3 - Weight per square meter of hull and deck. (Excluding keel, deadwood, bulkheads, stringers and local stiffening).

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SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session II MATERIALS FOR BOAT CONSTRUCTION
Paper II/3

# Timbers for boat building in East Africa

by

R.A. PLUMPTRE

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

## INTRODUCTION

Timber has been widely used in the building of boats for fishing in East Africa for many hundreds of years, firstly in the form of hollowed out logs or "dugouts" and secondly as planked boats or Sesse-type canoes.

It has held a pre-eminent position in the past owing to the absence of alternative competitive material, but the position is now changing with the availability of fibreglass, concrete and metal for boat building. The purpose of this paper is to summarize the past experience in using wood as boat building material and to suggest better methods of use in the future based on this experience and on modern technical developments in the preservation and stabilization of wood.

## ADVANTAGES AND DISADVANTAGES OF WOOD AS A BOAT BUILDING MATERIAL IN EAST AFRICA

Different woods vary in their properties and I will deal with this subject later, but all wood has a number of common properties some of which are an advantage and some of which are a disadvantage when it is used as a boat building material. They can be listed as follows:

### Advantages

#### Lightness

Volume for volume wood is light and, if used correctly, it can make boats that are strong, but light and easy to handle.

#### Cheapness and Availability

Timber is relatively cheap and easily available in East Africa and by selection and use of cheaper timber it should be possible to further reduce costs in future.

#### Ease of Working

Timber is easily worked and shaped to the required shape with tools that are well known and commonly used in the countries; no complicated moulds are required and the small boatbuilder can use it with the minimum of tools and expensive equipment.

#### Ease of Bending and Elasticity Under Impact

Wood is easy to bend into shape, is elastic under impact and returns to its original shape provided the impact does not fracture it.

#### Resistance to Abrasion

Provided the correct wood is used, boats made of wood will stand up to a great deal of abrasion and will withstand repeated hauling up and down sandy and rocky beaches. In this respect it is probably superior to fibreglass.

#### Ease of Jointing and Repairing

Wood is easily nailed and screwed together and damaged boats can be easily repaired. It is, therefore, easier to adapt or alter a wooden boat or add internal fittings such as thwarts than it is in the case of boats made of other materials.

## Disadvantages

The disadvantages of wood as a boat building material are as follows:

### Movement with Changes in Humidity

Wood swells when it gets wet and shrinks when it gets dry. That is a serious disadvantage since boats, more than most things, are subjected to alternate wetting and drying. The effect of this movement can, however, be reduced very greatly by correct methods of construction, use of timbers with low movement and the use of modern methods of waterproofing timber. I will deal with these in more detail later.

### Durability

All wood, however naturally durable, is liable to insect and fungus attack. The most serious in the case of boats is rot which is caused by fungus. The warm moist conditions to which boats are subjected in East Africa are almost ideal for this rot and timbers last less long than they do in temperate climates. Even naturally durable timbers like Muvule (*Chlorophora excelsa*) last only 4-5 years in a boat and Mahogany (*Khaya* and *Entandrophagna* species) only last 3-4 years in a normal fishing canoe. Timber can, however, be effectively preserved using modern preservatives to give them several times their natural life. Again, I will deal with this further later.

### Lack of Uniformity

Wood being an organic material is not uniform. It has a "grain" which renders it liable to split and it is stronger in some directions than in others. Plywood, where the grain direction of different laminae are at right angles, overcomes this to some extent, but may create difficulties of its own.

### Time required for Seasoning and Preparation for Use

Because of its movement with moisture wood must be seasoned or dried before use. Air drying takes between two and four months and it is therefore necessary to store the timber before use unless it is kiln dried in which case the process takes only 1-2 weeks. Facilities for kiln drying are not yet widely available in East Africa, but there are a few places where it can be done.

## PROPERTIES REQUIRED OF A GOOD BOAT BUILDING TIMBER

It is extremely difficult to choose a good boat building timber from tables of physical and mechanical properties of different East African woods. The following properties are known for most of the common timbers:

- Shrinkage % green to 12% moisture content
- Density
- Equivalent fibre stress in bending
- Modulus of elasticity
- Total work in bending.
- Impact strength
- Compression strength
- Hardness
- Shear strength (parallel to grain)
- Cleavage (splitting) strength

These properties are listed in "The Commercial Timbers of Tanzania" (1) and "Uganda Timbers" (2) which are the main reference books on the subject.

In a boat it is a combination of the correct properties which is required. There needs to be:

- Sufficient strength
- Good resistance to splitting
- Good bending qualities (elasticity)
- Good nailing and screwing properties
- Low movement (or slow absorption and loss of water)
- Not too much hardness
- Ability to absorb preservatives

Resistance to splitting of a wood may be high but if the timber is also hard a greater splitting force is exerted when a nail is driven than in the case of a softer timber which, though less resistant to splitting, may still be the best wood to use for building a boat. Similarly timber with relatively high movement but which is elastic enough to "accommodate" itself to this movement may be better than a less elastic timber which has a lower movement with changes in humidity. It is, therefore, almost impossible to say what timber is going to be most suitable without making a boat out of it and observing its performance. An interesting example of a timber which has a peculiar property which makes it suitable for dugout manufacture is Mukebu (Cordia millenii) which is light, soft and easily worked but which is, for some unknown reason, very impermeable to the movement of moisture and in spite of its softness takes several times the length of time to dry out than it takes Muvule which is much heavier and harder.

## EXPERIENCE IN UGANDA USING DIFFERENT TIMBERS

It is, therefore, necessary at our present state of knowledge, to build a boat out of a timber in order to determine its suitability for boat building.

The commonly used woods in Uganda have been Muvule and Mahogany and to a lesser extent Mukebu and Nongo (Albizia species). Muvule is usually preferred owing to its greater durability with Mukebu probably second and Mahogany third.

All these timbers suffer from one great defect which is that they are impermeable to treatment with wood preservatives which means that they cannot be preservative treated and have to rely on their own natural durability. An additional disadvantage in the case of Muvule and Mahogany is that they are the most expensive timbers available, costing on average sh. 2/50 per board foot (approximately sh. 1 050/= per $m^3$) for 12 inch by 1 inch timber.

As a result of these problems it was decided to try building a boat out of a timber which appeared to have suitable physical and mechanical properties, but which was permeable to preservative treatment and very considerably cheaper than Muvule or Mahogany. Mululu (Chrysophyllum perpulchrum) was chosen and Mr. Gooding of the Fisheries Training Institute built a boat out this timber. The cost of the timber was about sh. 1/50 per board foot (sh. 630/= per $m^3$) of 12 inch times 1 inch timber and the cost of treatment was cts. -/30 per board foot (sh. 126/= per $m^3$) making a total of sh. 1/80 per board foot (sh. 756/= per $m^3$) for the timber and the treatment. This is a reduction in cost of over 25%. The timber proved easy to build with and appeared, at the time of building, to be superior to the more expensive woods and from subsequent performance the timber has been equally satisfactory after having been in service for two years.

The preservative treatment was done with Celcure "A" wood preservative, a copper-chrome - arsenate preservative which was impregnated into the timber using vacuum pressure impregnation. It "fixes" in the timber and forms an insoluble preservative in the cells of the wood. Provided this process is properly done the life of the wood treated with it is very considerably extended. Fence posts treated with it and exposed to conditions as severe as those likely to be encountered in a boat in East Africa have lasted over 20 years and are still going strong. The timber used in this boat was tested for treatment and, although it could have been better since a number of untreated streaks were found when treatment should have been complete throughout, it is probably adequate to give the boat a longer life than the 5-year maximum normally obtainable with durable woods. Really good treatment should result in a boat with a life of 15 years or more and it would probably break up eventually from mechanical disintegration rather than rot.

## METHODS OF CONSTRUCTION

I am not a boat builder and am not competent to suggest methods of construction better than the present ones, but from the point of view of movement and shrinkage of the timber there is considerable advantage to be gained from using narrow widths of timber for planking where possible. An average percentage shrinkage laterally from green to 12% moisture content is 3%. In conditions obtaining in a boat it can be assumed that shrinkage or swelling of up to 2% might be encountered between the wettest and driest conditions to which the boat might be subjected. In a 12-inch wide board this would amount to a 1/4 inch whereas in a 6-inch wide board would have a shrinkage of only 1/8 inch. When timber is built into a boat probably some shrinkage is taken up by the natural elasticity of the timber and the rest in the construction of the joints. If it cannot be taken up in this way the boards split. Obviously, the narrower the boards the less shrinkage and swelling has to be taken up at joints. If the joints can be made so that they are better able to stand the shrinkage and swelling, so much the better. An additional advantage in narrower widths is that they are also considerably cheaper per board foot and easier to obtain since wide boards are always more expensive and difficult to obtain for the saw miller than narrow widths.

### Methods of Reducing Shrinkage and Swelling of Wood

Recently it has become possible to introduce a water-repellent wax into wood. This is done at the same time as normal vacuum pressure impregnation with a copper-chrome - arsenate preservative. The wax, "Tanalith plus" adds about 30% to the normal cost of cts. -/30 per board foot for treatment with "Tanalith C". The wax is deposited in the cells of the wood and greatly reduces the amount of water absorbed and lost by the wood. This, in its turn, reduces or slows down the shrinkage and swelling of the wood. Weathering trials are being carried out in Uganda to determine its effectiveness in reducing weathering and deterioration over a long period of time. It would be interesting to build a trial boat out of timber treated in this way.

### Painting and Finishing Timber Boats

On the outside of a boat it is necessary to use a waterproof material which does not wash off, and normal oil paint is probably the best material to use, preferably renewed yearly. Inside the boat paint tends merely to hold moisture which encourages rot. It is probably better to treat the inside of the boat with an oil-borne solution of pentachlorophenol which is a very strong fungicide. "Shell 58" or similar wood preservative applied once a year provides both water repellency and preservative protection and penetrates into cracks where paint would not go.

CONCLUSIONS

Even in highly developed countries the boat building trade has been conservative and has not utilized, to the full, possibilities offered by the correct treatment of wood to give it a really long life. For this reason wood has lost ground to fibreglass in particular. It is true that even with properly treated wood fibreglass has advantages in some respects, but I think in East African conditions wood, properly treated, can last up to 15 years or longer and my section will be happy to assist in any trials which may be planned in future using timber in boat building.

REFERENCES

(1) Bryce, J.M. The Commercial Timbers of Tanzania.
(2) Tack, C.H. Uganda Timbers.

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda, 22-27 February 1971

Session II    MATERIALS FOR BOAT CONSTRUCTION
Paper II/4

# Some notes on the survey of ferro-cement fishing vessels built in New Zealand

by

D.J. EYRES

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

INTRODUCTION

The New Zealand Marine Department is required by law to survey New Zealand registered fishing vessels of 35 ft registered length and over. Each new vessel is built under survey and subsequently inspected annually.

The Department first became involved with ferro-cement boats in 1964 with the building of two fishing vessels in ferro-cement at that time. Several yachts had been built in this medium in New Zealand but these were the first fishing vessels of sufficient size to come under the Department's jurisdiction. Neither the builders nor the Department at that time had any clear guidelines to work to and with one craft close liaison was maintained between the builder and the Department and many problems were discussed as the work progressed.

Since that date ferro-cement fishing vessels were built spasmodically, most being built professionally by contractors experienced in concrete technology and maintaining good quality control procedures but who were, nevertheless, finding their way with regard to the application of ferro-cement to boatbuilding. For these vessels, the Department accepted a signed certificate of construction by a registered engineer as evidence of satisfactory construction.

By the end of 1968 a considerable increase in the number of ferro-cement craft being submitted for approval was apparent. In order to provide our field surveyors with a yardstick for the construction of these boats, the Department decided to draw up its own requirements. The Department was fortunate in that a code of practice for the construction of ferro-cement boats had already been set by Lloyd's Register of Shipping1/. Taking this as a basis, the Department attempted to expand the code of practice in the light of experience and observations at the survey of boats coming under our jurisdiction and to be more definitive about the actual construction. These requirements have not been finalized at the time of writing due primarily to the problem of resolving two contentious issues, namely, the strength criterion with provision of adequate steel reinforcement and also the merits of different plastering techniques. Steps have been taken to clarify these two points and indications are that the requirements should be finalized shortly.

BOATBUILDING LOCATION AND CONSTRUCTION METHOD

Many of the ferro-cement boats built in New Zealand are constructed in the open with temporary cover during the curing period. This is particularly true of the large number built in the north of the North Island where year-round climatic conditions are suitable. The Department's requirements request that the boat be constructed at a site compatible with good boatbuilding practice and calls for suitable protection during the curing period.

All the boats surveyed to date have been built upright using the so-called "suspended hull method". To obtain the hull form, use is made of pipe frames often subsequently removed or fabricated web frames which are plastered and form excellent grounds for bulkheads. Wooden frames subsequently removed have also been employed. No approach has been made for a surveyed vessel to be built upside down on a wooden mould which has been tried with several pleasure yachts in New Zealand. The Department has some reservations at this stage as to the effects of the drying-out of the hull under these conditions.

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1/ Lloyd's Register of Shipping. Tech. Note: FC/REQ/1. "Tentative Requirements for the Construction of Yachts and Small Craft in Ferro Cement", 2 January 1967

MATERIALS

Steel: Mild steel, hard drawn wire or a reinforcing rod is commonly used for reinforcement but a high tensile steel rod is also used primarily because it gives a fairer curve when laid around the framing. Mild steel pipe frames or fabricated web frames of mild steel wire or rod are fitted. The welding of high tensile stringers, etc., to stem and stern mild steel formers and frames requires the surveyor's inspection. The wire mesh laid around each side of the reinforcing wires is usually 22 g or 19 g galvanized ½ inch or 3/4 inch hexagonal or square mesh. This galvanized wire mesh is often weathered before application of the mortar.

Cement: Ordinary Portland cement only is used in New Zealand for the boatbuilding mortar.

Water: The Department's requirements call for fresh water only to be used.

Aggregates: It is very important that a good quality aggregate should be used and this is obtained in New Zealand from river shingle free of deleterious materials. Under no circumstances should beach sand be used and there has been some concern in New Zealand with aggregates taken from a known volcanic area rich in pumice. It is suspected that the rapidly deteriorating condition of one fishing boat hull after five years' service could be accounted for by the high pumice content of the aggregate used in the original mortar mix. We have been told that if wet pumice is added to the mix it can react with the mixing mortar and produce a high water/cement ratio with subsequent inferior plaster. Where the pumice is dry before addition to the mix, it can absorb water from the mortar and there will not be enough water to hydrate the cement.

Additives: It is common practice in New Zealand to add pozzolan to the mix at the rate of about 10 percent by weight with the object of providing an aid to densification of the mix and also combine as a slow reaction, with the free lime generated during hydration of the cement to give the stable compound calcium silicate which is impervious to sea water. The Department's requirements do not specifically call for the addition of pozzolan as some builders believe it should since not everybody agrees with its use and perfectly good mortar mixes are produced with various proprietary additives, our only requirement being that approval is given where the material is added to directly or indirectly reduce the water/cement ratio and where approved standards are published for the additive.

Reinforcement: Longitudinal and transverse wires are arranged on the framing system. Longitudinal wires usually at 2 inch or 3 inch spacing are fitted in all the present vessels, there being considerable controversy regarding the provision of transverse wires which are arranged at a wider spacing between frames or diagonally at 45° to the keel. Four or three layers, depending on the gauge of the galvanized wire mesh, are fitted inside and outside the reinforcing wire, and closely wire-tied to the reinforcement. The Department requires the surveyor to make an inspection at this stage; the hull should be fair and the mesh firm so that there are no sagging or hollows after plastering. Hollows are often filled with mortar to fair the hull and an unsatisfactory non-uniform thickness shell results. Fittings such as the stern tube, rudder aperture and sea water inlets may be placed at this stage and examined. It is also perhaps as well to note that the hull is adequately suspended as it is not unknown for a hull to collapse under the weight of the mortar being applied.

Plastering: Undoubtedly, the most critical aspect of building a ferro-cement boat is the plastering. Nearly all defects or failures examined by the Department to date can be attributed to either deleterious materials in the mortar mix or poor application of the mortar.

The mortar mix used is commonly a 2:1 sand to cement ratio with the addition of pozzolan or other admixtures. In most cases the mix is prepared in an ordinary tilting drum concrete mixer but larger contractors claim advantages for the revolving paddle or revolving pan and paddle mixer. The Department has found no evidence that boat hulls built using the tilting drum mixer were in any way inferior to those built using the less common type of mixer.

Application of the mortar has been made in several ways:

(1) Mortar has been compacted from both sides of the reinforcement at the same time and smoothed off inside and outside. This practice is not approved by the Department as it leads to voids and laminations midway through the shell thickness in a non-compacted region. Plate 1 shows a cross-section through the fore deck of a boat plastered in this manner.

(2) The method favoured by the Department is for the mortar to be compacted from the inside, being forced right through the wire mesh and smoothed off with a wooden float outside. To plaster a 36-ft boat in one day with this method calls for a team of men with up to four men working inside the boat at the same time and care is needed to see that the reinforcement and mesh is not displaced. Adequate staging is required as it is not uncommon to see a distorted hull, due to men walking on the mesh covered with wet mortar or even external cracks in the hull.

(3) A method employed by a number of builders in New Zealand which has been carefully examined by the Department without showing any defect to date is to plaster the outside of the hull first, followed by a curing period before finishing the inside of the hull. The mortar is forced through the mesh from the outside until it is almost through the mesh, and it is a good idea to have an observer inside who watches for the possible occurrence of voids and who is then able to stick a wire through the soft plaster so that the plasterer outside can recompact the mortar at that point. The outer mortar is then cured for a period of 10 to 14 days and coated with a grout of cement and water, the inside of the hull being plastered whilst the grout is still wet. Plastering of the inside is done from the keel upward. Plate 2 shows a section through a test panel plastered by this method and used to establish the bond between the two layers which proved quite satisfactory.

It is normal practice to plaster the hull first and subsequently the deck, a clean interface with rich grout or bonding agent being employed. Some bonding agents are unstable in water and obviously should not be used. Similarly, on a large boat it is quite permissible to plaster the hull in sections.

At thicker sections, to obtain adequate compaction of mortar, it is as well to make use of vibrators. Plate 3 shows the section at a coaming of a ferro-cement deckhouse which was replaced by a wood deckhouse to reduce topweight. This shows clearly a lack of compaction at the thicker section.

The Department calls for a standard slump test on the mortar during preparation of the mix, and the slump must not exceed 2 inches. Also, standard compression tests are called for in the minimum crushing strength of the mortar required at 28 days' cure, being not less than 5 000 lb per square inch - a figure which appears to be comfortably obtained with the mixes used. These are the only tests required by the Department.

Curing is commonly achieved with the use of a water spray but many professionally-built boats are steam-cured. The Department insists on all surveyed boats being professionally plastered.

HULL FIXTURES

An early sports fishing boat built under survey was subsequently wrecked after running onto rocks and provided two lessons for the Department with regard to hull fixtures. This craft had wood bulkheads bolted to wood grounds which in turn were through-bolted to the hull. Also, the wood deckhouse trunking was through-bolted to the ferro-cement coaming, the bolts bearing directly onto the plaster. On inspecting the wreck, a surveyor found the collision bulkhead lying on the beach intact, the bent bolts still through the grounds where they had torn out of the hull and the aft bulkhead was also recovered in the same condition. The wood superstructure was washed ashore in a reasonable condition, the trunking still carrying the bolts which had pulled out of the ferro-cement coaming. The Department now requires that the grounds for bulkheads or the bulkheads themselves are cast integral with the hull, and also that wood or other suitable bearing surfaces are provided for tie bolts to harden onto.

Bulwarks which are an extension of the main hull are not considered a very desirable feature on ferro-cement fishing vessels, particularly if the pipe frames are extended to carry these. Ferro-cement is susceptible to impact damage and bulwarks standing 18 inches high or more above the deck would appear, in our experience, to be very vulnerable. The better New Zealand ferro-cement fishing boats do not have this feature and Plate 4 shows the condition that ferro-cement bulwarks can get into. Plate 5 shows the boat under construction, with the bulwarks illustrated in Plate 4, an undesirable feature of this construction being that the bulwark capping rail was fitted prior to the plastering being completed. Plastering was finished with the rail in place and secured to the reinforcement so that the plaster surface was not sealed and some of the subsequent bulwark deterioration could be due to sea water seepage into the plaster.

Considerable wood belting is called for in vulnerable areas of the ferro-cement hull to avoid impact damage. New Zealand boats have, from experience, found this necessary in the way of trawl board and landing areas. The initial boat design should avoid sharp or prominent appendages which would be susceptible to this form of damage.

SURVEY

At annual inspections the boat is slipped and it is useful to observe how the hull dries out. If wet patches remain the hull skin could be waterlogged and breaking of the outer surface could release this water (Plate 6 shows examples of this). A surveyor should not be afraid to drill holes in the hull if he suspects voids or laminations.

The hull can be inspected for cracks. It is not unusual to find that the paint surface has cracked and the mortar below is intact. Hair cracks are often observed on the surface which, if chipped out, are only found to penetrate 1/8 inch at the most into the plaster and can be disregarded.

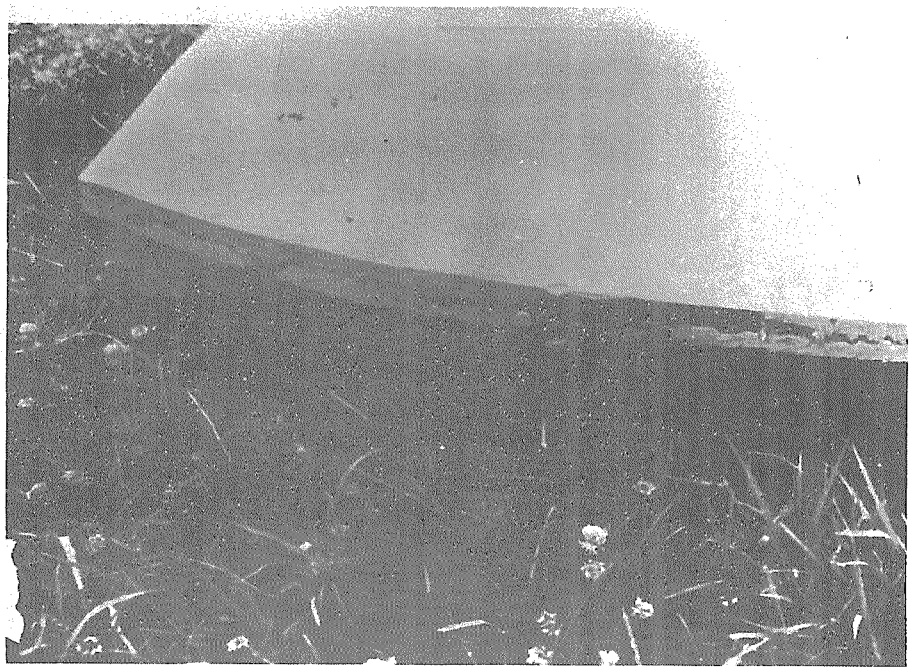

Plate 1

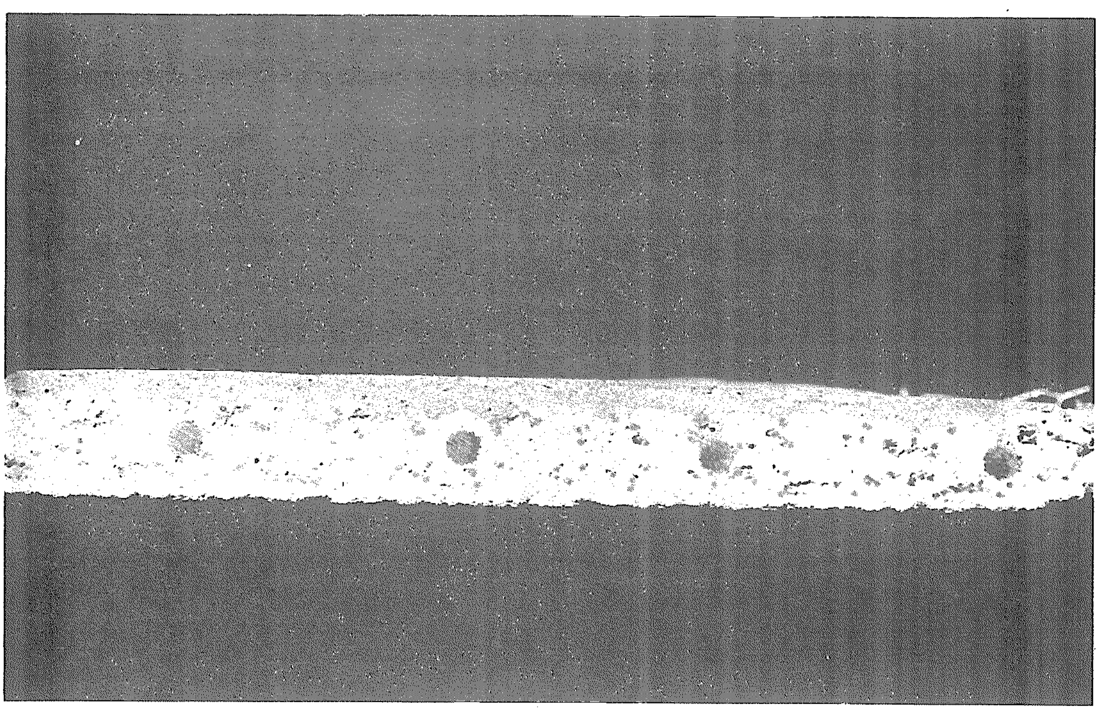

Plate 2

Plate 3

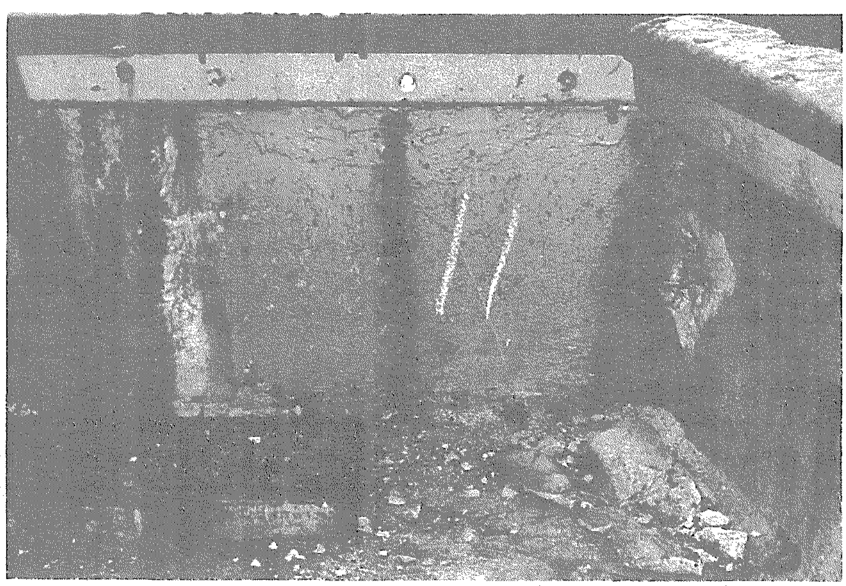

Plate 4

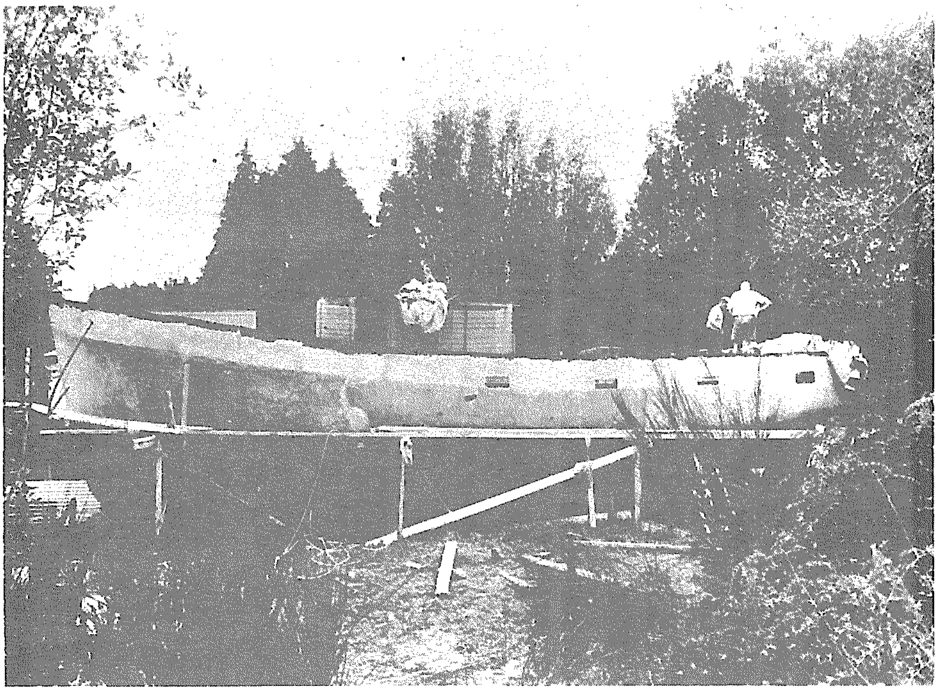

Plate 5

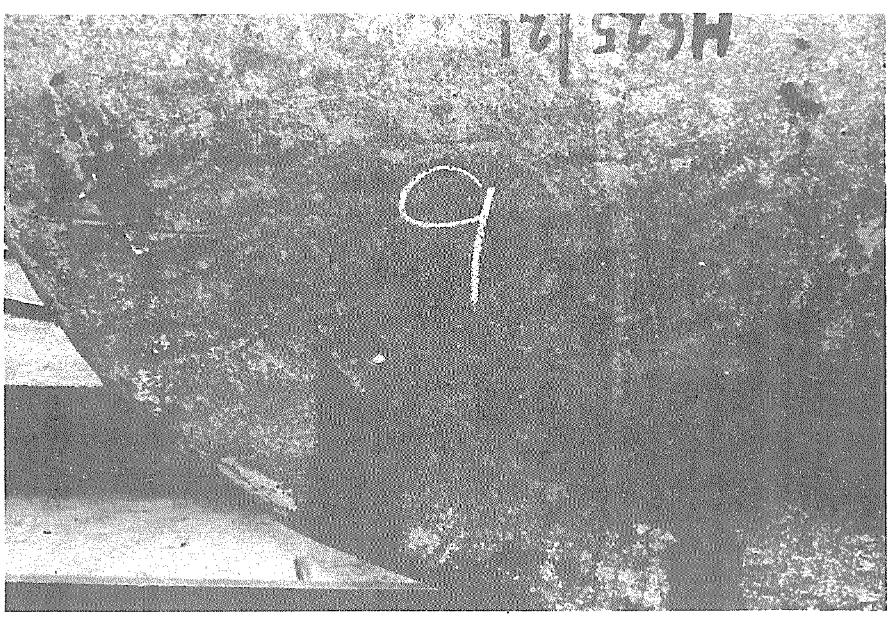

Plate 6

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session II MATERIALS FOR BOAT CONSTRUCTION

Paper II/D

# Discussion

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

TIMBER

MORNING SESSION

A.P.J. HOLNESS: Do the timber merchants hold stocks of seasoned timber in Uganda?

R.A. PLUMPTRE: No, they do not. Very few merchants have any stocks of seasoned timber.

A.P.J. HOLNESS: How long in advance do you have to order from timber merchants if you want seasoned timber?

R.A. PLUMPTRE: Approximately three months.

J.A. CRUTCHFIELD: What is the present situation regarding the available timber resources and possible future trend of timber utilization?

R.A. PLUMPTRE: In the case of muvule (iroko) this will be more and more difficult to get since it is very much in demand by the building industry. Regarding mahogany, the supply over the next ten years will go down but after that we will have mahogany timber available again, so the prospect for mahogany is quite good.

A.P.J. HOLNESS: In some countries one sees wooden boats treated with fish oil which seems to provide an excellent preservation of the timber. It seems, too, that this is in line with what Mr. Plumptre recommends, using an oily product incorporating a poison to kill the fungus causing rot instead of using paint.

R.A. PLUMPTRE: I do not think that paint is essential anywhere except for aesthetic reasons and a wood preservative will definitely give a better protection of the wood.

B. MACHUMIRWA: Experience has shown that the planking of a wooden canoe or boat which is constantly submerged in water is less subject to rot than the top-side planking.

N. ODERO: Can any type of timber suitable for pressure-impregnation be utilized in boatbuilding?

R.A. PLUMPTRE: The timber must also have sufficient mechanical qualities. It must be strong enough in bending, be relatively easy to work with hand tools to take fastenings well and be relatively stable when changing from wet to dry conditions. So far we have checked out muvule as a suitable boatbuilding timber when pressure-impregnated, but I am sure there should be other types of local timber that are equally satisfactory for boatbuilding after being pressure-treated with preservatives.

**A.P.J. HOLNESS:** In Kenya we tried once to utilize cypress for boatbuilding but it turned spongy after a time and was a complete failure. Possibly if this timber had been pressure-treated it would have performed satisfactorily.

**R.A. PLUMPTRE:** The problem with cypress is that it does not take pressure treatment very well. The treatment will be patchy, the preservative liquid will not penetrate equally in all parts of the timber. Pine, however, will soak up preservatives very well and has given excellent results when pressure-treated.

**Ø. GULBRANDSEN:** In Norway there are about 33 000 registered fishing vessels and still 95 percent of them are built of wood. Previously, to a large extent, oak was used in the keel and the framing of these boats but, due to the increasing scarcity of oak and increased prices, it has become more and more common to use pressure-impregnated pine in all parts of the construction. Experience so far indicates that the pressure-impregnated pine is not only cheaper than oak but has a higher resistance to rot and marine borers.

**W. CHRIS PAULUS MANYASSI:** The following case illustrates the difficulty of supplying timber. Our boatyard recently ordered some mahogany from a sawmill in Kampala. Not only did we have to pay a high price for the timber, which includes a 22 percent sales tax, but also the time of the delivery was very long. There was no mahogany in stock and consequently the timber had to be cut in the forest and then sawn at the sawmill. Probably about 4-5 months elapsed before the timber was properly seasoned and ready to be used.

**B. MACHUMIRWA:** It has previously been mentioned that there is a long delivery time for timber from Uganda to Kenya. However, if Kenya seriously wanted to utilize timber in boats it would not be difficult for them to build a shed for seasoning of timber and import timber well in advance of their construction programme. By means of proper seasoning and storage one would be assured of well seasoned timber all the time and when the stocks were getting low a new shipment could be ordered from Uganda.

**R.A. PLUMPTRE:** In the Uganda forests there are some 100 different commercial species of timber and the sawmill will not, at any time, carry stock of these timbers. They will supply them as they come in from the forest and this is why it might take up to five months to get a certain specified type of timber, like muvule. However, it is possible to cut this delivery time if one entered into an agreement with a reputable sawmill and asked them to deliver each year a set quantity of a certain type of timber.

J.A. CRUTCHFIELD: What are the long-term prospects of the developments for prices of timber? If there are strong demands for timber from users other than boatbuilders, then it is probable that there will be an increase in the price of timber

R.A. PLUMPTRE: I do not expect any great increase in the cost of timber. It will probably follow more or less the general price increase in the country. However, for some hard woods such as muvule there might be periods of shortage of supply partly caused by the fact that the forest takes some 60-80 years to renew itself.

B. MACHUMIRWA: Many of the boatbuilders around Lake Victoria use a type of timber called musizi, and canoes built of this timber are said to last five years. Would it be possible to pressure-impregnate musizi and thereby increase the service life of these canoes?

R.A. PLUMPTRE: Musizi takes pressure treatment very well and it might be interesting to try as an alternative to muvule.

Ø. GULBRANDSEN: Possibly one reason why the new canoe types introduced have not been a great success in the Lake Victoria area is that, although these canoes were more strongly built, the same timber as in the traditional canoes was utilized, which meant that the life expectancy was more or less the same as traditional canoes. It seems that a better way would be to utilize pressure-impregnated timber that would definitely increase the service life of the canoes.

A.P.J. HOLNESS: Suppose that Uganda wanted to increase their boatbuilding activities and therefore needed a greater supply of boatbuilding timber, would the Forestry Department take this into account in their long-range planning of the forests, for example by planting the type of species that are of interest for the boatbuilding industry?

R.A. PLUMPTRE: Generally, the Forestry Department has not enough resources to permit large-scale planting and we have to concentrate on species that are requested commercially. If we planted today, say muvule, it would take 40-50 years before we could start cutting the timber, and this is a very long time ahead into the future and will be difficult to incorporate in the planning. I would rather say that it would be better to select three or four species of timber that will be suitable for boatbuilding after pressure treatment. In this way, one would be assured of a steady supply of either one species or the other.

Regarding pressure-impregnation for boatbuilding timber, it is essential to insist on at least the double retention of the wood preservative in the timber compared with what is normally used for house construction. One needs at least 0.75 lb per $ft^3$, R.A. PLUMPTRE: (continued)

otherwise you are not getting the treatment that is required to ensure permanent protection. Probably the best solution is to request the timber merchant for a double treatment, that is, to be put together with the ordinary building timber in the treatment plant twice, because it will be difficult to convince the treatment plant to adjust the machines only for a limited quantity of timber destined for boatbuilding.

B. MACHUMIRWA:

Some years ago we paid East African Shillings 60 for a 9 mm marine plywood sheet 8 ft x 4 ft imported from the U.K. About two years later the price went up to E.A. Sh. 90. Today we are paying E.A. Sh. 135 for the same sheet of plywood.

Ø. GULBRANDSEN:

Would it be possible for the Fisheries Department to import bolts, nails and typical fittings duty free and then sell these items to registered boatbuilders with a small profit?

A.P.J. HOLNESS:

In Kenya, all Government departments are requested to purchase their goods through the Ministry of Works supply stores.

R.A. PLUMPTRE:

The problem of the shortage of supply of timber has been mentioned by several people. It is not the shortage of timber that is the main problem; it is the shortage of the suppliers, and I think this can be overcome to a large extent.

J.A. CRUTCHFIELD:

Nobody will underestimate the importance of the foreign exchange consideration in the selection of construction materials for fishing vessels. If the calculations show that the local material is as economic as any imported material, clearly the choice is to use local materials. But, even then, the problem is not clearcut. If you have a demand from the local furniture industry for the same type of woods as you need for boatbuilding, you might end up in a situation where, to satisfy the demand for building boats, the furniture industry had to import timber. What is interesting in the paper presented by Mr. Gulbrandsen is that the cost of construction utilizing different materials does not vary a lot and, therefore, the selection of construction material is not a critical factor in a fishing boat development programme on Lake Victoria.

B. MACHUMIRWA:

The countries of East Africa have a foreign exchange problem and it seems that import of raw materials for boatbuilding should be restricted as much as possible; we should try to utilize our own materials rather than import substitutes that might be technically superior but represent a heavy strain on our foreign exchange resources. Wooden boatbuilding should, therefore, be encouraged by reduced taxes on import of nails, bolts and fittings. There is the peculiar situation in Uganda that ready-made boats and fibreglass materials can be imported duty free, while a wooden boatbuilder has to pay high duties on the nails and bolts he imports. This is hardly the way to encourage a local boatbuilding industry.

**R.A. PLUMPTRE:** I would, in this connexion, like to mention that all timber in Uganda carries a sales tax of 22 percent which is endangering the competitiveness of local timber, compared with imported materials.

**D.A. GRAINGER:** Since bolts and screws can be used for other purposes, it is difficult to create a system whereby boatbuilders are excluded from paying sales tax. The only way seems to be that the government agencies import bolts, nails and fittings especially for boatbuilding purposes and sell them to registered boatbuilders tax free.

## FIBREGLASS REINFORCED PLASTIC (FRP)

**A.P.J. HOLNESS:** Are the prices for the raw materials such as steel, timber and FRP referred to in Mr. Gulbrandsen's paper based on prices in Uganda?

**Ø. GULBRANDSEN:** The cost calculations are based on prices in Uganda. Probably there would be fairly little difference between the prices in Kenya and Uganda regarding steel plates and steel reinforcements but the wood costs might differ. The price of FRP is based on purchase in fairly large quantities resulting in a low price per kg. No import taxes have been added to the cost of fibreglass and polyester resin. The cost, however, of the complete fibreglass laminate works out to approximately sh. 6.50 per kg. Maybe Mr. Beach can inform about the cost of fibreglass materials in the U.S.A.

**D.D. BEACH:** The cost of fibreglass materials depends considerably on the type of fibre reinforcement material utilized, random mat, unilateral cloth or roving. It is, therefore, difficult to estimate an average price for the fibreglass laminate. Roughly, however, one can say that the material cost of the ready laminate has been recently around 70 cents per lb (E.A. Sh. 11 per kg). I would like to mention that, although it is true that series production of fibreglass boats requires moulds that are relatively expensive, it is also possible to make cheaper moulds suitable for one-off construction. A female mould generally made of wood is constructed and the time required for this is barely more than what is required for setting up an alignment of frames in a conventional wooden boat construction. This will, therefore, mean minor expenses compared with first building a male wooden mould and then a female mould of fibreglass. We find in the U.S.A. that we can build one fishing boat or one patrol boat or one pleasure boat with this method competively with other construction methods. There is a lot to be said for wood, steel, aluminium or ferro-cement construction in developing areas, but I think the use of fibreglass needs serious investigation and one should not be scared away by the seeming complexity of the building process.

B. MACHUMIRWA: When you have to make a wooden mould before making a fibreglass hull, I doubt very much that the cost of one hull will be competitive with other materials.

D.D. BEACH: We have recently built four boats for South Korea using the female mould process, and we found that this was no more expensive than any other construction method. Especially with V-bottom boats, it is very simple to build female moulds since plywood sheets can be utilized in the fabrication of the mould. Such a mould can be economically competitive with only one boat built, but if need arises it is possible to use the same mould for up to 50 boats.

In the U.S.A. an FRP lay-up worker earns about $ 2.50 per hour, that is about sh. 18 per hour. One FRP boatbuilder decided to start building ferro-cement boats but ran into difficulty as the skilled plasterer required for this construction method in the U.S.A. would earn $6.50 per hour. In other parts of the world the situation will probably be radically different.

Ø. GULBRANDSEN: Smaller FRP boats can be built in a simple boatshed, without too much regard for temperature and humidity control; however, the construction of larger FRP hulls will, in tropical areas, require more elaborate facilities. You have seen what is required for building the 41-ft ferro-cement trawler at the boatbuilding training centre, which is simply a shed to give protection from the sun and rain. A similar size boat built of fibreglass will require an enclosed building which would give you some control of temperature and humidity. The question of humidity control is especially important in the bigger sizes of the fibreglass boats. The expenses of providing these facilities and maintaining the control of temperature and humidity will show up in higher overheads. For smaller FRP boats like the Sesse-type canoe built in Kenya and the "banana" boat built in Zambia, the quality requirements are not so high and less elaborate facilities can be used.

It was mentioned by Mr. Beach that FRP boatbuilders in the U.S.A. get approximately sh. 18 per hour, and I can mention that a skilled boatbuilder here in East Africa earns about sh. 2½ per hour. This vast difference in labour cost will influence to a large extent the choice of construction material. The main reason why FRP is taking over in Europe and the U.S.A. for the construction of boats upto 20 ft is the fact that it takes a lot more man/hours to put together wooden boats than it does to produce a similar size FRP boat. Although the basic material cost will be higher for FRP, the savings in the cost of labour are sufficiently great to make it economically competitive. The situation here in East Africa regarding labour cost and material cost is different from Europe and the U.S.A., and we cannot say that what is good in Europe is also good here. Rather, we must take each case separately and analyse carefully the pros and cons of each material.

**A.P.J. HOLNESS:** Is it true that the skill of labour required for fibreglass boat construction is considerably lower than for wooden boat construction?

**D.D. BEACH:** Many of the best fibreglass laminators in the U.S.A. come from Mexico. These people are competing with American labour; therefore they are motivated and they know they have to do a good job. The same applies to refugees from Cuba and therefore the best laminators we have in the U.S.A. are Mexicans and Cubans. To train a motivated person who is willing to learn and teach him to laminate fibreglass takes two days. We can train a man or a woman for the production line, make him produce samples on a formica table, showing him how to get an even thickness and roll out the air bubbles. At the end of the second day they will be on the production line; after three or four days more supervision they are able to build a good boat. The cost of training a fibreglass laminator is therefore negligible.

**J.A. CRUTCHFIELD:** FRP boatbuilders in Europe and the U.S.A. are producing for a very competitive market and the quality and finish of their production must, therefore, be very high. Would it be possible to reduce the cost of fibreglass boat production by building a work boat with a rougher finish that might still be satisfactory for the fishery in East Africa?

**A.P.J. HOLNESS:** We have a case in Kenya where one manufacturer has built an FRP canoe in luxury style while another has built a canoe without any trimmings. The strength is identical. The cheaper 26 ft canoe cost £ 175 while the more luxurious one cost £ 300. This shows that it is possible to construct a competitive fibreglass canoe if one avoids the trimmings and does not demand a high degree of polish.

**N. FUJINAMI:** It has been mentioned in the discussion and in the papers that, due to the changing conditions in various parts of the world, the selection of construction material will not be the same in one country as in another. In Japan, for example, they are building a large number of FRP boats mainly due to the very apparent increase in cost of labour during the last years.

There has been a tendency to reduce scantlings in order to make FRP boats more competitive with wooden boats which resulted in short life of some of the FRP boats.

**Ø. GULBRANDSEN:** A fishing boat receives quite a tough treatment, bumping against quays and other boats, and the laminate must be thick enough to withstand local shocks and abrasion. The scantling of a fishing boat is not determined by an overall strength calculation, but rather by experience from boats actually built.

The classification societies that have worked out scantling rules for fibreglass fishing boats require thicker shell laminates and more internal reinforcements than in FRP pleasure boats.

**N. FUJIMAMI:** Mr. Semakula and Mr. Holness stated that it will be very difficult to introduce a new type of boat to be utilized by small boat fishermen because his present boat, being a dugout canoe or Sesse-type canoe, costs him very little, and his economic situation is such that he cannot afford any expensive fishing vessels. Fibreglass canoes are expensive unless they are mass produced. This demands a market. I wonder how big is the market for such a type of boat.

**A.P.J. HOLNESS:** The situation in Kenya is somewhat different from Uganda since we have several areas where the traditional type of craft is very rudimentary. We are, therefore, building up a new fishery, with a new type of boat, and we have found that the Sesse-type has been accepted everywhere. It is not intended, therefore, to compete with an existing efficient type of fishing vessel, and I think it would be much more difficult to introduce a new type of fishing vessel in Uganda with a long tradition of boat-building.

I do not believe that it is possible to improve on the present type of Sesse canoe. This craft is as near as possible to the ideal for the type of fishing operation it is performing. The mechanized Sesse canoe has been very well accepted by the fishermen in Kenya and we believe that there is no need to try to improve further on this type of boat. Kenya is not so fortunate as Uganda in having sufficient supplies of boatbuilding timber within its own borders. Other construction material should, therefore, be looked for, and I believe that FRP offers the greatest advantages. A firm in Kenya made a model of a Sesse canoe and the Fisheries Department ordered the first seven of these to be used on Lake Rudolf. The experiences with this canoe have been very good and I believe it is a mistake to encourage construction of wooden canoes in Kenya. The FRP Sesse canoe can be built at the rate of 8-9 canoes per month from the one mould, and the skill required by the workers is low. FRP canoes are very easy to repair and they are also very light for transporting, which is an important factor when the boat has to be moved 200-300 miles from the boatyard to the lake shore.

The advantages of the FRP Sesse canoe versus the wooden Sesse canoe are: less maintenance cost, easy repair, longer service life - probably three times as long as a wooden Sesse canoe.

We have made some experiments in Kenya with Sesse canoes built of marine plywood but this did not prove resistant enough for the tough treatment that was given to these boats by the fishermen.

**J.T. MAKORO:** We have had one FRP Sesse canoe built in Kenya for trials on Lake Albert and we found that it was too small to cope with the type of weather we experience on this lake.

**A.P.J. HOLNESS:** The FRP Sesse canoe was designed for fishing close to the base and was never intended for offshore waters. They are used on Lake Rudolf, which can become very rough from time to time, and it is then a great advantage that this canoe can land on any beach and be hauled out of the water. This is an important point since storms can develop suddenly and the boat has to get back to the shore fast and be hauled out easily.

**S.M. SEMAKULA:** It is stated in the paper by Mr. Holness that a fibreglass Sesse canoe costs sh. 3 500. How many fishermen could afford to buy one of these canoes?

**A.P.J. HOLNESS:** We have four to five groups of fishermen that have obtained Sesse canoes through long-term payment schemes.

**Ø. GULBRANDSEN:** The difficulties in the supply of timber have been mentioned by several participants, but I wonder whether this is not mainly a question of planning. No matter in which material you are building boats, you need to plan ahead at least six months for the supply of materials, be it timber supplied locally or imported fibreglass and steel. One thing that must be taken into account with fibreglass is that the storage time of the polyester resin is limited and the time lapse between leaving the factory and being utilized in East Africa might be longer than the safe storage time, with the result that the quality of the laminate is reduced. I understand that examples of this have already happened.

It is estimated that there are about 6 000 fishing craft of all sizes utilized in Kenya, Tanzania and Uganda. Supposing that the life of each of these vessels is about ten years, which is probably higher than the actual case, the need for new construction is about 600 boats per year. This is a big quantity and probably 95 percent is covered by the local beach boatbuilders. So far, construction of fishing boats from commercial boatyards has been very limited. However, their importance will grow with the need for bigger fishing boats.

**J.A. CRUTCHFIELD:** Dealing with 40-ft trawlers for Lake Victoria, I think it is very important to realize that the total number of vessels of this size that will be built is going to be fairly limited. I think it is important too, already from the beginning, to try standardization of the boat types and the equipment on them as much as possible since this will facilitate operation, service and repair.

**FERRO-CEMENT**

**A.P.J. HOLNESS:** If a ferro-cement boat should be damaged below or in the water line resulting in water pouring into the hull, is there any set procedure to stop the leak in such an emergency situation?

**G. WHEELER:** In a ferro-cement boat the damaged area would be localized and the broken pieces of concrete would be kept in place by the mesh, thus preventing large quantities of water coming through the damaged area. However, I do not know about any specific procedure to follow in the case of major damage under the water line. In a recent case in New Zealand we had a 48-ft trawler where the pierced hole was about three inches across. The damaged area was about 12 inches across. The repair consisted of breaking out mortar in an area of 16 to 18 inches across in order to expose the mesh. In the hole

G. WHEELER: (continued) itself, mesh and rods had been broken and were replaced by new rods and new mesh. The whole area was then plastered over and left to cure.

Ø. GULBRANDSEN: I understand that several ferro-cement fishing vessels have been operated from Mombasa over the last couple of years, and it would be interesting to hear what experience you have had regarding maintenance and repair of these vessels.

A.P.J. HOLNESS: The ferro-cement boats in Mombasa are 32-ft trawlers. So far there has been no obvious deterioration of the hull. There have been some rust stains on the outer surface but I believe these are from the iron bolts used for fixing the rubbing strakes. There has been very little maintenance cost on these boats, and they have stood up very well during the past four years they have been in service.

G. WHEELER: Sometimes rust spots can be seen on the surface of the ferro-cement boats and these are often caused by carelessness with the wires used to tie the mesh to the rods. If the tie-wire is put through from the inside and twisted and cut on the outside a little point will normally protrude and might get an incomplete cover of mortar. It is the custom now, in my firm, to utilise stainless steel tie-wire, inserted from the outside and twisted and cut on the inside.

D.G.L. RIGBY: I have seen ferro-cement boats of similar size to the 41-ft trawler you are building here, with a specified hull thickness of 7/8 inch, and I understand that the trawler here will have a hull thickness of 1 1/8 inches; are there any particular reasons for this increased thickness?

G. WHEELER: It is usual practice in New Zealand for fishing boats up to 40 ft to have a hull thickness of 7/8 to 1 inch, while boats above 40 ft have a hull thickness in the region of 1 1/8 inches.

N. FUJINAMI: New Zealand is a country where ferro-cement boat construction has been well established. What type of boats have mostly been built of this material, pleasure boats or fishing boats, and which sizes of boats have been built? It would also be interesting to hear what the result of the operation of these vessels has been.

G. WHEELER: The company I am working in has built ferro-cement boats between 25 and 55 ft. The biggest trawler we have built so far is 48 ft. We have built seven or eight 36-ft fishing boats. The 55-ft boat was a motor sailer, and we have been building yachts. We have also been involved with ferro-cement boat construction in Hong Kong, a 55-ft fishing boat for longlining, and further, in Fiji Island, where we built a 38-ft tug and barges. In New Zealand, barges up to 3 000 tons carrying capacity have been constructed of reinforced concrete.

J.O. ACHOBAH: What is the smallest size of fishing vessel that can be built of ferro-cement?

G. WHEELER: The smallest fishing boat we have built in ferro-cement was 26-ft length over all. In this boat we utilised the pipe frame construction method, in fact we have a complete pipe frame mould braced on the inside so that it can be lifted out to the hull.

J.O. ACHOBAH: I noticed that the 41-ft ferro-cement trawler built here was plastered on the outside in one day. Is this necessary or can one leave joints in the hull and do the plastering over several days?

G. WHEELER: It is desirable to do the plastering on the outside in one day, but evidently for bigger vessels the work has to be distributed over several days. This is possible by applying wet to dry epoxy resin in the joints to ensure a perfect bond between old and new mortar. When plastering a ferro-cement boat, it was previously the custom in New Zealand to press the mortar from the inside through the mesh and then skim off on the outside. This method had several inconveniences. All the mortar has to be shifted to the inside of the boat and it is difficult to work due to the bracing and scaffolding on the inside, and it is difficult to ensure complete penetration of the mortar. Due to the extra time needed for carrying the mortar to the inside of the hull and forcing it through the complete thickness of the shell, there is little time for finishing on the outside before the mortar settles. Over the last three to four years it has been usual practice to plaster in two stages. The mortar is first forced through from the outside to about halfway through the thickness, and it is then finished off and left to harden. Some of the bracing can then be taken away from the inside before the second stage of plastering is done, that is, mortar is vibrated through the mesh from the inside to fill up any possible void.

I agree with Eyresthat it is advantageous to have low bulwarks on ferro-cement fishing vessels. It is also essential to have strong rubbing strakes in areas which are susceptible to abrasion and shocks.

N. FUJINAMI: I have had the impression that ferro-cement will be able to compete with other materials in countries with low cost of labour because the construction method still is fairly labour-intensive. What is the position in New Zealand in this respect?

G. WHEELER: In New Zealand the good boatbuilding timber is becoming scarce and there is, therefore, a trend toward other materials. Ferro-cement is one of these materials and our firm has been able to build competitively by employing unskilled labour for the actual tying of the mesh, which is the bulk of the work in the construction of a ferro-cement boat. Our permanent work force is relatively small and for the plastering we have a contract with an outside firm.

Ø. GULBRANDSEN: We are, in our projects, often faced with the problem of building one or two prototype boats in areas where little boatbuilding skill and facilities are available. In such a situation ferro-cement offers several advantages. We can bring in a man with experience in the construction of ferro-cement boats and he can construct a boat utilising labour that has no previous experience with boatbuilding. The fitting out of the boat, installation of engine, etc., will of course require skilled labour, but, at least for the boatbuilding, particularly, the amount of local skill and facilities required for building rather big fishing vessels is very limited. We do not believe in importing fishing boats into countries which have a potential for further fishery development. We think that the boat should be built in the area where it will be used, and tested out and modified according to the needs of that area.

J.A. CRUTCHFIELD: Are there any experiments going on at the present trying to utilise the same basic technique as in cement construction but maybe with other materials to improve on the weight or insulation properties?

G. WHEELER: There is a lot of development work being done in many countries in regard to ferro-cement, and in the future we might see boats being built of a combination of materials trying to utilise each material where its properties are most advantageous.

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FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
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Session III ENGINES FOR SMALL FISHING CRAFT
Paper III/1

# Experience with outboard mechanisation in the Lake Victoria area

by

J. STONEMAN

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

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## INTRODUCTION - OUTBOARDS IN GENERAL

The outboard, as applied to fishing craft, is generally regarded as totally unsuitable by what might be termed "the Establishment", i.e. the trained naval architects and boatbuilders. One is told, with great emphasis and weighty documentation, that outboards are flimsy, very uneconomic as regard fuel consumption due to their high-revving, two-stroke nature, that they are expensive per hp, that the weight on the transom of a small boat or canoe tends to spoil the trim, that they are complicated and expensive to repair, and that the small, high-revving propeller is grossly inefficient. The use of petrol as fuel is frowned upon for safety reasons as well as expense.

The pundits will tell you that you need a slow-revving, heavy-duty diesel engine, solidly bolted to massive engine-bearers, driving through a large reduction gear to a monstrous propeller. If your propeller is of variable pitch, and your engine was designed before 1910, you have achieved perfection.

## NUMBERS OF OUTBOARDS ON LAKE VICTORIA AND PRODUCTION INCREASE

All this may be true, but it does not appear so from experience in the Lake basin. The total landings of fish from Lake Victoria itself amount to over 110 000 metric tons per year, not an inconsiderable amount. The fish is landed by over 10 000 open boats, and much more than half are propelled by outboard motors.

Outboard motors were first introduced around 1950 when production from the area was about 25 000 tons, and the numbers have increased steadily year by year. Considerable increases in landings in Lake Victoria and in many other East African lakes are due to many factors, but it is generally agreed that the two most important were the introduction of synthetic fibre gillnets and mechanized craft. The role played by outboard motors in this increase in fish landings, which on Lake Victoria alone are worth £4 million sterling per annum, cannot be overestimated.

## REASONS FOR POPULARITY OF OUTBOARDS

The outboard motor is extremely convenient and it catches more fish. Given the opportunity to try various techniques and time to evaluate them, the African fishermen, like any other fishermen, are perfectly capable of finding out what suits them best. The introduction of powered craft was immediately and startlingly successful. The advantages to the pocket of sacking four paddlers were obvious. The extended range permitted much wider fishing grounds. The room vacated by the paddlers permitted the carriage of more nets and more fish, while the speedy return to base allowed fish to be off-loaded in much better condition. Any power would have provided most of these advantages, the only disadvantages being cost of fuel, capital investment, operation of the motor, and, one must presume, greater fire risk.

The outboard, with its notorious thirst - it was clear - could not compete with the economical diesel motor, and, indeed, fishermen in the early days who actually invested in 35 hp outboards found their fuel bills rather frightening. A few inboard motors were therefore tried out in the early days of mechanization, and it would not be true to say that the traditional canoe designs of those days were not suited to inboard motors. They could be, and were, adapted. However, the difficulties of installation and the space taken up by the motors were against them and despite all the experts' unanimous opinions that high speed was not required in the Lake Victoria fishing craft, the main reason for the fishermen's love of the outboard was the speed easily obtained by their long, thin canoes with a relatively small, high-revving engine. They abandoned with rapidity a few inboard installations that were attempted just as they dropped the larger, over 20 hp motors. They concentrated almost entirely on the lower-powered motors which obviously suited their requirements precisely.

In the Lake Victoria basin, 95 percent of outboards now in use are in the 5-10 hp range, of American manufacture, and are primarily intended by the manufacturers for sport and similar uses. These suit the fishing of Lake Victoria admirably. Loaded or light, the traditional canoe can be propelled at maximum displacement speed all the time by these motors, and, light, may even semi-plane to improve on the displacement speed. That this speed is of value to fishermen cannot be denied. Exactly where the economies of the slow-speed diesel advocate fall down is not entirely clear. However, it is clear that the small, high-revving propeller is not too unsuited to the easily propelled canoe-type hull. Even in Africa, time if of great value to fishermen and like all of us, they like their comfort and the speedy return home is greatly to be desired. If it results in more people fishing than otherwise would have been the case, it cannot be said that this is an unworthy desire.

Many advantages of the outboard have been given above, but, of course, the incredibly simple installation and ease of removal are most important. The outboard certainly simplifies beaching fishing vessels, but even where larger craft normally lie afloat, as at Wanseko on Lake Albert, outboards are preferred. The high power to weight ratio, of course, has its advantages in extra carrying capacity, as well as the ease of transport of power unit for repair or maintenance or primary installation. We see, therefore, why all the fishermen who should be chugging around Lake Victoria, their boats and themselves vibrating to the steady thump of slow-speed diesels, are now gaily skimming along in front of a high-revving, grossly inefficient, but extremely convenient outboard motor.

## TYPES OF OUTBOARDS USED

Most modern, low-powered outboards are generally similar in construction and operation, and there is very little difference between them in actual fact. In the early fifties, this was not the case, and a number of widely advertised and sold outboards of different makes were extremely unsatisfactory. One reason for the curious situation in some areas today, where one motor alone is used and others shunned, or one particular make resolutely refused, can be traced to the premature introduction of an unsatisfactory model. Fishermen's memories are long and no matter how much improved and altered that model may now be, it still cannot be sold. Conversely, where an early introduction was satisfactory, that particular motor may still be the only acceptable make, despite great improvements by its competitors.

On Lake Victoria, as has been said, it is the American O.M.C. 5-10 hp model that is popular. On Lake Albert, the rather more rugged and more primitive, horizontally-opposed 12 hp Penta (Archimedes) engine is almost alone in the field. Over 1 000 of these motors have been sold on Lake Albert since 1954. On Lake George there is, perhaps, one of the last surviving pockets of the Atco Boat Impellor. On Lake Kariba in Zambia and in much of Malawi, the British Seagull engine stands supreme. Many of these regional preferences can be traced to the original introductions by the Fisheries Departments, and to the presence of active and efficient trade distributors.

## DISADVANTAGES OF OUTBOARDS

Despite all the foregoing, the outboard still has many faults which it would be idle to deny. This is not surprising when one considers that they were not designed for the kind of use they receive in the fishing industry; nor, most likely, did the designers ever contemplate the standard of mechanic who would attempt to maintain and repair them. Generally, the faults are due to flimsiness of construction, the use of materials unsuited to continuous operation, neglect, and to failure to guard against excessive vibration. Propeller blades soon become chipped and bent in operation, mounting brackets become loose or broken, and vibrations become increasingly important. Greater use of lock nuts, lock washers and locking compounds would help, although it must be admitted that as soon as any nut or screw is touched during a repair job in the field, any locking washer or locking property of the fastening is immediately lost. It is difficult to see how engine manufacturers could justify extensive redesign or reconstruction for what is an extremely small part of their total market. Although motor-car manufacturers claim to design their family saloons on lines which closely resemble the current Grand Prix racing car, it does not appear that outboard manufacturers hope for much favourable publicity from the success of their models in the African fisheries, which might be termed "Grand Prix" of motor-boating (although we may yet see a "Safari" model Evinrude!).

To turn to some of the other quoted disadvantages of the outboard, there have only been two or three cases of fires in fishing boats on Lake Victoria since the outboard was introduced. The African mechanic has not found the complexities of the outboard construction and repair as difficult as was assumed. Petrol and lubricating oil are more widely available throughout Uganda than is diesel fuel oil. Most fishermen or their employees operate or are familiar with petrol-engined land vehicles, and find that a common stock of fuel can be kept. The flimsy nature of construction of many outboards is certainly unfortunate, but is not sufficient to militate against their use.

## ECONOMIC JUSTIFICATION FOR OUTBOARDS

The provision of outboard power, even where this is not linked with the necessity for an improved and more expensive hull, requires considerable immediate increase in landed value of the catch merely to maintain the same actual profit, and a much greater increase in catch to maintain or increase the ratio of profit to investment. Concrete figures for this type of costing are hard to obtain, but it does appear that the simplest outboard power requires a doubling or trebling of the previous catch to maintain the same actual profit to the owner. Despite the lack of accurate figures, it is perfectly clear that this requirement must be met and more than met for the outboard fishing boats of the Lake Victoria basin.

## FUTURE OF OUTBOARDS, POSSIBLE IMPROVEMENTS AND DEVELOPMENT PLANS

Much can be done in Africa by improving standards of maintenance and repair. It is obvious from the foregoing that the outboard will be a major factor in fish production in East Africa for many years to come. Investment in training and placement of mechanics and repair shops, therefore, are essential. Methods have varied somewhat in the three territories. In Uganda, the policy has been to leave the actual evolution of mechanics to the light of nature. In fact, with the general high standard of living and good communications, large numbers of small motor vehicles operate all over Uganda, and there is a considerable fund of mechanics competent to carry out minor repairs on cars. These people have proved remarkably adept at keeping outboards running. The Department's active help has been limited to providing communal workshop facilities at the more important landings, and to advice and assistance from the fisheries officers who are, at the moment, the only competent staff members who can help. The Fisheries Training Institute at Entebbe, however, is giving courses in outboard engine maintenance and shortly the 200 or so fisheries assistants in the field will be able to give mechanical assistance. In Tanzania, departmental employees carry out repairs and maintenance free, charging only the cost of spares to the engine owner. This appears to be an admirable scheme, and could well be copied elsewhere.

An important factor in the success of the outboard engine mechanization programme has been the sustained favourable economic climate. East Africa generally has maintained the high price of fish. There has been a steady improvement in landings and fishermen's profits have been high enough to absorb the relative inefficiencies of outboard motors without difficulty. The outboard is with us and is likely to stay. Let us, therefore, make the best of it.

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Session III ENGINES FOR SMALL FISHING CRAFT
Paper III/2

# Outboard engines for inland waters

by

A.P.J. HOLNESS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

The introduction of outboard engines to the fishermen on various lakes in Kenya started as late as 1964; even though the mechanization of fishing craft had been planned for a lot earlier, records show only single figures for boats under engine power, carrying out commercial fishing.

Uganda fishermen, of course, started on outboard engines some time in 1949 and in a short time a large number of boats in Uganda were powered by these engines. One of the reasons for rapid mechanization was the introduction by the Uganda Fisheries Department of advanced boatbuilding.

The standard Sesse canoe will be regarded as our main fishing boat to fit an outboard motor. If long-distance fishing is to be carried out, that is fishing in areas well away from the landing beach which could be from 3 to 10 mi, at least an 18 hp engine should be used. For fishing under 3 mi from the landing beach, a 9 or 10 hp engine is sufficient. In areas where high winds are apt to develop suddenly, a smaller engine should not be used.

It would not be proper to mention the makes of engines which can be obtained in various parts of East Africa. The only important thing is for the fishermen to be constantly advised as to who can give a satisfactory service to keep their engines working.

The author has spent considerable time in assisting organizations who wish to introduce new outboard engines to the fishermen. Progress in any fishery means experiments in all departments and it would not be progress to refuse to try a new engine, when the agents assure you of all sorts of advantages.

Engines, like boats, cannot be forced onto the fishermen; they have to be convinced. Once the fisheries staff have introduce a new engine to boat owners, it is the responsibility of the company or distributor to convince the fisherman that not only is the engine better than those he already has, but that the servicing and spares will be available at all times.

Since 1964, the author introduced two well known outboard engines to fishermen in Kenya and went to great lengths to convince not only the fishermen but also the fisheries staff, of the various advantages of having these particular makes on their canoes. Engines were purchased by the Kenya Fisheries Department for demonstration purposes.

One engine distributor wrote a letter to confirm that new service and spares would be established at Lake Victoria. Nothing was heard from these people again; the other firm did not follow up simple defects which were found on their engines and certain spares were not available.

The author considers that one should never contemplate or accept a new outboard engine unless you have definite proof of the following:

1. Efficient sales and administrative backing
2. Guaranteed quick moving parts in stock
3. Trained outboard mechanics to do repairs
4. Good stocks of different sizes of outboard engines
5. Guaranteed after-sales service

The prevention of overpowering of fishing craft is a very important factor. On a number of occasions the author has noted that a high horsepower engine is being used where almost half that power would have been adequate. The overpowering of fishing boats is not only uneconomical but dangerous. An overpowered boat, unless handled by a very competent person, could easily overturn by turning too sharply or could be swamped very easily in choppy water.

It has been proved beyond doubt that one will obtain greater benefits by using a single engine against two of equivalent horsepower.

It does not cancel the necessity of carrying a spare engine in case of emergency, if offshore work is to be considered.

With one engine being used, less fuel is consumed, less weight is carried, there are lower service charges and it is cheaper to purchase. If a second engine is required in case of an emergency, a much lower horsepower can be bought, and kept in new condition, so that there is very little depreciation and it can be kept as a stand-by for a number of years.

The servicing of outboard engines is most important; if being used in salt water and the motor is left for any period the cooling system should be flushed out with fresh water.

The normal service instructions will not be mentioned as they vary according to engines used. The above general advice applies to most makes on the market today, but it should, of course, be understood that the manufacturers' instructions issued with each individual make must also be strictly adhered to as these makes differ slightly, one from another.

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Session III ENGINES FOR SMALL FISHING CRAFT
Paper III/3

# Selection of engines for small fishing craft

by

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Contents:



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## INTRODUCTION

The mechanization of small fishing craft has been an important step in the modernization of fishing techniques the world over. In many instances the increase in landings from this innovation alone has been remarkable, and doubling or tripling the catch is not uncommon. Unfortunately, the increased profits from mechanization have not always kept pace with the increase in catches. Sometimes this has been caused by marketing or social conditions, but often the profits have been consumed by unwise investment in the engine itself or by lack of provisions to assure that adequate funds for keeping the equipment operational will be available. In this paper we will discuss the most important factors to be considered in selecting small engines of up to 30 hp for fishing craft.

## POWER REQUIREMENTS

### (1) Resistance of vessels underway

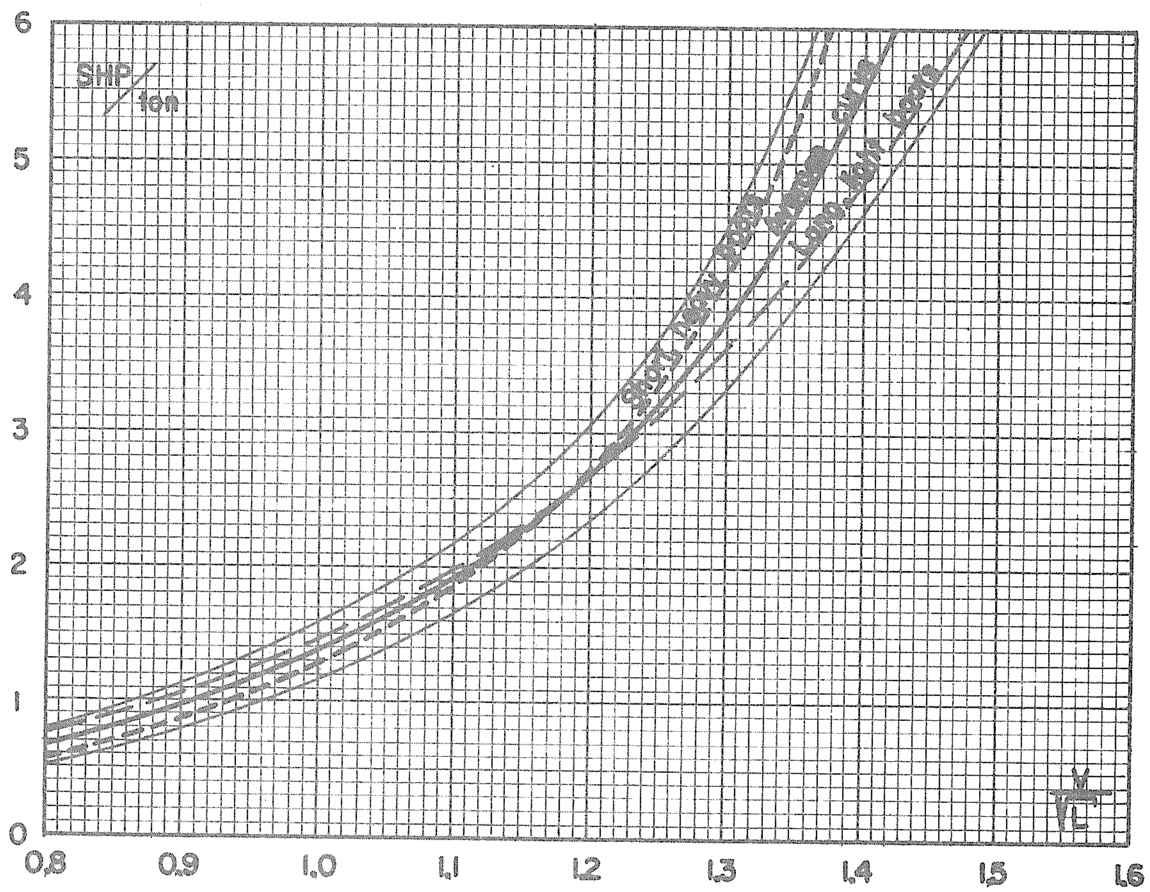
The force needed to drive a boat through the water is mainly used to overcome three kinds of resistance: friction caused by the rubbing of the water on the bottom of the vessel, eddies which are formed along the surface of the hull as soon as any appreciable speed is reached, and waves which form at the bow and stern of the vessel. At slow speeds friction accounts for most of the resistance, but as the speed increases the energy carried away by the eddies and particularly by the formation of waves increases rapidly. A fast moving boat with large bow and stern waves can be an impressive sight, but it is obvious at the same time that a great deal of power must be expended to create such a wave pattern.

A detailed estimation of power requirements which takes all the above factors into account can only be carried out by a naval architect. For big vessels the selection of a suitable power plant involves a great deal of money and mistakes will lead to increased operating costs on a large scale. Such vessels are never constructed or powered without the services of a naval architect to ensure an economic selection of the power unit. In the case of small fishing craft, especially existing craft which are to be mechanized, it is often necessary to proceed without any real detailed analysis of the power requirements. The problem then boils down to attempting to select a power unit which is satisfactory without being excessive.

Based on available data, staff of the FAO Fishing Vessels and Engineering Branch have prepared Figure 1. It contains the main factors influencing the engine power of a vessel, namely, speed, length of the boat in waterline, and displacement. Evidently the shape of the boat will also play a major role, so there are high and low curves depending on the form of the hull. The high curve corresponds to beamy and "fat" boats while the lower curves apply to narrow hulls with a sharp bow.

The curves in Figure 1 give shp (shaft horsepower) that is power delivered to the propeller. However, when we select an engine, we base this on bhp, that is the manufacturers' stated horsepower delivered by the engine on a test bench in the factory. Usually, this is the power delivered by the bare engine without reduction gear and generator. There will be power losses in the reduction gear and also in bearings in the stern tube and this often amounts to 5 percent of the bhp. The engine is tested at a certain temperature and humidity. In tropical areas it is common to have a temperature of 40°C and close to 100 percent relative humidity in the engine room. This has a marked effect on the power of the engine, and a loss due to high temperature and humidity of 10 percent must be reckoned with. Including the losses in reduction gear and bearings, this gives a total of 15 percent. On top of this it is wise to add another 5 percent and calculate the shp (shaft horsepower) to be 20 percent less than the manufacturers' stated bhp (brake horsepower). It is also wise to check that the bhp stated by the engine manufacturer is for continuous duty and not for an intermittent period. On the cover of a leaflet describing an engine it says that the engine develops 115 bhp at 2 800 rpm. One has to study the diagrams on the next pages to find out that this is only for a one-hour period and that for continuous duty the engine develops 95 bhp at 2 400 rpm. With the allowance for tropical conditions the power delivered to the propeller will be around 75 shp. At high altitudes, like Lake Victoria in East Africa situated at 1 100 m above sea level, there is a further 10 percent power reduction due to altitude giving a total power loss of 30 percent and a shaft horsepower of 67 shp.

Based on the average curve in Figure 1 and including an allowance of 20 percent for tropical conditions the bhp, for different waterline lengths and displacements, has been presented in Table 1. By nature, this type of diagram will give only a rough indication of the engine size required to obtain a certain speed, but it might prove useful as a guide. It certainly reveals clearly the large increase in power required for a rather small increase in speed. Take as an example a boat of 11 m (36 ft) overall length with a waterline length approximately 10 m (33 ft) and with a displacement of 8 tons. For a speed of 7 knots this boat will require 30 bhp and if we want to increase the speed to 8 knots, that is 15 percent increase, it will require a total of 54 bhp that is an increase in power of almost 50 percent.




Shaft horsepower per ton against speed / length ratio for displacement boats

Figure 1

Table 1

AVERAGE POWER REQUIREMENTS IN BHP INCLUDING 20 PERCENT ALLOWANCE FOR TROPICAL CONDITIONS

| Approx. length overall | Length waterline | Tons displacement | Engine power bhp | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 5 knots | 6 knots | 7 knots | 8 knots | 9 knots | 10 knots |
| 6.5 m (22 ft) | 6 m (20 ft) | 0.5 | 1 | 3 | 5 | | | |
| | | 1.0 | 3 | 5 | 11 | | | |
| | | 1.5 | 4 | 8 | 16 | | | |
| | | 2.0 | 5 | 11 | 21 | | | |
| | | 3.0 | 7 | 16 | 31 | | | |
| 8.7 m (29 ft) | 8 m (26 ft) | 2 | 4 | 6 | 12 | 21 | | |
| | | 3 | 5 | 9 | 19 | 32 | | |
| | | 4 | 6 | 12 | 25 | 43 | | |
| | | 5 | 7 | 14 | 31 | 54 | | |
| | | 6 | 9 | 17 | 37 | 65 | | |
| 11 m (36 ft) | 10 m (33 ft) | 4 | | 8 | 15 | 26 | 43 | |
| | | 6 | | 11 | 23 | 40 | 64 | |
| | | 8 | | 15 | 30 | 54 | 85 | |
| | | 10 | | 19 | 37 | 66 | 106 | |
| | | 12 | | 23 | 45 | 80 | 127 | |
| 13 m (43 ft) | 12 m (39 ft) | 8 | | 12 | 22 | 35 | 62 | 90 |
| | | 12 | | 17 | 30 | 52 | 93 | 135 |
| | | 16 | | 23 | 40 | 70 | 124 | 180 |
| | | 20 | | 30 | 50 | 87 | 155 | 225 |
| | | 24 | | 37 | 60 | 105 | 185 | 270 |

(2) Selection of operating speed

By use of Figure 1 and Table 1, we are in a position to estimate the power required for any reasonable speed. The power will vary very greatly depending on the speed actually selected, as is shown by the example above. Our next problem is to decide what speed should in actual practice be aimed at. If we could obtain speed free, we would say: "the faster, the better". This is not, however, the case by any means; power is expensive, and the choice of speed and power should be governed by economic considerations. The purpose of installing an engine is obviously to move the boat around. If the speed is too low we may be better off to continue using cheaper methods such as sailing or rowing. This is not to say that we should not mechanize unless this would enable us to travel faster than by sail. The main disadvantage of sailing is that it is unreliable. In a good, favourable wind a boat will usually be able to travel faster with sails than with an engine. The engine is justified because it does not depend on a favourable wind.

Motorization may offer many advantages: grounds which are too distant for the existing craft to frequent may be opened up; the catch may be brought to market on time more reliably; the quantity of fishing gear handled may be increased; new types of fishing gear may become feasible; the time spent in fishing operations may be increased, while the travel time is decreased; the crew may be afforded more leisure time; the quality of the catch may be improved; safety at sea may be increased (it may also be decreased by adding weight to the vessels); and so on. Almost all these advantages will be increased by increasing the speed and power of the vessel. The main disadvantage of mechanization is the increased investment and operating cost.

Most of the advantages mentioned above are difficult to subject to a rigorous economic analysis, due to the many uncertainties which surround almost any fishing venture. In many cases, however, even a cursory examination will at least narrow considerably the range of choice.

As an example let us take a 9 m (30 ft) boat with a waterline length of 8 m (26 ft) and a displacement of 4 tons. We are contemplating fitting this boat with either a 15 bhp or a 25 bhp engine and we want to find out what difference this makes in economic terms. Figure 1 or Table 1 will give us an idea what speed the boat will get with these two engines. Table 1 indicates that 15 bhp will give us a speed of around 6.3 knots while 25 bhp will give us 7 knots.

Part of the fleet is to be engaged in gillnet fishing at night time. Experience has shown that, for the best results, the nets should be in the water by 19.00 hours. In order to catch the morning market the vessels should return to their home base by 05.00 hours. The fishing grounds are on the average 20 mi from port and the average per fishing trip with 15 hp is 100 kg of fish worth U.S.$ 0.40 per kg, and the boats average 200 trips each year.

What advantage can we expect if we install 25 hp instead of 15? The travel time to the fishing grounds will be reduced from 3.18 hours to 2.86 hours, a saving of 0.32 hours or 19 minutes. One value of this saving is that the boat can leave 19 minutes later each evening. Usually no economic benefit can be ascribed to such a saving which adds to the leisure of the crew. In the morning, the boat with 25 hp will be able to continue fishing for 0.32 hours, longer than the 15 hp vessel. The latter vessel is able to spend 7.82 hours on the grounds during which time it catches 100 kg of fish or 12.8 kg per hour. The additional 0.32 hours should produce 4.1 kg more each trip for the 25 hp vessel or 820 kg per year, worth U.S.$ 328.

Let us assume that a 15 hp engine costs U.S.$ 1 500 and a 25 hp engine costs U.S.$ 2 000. The fuel consumption will be about 0.25 litre per hp/hour, assumed to cost U.S.$ 0.12 per litre. Lubricating oil consumption will be about 2 percent of the fuel oil and its price is assumed to be U.S.$ 0.20 per lb. Maintenance costs will be taken as 12 percent of the engine value per year and a life span of eight years assumed for both engines.

It is further assumed that both engines will operate at full power, going and coming from the fishing grounds and will idle at one third power while on the grounds.

<u>For the 15 hp engine the operating period will be:</u>

6.36 hours per day at full power, or 1 270 hours per year
7.82 hours at one third power
corresponding to full power for 520 hours per year
Total operating time at full power 1 790

Annual fuel consumption:

1 790 hours x 0.25 litre/hp/hour x 15 hp = 6 700 litres
Annual cost of fuel: 6 700 x 0.12 = U.S.$ 805

Annual lubricating oil consumption:

0.02 x 6 700 = 134 litres
Annual cost of lubricating oil 134 x 0.50 = U.S.$ 67

For the 25 hp engine the operating period will be:

5.72 hours per day at full power, or 1 144 hours per year
8.14 hours at one third power
corresponding to full power for 543 hours per year
Total operating time at full power 1 687 hours per year

Annual fuel consumption:

1 687 hours x 0.25 litre/hp/hour x 25 hp = 10 500 litres
Annual cost of fuel: 10 500 x 0.12 = U.S.$ 1 260

Annual lubricating oil consumption:

0.02 x 10 500 = 210 litres
Annual cost of lubricating oil 210 x 0.50 = U.S.$ 105

The annual owning and operating costs will be:

| | 15 hp | 25 hp |
|---|---|---|
| Depreciation - 8 years | 188 | 250 |
| Maintenance 12 percent | 180 | 240 |
| Fuel oil | 805 | 1 260 |
| Lubricating oil | 67 | 105 |
| Total: | U.S.$ 1 240 | U.S.$ 1 855 |
| Excess cost of 25 hp over 13 hp | | 615 |
| Excess income | | 328 |
| Net loss: | | U.S.$ 287 |

In this case the decision to insist on the specified speed of 7 knots would not be profitable. An additional investment of U.S.$ 500 would result in a loss of U.S.$ 287. The fairly large difference in yearly expenditure of the 15 hp engine and the 25 hp engine is mainly due to the high cost of diesel fuel in East Africa, U.S.$ 0.12 (Sh. 0.85) per litre. However, with a fuel cost of U.S.$ 0.5 per litre which is the case in many countries there still would be a loss in installing the bigger engine.

Let us take one more example, using the same hypothetical vessels. Some of these are to be rigged as small trawlers. It is found that the original boat with the 15 hp engine can tow a certain size trawl at 2.5 knots, which is suitable for the particular fish being caught. If the 25 hp engine is installed in future vessels, they will also tow at 2.5 knots but they will be able to use larger nets. As a first approximation we can assume that the power required varies as the cube of the net size, while the catch will vary as the opening, or as the square of the net size.

The expected ratio of catches will then be 25:15 to the two thirds power or 1.42:1. Let us assume that the net will be fishing for eight hours per day but the engine will be running for 12 hours at full load. The catch with the 15 hp engine will again be assumed to be 100 kg per day but U.S.$ 0.20 per kg. The catch with 25 hp should then be 142 kg per day. For 200 days' operation the owning and operating costs per year will be:

| | 15 hp | 25 hp |
|---|---|---|
| Depreciation | 187 | 250 |
| Maintenance | 180 | 240 |
| Fuel oil | 1 080 | 1 800 |
| Lubricating oil | 90 | 150 |
| Total: | U.S.$ 1 537 | U.S.$ 2 440 |
| Excess cost of 25 hp over 15 hp | | 913 |
| Excess income 42 kg x 0.20 x 200 days | | 1 680 |
| Net gain: | | U.S.$ 767 |

In this case the investment of U.S.$ 500 additional would be most profitable. Note that in the examples given it was not found necessary to analyse the overall project performance. What we are interested in at this point is merely to compare the effect of two different power plants.

(3) Overpowering

In the preceding section it was pointed out that power and hence speed selection are essentially a question of economics. Very often it may be difficult to reach a decision on purely economic grounds due to the scarcity of data, especially in the planning or early stages of motorization. In such cases recourse to simple principles may be helpful in preventing excessive, unwarranted investment.

In the earlier discussion of resistance we have seen how the power requirement rises rapidly after the wave-making resistance becomes dominating, and a point is reached beyond which the speed increase is negligible despite a large increase in power. Referring again to Figure 1 and Table 1, it will, after study, reveal that for the higher speeds the increase in engine power is drastic. Attempting to arrive at high speeds results in "overpowering" and is a wasteful procedure. In the event that an analysis indicates that the required speed to suit the intended purpose will result in overpowering, it is advisable to review the whole project. It will be more than likely that the basic defect is that the vessel is too short, and that a longer boat will obtain the desired speed with less power and a smaller total cost.

(4) Auxiliary drive

Motorization of fishing craft truly becomes mechanization when the power plant is used not only to propel the vessel, but also as an essential part of the fishing operation itself. The engine can profitably be used to drive winches, line haulers, net haulers, generators, hydraulic pumps and other modern equipment. In large vessels it is usually advisable to provide separate auxiliary engines for some or all of the purposes. In small vessels the main engine is normally used for this purpose.

In the context of the present discussion of the power requirements to obtain a given speed, auxiliary uses of the engine may reduce the power available for delivery to the propeller shafting, and if so, this should be taken into account when selecting the engine. Winches and haulers are normally not used while the engine is being required to deliver full power. On the other hand a part of the winch drive may be running continuously and if the main engine is small this power drain may become appreciable. Generators and pumps usually run continuously or at least for extended periods and should be allowed for when selecting the main engine. The increasing use of electrical and electronic devices on even small fishing vessels can result in placing unforeseen loads on the engine unless planned from an early stage of the design.

## SELECTION OF ENGINE TYPE

(1) General considerations

In small fishing craft the internal combustion engine still rules supreme. The future will no doubt see the introduction of other types of power plants but the present discussion will be limited to the more common types of internal combustion engines. A number of factors enter into the selection of engine type. The most important of these are: the design of craft, operating conditions, first cost, relative cost of different fuels, cost of lubricating oil, availability of repair facilities, weight of engine, fire hazard, permissible propeller size, the need for a reversing engine, and so on. These factors will be considered in more detail in the discussion below on the different types.

(2) Outboard motors - power poles

Outboard motors are cheap, light, portable, retractable and easily installed. For certain types of craft and for certain applications these advantages are so great as to make the outboard motor the automatic choice. This is particularly true when a fleet is to be built up by the mechanization of existing craft, many of which are narrow, flimsy and completely unsuitable for inboard engine installations, while they will readily take an outboard. For beach landing of light craft the outboard also offers specific advantages: the use of the propeller for steering in surf is superior to a rudder and the retractability of the engine permits the landing to be made as for a non-mechanized craft. In the worst case landing with an outboard will not be worse than in the case of the same craft without an engine. This is not true for many inboard installations which may seriously hamper beach landing. In the event that the craft is swamped, the portability and easy removal of the outboard is a major advantage, as it permits flushing in fresh water to be carried out very quickly, and getting the engine to a workshop can be done before deterioration due to salt penetration sets in.

In shallow, narrow, or fouled waters the outboard may also show to great advantage, due to the ease with which it can be lifted out of the water and to the automatic safety feature of the self-tilting arrangement of this drive.

The low first cost and installation cost make the outboard especially attractive where rapid mechanization is desired with limited funds. It is particularly suitable for use with mass-produced fibreglass hulls.

The servicing of an outboard can, in many places, be easier to arrange for than that of its main rival, the inboard diesel, due to a wider dissemination of experience in repairing petrol engines than diesels, as well as fewer demands for precision work for the former type of engine.

The main disadvantages of the outboard are lack of ruggedness and durability, high fuel consumption and the use (in most localities) of high-priced fuel.

A variation of the outboard motor is the so-called power pole. This is a petrol engine set on a swivel mounting similar to that of outboards, but with a shaft extending as a direct continuation of the crankshaft, ending in a propeller. In order for the propeller to be properly submerged, it is necessary to tilt the engine at a considerable angle. While most outboards operate on the two-stroke cycle, the power pole utilizes a four-stroke engine, with a considerable reduction in fuel cost. Aside from this it can be produced at a cost well below that of an outboard of comparable power as it eliminates the comparatively expensive underwater unit of the outboard. The power pole normally has neither a clutch nor is it reversible, which can be drawbacks for certain operations.

The steering ability of the power pole is much inferior to that of the outboard, and in particular it requires that the boat have a good keel to keep it on a steady course. It is not well suited to use in rough seas, but is ideal for many applications in rivers or on lakes with sheltered waters, if first cost and low operating costs are important.

(3) Inboard carburettor engines

Carburettor engines may use petrol or kerosene as a fuel, the former being much more common. Engines using kerosene will in any case use petrol for starting the engine.

Carburettor engines, when compared with diesel engines, have the following advantages:

Light weight, small size, low first cost, widespread maintenance experience and relative simplicity of repairs. Compared with outboard motors, the inboard motors are usually more reliable in operation and have lower fuel consumption on the average, as the four-stroke cycle is the one generally used. Due to the close resemblance of these engines to automotive engines good maintenance may be easier to obtain.

Whether the permanent installation is in itself an advantage or disadvantage will depend on local circumstances. As was pointed out earlier, it is a definite advantage to be able to remove an outboard, for example if it is submerged. It may also be desirable to do so for reasons of security but if a boat is kept at moorings offshore a permanent installation may be an advantage. The same is true for boats which may be required to operate on short notice or at irregular times.

Although the fuel consumption of inboard carburettor engines is usually lower than for outboards it is higher than that of diesels, and these engines also use a more expensive fuel. The ignition system and carburettor are not as reliable as the diesel system especially in a humid, salt-laden atmosphere.

If the operation calls for a reversing gear and clutch, some of the price advantage, when compared with diesel, may be lost.

(4) Diesel engines

The main advantages of diesel are low fuel consumption, particularly during part-load operation, cheap fuel, reduced fire hazard due to less volatile fuel and absence of electrical ignition, increased reliability of operation, longer life, longer periods between overhauls.

The main disadvantages are greater weight and size, higher first cost and the need for more highly trained mechanics. Sometimes the need for a larger propeller may be a disadvantage despite its higher efficiency.

The fuel consumption of petrol engines is greater for those operating on a two-stroke cycle than for a four-stroke cycle. This is not necessarily the case as far as diesel engines are concerned, and although most small diesels do in fact use the four-stroke cycle, two-stroke engines can be considered on an equal footing when selecting a diesel engine.

(5) Semi-diesels

The semi-diesel engines have not become popular in most of the fisheries which are presently undergoing mechanization. The main advantages which can be claimed for semi-diesels are simplicity of construction and the ability to burn low-grade fuel, even cheaper fuel than many full diesels require.

On the other hand these engines tend to be difficult to start and "temperamental" in the hands of inexperienced operators, which seem to have been the main factors working against their popularity.

For historical reasons, however, semi-diesels have developed along with controllable pitch propellers, and in many cases the propeller control system is built right into the engine itself with excellent results. Although full diesels can also be fitted with variable pitch propellers, these remain optional extras and tend to be expensive.

The semi-diesel still merits consideration if small engines with controllable pitch propellers are required and first cost is an important factor.

(6) Conclusions

In deciding on what type of engine to use, it is the authors' opinion that engines should be considered in the following sequence: diesel (with a glance at semi-diesel), inboard carburettor, outboards (including power poles). In other words, if there is no reason for not using a diesel, this would be the first choice. Similarly, if an inboard carburettor engine is suitable it would be the second choice. Outboard motors would be reserved for the very large class of operations where they are superior to the first two types. The above may appear to be no more than an obvious suggestion to use what is most suitable, but it does imply approaching the problem in the frame of mind of obtaining the best rather than the cheapest solution.

In comparing the costs of alternative engines the following can be used for making first estimates:

| Engine | Fuel consumption litre per hp/hour | Lubricating oil consumption percentage of fuel | Life expectancy years | Yearly Maintenance percentage of engine cost |
|---|---|---|---|---|
| Diesel | 0.25 | 2 | 7 | 12 |
| Petrol (four-stroke) | 0.40 | 3½ | 5 | 15 |
| Outboard (two-stroke) | 0.50 | 5 | 3 | 18 |

SELECTION OF ENGINE MAKE

(1) Price

Having settled the problems of size and type of engine to be used we are faced with the final difficult problem of selecting the make of the engine. Our concern throughout is to obtain the best value for the money invested, i.e., to make the purchase which will give the greatest return in the long run.

Marine engines for small craft are not custom built - we will wind up purchasing a standard model as produced by one manufacturer or another. If we attempt to specify our requirements in great detail we may wind up with a description of an engine which no one can offer, or we may be specifying one particular make. A private investor can do just that if he so decides. If, however, the purchase is to be controlled by a tender board or other similar body, such descriptions will not be acceptable, and we will be forced to state our requirements in such a manner that reasonably free tendering can be obtained. The outcome might well be that we do not feel that the lowest tender really represents the best value, although it complies with the (minimum) specifications. In this case we would like to be able to present some arguments for rejecting the lowest tender in favour of one of the others.

In the following, an attempt is made to marshal some of the factors which should be taken into account in attempting to compare the value, as distinguished from price, of various marine engines.

(2) Spares, servicing, workshop facilities

The success of mechanization depends critically on the ability of the operator to keep the vessel in working condition, for which spare parts and other facilities will be required. If the supplier of the engine will also be the source of spare parts and perhaps repair facilities as well, as is very usual, it is of the utmost importance that he would be willing and capable of keeping adequate parts available for immediate delivery or at least obtainable on short notice. If applicable, he should also have adequate facilities, and any doubt on this score should be sufficient reason for not accepting a low tender.

If maintenance and repairs will be the responsibility of some other party, an engine should be rejected if it has features which make it probable that the installation or maintenance of this type of engine will present particular difficulties. Careful preparation of tender documents can anticipate this type of problem, but the unexpected can also happen, and it is always possible that a cheap engine will prove to have undesirable features which are not covered by the tender description. For example, the engine may have an abnormally large fly wheel leading to an unsatisfactory installation, or the starter may be located so as to make starting difficult in this particular case, dismantling may require non-available heavy lift equipment, etc.

(3) Speed factor and weight

The variation in diesel speed covers a wide range. When we talk about engine speed we normally think in terms of revolutions per minute, but for purposes of comparison the product of the rpm and piston speed in metres per minute is more meaningful. As this product results in rather high numbers which are awkward to work and difficult to remember, the product is divided by 100 000 and the result is known as the speed factor. For most diesels the speed factor will fall between 3 and 10 and 4.5 and 15, the lower values representing what are commonly called slow speed engines and the upper ones high speed.

A high speed engine can produce a given amount of power in a smaller space than can a low speed engine. As a result the high speed will be lighter and hence cheaper per horsepower. If we are only interested in the power output of the engine our choice would almost automatically be for high speed engines. If weight is an important consideration this will be an additional factor in favour of high speed engines. However, from the point of view of maintenance, replacement of parts, and life span, slow speed engines have the advantage, particularly in locations where maintenance facilities are poor. It is the authors' opinion that on the average one is justified in paying more for a slow speed engine, particularly in localities lacking in modern facilities.

Under such circumstances, if we wish to compare the relative value of two engines of the same horsepower, we can first obtain the difference in speed factors. For each unit difference we increase the price of the higher speed engine by 5 percent and then compare prices. If the high speed engine is still cheaper, it is considered to be the better purchase as far as this item is concerned. If the adjusted price brings the price of the high speed engine above that of the lower speed engine the latter should be considered relatively cheaper, and it should not be rejected on the basis of price alone.

(4) Cooling system

Two systems for cooling boat engines are in use, water-cooling and air-cooling. For small, water-cooled engines it is usual to take the cooling water directly from the water in which the boat is operating. The water is passed through the engine once and discarded overboard. As the water is often corrosive, larger engines commonly use heat exchangers, so that the engine itself is cooled by circulating fresh water, which in turn is cooled by sea or river water. This system has the added advantage that it permits the designer of the engine to determine at what temperature the engine will operate. If salt water is used for cooling the engine, the water must not be allowed to become too hot as this will cause the formation of excessive deposits in the cooling system. As a result, engines directly cooled with sea water have a tendency to run too cool, which contributes greatly to engine wear. If a water-cooled engine is provided with a heat exchanger this will add to its cost, and should be allowed for in comparing prices.

One advantage of water-cooling in general is that the cooling water can be used for cooling the exhaust manifold and silencer, as well as the engine itself. This makes it much easier to work on or around the engine, but again such extra cooling adds to the price of the engine.

Air-cooling has the great advantage of simplicity. In an open boat the supply of cooling air is no problem. In a craft with some kind of engine room it will be necessary to provide ducting for the cooling air, and unless this has been planned from the start such ducting may become a considerable obstruction. Exhaust manifolds, silencers and pipes tend to have a much shorter life on air-cooled engines than on properly equipped water-cooled ones.

Air-cooled outboards become rather hot, and as the operator normally is required to sit quite close to the engine this is a disadvantage compared with water cooling. It can also add considerably to the fire hazard, if the outboard has a fuel tank mounted directly on the engine, as is common practice in the case of smaller outboards.

Air-cooling has a definite advantage, if it is necessary to operate in heavily silted or dirty water for extended periods. Air-cooling has also been advocated for use in beach landing craft because it is then possible to start the engine before launching the boat. Against this is the fact that air-cooled engines are much more likely to crack a cylinder head if they ship water with the engine running.

## (5) Accessories and auxiliaries

A marine engine is normally fitted with a number of accessorie which are essential or at least desirable for proper operation. These include items such as air cleaners, fuel and lubricating oil filters, sea water pumps, hand starters, pressure gauges, tachometers, speed control levers, skin fittings, etc. The amount and quality of accessories provided with different engines vary greatly, and consideration should be given to this point when comparing prices of engines.

One of the major accessories of a marine engine is the gear box, which may also have a reduction gear. In introducing motorization into low income fisheries it is tempting to eliminate the gear box as an economy measure. If the boat is used simply as a means of reaching the grounds and transporting the fish, the elimination of the gear box may not impose any great hardship. If, however, the engine is to be used during the fishing operation itself, then a clutch and usually a reversing gear become essential, and omitting these items is false economy.

The need for a reduction gear is more likely to arise in boats of a somewhat heavy construction than in, say, motorized dugouts. A reduction gear will permit the use of a relatively large propeller capable of developing high thrust and high efficiency. Most outboards have a reduction gear built into the motor, but with a relatively small reduction ratio for cases where the outboard will be used for towing, or for use on heavy hulls the purchase of outboards with an abnormal reduction ratio should be considered, despite the added cost.

While the various accessories are related to the operation of the engine itself, auxiliaries are provided for the purpose of filling some other need, such as providing electricity on board. If the engine is to be used for driving a piece of equipment such as a winch, some means of transferring the power to the winch, a power take-off will be required. Some engines lend themselves readily to the fitting of a power take-off while on others this may present a major problem. It does not pay to make a slight saving in the purchase cost of the engine, only to find that a larger extra expenditure may be needed in order to get the full benefit of the engine by driving some auxiliary equipment. When the details of this auxiliary machinery are known in advance, it may be advisable to obtain quotations from the potential engine suppliers for factory-made power take-offs as optional extras.

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session III ENGINES FOR SMALL CRAFT
Paper III/D

# Discussion

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

OUTBOARDS AND DIESEL ENGINES

D.G.L. RIGBY: Has anybody tried to put outboard motors on dugout canoes?

S.M. SEMAKULA: No dugout canoe in Uganda, as far as I know, has been equipped with an outboard motor.

Ø. GULBRANDSEN: In Senegal there are approximately 2 500 canoes fitted with outboard motors, and in Ghana approximately 5 000 large dugout canoes have been motorized in this way. Several attempts have been made to put inboard engines on dugout canoes but so far without success.

J. LAYN: Would it be possible to fit inboard diesel engines into beach landing canoes?

D.D. BEACH: In Ghana it was once tried to fit a diesel engine into a traditional Ghana canoe. This type of canoe is hollowed out of a tree trunk and has a pronounced curved longitudinal shape which makes it possible to bring the canoe up the beach, utilizing the rocking technique of the Ghana fishermen. The canoe for the inboard diesel engine was fitted with a straight skeg for the propeller shaft and the result was that the canoe could not be handled on the beach in the usual way and was, therefore, a failure. This problem might have been overcome if the people installing the engine had known beforehand the importance of keeping longitudinal rockers in the bottom of the canoe. In fact, most failures in boat design are due to the fact that all the problems involved have not been realized before the design was started.

One important thing to remember when building beach landing boats out of FRP is the necessity of fixing rubber strakes of wood under the keel and at the turn of the bilge. FRP has a lot of good properties but one of the poorer qualities is a fairly low resistance to abrasion, and vulnerable areas on the beach boat must, therefore, be sufficiently protected by wooden strips that can be easily replaced when worn out. This detail must be considered when the boat is being designed.

Ø. GULBRANDSEN: In Japan a large number of beach landing boats are fitted with inboard diesel engines utilizing a special type of liftable propeller shaft which makes it possible to withdraw the propeller, and part of the shaft, into a well in the hull when the boat is hauled up on the beach. With this system, there is no need for a skeg protruding outside the boat. It is a very simple arrangement and might be well worth further investigation in East Africa.

E.S. KANYIKE: In what area are the small dhows used?

**A.P.J. HOLNESS:** The small dhows are used on the Kenya side of Lake Victoria, partly for transport of fishing nets and fish. They are slow, heavy, flat-bottom boats with a deep keel to avoid drifting. This type of boat will be given up since it does not bring the fish back to the market fast enough to ensure satisfactory quality.

**E.S. KANYIKE:** Can the small dhows be fitted with an outboard motor?

**A.P.J. HOLNESS:** The dhows are generally too big for outboard motors. It is not economical in this region to put outboard motors of more than 15 hp in fishing boats because of the higher cost of fuel. Motorization of dhows will only be possible with inboard diesel engines.

**J.A. CRUTCHFIELD:** Would it be possible to modify the design of a Sesse canoe toward a semi-planing type?

**A.P.J. HOLNESS:** The Sesse canoe is, in fact, a semi-planing boat. It draws only four inches of water, and when you open the throttle it immediately starts skimming. I think it is a type of boat which is extremely difficult, if not impossible, to improve.

**M.M. MALE:** Are any of the fishing boats in Kenya using a sail?

**A.P.J. HOLNESS:** The Sesse canoe on the Kenya side of Lake Victoria can only use a small sail going with the wind. The bigger dhows are equipped with large sails and are able to tack against the wind.

**N. ODERO:** The use of sails was introduced to East Africa by the Arabs going down the east coast with their dhows. Later, large dhows were built at Lake Victoria for transporting goods and people from Mwanza and other parts of the lake. Smaller dhows are used for fishing and were later equipped with sails, and quite a number of these boats are still operating. They come out in the evening, helped by the offshore winds, and stay out all night fishing, going back to shore when the onshore wind starts blowing the next day. The dhows used for fishing are built by local boatbuilders at very low cost - a fairly big dhow costs around sh. 1 400. It is questionable whether fishermen would want to invest in a fibreglass canoe of smaller capacity than the dhow and costing sh. 3 500. However, he might be interested in installing an engine in his dhow. If outboard engines were used the power would need to be high and the running costs are prohibitive. The only alternative is an inboard diesel engine and, in fact, some of the bigger dhows have already been fitted with this type of engine and are working successfully.

J.A. CRUTCHFIELD: Outboard engines in the fishery of East Africa are, to a large extent, operated by persons who have no technical background and who have never opened an operating manual. The outboard motor must undergo an incredible amount of abuse in the hands of these unexperienced operators and, still, we find that they are giving a satisfactory service. Taking into account the fact that in any engine there must be a compromise between the first cost and dependability, I think the outboard engine is doing very well.

D.D. BEACH: For a number of years I have been involved with the utilisation of outboard engines in the U.S.A. These engines are primarily designed for the American pleasure boat market. It is true that a man who buys an outboard motor knows two positions of the throttle, wide open or dead stop, and there is nothing in between. He generally ignores the maintenance; he ignores it to the extent that he never even opens the engine when something goes wrong. An outboard engine is designed to run 1 000 h at close to full throttle, without giving trouble. For a fisherman, 1 000 h of running corresponds in many cases to one year's operation.

Compared with an inboard diesel engine, the outboard motor is considerably lighter. A 10 hp outboard motor may weigh around 30 kg, while a smaller size diesel engine will weigh around 250 kg. This saving in weight will also mean an increase in the speed of the boat or, if the same speed is maintained, a larger amount of net or other fishing gear can be carried. Alternatively, a smaller outboard engine can be purchased to give the same speed with the same amount of gear as inboard-powered boats.

A.S. OBURU: It has been mentioned that one advantage of outboard mechanization is the possibility of reducing the crew from 4 to 2 men. My experience, however, is that even an outboard-powered canoe needs a crew of 4 men in order to be able to haul the gillnets and clear out the nets sufficiently fast. I therefore doubt that outboard mechanization will lead to a reduction in the number of fishermen on the canoe.

N. FUJINAMI: In many parts of the world I have seen fishermen utilising car engines in their boats fitted with marine reverse reduction gear. It seems to me a very cheap solution, and it works satisfactorily in many places.

D.D. BEACH: A high percentage of the fishermen on the east coast of the U.S.A. are fitting car engines, converted for marine use, into their boats and it is impossible to find a more economic solution.

D.A. GRAINGER: The use of a car engine in a boat will certainly create serious problems with corrosion of the cooling system.

D.D. BEACH: Ninety-nine percent of American marine engines are based on automobile engines. Several well known, so-called marine engines, are based on Chevrolet and Ford engine block assemblies.

P. FROUDE: I would like to comment on the question of engine size in relation to the purpose for which the vessel is used. There are several views on, for example, what horsepower is required for trawlers in relation to whether you want to trawl at low speed with a large net or whether you want to trawl at high speed with a small net. This has been demonstrated particularly in Germany. From my understanding of the results of the trawling experiments executed by fisheries research projects at Jinja, it seems that the heaviest catches are when the speed is around 2.7 knots and this indicates that, in the local conditions, higher speed is not a critical factor. The results so far indicate however that we should go at a low speed and with as large a net as we can get for a given horsepower.

PROBLEMS WITH SERVICE AND SPARE PARTS

A.S. OBURU: The most discouraging point in outboard motorization projects here in East Africa has been the inability of the dealers to keep a sufficient amount of spare parts at all times. Some of the representatives from outboard engine dealers may be able to explain why this is so.

D.A. GRAINGER: One reason for the shortage of spare parts is the change in makes introduced by the engine manufacturers. They start off with make "A" then they change to type "B" and then to types "C" and "D", the result being that it is uneconomical for commercial companies representing these manufacturers to keep sufficient spares for all the makes. If there is a concentration on a certain make of engine, then it would be much easier to ensure an adequate supply of spare parts.

A.S. OBURU: I know cases where we have been waiting six months before obtaining spares for a certain make of engine. For a fisherman this would mean a great loss due to the fact he could not go fishing while his engine was out of order. We have many makes of outboard engines represented in Kenya, but it is common to all of them that spare parts are not available locally in sufficient quantities. This is endangering our outboard mechanization projects and, in fact, might cause failure, and I would like to ask any engine representative here to tell us how this can be avoided.

D.A. GRAINGER: I think the fact that you are dealing with four to five different makes of outboard engines explains why it is more difficult to obtain spare parts. Because the total number of engines is split up between different makes, each of them does not create enough sales volume to interest the trade in keeping spare parts.

**D.G.L. RIGBY:** The problem of spare parts supply is closely connected with the number of engines of a certain make in operation. Normally, an engine representative will carry fast moving spares in stock, but if there are only a few engines of a certain make in this area, it is not a commercial proposition to carry 100 percent spare part stocks to cover all eventualities.

**Ø. GULBRANDSEN:** One can understand the engine representative's point of view that to keep a full stock of spare parts for a limited number of engines is not a commercial proposition. I think a practical solution to this problem would be a certain standardization of the makes of engines to be used in motorisation projects. Would it be possible for the Fisheries Department, once they have decided what type and horsepower of engine they desire, to go out for tender and call bids from all interested engine representatives? Instead of buying ten engines from five different manufacturers, one could buy fifty engines from one manufacturer. It would be much easier to ensure sufficient spare parts and after-sales service if this is done. An additional advantage would be that the bulk order will often reduce the price.

**S.N. SEMAKULA:** One cannot expect that the engine dealer will be able to pay a visit to every fishing village in order to ensure that the engines are properly maintained and repaired. However, there are several big fishing centres such as, for example, Wanseko on Lake Albert. In this village there is a considerable number of outboard engines, and I am sure that, by paying periodical visits to this fishing centre, it would be possible for the engine dealer to find out what part of the engine normally needs repairs and to adjust the spare part stock accordingly. In this way, he will also assure that the engine sold is being operated and is making a profit for the fishermen, which will result in the purchasing of more outboard engines.

**J.A. HOLNESS:** Outboard engines are very easy to service. You do not need a mechanic with a great deal of technical background, and I think it is this factor that has made the outboard engines a success in the fishery. I do not think I am wrong in saying that there are not many fishing villages in Uganda without car mechanics who can do a top overhaul on a car and change a gear box. This is a nucleus that we, as fishery people, can build on. What is required for further action is more specific training in the repair and maintenance of outboard engines.

**P. PROUDE:** I think that the Departments of Fisheries in the three East African countries are now taking a more responsible attitude toward training in maintenance and repair of the fishermen's outboard engines. They are each running ad hoc training courses for outboard engine mechanics, which is most probably more efficient than trying to teach every individual fisherman how to repair his engine.

D.D. BEACH: In Ghana a whole new trade group has grown up, namely, the outboard engine mechanics; many of these are factory trained. In many of the fishing villages, I saw a considerable number of outboard engines fitted to the Ghana-type canoes. I watched the canoes land through the surf; a man would grab the outboard motor fixed on the side of the canoe, take it on his lap and sit down at the bottom of the canoe to prevent damage to the motor when the canoe runs onto the beach. As soon as the canoe was pulled up on the beach, he would carry the motor on his shoulder up the beach and turn the motor over to the outboard motor mechanic. The mechanic would do two things: he would wipe it off on the outside and put it into a 50-gallon drum filled with water and run the engine for several minutes. In this way he would wash off the salt from the inside of the engine and dry it off from the outside. It is very interesting to note that people with little technical background can pick up so quickly the basics of good maintenance of outboard engines. They have probably made mistakes once or twice but these mistakes will not be repeated.

E.S. KANYIKE: Are there any international agreements stating how many years manufacturers are responsible for keeping spare parts after the make has gone out of production? We are operating launches and some of them have fairly old engines, and we wonder for how long a time we will be assured spare parts for these engines.

D.D. BEACH: As far as American manufacturers are concerned, the answer is "no". A company that manufactures a product and wants to stay in business will, naturally, keep a certain amount of spares. As the model gets older and older, the likelihood of finding spares becomes less and less. There is no law in the U.S.A. that formulates how many years a manufacturer is obliged to keep spares after a certain make has gone out of production. It is only good business that tells the companies to keep spares for their products. If a man buys a product and cannot get spares he will soon turn to another company.

J. LAYN: The association of engine manufacturers in the U.K. has this matter very much under consideration, but it is up to each company concerned, when negotiating long-term contracts, to state exactly how long a time they will assure spare parts. The company I am representing is at present negotiating contracts to assure spare parts for, at least, the next ten years. I think it is very important that this point is brought into the negotiations regarding the contracts because not only will the user of the engine know for how long he can be sure of getting spares, but the dealer will also know how much stock he should keep and for how long he will keep these spares; this will be reflected in the cost of each engine. All big companies, and I am sure there are no bad companies that will manage to stay in business for long, do assure spare parts, but it must be clearly stated at the time of preparing a long-term contract. I propose that a statement be included in the contract, assuring that this model or make of engine will be available over the next 10 years, and that spares will also be supplied over the same period.

D.D. BEACH: There is often a clause written into many procurement contracts when marine engines are provided, stating that an anticipated list of spare parts has to be delivered with the engine, sufficient for the next couple of years of operation.

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
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Session IV BOATYARDS AND BOATBUILDING
Paper IV/1

# Establishing a boatbuilding yard

by

B.T. GOODING

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

WS/D5117/4

## INTRODUCTION

The establishment of a new boatyard which is to undertake serious production needs careful consideration and study. In developing countries one of the biggest problems is availability of capital to finance such a venture.

This can be overcome by an interest-charged loan from a commercial bank, a loan from the government or an individual who is in a position to be able to find sufficient capital from his own resources. The needs of the fishing industry are of prime importance when setting up a boatyard. A number of factors must be considered within this industry before any plans are finalized. Obviously, sizes of existing boats have to be considered, together with the development programme for the country which will be served by the boatyard. It is far better to have a yard bigger than the immediate demands require, if you are certain that the size of the craft are going to increase. But should it be found that there will be no need for larger boats than are already established, then to build a bigger yard with more space than is necessary would be a waste of very valuable capital.

When the above factors have been considered and a careful study made relating to the above, the size of the required yard can be estimated with accuracy.

## LOCATION

Location or site now becomes the most important factor. Once again a study should be made of a number of points. A few examples may well be useful at this juncture: (a) location - it would be unwise to establish a yard which was not easily accessible by either road or rail or both. This is of particular importance not only for the steady and easy flow of materials needed to run the boatyard successfully, but also for the transportation of the finished craft, if and when the need arises; (b) availability of materials, be they of local content or imported. Ideally, the yard should have a power supply although this is not absolutely necessary. The availability of power and machines cuts the cost of labour charges on a wooden craft by between 10-15 percent.

## PERSONNEL AND TRAINING

### The human element

A boatyard will only be successful if the skill of its personnel is of a high standard.

Here in Uganda, a four-year course in Yacht- and Boat-building is offered at the Fisheries Training Institute. There are other methods of obtaining personnel when a boatbuilding industry has been established in a particular country. To name just two: the training of apprentices under a well organized and recognized apprenticeship scheme within the industry, and secondly, taking carpenters who are familiar with the use of hand tools. These can and have been readily adapted to the boatbuilding trade, an example of this being in Ghana when the Fisheries Department there established their first boatyard.

The course in Entebbe covers a period of four years and the standard of intake for the boatbuilding trainee students in Uganda is from students who have completed their primary education. A great number of these have had little or no experience in the use of any type of tools connected with the boatbuilding profession.

An average of some 500-600 students apply annually for the 20 places which are offered.

Trainees are grouped into years - first year, second year, third year and fourth year. During the first year they are taught the basic uses of hand tools and the more common joints that are used in the field of boatbuilding. In the second year, the students start the actual practice of boatbuilding. They work on very simple types of construction, mainly of hard chine form with a skin of plywood. This gives them the basic knowledge of the problems which they are likely to encounter when constructing a boat and also the need for accuracy and care.

During the third year the trainees are engaged in more advanced types of construction, probably round bilged form and clinker or carvel construction. These craft are in the size range of 18-20 ft overall length and are fitted out ready for launching, and are powered mainly by outboard engines. It is during the third year that they are also given the chance to see and practise the skills which are needed to produce a high quality finish. This is done by building a small fast run-about type hull. During the fourth year, attention is placed on the construction of the more advanced type of craft. This includes the construction and fitting of components for an inboard powered craft. It is during this year that the examinations are held.

COST AND TYPE OF YARD

In many of the developing countries the climate does not require an elaborate shed and an open workshop on all four sides has served a very useful purpose.

The yard should be as self-contained as possible and have as many amenities as funds will permit. A good smooth floor space is of great importance. This should be of hard packed earth or concrete. Air circulation and ventilation must also be considered, even if the yard is open-sided. Should the roof of the yard be too low the temperature will, during the hot time of the year, be almost unbearable and will, without doubt, reflect on the working efficiency of the workmen.

Security must also be taken into consideration, and if an open-sided shed is used the storage area must be made thief-proof. The timber shed should be constructed in such a manner that there is air circulation throughout. This improves the air seasoning potential, but protection from the direct rays of the sun and also rain must be incorporated. The size of the timber store, like that of the yard, will be determined by the size and number of boats to be constructed within the workshop. The establishment of the larger type of boatyard involves more detailed study and planning, in particular when stationary electric power machines are to be used.

Two examples may be of some use regarding costings: a boatyard of very simple form, with a concrete floor, corrugated iron roof and a store with weld mesh or expanding metal enclosing the workshop for a size of some 1 500 ft$^2$ of floor space would cost, at the present time, approximately Uganda Sh. 10 000. A larger and more sophisticated yard of some 8 500 ft$^2$ of floor space would cost approximately Sh. 320 000.

The yard which has been quoted as costing Sh. 10 000 would be just a covered shed with a daily issue store, but nothing else. Whereas the yard which is quoted at Sh. 320 000 would include a larger mould loft, machine shop (the cost of machines would be an extra), timber store, office for staff, toilets and washing facilities, electrifications for power and light, and overhead gantries for three building bays. This yard would be able to cope with boats of up to 50 ft overall length and would be ideal from the construction of vessels in most of the conventional materials that are available at the present time.

The small yard would perhaps be more suited to timber construction but could, with a small increase in cost, be modified for the purpose of constructing in other types of materials but it is debatable if this modification would be suitable for the production of a first class marketable product - for example, glass reinforced plastics.

One very important point which must be remembered with a yard, such as the one in question of some 8 500 $ft^2$ of floor space, accommodating boats of up to 50 ft overall length, is the actual physical problem of moving the finished craft from the boatyard to the water. The size and weight of this craft would necessitate the provision of a slipway for launching, and also slipping for repair or refit.

To install a slipway of this nature would require a considerable increase in capital expenditure. A slipway could be constructed from timber, although it would be far more effective and lasting if it were constructed of concrete.

## MACHINES, TOOLS AND EQUIPMENT

Ideally, these machines should consist of the following: bandsaw, circular saw and planner/thicknesser.

Great care must also be exercised in the siting of these. Machine space must be sufficient between each machine to avoid interference to the operator when the machines are in use. Safety factors must be considered at all times, whether the yard is open-sided or enclosed, safety factors which not only include the personnel but the building itself. It is here that a very important item of workshop equipment might prove to be the most dangerous if not properly placed, namely, the steam box and boiler. Fire is a grave hazard when working with materials which are inflammable, such as shavings, off-cuts, paint, etc. The steam box should be positioned so as to be central so that it is convenient for all the craft in the yard, but for reasons already mentioned the boiler must be kept well clear of the machine shop, timber store and daily issue store.

A mould loft is an expensive undertaking. It is an important item if you are constructing the large type of craft, e.g., in the range of 25 ft and above. For the smaller type of craft, a mould loft is not an essential part of the yard. It has been found that to lay off full size, the plan and elevation sections are not really necessary for craft now under consideration. Hardboard and plywood sheet serve the purpose admirably for the transverse sections of the hull. This can be done either by laying a sheet of hardboard or plywood onto the workshop floor, or on the work benches or saw-horses.

Hand tool requirements vary considerably with the type of craft being constructed and materials used. A list of suggested hand tools for workmen is given below. The more specialized hand tools can be classified as workshop equipment, and a suggested list is also given below.

(1) Specialized hand tools:

½ inch capacity electric drill
Bench sanders - either disc or orbital
Portable electric circular saw
Jigsaw
Compass plane
Plough plane
Caulking irons
Pump screwdrivers

(2) Issue of tools to boatbuilding students:

Hand saw, 6 point - 24 inch
Panel saw, 10 point - 18 inch
Tenon saw, brass back
Ratchet brace
Hand drills
Smoothing plane steel - 2 1/4 inch
Jack planes, wooden
Ball peine hammers - 8 oz
3 ft folding rulers
Oil stones
Try squares - 12 inch
Combination marking gauges

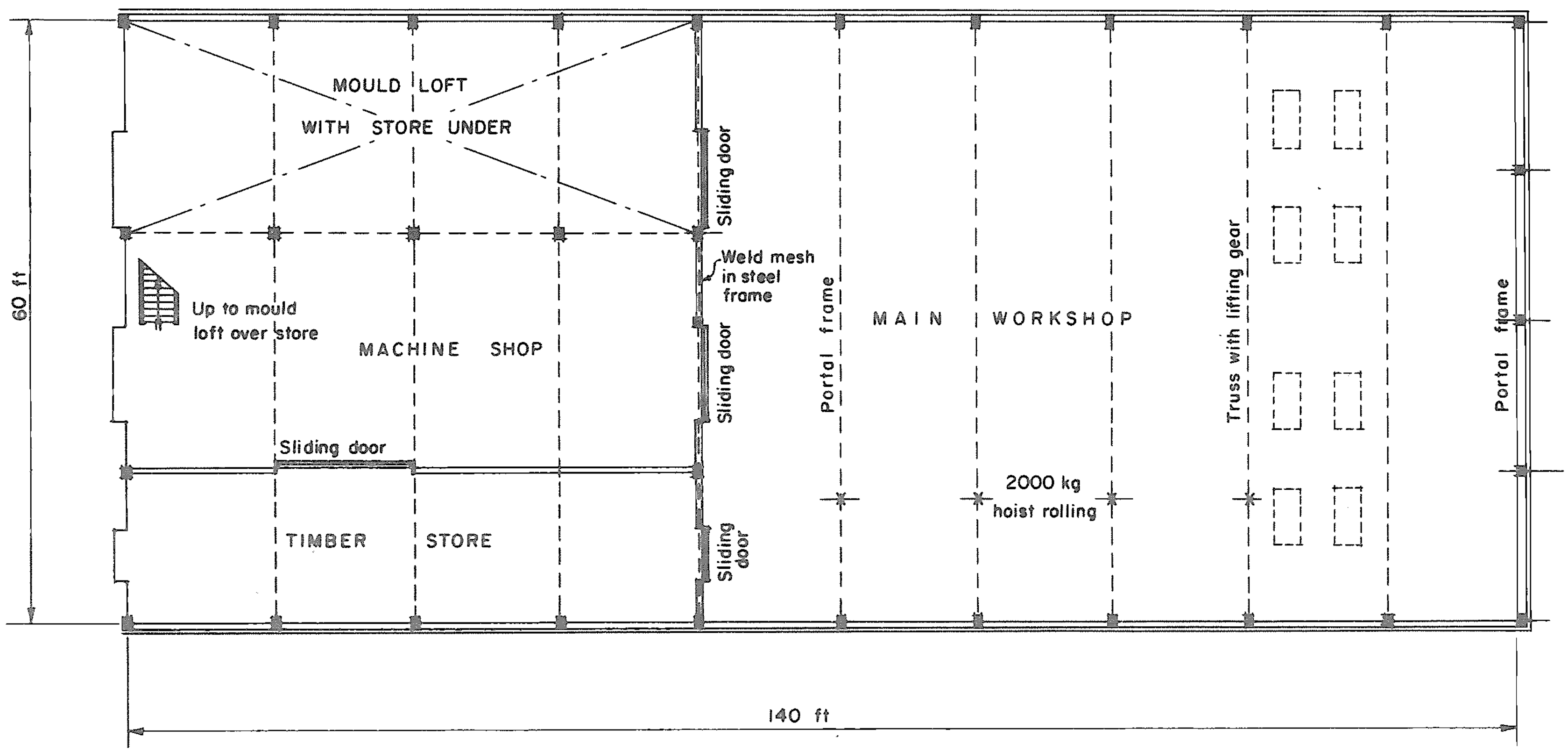
Screw drivers (cabinet) - 12 inch
Chisels, bevel, edge 1 1/4 inch, 1 inch, 3/4 inch, ½ inch
Mortice chisels, ½ inch, 3/4 inch
Cutter bits 1/4 inch, 3/8 inch, ½ inch, 3/4 inch, 5/8 inch, 1 inch
planes, steel
Claw hammer
Plumb bobs
Spirit levels, 12 inch
Spoke shave, flat
Adze
Countersink bits 3/8 inch
Draw knife
Set carbon drills, 3/32 inch to 1/4 inch
Sliding bevel squares
End cutters, 10 inch
Putty knife
Spoke shave, round
Gouge chisels

ASSISTANCE GIVEN BY FISHERIES OFFICERS

This assistance, given during the starting-up period, is of vital importance. In Uganda, this has been carried out by the Fisheries Department. The Regional Fisheries Officers have been of great assistance during this period. Without their assistance, the establishment of the boatyards in Uganda would, we feel, not have been as successful as they have proved to be.

One of the main stumbling blocks in the running of a boatyard is the business and financial side. Costings have proved to be the biggest problem. Here again, help is required. This has also been done by the officers already mentioned. It is so easy for a workshop that has very good workmen who can produce sailable craft to find that they are in financial trouble simply because not enough attention has been given to the actual costing of the finished craft. This needs careful consideration and without establishing the necessary business management and accurate costing facilities, the yard, no matter how well equipped with manpower and machines, will never show a worthwhile working profit.

Figure 1. Floor Plan of Boatyard Costing Approximately Sh. 320 000




FLOOR PLAN - SCALE 1/16

SEMINAR FOR FISHERIES OFFICERS
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Session IV BOATYARDS AND BOATBUILDING
Paper IV/2

# Pricing a new boat

by

A.F. HAUG

Contents:



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## INTRODUCTION

Calculating the price of a new boat is a task in which any boatbuilder will be involved. Any boatbuilder training should, therefore, have this included in its programme, as a supplement to the practical training.

A boatyard can only exist as a commercial activity if the income is sufficient. The most dangerous mistake in this connexion, therefore, is to take too low a price for the boat. There will not be sufficient coverage for the expenses and the boatyard will run at a loss.

However, being too expensive is also dangerous, especially if there is competition from other boatbuilders. The activity may cease due to lack of orders.

Pricing may be subject to a certain strategy, such as:

(a) Keeping low prices in the first years of operation to get into the market, gradually increasing the prices as time goes by;
(b) Taking advantage of a fishing "boom" and increasing the prices when the demand for boats is high;
(c) Underbidding a competitor to catch an important customer, etc.

We will, in the following, consider the normal case, where the purpose is to arrive at a price which gives sufficient coverage for all the expenses and a justified amount of profit on the investment.

## A SIMPLE METHOD OF PRICE CALCULATION

A simple but correct procedure for calculating the price of a new boat will be as follows:

| | | |
|---|---|---|
| (1) | Materials and supplies .................................. | |
| (2) | Labour .................................................. | |
| (3) | Other direct costs ...................................... | |
| | Sub-total direct costs .................................. | |
| (4) | Overheads ............................................... | |
| | Production cost | |
| (5) | Profit | |
| | Selling price | |

Obviously, the calculation will be more accurate if it can be carried out after the boat has been built, but often it is necessary to fix the price at the time of contract. In that case, all the above items will be estimates, based on experience from previous boats. We will assume that the boat has been built already and that there is access to information about suppliers' invoices, materials that have been taken out of stock, time cards, etc., to the extent this is necessary.

(1) Materials and supplies

Add together the cost to yourself of all materials, nails, bolts, paint, glue, engine, sterngear, winch, etc.; all the different bits and pieces that have gone into the boat. Make subdivisions for different materials like timber, steel, hardware, etc., or subdivide according to the purpose on board, like hull structure, deckhouse, outfitting, propulsion machinery, etc., whatever is found convenient. Give each job or boat a name or number, and keep a record as items are taken from stock. Any substantial expenses, like freight charges, incurred in connexion with the purchase of equipment, especially for this boat, must also be included. Interest should be calculated on expensive equipment which is kept in stock for a long time.

For complicated boats, it is almost impossible to remember all items unless they are classified according to a system that can be used for all boats built at the yard. Two methods for breaking down costs are proposed in Fishing Boats of the World: 2, 1960, pp. 328, 329, 330.

(2) Labour

Salaries and social expenses for work on the boat itself and the production of parts and equipment, as well as their installation, belong here. Launching and preparation for launching should also be charged directly to each boat.

If more than one boat is built at a time, it may be necessary to introduce a time sheet system. Time sheets will also help in keeping a division between skilled and unskilled labour, i.e. different salary groups. Time sheets may be completed by labourers or foremen.

All work of administrative nature that cannot be conveniently charged to any specific boat is charged to "Overheads".

(3) Other direct costs

If the boat in question is a GRP boat, being produced in an expensive mould, each boat's share in the mould expenses should be charged as a direct cost. In the same way, if one particular boat model has had an expensive development, with prototype construction and testing, these expenses must be recovered by entering one boat's share of the initial investment in the price calculation.

Miscellaneous expenses in connexion with the sale and delivery may also belong here but are often difficult to separate from the general administrative expenses and could be recovered through "Overheads".

(4) Overheads

Overheads are related to time and are therefore conveniently calculated as a percentage of the labour cost. Overheads are all the costs and expenses in connexion with the work that is necessary to keep the boatyard running, but not visible on the boat itself.

The safest method is to add up the overhead costs in a representative period, say, one year, and then compare them with the labour costs in the same period, to find the percentage to be applied.

Overheads are such items as electricity bills, telephone bills, stamps, paper, office equipment, manager's salary (if not charged directly to Labour), salaries of secretaries (if any), cleaners (if any), drivers (if any), sales staff (if any), as well as depreciation of buildings, machinery, hand tools, slipway, cranes, trucks, etc.

Overhead charges may be different in the different sections of the yard. They may also be different for building of a boat and for a simple repair or maintenance job.

If the market is seasonal, like the pleasure boat market, but production continues over the whole year, a considerable amount of money can be tied up in finished boats in stock. Interest costs on this capital must be divided between the boats in one year's production and recovered through "Overheads" or "Other direct costs".

The percentage to be applied for "Overheads" can vary considerably from as little as 10 percent for a simple one-man-and-a-helper boatyard to 150 percent for a boat factory with much machinery and a big administration.

(5) Profit

Profit is normally calculated as a percentage of the production cost. The purpose of it is, however, to give the owners a return on the capital invested. This return can be taken out or invested again by expanding the activity or by developing new products.

Capital is invested in buildings, tools, materials, etc., as well as personnel (training). One guideline could be that the profit on one year's production should be at least as big as the amount the same capital would earn if invested elsewhere or put in a bank. However, market situation and competition from other boatbuilders may reduce the anticipated sales volume in one year and thereby affect the profitability.

## CONCLUSION

Items (1), (2), (3) and (4) added together are the production cost of the boat. All this money will be paid out again to cover invoices from suppliers, bills and salary charges. When item (5), Profit, has been added, the calculation is complete.

It is most important that nothing is forgotten in the price calculation. Therefore, a certain system or procedure should be maintained from one boat to another. With system and order in the books, price estimates for any new designs will also be facilitated.

The price calculation is particularly difficult in the beginning of a boatyard's life, but it will be easier to carry out and probably more accurate after some years of operation.

SEMINAR FOR FISHERIES OFFICERS
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Session IV BOATYARDS AND BOATBUILDING
Paper IV/3

# Simplified small fishing boat construction

by

DAVID D. BEACH

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

SIMPLIFIED CONSTRUCTION DEFINED

To establish a definition of simplified construction we should first examine typical boatbuilding practices and consider what problems exist for the builder at each stage.

First, if a boatbuilder is to build a new boat, from drawings or from his experience and tradition, he must do some lofting. Most of us here have seen traditional builders who can visualize a complete craft when they have only a large natural crook at hand from which a stem will be fashioned. These envied builders can eyeball a pleasing set of lines by careful shaping in a manner only years of experience can produce. But that experience is not always available in areas where boatbuilding in new traditions is being encouraged. It takes a long apprenticeship to learn the methods of construction suitable for large craft, and to develop the skills to bring those methods down in scale to smaller craft scantlings. It takes even longer to learn how to build without lofting.

So it would appear that the craft that can be laid down with a minimum of fairing and cross checking would be desired. The most simply lined craft are those having straight sections and only sheer, chine and keel lines to be drawn. These are, it is obvious, much more simple than those with flare, round bilges and reverse curves under the after quarter.

Next, one must consider the shapes of chined craft that can be laid down so that the taking off of frame sections will be readily accomplished. It would appear that those boats having easy and small changes in sectional characteristics would be of that type. Also, it would seem proper to suggest that no rapid changes in any of the three basic lines be indicated. Rapid changes in shape mean complicated structure and considerable shaping of large structural sections. This applies to stems and transom structure also.

Now, how about planking? First, one of the most time-consuming boatbuilding practices which traditional building requires is the cutting of planking rabbets. There were good reasons for that practice, and they still apply, but if the boat could use other means to land the planking to the structure, that could simplify construction. Therefore, if we can eliminate the rabbet, and yet not ignore its purpose, we might reduce the complexity of construction. We could try then to land planking on structure without requiring that its edges be fitted to edge covering members. The proper sized structure to permit adequate mechanical fastenings, and to provide a good faying surface for adhesives or bedding compounds is essential. This means that structural sizes for simple boats are often heavier than those of more sophisticated construction.

Finally, we should consider that simple boatbuilding should be accomplished by simple tools. Therefore, no detail should be designed that cannot be fashioned and fabricated with fundamental equipment. I think, however, we must be practical and admit that while our builder may be limited in his equipment, somewhere he is near a sawmill where planking is cut and where larger sections are provided. If we were to eliminate the sawmill from the picture, and provide our simple boatbuilder only with logs, we would be quick to admit that the simple boat would be a canoe, pirogue or similarly carved craft.

Taking these above paragraphs, I would define a craft of simple construction as one having straight sectioned frames on a structure with no sharp curved lines, and planked with a system involving no fitting to butt edges on the structure. This could be amplified a bit, but the previous paragraphs fairly well define this designer's feelings on the subject.

ILLUSTRATIVE DESIGNS

Having defined what the simple construction characteristics are, it becomes necessary to determine how best to illustrate them in small fishing boat designs. It would appear, that since this Seminar has as its objects the demonstrating of construction techniques and the consideration of better ways to produce boats for the catching of fish, some good boat types should be discussed.

(1) For the initial boat I have provided the basic drawings for an 18-ft (5.5 m) outboard powered model. This is based on the single handed gillnetter used on the Great Lakes in the United States.

The fishermen who were the Great Lakes equivalent of the small artisanal fisherman in other parts of the world evolved a specific type of boat which bears some study. Figure No. 1 shows the basic type that was once quite numerous on the Wisconsin shore of Lake Michigan. This craft is approximately 18-ft (5.5 m) in overall hull length, and is distinguished by the net hauling roller set atop the stem. These boats could easily carry and set four short boxes of nets, each box containing about 600 ft (180 m) with floats and weights. The small boat fisherman set his nets in reasonably shallow water of 30-75 ft (9-23 m), but this could vary depending on season and species of fish being sought. The nets were normally cast over the side but were retrieved over the bow. The fisherman soon found that the nets were easier hand hauled over the bow than over the forward quarter or side and the stern roller was adopted to the bow. The outboard motor would obviously prevent any action over the transom. To aid in picking the catch from the mesh of the net, a tray was built on the sheer of the craft aft of the roller. This was carried aft far enough to permit the net to be picked and set back into a box for a subsequent resetting. The catch was tossed aft a catch-well that was simply a set of transverse bulkheads set against a pair of side frames, approximately amidships. Frequently, these catch-wells were flooded and the early catch would survive in the water circulating through drilled holes in the bottom. Simple cleated planks would shade the catch and an occasional bucket of cold lake water held the temperature in the non-insulated well to about that of the lake.

These boats provided many individual fishermen with a livelihood, almost until the decline of the fish population virtually brought commercial fishing to a halt.

While many of the small gillnetters were built by professional boatbuilders, a large proportion were built by the fishermen themselves. A number of construction variations should be noted, and reference is made to Figure 2. This drawing is made in the same type as I used a decade ago, and it provides the essential information whereby a boat can be built. All details are not completely mentioned, but the information considered important is shown.

The agency considering a boat of this type to be built as an evaluation prototype, would have little difficulty in constructing a first boat. The writer, with a longer experience in designing small recreational craft for amateur builders than in being concerned with small artisanal fishing craft, has adopted the basic philosophy that a drawing can often be more informative than a photograph. The careful preparation of sequential construction drawings in isometric of perspective projection are invaluable aids to the builders. The drawings, together with the explanatory notes as guidance, should point out all the information that the builder needs to know, which would not be obvious from the final assembly drawings of Figure 2.

The amateur builder, skilled or not, should be provided with step-by-step discussion of the construction process in the most detail possible. My own personal view is that the detailed construction information should be carried down to the size of the pilot holes for screw or lagbolt fastenings! This same philosophy is applicable, perhaps even more so, in the information provided for small fishing craft.

We learned, long ago, in the boatbuilding industry, that unskilled, but enthusiastic builders would undertake vast projects with only half vast ability. Good drawings and proper references to potential problems permit unskilled builders to develop considerable craftmanship in the building of even a "simplified construction" craft.

Returning to the drawings, it is rather easy to demonstrate that this craft meets the general definition of "simplified construction". All easy curves, no excessive bends, straight sections, no rabbets and simple bevels, all capable of being worked out on the erected frames. The planking can be lapped or butted (if heavy enough), or can be seam battened. All of these techniques, on a boat of these sections, are not unduly difficult.

In performance on the water of the Great Lakes, these craft proved adequate for their intended purpose. The dory style hull was fairly easily driven with outboard motors of 12-25 hp, even while laden with wet nets and perhaps 500 lb (220 kg) of lake fish. The bow transom under normal trim was not so full as to impede progress in waves. It did provide a reserve of buoyancy that held the boat up when the net was being lifted from the bottom and hauled over the roller. Some had more sheer than the drawings indicate, often being a bit more fine forward.

It is considered that there is a degree of merit in the type to warrant serious consideration by project officers concerned with the development of outboard gillnet fisheries.

(2) Another basic type which enjoyed a considerable popularity when small fishing craft provided an adequate income is the garvey. This type, originally flat bottomed athwartships, was modified, as power and speed increased, to incorporate a slighly vee'd bow. This was to present a less hard pounding forefoot to the waves of the waters on which it worked. The garvey hull is, in most respects, a simple craft to build.

The drawings of Figure 6 illustrate a boat having an extremely useful cockpit area, maintaining its width for its entire length. Because the chines do not tuck into the centreline of the boat, it has a full waterplane and is, therefore, quite stable transversely. This makes it adaptable to side net setting and hauling.

An inboard version of the modified garvey is shown, and this qualifies as "simplified construction" in most respects. It has one problem area and the generally used solution for that problem has long standing use. The garvey has considerable lift to her chines and centreline keel. In heavy scantlings, these do not readily bend into shape. Steaming will not soften a 3 inch chine enough to take the lines shown, so the technique is to slit the chine forward into three smaller planks, perhaps as far aft as Frame 5. This technique is only that the chine is first sawn to the moulded and sided dimensions for the full length, then run through the saw as long as needed. This does not cut the chine into full strips, but does produce a structural member that is one section at one end and three at the other. The erected frames are notched for the chine which is started from aft. As the installation proceeds forward, the top strip is first bent and fastened, then the second, and then the third. Each is glued and edge fastened, with the bottom fastenings countersunk to clear the bevelling tools used. This technique produces what is, essentially, a laminated chine. It is not beyond the capabilities of the semi-skilled builder, once he learns it.

Again, it could be pointed out that a series of perspective or isometric views would clearly illustrate the technique of sawing and fitting such a chine log to a boat. A construction sequence series of drawings for the garvey hull would be a most rewarding exercise when one could watch the relative amount of study that they would be given, as compared to the more conventional building plans.

The garvey is cross planked on the bottom aft, and with a slight "herring bone" forward. The planking is full width aft, but forward it is butted on the centreline, without rabbets. Garveys are often built with bolted frames and nailed planking. The typical construction was upside down, and the skeg was fitted atop the planking butts on the centreline. The skeg and keel construction was heavy and through-bolting was substantial.

Although many of the east coast garveys were provided with wheel type steering where the wheel was mounted on the cockpit coaming of the after deck, the more traditional steering was with the tiller mounted amidships to one side or the other. Other characteristics of the basic type are included in the drawing, which is informative.

(3) The last type which is recommended to the study of those attending this Seminar is the launch shown in Figures 7 and 8. The boat illustrated is a 24 footer (7.3 m) and is fairly narrow, having a beam of 7 ft (2.1 m). It is an open craft, having only short decked ends and a box enclosing a small engine amidships.

This meets our definition for a craft of simplified construction in all respects, even considering its length. The construction features are applicable, without problems, to craft exceeding 30 ft (9 m) when the scantlings should be increased proportionately.

All here is straightforward and the drawings are adequate for the knowledgeable boatbuilding expert to visualize the problems he would have in teaching this type of construction. There are only a few points that should be mentioned in this type of craft. Of these, the most important is shown on the section at Frame 1. Note that, because there is no rabbet, the deeply vee'd frames require that the bevel includes both the keel batten and the knee. This wide landing permits ample fastening of the diagonal planking. Also note that the planking on the bottom, which laps over the side planking at the chine cannot be feathered forward of Frame 2. For the forward 3 ft (1 m) of the chine, the side and bottom planking are butted on the chine centreline.

As boats get larger, the options that are available for the builder in the matter of details become greater. All the writer of a paper of this type can do is to suggest those options. However, it is hoped that these illustrations will stimulate some consideration of the features shown.

## CONCLUSION

While no strong conclusion can be reached regarding the "simplified" features shown in the several drawings prepared for this discussion, it is thought likely that a case can be made for the hard chined craft for small boat fisheries.

## REFERENCES

1. Beach, David D., 1960 Commercial Outboard Fishing Craft, Fishing Boats of the World, Volume 2.

2. Colvin, Thomas E., 1960 Gillnet Fishing, Deck Design and Equipment, Fishing Boats of the World, Volume 2.

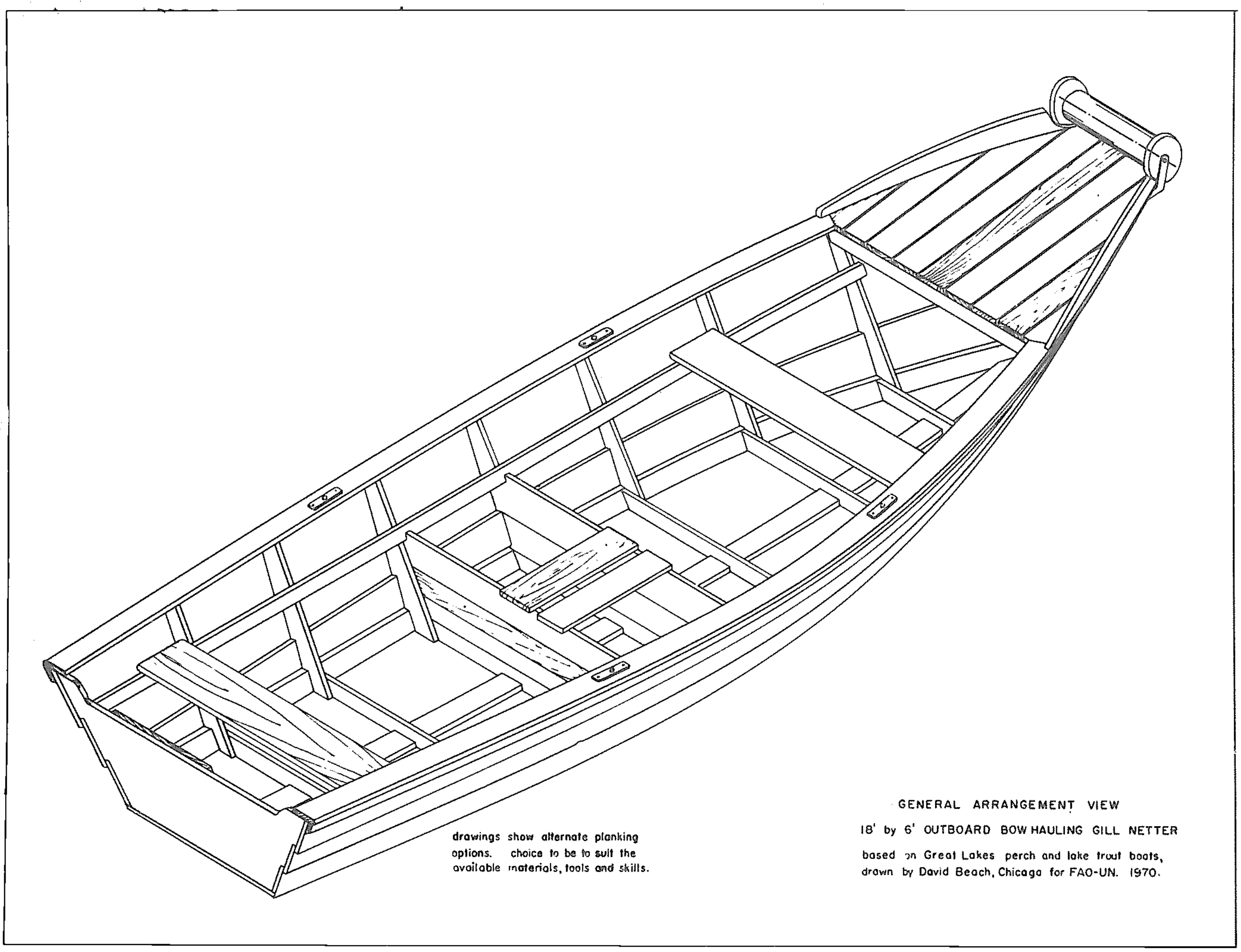
drawings show alternate planking options. choice to be to suit the available materials, tools and skills.
GENERAL ARRANGEMENT VIEW
18' by 6' OUTBOARD BOW HAULING GILL NETTER
based on Great Lakes perch and lake trout boats, drawn by David Beach, Chicago for FAO-UN. 1970.

FIGURE 1

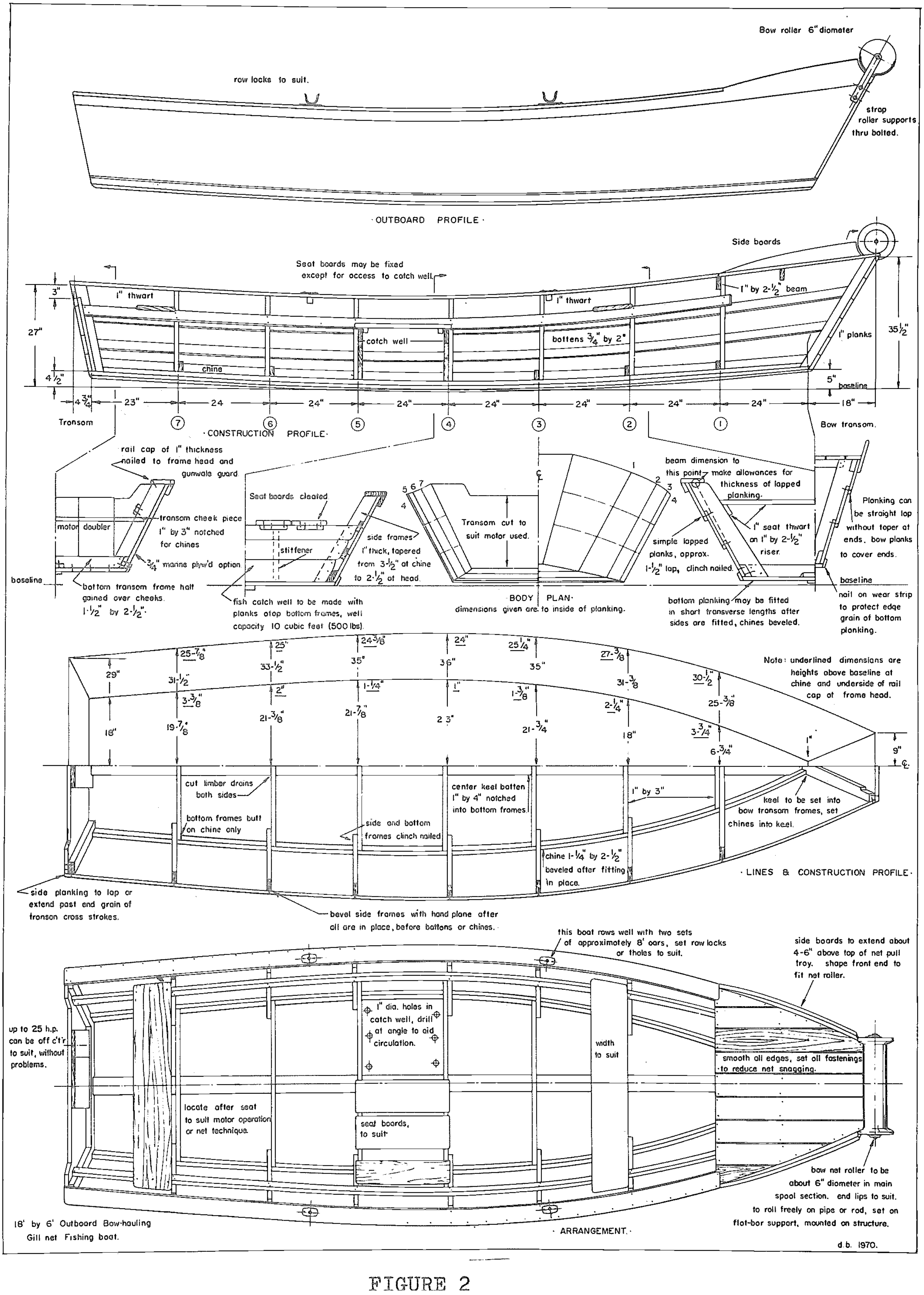
Bow roller 6" diameter
row locks to suit.
strap roller supports thru bolted.
OUTBOARD PROFILE
Side boards
Seat boards may be fixed except for access to catch well.
1" thwart
1" thwart
1" by 2-½" beam
catch well
bottens ¾" by 2"
1" planks
chine
baseline
Transom
CONSTRUCTION PROFILE
Bow transom.
rail cap of 1" thickness nailed to frame head and gunwale guard.
motor doubler
transom cheek piece 1" by 3" notched for chines
¾" marine plyw'd option
bottom transom frame half gained over cheeks. 1-½" by 2-½".
Seat boards cleated
stiffener
side frames 1" thick, tapered from 3-½" at chine to 2-½" at head.
fish catch well to be made with planks atop bottom frames, well capacity 10 cubic feet (500 lbs).
Transom cut to suit motor used.
BODY PLAN
dimensions given are to inside of planking.
beam dimension to this point make allowances for thickness of lapped planking.
simple lapped planks, approx. 1-½" lap, clinch nailed.
1" seat thwart on 1" by 2-½" riser.
bottom planking may be fitted in short transverse lengths after sides are fitted, chines beveled.
Planking can be straight lap without taper at ends. bow planks to cover ends.
nail on wear strip to protect edge grain of bottom planking.
Note: underlined dimensions are heights above baseline at chine and underside of rail cap at frame head.
cut limber drains both sides
bottom frames butt on chine only
side and bottom frames clinch nailed
center keel batten 1" by 4" notched into bottom frames
1" by 3"
keel to be set into bow transom frames, set chines into keel.
chine 1-¼" by 2-½" beveled after fitting in place.
LINES & CONSTRUCTION PROFILE
side planking to lap or extend past end grain of transon cross strokes.
bevel side frames with hand plane after all are in place, before battons or chines.
this boat rows well with two sets of approximately 8' oars, set row locks or tholes to suit.
side boards to extend about 4-6" above top of net pull tray. shape front end to fit net roller.
up to 25 h.p. can be off c't'r. to suit, without problems.
1" dia. holes in catch well, drill at angle to aid circulation.
width to suit
smooth all edges, set all fastenings to reduce net snagging.
locate after seat to suit motor operation or net technique.
seat boards, to suit
bow net roller to be about 6" diameter in main spool section. end lips to suit. to roll freely on pipe or rod, set on flat-bar support, mounted on structure.
18' by 6' Outboard Bow-hauling Gill net Fishing boat.
ARRANGEMENT.
d.b. 1970.

FIGURE 2

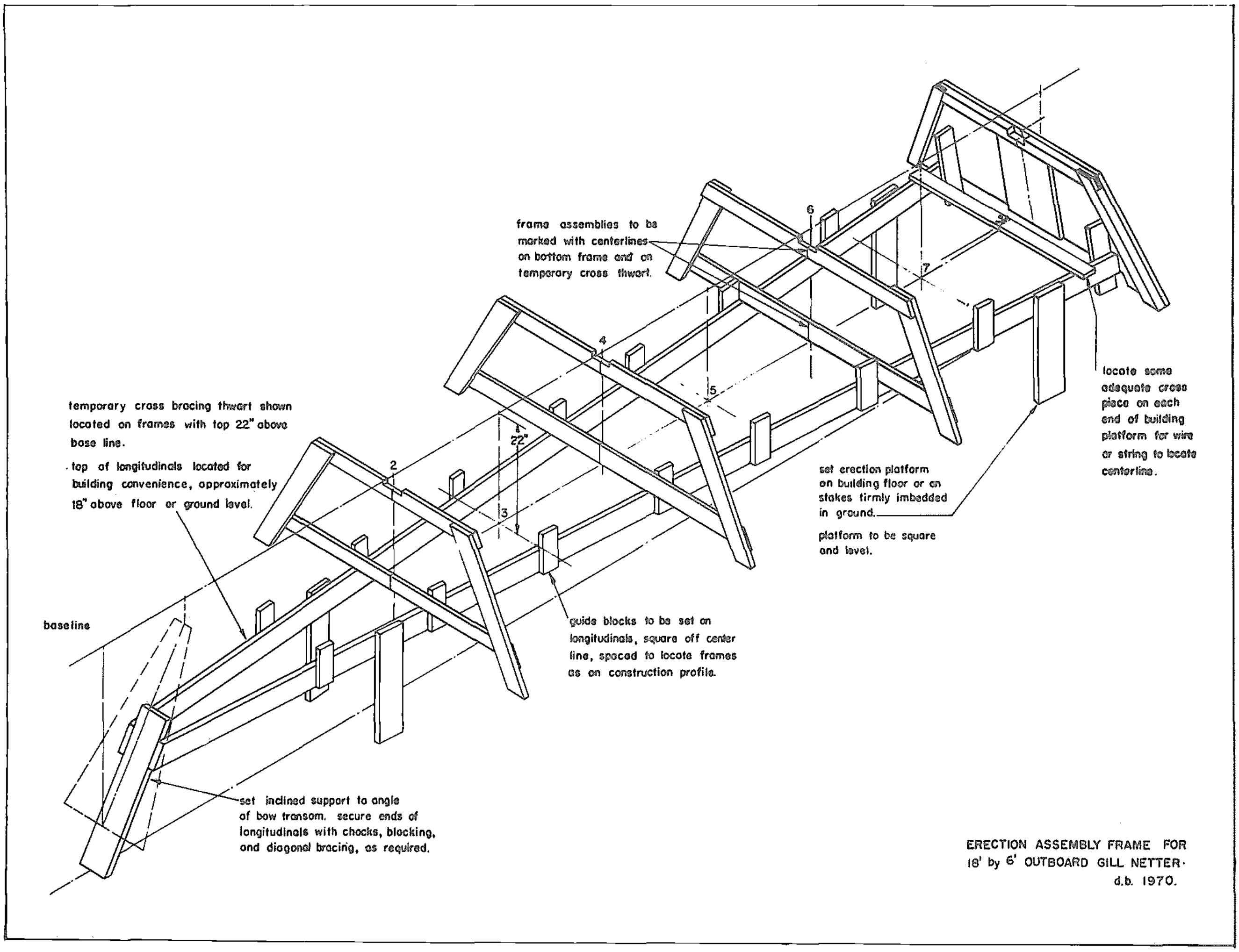
frame assemblies to be marked with centerlines on bottom frame and on temporary cross thwart.
temporary cross bracing thwart shown located on frames with top 22" above base line.
top of longitudinals located for building convenience, approximately 18" above floor or ground level.
baseline
22"
2
3
4
5
6
7
set erection platform on building floor or on stakes firmly imbedded in ground.
platform to be square and level.
locate some adequate cross piece on each end of building platform for wire or string to locate centerline.
guide blocks to be set on longitudinals, square off center line, spaced to locate frames as on construction profile.
set inclined support to angle of bow transom. secure ends of longitudinals with chocks, blocking, and diagonal bracing, as required.
ERECTION ASSEMBLY FRAME FOR 18' by 6' OUTBOARD GILL NETTER·
d.b. 1970.

FIGURE 3

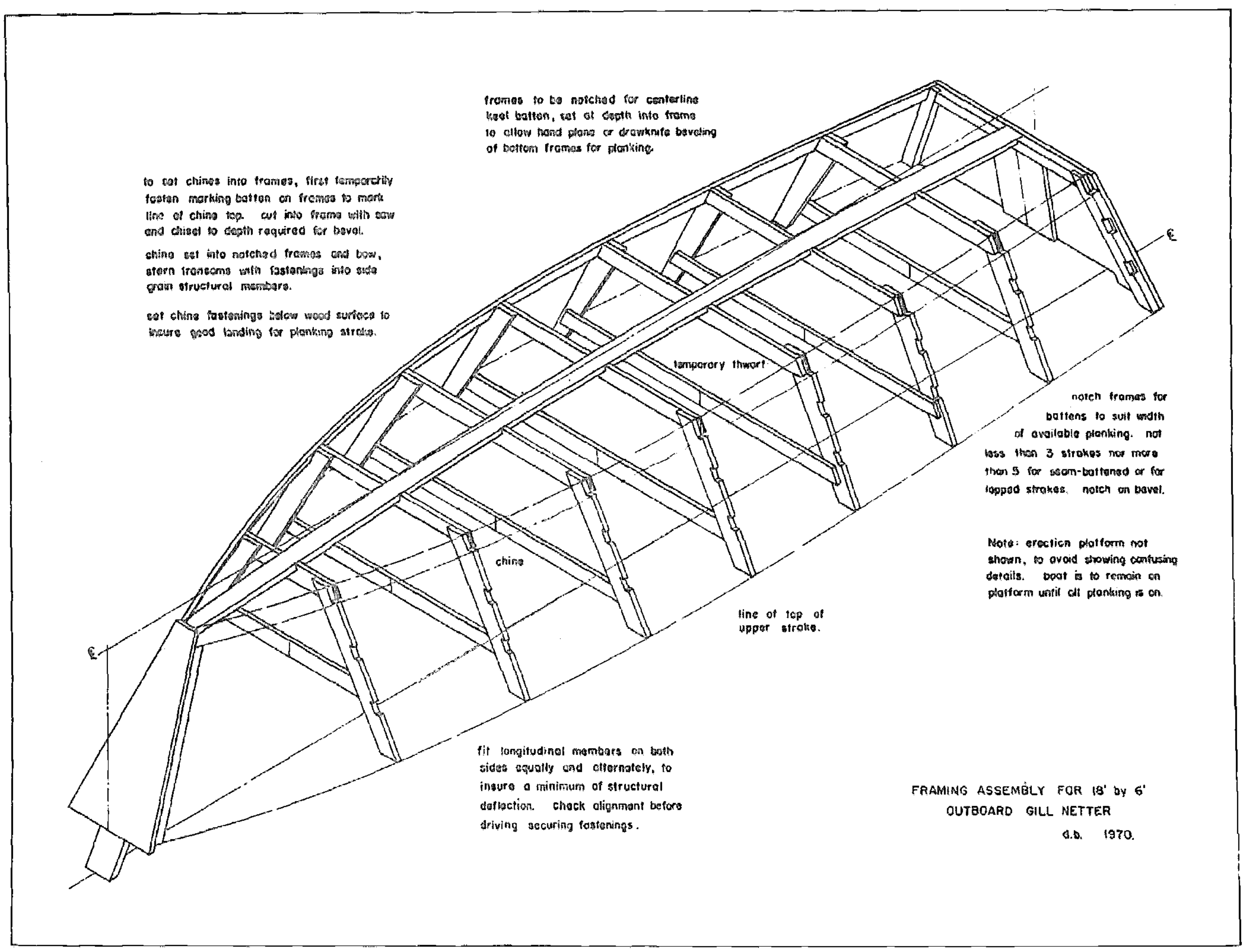
frames to be notched for centerline keel batten, set at depth into frame to allow hand plane or drawknife beveling of bottom frames for planking.
to set chines into frames, first temporarily fasten marking batten on frames to mark line of chine top. cut into frame with saw and chisel to depth required for bevel.
chine set into notched frames and bow, stern transoms with fastenings into side grain structural members.
set chine fastenings below wood surface to insure good landing for planking strake.
temporary thwart
℄
notch frames for battens to suit width of available planking. not less than 3 strakes nor more than 5 for seam-battened or for lapped strakes. notch on bevel.
Note: erection platform not shown, to avoid showing confusing details. boat is to remain on platform until all planking is on.
chine
line of top of upper strake.
℄
fit longitudinal members on both sides equally and alternately, to insure a minimum of structural deflection. check alignment before driving securing fastenings.
FRAMING ASSEMBLY FOR 18' by 6'
OUTBOARD GILL NETTER
d.b. 1970.

FIGURE 4

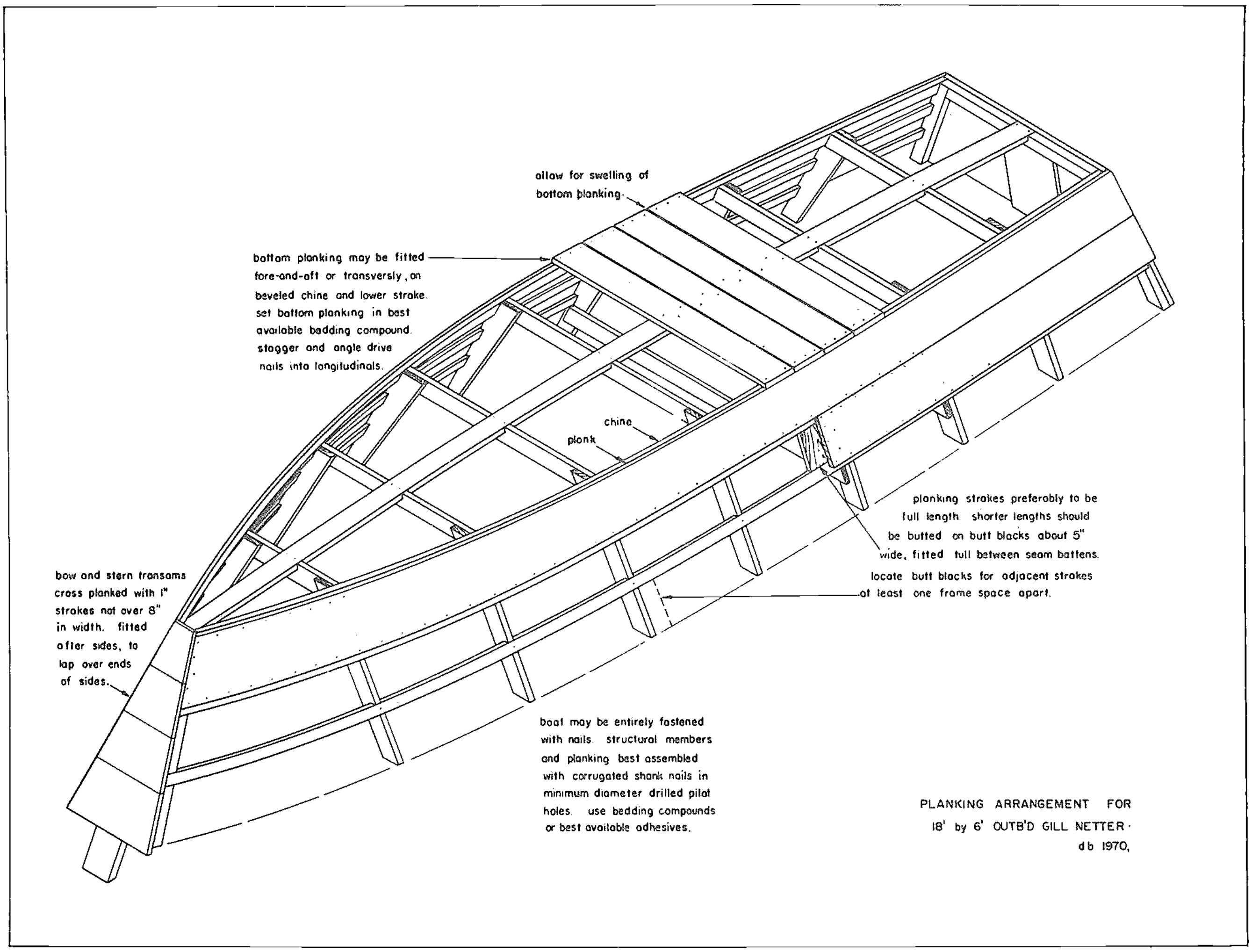
allow for swelling of bottom planking.
bottom planking may be fitted fore-and-aft or transversly, on beveled chine and lower strake. set bottom planking in best available bedding compound. stagger and angle drive nails into longitudinals.
chine
plank
bow and stern transoms cross planked with 1" strakes not over 8" in width. fitted after sides, to lap over ends of sides.
planking strakes preferably to be full length. shorter lengths should be butted on butt blocks about 5" wide, fitted full between seam battens.
locate butt blocks for adjacent strakes at least one frame space apart.
boat may be entirely fastened with nails. structural members and planking best assembled with corrugated shank nails in minimum diameter drilled pilot holes. use bedding compounds or best available adhesives.
PLANKING ARRANGEMENT FOR
18' by 6' OUTB'D GILL NETTER ·
db 1970,

FIGURE 5

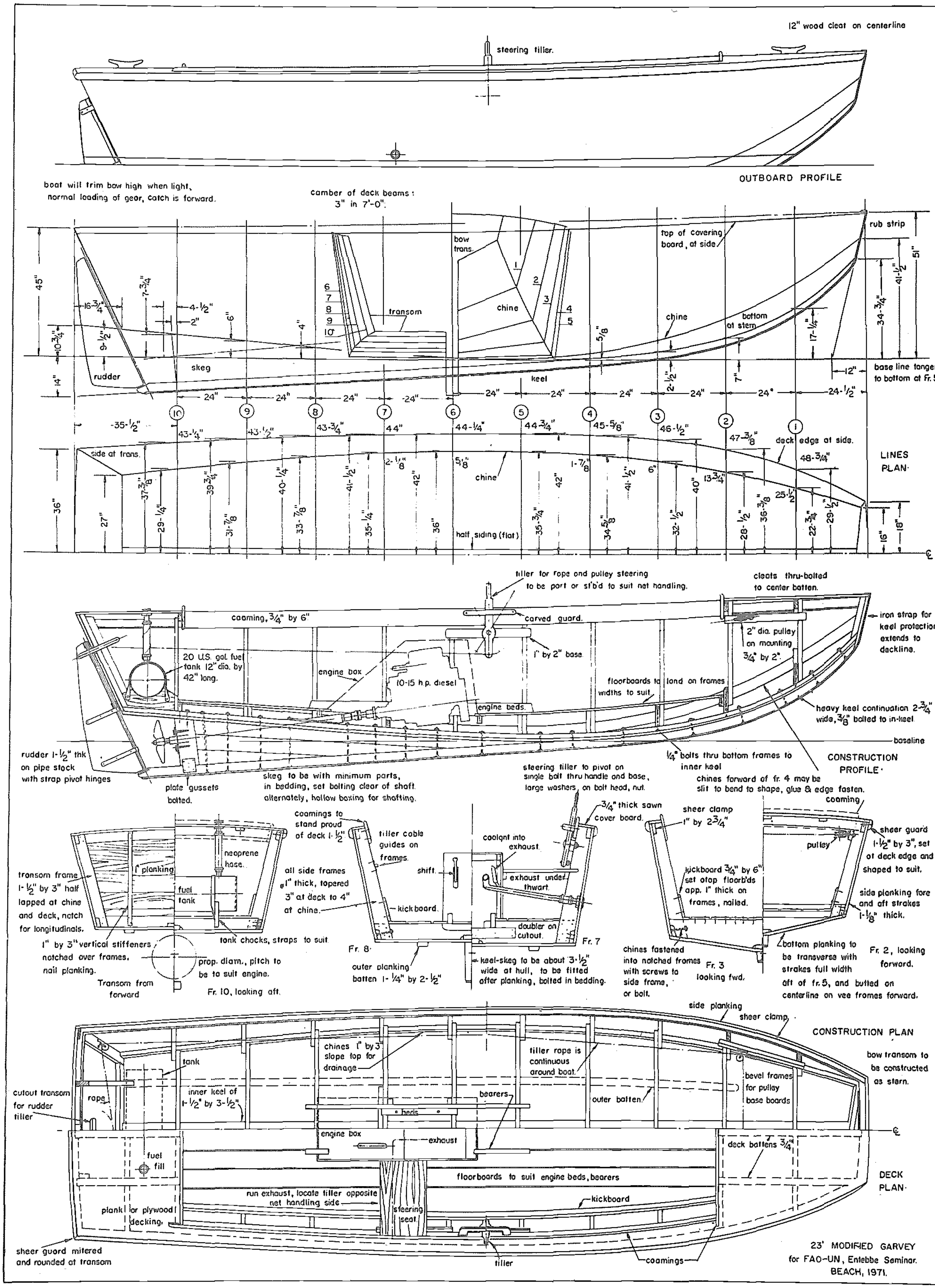
12" wood cleat on centerline
steering tiller.
OUTBOARD PROFILE
boat will trim bow high when light, normal loading of gear, catch is forward.
camber of deck beams : 3" in 7'-0".
bow trans.
transom
chine
top of covering board, at side.
bottom at stem
rub strip
rudder
skeg
keel
base line tangent to bottom at Fr. 5.
side at trans.
deck edge at side.
LINES PLAN.
half siding (flat)
tiller for rope and pulley steering to be port or st'b'd to suit net handling.
cleats thru-bolted to center batten.
coaming, 3/4" by 6"
carved guard.
iron strap for keel protection extends to deckline.
20 U.S. gal. fuel tank 12" dia. by 42" long.
engine box
10-15 h.p. diesel
1" by 2" base.
2" dia. pulley on mounting 3/4" by 2".
floorboards to land on frames widths to suit.
engine beds.
heavy keel continuation 2-3/4" wide, 3/8" bolted to in-keel.
baseline
rudder 1-1/2" thk on pipe stock with strap pivot hinges
plate gussets bolted.
skeg to be with minimum parts, in bedding, set bolting clear of shaft. alternately, hollow boxing for shafting.
steering tiller to pivot on single bolt thru handle and base, large washers on bolt head, nut.
1/4" bolts thru bottom frames to inner keel
chines forward of fr. 4 may be slit to bend to shape, glue & edge fasten.
CONSTRUCTION PROFILE.
coamings to stand proud of deck 1-1/2"
tiller cable guides on frames.
3/4" thick sawn cover board.
coolant into exhaust.
sheer clamp 1" by 2-3/4"
coaming
sheer guard 1-1/2" by 3", set at deck edge and shaped to suit.
pulley
neoprene hose.
planking
fuel tank
transom frame 1-1/2" by 3" half lapped at chine and deck, notch for longitudinals.
all side frames 1" thick, tapered 3" at deck to 4" at chine.
shift
exhaust under thwart
kickboard
kickboard 3/4" by 6" set atop floorb'ds app. 1" thick on frames, nailed.
side planking fore and aft strakes 1-1/8" thick.
doubler on cutout.
1" by 3" vertical stiffeners notched over frames, nail planking.
tank chocks, straps to suit.
Fr. 8
Fr. 7
prop. diam., pitch to be to suit engine.
Transom from forward
Fr. 10, looking aft.
outer planking batten 1-1/4" by 2-1/2"
keel-skeg to be about 3-1/2" wide at hull, to be fitted after planking, bolted in bedding.
chines fastened into notched frames with screws to side frame, or bolt.
Fr. 3 looking fwd.
bottom planking to be transverse with strakes full width aft of fr. 5, and butted on centerline on vee frames forward.
Fr. 2, looking forward.
side planking
sheer clamp
CONSTRUCTION PLAN
bow transom to be constructed as stern.
tank
chines 1" by 3" slope top for drainage
tiller rope is continuous around boat.
cutout transom for rudder tiller
rope
inner keel of 1-1/2" by 3-1/2"
bearers
outer batten
bevel frames for pulley base boards
beds
engine box
exhaust
deck battens 3/4"
fuel fill
floorboards to suit engine beds, bearers
DECK PLAN.
run exhaust, locate tiller opposite net handling side
kickboard
plank or plywood decking.
steering seat.
sheer guard mitered and rounded at transom
tiller
coamings
23' MODIFIED GARVEY for FAO-UN, Entebbe Seminar. BEACH, 1971.

FIGURE 6

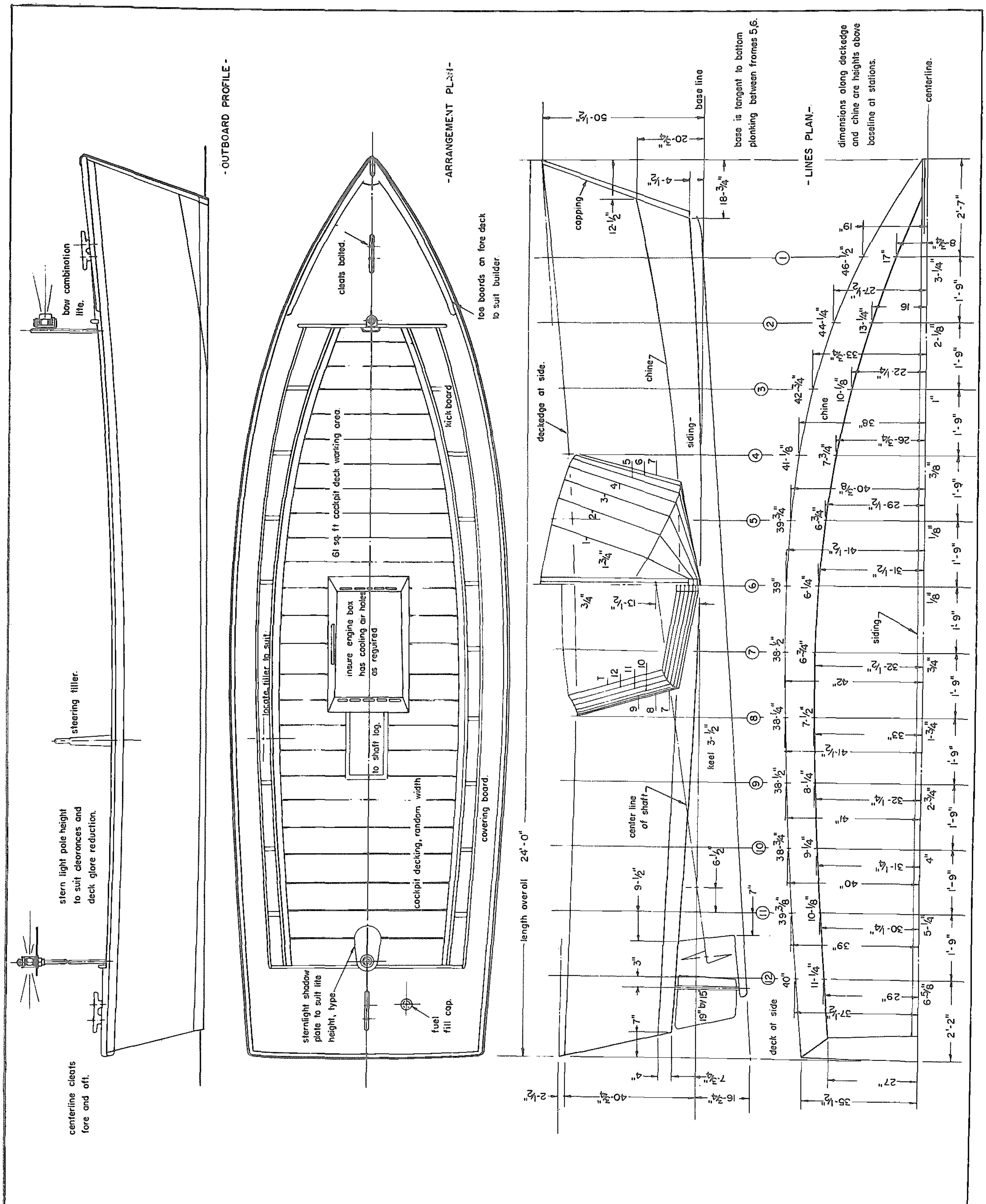
- OUTBOARD PROFILE -
- ARRANGEMENT PLAN -
- LINES PLAN -
bow combination lite.
steering tiller.
stern light pole height to suit clearances and deck glare reduction.
centerline cleats fore and aft.
cleats bolted.
toe boards on fore deck to suit builder.
kick board
61 sq. ft cockpit deck working area.
insure engine box has cooling air holes as required
locate tiller to suit.
to shaft log.
cockpit decking, random width
covering board.
sternlight shadow plate to suit lite height, type.
fuel fill cap.
length over all 24'-0"
deckedge at side.
capping
chine
siding
keel 3-1/2"
center line of shaft
deck at side
base line
base is tangent to bottom planking between frames 5,6.
dimensions along deckedge and chine are heights above baseline at stations.
centerline.

FIGURE 7

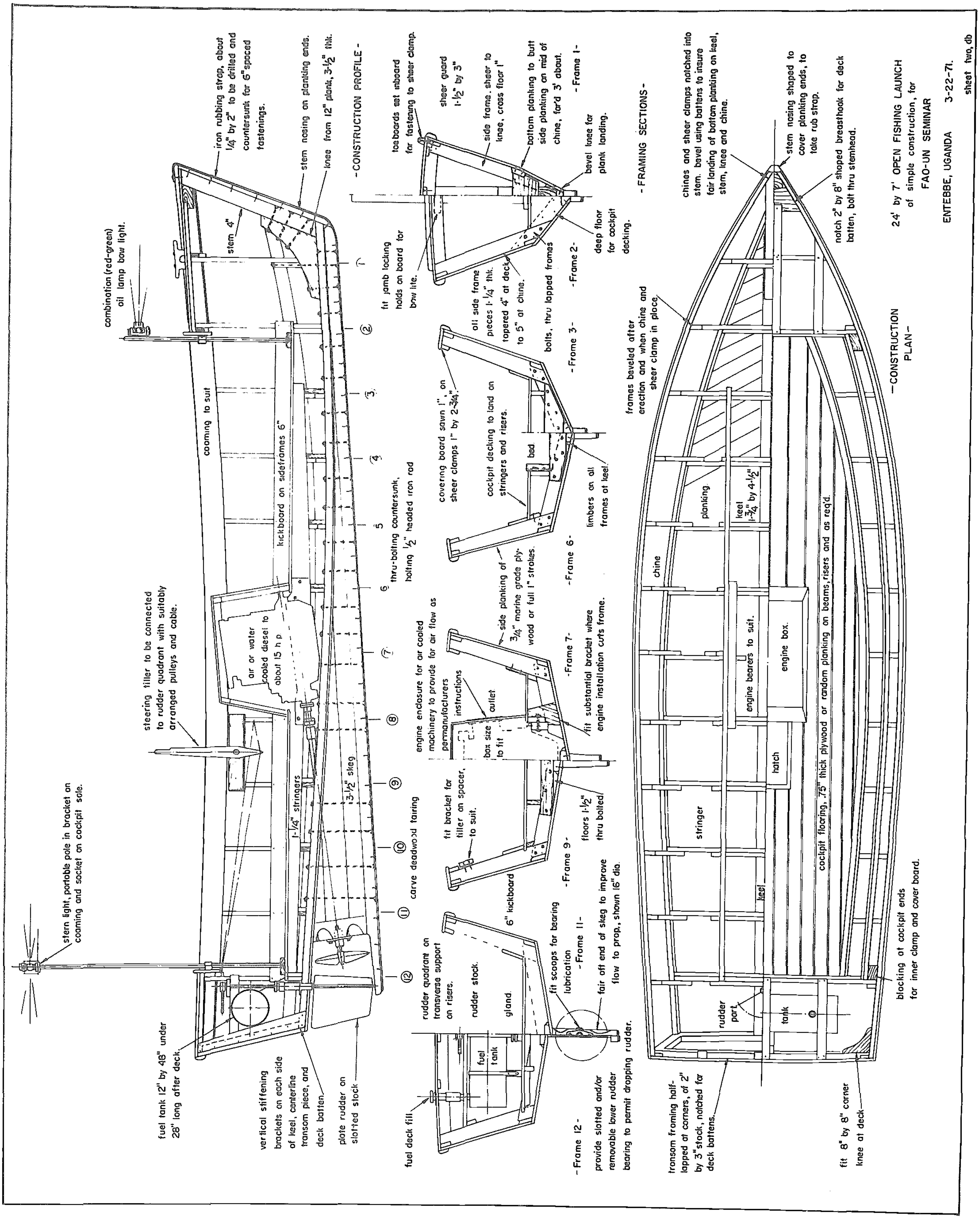
- CONSTRUCTION PROFILE -
iron rubbing strap, about 1/4" by 2" to be drilled and countersunk for 6" spaced fastenings.
stem nosing on planking ends.
knee from 12" plank, 3-1/2" thk.
stem 4"
combination (red-green) oil lamp bow light.
cooming to suit
kickboard on sideframes 6"
steering tiller to be connected to rudder quadrant with suitably arranged pulleys and cable.
air or water cooled diesel to about 15 h p
1-1/4" stringers
3-1/2" skeg
stern light, portable pole in bracket on coaming and socket on cockpit sole.
fuel tank 12" by 48" under 28" long after deck.
vertical stiffening brackets on each side of keel, centerline transom piece, and deck batten.
plate rudder on slotted stock
thru-bolting countersunk, bolting 1/2" headed iron rod
carve deadwood fairing
- FRAMING SECTIONS -
toeboards set inboard for fastening to sheer clamp.
sheer guard 1-1/2" by 3"
side frame, sheer to knee, cross floor 1"
bottom planking to butt side planking on mid of chine, for'd 3' about.
- Frame 1 -
bevel knee for plank landing.
deep floor for cockpit decking.
-Frame 2-
fit jamb locking holds on board for bow lite.
all side frame pieces 1-1/4" thk. tapered 4" at deck to 5" at chine.
bolts, thru lapped frames
-Frame 3-
covering board sawn 1", on sheer clamps 1" by 2-3/4".
cockpit decking to land on stringers and risers.
bed
limbers on all frames at keel.
side planking of 3/4" marine grade ply-wood or full 1" strokes.
-Frame 6-
engine enclosure for air cooled machinery to provide for air flow as per manufacturers instructions
outlet
box size to fit
-Frame 7-
fit substantial bracket where engine installation cuts frame.
fit bracket for tiller on spacer, to suit.
6" kickboard
-Frame 9-
floors 1-1/2" thru bolted
rudder quadrant on transverse support on risers.
rudder stock.
gland.
fit scoops for bearing lubrication
-Frame 11-
fair off end of skeg to improve flow to prop., shown 16" dia.
fuel tank
fuel deck fill
- Frame 12 -
provide slotted and/or removable lower rudder bearing to permit dropping rudder.
chines and sheer clamps notched into stem. bevel using battens to insure fair landing of bottom planking on keel, stem, knee and chine.
stem nosing shaped to cover planking ends, to take rub strap.
notch 2" by 8" shaped breasthook for deck batten, bolt thru stemhead.
frames beveled after erection and when chine and sheer clamp in place.
planking
keel 1-3/4" by 4-1/2"
chine
engine bearers to suit.
engine box.
hatch
stringer
cockpit flooring, .75" thick plywood or random planking on beams, risers and as req'd.
keel
blocking at cockpit ends for inner clamp and cover board.
rudder port
tank
transom framing half-lapped at corners, of 2" by 3" stock, notched for deck battens.
fit 8" by 8" corner knee at deck
- CONSTRUCTION PLAN -
24' by 7' OPEN FISHING LAUNCH of simple construction, for FAO-UN SEMINAR
ENTEBBE, UGANDA 3-22-71.
sheet two, db

FIGURE 8

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session IV BOATYARDS AND BOATBUILDING
Paper IV/D

# Discussion

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

TRADITIONAL BOATBUILDERS VERSUS TRAINED BOATBUILDERS

N. FUJINAMI: I understand that a school for the training of boatbuilders has been operating in Uganda for the past 15 years, with approximately 20 students per year being graduated. This makes, altogether, more than 300 boatbuilders over the whole period, and I wonder whether all these people at present are engaged in building boats.

The course for boatbuilders seems to be very popular since you have more than 500 applicants per year and only about 30 of them can enter the course. Does this indicate that boatbuilding is a very attractive business in Uganda?

B. MACHUMIRWA: Even though the boatbuilding courses start with around 20 students, after a 4-year period this number is reduced to around 10 to 12, so the number of graduate students is not so high as Mr. Fujinami estimates.

Of the students graduated from the boatbuilding course, some are employed in Mombasa, two or three in the East African Railway and Harbours, one is receiving training as a deck officer in a coastal port. There is a tremendous pressure on any kind of educational institution in Uganda, so that you get a large number of applicants for every possibility of further education. Many of the students applying for boatbuilding training have never been near to a lake and do not even know what a boat looks like. The essential thing is that they want to acquire a training, they want to acquire skill which will give them an opportunity to get away from farming. Since a trained boatbuilder is also able to do carpentry, a number of students have also gone into the building trade or furniture making.

S.N. SEMAKULA: Training of boatbuilders is a fairly recent development in Uganda and, although some new types of boats have been built by these boatbuilders, it has not been a success in the Lake Victoria area. It has only been successful at Lake Albert, where a new boat type has been built in a large number. The reason for the failure in the Lake Victoria area is mainly due to the big difference in cost. A 28-ft modified Sesse canoe built by trained boatbuilders costs sh. 3 000, while a beach boatbuilder in the Sesse Islands might knock together a similar size boat for sh. 600-800. The fishermen have not yet been convinced that the increased quality and longevity of the modified Sesse canoe is worth the extra cost.

I once asked a fisherman why he did not buy a modified type of Sesse canoe costing sh. 3 000. He answered that for that price he would be able to buy two locally built canoes and have both of them equipped with fishing gear. It is evident that, under those conditions, the fisherman will prefer to stay with the simpler and cheaper built local-type canoes. The trained boatbuilders, therefore, will have to concentrate on building bigger boats which demand more skill in the construction. These boats will have to be operated by the more industrious fishermen and fishermen's cooperatives.

S. N. SEMAKULA: (continued)

The "Kabalega"-type of boat built by boatbuilders in Wanseko, Lake Albert, has been successful because the fishermen of this lake were in need of a bigger and more suitable boat. This boat can carry more nets and enable the fishermen to fish in the middle of the lake. This would not be possible with the type of boat built by the beach boatbuilders. The cost of the Kabalega boat ranges between 3 500 and 4 000 shillings.

Ø. GULBRANDSEN:

I doubt that commercial boatyards will be able to build Sesse-type canoes at a competitive price. In Uganda, a commercial boatyard, which has to buy its timber from commercial sawmills and pay the workers a fixed salary and social security and on top have various overheads, will produce canoes that are considerably more expensive than the ones built by the beach boatbuilders situated in the fishing villages. The beach boatbuilder gets his timber by cutting it himself in the forest or straight from a local lumberer without going via the sawmills. He will charge himself relatively little for the construction of these boats or he will employ labour at a very low salary. His overhead costs are practically zero and his profit is minimum. The result is that he can build a 26-ft Sesse canoe for sh. 600-800, while a commercial boatyard will require sh. 3 000 for the same size canoe. Admittedly, the quality build for the established boatyard is higher, but one can hardly blame a fisherman if he judges that the difference in quality and longevity is not sufficient to warrant the great difference in the cost. I doubt that it is a commercial proposition to establish a boatyard to produce canoes in competition with the beach boatbuilder. Rather, the commercial boatyard will have to concentrate on bigger boats or on a type or size that the beach boatbuilder is unable to construct. I think that the Kabalega-type boat on Lake Albert is such an example. This boat is much bigger and has considerably more carrying capacity than the existing traditional type of craft. The development of a trawler fleet on Lake Victoria is another potential market for the commercial boatyard, and I think that establishment of boatyards at Lake Victoria should rather be directed toward constructing boats that will satisfy the requirements of the trawl fishery.

M. MUCHUMIRWA:

One difficult problem in the Lake Victoria area is that of the ownership of the land and trees that stand on this land. The owner can fell these trees after consultation with the Forestry Department and he can hire pit-sawers to fell the trees and saw them up in planks, and for him the timber can be much cheaper than buying it commercially,partly because he does not have to pay sales tax. The beach boatbuilder gets his timber from the landowner and, consequently, pays very little for it. This is one of the reasons why the beach boatbuilder is able to construct canoes very cheaply.

There were about six small boatbuilding yards being operated by our ex-students. Some of them had to close down after a short period of activity because of a lack of management ability. They were not able to cost their boats properly and sold them at a loss, or they were unable to adapt themselves to the requirements of the fishermen.

H.B. KIBEGO: We have experienced in the past that the boatbuilders we have trained during our four-year course have been unable to compete with the beach boatbuilder because the beach boatbuilder is employing inferior materials, for example ordinary steel wire nails, while the trained boatbuilder is using expensive copper nails. Some of the trained boatbuilders found that their boats became too expensive for the fishermen and they were obliged to start using steel screws and wire nails in order to cut down the cost. This is the problem we are up against. We teach the boatbuilders to use proper materials but the market forces them to build with cheap materials.

A.S. OBURU: We have to go to the root of the problem of competition between the beach boatbuilder and the trained boatbuilder. Unless we manage to convince the fishermen that the boats built by the trained boatbuilders are better and longer lasting than the traditionally built boats, we will not succeed. This might take a lot of demonstration work and convincing from the Fisheries Departments. First, however, it is essential that the Fisheries Departments are convinced that they have a better boat to offer the fishermen. We have had examples in Kenya where boats built of plywood were introduced to the fishermen and they were useless in less than a year. This has created distrust from the fishermen, and it will be more difficult to convince the same men the next time we try to introduce a new type of boat. It is, therefore, essential before introducing new boats that they are properly tested by the Fisheries Departments.

W. MANYASSI: It will be very difficult to convince a fishermen that he should pay three to four times as much for a canoe built by trained boatbuilders without this giving him advantages in higher catches. The boatbuilding industry must be guided by what the fishermen require and not by any wishful thinking about what the boatbuilders think is the best boat. In the last instance, it is the fisherman himself who pays out the money that decides what type of boats should be built.

Some time ago, our boatyard built some small fishing boats of the dory type about 17 ft long and powered with a 4/5 hp outboard motor. We could sell this boat for around sh. 2 000, and we went round to the fishing villages to inquire whether any fisherman was willing to try this boat out, even free of charge. The result was negative, none came forward to take up our offer, and I think this example illustrates an important point - that we must first find out what the fisherman wants to have and what he can afford to pay for it before we start establishing a boatbuilding industry.

Ø. GULBRANDSEN: The fisherman is not as stupid as some people believe. He may not be able to read or write but he certainly can count money. It might take time to convince the fisherman about the new type of boat, and nobody can blame him for being conservative in investing the little money he has into a new type of boat or gear. Our experience everywhere has been that the moment you manage to demonstrate to him that the new boat or gear will give him more catch, then you have started a snowball running, and after the first fisherman you will soon have more following.

D. ODERO: In Kisumu we brought some beach boatbuilders together and gave them some assistance in the form of tools and materials. These boatbuilders built an improved type of boat that the fishermen liked and they are coming back to this boatyard for new orders.

Ø. GULBRANDSEN: One of the ways that the Fisheries Departments can assist the beach boatbuilders is to make it easier for them to obtain the right type of materials. All the boats built by the beach boatbuilders at present are fastened with ordinary iron wire nails. Galvanized nails would, no doubt, prolong the life of the boats at very little extra expense. However, it is almost impossible to obtain galvanized nails in commerce. There are, however, firms who do galvanizing; for example, in Kampala, one firm is producing galvanized nails, and the Fisheries Departments could place a sufficiently big order with this firm to produce the size and type of nail that is suitable for the boatbuilders and assist in distributing it to these boatbuilders. Similarly, it would be possible for the Fisheries Departments to make good wood preservatives more easily available to the boatbuilders living far away from the big commercial centres.

A.P.J. HOLNESS: There have been several attempts to introduce European-type boats but these have been unsuccessful. The fisherman complains that he cannot operate this type of boat alone; they are too expensive in initial cost and the repairs are difficult and expensive. He will prefer a boat built by the beach boatbuilder costing from sh. 250 to 600 and lasting maybe 3½ to 4 years.

A beach boatbuilder will be able to improve his boats by being shown better ways of building them. He cannot afford to leave his home and his family to attend a boatbuilding course, but he will be quick to pick up new ideas when he is convinced that it will produce a better boat. The beach boatbuilder is doing a great service to the fishing industry, and he needs to be assisted rather than restricted in his work.

B. MACHUMIRWA: In Lake Albert it has been possible to arrive at the standard boat design which has become popular among the fishermen, namely the Kabalega-type of boats which are produced in three basic lengths - 24 ft, 26 ft and 28 ft. The Kabalega boat has been built in a number of three to four hundred since it was introduced. It has not been possible to arrive at the standard boat design for Lake Victoria in spite of several attempts. If such a standard design should be developed, it would greatly facilitate the ordering of materials and constructing boats of the standard pattern.

A.S. OBURU: In Lake Victoria, fishing is carried on with gillnets up to 10 miles from the shore, with traps and nets close to the shore and with beach seines on the shore itself. It will be difficult to standardize a design that will satisfy all these types of fishery.

**A.P.J. HOLNESS:** I do not think it is enough to look at only the type of fishing gear and the type of fishing areas in order to decide on a suitable type of craft. One has also to take into consideration the people and their social level and background. I have found that in Kenya there are three groups of fishermen. There is the beach or village fisherman.

There is a limited number of fishermen who are prepared to buy an outboard engine and there are groups of fishermen, rather than individuals, who can afford to operate bigger boats on more distant fishing grounds. One cannot force a certain type of boat or type of fishing gear on fishermen who are not prepared or not willing to depart from their traditional way of fishing.

The first group mentioned are individual fishermen owning a small canoe. They usually have big families and are not rich by any standard. Fishing is done two or three months, while the rest of the year is utilized for cultivating their little farm. These people are happy with small boats, and it will be useless to try and force on them a bigger type of boat than what they think they will be able to operate.

The second group contains the individual fisherman who is eager to improve his condition, to motorize his canoe, go further away, catch more fish. He is a very important man in the fishery, supplying the main bulk of the fish to the market. With some assistance, he might move up among the third group of fishermen.

The third group will own the bigger trawlers and the bigger inboard powered boats in the future.

## ESTABLISHING NEW BOATYARDS

**W. MANYASSI:** What size of boat shed and facilities is Mr. Holness referring to in his paper?

**A.P.J. HOLNESS:** I am referring to an open shed approximately 60 x 60 ft, which can handle three boats being built at the same time. It will have a concrete floor and the whole shed will be simple enough to be built by the local contractors.

**S.N. SEMAKULA:** I think the figures for the cost of the boatyard mentioned by Mr. Holness in his paper are underestimated. We have recently made an extension of a boatyard increasing the area by 20 x 60 ft, and this will cost sh. 60 000, including the concrete floor.

**W. MANYASSI:** It has been our experience that a good quality boatyard shed will cost approximately sh. 30/ft$^2$.

**A.S. OBURU:** The investment in a commercial boatyard will necessarily be subtial, and I wonder whether it would not be a good idea to try to concentrate on building a certain type of boat in one of the three countries around Lake Victoria, whether it is Kenya, Tanzania or Uganda. In this way the number of boats to be built will be sufficiently large to justify the investment in the boatyard.

B. MACHUMIRWA: For Lake Victoria, it would probably be a good idea to have one boatyard for all three countries since the transport of the completed boats to their destinations would not present any problem, and they could be easily towed from the boatyard to any place along the lake. The coastal waters of Kenya and Tanzania present different problems, and if any boat development were envisaged here, a separate boatyard would have to be established to cater for this need. When supplying boats to the other lakes in Uganda, the problem of transporting materials or finished boats must be taken into account. Since most of the sawmills and the timber merchants are situated in Kampala, it would facilitate the transport of materials if the boatyard was situated in Kampala or nearby. However, the completed boats would then have to be transported for long distances and over partly rough roads which might cause damage to the boats, so the question is whether it is best to transport materials or the finished boat.

A.S. OBURU: The construction of canoe-type boats could be specialized in one yard and the construction of, say, 30 ft boats, in another yard. Each boatyard would then be able to specialize in one type of craft and, by getting substantial orders, they would be able to plan their supply of timber and the work in such a way that the cost of construction could be reduced.

N. ODERO: Before investing, say, sh. 500 000 in a boatyard, it is necessary to have a clear idea about the size of the market, that is, what type of boat will be built and in what number. Any boatyard development will have to be based on some estimates on the need for fishing boats over the next five years and the financing available from private or Government sources.

A.P.J. HOLNESS: I do not think we should get side-tracked in discussing establishment of big boatyards or boatbuilding industries. It is more natural to start with establishing smaller boatyards around and in the main fishing centres that are owned and run by individual boatbuilders.

S.N. SEMAKULA: The idea about centralization of boatbuilding yards is not very practical. There are already boatyards established in main centres around Lake Victoria, and one cannot stop these boatbuilders in order to centralize the construction in one big boatyard. So far, canoes built by commercially established boatyards have been much more expensive than the ones built by the local boatbuilders in the fishing villages, and I do not think one would support the fishing industry by giving Government assistance only to fishermen who want to buy boats from commercially established boatyards. If a fisherman cannot afford to pay sh. 3 000 for a canoe from one of these boatyards, one should not prevent him from going to the local beach boatbuilder and acquiring a canoe for sh. 500.

**Ø. GULBRANDSEN:** One important point to consider when establishing a new boatyard for the construction of larger vessels is that any boatyard, besides building new boats, is also occupied with repairing old boats, and that the boatyard must be situated in such a way that the construction of a slipway or any other means of bringing boats out of the water is facilitated. The boatyard should also be situated close to the base of a fishing fleet so that the fishing vessels do not have to travel long distances in order to carry out repairs or regular maintenance.

**P. MANYASSI:** If you considered especially a commercial boatyard close to popular centres like Kampala, Entebbe, or Jinja, you will often find that the planning board or the town council will not permit you to put up the boatyard on the location that is most suitable for it from the aspect of access, electricity, construction of slipway, etc. We run into this problem, and the site finally chosen is the best we can find but not ideal. We will have to spend a considerable amount of money to construct a slipway because in our particular area we have to go out 75-100 yards into the lake to achieve sufficient depth for the boats.

**M. ODERO:** In Kenya there are several boatyards situated far from the lakes or on the coast which show that the problem of transportation of the boats is not too serious. However, the boats they are producing are small and evidently, when coming up to the size of trawlers for Lake Victoria, it is advantageous to have the boatyard situated at the lake itself.

**J.O. ACOBAH:** If I were going into the boatbuilding business I would start, first of all, with a modest building shed aimed at attracting repair work as much as new construction. One often finds that there is more money to earn on repairs than on new construction.

New boats can be all simply designed which do not require power tools. We recently constructed in Nigeria a 40 ft flat bottom boat in a shed that was 15 x 50 ft, and all the work was done by hand; we had no power tools at all. If later development was justified and the profit of the boatyard is sufficient, then the boatyard can be expanded and power tools added as you go along. If you start up with a big and expensive boatyard, your capital costs will be very high while the market for boats is not yet developed. It is better to start small and develop the boatyard in accordance with the market.

**Ø. GULBRANDSEN:** Who should run the commercial boatyards? Should it be the Government, cooperatives or private industry?

**A.P.J. HOLNESS:** It is my definite opinion that boatyards should be run by individuals and not by Governments. I do not think this is a field where the Governments should become involved, and it has been demonstrated here in Uganda that private individuals are quite capable of running their own business when properly trained. The Government's role is to guide and assist people, but not to run the business themselves.

SEMINAR FOR FISHERIES OFFICERS
FAO/SWEDISH TRAINING CENTRE ON SMALL FISHING BOAT DESIGN AND CONSTRUCTION
Entebbe, Uganda 22-27 February 1971

Session V FINANCING BOAT DEVELOPMENT
Paper V/1

# Experience with credit schemes

by

JAMES A. CRUTCHFIELD

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

WS/D5117/5

## INTRODUCTION

The emphasis in this seminar series is on practical aspects of "how to do it" with respect to fishing vessel construction, ownership and management. This paper, however, is oriented more to basic business and economic facts of life with respect to financing capital aspects - particularly fishing vessels - in the fishing industry of developing African nations. Particular emphasis is laid on the uses and abuses of grants, subsidies, and loans at subeconomic rates of interest as devices for accelerating investment in fishing vessels and their subsequent operation. Special note is taken of the different kinds of problems that may arise where fishing activities are carried on under different institutional arrangements: that is, by private individuals and enterprises; by cooperatives; by government enterprises; or by some mixture of these.

## EAST AFRICAN EXPERIENCE WITH VESSEL FINANCING

There are many present at this meeting who are more familiar than me with details of credit operations in East African fisheries; this section presents in general terms my impression of the successes and failures of these credit schemes, in the hope that subsequent discussion will provide a fuller evaluation of past experience.

### (1) General

In general, it seems that government credit schemes for the acquisition of fishing boats and gear have not been a spectacular success. In Uganda, efforts to introduce new types of fishing gear and outboard motors in the fifties and sixties were tied to relatively liberal credit from the Uganda Credit Savings Bank, with recommendations from the Department of Fisheries as the principal device for channelling credit to deserving fishermen (Semakula, 1970). There is no way of knowing how much of the rapid growth in modern nylon gillnets and outboard engines - now permanent features of the relatively modern and efficient small boat operations in Uganda - could be attributed to this liberal extension of credit. The record seems to indicate that a great deal of difficulty was experienced with defaults, resulting from failure to run fishing operations efficiently, expenditure of borrowed funds for purposes other than the purchase of fishing gear, and outright dishonesty.

Losses were so heavy that ultimately the implicit subsidy of the loan scheme was abandoned. The Uganda Commercial Bank became the only source of loans, and then only on normal commercial principles with a requirement that sound personal credit and security for the loan be demonstrated.

I am less familiar with similar attempts to modernize small boat lake fisheries in Kenya and Tanzania, but it seems likely that the same general type of experience was common in these countries as well. Attempts to have local governments provide loan guarantees and channelling loans through cooperatives (many of them virtually forced on groups of fishermen) did not appear to produce materially better results.

### (2) Coastal Fisheries

Neither Tanzania nor Kenya appears to have had much success in using government credit as a means of breaking the power of middlemen over coastal fishermen (Rhodes, 1966). The traditional reliance on marketers by coastal fishermen, not only for fishing supplies and gear but also for other credit needs as well, is part of a culture that goes far back in history. It could hardly be expected that the system could be permanently altered by a simple change in methods of financing purchases of equipment. Over the long run, it seems clear that the "tajiri system" has a strong tendency to perpetuate a rather unsatisfactory status quo, and that it must be replaced if any real progress is to be made in improving the productivity and economic welfare of coastal fishermen. This will require, however, a broad-based attack on a variety of problems: inadequate coastal receiving facilities; poor wholesale and retail markets; lack of knowledge about the distribution and yield capabilities of the various stocks available to coastal fishermen; and the development of vessels and gear adapted to the exploitation of those stocks. Credit is only one element of such a programme and probably not the most important. It is hardly surprising, therefore, that credit schemes in the coastal fisheries have not achieved spectacular success, though they have contributed to the introduction of some improved types of gear (e.g., modern nylon nets in the shark fishery).

The really interesting aspect of the East African experience is that the fisheries have managed to achieve an excellent rate of growth, at least on the fresh water lakes. As pointed out in an earlier article (Stoneman, 1967), government credit can account for only a small fraction of the total investment in outboard engines, modern Kabalega-type canoes, and nylon nets now used on the lakes by Uganda fishermen. The same is true, in varying degrees, in the fresh water fisheries of Kenya and Tanzania. Fishing does seem to generate sufficient private capital to permit fairly speedy adoption of any type of boat or gear that proves to be really profitable. Whether this type of funding would be available for larger and much more expensive boats (of the type required for a trawl fishery on Lake Victoria, for example) is more questionable, but it certainly should be expected to supplement any government programme.

(3) West African Experience

The experience of Ghana might be worth noting in this connexion. The Ghanaian Government developed a number of 30-40 ft boats, suitable for local construction, that seemed well adapted to Ghana's inshore ocean fishery, and which could operate much more efficiently than the beach canoes of the traditional fishery. It then undertook to speed up adoption of the new boats through a very liberal loan scheme. The receipts of the loans went in many different directions, as did the vessels; many mistakes were made in selection of borrowers; and a very considerable amount of government capital was dissipated. Over time, however, a reservoir of valuable fishing experience and knowledge accumulated and the harder working and abler skippers and crews began to earn excellent incomes with the new equipment. Thereafter, the fishery expanded rapidly, but largely on the basis of private funding. Even in the face of a government policy that tended to discourage private fishing operation in favour of a government corporation and cooperatives, the number of privately financed boats continued to grow (Lawson, 1969).

It would be illuminating to have a careful study of the actual sources of funding that underlie the rapid growth in privately owned fishing boats in both Ghana and East Africa. A preliminary analysis of the Ghanaian experience, by Kwei and Lawson (1969) indicates that most of the money invested in the modernized small boat fishery came from small African businessmen who had accumulated funds in various shore-based ventures, including but by no means limited to, fish marketing. This is not surprising. Even in the U.S.A. - a nation with highly developed capital markets - a surprisingly large proportion of the money required to finance fishing vessels comes from direct investment by individuals, both outside and inside the fishing industry, rather than from commercial banks or other financial institutions. There is every reason to encourage the tendency in East Africa for men who make successful investments in road transport, for example, to use some of the proceeds of those investments in financing skilled fishermen who can use better equipment profitably. In addition to the self-generating nature of this kind of investment activity, it involves a closer relationship between borrower and lender, and therefore a much smaller proportion of bad debts then most public loss schemes achieve. A private lender is likely to do a much more searching job of evaluating fishermen as borrowers than a government loan administrator or even a government or commercial bank.

This is not to say that government should avoid participation in providing credit to an expanding fishing industry. It does suggest, however, two important considerations. First, government fundings should be undertaken in a way that does not discourage an expanding flow of private capital at the same time. Second, the experience in both East and West Africa suggests that even where government aid is required to shift fishermen to a radically new type of level of investment in fishing vessels and gear, the ultimate objective can and should be self-sustaining internal investment once the industry has become well established. These points are developed below.

(4) Cooperatives as Financing Agencies

I have not had sufficient experience with cooperative fishing ventures as a vehicle for administering loan funds to comment on them with any degree of confidence. It is perfectly possible, in theory, that the cooperative could serve usefully as an intermediary between a government loan programme with money but no expert knowledge, and groups of fishermen with no money but with a range of fishing experience and knowledge. Nhwani (1969) stresses this aspect of the cooperatives. The important point is that the cooperative must be able and willing to subject its potential member-borrowers to the discipline of responsible, honest, and efficient use of borrowed funds. If it can perform that difficult rationing function, while retaining a close personal contact with the operating fishermen, it may be a good choice to handle vessel financing along with other service functions essential to the development of a new and more modern type of fishery (e.g., freezing and storage facilities, processing plants, vessel and engine repair facilities, and marketing capacity - outward for finished products and inward for raw materials and supplies). In fact, control over loan capital is a natural adjunct to some of these other activities. I cannot stress too strongly, however, the fact that these are difficult functions to perform, and that the cooperative is inherently a difficult type of business organization to manage. If it works well it works very well indeed; if it works badly it can be disastrous.

SOME GENERAL PRINCIPLES

The importance of going behind the financial aspects of fishing vessel construction and operation to more fundamental effects on physical and economic productivity is peculiarly important in the setting of developing African nations. From a purely strategic point of view, the fisheries are not as important as agriculture or as dramatic in developmental impact as manufacturing and foreign trade. Thus, the political weight of fisheries in most developing countries is not likely to be very great. It is therefore all the more important that fisheries programmes presented to governments by the departments of fisheries in East Africa be thoroughly documented. More specifically, it is simply inadequate to demonstrate that a programme involving commitment of capital funds to the development of new vessels or other equipment would pay for itself in terms of fishery output alone. It must also make clear that the impact on the overall economy of the country (or on a particularly hard-pressed region) is more favourable than any other use of the funds requested.

(1) Capital Allocation

The reasons for these words of caution are rooted in the basic economic problems of all developing countries. They are, above all, short of capital - physical and human (in the sense of trained personnel in whom governments have invested large amounts for education). Any programme that places additional demands on government budgets actually requires cutbacks in consumption standards or in other investment in private or government projects.

Even if funding can be obtained from international sources, the debt must ultimately be repaid; the burden is simply shifted in time. While some of the physical and human capital may be provided without cost by international or bilateral aid programmes, even these gifts place demands on the resources of the recipient country for raw materials, associated equipment and counterpart personnel at the required educational level.

The typical functional organization of governments conceals the disruptive effects of investment in one sector on potentially more productive activities in another. Thus, loan or other credit schemes must be evaluated within the broader setting of the national and regional economies affected. One could make a good argument that sound fishery programmes in Africa may have been severely restricted because of subsidized expansion in agriculture and some manufacturing enterprises, but fisheries are not likely to gain much by trying the same tactics in reverse.

(2) Interest Rate Subsidies

Zero (or very low) interest rates commonly associated with credit schemes aimed at development of a particular type of economic activity can be a particularly dangerous kind of subsidy if improperly used. First, this technique tends to encourage investment in larger units or larger numbers of units than the borrower is really equipped to manage, since the cost of capital is made artifically low. Perhaps more serious, the effect of a new type of fishing activity financed through interest-free loans may be seriously detrimental at a later period when government wishes to withdraw and transfer the activity to the private sector or to cooperatives. An industry built up on the basis of a subsidy of this type may prove to be a flat failure when the subsidy is withdrawn, and the subsequent shock effect may hurt future development for a long period of time, even where the underlying efficiency of the new type of vessel or gear is perfectly adequate to justify its use. Finally, the use of very low interest rates for government loans makes it extremely difficult to encourage private investment in the industry even after the basic technology has been worked out and the new methods have been widely adopted by the better fishermen. Private financial resources simply will not be attracted at rates lower than they can receive in other ventures of roughly the same degree of risk, and uncertainty about the length of time in which a government-subsidized loan scheme will be in operation always depresses private participation.

## THE NEED FOR GOVERNMENT FINANCING

If the introduction above sounds somewhat negative, bear in mind that all economists seem to be somewhat gloomy as a matter of professional pride. We turn now to the legitimate reasons for government participation in financing the development and use of new types of vessels and gear in fisheries like those of East Africa. There are a number of perfectly acceptable economic arguments for doing so.

(1) Poor Organization of Financial Markets

Even in the highly developed market-oriented and socialistic economies, the assumption that private or government capital is automatically allocated to the highest and most productive use by market forces or detailed government planning is at best a rough approximation. Barriers among various capital markets may be severe indeed, and wide differences in rates of return are anything but uncommon. In less developed countries, the absence of sophisticated financial institutions for mobilizing savings, coupled with the fact that the majority of the people are simply unfamiliar with banking and other savings institutions, makes it even more important to assure, through government action, that highly productive opportunities for investment are not passed up. This is peculiarly important with respect to the fisheries, since the industry typically operates on the "fringe" of both economic and social activities of most countries. Both the opportunities and the problems of investment in new types of fishing vessels and gear are often unfamiliar to enterpreneurs in other industries with capital to invest.

(2) External Benefits

In both developed and less developed countries, government participation in financing new types of investment, such as fishing vessels, may be desirable because of the existence of what economists call "external economies". In plain English, the development of a highly productive fleet of small trawlers, to use an appropriate illustration, may make possible a fundamental reorganization of processing and marketing systems in the East African countries, with major economic gains at each stage. But since these new profit opportunities lie outside the activities of the fishing enterprises themselves, they are not likely to be recognized and taken into account by private investors weighing the desirability of investing in new types of productive fishing gear. Moreover, many of the associated kinds of investment needed in order to make the most profitable use of the new type of equipment would be in public facilities: improved access roads to landings, construction of cold stores available to a variety of users, construction of proper docking facilities, etc.

(3) High Risks

A closely related reason for government participation is the restrictive effect of high risk on investment by private individuals or by small units of government with limited funds. Fishing ventures have always been regarded as rather high risk borrowers, even in highly developed fishing nations. The risks are multiplied if the credit programme is designed to speed the adoption of new types of boats and gear with potential operating problems that cannot be fully foreseen. Under these circumstances, it is perfectly possible, even with a generally favourable forecast of the results to be obtained by moving more energetic and competent fishermen into better equipment, that the individual risks involved are too great to attract private investors (or the limited funds that might be available from cooperatives or local government sources). In effect, the central government can, in accordance with the principle of large numbers, spread the risks efficiently so that the favourable outcomes will more than offset the occasional disastrous one.

(4) Credit Control by Marketers

In interior East Africa competition for fish at the landings is sufficiently vigorous in most areas so that the problem of middleman control over the fishermen is not very serious. In the coastal fisheries, on the other hand, the middleman so dominates financing and all other activities of the fishermen as to present a real obstacle to modernization and development of the fishery (Crutchfield, 1959). In cases like this, provision of government lending capacity may be essential if any important change in traditional fishing methods is to be achieved. As indicated above, breaking the hold of the middleman calls for much more than the elimination of his position as creditor to the fishing community. But that position is crucial to his control, and no broader development programme is likely to make much progress until it is eliminated. This might well require that credit be made available by government at low interest rates (and with substantial losses) for an extended period.

SOME KEY PRINCIPLES OF CREDIT MANAGEMENT

If we accept these reasons why government credit programmes may be necessary under some circumstances, what principles should govern the extension and administration of credit schemes to finance the purchase of new types of fishing vessels?

(1) Economic Feasibility

The first principle, general in nature, is that the loan programme as a whole should meet the test of economic feasibility. That is, the additional catches generated by the new boats, minus the costs of construction and equipment, should yield a net economic return as attractive as any alternative that might be considered. It follows that if this condition is met it should be possible to charge a reasonable interest rate on the loans, and the overall payment capacity of the borrowers should be sufficient to make the programme completely self-liquidating. In other words, the loans should be repayable within the useful life of the equipment with an attractive profit remaining for the average borrower.

(2) Administrative Control

The experience with credit programmes of every fishing nation - developed or developing - emphasizes the need for tight control over administration and collection procedures. I offer no magic formula for solution of the difficult problems involved. Fishermen are, by nature, highly individualistic, with a wide range of ability and energy, and a rather high degree of mobility (particularly when things begin to go badly financially). Under the very best of circumstances, there are bound to be high losses in any loan scheme involving large outlays for long periods of time (as would always be involved in financing the purchase of a vessel that can use inboard power efficiently and handle modern equipment, such as a trawl). Fishing is inherently a risky occupation, with many natural hazards and a variety of additional market problems imposed by the perishability of the product. Any credit scheme must therefore be prepared to assume a fairly high failure rate, at least in the early stages, and every effort must be exerted to minimize losses to the programme from outright fraud or dishonesty. Failure to provide rigorous control over scheduled repayment of principal and interest and the use of borrowed funds simply is an open invitation to failure of the associated development programme.

Unnecessarily high losses from dishonest or irresponsible fishermen reduce the amount and quality of the help that can be provided to fishermen who could make genuinely good use of it.

There is no single way to guarantee this kind of tight control. One measure that can definitely help is to tie the loan and repayment to the fishing licence. As long as the fisherman has a long-term interest in fishing, he will have a strong incentive to meet the conditions of his loan agreement in order to retain his licence and his right to engage in the fishery. On the other hand, the greatest trouble is likely to come from fishermen whose inability to repay loans and carelessness about maintaining equipment purchased with borrowed funds makes them indifferent as to whether they lose a licence or not.

(3) Incentives

It is critically important that loan conditions be written to provide maximum incentive for repayment. In general, this requires two things: first, a down payment large enough to guarantee that the owner's equity will always make it desirable for him to continue payments rather than to abandon the equipment; second, that the term of the loan be less than the expected useful life of the equipment. Under these circumstances, the original borrower stands to lose substantially more by failing to maintain the boat and gear (or abandoning it) than by continuing to make payments. If he should find it impossible to continue fishing, his equity should be sufficient to make it attractive for other investors to buy the vessel and assume the balance of the loan. It is also essential that the loan conditions include a reasonable degree of control over actual fishing operations. This is necessary to assure that the vessel will be operated in a way that provides funds for repayment (and, in the process, the best return to the owner). In addition, if the loan programme is tied to a more general programme of fishery development, control over credit arrangements frequently can be coupled with a requirement that the borrower keep records that will be of direct assistance to the department of fisheries. This is no particular burden, since the kinds of records that would be most useful for that purpose are likely to be equally useful to the vessel owner himself - for example, records of fishing effort, location and catch composition.

(4) Proper Definition of Optimal Vessel Type

Probably the single greatest cause of casualties among government credit schemes for fishing vessel development is inadequate analysis of the physical and economic setting within which the new boats will operate. There is a universal tendency to equate, uncritically, "bigger" with "better" and greater physical catching power with better economic performance when dealing with fishing vessels.

Unfortunately, neither generalization is necessarily true. The purpose of any fishing operation is, of course, to maximize the difference between value of catch and costs of operation (including amortization of the cost of the vessel and its equipment). Larger vessels, with more powerful engines and capable of using larger and more varied types of gear, will usually catch more fish. What is less obvious is that such vessels may impose unnecessarily high costs on a country in which capital is a very scarce and expensive factor, while labour, even with a reasonable degree of skill, is typically cheap and abundant. In addition, even though the vessels may be locally built, the engines and other specialized gear required to make them into efficient fishing units are certain to impose an additional demand for foreign exchange. The "optimal" vessel for a given type of fishery must be designed with a careful eye on the size and composition of the stocks to be exploited and their location, and with due attention to the effect of the new type of equipment on traditional fishermen. For many fisheries, small boats using cheap outboard or inboard engines and relatively large amounts of labour, are still the most efficient units.

The point to be emphasized is that a loan, grant, or subsidy scheme aimed at promoting the use of a particular type of vessel gives it a significant advantage over all other types. If the programme is worthwhile, it will have substantial and perhaps permanent effect on the structure of the fishing industry. It is vitally important that the right kinds of vessels be selected for promotion, and that a careful economic analysis justifying that selection, together with a study of the impact of the new gear on existing fisheries, be undertaken as the first step in preparing the programme.

(5) Relation of Credit Programmes to Overall Development

I must take this opportunity to hammer again at an old theme. Boat financing programmes usually mean growth and change, not only in the equipment used, but in the average size of landings, the location of primary markets, and the ultimate consumer markets to be served. Assuming that the proponent of the credit scheme has done his homework well, and can make a good case for improved efficiency and long-run profitability of the new vessels, the department of fisheries must make equally certain that the programme is integrated with other elements of its development activities. A change of any real magnitude in the kind of fishing effort exerted by the industry is almost certain to require additional investment in landings, marketing facilities, docking and repair facilities, and similar adjuncts of the fishing industry. Nothing is quite as sad as a successful scheme for promoting additional catching facilities for which no adequate market or support facilities exist.

In general, the East African countries deserve high marks for their attention to this broader view of fisheries development. The work now going on in all three Departments and in the UNDP project to expand fishing development on Lake Victoria are good examples of integrated planning that ties increased production to appropriate scaling-up of marketing and support capability. Newfoundland offers an excellent example of the consequences of an incomplete (and often politically motivated) programme in which loans and grants were a principal element (Copes, 1969).

CONCLUSION

In summary, a loan programme aimed at speeding up the introduction of more efficient fishing gear should be able to generate the means of its own repayment, thus meeting its obligation to the national economy and releasing borrowed funds for other purposes. It also implies that a credit programme of this type ought to be self-terminating; once a sufficient number of fishermen have shifted over to the new vessels and gear and demonstrated its profitability, it should be possible to finance both reinvestment and further expansion through conventional sources of funding. This would leave the government free to move ahead in other risky areas of development.

Although the wording of the discussion above implies an economy in which fishing is carried on by private operators or cooperatives, the principles are equally applicable to one in which government planning and direct economic activity are more important. The basic idea is the same in either case.

Unless investment in better fishing vessels and techniques produces enough additional output to recover all costs and yield a net return, it is subtracting from the productive potential of a socialist economy no less than from one geared to private markets.

It should be emphasized that the argument above is essentially a long-term one. If a segment of the fishing industry can only be kept alive by continuous direct subsidies, grants, or low-interest loans, it wastes national resources and may end up by reducing the overall strength of the fishing industry as a whole. There still remains the real possibility of using government funds to speed up the adoption of new gear - always a matter of concern in an industry as traditional and slow to change as fishing - but with a definite termination date. The cost of such a programme may easily be offset by the additional tonnage produced in a shorter changeover period.

If this situation exists, it would seem wise to follow the Uganda approach of providing a direct grant, once and for all, to each qualified applicant rather than the indirect subsidy of loose credit or excessively low interest rates. Such a scheme is easier to start, easier to explain to fishermen, and, above all, easier to wind up once the job is done. It also tends to encourage rather than frighten off private capital, and can easily be tied to an agreement that gives the Department of Fisheries the necessary control over operations and record-keeping.

REFERENCES

Crutchfield, J.A., 1959 Report to the Government of Kenya on the Sea Fisheries of Kenya. Report No. FAO/ETAP 998 Food and Agriculture Organization of the United Nations.

Kwei, E. and R. Lawson., 1969 The Fisheries of Ghana (unpublished manuscript).

Lawson, Rowena M., 1969 "Investment Criteria in African Fisheries Development", International Conference on Investment in Fisheries, Rome, September.

Nhwani, L.B., 1969 "Investment in Fisheries in Tanzania", International Conference on Investment in Fisheries, Rome, September.

Rhodes, D.H., 1966 Report to the Government of Kenya on Fisheries Development Possibilities, Report No. TA 2144, Food and Agriculture Organization of the United Nations.

Semakula, S., 1970 personal communication, November.

Stoneman, J., 1969 "Investment in the Fishery Industry in Uganda", International Conference on Investment in Fisheries, Rome, September.

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Session V FINANCING BOAT DEVELOPMENT
Paper V/D

# Discussion

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

FISHERMEN, TRADERS AND COOPERATIVES

A.S. OBURU: We must develop some kind of system that permits classification of the fishermen which will provide a basis for planning our assistance. In the past, too often the fishermen have been lumped together in one group and the assistance has been distributed to this wide group without a clear specification of the objectives one wanted to achieve with this assistance. We will be faced with two groups of fishermen on Lake Victoria, namely the industrial fishermen operating trawlers and the artisanal fishermen. These two groups should not be mixed together in one when we are talking about fisheries development in the future. Each group has its specific problems and must be treated separately.

P. PROUDE: It is imperative to know your fishermen, to know their habits, where and how they live, how well they fish, how reliable they are, and be on good terms with them so that you can select the right people. It is no good having an application from a man 50 miles away and saying "let us give him a loan". You must know the man you are dealing with so that you are sure to put your limited resources in the right baskets.

C.C. TAIT: Over a period of seven years, fisheries training was undertaken on Lake Kariba in Zambia. Fishermen were brought into training courses lasting two weeks to one month. Notes were made on the various qualities and abilities. Out of these fishermen, two were selected initially for an advanced course and given instruction in running an outboard engine, mounting their own nets, etc., and they were subsequently given a loan for boat and equipment worth approximately £ 500. These two fishermen were successful in their operation and managed to repay their loans. There is no reason why something similar could not be done with the introduction of larger fishing boats on Lake Victoria.

J.A. CRUTCHFIELD: There should be a close link between any loan scheme and an associated training scheme. Often, fishermen have been given equipment which they had not the faintest idea of how to operate properly.

J.S. MUMBA: The problem of the middleman taking a large part of the profit from fish distribution can probably best be solved by organizing cooperatives. In the past, there have been some failures with these cooperatives due to bad management, but I believe that, with assistance from the Government in training cooperative managers, this problem could be overcome.

J.A. CRUTCHFIELD: The credit schemes alone will not improve a situation where the middleman or somebody else has complete control of the marketing facilities. Loan schemes will not remove the fishermen from the dependency of this kind of control. Whether cooperatives are the best way to do it might well be an open question. In Kenya there are two extreme situations. Lake Rudolf is a place ideally suited for a cooperative, where the fish can be marketed without

J.A. CRUTCHFIELD: (continued)

much competition. The experience on Lake Victoria, where you have quite an active competition and where fish landings are more scattered, was that the cooperative meant an additional cost for the fishermen for which they felt they got very little in return. One may, in the same country, find both these extreme cases; in one case the cooperative is well adapted to it and, in the other, the cooperative represents an additional expense for the fishermen.

N. ODERO:

A cooperative will not succeed unless the fisherman in some way is obliged to deliver his catch through the cooperative. In a place where the Fisheries Department has full control over the fishermen, there will be little difficulty in having the fisherman sell his catch through the cooperative. One such cooperative in Kenya had made a saving of £ 5 000 and this was kept in a bank. We advised them to spend this money on bigger fishing boats and to lend these boats out to the members of the cooperative. This has worked very well and some of the members have put up as much as half the cost of the boat as their contribution. This success was only possible because of the centralized marketing of the fish. On the coast, the cooperative opened up a bank account for each fisherman and put 10 percent of his earnings in this account. In this way, individual saving was encouraged.

A.S. OBURU:

In an area where the fishermen land their catch at the same place and sell it at the same market, the problem of providing loan schemes is much facilitated because it is possible to take part of the fisherman's catch as a repayment of the loan. This situation exists in Lake Naivasha. On Lake Victoria, however, where there has been a traditional fishery for a long time and the landing places are scattered around the coast, it is extremely difficult to assure a proper control of loan schemes. It will, for example, be very difficult to convince a fisherman that he should land his catch in Port Victoria if he knows that he can obtain better prices for it in Jinja. In a loan scheme it is, therefore, necessary to introduce an element of compulsion, that the fishermen must land their fish at a certain place. In Kenya we have started with fitting in better facilities for handling fish at certain landings, but if the fishermen are not in some way compelled to market their fish at these facilities, we might find that they are under-utilized and will not justify the investment. The fisherman might want to market his fish in the old unhygienic way and any improvement will be impossible.

J.A. CRUTCHFIELD:

This seems like a contradiction. If the new facilities give the fishermen some advantages, you do not have to compel them to utilize the facilities. If you have to compel them to do it they you are in a very different situation, and it seems like somebody made the mistake in the decision of what type of facilities were required and where they should be placed. I had the experience with these kinds of projects that either did work and paid their way or did not work at all; but I do not think I would like to retrieve my mistakes by forcing the fishermen to utilize the facilities because the facilities were not what

J.A. CRUTCHFIELD: (continued)

the fisherman really wanted. I do not believe that it is possible to use the compulsion technique in order to get a cooperative to function. On Lake Rudolf there has been a clear demonstration that the cost of an operating cooperative is more than weighed by the return to the fishermen in that area. If that is not the case, and you restrict the fishermen to sell only to the cooperative, then you achieve only one thing; you create a whole new set of very efficient African fish traders who will take the fish around the cooperative in spite of the prohibition. Again, it either pays its way in return to the fishermen or it does not and, if it does not, then to try to force all the fish marketing into the cooperative is going to lead to economic waste.

N. ODERO:

A fisheries cooperative with landing facilities was established in Port Victoria. The cooperative had an insulated van that could transport the fish from Port Victoria to the more populous areas around Kisumu. The fish arrived in a very fresh condition and, after the initial scepticism, the customers started to prefer the fish that was brought from Port Victoria. However, the middlemen did not like this development and created problems for the cooperative. In the future we must ensure that somehow the middlemen are brought into the scheme so that one gets their cooperation.

J.A. CRUTCHFIELD:

I do not know whether any of us propose an alternative to the large number of fish dealers that operate around Lake Victoria. There is a real danger in underestimating the efficiency with which these dealers move large quantities of fish to supply a lot of people in a very substantial area. The problem on Lake Victoria is part of a larger issue. Even though the catching units on Lake Victoria are rather small and the production per unit is also small, the fishing trade itself is fairly efficient and highly sophisticated, and I would be very reluctant to see a vessel financing scheme tied up with restrictions that prevent the fish going to places where it would fetch the highest prices for the fishermen and for the country as well. I think that one of the reasons for the success of the fishery development on Lake Victoria has been the way in which the traders were able to sell different species of fish prepared in different ways on markets where they were most needed. Maybe more improvements could be introduced, not by forcing these fish dealers, but by offering them a better alternative in the form of, for example, more centralized landing.

N. FUJINAMI:

In many countries the fishermen's cooperatives provide real benefits for the fishermen in the form of reduced prices in engines, fishing gear and even clothes and shoes. This is possible by bulk purchases through the fisheries cooperatives. Unless the cooperative is able to give the fishermen special advantages, I think it is hopeless to try to organize them into cooperatives.

J.A. CRUTCHFIELD:

There are a couple of reasons for the rather limited success of cooperatives in fishery. One is to do with the attitude of government agencies that are in business to form cooperatives, and the success of these agencies is measured in how many cooperatives they are able to start, regardless of whether they are needed or not. In some cases, fisheries cooperatives were formed because somebody said "we have not done enough in the field of fishery so let us start up some cooperatives".

The second point is that access to Lake Victoria in most areas is very good and the concentration of population within short distances of the lake shore is very heavy, and anybody that has visited the shore landings will agree that there is vigorous demand for fish in most of the Lake Victoria area. You are not witnessing a monopolistic problem of the type that is so serious on the coast. The cooperative is often an expensive and difficult type of business to maintain, requiring good management and a high degree of personal loyalty among its members, and these are very severe requirements.

I have never been convinced that societies of people that did not know how to operate fishing boats will do better than individuals who do not know how to operate boats. If the people involved are efficient and hard-working fishermen, I think they will work well within the society and also as individuals. If they are inefficient and dishonest and if they are not able to judge the effectiveness of the boats and equipment available to them, you will not change that very much by organizing them into societies.

LOAN OR SUBSIDY

A.S. OBURU:

When studying loan schemes that have failed, one often discovers that this is often due to lack of understanding of what the loan scheme is intended to do. One might have cases where the loan scheme itself has been a failure, but it has created so much interest and it has demonstrated possibilities which has attracted capital from different sources, and the total result has been development of fishery. This whole aspect must be taken into consideration when judging the success of loan schemes. The loan schemes might be considered as a direct contribution to the industry rather than intended to create a revolving fund.

In Kenya, I have had personal experience of new boats being introduced without a prior testing of the life expectancy of the boat. I was, myself, involved in such a case with a private fishing boat which turned out to be a failure. Too often it is the government that has to carry the responsibility in such cases. Private industry often looks on the government services as an institution to test their new products and expects that the government will bear all the costs of making these experiments. When failure then comes, the government receives all the blame. I think that in the future, if private industry is interested in introducing a new type of boat, it should be requested to bear part of the costs of the experimenting, rather than piling it all up on the government. Another

A.S. OBURU: (continued)

experience from loan schemes is that one should not introduce a new type of boat without a similar introduction of a more efficient gear. The new boat will be more expensive than the traditional craft, and the fisherman will not be able to pay the increased expense unless he has, at the same time, more efficient gear. Introduction of new boat types should, therefore, be coupled with improving the efficiency of the fishing gear. In the gillnet fishery on Lake Victoria, it will be very difficult to convince the fisherman to invest in a new type of boat if he is continuing to use the present type of gear.

N. ODERO:

One problem we run into when trying to provide better boats and equipment for the fisherman is that the fisherman himself really cannot afford to put up the money required for the purchase of these items. Often, it is the richer people that will buy new boats and gear.

It is also important that equipment, boats or gear are well tried out by the fisheries departments before they are passed on to the fishermen through a loan scheme. You will have cases where the fishermen come back after a short time with their boats and say that they will not continue to pay the loan because the boat has been damaged.

J.A. CRUTCHFIELD:

There is often a tendency to regard financing from outside the fishing community as something undesirable. I cannot see anything wrong in getting investors that have earned money on road transport or other business investing their money on new boats as long as this does not extend to an undue control over the fisherman's life. The expanding of the fishery by financing from sources other than the fishery is something to be welcomed.

S.N. SEMAKULA:

Uganda has had a relatively long experience with both loan schemes and subsidies for fishermen. The problem we experienced with the loan schemes was that it is difficult to control the fishermen and to assure a regular payment from him. You give him a loan, he goes fishing and you might not meet him again. He might not be unwilling to repay the loan, but there are also many other things he would like to use his money for. He would like to build a house, take the kids to school or have a second wife. Due to these difficulties, we have given up the loan scheme approach and we have gone over to a subsidy scheme which is purely and simply an incentive. The problem then is that the funds are continuously drained and some sort of remedy has to be created to compensate for this.

We have had a couple of cases where the canoe and fishing gear that have been granted have simply disappeared and also the fisherman that owned it has disappeared. But, apart from that, our experience has been good.

It is clear that as your unit of operation becomes bigger it is easier to control loans. For the canoe fisherman, however, it is difficult to administer the loans partly because he has not sufficient securities. Suppose the fisherman was not paying back, you would go and try to seize some of his cattle, but

S.N. SEMAKULA: (continued)

you would find he had sold off most of it or the animals had died of some disease. He might have put security in his house, but by the time you come and want to seize, it is halfway to falling down.

J.A. CRUTCHFIELD:

I think this is an illustration of a case where there is no single answer to a specific question. From my own personal experience in Uganda, providing straight-out grants will cost you no more, and may cost you substantially less, if you are prepared to terminate it once you have made your point, that the gear will make money and that it is a good workable proposition for fishing.

However, it seems that the proposed trawler project for Lake Victoria will have to prove itself as a profitable venture without subsidy. If this cannot be done then you are in deep trouble.

P. PROUDE:

As a field officer, I was once involved with revolving fund loan schemes for inboard engines, new boats and new fishing gear, etc. Eventually, we ran out of funds and the money had to be written off because the fishermen would not pay back, but I believe the impact these projects had on the fishery development resulted in a tremendous surge from the private sector in further mechanization. The dealers brought in the new types of fishing gear at prices in reach of the fishermen, and the public was assured of a more regular fish supply. The total amount of money that was invested in each development by the Fisheries Department was about U.S.$ 25 000, which is a fairly small amount of money, taking into consideration the following development and the increases in the total catches of fish.

J.A. CRUTCHFIELD:

This example, I think, demonstrates a case where an initial subsidy or outright grant was justified, that is, provided you know beforehand that the type of gear, engine or boat you introduce will lead to increased catches and increased revenue for the fishermen. Extension work is fine if you know what to extend, but if the type of boat or the type of gear you introduced had not been the right ones for the local conditions, you might have ended up with U.S.$ 25 000 spent without having anything to show for it.

Ø. GULBRANDSEN:

I know of several cases where loan schemes failed because it was impossible to control the landings of the fishermen and thereby assure a regular repayment of the loans. If the fisherman knows that he can get a better price by landing on the open beach or even selling his catch to other boats at sea, he will do so, whatever measures are taken to try to force him to land at a certain point. This is one of the reasons that small boat mechanization schemes are so difficult to manage, and maybe a better formula is to give outright subsidy to selected fishermen for buying new equipment and boats.

B. MUCHUMIRWA: In Uganda, the subsidy schemes have succeeded in providing new boats and outboard engines and new gear for the fishermen and, even though this has been done by using taxpayers' money, I think the result has justified the expense. The success of the scheme can be measured by the large number of applicants for new boats and engines.

J.A. CRUTCHFIELD: When you reach the point where you have started the snowball rolling and you have a substantially higher number of well qualified applicants than your funds allow for, then I think there is an indication that it is time to stop the subsidy scheme.

In Kenya, we have experienced that fisheries loan schemes have, in general, been more successful than loan schemes in other areas of the economy. In spite of the inherent difficulty in obtaining payments from a fisherman, there have been fewer cases of defaults in payments in fisheries loan schemes than in agricultural loan schemes.

N. ODERO: On Lake Naivasha the income of the fishermen has been quite good, and most of them have been able to repay their loans. However, we find that the earnings from the fishery are often invested in areas outside the fishing industry such as new houses, shops, etc. In this way, the fishing industry is drained for capital which should have been utilized to purchase better boats and better equipment.

J.A. CRUTCHFIELD: I find it frightening that some of your countries have borrowed the worst type of agricultural subsidy schemes from the U.S.A. Agricultural subsidies are likely to be large enough in coverage and to involve a sufficiently large number of people that once they are established they are extremely difficult to get rid of. We are still subsidizing in my country crops already in surplus supply that cost us millions of dollars to store. Subsidies of this sort are far less justified than the type of subsidies you normally find in fisheries. I have no other explanation for this other than that once a large number of people become involved, the political attraction of doing this becomes very great and hard to get rid of.

A point which has come up repeatedly in the discussion is the mere fact that a loan scheme or subsidy scheme involves, for a shorter or intermediate length of time, non-recoverable cash outlay by governments. This means a responsibility on the government's side in picking which of the several ways you can obtain the broader social gain, and there is no justification for using an inefficient way of doing it when a more efficient one with better economic analysis can be selected.

SEMINAR FOR FISHERIES OFFICERS
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Session VI FUTURE DEVELOPMENT
Paper VI/1

# East African fishing boats – 1980

by

S.N. SEMAKULA

Contents:



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

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## INTRODUCTION

Fishing in East Africa has, for a long time, been an important occupation of the people living in the coastal and lake-shore areas. It has, however, been a simple operation, carried out in rudimentary rafts, log-boats and dugout canoes of various kinds. The fishing has been mainly of a subsistence nature, and consumption has been restricted to the coastal and lake-shore areas. Fishing activities have, at most times, been part-time, and levels of investment in fishing vessels have been very low. Recent developments in the fishing industry, however, have changed the pattern of consumption and the scale of operation, and fishermen now need to equip themselves with a different type of vessel.

## FISHING BOAT DEVELOPMENT

### (1) Traditional vessels

Fishing boats used in East Africa have, for a very long time, ranged from rafts to canoes of various types. Dugout canoes of up to 27 m in length have been recorded, although it is probable that these large canoes were only used in warfare, while those of up to 9 m in length were used mainly for fishing. These vessels were propelled by paddles or long poles, and their operations were limited to the inshore waters, since they were unstable and not capable of withstanding severe storms. The cost of these canoes was estimated at only about EA Sh. 300-500. Dugout canoes, however, were of long life which further reduced the amount of money involved in the initial investment. No loan system existed to enable fishermen to acquire boats, but, in many cases, the entire amount of money for the purchase of such boats did not necessarily have to be in cash, as this could be off-set by other items such as food in lieu of cash, or the sharing of the catch between the boat-builder and the canoe owner, when the boat had started operating.

### (2) The Sesse canoe

As fishing spread to the open waters of lakes, a more stable type of vessel was required. The first stages in the modification of these traditional dugout canoes was the introduction of the Sesse-type canoe, which, in its original form, was made up of four planks, attached to the rudimentary keel of a traditional canoe. Again, these were very cheap boats, the fastenings being made of raffia palm, and the labour for building them not necessarily having to be paid for in cash. These canoes were of greater stability and carried a larger catch than the traditional dugout canoe which, therefore, encouraged wider fishing activities by the fishermen.

### (3) Introduction of new fishing gear and outboard motors

With the coming into existence of the Fisheries Department, the technical off-shoot of the then Game and Fisheries Department, new types of fishing gear were introduced in the form of flax gillnets, which were followed by nylon gillnets at a later date. This innovation encouraged greater exploitation of fishery resources in various lake regions. As communications opened up more distant areas of lakes, new markets were established and extended fishing activities were stimulated. However, the inshore waters of lakes appeared to be in immediate danger of depletion, and the Sesse-type canoes were slightly modified in order that they should be able to brave the more distant waters.

At this time, outboard motors were introduced and it was discovered that the Sesse canoe was easily adaptable for mechanization; this only required the cutting off of one of the pointed ends of the canoe to form a transom, onto which could be installed the outboard motor.

(4) The Kabalega canoe

Several attempts were made to introduce boats constructed overseas, but these were not as successful as the traditional Sesse-type canoe, nor its modification, the Kabalega canoe. The Sesse canoe has remained predominant on Lake Victoria while the Kabalega canoe is more widely used on Lake Albert, these being the two areas where these particular types of canoe originated.

BOATS OF THE FUTURE

In recent years developments in East Africa have increased the urban populations, and the consumption of fish has followed a similar pattern. It has thus been noted that inshore waters of lakes have been greatly depleted of their stocks of fish. These trends have led to investigations into the deeper waters for different fish species. Much important work has been done on Lake Victoria where it has recently been shown that vast stocks of Haplochromis and Bagrus remain untapped in offshore waters. However, in order to exploit these fishery resources, it is essential that a new type of fishing vessel and more sophisticated kinds of fishing gear are brought into operation. The most fitting type of vessel would, therefore, seem to be the small trawler in the size range of 12-16 m in length.

It will be noted that, in the earlier part of this paper, the simplicity of the vessel which the East African fisherman is used to has been mentioned, this being an open boat which, until recently, has been propelled by paddles. Such a boat requires no beaching facilities, which accounts for the total lack of harbours and piers in some areas. The fishing gear which the fisherman has been used to is the longline and gillnet and, in some places, the beach seine, and the only form of mechanization has been the outboard engine which has not exceeded 18 hp in most cases. This is the situation, even in 1970.

If we are to exploit the vast fishery resources indicated in Lake Victoria, for instance, it is imperative that we operate the right type of vessel. The only vessel suitable for this purpose, as has been said previously, appears to be the trawler, ranging between 12 and 16 m in length and powered by inboard engines of 80-150 hp. This, of course, raises one most important factor which is the training of the various types of people involved in the construction and operation of this type of boat. In the first instance, it requires special training for the boatbuilders themselves who will be the people who will construct the new fleet of fishing vessels to operate in East African waters. These boatbuilders have been used to constructing open boats of between 8 and 15 m in length, and have been highly successful in this endeavour. It should be noted, however, that the bulk of present-day boatbuilders in East Africa are not formally trained but have merely picked up their skills from their forefathers. They lack adequate equipment and are not used to the manoeuvres required in the construction of larger boats. They also have a complete lack of knowledge regarding the installation of inboard engines. However, it would appear that in some places in East Africa there are the beginnings of formal training for boatbuilders. The Fisheries Training Institute of Uganda, for instance, runs a four-year boatbuilding training course where students are given preliminary training in the construction of boats of up to 9 m in length, powered with inboard motors of between 35 and 110 hp. It would appear that such a group of boatbuilders could adapt itself to the construction of considerably larger boats.

The other problem lies in the training of simple fishermen to operate these more sophisticated vessels. They would have to be trained in the handling of the boats and in the operation of new fishing gear as well as other deck machinery. Shore facilities would also have to be provided, such as cold rooms, ice plants, etc., to allow for the handling of larger quantities of fish that would be landed.

MATERIALS FOR BOATBUILDING

While on this subject, it is important to consider some other aspects that are involved in the production of these fishing boats, and one of these concerns boatbuilding materials. While smaller boats have been successfully constructed from timber, the building of larger boats creates problems in that high-quality timber would be required, which would last for a sufficiently long period of time in order to repay the investment involved. In East Africa, the best type of timber for these trawlers would be Muvule (Chlorophora excelsa). However, this type of timber is very heavy and this might prove a problem in building the larger boats, apart from the fact that this particular timber is widely used in the manufacture of high-class furniture which would make the cost of each boat somewhat prohibitive. Experiments are being carried out with other types of timber, such as Mululu (Chrysophyllum perpulchrum) and Muninga (Pterocarpus angolensis), and serious consideration is being given to the use of pressure-impregnated timber but so far no conclusive results have been obtained. As the populations of East Africa are growing and settlements are rapidly encroaching upon the forests, the future of boats constructed from timber would not, therefore, appear to be very bright.

It is for this reason that we must look to alternative sources of materials for construction of these boats, and two possibilities come immediately to mind: fibreglass and ferro-cement. Fibreglass has the advantage that, if properly maintained, a boat made of this material will last almost forever. However, at the present moment no boatbuilders in the East African region have the skill to construct such fibreglass boats which would require intensive training before the boats could be constructed. The main disadvantage of fibreglass boats is that the materials would invariably have to be imported from overseas, which would raise the cost of each boat beyond the reach of most fishermen.

Boats constructed from ferro-cement would appear to offer a better alternative, since cement is locally available within East Africa and it would only be the reinforcing materials that would have to be imported. Ferro-cement boats, like those made of fibreglass, also have the disadvantages of being completely new to East Africa, and boatbuilders would need to be specifically trained in this type of construction.

FINANCE

A discussion of new types of boats and the exploitation of fishery resources in the eighties would be incomplete without an examination of the sources of finance to enable fishermen to acquire these new boats.

As mentioned earlier, the East African fisherman is an independent person, who has bought his own fishing vessel at very low cost and who, in most cases, has not had to raise the full amount of the cost of the vessel himself. Such boats have been estimated to cost between EA Sh. 300 and EA Sh. 500. The new fishing trawlers would be in the price range of EA Sh. 80 000 to EA Sh. 100 000 each, excluding the fishing gear to be used on such boats. At the present time, it would appear that no single fisherman in the East African region could produce sufficient cash to acquire such an expensive type of boat.

Due to the fact that fishing in East Africa has been a part-time occupation for so long, it has been difficult to assess the actual income of fishermen over a period of one year. This has made it almost impossible for fishermen to establish a regular income for themselves, thus enabling a financial organization to treat them as credit-worthy. It is, therefore, important that new systems of financing fishermen be investigated, by which loans or credit facilities could be extended to fishermen to allow them to acquire the necessary funds to purchase these larger boats.

It should also be realized that most of these fishermen are simple people, who lack a knowledge of business administration. Experience in some East African countries has shown that where credit facilities have been extended to fishermen, they have failed to repay the loans, not necessarily because their fishing businesses could not provide sufficient cash for the repayments but simply because such businesses have been badly administered, and any profit obtained used for their personal satisfaction.

One possibility of enabling at least a few progressive fishermen to own the larger types of boats would be through a subsidy scheme such as that operated in Uganda, where a fisherman is assisted with a subsidy to the extent of one third of the total cost of the boat, to enable him to acquire an improved vessel.

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Session VI FUTURE DEVELOPMENT
Paper VI/2

# Problems of mechanising fisheries in East African lakes

by

F.B.N. JACKSON

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

The need for constructing larger fishing boats, as exemplified by the existence of this Training Centre, carried with it many implications, not least of which is the recognition of the necessity for larger boats and more efficient methods of fishing than have been carried on in the past. It implies almost a revolution, with problems inevitable with all industrial revolutions. The Industrial Revolution which took place in Europe 150 years ago brought with it problems, both human and social in the moving of large sectors of the populations from rural to urban areas, and technical in devising the new machinery and methods needed for the new era. In the same way, a fishing revolution, in the catching of fish by mechanized methods, will bring both social and technical problems with it.

In the past, while several methods of fishing have been used in African fresh waters, only three to date have been of real commercial importance in most areas. These are gillnetting, longlining and beach seining, and of these gillnetting is, in African lakes in general, by far the most important, accounting for more than 90 percent of the catch value. This is despite the fact that, unlike longlining and seining, which are much older methods, being for example already in existence on Lake Malawi (Nyasa) when Livingstone first saw the Lake in 1859, gillnetting was first introduced into Africa as recently as 1905 (Jackson, 1971). Gillnetting is a simple method of fishing, easy to learn and requiring only a small investment in equipment and gear. On the other hand, mechanized fishing (which may be defined as fishing where the gear is hauled by powered winch instead of by hand) is costly, requiring a large investment in boats and landing facilities and is much more difficult to learn.

Because of its simplicity it has been possible for very large numbers of people to establish themselves in the trade of fishing using gillnets, seines and longlines. Thus on many lakes, Lake Victoria for example, there are fishing villages or fish landing beaches being used at very short intervals, there being often only a few miles between each along the lake shorelines.

To discuss the advantages and disadvantages of these methods, it can first of all be said that advantages are quite considerable. This is due to the cheapness and simplicity of the gear, and which concerns us more at this Boatbuilding Centre, the inherent advantages of simple canoe-type fishing vessels. The two great advantages of native canoes are the low first cost and their ability to be beached on landing. This facility makes for numerous small landings simply on the beach, these needing no costly capital construction such as wharves or jetties. Even access roads are not essential, as the catch, either fresh or dried, can be transported by head-load or bicycle. Such small-scale camps, as mentioned above, repeat themselves innumerably around the shoreline of many lakes, and their simplicity militates against mechanized craft entering the gillnet fishery. To haul gillnets by powered drum means much greater capital cost of vessel and facilities; to ensure profitability the catch must be high, requiring a large vessel which in turn requires the large cost of a jetty to lie alongside, a cold store to preserve the large catch until sold or processed, and a good access road to enable trucks to bring in supplies and transport the catch. It is very probable that the mechanized gillnetter cannot profitably compete against the canoes. Thus, because of the low establishment cost the gillnet/longline/canoe fishing technique provides a livelihood for many thousands of otherwise perhaps unemployed people, an advantage which, for economic reasons if no other, is unlikely to be eliminated by large mechanized gillnetters. From a marketing point of view, the system also has its advantages insofar as the widely scattered points of landing greatly facilitate the distribution of the catches to consumers in the neighbouring hinterland without the necessity for elaborate and costly road systems, with garages, refueling points for vehicles, bridges, etc.

It has been said above that a mechanized gillnetter cannot profitably compete against the canoes and when the above additional advantages of a canoe fishery are considered, one may be tempted to wonder whether it is in fact necessary at all to change such an apparently satisfactory system. However, the system has its disadvantages as well. Gillnetting is by and large an inefficient method of fishing, in using much manpower for low returns. It is essentially an inshore, sheltered water method and because of this it may raise the threat of over-fishing of certain species, particularly Tilapia, because it often takes place near nursery grounds. Above all it cannot, in bodies of water of any size or depth, yield by itself the total harvest of which the water is capable. The canoes are not seaworthy enough, do not go out far enough, and do not bring back big enough catches. Beach seining, too, is at once inefficient in exploiting only the immediate shoreline area and at the same time very likely detrimental to a Tilapia fishery, almost the most commercially valuable of all fisheries of the region. Tilapia is an inshore fish with an elaborate breeding behaviour, using courtship displays and the construction of often elaborate nests in which to rear the young in the early stages. A seine net may interfere with this process by dragging over and flattening out nests, interfering with pre-breeding courtship behaviour and taking brooding females with eggs and fry in the mouth. There is considerable evidence that any reduction in beach seining, such as caused in the last decade in many African lakes due to unprecedentedly high rises in lake level, flooding the seine beaches, has proved beneficial to the Tilapia fishery. For these reasons it is desirable to introduce mechanized fishing using larger boats, but the difficulties that the mechanized fishery is up against, particularly in the early stages as outlined above, must be clearly understood if the venture is to be a success.

While the mechanized gillnetter cannot, as previously mentioned, profitably compete against the canoes, a trawler or purse seiner can compete. This is because it will in a short time, and from further away, greatly exceed the catch of a large number of canoes whose gillnets require sets of approximately 14 hours to bring in very much smaller catches. In other words, the present methods of fishing do not yield very much per man-year. One canoe with a crew of three men will catch, on the average, about 6 tons of fish per year. Compared with modern fishing methods this is very little indeed. A modern fishing trawler, for example, also with a crew of three men working on Lake Victoria, might easily catch the same amount in a day, but considerations of the high cost of the vessel and shore installations apply. The vessel must be large, which in turn, requires the high cost of a jetty to lie alongside, a cold store to preserve the large catch until sold or processed, and a good access road to enable wheeled vehicles to bring in supplies and transport the catch. For profitable operation, vessel size must be large enough to bring in a large catch per unit time of use.

Such considerations are critical on Lake Victoria where long shore installations such as jetties, cold stores, ice plants, etc., are at present entirely lacking. This prompted the UNDP(SF)/FAO Lake Victoria Fisheries Research Project to calculate that the minimum size of craft, more efficiently and economically to catch a significantly larger amount of fish than the present canoe fishery, is about 11-12 m in overall length with an insulated hold of about 10 $m^3$ to hold approximately 5-6 tons of fish at a time. Ideally, such a vessel with a crew of four or five would catch 6 tons of fish at an average of 300 kg/hour in 24 hours continuous fishing, say 60 hours practical sea time. Using the data of Whiting (1969), an average daily catch of 16 kg by one-sail power craft carrying 60 gillnets totalling 3 000 yd of hung length in 20 hours practical sea time, it would take approximately 125 canoes with a crew of 375 men to catch this quantity of fish in the same time. They would, however, need no jetty and as 6 tons of fish can be handled by bicycle or head-load at a 120-canoe fishing camp in two and a half days, they would need no ice plant or cold room, or no access roads.

These criteria encourage the belief that, under prevailing conditions, the "next size up" from the native canoe is a vessel 40 ft long. Nothing in between is economically practicable in the first stages of a breakthrough into mechanized fishing. But there are, of course, other considerations, the most important of which is the need to increase greatly the present catches to provide additional animal protein, to distribute it more widely and to increase its quality. For this reason fleets of about 15-20 trawlers as a minimum are envisaged as being economically viable units for Lake Victoria, catching enough fish (500 tons per annum each) to justify the cost of erection of the presently non-existent shore-side facilities essential for their use.

The trawler of approximately 12 m in overall length which is being constructed at this Centre follows very largely as a result of the above considerations. It is also the result of other considerations, some of them human, i.e., to do with the crew to run her, and technical in regard to the details of construction and equipment. From the personnel side it was necessary, as is usual in many developing countries, that the vessel itself in general, and its equipment and gear should be as simple as possible to operate in view of the present lack of expertise in any field of mechanized fishing or of larger vessel construction. From the economic standpoint, capital costs should be kept as low as possible. From the technical viewpoint, it was desirable that such vessels, of which this may hopefully be the prototype, could be constructed locally in Africa. To import fishing vessels for a mechanized fishery enterprise from well established boatyards overseas would have the disadvantages both of having to pay foreign currency for the vessels and to lose the employment, job and skill opportunities that the establishment of local boatyards would provide. Because such ships are to be built locally, similar considerations enjoined that local materials be used as much as possible. This ruled out the use of glass reinforced plastic as a construction material since it would all have to be purchased overseas. The present high cost of timber, due to its relative scarcity and its increasing demand for use in the building and furniture trades together with high incidence of dry rot, militated against the use of this material. Because of these factors, ferro-cement was finally decided upon as a building material due to the fact that both cement and sand are locally available and much of the reinforcing metal work is also locally manufactured. Other papers deal with technical details of manufacture of this type of vessel; let it suffice to say that with its very large hold, its simple winch and gantry-type gallows, such a vessel as this holds out every opportunity of providing the medium for the very desirable breakthrough into mechanized fishing on a large scale in African lakes.

REFERENCES

Jackson, P.B.N., 1971 The African Great Lakes Fisheries; Past, Present and Future. Afr.J. Trop.Hydrobiol.Fisheries (in press)

Whiting, P.S., 1969 Costing Study of a Karua *Tilapia* Gill-netter on Lake Victoria. EAFFRO Ann. Rep., 1968. E.A. Community Printer, Nairobi

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# Discussion

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 1972

TRAWLERS AND INFRASTRUCTURE

J.A. CRUTCHFIELD: At this early stage of development of the offshore fishery on Lake Victoria, it is desirable to lay the groundwork for a very close cooperation at every level among the three countries involved. For example, there seems to be a tremendous advantage in having the right of a trawler belonging to one of the countries to land the catch in any of the other countries. There are good reasons to do so - the market will fluctuate and there might be a stronger demand in one country than in another. There are many advantages in regarding the Lake as a whole for production and marketing reasons, but solutions to the problems must be planned for now.

S.N. SEMAKULA: There is generally a good cooperation among the three East African countries in this field but there are some instances where the cooperation could be better. A citizen from Uganda takes out one type of licence and a citizen from another country will have to have a different type of licence. When we go fishing in Lake Victoria, we do not know where the boundaries between Uganda, Kenya and Tanzania are, and we hear from time to time about fighting on the Lake between Kenyan fishermen and Ugandan or Tanzanian fishermen. As far as I know, there are no restrictions regarding the landings. A Kenyan fishing boat may land its catch in Uganda and there should be no restrictions regarding landings in any of the countries. This should only be directed by the flow of the market. If necessary, it can be decided that the vessel pays a certain landing charge for the facilities that are used. We might, however, foresee problems when it comes to the establishment of shore facilities for the new development in a regional project. Some decision will have to be taken on where shore facilities will be installed, at least in the initial stage, and here national pride will come into play. If each of the three countries want the same facilities then we no longer have any regional project; we may just as well have national projects.

P.B.N. JACKSON: What is required here on Lake Victoria is some kind of commission that meets regularly and discusses problems and tries to decide on a management policy that creates, as far as possible, uniform rules for the management of the Lake. Such a commission to deal with practical problems in the management of the Lake does not exist at the moment. The East African Freshwater Fisheries Research Organization is limited to research and is therefore not the right medium.

N. FUJINAMI: Has any estimate been made on how many trawlers could operate on Lake Victoria?

P.B.N. JACKSON: The UNDP/FAO Lake Victoria Fisheries Research Project in Entebbe has made a very thorough investigation by biological surveys

P.B.N. JACKSON: (continued)

and by trawling to try to establish the maximum sustainable yield in Lake Victoria. The stock assessment experts have come to the conclusion that a cautious estimate is a doubling of the present catch. The present catch, according to statistics provided by the three countries around the Lake, is around 110 000 t of which roughly 3 000 t are Haplochromis. Most of the increase in the catch will have to consist of Haplochromis, but it would not be realistic to expect a substantial increase by utilizing gillnets. It has been clearly demonstrated that trawling is a very efficient method for catching this type of fish. Market investigation has indicated that a rather small part of this catch increase can be absorbed in fresh form. However, our investigations showed that there was a great deal of fish meal being imported into the three countries for feeding chickens, cattle, pigs, etc. Approximately 1 000 - 1 500 t of fish meal could be easily sold in Uganda alone. This means approximately 7 500 t of fresh fish to 1 t of fish meal. A 40-45 ft trawler would catch approximately 400 kg of fish per hour working 220 days per year giving a total of approximately 500 t per year. If we divide 7 500 t by 500 t we come out with 15 boats. The speed of development of the trawling fishery on Lake Victoria will therefore be determined by the development of the market.

A.S. OBURU:

Some thought should be given to the future management of the trawlers. If the initial project shows success, private investments will come in and might dominate the development, while the fisherman maybe receives very little out of the whole business. Uncontrolled private development might also lead to overfishing of the Lake.

P.B.N. JACKSON:

I quite agree that the development of the trawling industry on Lake Victoria must be managed properly. If it is proven profitable, private enterprise will come in and there might be chaos if the development is not properly controlled. One thing is sure, it will be relatively easy to acquire dependable data on the operation and catches of these trawlers since they will be based in a few major ports around the Lake. Based on the data available, licensing regulations will have to be introduced sooner or later to avoid the depletion of the fish stock. Nobody can at the moment establish a maximum number of trawlers that should be permitted to fish in a certain area. These will, to a large extent, depend on how efficient this trawler is in catching fish. For one thing the size of the boat is not yet determined and only after trying out various types will we be able to determine which size is more profitable. The training of crews for the trawlers will be of utmost importance and, foreseeing the development in this field, there are already plans being made for an extensive training scheme for trawler fishermen. In fact, a mission is arriving very soon to look into this matter and we are hoping that external financing can be ensured to finance the training vessels and the required technical assistance.

J.A. CRUTCHFIELD:

In most fishing countries of the world, a large bulk of the catch is brought ashore by a relatively small but efficient number of operators, using large type vessels, while the rest of the catch is contributed by a large number of smaller fishermen. In any fishery development one has to take both groups of people into consideration and, referring to the situation in Lake Victoria, I am sure also that need for protein created by the increasing population must somehow be brought into the picture. Thirty trawlers on Lake Victoria, I am just taking a number, will employ no more than 150 people directly involved in fishing, and maybe 250 engaged on the shore. This is a very small number of people in relation to the total number of fishermen on Lake Victoria but the contribution these people will make to the supply of much needed protein by landing thousands and thousands of tons of fish is going to be very substantial.

D.D. BEACH:

The problem of providing infrastructure for new fishing fleet development has been mentioned by several participants, and I would like to draw attention to the technology that is used on the Pacific northwest coast of the U.S.A. and Canada. Almost all of the fishing fleet, which is comparable in size to the small trawlers you are talking about here, is serviced from the type of floating dock which is made out of concrete. By floating dock I simply mean a series-produced barge made of ferro-cement. Construction of such a barge involves basically the same method as was used for the 41-ft trawler built here in Entebbe. This is a much more economic solution than constructing jetties and is perfectly satisfactory for the size of fishing boat in question. This possibility is certainly worth further investigation.

P.B.N. JACKSON

The ferro-cement floating barge is an interesting solution to the problem of finding quays for the trawler fleet. Although we do not have a problem of tides, there are long-term fluctuations in the Lake. In 1961, Lake Victoria and most other lakes in the region decided to go up by around 12 ft and as a result all the old jetties made by driving piles of logs had to have an extra 6 or 8 ft added on to them. Good floating docks might well be a very desirable and economical method of dealing with this kind of problem, providing the infrastructure is an important part of developing the new fishery. For larger boats, jetties will be required. You cannot anchor a 40-ft boat off the beach and transport the fish by canoe to the shore. This would be much too time-consuming. Shore facilities will often be of help to the fishermen for a long period of time, and it is a bit hard to request a scheme like the one we are contemplating on Lake Victoria to repay these shore facilities over a period of, say, 10 years. However, in 10 years the boats might well be on the bottom of the sea but shore facilities might last for another 100 years. Provision of shore facilities is a field where Government participation should come in strongly.

J.E. ENGSTRÖM: As a comment on Mr. Jackson's statement, I might explain how FAO is currently evaluating harbour construction schemes in India. The team contrives to find out the most suitable location for the construction of harbours, utilizing a cost/benefit analysis. The benefit of the harbour scheme is the estimated value of the fish exported from this harbour and the fish consumed by the consumers. In the case of shrimp, this is the export price; in the case of fish locally consumed, it is the market price.

The costs are the direct costs to the country excluding taxes, and the evaluation is done over a period of 20 to 30 years, with a rate of interest of around 6 percent. The schemes I have seen so far have quite good returns on capital invested ranging from 30 to 50 percent. This is before the tangible benefits, like employment, health, etc., have been taken into consideration.

There must be a close coordination between the harbour construction and development of the fishing fleet and the market. If this is not done the benefit of the harbour will not accrue as fast as it could have done.

INTERMEDIATE STEPS IN BOAT DEVELOPMENT

Ø. GULBRANDSEN: From the papers and the following discussion, I have the impression that there is general agreement on the one hand that the canoe fishery will continue to play an important role in fishery in the next ten years. On the other hand, the new development seems to be mostly represented by fairly large trawlers operating in the offshore waters of Lake Victoria. In the first case we have an investment of around sh. 1 000, which may be increased to around sh. 4 000 if an outboard motor is used. In the second case, we have an investment of sh. 150 000. I would like to ask the participants where they think there might be an intermediate step between these two investment levels. It is possible that an inboard-powered boat, fishing with gillnets and representing an investment of sh. 15 000, could profitably be employed in the fishery at Lake Victoria, or should this alternative be discarded and the conclusion be made that there is no intermediate step for the fishing boat development on Lake Victoria between the canoe and the trawler in the 40 to 50-ft range?

P.B.N. JACKSON: I think there is room for an intermediate boat that would be a lot cheaper than the trawlers we have in mind at the moment. Such a boat would not fish with the same gear and on the same grounds as the canoes. It will have to catch more fish to cover the increased expenses and it would have to operate offshore and will need shore facilities such as quays, cold storage, etc. I do not think that a scheme consisting of, say, boats around 25 ft with an 8-15 hp engine, will justify the expenses of establishing these facilities. The trawlers, however, are catching fish in sufficient quantity and on a sufficient scale to justify expenses of the infrastructure, but, once the facilities have been established, there is no reason why they should not also be utilized by smaller boats and I then foresee a development in small boat fishing, operating on the same basis as the trawlers.

S.N. SEMAKULA: If a shore base for the trawlers were established in Port Bell, I am certain this would stimulate investment into the fishery from people in the Kampala area and they would probably see a development of a variety of fishing boats, not only trawlers, but also gillnetters operating from this port.

J.A. CRUTCHFIELD: Boats fishing with gillnets will have to operate on inshore fishing grounds. I cannot see that such a boat will fish for Haplochromis in offshore waters. A new fishing boat operating with gillnets will therefore not come as an addition to the canoe but more as a phasing-out of the canoe when the time has come to do so. This is probably going to happen in areas close to the main cities where cost of labour will, maybe in the next ten years, rise to a level where it will make the present type of canoe fishery unprofitable.

N. FUJINAMI: As I mentioned before, half a century ago there were about 400 000 fishing vessels in Japan. Today there are still almost the same number of fishing vessels. This is in spite of the development toward bigger units and high-sea fishing operation. The main reason is that the men practising fishing did not have any other opportunities for work. Over the last 10 years, however, the industry has absorbed a greater part of the labour force mainly from agriculture and fishery. Ten years ago about 40 percent of the Japanese population was engaged in agriculture, including fisheries. Today, the percentage is less than 20 percent. This is, however, only a recent development and for a long time the main problem of the Fisheries Agency had been to protect the poor fishermen and it was well known that this was not an economic problem but mainly a social one. Fifty years ago the fishing fleet consisted of a very small craft not much bigger than the canoes that you are using on Lake Victoria. The first steps toward development were mechanization with inboard engines. The further introduction of modern equipment made it possible to build larger boats and it has lead to today's big factory trawlers. A lot of this development was due to support of the Government. Capital has been concentrated and 30 percent of the Japanese fishing fleet is owned by a few large companies. However, this development left a large number of poor fishermen. Unless the industry is able to absorb the large amount of labour in East Africa, you will have for a long period the problem of the poor canoe fishermen, which is not really an economic problem but mainly a social one.

N. ODERO: It must be remembered that there has already been a development from the present type of canoe toward bigger craft. This we can see on the Kenya side of Lake Victoria where the fishermen are now utilizing bigger boats, and their main problem is in what way they can fit an inboard diesel engine to these boats to extend their radius of action. Here we have a natural development which is supported by the Fisheries Department.

P.B.N. JACKSON: The Kenyan fishermen are already now venturing out in some open water and setting their gillnets outside Mfangamu Island. They are returning to shore and maybe picking up the gillnets two or three days later with the result that much of the fish has gone rotten. We have come across lots of catfish floating on the surface, killed by the gillnets and so this is obviously a wasteful method. This is an area where a mechanized gillnetter with crew accommodation to stay out for several days could operate, and there are also other places where an offshore gillnet fishery could be established.

P. PROUDE: The question of what will be the future fishing vessel for Lake Victoria should be kept open for one very good reason: bottom trawling has been demonstrated to work but we still have to find out what fish can be caught in mid-water and near the surface. This work, I hope, will be carried on by the Fisheries Project in Jinja if we have the anticipated extension of the project. We cannot, therefore, at this stage, lay down what is going to be the ideal deck arrangement for a fishing boat on Lake Victoria. We may have to have combination vessels which will make possible trawling and purse seining or trawling and gillnetting.

Ø. GULBRANDSEN: Do you know anywhere else in the world where such a combination boat is used for gillnetting and trawling?

P. PROUDE: I believe on the great lakes in Canada a peculiar type of combination gillnetter/trawler was utilized. However, I do not think we should copy the deck layout of these boats as they were designed to operate in a different climate and conditions.

J.A. CRUTCHFIELD: Although we have many examples of combination trawler/purse seiners, I do not know about any cases where gillnetting and trawling are done from the same boat.

D.D BEACH: In the coastal waters of Florida small inshore vessels around 30 ft are trawling for shrimp part of the year and gillnetting for the rest. The number of these boats is very limited.

C.C. TAIT: Gillnetters should have the wheelhouse aft so that the helmsmen have a clear view of the hauling operation and the hauling is carried out with the vessels going slowly ahead. Since the ideal layout for a trawler is with the deckhouse forward and clear working deck aft, it seems that it is difficult to achieve a satisfactory deck arrangement that will suit both trawling and gillnetting. The deck layout for a combination of purse seining/trawling is easier to achieve.

**Ø. GULBRANDSEN:** From the discussion I think we can draw the conclusion that a combination gillnetter/trawler does not seem to be a reasonable proposal for Lake Victoria and that boats in the future will be either 100 percent trawlers, maybe with a possibility of purse seining, or 100 percent gillnetters.

Can the past experience indicate approximately what type of improved gillnet boat will be suitable for Lake Victoria? Experimental fishing has been done with a 32-ft aluminium gillnetter from Canada fitted with a hydraulically driven drum. What has the experience been so far with this boat?

**S.N. SEMAKULA:** The 32-ft aluminium gillnetter was intended for catching Haplochromis with gillnets. This did not work out well because the Haplochromis got entangled in the net and too much time was wasted in clearing the nets when hauling. Even though the nets can be set out very quickly, the hauling operation took a very long time. Later, trawling has proved to be a more efficient way of catching Haplochromis.

**C.C. TAIT:** The deck layout of the 32-ft mechanized gillnetter could be improved. The hydraulic drum is placed too far aft and there is not enough working space between the drum and the stern of the boat.

Personally, I do not think that sufficient experience has been gained with mechanized gillnetters on Lake Victoria setting long lengths of net.

**Ø. GULBRANDSEN:** Even though the experience with the 32-ft mechanized gillnetter has not been successful, are there any indications that mechanized gillnetting could be profitable on Lake Victoria or on any of the other East African lakes?

**J.A. CRUTCHFIELD:** Since the fish caught by gillnets are mainly found in inshore waters, I fear that a mechanized gillnetter will have to work in competition with inshore canoe fishermen. I doubt very much that, on the cost basis, such mechanized gillnetters would be able to compete with canoe fishermen, taking into account the very high investment needed for the bigger vessel and the mechanized hauling equipment.

**P. PROUDE:** I think this might be true for Lake Victoria but for other less exploited lakes in East Africa they might work very well indeed. However, competing on the same fishing grounds and in the same markets as the canoe fishermen might cause social problems.

**M.M. MAIE:** The mechanized gillnet fishing boat seems a rather big and expensive craft. Is there any possibility of bringing this boat within the financial grasp of the small fishermen?

A.P.J. HOLNESS: I do not think that this boat was meant for the individual fisherman; it would have to be run by cooperatives or companies.

C.C. TAIT: There is no doubt that the gillnets utilized by the fishermen here on Lake Victoria could be improved upon. These nets are not very efficient.

A.P.J. HOLNESS: It is my impression that the gillnets utilized by the fishermen on Lake Victoria are fairly efficient and I do not think that any expert on gillnetting would be able to improve on the construction and the hanging of the nets. I think that the catches are very high in relation to the amount of fish available in a certain area.

C.C. TAIT: I would like to take Mr. Holness down to the nearest fish landing and show him that there are obvious faults in the construction of the gillnets utilized. The weights for example do not give an efficient hanging of the webbing. These things definitely can be improved upon. If you hang your weights from 4 to 5 m apart you are bound to have an uneven hanging and therefore an inefficient net. On the average, the nets are not maintained very well, but this is probably due to economic considerations. The nets are made of very fine twine and are therefore cheap; it might be more economic to use the net until it is worn out and then replace it with a new one.

S.N. SEMAKULA: I think we must make a distinction between the inshore gillnet fishing and the type of gillnet fishing we are talking about now, namely, mechanized fishing in offshore waters where nets as long as 3 mi will have to be set and hauled. With this type of advanced gear it will be necessary, for example, to replace stones with lead. These nets will also have to be maintained properly. At the moment the fishermen are not doing any repairing of their nets at all. They set their nets even when they are full of gaps and holes.

P. PROUDE: The type of deck layout for gillnet fishing boats, as proposed by Mr. Illugason and Mr. Tait, would undoubtedly be a great step forward from what is generally practised in this fishery. Even though it might seem radical, I believe that this deck layout or something very similar will be used on future gillnet fishing vessels. I believe that once we can get the right type of vessel here on Lake Victoria, it would be relatively easy to demonstrate the possibilities such a boat has in offshore gillnet fishing.

J.A. CRUTCHFIELD: What kind of compromise in the general arrangement of gillnet fishing boats will be necessary to make it possible to also perform a general type of fishing?

**C.C. TAIT:** This is a question which is difficult to answer without knowing specifically what alternative fishing gear would be utilized, how much of the year one would fish with a different type of fishing gear, etc. It is the opinion of Mr. Illugason and myself that for Lake Victoria the idea of having a gillnet fishing boat arranged also for other types of fishing should not be pursued.

**J. LAYN:** In the U.K. it is normal for a trawler of around 40-45 ft to be operated with a crew of 3 men. It would simply not be economical to have more people on board.

**C.C. TAIT:** I think the level of salaries in East Africa is such that it allows us to have a crew of 5 men on board.

**P. PROUDE:** You can either go in for a highly sophisticated operation with as much mechanical or hydraulic equipment as possible and thereby reducing the number of crews, or you can try to keep the amount of mechanical equipment to a minimum and go, rather, for more labour-intensive methods. I think that we should follow to a certain extent the second line in the trawler development on Lake Victoria, having regard to the countries' need for higher employment.

**C.C. TAIT:** Does the Fishery Research Unit in Jinja have on its programme a project for experimenting with smaller fishing boats and types of gear other than trawling and purse seining?

**P.B.N. JACKSON:** We have not done very much in this field since we have mainly been working with exploratory fishing over the whole Lake area. We have experimented with a two-boat trawl, 2 canoes fitted with outboard motors and this worked very well provided that the bottom was smooth and the operators possessed the required skill.

**C.C. TAIT:** It is all very well to say that in 1980 there is going to be on one side a canoe fishery and on the other side a highly developed trawl fishery. There must be room for some intermediate development away from the present canoe fishery which is very restricted to inshore waters toward somewhat bigger boats and more sophisticated gear. Pilot projects should determine what type of gear and what type of boat this could be.

Appendix 1

# Participants in Seminar for Fisheries Officers

(22 to 27 February 1971)

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