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Ferrocement Fishing Boats: Their Potential for Small-to-Medium Scale Fishing in Lake Malawi

by

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The Contents of this paper do not necessarily represent the opinions of Appropriate Technology International or the government of Malawi.

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INTRODUCTION

This technology assessment reports on the experience of a ferrocement fishing boats demonstration project of the Malawi Fisheries Department funded by Appropriate Technology International. The project was concerned with the (1) production and dissemination of ferrocement fishing boats in the northern portion of Lake Malawi, (2) comparison of alternative propulsion methods for these boats, and (3) carrying out of fishing trials using these boats with alternative types of fishing gear. Although the results were mixed for the project area, some useful lessons were learned about these technologies and about the design and implementation of appropriate technology projects in general. Moreover, these technologies may have a significant replication potential elsewhere.

Part I of this report begins by discussing the origins and objectives of the project, its geographic and socioeconomic context, and the nature of the fishery resources in the project area. It then examines the reasons for the need for larger boats as a supplement to traditional wooden, dugout canoes, and the choice of ferrocement as the material for the boats instead of wood, steel, or fiberglass.

Part II discusses the achievements of the project and implementation problems in production and dissemination of the boats. It includes a description of the boats and their construction process. Special attention is paid to durability and safety issues. Three propulsion methods (sails, outboard motors, and inboard motors) and three fishing methods (gillnets, longlines, and purse seines) for the ferrocement boats are assessed.

Part III compares the current production costs and prices of two sizes of ferrocement boats, several sizes of wooden plank boats, and dugout canoes. It also looks at maintenance, repair, and replacement costs for these various kinds of boats. Some information on operating costs and current returns to fishing in the northern section of Lake Malawi are included in a preliminary benefit-cost analysis. To date, the financial returns to fishermen have been very much affected by policy issues surrounding the pricing of fish.

Part IV draws conclusions about the appropriateness of the technologies given the capacity and scale of fishing enterprises in the project area. Attention is also given to the replication potential of the technologies elsewhere. Finally, recommendations are made for the future uses of these boats, provision of credit for financing boat purchases, demonstration and extension programs, and relocation of the boatyard.

Origins and Objectives of the Project

The fishing industry is much less developed on the northern part of Lake Malawi than on the central and southern waters. As a result, the Government of Malawi places a high priority on development of the northern fishery. A necessary condition for this development is further research to find out what fishery resources are available in the north and the best ways to take advantage of them.

As a follow-on to a similar project in the central part of Lake Malawi, the government began to seek funding in the early 1980s for a northern region fisheries development project. This proposal for a five-year project includes a commercial stock assessment of four major and two minor fisheries in the north and the development and dissemination of suitable fishing gear and craft.

Since the sea conditions of the lake are significantly different in the north, it was thought that the kinds of fishing craft used would have to be upgraded to tap new fish resources. The government already had two boatyards for construction of wooden plank boats located on the central and southern lakeshores. Consequently, the Malawi Fisheries Department sought ATI funding for a ferrocement fishing boats project in the north. In mid-1981, ATI awarded a grant of $75,083 for raw materials, plant and equipment, and contractor fees for the project. The Government of Malawi provided some support for staff salaries, facilities, tools and equipment, landing and transport boats, fishing gear, fuel, and housing. However, funding for the broader northern fisheries development project that the boats project was supposed to complement did not materialize during the project lifetime although it may soon be available through the European Development Fund.

The purpose of the ferrocement boats project was to produce and test six boats with the objectives of maintaining a boat building capacity at Karonga and disseminating these boats to small- to medium-scale fishermen on credit arranged through other government programs. A secondary objective was to assess the relative merits of alternative propulsion methods for the boats: sails, outboard gasoline engines, and inboard diesel engines.

Geographic and Socioeconomic Context

Lake Malawi is the twelfth largest lake in the world. It is 580 kilometers (km) long, spanning from 9°30'S to 14°30'S. It extends over 30,800 km of land area and is an average of 475 meters (m) above mean sea level. More than three-fourths of the lake is controlled by Malawi; the rest is considered part of Mozambique. The maximum depth in the northern part of the lake exceeds 700 meters. The salinity of the lake is low at about 240 milligrams per liter and the pH is alkaline.

The topography of the northern part of the lake consists of (1) a flat lakeshore plain in the Karonga district with a gently sloping sandy shore, (2) a precipitious rocky coast south of the plain with mountainous shores rising directly from the water with an occasional beach, and (3) a narrow coastal strip with high land close to the shore south of Nkhata Bay. There are few natural harbors along the shore and deep water is close offshore. The maximum depth of the lake is approximately 750 m; the lake and water levels may vary 3 m per year.

Malawi's population was estimated to be 7,152,000 in 1985. The two districts most closely associated with this project, Karonga and Nkhata Bay, have a population of about 261,700. The whole northern lake region contains about 11% of the national population, approximately 808,000 people. The national population growth rate is currently 3.2%, but there is a high rate of net migration of northerners to the south. Malawi's per capita GDP was M.K. 249 in 1984 and average household cash income is about 80% of this figure (in early 1986, 1 Malawi Kwacha was worth approximately U.S. $0.57). Average household income is roughly the same for Karonga district and the country as a whole (Nthenda 1985).

Fish is a very important food because it comprises 53-70% of the animal protein consumed in Malawi. The per capita meat consumption is among the lowest in the world, 5 kg per year (FAO Investment Centre 1982). In 1981-82, 27% of the children in Malawi were considered malnourished; the proportion was 24% in Karonga district. About 40% of Malawian children die before their fifth birthdays and malnutrition is a major contributing factor. Yet, per capita fish consumption in Malawi is only 14.4 kilograms (kg) per year and it is just 5.2 kg per year in the north (Schroedter 1982; Landell Mills Associates 1983). This difference is mainly due to availability because cultural preferences toward fish consumption are similar in the north and south. An increase in the supply of fish in northern markets would probably increase per capita fish consumption there to the level found in the south.

Fishing is also an important occupation around Lake Malawi. In 1984, 19,787 full-time or part-time fishermen using 6,220 operable fishing craft were counted at 606 sites throughout the country. The two northern lakeshore districts contained almost 26% of the fishermen and 31% of the fishing craft in the country, but these are mostly the smallest scale operations (Alimoso 1985). About 90% of the total fish catch in Lake Malawi is by traditional fishermen and only 10% by commercial fishing enterprises.

About 38% of fishermen in the north own their own craft and gear compared to 26% nationally, but the northern fishing enterprises generally are more marginal. Nationwide, 76% of the operable fishing craft were dugout canoes, 19% were wooden plank boats without engines, and 5% were plank boats with engines. In

the north, 99% of the craft in use were dugout canoes and 1% were plank boats mostly without engines (Landell Mills Associates 1983). Purse seining and chirimila netting require the use of two boats.

The average number of gear per owner-fisherman in Malawi in 1984 was 2.4 gillnets, 0.3 handlines, 0.1 longlines, 0.3 chirimila nets, and 0.1 chambo seine nets. The corresponding figures for northern fishermen were 1.9 gillnets, 0.2 hand lines, 0.2 longlines, 0.1 chirimila nets, and 0.1 chambo seine nets. The most important types of gear used on Lake Malawi as a whole, in decreasing order of catch size, are gillnets, chirimila nets, Kambuzi seines, and mosquito nets. The relative importance of the various types of gear is different in the north and it varies from year to year. In Karonga district, 45% of the catch is by chirimila nets, 25% by mosquito nets, 18% by gillnets, 10% by Kambuji seines, and 2% by longlines. Over 41% of the catch in Nkhata Bay district is by gillnets, 27% by mosquito nets, over 23% by chirimila nets, over 4% by longlines, 2% by beach seines, 1% by chambo seines, and 1% by hand lines (Alimoso 1985).

In general, the fishermen in the north are more spread out over a larger number of less productive sites which have relatively poor access to roads and markets. About 90% of the fish caught in the north is consumed within 10 km of the shore and about 62% is consumed by the families of the fishermen (Ibid.). The marketed share is relatively low in the north because the fish catch is smaller, transport is more difficult, and pricing policies are disadvantageous to the fishermen.

Fishery Resources in the Project Area

About 43-50% of the national fish catch comes from Lake Malawi; the rest is from other lakes, rivers, and marshes. Although 50% of the area of Lake Malawi is in the north, the north provides only 14% of the total fish catch of the lake (Landell Mills Associates 1983). The northern waters are less productive because they are deeper than the central and southern waters and are less subject to nutrient upwelling caused by the predominant, strong southeast winds. The open lake is relatively oligotrophic. Few fish live in Lake Malawi at depths below 250 m because these areas tend to be anoxic (FAO 1982). The southern waters produce the largest fish catches, but may be close to the maximum sustainable yield. The central waters have fish stocks that are smaller than those in the south, but larger than those in the north. Some expansion of fishing in the central part of the lake is possible before maximum sustained yield is reached (FAO Investment Centre 1982).

The annual fish catch in the north consists of 1,100 t in Karonga district, 2,000 t in Nkhata Bay district, and 500 t around Likoma and Chizumulu islands. The freshweight equivalent of another 310 t of fresh and dried fish is brought into northern

markets from the central and southern part of the lake. The productivity of the fishing grounds in the north declines around Nkhata Bay from both the northern and southern directions (Landell Mills Associates 1983). Variations in the catch rate among traditional fishermen are large depending on the type and condition of boats and gear, their degree of access to better fishing grounds, and amount of labor available.

The fisheries potential of the northern part of the lake is not completely known. As a rule of thumb, the maximum sustainable yield of fish in Lake Malawi is 45% of the standing stock (Tweddle 1982). Limited data indicate that the potential incremental catch in the north is 2,110 t per year. About 56% of this additional catch would be from large-scale deepwater bottom trawling, 24% from near-shore resources beyond the range of traditional craft, 19% from extending the existing traditional fishery, and the rest from trapping crabs and catfish. Even if only half of the expected incremental catch can be tapped, this could provide an additional 1,100 t of fish per year which is a 30% increase over the current catch (Landell Mills Associates 1983).

Fresh fish must be sold on the day it is caught because of the lack of cold storage facilities. Traditional fishermen do not use ice on their boats, beach landings, or in transport and the fish sold in public markets is not stored on ice. The beach demand for fish is roughly stable, but the supply is variable. Any amount in excess of the daily demand must be sold at a low price or dried. Traders must charge a high retail markup on fresh fish because they bear the risk of spoilage. Although the markets are closer to the beach landings in the north, transportation costs are about the same as in the rest of the country because of poorer infrastructure. Fresh fish are only available at a few inland locations since roads are often poor in fishing areas and vehicles are hard to come by. Small amounts of fish are carried by hand, bike, or on small vehicles and sanitation and quality standards are low.

The retail price of fresh fish is higher in the north than in the central and southern parts of the lake, mainly due to high markups between the beach and the lakeshore communities. Despite the higher retail prices, fishermen in the north receive a lower beach price for fish than those in the south due to local government price controls. As a result, there is little incentive to expand fishing effort in the north. An increased catch would also require improvements in marketing and transport. Yet, in the current economic plan, the fisheries sector is allocated only about 0.7% of government expenditures (Landell Mills Associates 1983).

Nationwide, about 39% of the fish catch is sold fresh, 36% is dried, and 25% is smoked. Because less fresh fish is sold in the north, a higher proportion is dried or smoked, 85% (Ibid.). Most of the fish caught in the north is dried at the landing by women in fishing families because much of the profit in the

fishing trade in the region is in drying and transport. By contrast, fishermen in the south often sell fresh fish to male traders who resell it in bulk or process it. The demand for dried fish is relatively constant in inland markets. Dried fish is sold by the piece making price comparisons difficult for consumers. Dried fish is about twice as expensive in the north than in the rest of the country.

Fish is sun-dried by spreading it out on the ground, straw mats, or wooden racks in the open air. Small fish sometimes are held on strings and larger fish are split before drying. In the rainy season, it is difficult to dry fish and drying can take 3-4 days for small fish (Schroedter 1982). About 4 kg of fresh fish are needed to produce 1 kg of dried fish by traditional methods. If improved smoking kilns are used, the ratio can be reduced to 3.5 to 1 and the quality of the product would be better so that it could command a higher price. Dried fish has a shelf life of several weeks to a few months. Although salting could extend the shelf life, salt is rarely used in drying fish in Malawi because it is expensive and most people are not accustomed to the taste of salty fish (Disney 1974).

Lake Malawi contains a large number of mostly small fish. **Pelagic** fish live in the upper part of the water and are often active during the day. **Demersal** fish are bottom-dwelling, and tend to be easier to catch than pelagic fish because the latter are more dispersed, and the gear has to operate vertically as well as laterally.

The most important fish caught in the north is *Haplochromis sp.*, a group of small cichlids that is usually pelagic and caught with chirimila nets. The most important economic species in the south is *Oreochromis shiranus*, which forms large shoals and is caught in beach seine nets. *Engraulicypris sardella* is a tiny, high-valued fish usually caught in purse seines, mosquito nets, scoop nets, or beach seines and sold dried. *Bathyclarias sp.* is a large catfish which is caught in gillnets and longlines. *Bagras meridionalis* is a large catfish that can be smoked for the upper income market if the appropriate equipment is available. This fish is caught in longlines or bottom-set gillnets. *Opnoridium microlepis* is a high-value cyprinid that is seasonally important, but becoming scarce. *Rhamphochromis sp.* is a medium-sized fish that is smoked whole. *Lethrinops sp.* is a medium-valued fish that dominates the catch from deeper waters and although it is scarce in the north now, it could become more available with deepwater trawling.

The largest potential for increasing the fish catch in the north is for small pelagic fish, offshore pelagic catfish, and offshore demersal fish; however, the potential pelagic resources there may be less than was previously thought (FAO Investment Center 1982). In addition, a large number of other species that are not currently used commercially exist in the lake, but most are low-value or little information is available on their life histories.

The Choice of the Scale of the Boats

At present, nearly all of the fishing boats on the northern part of the lake are dugout canoes. A dugout canoe is scooped out of a single, straight, unburned tree trunk. A dugout has a triangular cross-section; the bottom is thicker than the sides and the sides taper up in thickness. The shape curves inward so that the opening at the top is narrower than the canoe's beam. Occasionally, a wooden brace connecting the top sides is added. Most dugout canoes in Malawi range from 2.0-8.0 m in length and 0.4-1.0 m in width. Due to the increasing shortage of suitable wood, new dugout canoes are becoming smaller and misshapen. Canoes are usually paddled with a long wooden oar or a pole. Sometimes, a fisherman sits astride the canoe and uses his feet as flippers (Landell Mills Associates 1983).

Wooden plank boats began to be accepted in Malawi in the 1940s. FAO provided design and training assistance for plank boat construction in Malawi in the early 1960s. These are open boats without a deck. Most plank boats in Malawi are between 5.2 and 5.8 m in length, but a few 7.6 m plank boats are built for the southern part of the lake where the waters are relatively calm. Only a small number of wooden plank boats are in use by fishermen in the north.

Two types of plank boats are made in Malawi. V-bottomed plank boats can travel faster than flat-bottomed plank boats which is an important advantage when fishermen are trying to return to the shore quickly to escape rising winds. However, flat-bottomed plank boats are more stable under calm lake or shallow river conditions. They also offer more working space for gillnetting and are easier to construct using simple templates (Haug 1974).

There are two government boatyards making plank boats in Malawi, one is on the southern lakeshore at Mpwepwe and the other on the central lakeshore near Salima. The Mpwepwe boatyard has some machine tools and predominantly uses carvel construction. The Salima boatyard only uses hand tools for seam batten construction. In 1984, the Mpwepwe boatyard made 2 small clinker boats for transporting fishermen to larger boats, 12 flat-bottomed plank boats, and 10 V-bottomed plank boats. Those plank boats ranged in length from 4.6 to 7.6 m (Saiti 1985). In 1984, the Salima boatyard produced 26 V-bottomed boats ranging in length from 4.3 to 6.1 m (Bandula 1985). In addition, a small number of cheaper plank boats are made by private individuals along the central and southern parts of the lake.

Dugout canoes and other small fishing craft are at a serious disadvantage on Lake Malawi for three reasons. First, a dugout canoe has a limited range of less than 1.0 km, compared to about 8.0 km for one of the ferrocement boats. The distance to shore is critical for a dugout canoe because the fishermen have

to be able to paddle to safety if the weather turns bad. In the northern part of the lake, deep waters are located close inshore (Seymour 1985b). As a result of the limitation on distance from land, a dugout canoe can only fish in waters shallower than 100 m in Lake Malawi, yet commercial stocks of fish are available at depths of 200 m in the lake (Tweddle 1985).

Second, the fishing season is very short for a dugout canoe because it cannot go out when the dry season winds make the waters rough. Since a dugout has a low center of gravity, it is easily waterlogged and prone to sinking. Safe fishing requires waves below a certain height which varies by type of boat. The maximum wave height is about 0.9 m for a dugout canoe; 1.2 m or so for an average-sized, wooden plank boat; 1.8 m for a 5.6 m ferrocement boat; and 2.1-2.4 m for a larger steel boat. The waves on Lake Malawi are highest during the dry season because of the wind patterns. Although catch rates are usually better in the rainy season, fish processing and trading are easier in the dry season. Only 120 days per year are fishable in a dugout canoe, compared to 300 days per year in the ferrocement boats (Seymour 1985b).

Third, a dugout canoe has much less working space than a plank boat of the same length. The crew size on a boat depends on its capacity, the fishing method used, and, to a lesser extent, the availability of labor. The ferrocement boat designs built under this project have a much bigger carrying capacity than a plank boat of the same length. A 2.1-2.7 m dugout canoe holds a crew of 3-4 fishermen, compared to 4-6 fishermen in a 4.6 m canoe or a 4.3-4.6 m plank boat, 8-12 fishermen in a 4.9-5.2 m plank boat, 10-20 fishermen in a 5.5-6.1 m plank boat, and 20 or more in a 7.6 m plank boat (Bandula 1985; Saiti 1985; Seymour 1985b). The length of gillnets that could be operated by the crew of these various boats ranges from 275-730 m in a 1.5-2.7 m dugout canoe, 915-1,100 m in a 5.2-5.8 m dugout canoe, 1,830 m in a 5.8 m plank boat, to 3,660 m in a 5.6 m ferrocement boat. Thus, a 5.6 m ferrocement boat can catch much more fish per fishable day than a canoe or plank boat (Mzembe 1985; Saiti 1985; Seymour 1985b).

The Choice of Boat-Building Material

Wood

Wood has many advantages as a material for boats. Since wood is light in weight per unit volume, wooden boats are strong and easy to handle. Wood can be worked with simple tools without the use of complicated molds. It is easy to bend into shape, is elastic under impact unless fractured, and is easy to join through nails and screws. Wooden boats resist abrasion from repeated handling across sandy and rocky beaches, and are easy to repair (Plumptre 1971).

Wood also has some disadvantages in boatbuilding. It swells when wet and shrinks when it dries. This is a serious problem in a boat although it can be reduced by waterproofing and use of low movement timber species and correct construction techniques. A wooden boat must be painted frequently. Wood is susceptible to rot caused by fungus and attack by insects and borers. The lifetime of timber is much shorter in the humid tropics, commonly 4-5 years for a durable species. Chemical preservatives can extend the lifetime, but are expensive and toxic to workmen, and some local species of wood such as Albizzia lebbek and Chlorophora excelsa are relatively impermeable to preservatives. Plywood rots quickly in Malawi.

Wood lacks uniformity because it splits along the grain and is stronger in some directions than in others. Plywood is perpendicular to the grain direction of the laminae, but is subject to other difficulties, particularly in joining it together. It takes a long time to season wood -- 2-4 months of air drying. Kiln drying in 1-2 weeks is possible, but these facilities are not widely available in developing countries (Plumptre 1971). The construction of wooden hulls requires considerable skilled labor for handling of tools and fitting together the many pieces of the hull (Fyson, Gulbrandsen, and Haug 1973). Suitable timber for boatbuilding is often scarce (Sutherland 1972). Wooden boats also require a lot of labor for maintenance (Sannergren 1976).

In the early 1980s, the government of Malawi became increasingly concerned about the future availability of high-quality timber for boatbuilding. Small canoe makers also began experiencing difficulties in obtaining satisfactory hardwood boles needed for large canoes. The government decided to investigate the feasibility of ferrocement as a substitute for wood in larger boats since cement is domestically produced. Over the past five years, increases in the price of wood have been more of a constraint than its availability because less-desirable species have been substituted.

Malawi has 866,000 hectares (ha) of usable forest cover which is only 9.2% of its total land area. Another 11.1% of the land area is composed of national parks and game reserves, but these sites have too few trees to be worth harvesting commercially and logging is prohibited there. About 29.0% of the land area is unreserved brush and scrub vegetation which does not provide useful boat timber. The cultivated area is increasing 3.5% per year, largely at the expense of the area of brush and scrub. The 495,000 ha of stocked forest is already being selectively harvested. About 146,000 ha of closed forest is topographically inaccessible or reserved for protection of land or water resources (FAO/UNEP 1981). To date, no inventory of the composition of natural forests has been conducted in Malawi (Sakanda 1985).

The best tree in Malawi for boatbuilding is Mulanje cedar (Widdringtonia nodiflora). This softwood timber is very durable and resistant to rot and termites because it is oily. Yet, it is easy to work because it has a straight grain and is relatively free of knots. It frequently is available in lengths of up to 7.5 m and makes excellent planking if seasoned (Nordlund 1975).

In Malawi, Mulanje cedar only occurs naturally in patches of evergreen forest on 140 ha of plateau on Mt. Mulanje at elevations over 2,000 meters (Sakanda 1985). Only dead Mulanje cedar trees may be cut legally from natural stands and it takes about 75-150 years for this tree to reach full maturity and die naturally. The controls on Mulanje cedar cutting are strictly enforced under licenses. Natural Mulanje cedar can be obtained through the Forestry Department, but the Fisheries Department does not receive any priority in the allocations. In recent years, government-owned hotels have used large quantities of cedar for panelling.

About 152 ha of Mulanje cedar plantations have been established on the Zomba plateau and Dedza mountains, and the Forest Department is planting an additional 2 ha per year. These trees are cut live at 40-45 year rotations, yielding 5-9 cubic meters per ha per year. However, the plantation trees grow much faster because they are planted on lower elevations. As a result, the plantation grown wood is much less desirable for boatbuilding because it is softer, has a lower specific gravity, and has more knots.

The increasing scarcity of natural Mulanje cedar is reflected in its wholesale price per cubic foot which was M.K. 2.10 in 1975, M.K. 4.50 in 1980, and M.K. 14.73 in mid-1985, excluding transport costs. These government-administered prices are probably lower than the equilibrium market prices. Per cubic foot, local hardwoods for boatbuilding wholesaled at an average of M.K. 2.10 in 1975, M.K. 3.70 in 1980, and M.K. 5.10 in 1985, excluding transport costs (Wilson 1985). Transport costs to the Salima boatyard currently add another M.K. 1.90 to the cost (Bandula 1985). The increase over the past ten years is not due to labor costs because the wages of sawyers have not gone up very much during this period (Wilson 1985). Over the past 5 years, the price differential between Mulanje cedar and the hardwoods jumped from 22% to 189% as the price of cedar increased 227% while the price of local hardwoods increased only 38%. Because of its higher cost, the government boatyards only use Mulanje cedar now for planks whereas it used to be the main timber for construction of the whole boat (Bandula 1985).

The cheaper hardwood species can be used for boatbuilding, but they rot more rapidly than Mulanje cedar. The following species currently are used by the government boatyards. Chlorophora excelsa is suitable for many parts of boats if properly seasoned and it is still available in the north, but the stocks are becoming depleted. Pericopsis angolensis resists rot well and may be used for the frames, transom, keel, stem, and

seats. It is not a protected species since it is used by the wood products industry and is available in large quantities throughout the country even though it is slow growing. Adina microcephala may be used for the frames. Long pieces of Albizzia versicolor or A. lebbek can be used for the gunwhales. Pterocarpus angolensis is fairly hard and not very prone to movement after it is seasoned although it is susceptible to cracking. The heartwood of this species is durable, but the sapwood can be attacked by insects quickly. It is still available in lengths up to 3.5 m and widths up to 300 mm. The longer lengths are good for planking frames and the keel. It is becoming scarcer because it takes 60 years to reach maturity. Afzelia quanzensis is used for frames because it is dense, fairly durable, and available in long lengths, but its silica content makes it hard to work. Cordyla africana is common, dense, and durable as backbone timber or boat seats. However, it is brittle and hard to work and is susceptible to warping if not seasoned properly. Pseudolachnostylis maprouneifolia may be used for boat seats (Nordlund 1975; Bandula 1985; Sakanda 1985; Wilson 1985).

Other indigenous species could be used in boatbuilding as well. Khaya nyasica has a medium density, is not too hard to work, and is available in long lengths. However, it often has interlocking grain and is not too durable. Sterculia quinquiloba is of minor use in boatbuilding, but it is common along certain rivers and outside forest reserves throughout the country. Plantation grown Eucalyptus sp. are abundant and cheap, but season poorly and are little used in boatbuilding except for masts (Nordlund 1975; Bandula 1985).

Trees with the long, straight bole needed for a dugout canoe are becoming harder to find. Local canoe makers use a large number of hardwood and softwood species including Khaya nyasica, Pterocarpus angolensis, Chlorophora excelsa, Acacia albida, Terminalia sericea, Adina microcephala, Cordyla africana, Mangifera indica, Ficus sp., and occasionally Eucalyptus sp.. Private, local plank boat builders use Pterocarpus angolensis and marine plywood.

Expensive Alternatives

Steel and fiberglass are alternative materials for boatbuilding that are much more expensive than wood or ferrocement. As a landlocked country, Malawi is dependent on other countries for overland transport of imported goods.

Steel is extremely durable and long-lived in freshwater like Lake Malawi although it is susceptible to corrosion in seawater. Construction of a steel boat requires sophisticated metal working facilities with skilled workers and scarce foreign exchange to obtain the metal. At present, steel fishing boats are only used on the southern shore of Lake Malawi by the Government Fisheries Department and by a large parastatal, Maldeco. Maldeco operates

the following steel boats: two stern trawlers (11.6 m and 17.7 m in length), six purse seining boats used in pairs (11.6 m), and five small carrier boats.

The Fisheries Department is doing some fishing trials to determine whether a steel catamaran (a twin-hulled boat with a broad platform stretching between the hulls) would be feasible for a medium-scale commercial fishing enterprise. Catamarans have long been used elsewhere for recreational boats, but their use as fishing boats is relatively new. They do have a large working area which is suited for purse seining. The broad base makes a catamaran less prone to capsize but it can cause problems in slamming into the water under storm conditions. A catamaran does not have to be made out of steel; large ones (15 m or more), could be made out of ferrocement (Jones 1985).

Fiberglass-reinforced plastic is quite popular as a boat material in developed countries, but its expense makes it inappropriate for traditional fishing applications in an LDC. The molds for fabricating fiberglass are costly and the materials which are petrochemical derivatives would have to be imported into Malawi. A fiberglass boat is likely to be more expensive than a steel boat of comparable size. Domestic production of fiberglass boats can be commercially viable only if a large number of identical boats are produced, so there is less flexibility in design with this material. The ingredients are temperature sensitive and pose a fire hazard. Skilled workers are required to build these boats, but production is not very labor intensive. Fiberglass can last a long time, but it is subject to abrasion in repeated handling across sandy or rocky beaches (Gulbrandsen 1971; Plumptre 1971). The unusually low conductivity of the water in Lake Malawi can cause pocking of the surface of fiberglass due to osmosis, but new treatments are available to prevent this problem (Jones 1985).

Ferrocement

Ferrocement is a mortar of cement, sand, and water that is densely reinforced throughout with steel mesh wire and formed into a thin shell. Steel mesh comprises 2-10% of the material by volume. A minimum of two layers of wire mesh is sufficient for the mortar to adhere to the shell which can be as thin as 2-3 cm for some applications if the skeleton is rigid. This mixture becomes a composite material with different properties than the cement or the steel mesh alone. It has a higher tensile strength than ordinary concrete. The ductility of the wire mesh increases the resistance to impact and prevents complete collapse of the structure if it cracks from the load. Ferrocement differs from reinforced concrete which is thicker and contains more widely spaced steel rods to resist tension and shear forces and control cracking from shrinkage (Bigg 1973; Smith 1976).

Ferrocement was first used in the 1840s. A ferrocement boat was patented in France in 1847 by Joseph-Louis Lambot. The material was neglected at first and then rediscovered in the United Kingdom and the United States in World War II following a shortage of steel plates. Pier Luigi Nervi studied the properties of ferrocement in the early 1940s, but it did not become a common construction material in developed countries until the 1950s. The first ferrocement boats were large marine trawlers with western style hulls for commercial fishing. In the late 1960s and early 1970s, FAO prepared designs of ferrocement fishing boats suitable for use in less developed countries (LDCs). Ferrocement is now being used extensively for small-to-medium scale commercial fishing boats, particularly in the Asia and Pacific regions (BOSTID 1973; Fyson, Gulbrandsen, and Haug 1973; Pama, Lee and Vietmeyer 1976).

Ferrocement offers many advantages as a boatbuilding material. It can be fabricated into virtually any traditional boat design or a new design. Unlike wood, it can be formed into complex curves that improve boat performance. As a shell structure, ferrocement accommodates stresses from imposed loads, alternate heating and cooling, and wetting and drying. Ferrocement boats are said to be low cost and easy to to build. Although it is a labor-intensive technology which is an advantage in LDCs, it requires less skilled labor than wooden boat construction. Since cement construction is widely known, little new training is required. The inputs needed are readily available in most LDCs -- chicken wire for the mesh (preferably galvanized) and the same grade of cement used for buildings. A ferrocement boat only needs to be painted for aesthetic reasons. Large investments in plant and machinery are not needed for a ferrocement boatyard, but electricity is desirable. Ferrocement boats can be turned out faster than wooden boats and could even be mass produced in LDCs. It is easy to experiment with different hull designs by altering the molds for a ferrocement boat. By contrast, building a new wooden hull design is much more time-consuming and requires more engineering work and skilled labor.

Ferrocement is a durable material which increases in strength with age. It can have a long life because it is rot-proof and immune from attack by termites or shipworms, unlike wood. It also resists corrosion by freshwater or seawater and can withstand a major fire without damage. Ferrocement boats that have been wrecked on reefs and pounded can survive. Any damage is often localized and repairs are easy to make by chipping off the damaged area, fixing the mesh if necessary, and replastering (BOSTID 1973; Sharma and Gopalaratram 1980).

Ferrocement boats also have some real and perceived disadvantages. Since most small-to-medium scale fishermen are not familiar with this material, extensive demonstration and marketing may be necessary to sell these boats. Laughter is a common response when fishermen are asked whether they would consider using a cement boat because it sounds as if it would

sink. Below a certain size of boat, the life cycle costs of a ferrocement boat would exceed those of a wooden boat. Even where the discounted cost savings from the longer expected lifetime of a ferrocement boat over a wooden boat outweigh the higher capital costs, fishermen might be unable or unwilling to pay the higher initial costs.

The weight of a ferrocement boat frequently is raised as an issue, but this issue is often misunderstood. A boat with a relatively high displacement provides a stable working platform for fishing. In fact, it is often necessary to add extra weight (ballast) on a light-weight boat such as a fiberglass boat or even on a large steel or ferrocement boat to get the hull down in the water and reduce rolling action in the waves (Gulbrandsen 1971). The location of the ballast on board can be varied for maximum stability. A single-hulled, wooden boat of the same displacement as the 7.2 m ferrocement boat would probably have a concrete slab on the keel to keep the boat lower. A boat is marginally more buoyant in seawater than in freshwater due to the difference in the water density.

Ferrocement has a minimum thickness of about 19 mm and this does not need to increase much as the boat's length and width are increased. As a result, large ferrocement boats are proportionally lighter than small ones because the thickness is spread out over a larger surface area. In fact, for boats longer than 16 m, a ferrocement boat is lighter than a steel boat of the same size (Fyson, Gulbrandsen, and Haug 1973). At speeds of less than 3-4 knots (a knot is 1 sea mile or 6,076 feet per hour), the extra weight of a ferrocement boat compared to a wooden boat has little effect on the propulsion effort required (Pama, Lee, and Vietmeyer 1976).

Below a certain size, the weight might be a real problem for a ferrocement boat. Before this project, it was thought that a ferrocement boat had to be at least 9-10 m long to be acceptable. An innovative construction method tested through this project allowed ferrocement boats to be as small as 5.6 m in length. Since, ballast is rarely needed on boats shorter than 6.0 m in length that have a daggerboard, most fishermen in Malawi are not familiar with the handling of a ballasted boat. That is why traditional fishermen in Malawi might perceive that a ferrocement boat feels heavy. The motion of a ferrocement boat should be more comfortable because the weight is distributed evenly through the hull rather than being concentrated as ballast. A heavier boat can be an advantage on rough waters. A lighter boat has the advantage that it can be pulled up on the beach in calm weather.

Quality control is important in construction of a ferrocement boat. If the mortar mix contains too much water, the cement will be weak. Poor mixing will result in shrinkage of the material. Plastering is also critical because exposed mesh can rust. If the mortar has not been cured properly, the compressive

strength will be low and cracking will occur. Small hairline cracks that do not penetrate beyond the outermost layer of mesh are not significant (Sutherland 1972; Bigg 1973).

Ferrocement is subject to certain kinds of damage. It is very susceptible to punching--the localized impact of collisions with sharp or hard, protruding objects such as an anchor fluke, rocks, the stem head of another boat, or bolts at a wharf. Even after one punching, the mesh and broken concrete is usually intact, preventing uncontrolled flooding of the hull (Sutherland 1972). Diesel oil can damage ferrocement so the area around the engine should have a protective coating. Faulty grounding of engines and equipment can lead to rusting of the hulls through electrolysis (Moar 1973).

Ferrocement is resistant to the impact of storm waves if the hull curvature is adequate. It also has fairly good resistance to a force applied evenly across its surface (e.g. being run up on a sandy beach). Watertightness is not a problem for a ferrocement hull.

Project Administration

The project originally was supposed to last one year. Although two years would have been a more realistic time frame, the project ended up taking over four years largely due to administrative difficulties. In particular, the fitting out of the boats took much more time than anticipated.

The project began in September of 1981 with the arrival of the project manager, Christopher Spencer Chapman, a capable boatbuilder hired by the consultants, MacAlister Elliott and Partners Ltd. The plans for the boat designs were provided by that firm. The final designs turned out to be for considerably larger boats than was originally planned in the proposal. A watertight deck also was added to the boats. The increase in the size of the boats increased their cost and the time required to build them, and made the boats less feasible for small-scale fishing enterprises.

Malawi government procedures for disbursement of funds through a revolving advances account caused extensive delays. ATI funds had to go to the Treasury Department which held or misplaced them for excessive periods of time. Since the Fisheries Department did not receive the first release of funds until March of 1982, the limited time of the project manager was not well utilized. In retrospect, the project manager should not have been brought in until the funds were made available. This problem was partly mitigated by the project manager's generosity in staying three months beyond his six-month contract period without being paid his regular rate, and by the project's borrowing of some money from the operating budget of the Fisheries Department's local station.

The Government of Malawi does allow an alternative procedure for directly setting up special funds for donor projects. Although a special fund could have greatly expedited the project's progress, parliamentary approval is required and the Fisheries Department had not applied for the establishment of such a fund. As a result, the Karonga boatyard did not have the financial framework to operate as a commercial boatyard. The boatyard could not set aside funds for depreciation of equipment and it could not have reinvested its profits if it had any.

Similarly, all of the necessary inputs should have been obtained before the arrival of the project manager. Due to the remoteness of the Karonga site, procurement was cumbersome. Transport is poor between the northern lakeshore and Blantyre, the point of entry in the south for imported goods and a center for much domestic manufacturing.

For long periods of time, some raw materials such as marine glue were simply unavailable in the country. At one point, steel purchases were held up by the Ministry of Natural Resources due to an accounting question. The consultants underestimated the requirements for steel rods and overestimated the amount of chicken wire mesh needed. Due to a mistake by the manufacturer, two imported Petter engines arrived incomplete and it took some time to obtain the necessary air duct conversion kits for these engines. The boatyard's timber supply for fitting out the boats eventually ran out. Not all of the time spent waiting for raw materials to arrive was wasted because workers could sometimes switch to doing other tasks, but continuity was lost and this adversely affected motivation.

In addition, the budget turned out to be tight. Under an IMF-recommended austerity program, the government made a large cut in the budget of the Fisheries Department which forced the Karonga boatyard to layoff many workers and to transfer the senior project supervisor to the larger Nkhata Bay fisheries station. A fisheries officer who was inexperienced in boat building was then left in charge at Karonga.

A large percentage of the project's budget went to the British consulting firm, MacAlister Elliott. Some money was saved in the cost of the MacAlister Elliott consultancy due to the increase in the exchange rate for the U.S. dollar relative to the British pound. At one point, the Fisheries Department made a sizeable overpayment to the firm and it took a long to obtain a reimbursement which further set back the project. Some money was also saved because of donations. The Japanese Overseas Cooperation Volunteers organization donated a large Yanmar inboard engine, the British Seagull Co. donated a small outboard engine, and the British government donated the imported material for one set of sails. However, one of the 7.3 m boats had to be stretched to 8.2 m to accommodate the donated engine. Eventually, the money ran out for painting and fitting out the hulls, installing bilge pumps, buying imported sailcloth for the

rest of the boats, and adding auxiliary equipment such as life preservers.

The Karonga boatyard did not have its own facilities. It was set up on land borrowed rent-free from the Karonga Agricultural Development Division (KRADD), an organization now under a different ministry. The boatyard also had to rely on the KRADD for planing of planks and various machining services at cost. At first, this arrangement was satisfactory, but it deteriorated as leadership changed within the KRADD and its mission retrenched from integrated rural development to agricultural development. Later, the KRADD began harrassing the boatyard repeatedly over some bills that allegedly had not been paid even though the Fisheries Department produced payment receipts. It eventually became apparent that the KRADD was trying to force the boatyard off the site.

Chapman's departure left a gap because the local staff was capable of continuing to build the boats, but no one was knowledgeable about setting up and testing different sail riggings since there is little tradition of sailing in Malawi. Consequently, the project obtained the services of a British volunteer sailing instructor in September of 1983 through Voluntary Services Overseas. Although this volunteer was relatively well-qualified technically, he had difficulty communicating and working with Malawian counterparts. He also made some technical errors in making the design modifications for the 8.3 m boat and in rigging a sail. Due to persistent health problems, he had to leave the project prematurely in mid-1984.

Achievements of the Project

As of mid-1985, only three of the six ferrocement boats had been completed. All of the ferrocement work on the hulls for the other three was done, but the fitting out had not been finished (table 1). Table 2 lists the specifications of the completed boats.

Only a few months of work would have been required to complete the rest of the boats. The hold-up was in obtaining about M.K. 2,900 to purchase the necessary materials including galvanized pipes, welding rods, marine plywood, paint, bilge pumps, chain, wire, a fuse box, vents, lights, batteries, safety equipment, lubricating oil, transmission fluid, and fuel. The Karonga Fisheries Department station has been reluctant to spend any more of its money pending the possible transfer of some of these boats to other stations when they are completed. The necessary materials or money could be obtained from other Fisheries Department stations. Apparently, no further progress was made in completing the boats as of the beginning of 1986.

TABLE 1
Completion Dates of the Boats

Boat	Hull	Whole Boat Including Fitting Out
5.6.1	12/81	6/82
5.6.2	4/82	6/83
5.6.3	11/83	-
7.2.1	3/82	6/83
7.2.2	7/83	-
8.3	6/84	-

TABLE 2
Characteristics of the Ferrocement Boats

	5.6 m Boat	7.2 m Boat
Dimensions		
Length overall	5.6 m	7.2 m
Length waterline	4.5 m	5.7 m
Beam (width at midpoint)	2.43 m	2.83 m
Draft (maximum depth)		
Daggerboard up	0.61 m	-
Daggerboard down	1.2 m	-
Daggerboard absent	-	1.0 m
Displacement (volume of water)	1,500 kg	2,800 kg
Recommended engine	10 hp, 4,000 rpm outboard gasoline	12 hp, 3000 rpm inboard diesel[a]
Fuel capacity	10 l (portable)	40 l (built-in)
Fishhold capacity	500 kg (boxed)	1,000 kg (boxed)
Design		
Hull thickness		
Designed	17 mm	19 mm
Actual	16.5 mm	18.3 mm
Keel reinforcement	Bottom of keel has 2 longitudinal rods, 6 mm in diameter. Total thickness of keel 40 mm, no shoe.	Box construction with 6 mm plywood on hardwood frames, strengthened externally with 6 mm vertic rods and 2 longitudinal rods. Keep capped with 30 mm hardwood shoe.
Skeletal steel	Diameter 6 mm at 65 mm centers.	Diameter 6 mm at 55 mm centers.
Mesh reinforcement	Galvanized 13 mm mesh; 3 layers inside rods and 3 layers outside.	Galvanized 13 mm mesh; 4 layers inside rods and 3 layers outside.
Framing	None	None
Longitudinal stiffening	None. Wood-cored ferrocement stringer in bilge.	Same

TABLE 2 (continued)

	5.6 m Boat	7.2 m Boat
Bulkheads	Plywood-cored ferrocement dividing hull into 3 compartments of equal length.	Same
Deck material	Hardwood beams 30 x 50 mm, 18 mm thick. No longitudinal girders.	Hardwood beams 60 x 40 mm, 18 mm thick. Reinforced by 25 mm thick longitudinal girders 200 mm deep amidships allowing water to drain to sides.
Engine beds	Ferrocement 50 mm thick, with hardwood capping.	Same
Fishhold	No insulation, lining or refrigeration.	Same
Deckhouse	None	None
Tanks	Steel	Steel
Bulwarks	Ferrocement	Ferrocement
Deck gear	One forward mast, no winches or gallows.	Same
Fendering	Wooden gunwhales 18 mm thick	Wooden gunwhale 20 mm thick
Special provisions against abrasion or impact	None	None
Painting	Chlorinated rubber paint inside and out.	Same

[a]The stretched 7.2 m boat (8.3 m) has a 22 hp, 2,000 rpm inboard diesel engine.

No progress has been made in disseminating the boats to fishermen although the National Bank of Malawi confirmed in mid-1985 that it was still willing to provide one loan of M.K. 12,000 for a 5.6 m ferrocement boat and associated gear if the Fisheries Department is able to identify a suitable candidate for the loan. Since only one loan was available, the Fisheries Department worried that if the first loan did not work out, the technology would be abandoned. The Fisheries Department felt that there were no suitable applicants. Most of the candidates were entrepreneurs rather than fishermen and the search was confined to the north.

Nevertheless, the completed boats were not left idle. Although testing of fishing gear was not one of the original objectives of this project, some trials of gillnetting, longlining, and purse seining on these boats were added later. The following sections of this report discuss the steps in constructing the ferrocement boats, and the testing of alternative propulsion methods and fishing gear for the boats.

Steps in Constructing the Ferrocement Boats

Several different methods are available for constructing ferrocement boats based on a (1) pipe frame, (2) web frame, (3) female mold, (4) male mold, or (5) injection mold. Nervi used the first method, joining a suspended pipe frame by welding or bolting bent pieces of pipe. The pipes were then covered with mesh. This process requires considerable skill. Pipe frames do not provide additional strength to the hull except the rigidity provided by the mesh folded over the pipe. A vibrator must be used to plaster the mortar through this mesh. Unsealed pipes leave a channel for water movement inside the hull. Since the pipe can sag under the weight of the mortar if the workers step on the hull, it needs to be braced. A pipe frame can be removed for reuse after curing, but the voids caused by its removal must be patched. Sometimes, a pipe frame is left in the hull.

A web frame is somewhat similar to a pipe frame. A web of steel rods is reinforced with trusses and suspended to form the hull. Small ferrocement boats are heavy when built over either a pipe frame or web frame.

The usual method of constructing ferrocement boats is to build the hull upright by making a female mold framework out of steel pipes bent to shape and welded in place. Plaster is applied to the inside rather than the outside of this framework. Longitudinal reinforcing rods are then welded or tied onto the framework and the mesh is tied on. A female mold has two main advantages. First, the interior bulkheads, stiffeners, and fastenings can be secured to the mesh before plastering. Second, the exterior finish does not depend entirely on the skill of the plasterer, but also on the quality of the mold.

A female mold has several disadvantages. First, the meshed mold is susceptible to distortion from the inside as well as the outside of the framework. This problem can be reduced if the female mold is suspended and work on the hull is done from scaffolding. Second, it is difficult to plaster concave sections of a female mold. Third, the method tends to produce heavier boats which makes this method unsuitable for small boats.

An injection mold is a sophisticated process using pre-cast concrete. It can be useful where a large volume of standard construction is required, but there are many technical problems with this method.

A male mold allows the construction of smaller ferrocement boats. This method is fast and requires less labor, especially skilled labor. The frame can be removed in sections or in a single piece after the hull is cast. This method also leaves higher tension in the mesh which makes the hull stronger. The problems with a male mold are (1) the placement of the steel so it is adjacent to but not touching the mold, (2) ensuring thorough mortar penetration, (3) avoiding mortar shrinkage, (4) attaching the bulkheads, and (5) plastering of the outer surface of the hull (Sutherland 1972; Fyson, Gulbrandsen, and Haug 1973).

The male mold construction process used in the Malawi project was developed by MacAlister Elliott and Partners Ltd. The first step was the preparation of an upside-down, strip-planked, hardwood, male mold which is eventually removed from the hull. Space was left between some of the planks to allow someone inside the mold with a torch to check for air bubbles and voids in the plastering. For boats with inboard motors, shuttering boxes were made for the mold to allow precise placement of the engine bearers for proper alignment. Wooden plugs for the mold were cut to the shape of the scuppers to leave drain holes in the hull. Then, one layer of chicken mesh was placed over the mold and it was covered with polythene sheeting. The mesh and sheeting protect the mold and keep cement from penetrating it. The construction of a male mold is exacting and time-consuming and requires skilled carpenters. However, if properly handled, one male mold can be used to build at least six boats.

The second step was to build the hull's armature of wire mesh and steel rods around the mold. It is easy to teach unskilled workers the meshing technique. The mesh was stretched tightly on each side and nailed to a wooden nail bar on the bottom of the mold. The nail bar runs parallel to the shear line of the boat, one foot below it. For the 5.6 m boat, three layers of mesh were attached followed by a layer of steel rods and then three more layers of mesh. The 7.2 m boat has four layers of mesh inside the rods and three layers outside. Adjacent layers of mesh were laced together with wires so that they touched each other. The rod reinforcement consisted of cold-drawn, hard steel rods placed 2.0-2.5 in. apart. The rods were fixed with wire ties where they needed to be joined instead of being welded. Some rods ran the entire length of the keel down to the boat bow.

In addition, longitudinal rods went around the main body of the hull shell and were bent to overlap on the other side where they met the bow.

At the same time, construction proceeded on the engine bearers (for boats with an inboard motor). The engine bearers are two vertical slabs cast in reinforced concrete. A daggerboard was made for the 5.6 m boat. A daggerboard is a piece of hardwood, 6 ft. long with a handle at the top which is raised to reduce sideward motion when sailing at an angle. The casing for the daggerboard was a watertight box from the deck to a hole in the bottom of the boat. The casing was prefabricated, left to cure, and then firmly fixed to the hull structure. Since the 7.2 m boat has a deeper keel, it does not need a daggerboard because it does not have a lateral resistance problem.

The keel was prefabricated. The keel for the 5.6 m boat was a flat, plywood fin with large holes drilled in it which extends from underneath the boat. Steel rods were bent to fit over the holes and the ends of the rods were worked under the longitudinal rods that cover the hull structure. The keel for the 7.2 m boat was more complicated to build because it is thicker and extends forward farther than the keel for the smaller boat. The larger boat's keel consisted of sheets of plywood over wooden formers. It was densely reinforced with vertical rods and some longitudinal rods run over the vertical rods. After meshing was completed, a hardwood former was fixed into position on the outside of the armature where the gunwhale (top rail at the shear line) goes. The former clamps all of the mesh reinforcement to the mold. This former was attached with long screws from inside the mold. Then, the nails were pulled out of the nailbar. The loose foot of mesh at the edges was rolled over the former and hammered down from inside. The screws were taken out later since they were on the inside.

The next step was to prepare for plastering in a covered boatyard. Scaffolding was built around the hull structure for easy access. Bits of wood, dust, and cobwebs were blown and brushed out of the reinforcement before plastering. The basic mortar mix was composed of a 2:3 mix of Portland cement and sand, but a 1:1 mix was used for the final coating. Water was added gradually until a workable consistency in the mix was reached. The cement should be freshly mixed. The sand should be poorly sorted and contain some fine particles, and it must be washed and sieved to remove organic material, pebbles, and other debris.

The main plastering was done by unskilled laborers who pushed the mortar mix in with gloved hands until the whole structure was covered. An electric pencil vibrator was used to force the plaster in throughout the framework. The vibrator is especially important for complete penetration of the mortar mix on the keel, gunwhales, and transom. When bubbles and voids were identified, a person inside the mold poked them with wire to indicate where the vibrator should be applied. There was a

tendency for the workers to use the vibrator too much which shook the water and fine particles out of the mortar.

Skilled plasterers were needed for the rough finishing work with a trowel so that the plaster is flush with the outer layers of the mesh. When the whole hull was finished and the surface has been allowed to dry some, the final coating of plaster was trowled on carefully by skilled plasterers. This coating should be as thin as possible (1-2 mm), but should cover the outer mesh.

Proper curing of ferrocement after plastering or repairs is very important to maintain the physical strength of the mortar and to prevent cracking. After the surface has stabilized for 2-3 hours, wet burlap sacks were placed over the entire hull which was then covered with plastic sheeting. The next day, the plastic was removed and a sprinkler system arranged along the keel to keep the ferrocement wet. The sprinkler consisted of plastic pipe drilled with holes and connected to a hose. The burlap sacks and sheeting were then replaced. The hull was kept constantly wet for three weeks. Some hairline cracks from uneven curing were observed on these boats at the thicker points where two layers of mesh are joined, but these cracks were not large enough to require filling.

After the curing, the sacks and sheeting and the screws holding the gunwhale former in place inside the mold were removed. A hydraulic jack suitable for raising a truck was used to lift the hull so that it rested freely on the mold. The mold was unbolted from its connections on the ground. It took 50 people to pick up the 7.2 m hull and mold, carry it out of the covered boatyard, and turn it over using ropes, levers, and car tires to gently roll it. Once it was upright, legs were put under the hull and mold to prevent rolling. Then, the mold which is much lighter than the hull was lifted out and returned to the boatyard.

Next, the hull was pushed to the fitting out bay using rollers. The hull was then checked for voids by tapping it with a hammer and cold chisel. Some back plastering was required at this stage, especially inside the gunwhale former, at the place where the engine bed joins the hull, and along the daggerboard casing. A spirit level was used to ensure that the design water line is level. The hull was jacked up carefully because it was still elastic at this stage and could be deformed. Then, the inside hull position of the deck line and guidelines for attached structures were marked.

The rest of the rigging out was basically the same as for comparable wooden boats. There are a few exceptions. For example, the bulkheads were formed from plywood or hardwood sheeting covered with two layers of mesh on each side. A layer of cement was chipped away on the inside of the boat to expose the top layer of mesh and the bulkhead was sewn in place with

soft wire looping through the hull meshing. Then, the bulkheads were plastered on both sides and cured.

Unlike the smaller boats, the 8.3 m boat will also have a small after wheelhouse recessed into the deck aft of the engine. It will also have two masts -- one well forward and the second a mizzer mast to carry a small sail aft of the wheelhouse. These additiona are proposed, but have not yet been constructed.

Several innovations were made in the construction process for these boats. MacAlister Elliot and Partners were the first to use the method of stretching the mesh over the male mold. Some lessons also were learned in the construction of these boats. For example, the 5.6 m boat was designed to have an anti-rolling bilge rubber. A bilge rubber is a wooden beam that is steam bent to fit the hull. Since it was found that the bilge rubber did not do much for hull stiffness or rolling, but required a lot of additional construction time, it was omitted after the first boat was tested. The number of hatches was reduced from three to two to provide more deck space for fishing gear. An outboard motor well was excluded from the 5.6 m boat because these engines generally are not economical for a boat of this size.

Another modification which was not done but is suggested for future construction of ferrocement boats is to provide a stronger skeg. The skeg is the bottom end of the keel which protects the rudder and allows the attachment of the propeller. In the boats built under the project, the skeg is susceptible to damage from rocks when the boat runs aground or is brought ashore because it is the lowest point of the boats. However, it would be a simple matter to make a stronger skeg shielded with hardwood and the cost would be low. If done at the time of construction, better protection of the skeg would only cost M.K 50 for materials. Existing boats could also be retrofitted with an improved skeg at an additional labor cost of M.K 100 (Seymour 1985). A mild steel skeg and rudder are proposed for the 8.3 m boat. Although they were not used in this project, new additives are available to improve the workability, setting time, strength, bonding, and durability of ferrocement (Asian and Pacific Centre...1985).

Testing of Alternative Propulsion Methods

There are three possible propulsion methods for the ferrocement boats: a sail, an outboard motor run on a mixture of gasoline and lubricating oil, and an inboard diesel motor. A sail can also be used in conjunction with a motor.

Sails

Only a light breeze is needed for sailing. In the dry season in Malawi from May to August, there are consistent, strong southerly and southeasterly trade winds. In September, intermittent, but sometimes very strong winds blow from the east. These winds can increase rapidly with little warning, occasionally generating waves 4-6 km high which are especially dangerous for canoes. During the hot rainy season in October through April, the prevailing winds are from the north and northwest and are associated with thunderstorms (Landell Mills Associates 1983). Table 3 summarizes the wind conditions along the northern lakeshore. The wind conditions throughout the lake are suitable for sailing most of the time (Tweddle 1985).

Despite the potential for sailing, small-scale fishermen in Malawi generally do not make use of sails. A few fishermen around Monkey Bay in the south and Likoma in the north have attached sails (generally sacks stitched together) to their canoes. Some large passenger boats (9.1-12.1 m carved plank dhows) use sails for inter-island transport around Makinjira. Since there is little tradition of sailing in Malawi, most fishermen are not familiar with the idea and hardly any have learned the skills for it. Sailing is common on canoes in some other LDCs, including the portions of Lake Malawi controlled by neighboring Mozambique.

It would only cost about M.K 50 to add an outrigger to a dugout canoe (Jones 1985). Although this is a small amount of money, a large share of the fishermen on Lake Malawi do not have enough money to buy their own canoe. Many fishermen who do own a canoe would prefer to buy additional fishing gear instead of an outrigger because they can see a direct resulting increase in the fish catch from having more gear. Traditional fishermen also may worry that sailing is dangerous when winds are strong.

A ferrocement boat could fish 200 days a year using a sail as the sole propulsion method. It takes about 2 months to train a fishermen to become proficient in sailing (Mauwa 1985). In the future, these skills could be passed along from father to son.

Sailing is good for fishing methods that require long periods of free running at low speed. In decreasing order of suitability, these methods include (1) trolling for surface and near-surface pelagic fish, (2) longlining, (3) pot and trap fishing, (4) gillnetting, and (5) seining and lift netting with lights. Sails are less useful in purse seining and deep bottom or midwater trawling (Fyson 1982).

There may be a good potential for adding sails to motor-powered wooden plank boats or ferrocement boats because these fishermen could realize a cash savings from reduced fuel consumption. The motor could just be used during periods of insufficient winds. Another 100 days a year would be fishable in a ferrocement boat if a motor is used with the sail. Or, sail

TABLE 3

Wind conditions on the northern shore of Lake Malawi

A. **Principal Wind Direction**

Month	**Location**	
	Nkhata Bay	**Karonga**
January	270°-60°	300°-90°
April	150°-300°	90°-180°
July	150°-270°	90°-180°
October	0°-150°	60°-180°

B. **Wind Speed**

Kilometers Per Hour	**Percent of Recordings**	
	Nkhata Bay	**Karonga**
Calm	6.0	7.6
2-4	67.4	45.6
7-15	25.1	31.0
16-25	1.5	14.5
26+	0.0	1.3

Source: Landell Mills Associates 1983

power could be used together with a motor to significantly increase the speed at a given rate of fuel consumption or to decrease fuel consumption at a particular speed. A sail also makes a boat steadier in the wind and less prone to rolling.

The second 5.6 m ferrocement boat was the first of the boats provided with a sail. This **dip lug sail** consists of a single main sail with a square edge and a trapezoidal shape. It has a yard at the top and a boom at the bottom, and the mast is near the forward end. This rigging can be handled easily by two people. The project did not attempt to test other riggings although some alternatives may have merit. For example, a sprit sail with the mast near the forward end might be more efficient for fishing (Seymour 1985b).

The first sail was made in strips of 45.7 mm that were stitched together for greater strength and resistance to stretching. The sail has **tablings** or reinforced patches at the corners. The bolt rope was stitched on the sail with nylon thread. There are eyeholes in each corner of the sail and along the top and bottom. Reefing points are used to reduce the size of the sail when winds are strong.

The first sail was made correctly by Chapman. The sail on the second 5.6 m boat was made by the VSO volunteer and needs alteration because it is the wrong size although it is usable. Sails have not been installed on any of the larger ferrocement boats yet. The 8.3 m boat will have two sails, a large one in the front and a small one in the back, to keep it pointed in the right direction.

The shortage of cash for buying imported sailcloth was the reason for the slow progress in preparing sails for all six boats. Imported sailcloth costs over M.K. 21 per square meter (m^2). About 15.5 m^2 of sailcloth is required for a 5.6 m ferrocement boat and 28.2 m^2 is needed for a 7.2 m boat. Imported sailcloth has a very tight weave and should last for about 3 years of use. Although there is a major textile firm in Malawi, it is unwilling to make a small order of sailcloth because it would disrupt the looms. That firm does make a cotton drill cloth that could be used as a substitute. Although the drill cloth is inferior and would only last about 1 year, it only costs about M.K. 3.00 per square meter and is readily available (except where stated, all costs and revenues are as of mid-1985). Since local drill cloth is cheaper even after considering the materials and labor for its more frequent replacement, the production cost estimates for the ferrocement boats are based on this type of cloth.

Outboard Motors

An outboard motor consists of an engine, propeller, and vertical drive shaft attached to the transom (the outside of the hull at the back of the boat). Usually, this type of engine

operates on a 25:1 mixture of gasoline and lubricating oil at a cost of M.K. 1.48 per liter. Nearly 32% of the fuel cost is due to import tariffs and surtaxes. The main advantage of an outboard motor is its low capital cost. For example, a 10 hp Seagull 170 engine costs M.K. 2,067.

Another advantage of an outboard motor is that it leaves more space available on the boat for storing fish or gear. The engine room for an inboard motor for a 5.6 m ferrocement boat takes up 40% of the below deck storage volume (Seymour 1985b). Furthermore, the hold space is in a better position when an outboard motor is used, improving the center of gravity of the cargo. If carelessly loaded, a boat with an inboard motor is subject to dangerous forward motion. Because there is no need to cut away an area for the propeller aperture with an outboard motor, the performance of a sail is improved since the lateral plane area is increased, a bigger skeg can be added, and the tendency to move leeway (drifting toward the direction in which the wind blows) is reduced. An outboard motor is also much lighter than an inboard motor. An outboard motor can easily be lifted out of shallow or polluted water. An outboard motor is also easier to repair than an inboard motor using less skilled labor. However, an outboard motor may be less reliable in deep and rough water.

The average fuel consumption per trip can be calculated if the trip times, distance to the fishing grounds, time spent actually fishing, power requirements in fishing, and average speed of travel are known. An outboard motor without the use of a sail for supplementary power would consume about 3 l of fuel per hour (Seymour 1985b).

Most of the small fishing boats with motors are on the southern part of the lake. The number of operable outboard motors on fishing boats in Malawi has been going down due to the high costs of fuel and replacement of the motors.

Inboard Motors

An inboard motor rests on engine bearers on the inside of a boat and is connected by a drive shaft to a propeller below the boat. It usually runs on diesel fuel. The main advantage of an inboard diesel is that it consumes only one-quarter of the fuel that an outboard motor requires for an equivalent propeller thrust. This fuel savings is due to the low power/fuel ratio of a two-stroke outboard motor and the slower, but more efficient propeller of a diesel engine with a reduction gear ratio exceeding 2:1.

A two-stroke outboard motor also requires large quantities of lubricating oil. Furthermore, an inboard diesel engine has a longer life than an outboard motor and needs fewer replacement parts. An air-cooled diesel engine is four times as powerful as an outboard motor with the same rated horsepower (Gifford 1982).

However, a small ferrocement fishing boat such as the 5.6 m boat does not require this much power.

The project began during a period of rising petroleum prices. As a result, it was thought that fuel efficiency would be an overriding consideration in selecting a type of motor even if the capital costs were higher. Since, fuel prices did not continue to rise as expected, the operating cost savings from substituting a 6 hp inboard diesel engine for a 10 hp outboard motor in the 5.6 m ferrocement boat do not make up for the much higher capital costs of the diesel engine. A 12 hp inboard Lister motor including stern gear cost M.K. 11,500, more than 6.5 times more than the cost of the Seagull outboard motor. The cost of diesel fuel was M.K. 1.25 per liter in mid-1985. An inboard motor is usually more rugged and durable than an outboard motor. A diesel engine is less of a fire hazard than an outboard engine and the absence of an electric ignition increase the reliability of operation. Other disadvantages of a diesel engine include the need for more skilled mechanics and a large propeller. Due to its larger size, the 7.2 m ferrocement boat does require an inboard motor with 12 hp.

Types of Fishing Methods

Gillnets

Gillnets are the most popular type of fishing gear used in the north although they are relatively unproductive. A gillnet is a single-walled net that catches the gills or dorsal fins of fish that swim into it. The lower end of a gillnet is weighted by sinkers and the upper end is raised by floats. A gillnet is set perpendicular to the main direction in which fish are moving so that they swim into it. Gillnets may be stationary or may drift with the current or the motion of the boat. They may be set on the bottom of a lake, may hang between the bottom and the surface, or rest on the surface. On Lake Malawi, the catch tends to be better for bottom-set gillnets than mid-water gillnets (Landell Mills Associates 1983). In deep water, the hauling of bottom-set gillnets takes more labor and the nets are more likely to get lost or damaged. Gillnets are usually set as the sun goes down and hauled in the early morning so that there is too little light for the fish to see them. Gillnets generally are passive fishing gear, but noise can be used to drive fish into them.

The size and shape of the mesh determines the size and kind of fish caught in a gillnet. Fish smaller than the mesh size can swim through a gillnet. By restricting the mesh size in a gillnet, fishing authorities can more easily regulate the exploitation of young fish or small fish caught than they can with dragged gear. The mesh shape depends on the hanging coefficient--the ration of the rope length to the net length. Since fish will avoid the mesh if it looks like an impenetrable wall, the mesh is often dyed to blend with its surroundings.

Some synthetic fibers are less visible to fish, but since these fibers do not rot, lost gillnets continue to kill fish in the water. Bait can be fixed in the mesh, but this is not customarily done in Malawi.

Nearly all small-scale fishermen in Malawi use unmounted (reeved) gillnets although the Fisheries Department has been encouraging them to mount the nets on a head rope. Mounted nets last longer because they are less susceptible to bunching and getting tangled with the floats or getting caught on rocks or debris. An unmounted gillnet lasts about 9 months (Tweddle 1982). It takes a little more time to mount a gillnet and there is a small extra cost for twine.

In Malawi, new gillnets are about 100 m long; used gillnets become shorter as sections get torn off. The netting material costs about M.K. 48 and a reeved net can be assembled in 1 day. Between 30 and 40 floats are needed per net, at a cost of M.K. 0.05 each. The floats are made of the bark of tree. Rocks are used as the weights. Rather than buying new netting material, the nets are mended. It takes about a month to mend a badly torn net. Mending nets is considered a man's work in Malawi and the workers are paid M.K. 15 for the job.

The ratio between the quantity of netting needed to catch a certain amount of fish is unfavorable in a gillnet compared to purse seines or trawls in bulk fisheries. Thus, gillnets are only economical for commercial fishing of high value species that are scattered or for subsistence fishing (Brandt 1972). Typically, 2 fishermen would handle up to 10 gillnets in a 4.0 m long dugout canoe or 5-8 gillnets in a 2.7 m canoe. The 5.6 m ferrocement boat can accommodate a crew and 40 gillnets. Twice as many gillnets could be used on the 7.2 m ferrocement boat, but it is unlikely that gillnets would be used on a boat that size (Seymour 1985b).

The average catch from gillnets in a large dugout canoe or a wooden plank boat on the southern part of the lake is much lower in the north than in the south. Fisheries Department studies of traditional gillnet fisheries in 13 locations in the north between 1979 and 1983 show an average catch ranging from 1.02 to 7.86 kg per net-set. The catch rates were highest around Chizumulu, Chinteche Center, Likoma, and Chilumba. In the other areas where the catch rate is below 3.0 kg per net-set, commercial-scale gillnetting probably would not be viable (Seymour 1984). The five suitable areas are not so large and if more than a few commercial-scale gillnetting enterprises were developed there, the stocks of fish could decline making the enterprises unprofitable (Eccles 1985).

Longlines

Longlines consist of a lengthy main line with a series of attached short branch lines called snoods. The distance between

snoods is at least twice the length of the snood to avoid tangling. Each snood contains a partly fixed bait on a hook which is attached with nylon twine. The hook makes it difficult for the fish to release the bait and escape from the fisherman.

Longlines can be set or left to drift from a boat; they are usually set at night and hauled in the next morning. The fisherman does not have to be present all the time, but must secure the fish. If the lines are not watched or are left too long, the hooked fish can rot or be eaten by predatory fish or shellfish.

Longline fishing is less common than gillnetting in the northern part of Lake Malawi; however, a larger potential may exist for commercial-scale longlining over a wide area, including deep waters. Gillnets and longlines can be used at the same time. Usually, 100-200 hooks are attached to a longline set from a dugout canoe and between 1,000 and 2,000 from a wooden plank boat. About 2,000 hooks would be fished from the 5.6 m ferrocement boat. With one boat moving at 2.3 knots, it takes 3 hours to set 2,000 hooks. Since the speed of setting and hauling rather than storage space limits the number of hooks that can be used, the 7.2 m ferrocement boat would probably not carry more than 2,500 hooks. A box of 100 average-sized hooks costs M.K. 2.00.

The Fisheries Department trials used floating longlines on some ferrocement boats to catch catfish. The enclosed hold space in the ferrocement boats is much better for keeping caught catfish alive than the open area in a wooden plank boat because it is cool and dark in the hold. However, the progress of these trials was limited by lack of a systematic research design, poor supervision, and shortages of fuel. Although traditional longline fishermen in the north average yields of 7.0 kg per 100 hooks, the Fisheries Department's crews only obtained yields of 2.3 kg per 100 hooks because they were more accustomed to gillnetting (Seymour 1985b). Since the fish caught in the trials were sold to Department staff at a moderate cost and they got tired of eating catfish, the crews ignored their instructions to do longlining and kept switching back to gillnetting.

Fisheries Department statistics from traditional fisheries have identified the best areas for longlining in the north. In decreasing order, these are Likoma, Mulale, Chinteche South, Kaporo, and Chizumulu. It was also found that short snoods (less than 50 cm) were more effective than long ones because big catfish swim near the surface at night. Short snoods also are cheaper and easier to handle. The hook size did not appear to affect the total catch very much. Small hooks catch a larger number of small fish, but large fish can take the bait and escape from a small hook by straightening it out (Seymour 1985a).

Purse Seines

Purse seines (also known as ring nets) reach downward from the surface to surround fish from the sides and below. Usually, two boats are used to lay the net in a large circle--one large boat and a small rowboat called a skiff which is towed to the fishing grounds behind the large boat. It is also possible to throw the net attached to a dahn buoy from a single large boat which circles around and picks up the buoy. Before the net is hauled in, the fish are trapped in the pouch formed by pulling rope through wooden or iron rings at the lower edge of the net. This process is called pursing because the net is drawn together like a purse with a pull-string. The success of purse seining depends on the speed of setting and pursing. Weights are often added to the lead line to increase the sinking velocity of the net.

A purse seine can catch fish in pelagic fish in deeper water than can gillnets. The net may be set on the bottom of the lake. Mechanically hauled purse seines produce the largest share of the total world catch of fish (Brandt 1972). Hand-hauled purse seines could be very effective in catching Oreochromis shiranus and Haplochromis sp. on Lake Malawi (Turner 1976). The value of the catch per unit effort would probably be higher for purse seining than gillnetting. However, purse seines are still not in commercial use in the north, mainly because they require a large boat. A 7.6 m wooden plank boat or a 7.2 m ferrocement boat would be needed for a purse seine with a circumference of 200 meters. A catamaran might offer greater stability for purse seining in rough weather than a ferrocement boat (Seymour 1985b). The Fisheries Department has conducted purse seine trials with a steel catamaran at Nkhata Bay, but it has not yet done so for the ferrocement boats.

Maldeco operates pairs of large steel boats for purse seining on the southern lakeshore. Each of these boats has a crew of 16, an echo sounder, and a net with a circumference of 200-300 meters (Kingstone 1985). Maldeco is not interested in using ferrocement boats for purse seining for fear of damage from collisions between the pairs of boats. Maldeco also has two very large steel boats that are used for trawling in conjunction with smaller carrier boats for the catch. Again, they are concerned about collisions between non-steel trawlers and the carrier boats.

Comparative Production Costs

This section compares the production costs and sales prices of dugout canoes, wooden plank boats, ferrocement boats, and steel boats.

Dugout Canoes

Although a few fishermen make their own dugout canoes, most canoes are built by specialized artisans. One part-time canoe maker reported that it takes him 23-27 days to make a 6.7 m canoe without an assistant, depending on the hardness of the wood. Hardwoods are best for canoes, but more softwood canoes are being built now because of the scarcity of hardwoods along the lake. Also, the average size of a dugout canoe is decreasing because long tree boles are becoming hard to find. Previously, most dugout canoes in Malawi were 5.2-5.8 m long; now new ones average 2.7 m in length (Mzembe 1985). It takes four times as much prime wood to build a dugout canoe than a plank boat of similar capacity. Transport costs can be a sizeable portion of the total costs of buying a canoe as canoe makers move closer to the wood sources or have to bear the costs of moving logs. One canoe maker reported that he had to bring logs from 13 km away.

There is a lot of variation in the price of dugout canoes due to differences in the size and quality of the product as well as the location of sale. A 2.4 m canoe made of low grade softwood (e.g. *Piliostigma thonningii* or *Cordyla africana*) may cost M.K. 30 while one made of better softwood or hardwood (e.g. *Acacia albida* or *Pericopsis angolensis*) may cost M.K. 55. A 4.6 m canoe may cost M.K. 45 if made of low grade wood or M.K. 75-200 if made of high grade wood (Bandula 1985; Saiti 1985). A 7.6 m canoe made from a very high quality wood (i.e. *Erythrina sp.*) may cost M.K 400-500, which is almost as much as a small plank boat. A pair of wooden oars for a canoe or a plank boat cost M.K. 40. Due to the increasing cost of dugout canoes, a larger proportion of them are being bought by businessmen who rent them out to small-scale fishermen for a share of the catch or, less frequently, for a set monthly rent in cash.

Wooden Plank Boats

Table 4 lists the production costs for wooden plank boats built at the two government boatyards, excluding overhead. More Mulanje cedar was used in the plank boats before 1983, but local hardwoods were substituted for much of that wood as the price of cedar rose. At present, timber amounts to nearly 55% of the production costs for a 5.8 m V-bottomed plank boat. The Forestry Department raised its prices for local hardwoods in 1964, 1978, 1982, and 1983, but now anticipates "more frequent revisions as it is intended to bring the prices to the true production cost in due course and to use prices for protecting indigenous wood resources" (Sakanda 1985). The costs of wooden plank boats are very sensitive to changes in wood prices. Labor costs comprise almost 29% of the production costs for the 5.8 m plank boat and other materials represent less than 17% of the costs. It takes

Table 4
The Cost of Wooden Plank Boats in Mid-1985 (M.K.)

Salima Boats[a]

	Length (meters)							
Production Costs	**4.3**	**4.9**	**5.2**	**5.5**	**5.6**	**5.8**	**5.9**	**6.1**
Timber	575	575	575	611	611	611	611	647
Other materials	91	115	128	147	172	187	248	227
Labor	170	170	213	255	255	319	319	227
Total[e]	**836**	**860**	**916**	**1,013**	**1,038**	**1,117**	**1,178**	**1,342**
Sales price	**540**	**740**	**910**	**1,000**	**1,100**	**1,250**	**1,300**	**1,560**

Mpwepwe Boats[f]

	Length (meters)				
Production Costs	**4.6[b]**	**5.2[a]**	**5.2[b]**	**5.8[a]**	**7.6[a]**
Timber	262	230	230	715	1,553
Other materials	190	315	274	503	1,036
Labor cost	210	523	350	425	2,314
Total[e]	**662**	**1,067**	**854**	**1,643**	**4,903[d]**

Sources: Bandula 1985; Saiti 1985

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[a]V-bottomed

[b]Flat-bottomed

[c]A 10 hp Seagull outboard motor costing M.K. 2,067 would be suitable for all of the above except the 7.6 m boat. That boat would require an inboard motor costing M.K. 11,500. Costs also exclude oars.

[d]Made with local hardwoods. The same boat made out of Mulanje cedar would cost M.K. 9,000.

[e]Excluding overhead for the boatyard which would be higher at Mpwepwe than at Salima.

[f]Sales prices are supposed to equal production costs plus a small margin.

about 320 hours of work for one carpenter and one assistant to build a 5.8 m plank boat.

The usual arrangement is for the buyer to pay a deposit of one-third of the price on ordering a boat, another one-third when the boat is half-completed, and the rest on delivery. Although the sales prices for the plank boats are set to cover production costs plus a small margin, they often lag behind current production costs. For example, production costs for the 4.3 m Salima boat are 55% higher than the current sales price, even excluding the overhead costs for the boatyard. This difference is an unintended result of not adjusting the prices frequently enough as inflation increases the production costs. Nevertheless, it amounts to a substantial subsidy for the small proportion of fishermen/entrepreneurs who can afford to buy plank boats.

A few local artisans make wooden plank boats which are cheaper but of lower quality than the the ones from the government boatyards. One such boatbuilder on Lake Malombe makes 4.6 m flat-bottomed boats with seats. These boats sell for M.K. 450. The timber for this boat costs about M.K. 195. Other materials for one boat cost M.K. 123. He sells these boats at M.K. 450. It takes this artisan and one assistant 70-84 hours of work to make one boat and they make 12-15 boats per year.

Ferrocement Boats

Table 5 summarizes the production costs for the Karonga ferrocement boats in mid-1985 values. These costs are itemized in greater detail in Table 6. Excluding the motor, replacement costs would be about M.K. 3,650 for the 5.6 m boat and M.K. 4,900 for the 7.2 m boat. Timber costs amount to less than 15% of total costs for the smaller boat and 18% for the larger boat. Table 7 lists the kinds and amounts of timber used. Labor constitutes 33% of total costs for the smaller boat and 43% for the larger boat. With more experience in constructing ferrocement boats and a more reliable supply of raw materials, the labor costs could be significantly lower. The other 50% of the costs of the smaller boat or 39% for the larger boat is for other materials. Most of these other materials are imported (e.g. steel wire, fastenings, paint, and glue). The cement and some cordage are domestically produced, but are a small portion of materials costs. The remaining 4-5% of total costs is overhead for the boatyard.

A 10 hp outboard motor for the 5.6 m boat costs M.K. 2,067 while a 12 hp inboard motor for the 7.2 m boat costs M.K. 11,500. Thus, excluding gear and working capital, an investment of M.K. 5,700 is needed for a 5.6 m boat, or M.K. 16,400 for the 7.2 m boat. The large difference in costs is mainly due to the expense of the motor required for the larger boat.

TABLE 5
Summary Production Costs for Malawi Ferrocement Boats in Mid-1985 (M.K.)

Item	Total Costs by Boat Size 5.6m	7.2m
Materials for mold[a]	58	98
Hull construction materials	561	900
Timber	501	798
Fastenings	126	161
Paint, glue and sealants	184	241
Rigging, chandlery, and misc.	445	493
Sail	54	[illegible]
Subtotal materials	**2,429**	**2,785**
Labor for mold[a]	74	73
Labor for construction	791	1,497
Hired services for mold[a]	13	13
Hired services for construction	185	297
Subtotal labor and services	**1,063**	**1,880**
Boatyard overheads	149	229
Engines	1,500[b]	11,500[c]
Subtotal other costs	**1,649**	**11,729**
Total costs, excluding engine	**3,641**	**4,894**
Total costs, including engine	**5,141**	**16,394**

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[a]Prorated per boat; each mold can be used to build 6 boats.

[b]10 hp outboard gasoline/oil engine

[c]12 hp inboard diesel engine, including stern gear

TABLE 6
Detailed Production Costs for Malawi Ferrocement Boats in Mid-1985 (M.K.)

Item	Unit Cost	5.6 m Boat Qty	5.6 m Boat Cost	7.2 Boat Qty	7.2 Boat Cost
Materials for mold					
Hardwood timber, ft^3	7.20	25.8	185.76	61.6	443.52
Cascamite wood glue, 3.5 kg tins	17.25	2	34.50	2	34.50
Steel woodscrews, 3" X 12	.06	20	1.20	-	-
Steel woodscrews, 2" X 12	.04	300	12.00	100	4.00
Steel woodscrews 1.5" X 10	.04	700	28.00	400	16.00
Mild steel bolts and nuts, 5" X .375"	.92	16	14.72	16	14.72
.4375" flat washers	.06	16	.96	16	.96
Assorted nails, kg	2.00	13	26.00	7	14.00
15 mm wire mesh, m	2.81	15	42.15	20	56.20
Subtotal	-	-	**345.29**	-	**583.90**
Subtotal prorated per boat[a]	-	-	**57.55**	-	**97.32**
Hull construction materials					
Portland cement, 50 kg pkgs.	12.08	7.5	90.60	13	157.04
15 mm wire mesh, 30 m rolls	84.18	4.5	378.81	7	589.26
Hard-drawn steel rods, 6 mm x 6 mm	1.48	62	91.76	104	153.92
Subtotal	-	-	**561.17**	-	**900.22**
Timber					
Hardwood timber, ft^3	7.20	64.7	465.84	101.6	731.52
6 mm plywood, 8' X 4' sheets	15.50	2	31.00	4	62.00
Selected bluegum poles, delivered	1.50	3	4.50	3	4.50
Subtotal	-	-	**501.34**	-	**798.02**
Fastenings					
Galvanized bolts and nuts, 5" X .500"	1.19	5	5.95	7	8.33
Galvanized bolts and nuts, 4" X .3125"	.21	7	1.47	12	2.52
Galvanized bolts and nuts, 5" X .375"	.92	12	11.04	20	18.40
6 mm gutter bolts and nuts	.12	54	6.48	60	7.20
Flat washers, .4375"	.06	54	3.24	60	3.60
Nuts, [illegible]00"	.09	-	-	10	.90
Galvanized eyebolts, .750"	4.05	1	4.05	-	-
Galvanized eyebolts, .500"	2.70	5	13.50	5	13.50
Galvanized washers, .500"	.06	5	.30	5	.30
Zinc-plated screws, 2.5"	.07	15	1.05	360	25.20
Zinc-plated screws, 1.5"	.05	1,200	60.00	1,440	72.00
Zinc-plated screws, .75"	.03	30	.90	30	.90
Subtotal	-	-	**125.98**	-	**160.65**

TABLE 6 (continued)

	Unit Cost	5.6 m Boat Qty	5.6 m Boat Cost	7.2 m Boat Qty	7.2 m Boat Cost
Paint, glue, and sealants					
Cascamite wood glue, 3.5 kg tins	17.25	2	34.50	2	34.50
Alkyd concrete paint, 5 l tins	43.03	3	129.09	4	172.12
Marine glue, kg	6.57	3	19.71	5	32.85
Caulking cotton, cops	.50	2	1.00	3	1.50
Subtotal	-	-	**184.30**	-	**240.97**
Rigging, chandlery, and misc.					
6 mm ungalvanized wire rope, rope, 6 x 19 m	3.42	12.5	42.75	16	54.72
Misc. cordage	-	-	73.02	-	93.88
16 mm polypropylene	.50	50	25.00	50	25.00
anchor warp, m	.50	50	25.00	50	25.00
Galvanized .375" short link chain, m	21.30	5	106.50	5	106.50
7 kg anchor	30.00	1	30.00	-	-
12 kg anchor	45.00	-	-	1	45.00
1.25" semi-rotary bilge pump	120.00	1	120.00	1	120.00
Reinforced mining hose, m	7.1	5	35.50	5	35.50
Hose clamps	1.49	4	5.96	4	5.96
Subtotal	-	-	**444.62**	-	**492.45**
Sail					
Local white cotton drill cloth, m^2	3.00	15.5	46.50	28.2	84.60
8 mm polyethlene bolt rope, m	3.00	20	6.00	25	7.50
3-ply nylon twine, 100 g	1.89	1	1.89	1	1.89
Subtotal	-	-	**54.39**	-	**93.99**
Labor for mold construction (person-days)					
Boat builder	6.08	22	133.76	20	121.60
Carpenter	3.28	35	114.80	41	134.48
Assistant carpenter	2.02	30	60.60	14.5	29.29
Workmen	1.15	63	72.45	71	81.65
Subtotal			**381.61**		**367.02**
Repairs to mold	-	-	11.50	-	11.50
Subtotal prorated per boat[a]	**74.10**		**72.67**		

TABLE 6 (continued)

	Unit Cost	5.6 m Boat Qty	5.6 m Boat Cost	7.2 m Boat Qty	7.2 m Boat Cost
Labor for boat construction (person-days)					
Boat builder	6.08	43	261.44	91	553.28
Carpenter	3.28	69	226.32	115	377.20
Assistant carpenter	2.02	55	111.10	84	169.68
Workmen	1.15	167	192.05	345	396.75
Subtotal	-	-	**790.91**	-	**1,496.91**
Hired services					
Machining of mold prorated per boat[a]	80.00	-	13.17	-	13.17
Welding, including steel supply	-	-	75.00	-	118.00
Timber machining	-	-	42.00	-	103.00
Sewing of sail	-	-	25.00	-	32.00
Plastering	-	-	21.67	-	22.56
Cement mixing	-	-	21.50	-	21.50
Subtotal	-	-	**198.34**	-	**310.23**
Overhead per boat					
Land rover transport, km	.72	20	14.40	30	21.60
Truck transport, km	.86	53	45.58	53	45.58
Replacement of tools	-	-	45.00	-	90.00
Staples, box of 1,000	9.14	1	9.14	2	18.28
Polythene sheet, m	.85	20	17.00	20	17.00
Misc.	-	-	18.00	-	37.00
Subtotal	-	-	**149.12**	-	**229.46**
Engines					
10 hp outboard petrol/oil[b]	-	1	1,500	-	-
12 hp inboard diesel[b]	-	-	-	1	11,500

[a] Each mold can be used to build 6 boats.

[b] Excludes 20% import duty and 15% surtax if obtained through the Fisheries Department.

TABLE 7 Timber Used in Construction of Ferrocement Boats (cubic feet)

Size	Timber Species	5.6 m Boat	7.2 m Boat	Uses
2.5" x 24"	*Chlorophora excelsa*	-	5.8	Rudder and tiller
2" x 9.5"	*Pterocarpus angolensis*	6.0	20.0	Deck beams
2" x 8"	*Chlorophora excelsa*	-	2.0	Rudder checks
2" x 6"	*Chlorophora excelsa*	4.0	8.0	King plank, air vent
2" x 6"	*Khaya nyasica*	1.0	-	Rudder
2" x 4"	*Sterculia quinquiloba*	8.0	3.8	Beam shelves, bilge stringers (5.6 m boat)
1.5" x 12"	*Chlorophora excelsa*	-	4.9	Rubbing band, king plank
1.25" x 12"	*Chlorophora excelsa*	7.8	-	Rubbing band, rudder checks, coamings
1.25" x 10"	*Chlorophora excelsa*	6.1	44.2	Decking (7.2 m boat), air vent
1" x 12"	*Chlorophora excelsa*	-	1.0	
1" x 12"	*Khaya nyasica*	27.0	8.3	Decking
1" x 10"	*Chlorophora excelsa*	4.0	1.9	Gunwhale and capping
Assorted	*Pericopsis angolensis*	0.8	1.7	Samson posts, engine bearers (7.2 m)
Total hardwood timber		64.7	101.6	
6 mm plywood, 8' x 4' sheets		2	4	Bulkhead and skeg formers
Bluegum poles		3	3	Masts and spars

The Fisheries Department established the sales prices of the in early 1984 based on production costs at that time with a small margin. Fully rigged with a sail but without a motor, the 5.6 m boat will sell for M.K. 3,260 and the 7.2 m boat will sell for M.K. 5,150. Despite the inflation since then, the prices have remained fixed because Treasury Department approval is needed to raise them and the Fisheries Department has not sought an increase since the demand for the boats has been low. The motors could be purchased through private dealers or through the Fisheries Department. If the government purchases the motors and sells them to private individuals as a package with the boats, they are exempt from the 20% import duty and the 15% surtax.

In comparing production costs, note that the ferrocement boats are larger than wooden plank boats of the same length. The 5.6 m ferrocement boat has about the same working space as a 6.1 m plank boat and the 7.2 m ferrocement boat is roughly the same size as a 7.6 m plank boat (Seymour 1985b). Since overhead costs are relatively low and should not be too different for the two types of boatyards, the comparison of production costs for ferrocement and wooden plank boats excludes overhead. A plank boat and a ferrocement boat of comparable size would take the same type of motor.

If at least six of each type of ferrocement boats are made in Karonga, the production costs would be 124% higher for the smaller ferrocement boat than for a wooden plank boat of equivalent size and quality. However, the larger ferrocement boat would be 5% cheaper to produce than the equivalent wooden plank boat. The smaller ferrocement boat could also be cheaper in the long run than the wooden boat if it has a longer lifetime that compensates for its higher capital costs.

Steel Boats

Each of Maldeco's 10.4-11.6 m steel purse seine boats has an inboard diesel motor (usually 85 hp, but varies between 50 and 125 hp) and an echo sounder. Maldeco made these boats itself using imported materials at a cost of M.K. 55,000 plus another M.K. 35,000 for the motor. Maldeco purchased an 11.6 m, steel stern trawler which would cost over M.K. 100,000 to replace, including the motor. It also purchased a 17.7 m stern trawler (Kingstone 1985). Expensive steel boats like these are not an option for any other existing fishing enterprises in Malawi. Few if any traditional fishermen in Malawi could manage that level of fishing enterprise even if loans were available for purchase of the boat and gear.

The Fisheries Department built an 8.5 m steel catamaran using imported materials. It took an experienced boatbuilder, three welders, and a mechanical engineer one year to build this boat. An expatriate was hired to supervise construction of that boat, but a similar boat could be made by a government-qualified

boatbuilder using plans from FAO. Such a boat could be made for about M.K. 30,000, including labor costs of M.K. 9,000 and the costs of importing 5 tonnes of steel. This catamaran has a hydraulic winch that cost M.K. 5,000 and two stainless steel fuel tanks that cost a total of M.K. 1,000. Its two 22 hp diesel engines cost an additional M.K. 20,000 (Seymour 1985b).

Comparative Operation, Maintenance, and Replacement Costs

The operation, maintenance, and replacement costs also differ significantly for dugout canoes, wooden plank boats, ferrocement boats, and steel boats.

Dugout Canoes

A typical softwood canoe lasts 2-3 years while an ordinary hardwood canoe should last 4-6 years (Landell Mills Associates 1983; Bandula 1985). A canoe made out of a special hardwood (e.g. *Pterocarpus angolensis* or *Erythrina sp.*) may last 10-15 years (Bandula 1985; Mzembe 1985). The lifetime of a canoe is often extended by patching it with pieces of wood and sometimes metal. Some fishermen who could afford a plank boat prefer a hardwood canoe because it does not need to be repaired as much.

Wooden Plank Boats

Many wooden plank boats on Lake Malawi are propelled by oars or paddles rather than a motor. An outboard motor can be used on small- and medium-sized wooden plank boats, but an inboard motor may be required for a large plank boat. The motors can be expected to last for 3-4 years of full use without a major overhaul.

The plank boats made from local hardwoods at the government boatyards may need minor repairs after 3 years, but it should last 8-10 years before major repairs are needed. The total lifespan of the boat could then be 15-25 years. A plank boat made of Mulanje cedar would not need major repairs for 15 years or more (Bandula 1985). Although this is not done in Malawi due to the cost, the wood for plank boats could be pressure-treated with preservatives for greater rot resistance.

A minor overhaul on a 7.6 m wooden plank boat at the government boatyard might take about 2 weeks and cost M.K. 200 while a major overhaul might take 4 weeks and cost M.K. 600-700 (Saiti 1985). A major overhaul on a 5.2 m boat would cost M.K. 400-500, half the costs being for labor and the other half for materials (Bandula 1985). Some former employees of the government boatyards also do this work as private enterprises.

One local plank boat builder claims that his boats last about 8 years before they need major repairs. The repair costs would be M.K. 100-150 and then the boat could last another 4-5 years.

Ferrocement Boats

A ferrocement hull should last at least 25 years if properly handled. Ferrocement is supposed to get stronger as a material for the first 100 years, but a boat may get damaged in use. Impact damage is easy to repair if the boat can be recovered. Normal wear and tear should be repaired every year during the period when fishing is not done (July or August on the northern part of Lake Malawi due to the winds). These repairs would take about 2 weeks for the 5.6 m boat and 1 month for the 7.2 m boat. The fittings on the boat may need replacement after 8 years (Seymour 1985b).

Fuel and engine maintenance costs for a ferrocement boat would be similar to those for a plank boat with the same kind and size of motor operating for the same amount of time. If the sail were used for supplementary power, a ferrocement boat would have lower costs for fuel and maintenance of the motor than a plank boat.

Steel Boats

A mono-hulled steel boat should last 20-30 years or more. It will require some annual scraping and painting and a more thorough cleaning of corroded areas, welding, and repairing every 5-6 years. The scraping and painting of one 11.6 m steel boat takes 7 days of work for a crew of 7, and the paint costs M.K. 500. Twice as much labor and paint is needed for the 17.7 m stern trawler (Kingstone 1985).

Financial Analysis

A fishing entrepreneur with an outboard-powered, wooden plank boat would bear costs of M.K. 2,000-5,000 and net M.K. 500-1,250 per year (Saiti 1985). A fishing entrepreneur who has a locally produced wooden plank boat without a motor might gross M.K. 600 and net M.K. 300 in a year (Donda 1985).

Hired fishermen might earn M.K. 10 per month in cash, a ration of 1-4 fish per day, and a bonus if the catch is large (Saiti 1985). By comparison, the Fisheries Department pays fishermen on its research vessels M.K. 25 per month (Bandula 1985).

The most efficient propulsion method for a 5.6 m ferrocement boat is the combination of a sail and an outboard motor. Including the boat, fittings, motor, and gear, the capital costs of a hypothetical gillnetting enterprise would be M.K. 8,335. At the 12% interest rate offered by the National Bank of Malawi for one such enterprise, a 5-year loan to cover the capital costs would require an annual repayment of M.K. 2,313. Other annual operating costs would amount to M.K. 6,445. Replacement costs would be M.K. 54 in years 1 and 4, M.K. 865 in years 2 and 5, and M.K. 1,165 in year 3. The gross revenues would be M.K. 14,136 per year if the enterprise sold fish at the prevailing lakeshore wholesale prices rather than to middlemen at the government controlled beach prices. There would be a salvage value of M.K. 2,525 in year 5. This enterprise would have an IRR of 83.9% without financing. With financing, it would have a net present value of M.K. 17,355 at a 15% discount rate (table 8). The net economic benefits would be higher than the financial profitability because the government extracts some of the surplus for duties and surtaxes on imported goods (table 9).

If other propulsion methods were used, the net present value of the hypothetical fishing enterprise analyzed above would be reduced. It would decrease by M.K. 4,351 for an outboard motor alone, M.K. 10,975 for an inboard motor and sail, M.K. 11,201 for a sail alone, and M.K. 16,732 for an inboard motor alone. The net present value would remain positive for each of these cases, but would be marginal if an inboard motor were used without a sail (table 10).

Since the 7.2 m ferrocement boat would be powered by an inboard motor with a sail, it would probably be less profitable than the 5.6 m ferrocement boat for a gillnetting enterprise in Malawi. The profitability of the larger boat would be better for an enterprise combining purse seining and longlining.

One of the alternatives to the 7.2 m ferrocement boat for a large fishing enterprise would be a steel catamaran used together with five wooden plank boats to attract fish with lights and one small skiff boat to tow the catamaran out of the purse seine. In a typical year, such an enterprise could do purse seining for 168 days and longlining for an additional 132 days (table 11). The capital costs of this operation would be nearly M.K. 63,000 and it would have an internal rate of return (IRR) of more than 20% over 5 years. If financed through a 5-year loan at an interest rate of 12% compounded annually, the net present value (NPV) of the investment would exceed M.K. 13,300 over 5 years. It might be possible to do without the skiff by throwing a dahn buoy out with one end of the net and circling around to pick up the buoy so both ends of the net are brought in, but that would not increase the financial viability very much.

Table 8
Financial Analysis of a Hypothetical Fishing Enterprise Based on a 5.6m Ferrocement Boat in Mid-1985 (M.K.)[a]

Capital Costs	
5.6 m ferrocement boat with sail	3,650
Outboard motor	2,067
Gillnets (50 at M.K. 15.20)	760
Frame lines (25 coils at M.K. 20)	500
Mounting twine (4 kg polypropylene at M.K. 12.65)	51
Floats (12.5 sacks at M.K. 15)	188
Dahn ropes (10 coils at M.K. 30)	300
Moorings	500
Miscellaneous (weights, anchors, buoys)	120
Smoking kiln construction	200
[Year 0] Subtotal	8,335
[Years 1-5] Loan payments to amortize capital costs[b]	2,313
Other Annual Operating Costs	
Mending twine (3 kg at M.K. 18.52)	56
Fuel (300 liters petrol/oil mix at M.K. 1.48/l)	444
Gearbox oil and grease	40
Manager's wages	1,500
Wages for crew (10 at M.K. 1.23/d)	3,690
Maintenance of motor	210
Boat maintenance	100
Maintenance of mooring	50
Maintenance of smoking kiln	20
License fees (50 gillnets at M.K. 1.00)	50
Boat insurance	285
[years 1-5] **Subtotal**	6,445
Replacement Costs	
[Years 2, 3, and 5] Gillnets (50 at M.K. 15.20)	760
[Years 2, 3, and 5] Mounting twine (4 kg at M.K. 12.65)	51
[Year 3] Dahn ropes (10 at M.K. 30)	300
[Years 1-5] Sail	54
[Year 1] Subtotal	54
[Year 2] Subtotal	865
[Year 3] Subtotal	1,165
[Year 4] Subtotal	54
[Year 5] Subtotal	865

Table 8 (continued)

Gross Revenues[c]

[Year 0] Loan amount	12,000
[Years 1-5] Fish catch (1.55 kg/net-set at M.K. 0.76/kg)	14,136
[Year 0] Subtotal	12,000
[Years 1-5] Subtotal	14,136

Salvage Value

[Year 5] Ferrocement hull (75%)	2,356
[Year 5] Boat fittings (38%)	169
[Year 5] Subtotal	2,525

Net Cashflows

	With Financing	Without Financing
Year 0	0	-8,335
Year 1	5,324	7,637
Year 2	4,513	6,826
Year 3	4,213	6,526
Year 4	5,324	7,637
Year 5	7,038	9,351

Financial net present value at 15% = M.K. 17,355 (with financing)
Financial IRR = 83.9% (without financing)

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[a]Fishing areas are the best sites in the northern part of Lake Malawi. Period of analysis is 5 years. Gillnetting for 300 days a year (12,000 net-sets).

[b]National Bank of Malawi loan for 5 years at an interest rate of 12% per year.

[c]At expected lakeshore wholesale prices since a large enterprise would not sell to middlemen at beach prices.

Table 9
Rates of Duty and Surtax on Imported Inputs for Fishing Enterprises

	Duty	Surtax
Outboard motors under 200 cc	15%	10%
Outboard motors over 200 cc	20%	15%
Inboard motors	20%	15%
Nets and gear	15%	10%
Hooks	30%	30%
Sails/sail cloth (not local)	20%	15%
Lubricating oils (Bulk)	20%	15%
Lubricating oils (retail)	25%	25%
Gasoline (per liter)	M.K. 0.215	M.K. 0.215
Diesel (per liter)	M.K. 0.185	M.K. 0.185

Source: Jones 1985

Table 10
Financial Comparison of Various Propulsion Methods for a 5.6 m Ferrocement Boat in Mid-1985 (M.K.)[a]

Item	Type of Propulsion			
	Sail Only[b]	Outboard Motor Only[c]	Inboard Motor and Sail[d]	Inboard Motor Only[c]
Capital cost savings [year 0]	2,067	1,035	-9,818	-8,898
Insurance cost savings [years 1-5]	103	52	-491	-445
Fuel cost savings [years 1-5]	444	-1,332	236	-374
Maintenance cost savings [years 1-5]	207	-207	-943	-1,518
Replacement cost savings [years 2 and 4]	0	-2,067	0	0
Change in gross revenues [years 1-5]	-4,712	0	0	0
Change in salvage value [year 5]	0	1,034	5,750	0
Change in net present value [5 years, r=15%]	-11,201	-4,351	-10,975	-16,732

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[a]Figures shown represent how differences relative to the base case (sail and outboard motor) affect the net present value. A positive change represents a cost savings or an increase in gross revenues or salvage value.

[b]An outboard motor is not purchased. Insurance cost savings amount to to 5% of the difference in capital costs. No fuel or maintenance and replacement costs for motor. Reduction of 4,000 net-sets per year at 1.55 kg/net-set and M.K. 0.76/kg.

[c]Omission of sail, mast, daggerboard and its casing, rudder, and tiller. Annual consumption of gasoline/oil fuel mix increases by 900 liters. Engine maintenance costs double. Engine life decreases to 2 years.

[d]Inboard motor costs M.K. 11,500. Additional construction costs for engine beds, cooling air intake and outlet vents and ducts, and engine exhaust system. Annual fuel consumption of 164 liters of diesel at M.K. 1.25/l instead of 300 liters of gasoline/oil fuel mix.

[e]Omission of sail, mast, and daggerboard and its casing. Diesel fuel consumption of 654 liters/year. Motor lasts 5 years. Annual maintenance costs of motor at 15% of purchase price.

TABLE 11
Financial Analysis of a Hypothetical Fishing Enterprise Based on a Steel Catamaran in Mid-1985 (M.K.)[a]

Capital Costs

Steel catamaran	30,000
Two motors for catamaran	20,000
Five light boats (at M.K. 560)	2,800
Tilley lamps (10 at M.K. 70)	700
One skiff[b]	560
Purse seine net	4,100
Line hauling attachment to winch	2,000
Hooks (4,000)	90
Snood material (3 kg at M.K. 70)	60
Floats (2 bags at M.K. 15)	30
Grapnels[c] (20 at M.K. 5)	100
Back lines (50 coils at M.K. 10)	500
Dahn lines (10 at M.K. 30)	300
longlines boxes	40
Smoking kiln construction	200
Moorings	1,500
[year 0] Subtotal	**62,980**
[years 1-5] Loan payments to amortize capital costs[d]	**17,471**

Other Annual Operating Costs

Diesel fuel for purse seining (2,595 liters at M.K. 1.25/l)	3,244
Petrol for skiff (1,222 liters at M.K. 1.31/l)	1,601
Kerosene (652 liters at M.K. 0.91/l)	593
Oil (55 liters at M.K. 5.64/l)	310
Manager's wages	1,500
Skipper's wages	1,500
Engineer's wages	1,000
Wages for crew in catamaran for purse seining (7 at M.K. 1.23/d)	1,446
Wages for crew in light boats and skiff for purse seining (6 at M.K. 1.23/d)	1,240
Boat insurance (5%)	2,668
Moorings and licensing fees	400
Engine maintenance (20%)	4,000
Purse seine net repair (20%)	820
Diesel fuel for longlining (40 liters/day at M.K. 1.25/l)	6,600
Oil for longlining	990
Crew for longlining (4 at M.K. 1.23/d)	649
Smoking kiln maintenance	20
[years 1-5] Subtotal	**28,581**

Table 11 (continued)

Replacement Costs

[year 3] Dahn lines (10 at M.K. 30)	300
[year 3] Back lines (50 coils at M.K. 10)	500
[year 3] Hooks (2,000)	45
[year 3] Subtotal	**845**

Gross Revenues[e]

Purse seining catch (3.75 tonnes per month at M.K. 760/t)	34,200
longline catch (100 kg/d at M.K. 0.94/kg)	12,408
[years 1-5] Subtotal	**46,608**

Salvage Value

Steel catamaran (75% of capital cost)	22,500
Wooden plank boats (50% of capital cost)	1,680
[year 5] Subtotal	**24,180**

Net Cashflows

	With Financing	Without Financing
Year 0	0	-62,980
Year 1	556	18,027
Year 2	556	18,027
Year 3	-289	17,182
Year 4	556	18,027
Year 5	24,736	42,207

Financial net present value at 15% = M.K. 13,330 (with financing)
Financial IRR = 20.1% (without financing)

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[a]Purse seining for 168 days per year and longlining with 2,000 hooks for 132 days per year. Fishing areas are the best sites in the northern part of Lake Malawi. Period of analysis is 5 years. All data from Seymour 1985b.

[b]To tow catamaran out of net.

[c]Anchors for rocky ground.

[d]100% financing of capital costs at an interest rate of 12% per year over a 5-year repayment period.

[e]At expected lakeshore wholesale prices since a large enterprise would not sell to middlemen at beach prices.

Problems Encountered in the Project

Some serious problems were encountered in the project due to the bad reputation of a defunct project elsewhere in the country that produced unsatisfactory ferrocement boats, improper handling of the boats produced under this project which resulted in damage and delays, selection of an inappropriate boat design for the project area, and government policies toward the pricing of fish which make fishing marginally profitable. The project probably should have been deferred until funding for the complementary Northern Region Fisheries Development Project had been secured.

The Negative Demonstration Effect of Another Project

The progress of this project was adversely affected by the reputation of a defunct ferrocement boats project that was based in another part of the country. The boats built under the earlier project were of a different design and were poorly constructed. Since Malawi is a small country, the unfortunate experience of the Malindi ferrocement boats was well known among medium-scale fishermen on Lake Malawi.

The Malindi ferrocement boatyards project was established in Mangochi on the southern shore of Lake Malawi in mid-1979. The project was administered by the Anglican church with M.K. 149,998 of financing from the Barclays International Development Fund and CODEL. The boat designs and technical assistance were provided by MacAlister Elliott--the same firm that was later involved in the Karonga boatyard at the request of the Fisheries Department.

Between 1979 and early 1982, the Malindi boatyard produced nine 4.6 m boats, sixteen 5.8 m boats, four 8.5 m boats, and one 9.8 m boat. Fishermen bought only five of the 4.6 m boats and five of the 5.8 m boats and the Fisheries Department bought three 8.5 m boats which use a 35 hp inboard diesel engine. Four boats remained unsold and the rest were sold for patrol, pleasure, and transport uses. As their sales dwindled over time, the Malindi boatyard experienced cashflow problems and shut down in early 1982 (Mang'oma and Poldervaart 1982).

What were the reasons for the failure of the Malindi boatyard? First, the boat designs were flawed. As open boats without watertight decks, they filled up with rain and tended to take a lot of spray. The 4.6 m boats were too unstable for Lake Malawi, the 5.8 m boats were too heavy for their size, and the 8.5 m boats were poorly balanced. All of these boats had a buoyancy system consisting of polystyrene foam enclosed in wooden compartments which did not work. The scrap polystyrene became waterlogged and lost its effectiveness after a few immersions. Consequently, they did not handle well in rough weather and they

tended to sink to the bottom of the lake when they were damaged. The larger Malindi boats are of a suitable size for pair trawling, but they lacked a fishhold.

Second, the first boats were badly constructed because they were rushed into production and the workers had not been properly trained. For example, the port gunwhale was lower than the starboard gunwhale on one of the boats purchased by the Fisheries Department, indicating that the hull was out of true. In addition, the frames were not parallel because they probably had been moved during plastering, and the stern tubes were out of alignment and had to be knocked out. The boats were supposed to have a steel brace fitting between the engine bearers to support a capstan head of a hydraulic winch. This brace was omitted because it was difficult to make locally, but that caused the bolts holding the wooden engine bearers to the engine beds to come adrift. One of the three boats owned by the Fisheries Department was a tonne heavier than the other two although they were supposed to be the same size (Tropical Development and Research Institute 1983). Also, the concrete engine bearings were subject to seriously cracking. Rusting steel mesh can be seen on some of the boats because of the poor job done in plastering. In actuality, the greatest care should have been taken on the first boats because a bad reputation can be established quickly, destroying the market.

Third, there was an insufficient assessment of the market. Although the initial goal was to produce small boats, Malindi had to switch to larger boats when the market did not materialize. Nor was there a market for the larger boats. It is unclear whether a sufficient market would have existed on Lake Malawi even if the boats had been of acceptable quality. The Malindi boats were designed for fishing in shallow, sheltered areas that can be easily reached by wooden plank boats or even dugout canoes.

Fourth, potential buyers were also scared away by an accident that occurred in late 1981. One of the Malindi boats owned by the Fisheries Department was swept ashore after having swung on its anchor in a storm. The accident left a hole in the side of the boat and the engine had to be cleaned. Later, another Malindi boat sank on its moorings.

Fifth, project administration was deficient. The boatyard was deliberately sited in a remote location to help develop the area even though there was no previous boatyard in the area. As a result, transport facilities were poor and the boatyard lacked the equipment and experience to complete the fitting out or installation of machines so it had to send the hulls to one of the government boatyards. The enterprise was not really operated like a business and it made no attempt to diversify into other product lines when boat sales fell. Perhaps most important, there was no effective program for demonstration and promotion of the boats. Although the National Bank of Malawi set aside some

credit for purchase of these boats, few loans were made to fishermen.

The kinds of problems experienced by the Malindi boatyard are not unusual in development projects. What is surprising is that many of the same mistakes were repeated in the Karonga project. Another important lesson is that a project to disseminate an appropriate technology should not have been attempted so soon after the negative demonstration effect of a similar project in a not too distant geographic area.

Durability and Safety of the Ferrocement Boats

The Fisheries Department had quite a bit of trouble with boat accidents in this project due to inexperience and poor labor supervision. About 10 incidents occurred over a 2-year period. Fortunately, these violations of basic safety practices did not result in any serious injuries to the crews.

The first incident occurred during late 1983 when some Fisheries Department staff were using the 5.6.1 boat in bad weather for their own fishing without authorization. The boat capsized in a strong wind because the crew set the sail full and tied down the main sheet (the rope controlling the sail) while trying to start the engine. Two of the basic rules of sailing are to reef down the sail in bad weather and to hold the sheet so that it can be released to spill the wind during a gust. As a result, the boat floated upside down for over an hour until the mast touched the lake bed in shallow water. The crew members were safe because they sat on the overturned hull. The boat would not have capsized if it had been turned head into the wind to decrease its speed.

In an attempt to rescue the 5.6.1 boat that same day, the 7.2.1 boat was run aground on a sand bank. The 7.2.1 boat was recovered without damage by using a hand winch. Eleven days later, divers attached lines to the 5.6.1 boat so that it could be winched by hand and towed by a steel boat. The upper spar was broken during the capsizing and a large crack was opened near the base of the daggerboard during the recovery of the boat. The spar was replaced at low cost, the crack was chipped out and replastered, the engine was cleaned and reassembled, and the deck was recaulked.

When the 5.6.1 boat was launched, the crew forgot to take the mast down so the steel wires that stretched from the side of the ship to the mast got caught in electric lines. Another problem on that boat was that the engine had been mounted with a thin aluminum sheet instead of a thick steel plate with thin shims. As a result, the bolts that hold the engine came loose.

In late 1984, a wooden plank boat was tied to the 7.2.1 boat on a short rope. Strong winds brought a lot of water into the

plank boat, leaving it low in the water while large waves caused the ferrocement boat to move up and down. The plank boat was pulled under the transom of the ferrocement boat each time the stern lifted. The ferrocement boat sank because five holes were made in the hull as it fell on the stem of the planked boat. The ferrocement boat was recovered four days later, but the propeller shaft and wooden gunwhale were damaged in this process. The damage to the ferrocement hull was repaired and the engine had to be rebuilt. Under the same circumstances, a wooden boat would also have sunk, but a steel boat would only have been dented.

Also in late 1984, the 5.6.1 boat broke its moorings twice, shattering the skeg and leaving a hole in the bow. The damage was replastered. Around the same time, the mooring broke on the 5.6.2 boat. As it was washed ashore, rocks made holes in several places in that boat. The holes were later repaired, but the lesson that a stronger mooring was necessary was still not heeded. In early 1985, the rope mooring broke again when another boat dragged its anchor too close to the 5.6.1 boat. The 5.6.2 boat washed ashore again in early 1985 because its thin wire mooring rope was frayed. No damage was done in these last two incidents.

These incidents did not result from an inherent problem with the design of the ferrocement boats. They resulted from the fact that staff used the boats without authorization and displayed ignorance of basic rules of boating and sailing. This indicates a lack of proper training and supervision of Fisheries Department staff. Although more than the expected amount of damage occurred, it was repaired without much difficulty. No serious injuries to the crews occurred.

Several things could have been done to reduce the damage. Since a ferrocement boat has a lot of momentum, it must be securely moored with chain or a combination of chain and heavy wire rope or braided nylon. Fenders made of old tires could have been added to the boats for protection. A heavier skeg would have been less susceptible to damage. The Fisheries Department could have obtained government insurance for the boats if the boats had been assigned a government registration; however, then the boats could only have been sold through the Central Tender Board. The annual cost of private insurance is 5% of the value of the boat, which is expensive relative to the Fisheries Department's budget.

Selection of an Inappropriate Scale of Boat for the Project Area

The appropriateness of a boat design depends on how well it fits into a system that includes the abundance and location of fishery resources, fishing methods and the skills of the crew, transport and distribution facilities, market conditions, and the policy environment. By this definition, a ferrocement boatyard is inappropriate for the northern part of Lake Malawi at this time. The appropriateness of ferrocement boats on the central

and southern part of Lake Malawi is uncertain and remains to be demonstrated. However, ferrocement boats are very appropriate in some other less developed countries.

One of the rules of thumb in small-to-medium scale fishing is that a fisherman should gradually upgrade the type of boat used, going from one size to the next larger size. This project tried to get around this rule. Since almost all of the fishermen in the northern part of Lake Malawi are using dugout canoes, a wooden plank boat would be the next step up for them. These fishermen generally have little invested capital in their operations and maintain low fixed costs; often they do not even keep financial records. Some fishermen who could afford a plank boat resist buying one because they could make more money with less risk by purchasing more fishing gear or another canoe that can be rented out. Consequently, the demand for a medium or large fishing boat in the project area (whether ferrocement, steel, or fiberglass) is very low at present. A 5.6 m boat is about at the lower limit of the size that is practical for ferrocement although some work has been done on a ferrocement canoe (Sharma and Gopalaratnam 1980).

If a ferrocement boat were properly handled, its discounted life-cycle costs at current prices could be lower than those of a wooden plank boat of comparable size which needs to be replaced more frequently. The catch here is that most of the fishermen/entrepreneurs who do want a medium-sized boat prefer to pay lower capital costs even if the present value of future replacement costs is higher. Capital is very short in the fishery sector in Malawi and there are many competing needs. Since the risks are high, fishermen are not looking for a boat that lasts 25 years or for large loan obligations.

This ferrocement boats project was probably premature because a critical level of wood scarcity has not yet been reached in Malawi. While suitable timber stocks last, wood will remain the principal material for small- and medium-sized fishing boats. In the future, however, the relative attractiveness of ferrocement as a substitute for wood in boat building may increase. With continued deforestation, the price and availability of timber may become more limiting and government regulations on wood cutting may become more stringent.

Successful operation of a ferrocement boat requires an enterprise with a relatively high level of organization. This enterprise would have to fish nearly every day of the year when conditions permit. It would also need a sufficient amount of gear in good condition and excellent access to distribution channels for marketing of fish. Such enterprises are rare in the fisheries sector in Malawi, but could be profitable. An absentee owner whose only role is to provide a boat and take 50% of the catch is not likely to work out at this scale. The prospects for success may be better for an active entrepreneur who understands the fishing business and hires a good crew than for a traditional fisherman.

The experience to date also raises questions about the likelihood of proper handling of a ferrocement boat. Nevertheless, a fishing entrepreneur who has a financial stake and manages and trains his crew well may have more success in this regard than poorly motivated and supervised government fishing crews have had to date. A ferrocement boat would not be an ideal choice for a very large purse seining or stern trawling operation (such as the parastatal Maldeco) because of the risk of impact damage when several boats are used in tandem.

The project did point out the desirability of sails as a propulsion method for small- and medium-scale fishing boats. As a supplemental source of power in wooden plank boats equipped with motors, sailing can significantly reduce fuel costs. A sail could also increase the performance of a dugout canoe. Although wind conditions are suitable on Lake Malawi, there is really no tradition of sailing in the country although it exists in neighboring Mozambique.

Fish Pricing Policies

The pricing of fish is complicated in Malawi. There have been four types of prices: (1) beach prices, (2) prices at government landings, (3) wholesale prices, and (4) retail prices. Beach prices are paid to fishermen by middlemen at the places where the catch is landed. In some areas, maximum beach prices are controlled by district councils and tribal chiefs. These local authorities tend to enforce price controls more rigidly on the northern lakeshore than in the rest of the country. The maximum prices at government landings (including the parastatal Maldeco) were controlled by the Treasury Department until November of 1985. The beach prices average 35% of the retail prices while wholesale prices received by middlemen are about 60% of the retail prices (Landell Mills Associates 1983). Retail fish prices are higher in the north and are higher further inland, where fish is available. Table 12 compares these various prices of fish in the north in mid-1985. In some places, the locally controlled beach prices were much lower than the average; for example, M.K. 0.07 per kg at Likoma. Prices tend to be higher in the dry season and lower in the rainy season, reflecting the supply.

As a result of the price controls, many fishermen in the north do not sell fish sell at the beach. Instead, they barter fish within the community or have their families smoke or dry fish and transport it to obtain the wholesale price. It takes 3.5-4.0 kg of fresh fish to make 1 kg of dried fish. When price controls are imposed at the beach or government landings, fishermen also have less incentive to market their catch instead of consuming it for subsistence, increase fishing effort with

Table 12
Controlled Prices, Observed Prices, and Expected Market Prices of Fish in the Northern Part of Lake Malawi (M.K. per kg)[a]

Species	Controlled Beach Price at Government Landings[b]	Observed Beach Price at Karonga[c]	Observed Beach Price at Nkhata Bay[c]	Observed Inland Retail Price[d]	Expected Lakeshore Wholesale Price
Oreochromis shiranus	0.63	0.61	0.50	1.49	0.89
Lethrinops sp.	0.29	0.20	0.46	0.70	0.42
Bagras meridionalis	0.46	0.38	0.50	1.21	0.73
Bathyclarias gariepinus	0.34	0.34	0.76	1.56	0.94
Other	0.46	0.61	0.28	1.35	0.81
Unweighted Mean	0.44	0.43	0.50	1.26	0.76

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[a]All data are from Fisheries Department records except for expected lakeshore wholesale price which was estimated at 60% of the observed inland retail price.

[d]Decontrolled in November of 1985.

[c]Average for April 1984 through March 1985.

[d]In mid-1985.

their existing equipment, or upgrade their gear or boats. The lack of retail price controls means that middlemen are the main beneficiaries of the price controls on the catch. Retail price controls would still adversely affect the profitability of fishermen and the quantity of fish on the market, but might reduce the cost to consumers of the marketed fish. Retail price controls might be harder to monitor.

The hypothetical fishing enterprises analyzed earlier which could be very profitable at the expected lakeshore wholesale prices become money-losing ventures if they can only sell fish at the controlled government landings prices (like Maldeco). At the controlled prices, the annual gross revenues of the gillnetting enterprise with the 5.6 m ferrocement boat would be reduced by M.K. 5,952. This would make the net present value of the ferrocement enterprise at a 15% discount rate M.K. -2,600 and the internal rate of return would be -0.4%. Similarly, the annual gross revenues of the purse seining and longlining enterprise with the steel catamaran would decrease by over M.K. 22,300. The catamaran enterprise would then have a net present value of almost M.K. -61,600 or an internal rate of return of -28.8% (table 13).

Recommendations for Subsequent Activities

Many lessons have been learned through this project about the design of appropriate fishing boats for Lake Malawi and ferrocement as a construction material. It would be desirable to build on what has been learned rather than letting the experience get lost. To this end, this section makes recommendations for relocation of the ferrocement boatyard for maintenance of repair and servicing and possibly production facilities, disposition of the boats that were produced, financing of boat sales, and promotion and demonstration of ferrocement sailing boats.

Relocation of the Ferrocement Boatyard

The project had established a new boatyard in a remote location at Karonga to meet a hypothesized demand for medium- and large-sized boats in the north and to promote development of the area. Building the boats at one of the existing boatyards and transporting them to the north was thought to be impractical. In hindsight, the siting of the boatyard was a mistake. The demand for boats of those sizes did not materialize in the north. At present, there is no commercial-scale fishery in the north, mainly because of the limited quality of the resource base, low fish prices, and poor infrastructure. Furthermore, traditional-scale fishermen either are not interested in the level of risk associated with a loan to buy one of these boats or lack the managerial capability needed to run such an enterprise.

Table 13
Financial Analysis of the Steel Catamaran and Ferrocement Boat Fishing Enterprises At Controlled Prices of Fish in Mid-1985 (M.K.)[a]

	Net Cashflows			
	Steel Catamaran[b]		5.6 m Ferrocement Boat[c]	
Year	With Financing	Without Financing	With Financing	Without Financing
0	0	-62,980	0	-8,335
1	-21,783	-4,312	-628	1,685
2	-21,783	-4,312	1,439	874
3	-22,628	-5,157	-1,739	574
4	-21,783	-4,312	-628	1,685
5	2,397	19,868	1,086	3,399

	Steel Catamaran	Ferrocement Boat
Net present value (r=15%)	-61,554	-2,597
IRR	-28.8%	-0.4%

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[a]Controlled prices at government landings are M.K. 0.34/kg for *Bathyclarias gariepinus* caught by longlines and an average of M.K. 0.44/kg forother species caught in purse seines orgillnets.

[b]See Table 7 for assumptions.

[c]See Table 9 for assumptions.

The production costs of the ferrocement boats would have been a little cheaper if the ferrocement boats facility had been located at the existing plank boatyard at Salima instead of at Karonga. Most domestic or imported raw materials come through Blantyre. From Blantyre, the distance to Karonga is 869 km while it is only 266 km to Salima. To reach Karonga, they are sent by lake transport to Chilumba and then trucked 72 kilometers. Goods sent to Salima pass by train to Chipoka and then 46 km by truck. Hardwoods are available locally at both sites. Steel mesh is sold at the same price in both places by local branches of a nationwide chain of hardware stores. Plywood comes from Lilongwe, but a special trip is not required because headquarters staff visit branch fisheries stations at both locations. There would be a small transport savings for steel rods and cement.

A more significant savings would be in reduced waste of labor. Shortages of various raw materials plagued the Karonga site and would be less of a problem at Salima. The Karonga boatyard still had to pay its workers even when they were idle for lack of some raw material. The poor relations between the Karonga boatyard and the site owner, the Karonga Agricultural Development Division, also blocked receipt of needed services. About 20% of the labor time at the Karonga boatyard was wasted for these reasons.

ATI had first advised that the boatyard be moved in July of 1984, but this was put on hold by the Fisheries Department. The reasons cited were the development objectives for the north and administrative difficulties in transferring staff. It would still be best to merge the staff and equipment from Karonga with the existing government boatyard at Salima as soon as possible to maintain the expertise. It is doubtful that a facility that only makes ferrocement boats could be commercially viable in Malawi. The development objectives for the north are not served by the presence of a boatyard that is not producing anything and idle employees would lose the ferrocement construction skills that they had developed. Since a ferrocement boatyard does not require large equipment, it would be easy to transfer. The boat plans, two molds, small equipment, and a small number of employees would have to be moved.

Any future demand for ferrocement boats in the north could be met at a facility at Salima which would be better positioned to meet the possible demand on the central and southern lakeshores. Potential buyers who go to the Salima boatyard to look at a plank boat would have the chance to observe a ferrocement boat as well. This boatyard should also consider building wooden plank boats with sails and fitting dugout canoes with an outrigger.

Disposition of the Boats That Were Produced

The Fisheries Department plans to continue using the six ferrocement boats when they are all completed. One 7.2 m boat will be turned over to the government's ongoing Central Lake Fishery Development Project. Three of the boats would be used in the proposed Northern Region Fisheries Development Project when the funding is received. In that case, one 7.2 m boat would be paid for by the European Development Fund and another 7.2 m boat (possibly the stretched version) and a 5.6 m boat would be considered as government cost-sharing for this project. That would leave one 5.6 m boat for sale under the National Bank of Malawi loan and another as a demonstration model for the boatyard that eventually will be in charge of repairs and/or construction of ferrocement boats.

Since the intention of the project was to set up a self-sustaining boatyard, it would be best if the Fisheries Department transferred sufficient funds to the boatyard to cover the costs of the boats that are to be devoted to other government projects. The proceeds from the sale of the first 5.6 m boat to a private entrepreneur should also go into a revolving fund for boat construction. These funds would help ensure that the skills and facilities for ferrocement boat construction would be maintained and would provide working capital if the decision were made to build more 5.6 m ferrocement boats for sale on the central and southern lakeshores. The proceeds from the sale of the first 5.6 m boat to a private entrepreneur should go into a revolving fund for boat construction. Before the boats are sold or transferred, strength tests should be carried out to make sure that the damage that has been incurred has been repaired and is not due to any defects in the mortar or plastering of the boats.

Financing the Purchase of Boats

Even if the commercial viability of a ferrocement boat is good, without financing, few fishermen/entrepreneurs in Malawi could afford the higher initial capital costs to buy one. Despite the bad repayment record of loans for the Malindi boats, the National Bank of Malawi agreed in mid-1984 to make one loan available to the purchaser of a 5.6 m ferrocement boat from the Karonga boatyard. The loan would be for up to M.K. 12,000 to cover the costs of the boat, motor, gear, and working capital. The loan could probably be lower than that amount without adversely affecting the viability of the enterprise. The National Bank has agreed that repayments from this loan could be reloaned to a similar enterprise. Other sources of small loans would also be available once the commercial viability of such an enterprise had been demonstrated.

So far, no loan has been made yet. The Fisheries Department is responsible for identifying and reviewing applicants and briefing them on the high level of fishing effort needed to make

a ferrocement boat commercially viable. Because the prospects for dissemination of the technology in Malawi rest so heavily on the success of a single loan, the Fisheries Department has been extremely cautious in recommending a loan applicant. Many of the applicants are retired civil servants or young people who do not have experience in managing a commercial fishing venture. Although caution is wise under these conditions, the technology will not be disseminated if no loan is made. The Fisheries Department's insistence that the selected applicant be from the north may be counterproductive. The prospects of running a successful enterprise may also be better for an entrepreneurial type than for a traditional fisherman.

The National Bank had asked for more direct involvement of the Fisheries Department with administration of the loan, but it would not be possible for the Fisheries Department to do some of the things that the National Bank requested. For example, the Fisheries Department could not dictate the fishing area for the enterprise by license although this could be incorporated in the loan agreement. The Fisheries Department would not be able to facilitate the loan repayments unless it marketed the catch. Before November of 1985, it would be undesirable for the Fisheries Department to have marketed the catch because it would have had to impose the controlled government landings prices, which are lower than the wholesale prices that the enterprise could have obtained.

Promotion and Demonstration

The dissemination of any technology that is new to an area requires throrough promotion and demonstration, whether by the public sector or the private sector. Fishermen/entrepreneurs want to be reasonably sure that they can earn more profits from a ferrocement fishing boat than they could from an investment in a different type of boat, more gear, or an alternative outside of fishing. For this to be possible, hired fishing crews would have to accept the boats as being relatively safe and convenient to use given their skills in launching, handling, sailing, and mooring the boats' setting and hauling gear; and storing the catch on-board.

The budget of the Fisheries Department for promotion and demonstration of new types of fishing boats or gear has been limited. The Fisheries Department is negotiating with Voluntary Service Overseas to obtain a volunteer sailing instructor who could train government staff to teach sailing techniques to small-scale fisherment and encourage them to add sails to dugout canoes and wooden plank boats.

Replication Potential Elsewhere

Thousands of simple ferrocement hulls have been produced in China; most of these are not motor-powered and are intended for use in smooth waters. Large numbers of ferrocement boats with outboard engines are in use in Thailand (BOSTID 1973). Ferrocement fishing canoes with a length of 6.0 m are being made in Thailand (Sharma and Gopalaratnam 1980), but they would probably not be appropriate for traditional fishermen in Malawi. Other countries in the Asia-Pacific region where ferrocement boats are being used for fishing include Australia, Bangladesh, Hong Kong, India, Fiji, South Korea, Malaysia, New Zealand, Singapore, Sri Lanka, Vietnam, and Western Samoa (Visvesvaraya 1976). With Asian Development Bank funds, the Bangladesh Krishi Bank plans on supporting the construction of more ferrocement boats for gillnetting and some for trawling (Fishing News International 1985). ITDG is supporting a demonstration project for the construction of two 11-m ferrocement gillnetting boats in Maharashtra, India as a substitute for teak.

Much less work has been done on disseminating ferrocement boats in Africa. ITDG supported a project for ferrocement transport boats in the Sudan. Some 12.8 m ferrocement fish transport boats have been built for a SIDA project in Guinea Bissau. The Ferrocraft boatyard in Kilifi, Kenya is producing 50 6.0-10.0 m ferrocement boats per year for fishing and transport. Some 20.0 m ferrocement boats have been used in Burundi as mid-water trawlers.

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Dr. David Eccles - Consultant, Southern Africa Development Coordination Conference
Ms. Catherine Fort - Appropriate Technology International
Mr. David Garms - U. S. AID, Lilongwe
Mr. Im'wa - Technical Assistant, Mpwepwe Boatyard
Mr. Trevor Jones - Principal Fisheries Officer, Lilongwe
Mr. M. M. Kaluwa - Assistant Accountant, Senega Bay Boatyard
Mr. Kingstone - Marine Engineer, MALDECO
Dr. Digby Lewis - Senior Fisheries Research Officer, Monkey Bay
Mr. Maxwell Malilo - Supervisor, MALDECO
Mr. Michael Matumba - Fisherman, Namiasi
Mr. Jim Maund - Field Director, Voluntary Service Overseas
Mr. Francis Mauwa - Fisheries Assistant, Karonga
Mr. Mkandawirie - Fish Recorder, Chinteche Centre
Mr. Mkandawire - Officer-in-Charge, Namiasi Landings
Mr. Boniface Mkoko - Chief Fisheries Officer, Lilongwe
Mr. Richard Msosa--Technical Officer, Senga Bay
Mr. J.R. Musa - General Manager, MALDECO
Mr. Geoffrey Mzembe - Senior Fisheries Assistant, Chinteche Centre
Mr. Charles Nthenda - Chief Economist, Economic Planning Division
Mr. Bruno Phiri - Technical Assistant, Chinteche Centre and South
Mr. Phiri - Mpwepwe Boatyard
Mr. L. Phiri - Statistics Officer, Fisheries Department, Lilongwe
Mr. Richard Russell - Advances Manager, National Bank of Malawi
Mr. Ali Saiti - Boatyard Manager, Mpwepwe
Mr. G.P. Sakanda - Chief Forestry Officer, Lilongwe
Dr. Anthony Seymour - Senior Fisheries Officer for the North
Mr. Ken Stride - Consultant, Southern Africa Development Coordination Conference
Mr. Leonard Swetala - Clerical Officer, Karonga
Dr. Dennis Tweddle - Fisheries Research Officer, Monkey Bay
Dr. J.G.M. Wilson - Project Manager, Central Lake Fisheries Development Project