ENERGY OPTIMISATION STUDIES IN TRAWLING OPERATIONS ALONG THE KERALA COAST

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BY

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CERTIFICATE

This is to certify that this thesis is an authentic record of research work carried out by Shri. Ajith Thomas John, M.Sc. under my supervision and guidance in the School of Industrial Fisheries, Cochin University of Science and Technology in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY and that no part thereof has been submitted for any other degree.

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DECLARATION

The work presented in this thesis is the result of my own investigation and has neither been accepted, nor is being submitted for any other degree. All the sources of information have been duly acknowledged.

Ajith Thomas John

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C O N T E N T S

CHAPTER 1

INTRODUCTION

Energy optimisation in fishing means using energy which leads to the greatest overall benefit of the individual fishing enterprise, national economy and global environment. The main objective of energy optimisation is to ensure the optimum use of fish stocks, capital, manpower and energy, so that together these may yield greatest sustainable benefit to the present generation, while also maintaining the potential to meet the needs and aspirations of the future generations.

Fishing is one of world's most important producers of animal protein and the protein requirements of mankind can be fully met only from the immense fishery wealth of the worlds oceans. But the developments in fishing technology has converted the fisheries of developed countries into one of world's most energy intensive methods of producing food. The energy efficiency of different types of food production has been presented by Endal (1988). Rice production is very energy efficient. The energy spent on producing one unit of food energy is around 1/10 of the output. Milk production from grass fed cows and artisanal coastal fishing are methods where the ratio between energy input and output is close to unity. Distant water fishing in the north Atlantic is extremely energy intensive, consuming fifteen to twenty times more energy than it produces. The energy intensity is equal to that of feed-lot beef production in the USA. This high energy intensity will make the produce from the sea costlier in the market place and negate the role of fisheries as a cheap source of protein for the developing countries. But there has been a tendency for developing countries to adopt energy intensive fishing methods in their fisheries, making the products from the sea too expensive for their own people and also aggravating their balance of trade problems due to increased fuel importation. Thus a continued high energy profile in the technologically advanced countries will continue to influence the choice of technology in the fisheries sector of the developing nations, with adverse effect on the energy intensity there.

The world population is increasing by the day in concurrence with the increasing protein requirements. But, whether fishing is capable of satisfying this requirement in the face of dwindling oil resources of the industrialised world, roller coaster fuel prices, energy scarcity of the third world and a potential environmental disaster due to carbon dioxide pollution, is questionable.

The remedial measures for this can be viewed in the context of energy conservation and utilising alternative energy sources. In the field of energy conservation important opportunities are found in areas like improved methods for fisheries regulation and management, more productive low energy fishing methods and more energy efficient design and operation of fishing vessels and machinery. Improvements through extensive research in the field of fishing vessel and machinery design, can lead to an operational saving of upto 50% (Endal, 1988). An universally accepted method of conservation of fish stocks is by regulating the type, volume and mesh size of the gear used for each fishery.

The drastic increase in the fuel prices in the seventies, prompted a flurry of activity to reduce fuel consumption of fishing vessels. The important measures which were adopted to reduce the fuel consumption in fishing include, reduction of propeller RPM, addition of bow and stern bulbs, increasing vessel length, improving machinery and waste heat recovery.

One of the most important factors affecting fuel consumption in a vessel is its speed, by increasing speed the operators buy time by spending oil. If the value of time gained exceeds the extra cost of fuel, the increased speed is justified. Another important factor is the vessel length. Limiting vessel length has a very little effect on the catching power but a considerable adverse effect on the fuel efficiency.

In the field of utilising alternative energy sources to supplement the energy requirements of fishing vessels, the following measures were researched upon. The utilisation of wind power through the incorporation of sails on a fishing vessel lead to improved propeller efficiency of the vessel. Trapping the latent energy of waves using foil systems, thus utilising the vessel's motion in waves for propulsion.

Energy optimisation of mechanised fishing vessels involve optimisation of energy through standardisation of almost all aspects of fishing vessel and gear operation including design parameters. International efforts towards on energy optimisation in fishing are presented below.

Fridman (1989), has published a paper on " The problems of fishing energy optimisation", characterising the main tendencies of energy optimisation researches which are underway in the Soviet Union. Kwidzinski (1989), in "Developments in pelagic trawl construction aimed at fisheries energy Optimisation", has given the method to reduce the resistance per trawl mouth surface area unit using rope trawls and large mesh trawls.

Problems relating to hull shape optimisation, optimal matching of the hull, engine and propeller and the issues relating to the problems associated with propeller size have been discussed by Sevastianov (1989). Introduction of improved propulsion system such as the installation of regular propeller nozzles, "Kaplanisation" of the existing or fitting new propellers, slotted blade propellers, slotted nozzles, anti-aeration air divertors and nozzle fins etc. in Israel's trawling fleet brought about improved fishing power and fuel economy has been described by Kohane and Ben-Yami (1989). Williams (1989), in "Pull force at bollard and trawling-Full scale measurements of pull force of three fishing vessels", gives an account of the investigation carried out to measure and compare the efficiency (regarding pull force) of different propellers, conventional and ducted, running with different RPM from three different vessels.

Studies on computer aided design and manufacturing by Hatfield (1988), shows that it will help to a great extend the recent tendencies towards decreasing vessel size, increasing effective electronics, hydraulics, electrical and mechanical power assist, augmented propulsion thrust, improved manoeuvrability and development of construction techniques with new materials.

Anon (1993), gives details of an equipment called Fish Reporter System which saves a vessel's fuel costs by providing the skipper with information on fish schools at distant locations. Knowing where to go ensures that time is spent more profitably and that fuel is not wasted on often fruitless searches. Miurhead (1988), in "The use of electronic charts to increase both energy efficiency and unit productivity within the fishing industry" details the development of the FISHCHART an electronic display and information system custom built to meet the needs of the Canadian fishing industry and will enable both the individual fishing vessel and fleet operations to optimise vessel movements and and to increase fishing productivity.

Gulbrandsen (1986), in "Reducing fuel costs of small fishing boats" describes the principles of power requirements of small fishing boats and details ways of saving fuel which can be applied both with existing boats and new boats. It also illustrates by example how to estimate the savings from measures to conserve fuel. Amble (1988), in "Energy saving in fishing vessels: Review of some recent works in Norway" gives an account of some recent works in Norway related to improving the energy economy of fishing vessels.

Dickson (1988), in "Energy saving in fisheries and evaluation of its effects" detailed the advantages and disadvantages of the main fishing methods in light of the possible objectives and with particular note as to their energy saving possibilities. The effects of introduction of pair trawling as an energy saving method (relative to single boat trawling) are shown not only as to how they save energy, but also as to how, the species composition of the landings differ.

Burchett (1988), in "Vessel management : The second generation" says that energy optimisation and vessel operating efficiency depend on accurate and timely information. He gives an overview of the past, present and possible future uses of on-board computerised information systems. Hinds (1988), in "Underutilised fishery resources and energy efficiency in the fishing industry", says that with an increase in the total utilisation of the harvest today, upgrading of technology currently employed in the industry, world fish production could at least be doubled within a decade. He further goes on to give the possible reasons for the underutilisation of certain species of fish and to highlight where energy inefficiencies occur in the industry.

In India energy intensity remains very high. Organisations like the Petroleum Conservation Research Association (P.C.R.A.) and the

National Productivity Council (N.P.C.), instituted energy conservation consultancy services in the mid seventies itself. But very little effort has been put to conserve the energy input, especially in the fisheries sector, as is evident from the obsolete fishing vessel designs, incompatibility of the engine to the vessel and the irregular maintenance schedules of the mechanised fishing vessels, all of which have led to excessive fuel consumption.

Sheshappa (1991), in "Design of propulsion plants for energy efficient fishing vessels", has given emphasis for the selection of main engine for the fishing vessel adopted for a particular fishing technique. He also dealt with the selection of the propeller for the given engine to get the maximum propulsion efficiency. Choudhari (1984), in "Ducted propellers and economics of trawlers" has charted out the factors affecting the economics of trawlers. A criterion for judging the economic performance is developed based on the above factors.

According to Sheshappa et al. (1988), the criteria for the selection of the installed engine power of a fishing vessel depends on choosing the maximum power among the powers calculated at free running or towing conditions and the maximum expected time value of the fishing vessel for the given fishing situation. A mathematical approach is presented to know the power and time distribution for each phase of the trip cycle and fishing cycle, in order to attain fuel efficiency in fishing operation. Ravindran (1990), in "Frictional resistance and power in relation to fuel savings in fishing vessels", says that the increased power input based on relatively unscientific approach results in power losses owing to losses of transmission efficiency, lower propeller efficiency and factors involved in the power-propeller-hull interactions. This results in over investment of capital, wastage of fuel, increased maintenance and operating costs besides causing intense pollution of the heavily exploited inshore waters. Iyer et al. (1983), studied the effect of increase in the number of fishing trips on the economic efficiency of 9.82m and 11m fishing trawlers along the Kerala coast.

Choudhari (1985) in "Trawler operation a system analysis for the determination of optimum parameters" say that the successful operation of a trawler depends on the close coordination of several variable factors that may be called operational factors. The operational factors are directly linked to the operational conditions which will in turn determine the optimum parameters of the fishing vessel and size of the trawl net to be used. The cost factors and return on investment, the ultimate measure of the effectiveness of a trawler are considered together with guidelines for the designer.

Panikkar et al. (1991), in "A study on the economics of different fishing techniques along the Kerala coast with special reference to fuel efficiency" has analysed the fuel cost and its impact on the profitability and the fuel efficiency of different fishing units with mechanised and motorised craft-gear combinations engaged in inshore marine fishing along the Kerala coast.

George et al. (1993), in "Energy consumption and conservation in Indian fisheries" says that by resorting to careful selection of fishing vessel design and equipment as well as less wasteful trapping methods, fuel consumption may be cut by as much as 25-30%. Sheshappa (1991), in "Design of propulsion plants for energy efficient fishing vessels", says that for the fishing vessels in India, very little attempt has been made to select the right type of engine and propeller. In this paper selection of the main engine is based on whether the vessel is doing active or passive fishing. The selection of the right type of propeller for the fishing vessels engaged in the above types of fishing methods to give better propulsion and fuel efficiency is also dealt with.

A comprehensive study on the energy consumption pattern of fishing boats operating in the inshore waters of he south-west coast of India has been done by Hameed and Hridayanathan (1989). Several reasons have been attributed to the excessive fuel consumption of the three main fishing methods , gill netting, trawling and purse seining. The most important of which are :

- Over-powering of the vessels
- Obsolete designs
- Under-water fouling of the hull
- Inefficiency of the propellers in use.

Further, Hameed and Kumar (1991), have studied the problems of energy optimisation in fisheries, analysing the causative factors of energy wastage in fishing operation and suggesting suitable remedial measures. These works will form the basis for the study.

OBJECTIVES

Appraise the structure of the motorised and mechanised trawl fishing fleet of Kerala.

Assess the availability of resources and its extent of exploitation.

Observe the performance of small motorised boats operating trawl nets from selected centers along the Kerala coast.

Analyse the operational details of selected medium sized mechanised trawlers and deep sea trawlers operating from selected landing centers along the Kerala coast.

Survey the design of trawl nets and otter boards.

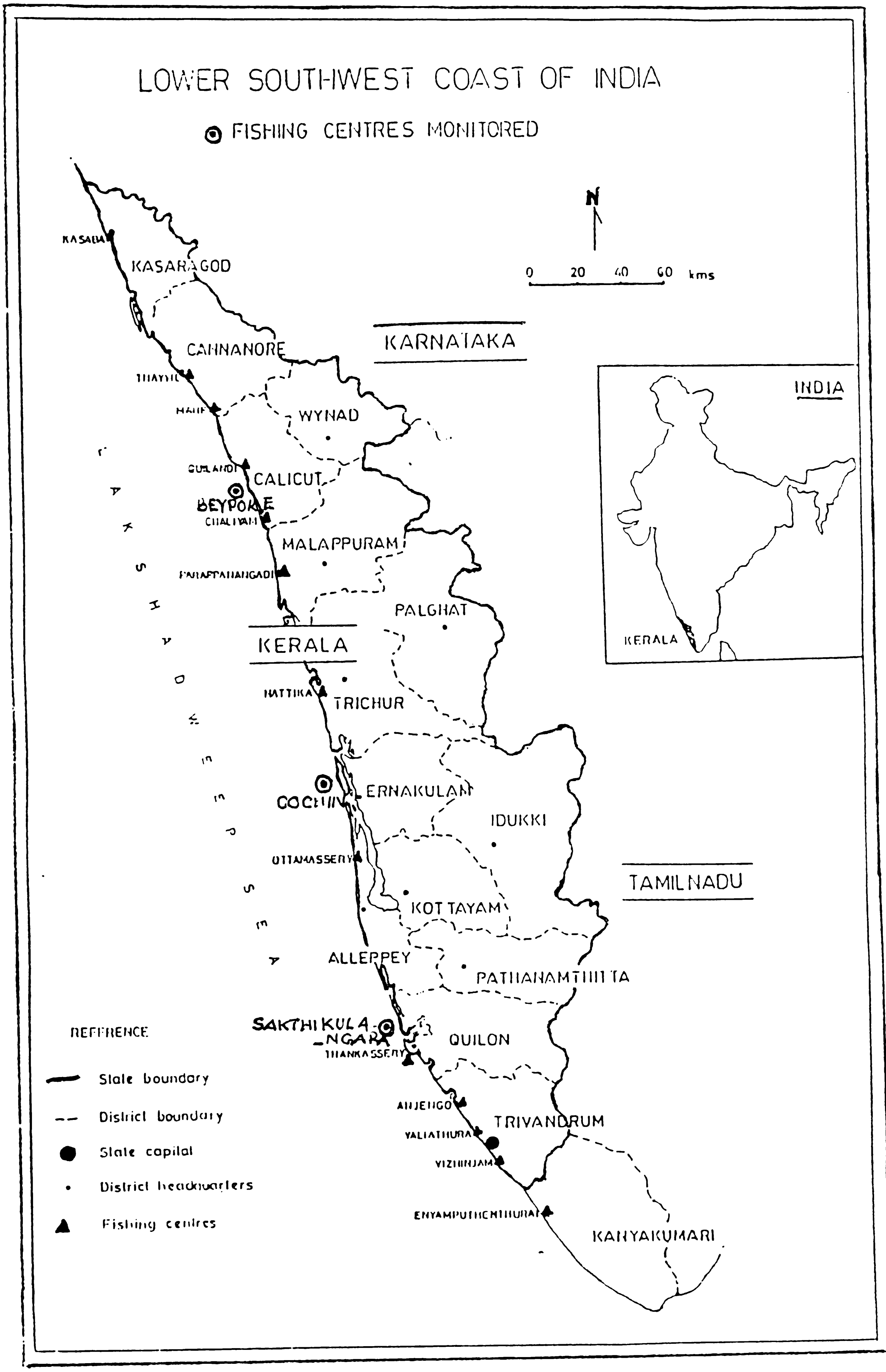
Study the type and material of construction of the propellers used in selected crafts and the efficiency of the propeller.

Study the fuel consumption pattern of selected medium sized trawlers in relation to RPM of engine, hull fouling and material of construction.

Analyse the economics of operation of selected fishing crafts and to analyse the optimum level of use of various inputs of fishing.

Calculate the percentage of over powering in medium trawlers along the Kerala coast.

Suggest methods for reducing fuel consumption in trawling.


LOWER SOUTHWEST COAST OF INDIA
FISHING CENTRES MONITORED
N
0 20 40 60 kms
KARNATAKA
KASARAGOD
CANNANORE
WYNAD
CALICUT
BEYPORE
MALAPPURAM
PALGHAT
KERALA
TRICHUR
COCHIN
ERNAKULAM
IDUKKI
TAMILNADU
KOTTAYAM
ALLEPPEY
PATHANAMTHITTA
SAKTHIKULANGARA
QUILON
TRIVANDRUM
KANYAKUMARI
INDIA
KERALA
LAKSHADWEEP SEA
REFERENCE
State boundary
District boundary
State capital
District headquarters
Fishing centres

CHAPTER 2

STRUCTURE OF MARINE FISHERIES SECTOR OF KERALA

2.1 FISHERY RESOURCES OF THE INDIAN EEZ

The Indian Ocean comprises total area of 51 million Sq. km. The total area of the EEZ of India is estimated at 2.02 million sq.km comprising 0.86 million sq.km on the West Coast, 0.56 million sq.km on the East Coast and 0.60 million sq.km around the Andaman and Nicobar Islands.

The declaration of the Exclusive Economic Zone in 1976 provided both an opportunity and challenge to India for exploration and exploitation of the marine fishery resources in an extensive area of 2.02 million sq.km. Attempts to assess the fishery potential of the Indian Ocean have been contributed by Prasad et al. (1970), Gulland (1971), Cushing (1973), Jones and Banerji (1973) and Mitra (1973). These were based on primary production, exploratory surveys and other data. In 1977, the marine fishery potential of the EEZ was estimated as 4.464 million tonnes (George et al., 1977). Region-wise this estimate was distributed as 0.883, 1.442, 0.674 and 0.735 million tonnes for North West Coast, South West Coast, Lower East Coast and Upper East Coast respectively. An estimate of 0.75 million tonnes was assigned to the oceanic regions of EEZ including Andaman and Nicobar Islands and Lakshadweep. In the coastal areas off the mainland the potential yields of 0-50m zone and 50-100m zone were estimated as 2.261 and 1.453 million tonnes respectively. Based on exploited and exploratory data maximum production rates were indicated for the South West coast and Upper East Coast.

Similar exploratory surveys carried out by the Fishery Survey of India have also indicated potential yields around 4.2 million tonnes. The Fishery Survey of India recently reviewed these estimates and indicated a potential yield of 3.92 million tonnes (Sudarsan et al., 1990a) in the EEZ of India. Other estimates of the potential yield have been obtained by Joseph (1985 and 1987), Nair (1985), James et al. (1986 and 1989) James and Pillai (1990), Sudarsan et al.(1988, 1989 and 1990 a), Alagaraja (1989), Desai et al. (1989) and Mathew et al. (1990). More recently an estimate of the potential yield is made by Sudarsan et al. (1990 b).

The Report submitted by the Working Group of fishery specialists in 1991 (Anon, 1991b), constituted by the Ministry of Agriculture (Department of Agriculture), Government of India, revalidated the fishery resource potential of the Exclusive Economic Zone of India at 3.9 million tonnes with a break-up of 2.21 million tonnes within the 50m depth zone and 1.69 million tonnes beyond 50m depth.

Mechanised vessels annually contributed on an average 1.17 million tonnes followed by motorised country craft (0.21 million tonnes) and non-mechanised craft (0.39 million tonnes) (James et al., 1991). Among the mechanised craft, trawlers contributed the maximum of about 0.69 million tonnes followed by purse seiners, dol netters and gill netters. Information on the effort expended and the catch per unit effort for the important gears given state-wise has also been worked out (James et al., 1991). Commercial exploitation by the deep sea fishing vessels was approximately 1% of the total fish landings. Precise information about the catch landed by this sector is inadequate. It is reported that the chartered vessels in 1988-1989 and 1989-1990 landed between 2074 and 4214 tonnes of tuna and related resources by long lining from oceanic region of EEZ and adjoining seas (Sudarsan et al., 1990a).

Considering the fluctuations due to fishery independant and fishery dependant factors and the fluctuations in the availability of certain groups particularly those of pelagic species. Alagaraja (1989) suggested 2.0 million tonnes as the catchable potential upto the depth of 50m for the east and west coast. Present studies on productivity have indicated a level at about 2.4 million tonnes. Hence the catchable potential for the 0-50 m depth zone off the main land may be considered in the range between 2.0 to 2.4 million tonnes.

The revalidated potential yield of marine fishery resources of 3.9 million tonnes of the Indian EEZ consists of three major components viz. the inshore fishery resources of upto 50m depth all along the east and west coast contributing 2.21mt, offshore and deep sea resources from 50-500m depth contributing 1.395mt and oceanic resources consisting tuna and allied fishes and shark of 0.295mt (James et al., 1991).

The unexploited and underexploited resources beyond the 50m depth estimated to the tune of 1.69mt should be the resource for the future developmental strategy. Considering the availability of the present infrastructural facilities, human resources, economics of operation, financial commitment and possible influx of vessels to cater to the demand of certain specific resources of importance, only a 50% level of exploitation was suggested by the Working Group for computing the additional vessel requirement for the validated resource potential beyond 50m depth of the Indian EEZ. The Working Group suggested a total of 2630 vessels for exploiting 50% of the additional resources beyond 50m. The split-up of these vessels include 50.57% demersal-cum pelagic trawlers, 41.83% gill netter-cum-long liners, 2.85% long liner-cum gill netter (for sharks), 3.8% long liner-cum gill netter and 0.95% purse seiner for oceanic skipjack tuna (James et al., 1991).

Such an indepth review into the resource potential, effort levels and suggestions for directing the effort has not been undertaken after the Working Group study report presented in 1991.

2.2 MARINE FISHERY RESOURCES EXPLOITATION OF KERALA

Kerala, located on the south-western part of peninsular India has a narrow stretch of land with a long surf-beaten coast of 590 km. The sea bordering the Kerala coast is highly productive and produces an average of about 24.21% (Table 2.2.1) of the annual marine fish landings of India.

The shelf waters of Kerala are influenced by both monsoons, characteristic of the sub-continent. The upwelling and other environmental changes brought about by the south-west monsoon strongly influence the spatial and seasonal distribution and abundance of living resources of the coastal waters which in turn make the dependant fisheries highly dynamic. Though for reasons unknown, minor variations do occur in the landings, the cyclic behaviour of the climatic events and the physico-chemical characteristics of the fishing grounds make a majority of the fisheries predictably repetitive every year.

Statistical enumerations on the marine fish production of the

State of Kerala is available from 1950 onwards (James et al., 1991). The production which was of the order of 200,000 tonnes in 1950 suffered in the subsequent years. The fishing activities gained momentum only in 1957 when the fish production was a substantial, 3,01,000 tonnes. Thereafter the production trend has been that of sustained development. Upto 1964, there has been an increasing trend. In 1965, the production was 3,40,000 tonnes. But in the subsequent two decades, 1970-'79 and 1980-'89 the production fluctuated between 2,90,000 tonnes and 4,50,000 tonnes. In these two decades, inspite of occasional spurts in 1970-1975 and 1980-1984, the production was mostly stagnant. The latter half of the eighties witnessed a spectacular increase in production. Compared to the seventies, the eighties showed a decrease in the annual production by 0.05%. With reference to the seventies, the first half of the eighties witnessed a reduction rate of 2.26% with an annual production of 3,31,000 tonnes. But, the latter half of the eighties recorded an annual production of 4,26,000 tonnes which registered a growth rate of 5.1% compared to the first half.

As per the Report of the expert committee on Marine Fisheries Management in Kerala (ECMFM, 1989), during the fifteen year period, viz. 1974-1988, the annual marine fish landings in the state varied from a minimum of 2.74 lakh tonnes in 1981 to a maximum of 4.69 lakh tonnes in 1988. Starting with 4.20 lakh tonnes in the beginning of the period the landings dropped to 2.74 lakh tonnes in 1981. Afterwards the landings started picking up reaching 3.93 lakh tonnes in 1984 then dipping to 3.83 lakh tonnes in 1987 then increased to 4.69 lakh tonnes in 1988. From 1988 to 1989 there was a sudden increase in the landings from 4.68 Lakh tonnes to 6.47 lakh tonnes. This increase in landings was contributed by the steep increase in the landings of oil sardines and mackeral. In 1990 the landings further increased to 6.62 lakh tonnes. From 1991 to 1993 the total fish landings were steady at around 5.6 lakh tonnes. Broadly classifying the resources as pelagic and demersal, it is noticed that the landings of the pelagics varied from 1.47 lakh tonnes in 1980 to 2.92 lakh tonnes in 1988. In the case of demersals, the minimum landings of 0.71 lakh tonnes was recorded in 1981 when the total marine fish landings were a minimum and the maximum of 2.05 lakh tonnes in 1975 when the total marine fish landings of the state stood at 4.21 lakh tonnes. The decline in the total landings during 1990 to 1993 can be attributed to the lower landings of pelagic resources of sardine and mackeral. Since about 63% of the total landings is accounted for by the pelagics, the general trend of the total landings depend on the trend of landings of the pelagics. In the case of demersals the maximum is almost three times its minimum. During the years were there was good landings of both these groups, the total landings always crossed 3.70 lakh tonnes.

Among the pelagics the dominant ones are Oil sardine (Chala) and Mackeral (Ayila). Anchovies (Netholi) and Tunnies (Choora) have also been exploited in good quantities in recent years (James et al., 1991; Anon, 1995).

Oil sardine :

The contribution from this single component varied from a minimum of 41,000 tonnes in 1986 to a maximum of 1,55,000 tonnes in 1983, with no clear cut trend. However during 1976 - 1979 the average annual contribution was 1.20 lakh tonnes : it then dipped to 0.70 lakh tonnes in 1980, then proceeded with an average of 1.48 lakh tonnes during 1981-1984 followed by an average of 0.56 lakh tonnes during 1985 -1988. During 1989 to 1991 the landings showed a steep decline and averaged 1.57 lakh tonnes. After 1991 the catches declined and averaged only 0.52 lakh tonnes for the period 1992-'93 indicating wide fluctuations in the landings.

Mackeral :

In the landings of mackeral no such trend could be noticed. The magnitude of the landings varied from a minimum of 10,000 tonnes in 1974 and 1987 to a maximum of 44,000 tonnes in 1988, which is less than half of what was landed in 1971 (95,000 tonnes). In the year

1989 the catches almost doubled to 85000 tonnes. From 1990 to 1992 the catches declined at a constant rate from 78000 tonnes to 38000 tonnes. There was a slight increase to 59000 tonnes in 1993.

Stolephorus :

Wide fluctuations have been noticed in the landings of Stolephorus spp. During the fifteen year period 1974-1988 the landing varied from a minimum of 4300 t in 1981 to a maximum of 55,000 t in 1983. In the years 1989, 1991, 1992 and 1993 the catches averaged around 47000 tonnes except in 1992 which showed a decline of landing to 27000 tonnes.

Tunnies :

Since the quantity landed by this group is relatively small when compared to the other pelagic resources indicated above, the variations in the landings of this group are not very significant. The total landings of tunnies varied from a minimum of 5500 t in 1981 to a maximum of 15,400 t in 1979 during the fifteen year period. The average landings for the years 1989 and 1990 was 27500 tonnes while for the next three years 1991 to 1993 it was 14000 tonnes showing almost 50% decline in the landings.

Other pelagic resources such as ribbon fish, carangids etc.

also exhibited wide fluctuations without any definite trend in their annual landings.

Demersals :

Among the demersal resources three items alone are considered here, namely penaeid prawns, cephalopods and cat fishes due to their economic importance and otherwise as indicators of the general trend of demersal resources. Relatively the fluctuations in the landings of these resources are expected to be less than those of the pelagic groups.

Penaeid prawns :

The landings of the penaeid prawns during 1974 - 1988 ranged from a minimum of 22,300 t in 1981 to a maximum of 77,200 t in 1975. With 61,000 t in 1974, the annual landings touched 77,200 t mark in 1975, then came down to 34,500 t in 1976 with an increasing trend then on till 1978, with 45,000t. In 1979, the catches once again went down to 29,500 t, with a sudden jump to 52,600 t in 1980 and then a drop to 22,300 t in 1981, the minimum during the period of reference. Then onwards there was an increasing trend till 1984 with 35,500 t during 1984. Though this type of wild fluctuations in the case of demersal resources, particularly that of penaeid prawns, is to be viewed seriously, it could be seen that during the years 1989 to 1993 there was a steady landing of around 51000 tonnes negating the role of any concern.

Cephalopods :

In recent times as a result of the export demand, this item has assumed significance and though there is no directed fishery for this item, its exploitation has been intensified resulting in its increased catches. Attempts are being made to introduce squid jigging to exploit the cephalopod resources more intensely and efficiently. During the last fifteen years, viz., 1974 - 1988, the magnitude of their catches varied from a minimum of 900t in 1976 to a maximum of 15,000 t in 1988. In this case also it is clear that wide fluctuations do occur in the quantity of landings. During the five year period 1989 to 1993 there was again wide fluctuations in the landings with a maximum of 30000 tonnes in 1992 and a minimum of 19000 in 1991.

Cat fishes :

The landings of cat fishes have a different picture altogether. Starting with a maximum of about 34,000 t in 1974 and reaching a minimum of 4700 t in 1987. But in 1988 the landings touched 10,000 t. Though there were upward jumps in the level of catch between 1974 - 1988, the quantum never reached the level obtained in 1974 and

1975. From 1989 to 1993 a steep decline in the catches was observed with only 0.6 tonnes being landed in 1993. Since this group forms a by-catch of the trawls, perhaps due to intensive exploitation of the trawler grounds subsequently and catching more of young ones, not only of cat fishes but also of other fin fishes, the catches could not reach the levels of 1974 and 1975.

Traditionally, the trend of marine fish production in the state has been determined by the availability of pelagic resources, mainly oil sardine (*Sardinella longiceps*) and mackeral (*Rastrelliger kanagurta*). Though it is the pelagics which determine the quantity of the landings, the value of the landings depends upon the demersal resources of shrimps and cuttle fish. The steep decline in the landings of catfish, a by-catch of the shrimp trawls, if analysed in a broad perspective, may be an indication of the intense exploitation of the demersal resources calling for immediate attention towards by-catch reduction in shrimp trawling.

2.3 INFRASTRUCTURAL SUPPORT FOR THE MARINE FISHERIES OF KERALA

In fisheries the production activity is supported by various ancillary factors such as manpower and infrastructural facilities in addition to the craft and gear employed in fish capture. The CMFRI conducted an all India census of marine fishermen and craft and gear in 1980 (Jacob et al., 1987). In Kerala, the census was conducted in eight coastal districts, namely, Trivandrum, Quilon, Alleppey, Ernakulam, Trichur, Malappuram, Kozhikode and Cannanore. Another source of updated information was the Facts and Figures 1990, published by the Department of Fisheries, Kerala. Further information on the number of crafts operating along the Kerala coast was available from the report of the Expert Committee on Marine Fishery Resources Management in Kerala (ECMFRM, 1989).

2.3.1. Fishing Villages and Landing Centers

According to Jacob et al., 1987, out of the 304 fishing villages/hamlets in Kerala, the largest number was in Cannanore district (65) and the least in Malappuram district (18). The same census gives a figure of 222 for the fish landing centers in the state. The major fishing harbours in the state in 1980 were, Cochin and Sakthikulangara, while the centers where mechanised boats berth included Munambam, Azhikkal, Ponnani and Beypore.

The major fishing harbours in Kerala in 1994 as per the Directorate of Fisheries, Government of Kerala are Neendakara, Cochin and Beypore. The fish landing centers for mechanised boats in Kerala numbered 9, while the fish landing centers for traditional fishermen were 8 as per Directorate of Fisheries, Government of Kerala. According to the Planning and Statistical cell, Directorate of Fisheries, Government of Kerala, the number of fish landing centers proposed for the traditional fishermen in the different coastal districts of Kerala are Thiruvanamthapuram (7), Kollam (6), Allapuzha (4), Ernakulam (5), Thrissur (6), Malappuram (7), Kozhikode (4), Kannur (4) and Kasargode (7).

2.3.2. Fishermen Population

The estimated district-wise distribution of marine fishermen population and the percentage distribution of active marine fishermen in Kerala (1993-'94) as per the Kerala State, Department of Fisheries is presented Table 2.3.1.

2.3.3. Fishing Craft

According to CMFRI census, 1980, the estimated total number of mechanised craft in Kerala in 1979-'80 was 3038, which comprised 2630 trawlers, 362 gill netters, 37 purse seiners and 9 'other categories'. In the mean time, the process of motorisation had started in Alleppey district and soon spread to other parts, between Munambam in the North and Vizhinjam in the South, the number of craft taken to motorisation grew to 4000 by the end of 1984. Soon motorisation picked up in North Kerala and the number of mechanised craft in the state grew to about 6000.

The number of mechanised craft in the state was 986 and the non-mechanised craft 26,000 as per the CMFRI census. Of the 26,000 non-mechanised craft, catamarans formed 44%, dug-out canoes 40% and plank-built boats the rest. Catamarans were found only in Trivandrum (90%) and Quilon districts (10%). Plank built boats were concentrated more in southern districts, namely, Trivandrum, Quilon and Alleppey, whereas dug-out canoes were comparatively more in northern districts, namely, Trichur, Malappuram, Kozhikode and Cannanore.

Details of mechanised and non-mechanised fishing craft in Kerala, 1987, according to the Report of the Expert Committee on Marine Fisheres Management in Kerala, 1989, is presented in Table 2.3.2. In the non-mechanised section, non-motorised crafts were estimated to be 26137 and motorised crafts numbered 9657. The total number of mechanised boats were estimated at 3548 (Table 2.3.2).

2.3.4. Fishing Gear

As per the CMFRI census 1980, There were about 1500 trawl nets in the state, the bulk of which were in the districts of Quilon (41%), Cannanore (18%), Ernakulam (16%) and Kozhikode (14%). The most commonly used gear in the state of Kerala was the drift/set gill net. Boat seine was the next important gear found in all the districts. Hooks and lines, traps and scoop nets were mainly concentrated in Trivandrum district. In all the coastal districts of Kerala except Trivandrum, indigenous fishing operations were carried out either by drift/set gill net or by boat siene. In Trivandrum district, fishing activity was more diversified, with the use of various types of gear such as drift/set gill nets, shore seines, boat seines, scoop nets and traps. Among the other gears, cast nets constituted a major portion.

Facts and Figures, 1990 (Anon, 1990), gives information on the district-wise distribution of fishing gears in Kerala in the year 1990 (Table 2.3.3). In this estimate, trawl nets figured only 8.09% of the total number of gears.

2.3.4. Ice Plants and Cold Storages

As per statistics pertaining to the year 1980, there were five ice and cold storage plants, in the public cooperative sector in Cannanore district. The number of ice and cold storage plants in the other districts were four in Kozhikode, two in Malappuram, three in Trichur, three in Ernakulam, three in Alleppey, two in Quilon and two in Trivandrum. The total ice plant capacity was 186 tonnes/day, ice storage capacity was 726 tonnes/day, fresh fish storage capacity was 584 tonnes/day, freezing capacity was 56 tonnes /day and frozen fish storage capacity was 1530 tonnes/day.

In the private sector the number of ice plants and cold storages in Kerala during 1989 numbered 353, while in the public and co-operative sector it was only 16 (Anon, 1990).

2.3.6. Boat Building/Repairing Yards

According to the CMFRI census 1980, the number of boat building yards in the public sector were two, one in Sakthikulangara and the other in Beypore. In the private sector there were 14 yards in Quilon district, 4 in Alleppey, 13 in Ernakulam and five in Kozhikode. The yards undertook repairing works also. Further authentic data on the existing number of yards in the private sector was not available while in the public sector no new yards were added to the existing yards at Sakthikulangara and Beypore.

Table 2.2.1 Marine fish landings (in tonnes) in Kerala compared to landings in India during 1980-'93

Year	India	Kerala	%
1980	1249837	279543	22.37
1981	1378457	274395	19.91
1982	1420624	325795	22.93
1983	1548475	385765	24.91
1984	1630678	393472	24.13
1985	1522517	325536	21.38
1986	1679373	382791	22.79
1987	1649165	303286	18.39
1988	1785549	468808	26.26
1989	2208598	647526	29.32
1990	2142713	662890	30.94
1991	2222111	564161	25.39
1992	2277008	560742	24.63
1993	2245124	574739	25.60

Source : CMFRI

Table 2.3.1 DISTRICT-WISE DISTRIBUTION OF MARINE FISHERMEN POPULATION AND THE PERCENTAGE OF ACTIVE FISHERMEN 1993-94(ESTIMATED)

District	Male	Female	Children	Total	No. of Active Fishermen	% of active Fishermen
Thiruvananthapuram	43176	46178	66008	160362	30180	18.82
Kollam	28983	26524	34899	90406	17810	19.7
Alappuzha	33302	32393	41477	107172	23396	21.83
Ernakulam	22698	22035	25219	69952	14690	21
Thrissur	20706	20932	25549	67187	12443	18.52
Malappuram	22730	23267	31137	77134	15990	20.73
Kozhikode	29920	28947	36499	95366	19893	20.86
Kannur	16578	15723	21482	53783	12919	24.02
Kasargode	13557	13018	15450	42025	10027	23.86
Total	236650	229017	297720	763387	157348	20.61

Source : State Fisheries Department

Table 2.3.2 DETAILS OF MECHANISED AND NON-MECHANISED FISHING CRAFTS IN KERALA (1987)

Craft type	Non-mechanized		Mechanized
	Motorized	Non-motorized	
Plank built Cano	5869	7023	----
Dug-out Canoe	3496	9165	----
Catamaran	235	9949	----
Plywood Canoe	57	----	----
Trawling boats	----	----	2510
Gill netting boa	----	----	846
Purse seine boat	----	----	51
Others	----	----	141
Total	9657	26137	3548

Source : State Fisheries Department

Table:2.3.3 DISTRICT-WISE DISTRIBUTION OF FISHING GEARS IN KERALA 1990

District	Ring seine	Encircling net	Boat seine	Shore seine	Gill net	Drift net	Trawl net	Cast net	Hooks line	Purse seine	Others	Total
Trivandrum	3	254	403	408	4955	161	31	129	6477		517	13338
Kollam	118	1098	54	359	3365	496	1385	2024	5025		125	14076
Alapuzha	519	2634	4	493	3312	302	362	3607	1035		2314	14582
Ernakulam	280	438	41	193	2698	179	1432	2074	121	40	1074	8570
Thrissur	133	273	159	1	3285	97	194	170	396		254	4962
Malappuram	36	118	1		735	6	277	106	100		109	1488
Kozhikode	72	169	343	43	3268	81	1228	415	102		1047	7068
Kannur	1	52	41	10	889	218	422	662	914		2338	5547
Kasargode	62	1	10		1074	51	475	103	54		350	2180
Total	1224	5037	1056	1507	23581	1591	5806	9290	14524	40	8155	71811

Source : Facts and Figures - 1990

CHAPTER 3

TRAWL NETS AND OTTER BOARDS

3.1 INTRODUCTION

Fishing is the art of catching aquatic living beings. Various methods are adopted for the capture of fishes. Due to the advancements in science and technology many progressive changes have been introduced in the design, construction and operation of the fishing gear. The introduction of trawls and trawling is one of the latest development. Over the years the trawl fishing method has gained rapid advancements from the beam trawls used for the first trawls for mouth opening of the net, to the use of various types and designs of otter boards for efficient mouth opening of the net to the latest Variable Thrust Vector Devices (VTVD's) (Shenker, 1995), capable of moving over any type of terrain in the sea bottom which could not earlier be traversed using other types of otter boards. Simultaneous with the developments associated with otter boards the nets designs changed at a fast pace, through the use of newer types of synthetic materials and better designs capable of reducing the drag offered by the net and thereby resulting in reduced fuel consumption in trawling.

In India studies on aspects related to design and efficiency of operation of trawl nets have been attempted by many authors (Kurien et al., 1964; Nair, 1969; Kartha et al., 1977; Pillai et al., 1978 and 1985; Kunjipalu et al., 1979; Mahalatkar et al., 1982; Rao and George, 1983; Narayanappa et al., 1985).

Many authors have tried to improve the design and performance of otter boards (Matrosov, 1958; Catasta, 1959; Takayama and Koyama, 1962). A number of studies have been conducted by Indian authors to study the efficiency and performance of the flat rectangular boards (Satyanarayana and Mukundan, 1963; Mukundan et al. 1967, Narayanappa, 1968, Deshpande et al., 1970, Satyanarayana et al., 1978; Ramarao et al., 1985). The polyvalent design of otter board is said to have better efficiency (FAO, 1974; Anon, 1979; MacLennan and Galbraith, 1979) and easily ride over obstacles.

Statistics of the marine products exports from India during 1992-'93, 1993-'94 and 1994-'95 (Table 3.1a), indicate that frozen shrimps formed on an average 34.66% and 69.16% of the total exports in terms of quantity and value respectively during these years and cuttle fish and squid together formed on an average 22.29% and 13.88% of the total quantity and value of exports. It is a well known fact that these high export value products are landed by the trawl net operating craft of the artisanal sector and the medium trawlers and deep sea trawlers of the mechanised sector.

Since shrimps are exploited trawl nets and the more price obtained due to the export of the same to foreign countries. New design aspect of trawl and otter board are undertaken by the research institutions to promote trawling in Indian waters.

3.2 TRAWLING IN INDIA

The trawl is an economic gear, in terms of investment and yield, even inspite of the fact that the total trawl catches come only second to that of the seines. Commercial trawling in Indian seas is of recent origin and seems to have been initially introduced for the purpose of ground resources survey. The trawling surveys conducted till now in India can be grouped into two distinct periods; a) those undertaken during the pre-war days and b) those of the post-war period (Nair et al. 1973). The former covered roughly three decades from 1900 to 1930 and the latter commenced from 1946. The earliest attempt for the exploration of the trawling grounds was done by PREMIER in 1900. Later the Ceylon Company for pearl fishing (1906-07) carried out some exploratory trawling in the seas between India and Ceylon.

During the post-war period a great change in the trawling surveys was visible. The concept that only large vessels could undertake trawling was given up and small boat trawling was introduced and has come to stay. Similarly starting from the simple beam trawl the more effective otter trawling gear have been developed.

Beam trawls are probably the simplest among dragged gears. On the coast of Travancore the gear was used to survey the bottom fauna. A design of beam trawl was developed on Bombay coast for low powered vessels. Although beam trawl has limited application, it can be effectively used as 'try-net' to assess the potentiality of the ground.

In the wake of large scale commercial exploitation of the prawn resources the demand for trawling gear of greater capacity increased considerably and paved the way for the introduction of the otter trawls. The first attempt with a small otter trawl was made by G.S. Illugason on the Malabar coast (Tellichery). This was followed up by more intensive study by the CIFT under the guidance of Dr. H. Miyamoto. Small trawls were also tried by the Indo Norwegian Project and Off-shore Fishing Stations.

After its introduction in the Indian waters, a number of experiments were conducted to improve the design, rigging and operation of otter trawls to suit the local conditions. The design of trawls introduced earlier were either Japanese or Mexican types or a combination of these two concepts. Limited use of Russian designs were also noticed.

Though the trawling technique has now been well established in India, the majority of trawlers are in the range of 9.3m to 11m OAL, exploiting the inshore region. The mechanised fishing boats are forced to shift their activities to deeper waters due to fleet expansion, decrease in catch per unit effort as well as zone demarcation along the coast for mechanised and non-mechanised fishing (Mhalatkar et al., 1985). Hence it became imperative to introduce larger vessels for the exploitation of deeper waters. Large sized deep sea trawlers for the capture of prawns from the deeper waters were introduced from 1970.

3.3 TRAWLING IN KERALA

Mechanised fishing was started in Kerala in mid-fifties by the erstwhile Indo-Norwegian Project. By mid-sixties, individual entrepreneurs entered the scene paving way for the fast development of trawl fishery in the state. With the introduction of large scale commercial trawling in Kerala in the inshore waters during the early seventies, the production of marine fish showed substantial increase. The annual marine fish landings in Kerala increased from 3.26 lakh tonnes in 1985 to 5.75 lakh tonnes in 1993 (Anon 1995). It is well known that a good monsoon fishery exists in Kerala, at Sakthikulangara and Cochin for the prawn *Parapenaeopsis stylifera* popularily known as 'Karikkadi'. Karikkadi along with other finfish resources particularly the kilimeen (*Nemipterus japonicus*) have not hitherto been exploited in any big way by the traditional craft. Only mechanised craft, the medium trawlers, have been exploiting them ever since these resources were located. The major landing centers for this fishery are Sakthikulangara, Cochin, Munambam and Calicut. The trawl fishery usually commences by September or October and extends upto the onset of the south-west monsoon except at Sakthikulangara and Cochin were it continues during monsoon reaching a peak in July-August (James, et al. 1991). Trawlers accounted for about 95% of the total 'Karikkadi' landings in the state and two thirds of this is caught in the monsoon season particularly at Sakthikulangara.

Trawling operations during monsoon months has been a subject of controversy between trawler operators and traditional fishermen. As a result of the continuing conflicts Kerala Government imposed partial ban on trawling during monsoon season during 1988 and throughout the state in the following years. In order to fill the lacunae created in the exploitation of the demersal resources in the inshore region by the movement of the mechanised crafts for exploitation of regions alloted to them under the Kerala Marine

Fisheries Regulation Act 1980, a new gear called the mini trawl nets operated from traditional craft fitted with out board motors of 7.5hp Yamaha became operational upto 10m depth in the inshore waters of Kerala. Later to increase the size of the gear, out board motors of higher horse power like 12hp Suzuki, 15hp Yamaha and Mariner, 20hp and 25hp Yamaha were introduced. This method of fishing is popular and is the mainstay of the economy of a large number of families along the Kerala coast.

In 1988, the exploitation of the deep sea resources of Kerala got a boost with the influx of a large number of deep sea trawlers from Vizhakapatnam, with the aim of exploiting the deep sea lobster and deep sea shrimp resources of the south west coast. But after a few years of intense exploitation the production levels could not be sustained and most of the trawlers had to return to their base in Vizhag. A few deep sea trawlers are still operating from Cochin and have diversified their operation to aim at the cuttle fish and deep sea shrimp resources.

3.4 DESCRIPTION OF THE TRAWL NET

The trawl net is basically a large bag of netting which is drawn along the sea bed to scoop up fish on or near the bottom in the case of bottom trawling. The net when used in the water column is referred to as midwater trawl and pelagic trawl. Depending upon the manner in which the net is constructed and rigged its operation characteristics can be altered to permit it's use on various types of bottom, different species of fish and prawns and at different levels of the water column.

The Fig. 3.4a shows the trawl in detail. It can be seen as a large bag shaped net, wide at one end, the mouth, which is open, leading to the body of the net, which tapers to the closed end. Fish and prawns that enter through the mouth are trapped in the cod-end. The mouth takes up an oval shape when viewed from the front and the two wings stretch out in front on either side to increase the area swept and to guide the fish in the net's path down to the cod end. Around the upper edge of the mouth runs the 'headline' to which are fixed a number of floats, and around the bottom of the mouth is the ground rope or foot rope, which is weighted. The combined effect of the floats on the headline and the wieghted ground rope keeps the mouth of the net open vertically.

The ground rope may be weighed with chain or may be merely the wire rope when operating on a clear bottom. When used on rough bottom, iron or rubber rollers are rigged to assist its passage. The headline and top of the mouth usually overhang the footrope and bottom of the mouth to ensure that the fish disturbed by the ground rope do not swim upward and escape, but are guided down to the cod end.

The horizontal spread of the net is attained by 'otter boards' or 'doors' towed ahead of the net and set at an angle of attack to the towing direction, so providing the outward force necessary to spread the wings to which they are fastened. The boards may be connected directly to the wings or separated from them by a length of wire known as 'ground cable' or 'sweep line'. In the latter case the sweeplines are connected to the door by a backstrap and to the net by a bridle or 'danleno' arrangement. Actual arrangement of the connection between the backstrap and sweeplines varies, depending on the handling arrangements aboard the operating vessel.

The codend is a funnel of netting closed at the rear end by a rope looped through the meshes or rings and tied with a special codend knot which is easily released. At about midlength is the splitting strap, a rope running through metal rings fastened to the outside of the net, so that when it is pulled tight the net is bunched together at this point.

The present day trawls may be classified as shown in Table 3.4a (Nair 1976) According to the method of construction, trawls may be classified in relation to the number of seams that constitute the net viz. Two seam, Four seam and Six seam. The two seam net has only two parts - one upper and one lower, seamed together at the sides. These are usually overhang nets. In the four seam nets there are four parts, the upper, the lower and the two lateral sides. This type of nets may be constructed with or without overhang. In a non-overhang net both the upper and lower parts are of identical dimensions. For effecting a smooth catenary curve at the mouth, both the upper and lower bellies are provided with jibs on either sides. The jibs are triangular pieces of webbings attached at the quarters. Jibs of the same panel are symmetrical in size and shape and may be constructed in two ways; the slanting jib and the straight jib. When the lateral side wedges are fabricated with tapering edge in one side only, the tapering edge is always attached to the upper belly and the straight edge with the lower belly. The six seamnet is a modification of the four seam net. These nets have six panels hence six seams. Between the two lateral sides and the upper side, two mini-side-wedges are seamed to form the six seam.

3.5 SURVEY ON TRAWL NET DESIGNS

The trawl net designs of the Kerala coast coast has been surveyed from a very broad perspective. Net designs used by three classes of vessels; the artisanal craft fitted with out board motor (small trawler), mechanised fishing trawlers fitted with inboard diesel engines (medium trawler) and the deep sea trawlers have been studied. In case of the artisanal craft the nets designs used by 7.5hp, 15hp, 20hp and 25hp out board motor (OBM) fitted craft have been surveyed, these being the most common horse power OBM's used in this sector. For the medium trawlers the net designs of the 37.5hp engine fitted trawlers in the 25-30ft class and net designs four models of Ashok Leyland Marine (ALM) diesel engine (ALM 370, ALM 400, ALM 402 and ALM 680) fitted trawlers, of horse power 81hp, 90hp, 100hp and 148hp, respectively, of 30-35ft length class to 50-55ft length class, have been surveyed. The period of survey was 1994-'95 for all the classes of vessels.

From the survey conducted at five centers along the Kerala coast on the mini trawl net designs operated by the artisanal craft fitted with out board motors, it was observed that the type of net varied with the horse power of the OBM used. The design of net operated from 8hp and 15hp OBM fitted craft from Chaliyam and Parappanangadi are presented in Fig. 3.5a and Fig.3.5b respectively. The 15hp OBM operated craft of Ambalapuzha used a design similar to the one from Parappanangadi. The 15hp OBM operated craft of Ambalapuzha and Valanjavazhi had similar design of mini trawl nets and they were also similar to the design of 12 hp OBM operated craft of Azhikode. Design of mini trawl nets operated by 20hp (Fig. 3.5c) and 25hp (Fig. 3.5d) OBM fitted craft is also presented and was observed only along the Alleppey coast at Ambalapuzha and Valanjavazhi. All the nets were of two seam construction. Another feature of all these nets was that the net including the jibs, overhang and square was constructed in 1/4mm polyethylene webbing, while the throat and cod end was constructed in 1/2mm polypropylene webbing.

The data sheet for these nets are presented in Table 3.5a. From the data sheet it can be observed that the material and diameter of the head rope and foot rope are similar. The material used for the floats was polyvinyl chloride. Though the diameter of the floats used by all the nets were same at 3.25", the number of floats increased as the size of the nets increased (Table 3.5a). All the nets used mild steel chain as weight and the weight of the chain increased as the number of floats increased.

The survey on the designs of trawl nets operated by the medium trawlers was centered at the Cochin Fisheries Harbour. The common names of these nets and the target species are given in Table 3.5b. The nets have been grouped into four classes depending on the type of net and the horse power of the engine installed. A datasheet (Table 3.5c) also has been prepared for all the nets surveyed put together.

In Class I only one net was present and this net (Fig. 3.5e) was operated by 37.5hp fitted 28ft boats. From the figure it can be seen that 0.5mm twine was used for the construction of this net except the cod end which was constructed in 0.75mm twine. The mesh size of the cod end was only 18mm There were three nets in Class II. All the nets in this class was operated by ALM 370 engine fitted trawlers. In the first case (Fig. 3.5f), was a shrimp net .The net was made out of 0.5mm twine, except the cod end, which was constructed from 1.25 mm twine. The cod end mesh size for this type of net was observed to be 18mm. The second net (Fig. 3.5g) of this class, was also a shrimp net. The difference was that the twine size used in the construction except the cod end was 0.75mm. The cod end constructed in 1.25mm twine with a mesh size of 18mm. The third net (Fig. 3.5h) in this class was a fish trawl. The whole net including the cod end was constructed in 1.25mm twine. In this case the cod end mesh size was 22mm. For the shrimp trawl nets the cod end was 25ft long and for the fish net the cod end was 30ft long.

Class III included five design models and were operated by both ALM 400 and ALM 402 engine fitted trawlers. The first net of this class is a shrimp trawl (Fig. 3.5i) with the three types of twine sizes used in the construction as shown in the figure. The mesh size of the cod end was only 18mm. The second net in this class is also a shrimp trawl (Fig. 3.5j), but aimed at a particular species of shrimp (Table 3.5b). It can be seen from the figure that there are only two twine sizes used in the construction, 0.75mm and 1.25mm. The cod end mesh size can be observed at 18mm. The third net of this class is a variation of the second net. It is a larger sized shrimp trawl (Fig. 3.5k) aimed at another species of shrimp (Table 3.5b). The twine sizes used for the construction is similar to the second net and the cod end mesh size is also similar at 18mm. The fourth net is a fish trawl (Fig. 3.5l), with a single twine size (1.25mm) used in it's construction. The cod end mesh size can be observed to be 22mm. The fifth net in this class is a larger type of fish trawl (Fig. 3.5m), with three twine sizes used in it's construction. This net is directed at a particular species of fish and is used only rarely. The cod end mesh size is reduced in this net to 18mm. In all the nets of this class except the fifth net, the length of the cod end can be observed to be 30ft, while for the fifth net it was 35ft, indicating the larger size of the net.

Class V of this group included only one type of net operated by the ALM 680 model engine fitted trawlers. It was basically a shrimp trawl (Fig. 3.5n). It was constructed out of two twine sizes 1.25mm and 2mm, indicating a heavier type of net. The mesh sizes varied from 160mm at the wings to 20mm at the cod end. The cod end was 35ft long.

The material of construction was observed to be polyethylene for all the net designs of all classes.

From a look at the data sheet of the net designs of this class (Table 3.5c) polypropylene can be observed to be the material used for the ropes. The floats in all designs were of polyvinyl chloride, while the weights were mild steel chain in the case of the shrimp trawl designs and lead for the fish trawl designs. The twine size and mesh size of the cod end can be observed to be similar in all designs except for design 3.5e in which case a cod end cover was not used due to the low horse power of the engine installed.

In the case of the deep sea trawlers it was observed that two types of nets were used by all the four trawlers of 27m surveyed. One net was a four seam net (Fig. 3.5o) used for the capture of deep sea shrimp and deep sea lobster while the other was a six seam net (Fig. 3.5p) aimed at cuttle fish and squid.

The data sheet for these net designs (Table 3.5d) indicate that steel wire rope was the material used for the head rope, foot rope, ground rope and warps in both designs. The otter boards used were polyvalent otter boards of 500kg in both designs. The floats used in both designs were high density poly ethylene (HDPE) floats of 12 inch diameter. The weights used for both designs can be observed to be rubber bobbins, to withstand the ground friction.

3.6 COMPUTATION OF TRAWL RESISTANCE

In order to calculate the resistance of a trawl net, the method followed by Koyama, T. (1967) has been adopted. According to him the resistance of a complete trawl net (with accessories) (R) with no fish catch can be expressed as

$$R = 8\ a\ b\ d/l\ V^2$$

Where, R (kgf) = resistance of trawl net

V (m/s) = towing velocity

a (m) = the maximum circumference of the net

b (m) = the maximum length of the net

d/l = in case of four and six seam nets : the average value of the ratio d = diameter of the net twine to l = length of each mesh bar at side panel sections.

d/l = in case of two seam nets : the average value of the ratio d = diameter of the net twine to l = length of mesh bar at upper net.

In computing d/l, Koyama has not considered the d/l of the intermediate piece and the cod end, because of the use of double twines in some trawl nets. In this calculation, since no instance of the use of double twines was observed in the intermediate piece in any of the trawl net designs surveyed, the d/l ratio of the intermediate piece has also been taken to compute trawl resistance. In the case of the cod end, since the use of a cod end cover was observed in many trawl net designs, the d/l ratio of this part is not included.

The trawl resistance has been calculated for the mini trawl nets (Section 3.5: Fig. 3.5a, Fig. 3.5b, Fig. 3.5c and Fig. 3.5d) operated by the OBM fitted artisanal craft, for the trawl net designs of medium trawlers (Section 3.5: Figs. 3.5e, 3.5f, 3,5g, 3.5h, 3.5i, 3.5j, 3.5k, 3.5l, 3.5m and 3.5n) operating from cochin Fisheries Harbour and for the deep sea trawl net designs (Section 3.5: Fig. 3.5o and Fig.3.5p) of the deep sea trawlers sampled from Cochin Fisheries Harbour. In all cases the resistance was calculated in kilogram force (kgf). The speed of trawling for shrimp trawls has been taken as 3knots and for the fish trawls as 3.5 knots (Traung, 1963). The figure numbers followed in Section 3.5 is repeated here.

In the case of the mini trawl nets operated by the OBM fitted artisanal crafts, the trawl resistance calculated is presented in Table 3.6a. Since these trawl nets concentrate mostly on shrimp fishing the speed of trawling has been taken as 3 knots. From the Table 3.6ait can be observed that the resistance values increase as the length of the trawl net increases, which in turn is in proportion to the horse power of the OBM used.

The trawl resistance calculation of the medium trawlers is presented in Table 3.6b and Table 3.6c. The classification of trawl net designs presented in Section 3.5, is adopted here also for trawl resistance calculation. Thus the trawl nets used by medium trawlers have been grouped into four classes.

In Class I (Table 3.6b), only one net is present. This net (Fig. No. 3.5e) is operated by the 28' boats powered with a 37.5hp engine and these nets are mostly used for shrimp fishing. The resistance values worked out to 27.8kgf for a net length of 18.28m.

Class II (Table 3.6b) had three nets. All the three nets were operated by ALM 370 engine of 89hp at 2000 RPM. Of these, Fig. Nos. 3.5f and 3.5g, (Table 3.6b) were used for shrimp trawling, while Fig. No. 3.5h (Table 3.6b) was a fish trawl. It can be observed that though Fig Nos.3.5f and 3.5g were of the same length 25.75m and 25.6m (Table 3.6b, b - value) respectively, the resistance values are found to vary from 43.73 kgf for Fig. No. 3.5f to 64.47 kgf for Fig. No. 3.5g. This is mainly because of higher d/l values of Fig. No.3.5g, due to the use of larger meshes in the square and throat regions. For Fig. No. 3.5h, the resistance value shows a sudden spurt to 163.37 kgf (Table 3.6b) for a 33.6m long net, mainly due to the increased speed (3.5 knots) at which this net is towed.

In Class III (Table 3.6c), the resistance calculations for five nets are presented. Of these Fig Nos. 3.5i, 3.5j and 3.5k are shrimp trawls (speed of tow, 3 knots) and Fig Nos. 3.5l and 3.5m are fish trawls. All these nets are used by two models of engine fitted trawlers (ALM 400 and ALM 402). For Fig Nos.3.5i, 3.5j and 3.5k (Table 3.6c), the resistance values averaged only 78.32 kgf. In the case of the fish trawl (Fig.No. 3.5l), the resistance value was highest at 279 kgf for a net length of 41.6 m. But in the case of fish trawl (Fig.No.3.5m), though the net was 44m long the resistance value was as low as 86.33 kgf. This is mainly because the average d/l was the lowest (0.0013) of the Class, due to the larger mesh sizes and the larger number of sections, in the net. Here it can be seen that the larger mesh sizes are contributing to reduced resistance in trawls.

Only one net was present in Class IV (Table 3.6c). This net being considered separately because it is operated by 148 hp engine fitted trawlers. The resistance value was calculated at 305.76 kgf (Fig. No. 3.5n), which is the highest for all the classes of nets of the medium trawlers. This mainly because the d/l value was observed to be very high in this case, due to the small mesh sizes used in the sections behind the square (Fig. 3.5n). Thus it is evident that the smaller mesh sizes are contributing to increased resistance in trawls.

In the case of trawl net resistance of medium trawlers, it can be concluded that the speed of tow is contributing towards added resistance (Class II, Fig. No. 3.5h) and that the smaller mesh sizes is also an important factor in increasing the resistance of trawls (Class IV, Fig No.3.5n) while the larger mesh sizes are found to reduce the resistance of trawls (Class III, Fig No. 3.5m).

The trawl resistance calculation of the deep sea trawlers is presented in Table 3.6d. Only two trawl net designs were observed to be used by the deep sea trawlers (Section 3.5 : Fig. No. 3.5o and 3.5p). The same figure numbers are repeated for Table 3.6d. Of these two trawl nets Fig. No. 3.5o, is a four seam shrimp trawl net aimed at deep sea shrimp and deep sea lobster, while Fig. No. 3.5p is six seam fish trawl aimed at cuttle fish and the speed of tow for these nets is 3.0 knots for the shrimp trawl and 2.5 knots for the fish trawl. The resistance values worked out to 603.25 kgf for the shrimp trawl and 414.24 kgf for the fish trawl. Here it can be observed that the reduced resistance of the fish trawl (Fig. No. 3.5p) is due to the low d/l values, lower total circumference (a - value) of the net and lower speed of tow.

3.7 OTTER BOARDS

3.7.1 Otter board types

The flat rectangular otter boards are used along the Kerala coast by the small trawlers (Plate 3.7.1a) and the medium trawlers (Plate. 3.7.1b) while in the deep sea trawlers operating from Cochin used the polyvalent design (Plate 3.7.1c).

3.7.2 Survey on flat rectangular otter board designs

A preliminary survey of the otter board designs used by the small trawlers and medium trawlers operating along the Kerala coast showed that the flat rectangular (FR) otter board is the most common type of board used. In the case of small trawlers, the design of FR otter boards were collected from five centers along the coast. Designs of FR boards used by the medium trawlers fitted with Ashok Leyland Marine (ALM) diesel engines were collected from three centers, since at all the three centers the ALM engines were the most common type of engine installed. From a survey of the otter boards used by the deep sea trawlers it was observed that the polyvalent board was commonly used. In each of the three classes of vessels the most popular design is presented here.

The mini trawl nets operated by the small trawlers use a smaller version of the conventional flat rectangular otter boards used by the medium trawlers. These otter boards are the most prevalent type along the Kerala coast for the traditional fishermen for bottom trawling. The boards were fabricated in wood and the common timber used are venteak, aini or other hard wood which can withstand sea water. The board is assembled by joining planks and in cases were a single plank width is not available the planks are joined by fixing them together with long bolts or mild steel straps. A wide shoe is used to prevent digging into the mud and is mounted off at the leading edges so that the board can ride over obstacles.

Fig. 3.7.2a shows how the flat rectangular otter board is proportioned for normal operation. It can be noted that the first stage is the half way positioning of the main bracket followed by the smaller bracket, which is fitted at one quarter of the total length of the board, with the apex or joining position of the two brackets calculated at a position equal to one third of the overall length. The brackets are so arranged and connected to the towing warp so as to keep the board obliquely to the direction of motion and thus force them sideways by the flow of water. The legs of the trawl net are attached to rings which are fitted usually at approximately one quarter of the length of the board on the other side. Mild steel straps are fixed to three sides of a board on both sides as shown in the figure. An iron shoe which helps to withstand the friction of the board while moving along the seabed is attached to the base of the board.

The survey showed that basically three different dimensions of otter boards are used by the mini trawl nets operating along the Kerala coast depending on the length of the net and the horse power of the OBM used. The different dimensions of boards used are illustrated in Fig.3.7.2b, 3.7.2c, 3.7.2d and 3.7.2e. Fig.3.7.2b represents the otter boards used by a 7.5 hp OBM fitted craft. Though it was found that the dimensions in the length and breadth of the boards used by the 15 (Fig. 3.7.2 c) and 20hp OBM (Fig. 3.7.2d) were similar, they varied in their weights and position of attachment of brackets and rings, depending on the difference in weight of the iron accessories used by each design. Fig.3.7.2e represents the otter boards used by a 25hp OBM fitted craft.The relationship between the horse power of the OBM used, length of the net, dimension of the otter board and the weight of the otter board is shown in Table 3.7.2a. The economics of construction of these four dimensions of FR otter boards has been worked out by John and Hameed (1995).

From the design of FR otter boards used by the medium trawlers collected from three centers along the Kerala coast viz. Beypore, Cochin and Sakthikulangara, it was observed that the trawlers in the 25-30 feet length used a different design of flat rectangular otter board (Fig. 3.7.2f), while the medium trawlers above this length class fitted with ALM engine models 370, 400, and 402 used the same design of otter board except that the weight of the boards increased as the horse power increased. In the case of the ALM 680 model engine the boards used were slightly bigger in size and also weighed more. The design of otter board used by ALM 370, 400 and 402 engine fitted vessels are shown in Fig. 3.7.2g. The otter board design of an ALM 680 engine fitted vessel is shown in Fig. 3.7.2h.

Conclusion

Trawl net and otter boards are integral component of trawl fishing gear. Though earlier trawling initiated in India were of an exploratory nature, later this gear become the most important fishing method along the coast due to the high unit price of the commodity landed. The survey conducted along the coast indicates the different types of designs suitable for each horse power of engine. The flat rectangular otter board designs confirming to the particular horse power of engine are identified. The resistance values calculated have helped to conclude that the added resistance was contributed by the mesh size of the net and speed of towing.

Table 3.1a STATISTICS OF MARINE PRODUCT EXPORT OF INDIA DURING 1992-'93, 1993-'94, 1994-'95

Qnty in tonnes
Value Rs. in crores

	1992-'93				1993-'94				1994-'95			
	Quantity	%	Value	%	Quantity	%	Value	%	Quantity	%	Value	%
Frozen shrimp	74051	35.43	1176.83	66.54	86541	35.47	1770.73	70.73	101746	33.10	2510.29	70.20
Frozen fish	75794	36.26	233.53	13.20	94022	38.54	296.00	11.82	122529	39.86	446.57	12.49
Frozen squid	30364	14.53	151.90	8.59	34741	14.24	192.47	7.69	37217	12.11	245.24	6.86
Frozen cuttle fish	18981	9.08	118.88	6.72	18998	7.79	138.18	5.52	28145	9.16	224.00	6.26
Others	9835	4.71	87.42	4.94	9658	3.96	106.24	4.24	17731	5.77	149.81	4.19
Total	209025		1768.56		243960		2503.62		307368		3575.91	

Table 3.4a CLASSIFICATION OF TRAWL NET

TRAWLS

- Based on the method of mouth opening of net
  - Beam Trawl
  - Otter Trawl
  - Bull or pair trawl
- According to depth of operation
  - Bottom trawl
  - Midwater trawl
  - surface or pelagic trawl
- based on method of construction of net
  - Two seam
    - Over hang
  - Four seam
  - Six seam
    - Over hang
    - Non Over hang

Table 3.5a DATA SHEET ON TRAWL NETS OPERATED BY OBM FITTED ARTISANAL CRAFT

FIGURE NUMBER	1	2	3	4
HEAD ROPE				
Material	PP	PP	PP	PP
Diameter (mm)	8	8	8	8
FOOT ROPE				
Material	PP	PP	PP	PP
Diameter (mm)	8	8	8	8
FLOATS				
Material	PVC	PVC	PVC	PVC
Number	3	5	7	9
Diameter (inch)	3.25	3.25	3.25	3.25
SINKER				
Material	MS	MS	MS	MS
Chain (kg)	5	6.5	7.5	9

Table 3.5b COMMON NAMES OF THE NETS OF MEDIUM TRAWLERS AND TARGET SPECIES

Common Name	Fig.No.	Target Species	Scientific name	Engine model
Aravala	3.5e	Poovalan	Metapenaeus dobsoni	RUSTON
Aravala	3.5f	Poovalan	Metapenaeus dobsoni	ALM 370
Mukkalvala	3.5g	Naran Kazhanthan	Penaeus indicus Metapenaeus affinis	ALM 370
Meenvala	3.5h	Fish Cuttle fish Squid	 Sepia Spp. Loligo Spp.	ALM 370
Aravala	3.5i	Poovalan	Metapenaeus dobsoni	ALM 400 ALM 402
Mukkalvala	3.5j	Naran Kazhanthan	Penaeus indicus Metapenaeus affinis	ALM 400 ALM 402
Mukkalvala	3.5k	Karikkadi	Parapeneaopsis stylifera	ALM 400 ALM 402
Meenvala	3.5l	Fish Cuttle fish Squid	 Sepia Spp. Loligo Spp.	ALM 400 ALM 402
Choodavala	3.5m	Netholi Kozhuva Squid	Anchovis Spp Stoliferus Spp Loligo Spp.	ALM 400 ALM 402
Meenvala	3.5n	Fish Cuttle fish Squid	 Sepia Spp. Loligo Spp.	ALM 680

Table 3.5c DATA SHEET ON TRAWL NETS OPERATED BY MEDIUM TRAWLERS

CLASS	I	II	II	II	III	III	III	III	III	IV
FIGURE NUMBER	1	1	2	3	1	2	2A	3	4	1
HEAD ROPE										
Material	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Diameter (mm)	12	14	14	14	14	14	14	14	14	16
FOOT ROPE										
Material	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Diameter (mm)	12	14	14	14	14	14	14	14	14	16
FLOATS										
Material	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Number	7	13	15	13	17	15	16	11	21	11
Diameter (inch)	5	5	5	6	5	5	5	6	6	6
SINKER										
Chain (kg)	16	20	22		25	26	25			
Material	MS	MS	MS		MS	MS	MS			
Solid weight (kg)				26				38	20	40
Material				LEAD				LEAD	LEAD	LEAD
SWEEP LINE										
Material	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Diameter (mm)	14	16	18	18	18	18	18	18	18	18
BRIDLE SET ROPE										
Material	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Diameter (mm)	14	20	20	20	20	20	20	20	20	22
COD END COVER	NIL									
Material		PP	PP	PP	PP	PP	PP	PP	PP	PP
Twine size (mm)		3	3	3	3	3	3	3	3	3
Mesh size (mm)		160	160	160	160	160	160	160	160	160

Table 3.5d DATA SHEET ON TRAWL NETS OPERATED BY DEEP SEA TRAWLERS

FIGURE NUMBER	1	2
HEAD ROPE		
Material	SWR	SWR
Diameter (mm)	12	12
FOOT ROPE		
Material	SWR	SWR
Diameter (mm)	14	14
GROUND ROPE		
Material	SWR	SWR
Diameter (mm)	16	16
WARP		
Material	SWR	SWR
Diameter	16	16
OTTER BOARD		
Type	POLYVALENT	POLYVALENT
Weight (kgs)	500	500
FLOATS		
Material	HDPE	HDPE
Number	9-12	3-6
Diameter (inch)	12	12
WEIGHTS		
Material	RUBBER BOBBINS	RUBBER BOBBINS
Dimension	1"T X 6"D	1"T X 6"D

Table 3.6a TRAWL NET RESISTANCE VALUES OF OBM FITTED ARTISANAL CRAFT

Fig. No.	a	b	SECTION	d/l	V^2 (m/sec)	R (kgf)
3.5a	1320	1257	1	0.0023	2.3815	6.90
	13.2	12.57	2	0.0023		
			3	0.0020		
			AVERAGE	0.0022		
3.5b	1496	1496	1	0.0023	2.3815	9.30
	14.96	14.96	2	0.0023		
			3	0.0020		
			AVERAGE	0.0022		
3.5c	1584	1573	1	0.0023	2.3815	10.36
	15.84	15.73	2	0.0023		
			3	0.0020		
			AVERAGE	0.0022		
3.5d	1760	1708	1	0.0023	2.3815	12.50
	17.6	17.08	2	0.0023		
			3	0.0020		
			AVERAGE	0.0022		

Table 3.6b TRAWL NET RESISTANCE VALUES MEDIUM MECHANISED TRAWLERS

CLASS I	Fig. No.	ENGINE MODEL	HP	a	b	SECTION	d/l	V^2 (m/sec)	R (kgf)
	3.5e	RUSTON	37.5	2240	1828	1	0.0031	2.3815	27.28
				22.4	18.28	2	0.0031		
						3	0.0036		
						4	0.0042		
						AVERAGE	0.0035		
CLASS II									
	3.5f	ALM 370	89	3120	2575	1	0.0029	2.3815	43.73
				31.2	25.75	2	0.0029		
						3	0.0029		
						4	0.0029		
						5	0.0029		
						AVERAGE	0.0029		
	3.5g	ALM 370	89	3150	2560	1	0.0038	2.3815	64.47
				31.5	25.6	2	0.0038		
						3	0.0043		
						4	0.0050		
						AVERAGE	0.0042		
	3.5h	ALM 370	89	4800	3360	1	0.0016	3.2414	163.37
				48	33.6	2	0.0016		
						3	0.0021		
						4	0.0031		
						5	0.0042		
						6	0.0031		
						AVERAGE	0.0039		

Table 3.6c TRAWL NET RESISTANCE VALUES MEDIUM MECHANISED TRAWLERS

CLASS III	Fig. No.	ENGINE MODEL	HP	a	b	SECTION	d/l	V^2 (m/sec)	R (kgf)
	3.5i	ALM 400 & 402	99 & 100	3968	3135	1	0.0029	2.3815	84.11
				39.68	31.35	2	0.0029		
						3	0.0031		
						4	0.0054		
						AVERAGE	0.0035		
	3.5j	ALM 400 & 402	99 & 100	3600	2570	1	0.0030	2.3815	63.62
				36.00	25.7	2	0.0030		
						3	0.0038		
						4	0.0047		
						AVERAGE	0.0036		
	3.5k	ALM 400 & 402	99 & 100	3780	2950	1	0.0038	2.3815	87.25
				37.8	29.5	2	0.0038		
						3	0.0038		
						4	0.0043		
						5	0.0050		
						AVERAGE	0.0041		
	3.5l	ALM 400 & 402	99 & 100	5520	4160	1	0.0016	3.2414	279.13
				55.2	41.6	2	0.0016		
						3	0.0021		
						4	0.0031		
						5	0.0042		
						6	0.0063		
						AVERAGE	0.0047		
	3.5m	ALM 400 & 402	99 & 100	5760	4405	1	0.0016	3.2414	86.33
				57.6	44.05	2	0.0016		
						3	0.0013		
						4	0.0006		
						5	0.0008		
						6	0.0014		
						7	0.0019		
						AVERAGE	0.0013		
CLASS IV									
15	3.5n	ALM 680	156	5280	3970	1	0.0019	3.2414	305.76
				52.8	39.7	2	0.0019		
						3	0.0025		
						4	0.0038		
						5	0.0050		
						6	0.0075		
						AVERAGE	0.0056		

Table 3.6d TRAWL NET RESISTANCE VALUES OF DEEP SEA TRAWLERS

Fig.No.	ENGINE MODEL	HP	a	b	SECTION	d/l	V^2 (m/sec)	R (kgf)
3.5o	YANMAR	550	12320	3954	1	0.0075	2.3815	603.25
			123.2	39.54	2	0.0075		
					3	0.0075		
					4	0.0100		
					AVERAGE	0.0065		
3.5p	YANMAR	550	6810	10217	1	0.004	1.6538	414.24
			68.1	102.17	2	0.004		
					3	0.004		
					4	0.004		
					5	0.005		
					6	0.008		
					AVERAGE	0.0045		

Table.3.7.2a RELATIONSHIP BETWEEN HORSE POWER OF OBM, LENGTH OF NET AND WEIGHT OF OTTER BOARD OF MINITRAWL NETS OPERATED BY ARTISANAL CRAFTS

HP OF OBM	LENGTH OF NET INCLUDING JIB (m)	WT. OF OTTER BOARD (kgs)
8	12.5	10
15	14.9	15
20	15.7	17
25	17.08	22

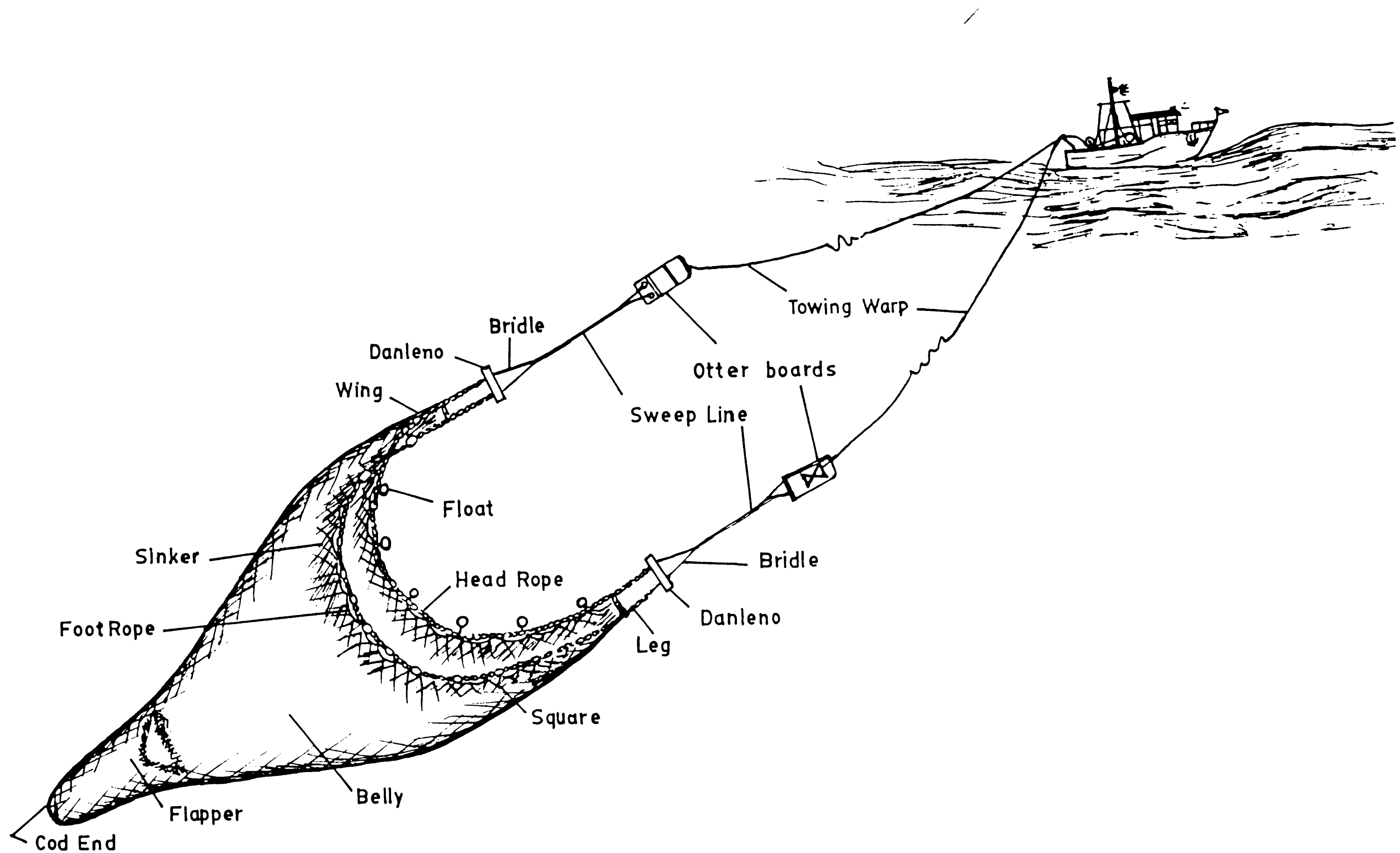


Fig.3.4.a THE TRAWL NET IN DETAIL.

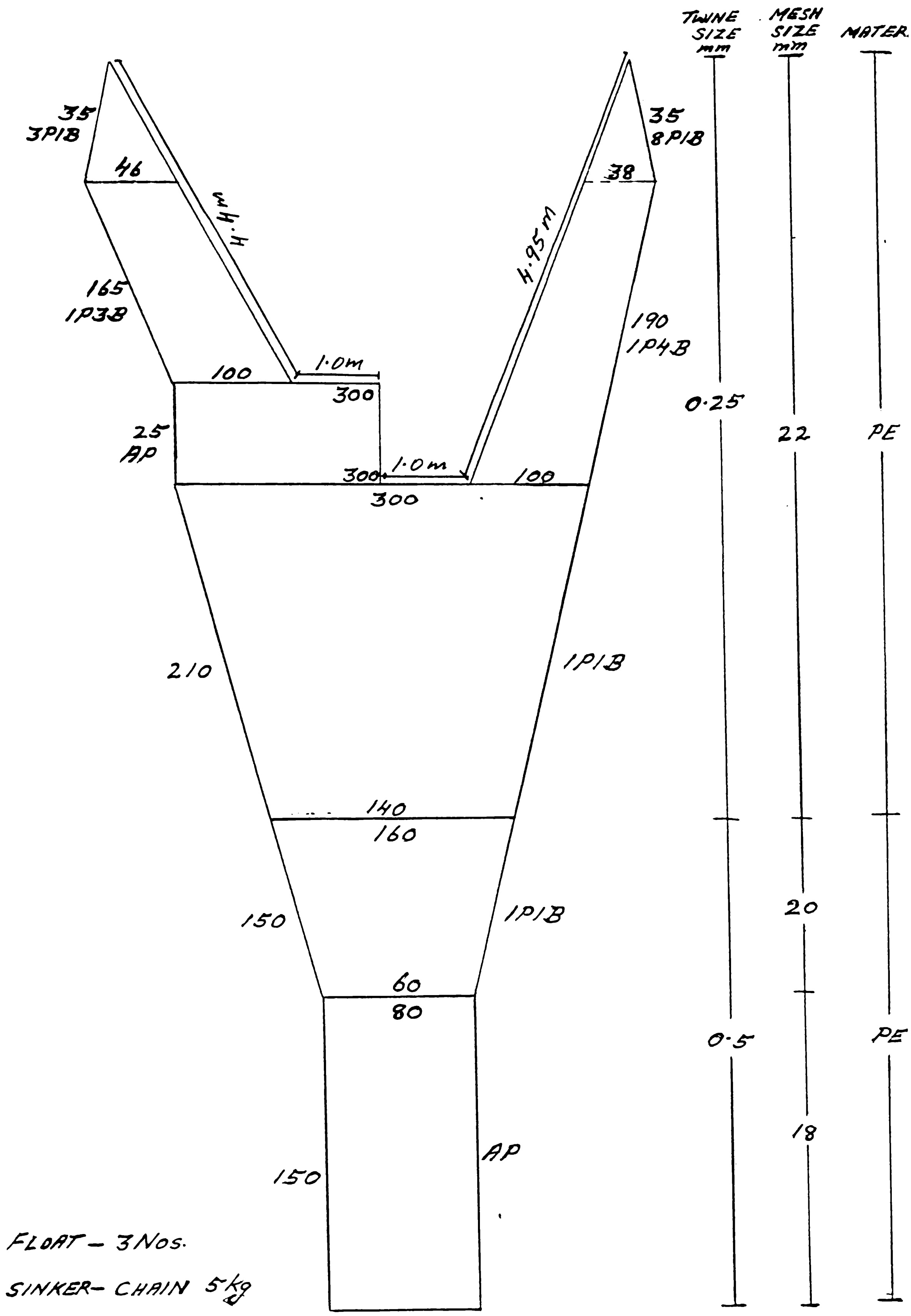


Fig.3.5.a MINI TRAWL NET USED BY 7.5HP OBM FITTED CRAFT.

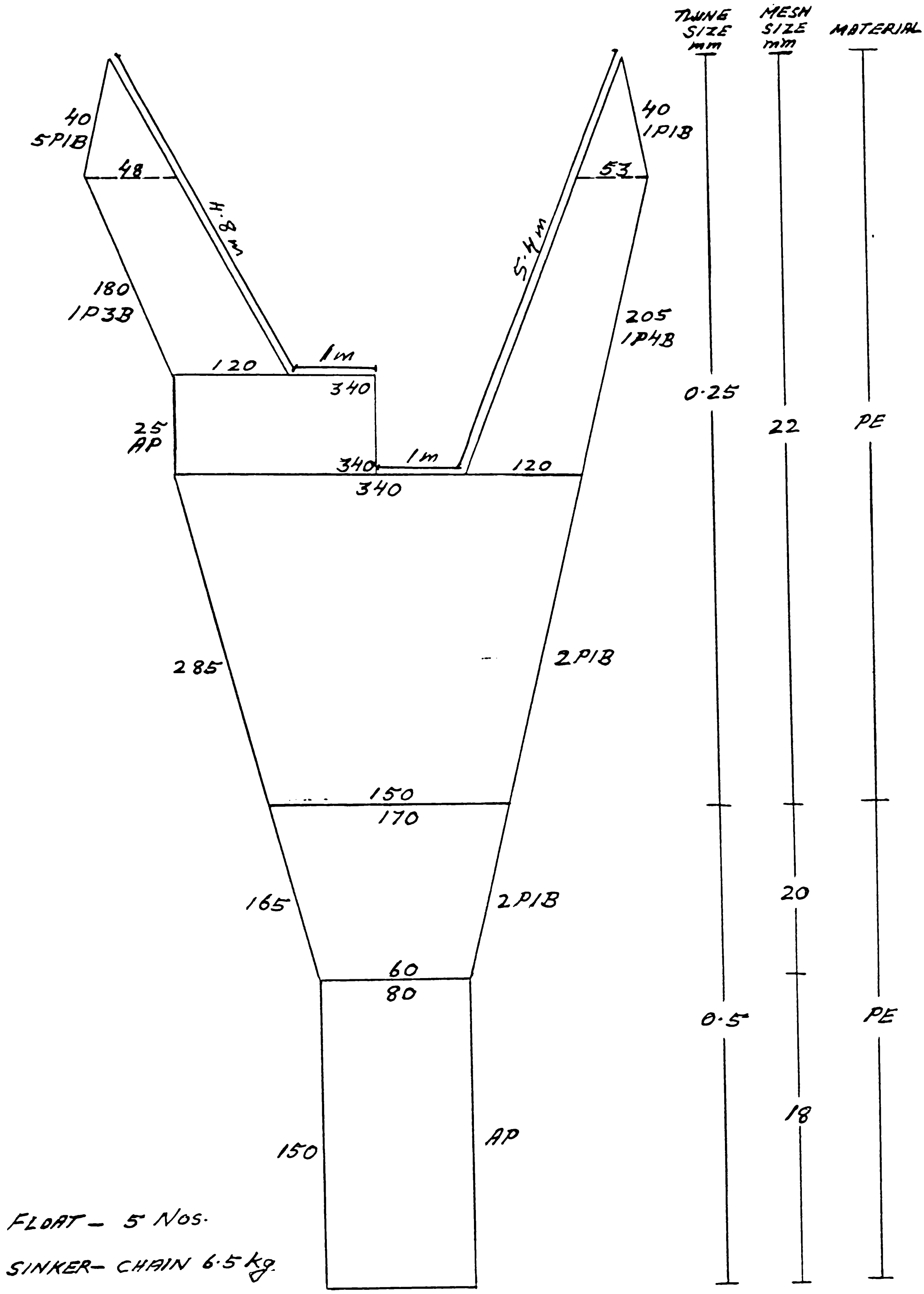


Fig.3.5.b MINI TRAWL NET USED BY 15HP OBM FITTED CRAFT.

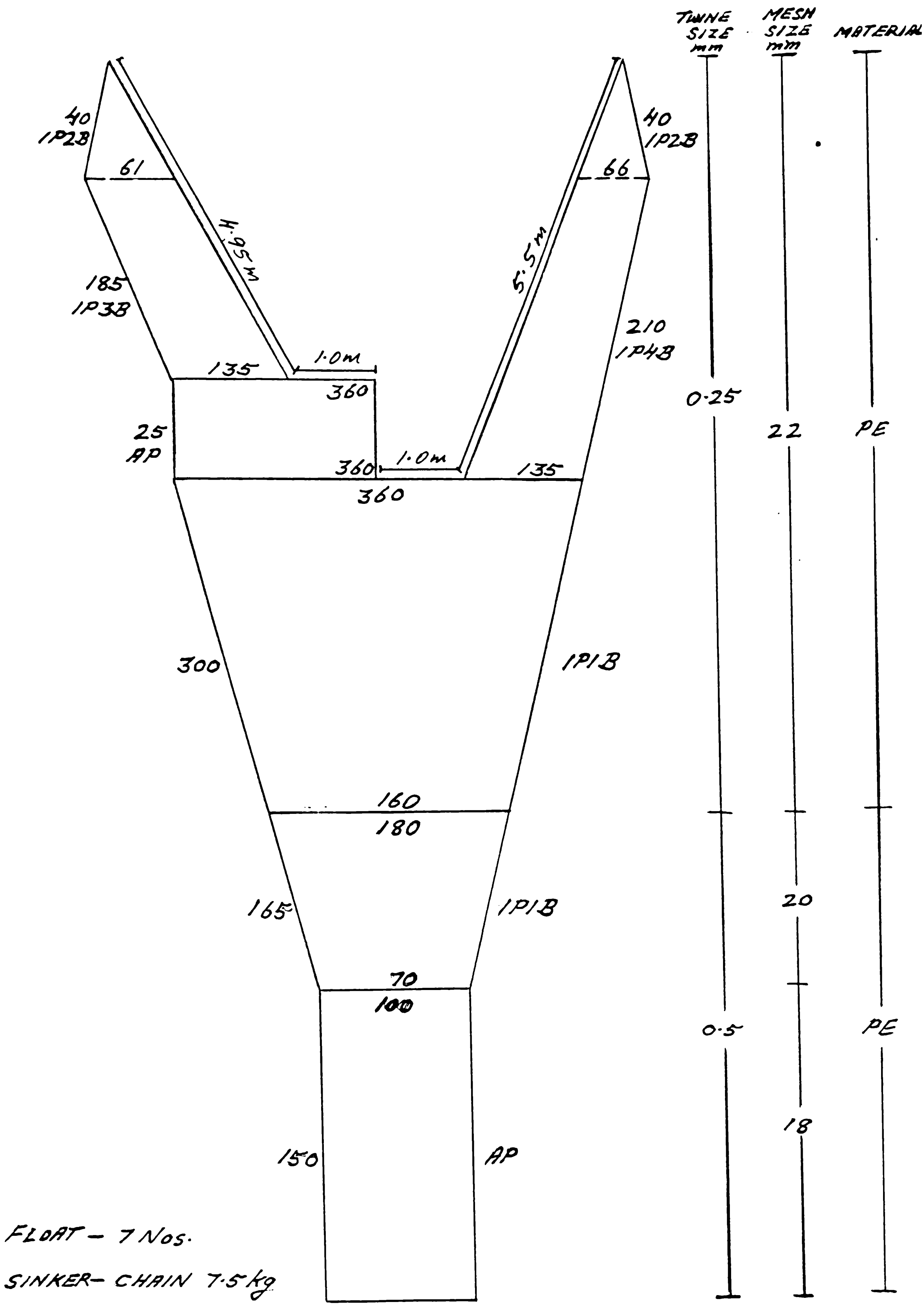


Fig.3.5.c MINI TRAWL NET USED BY 20HP OBM FITTED CRAFT.

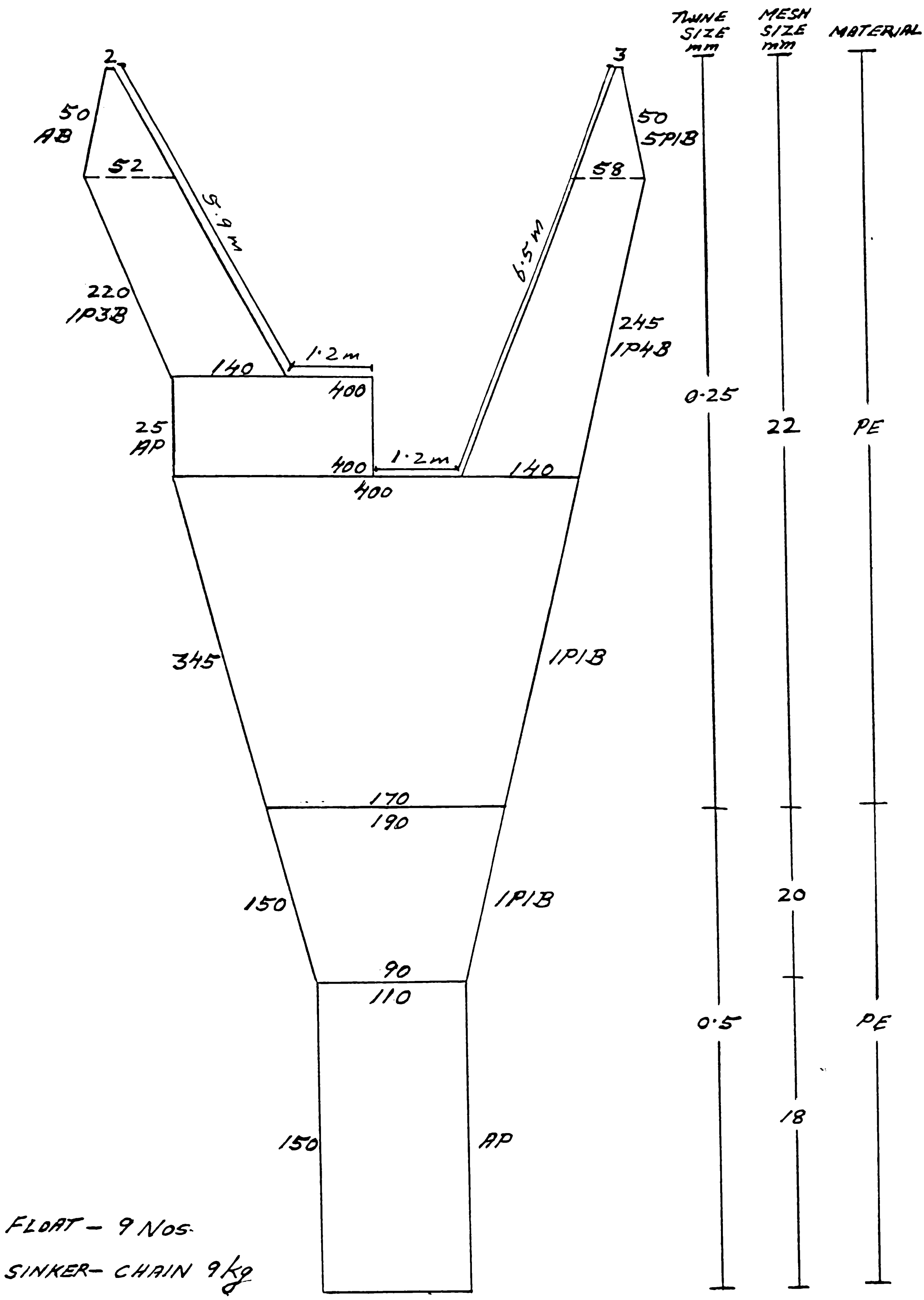


Fig.3.5.d MINI TRAWL NET USED BY 25HP OBM FITTED CRAFT.

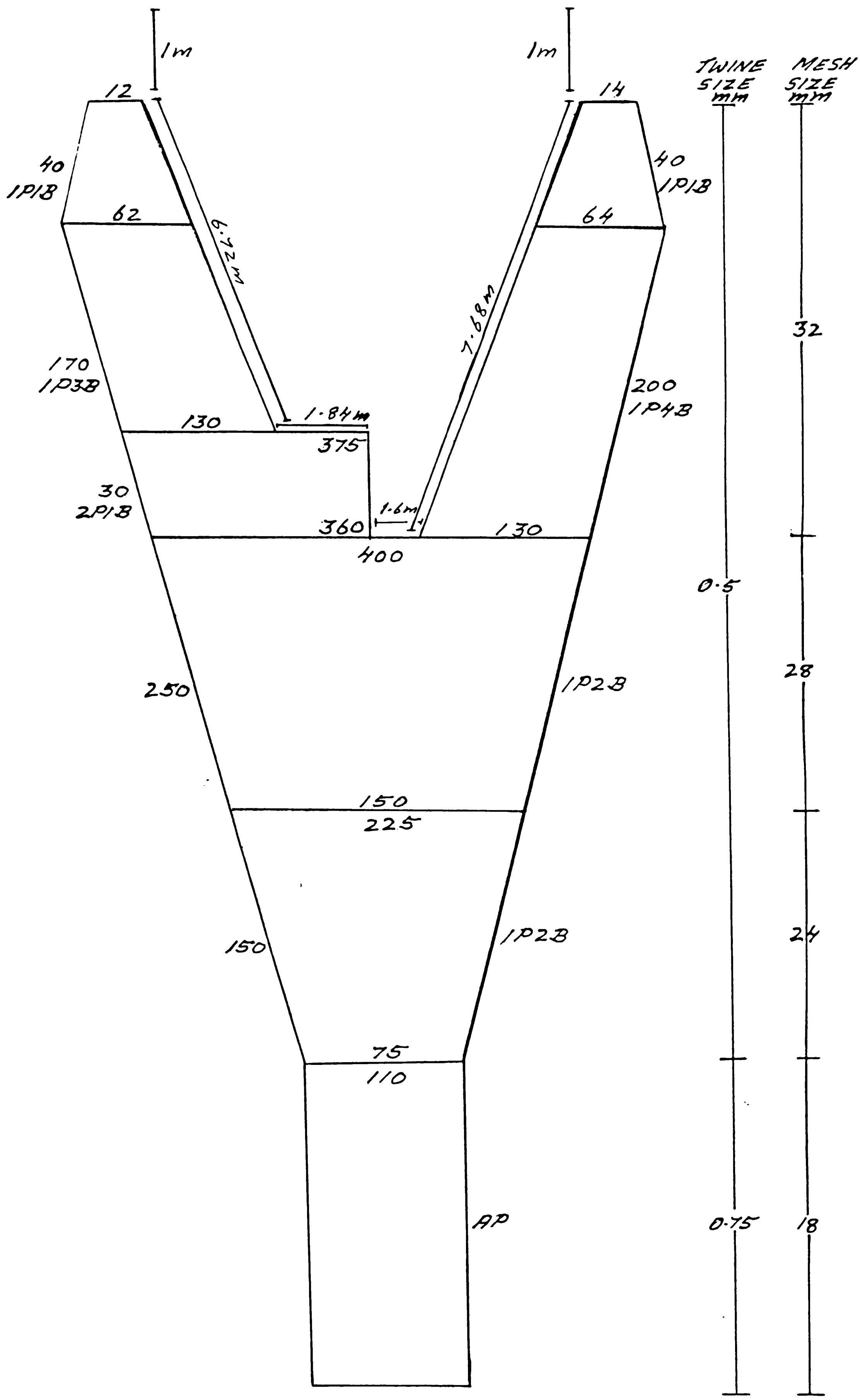


Fig.3.5.e SHRIMP TRAWL USED BY 28'MEDIUM TRAWLERS.

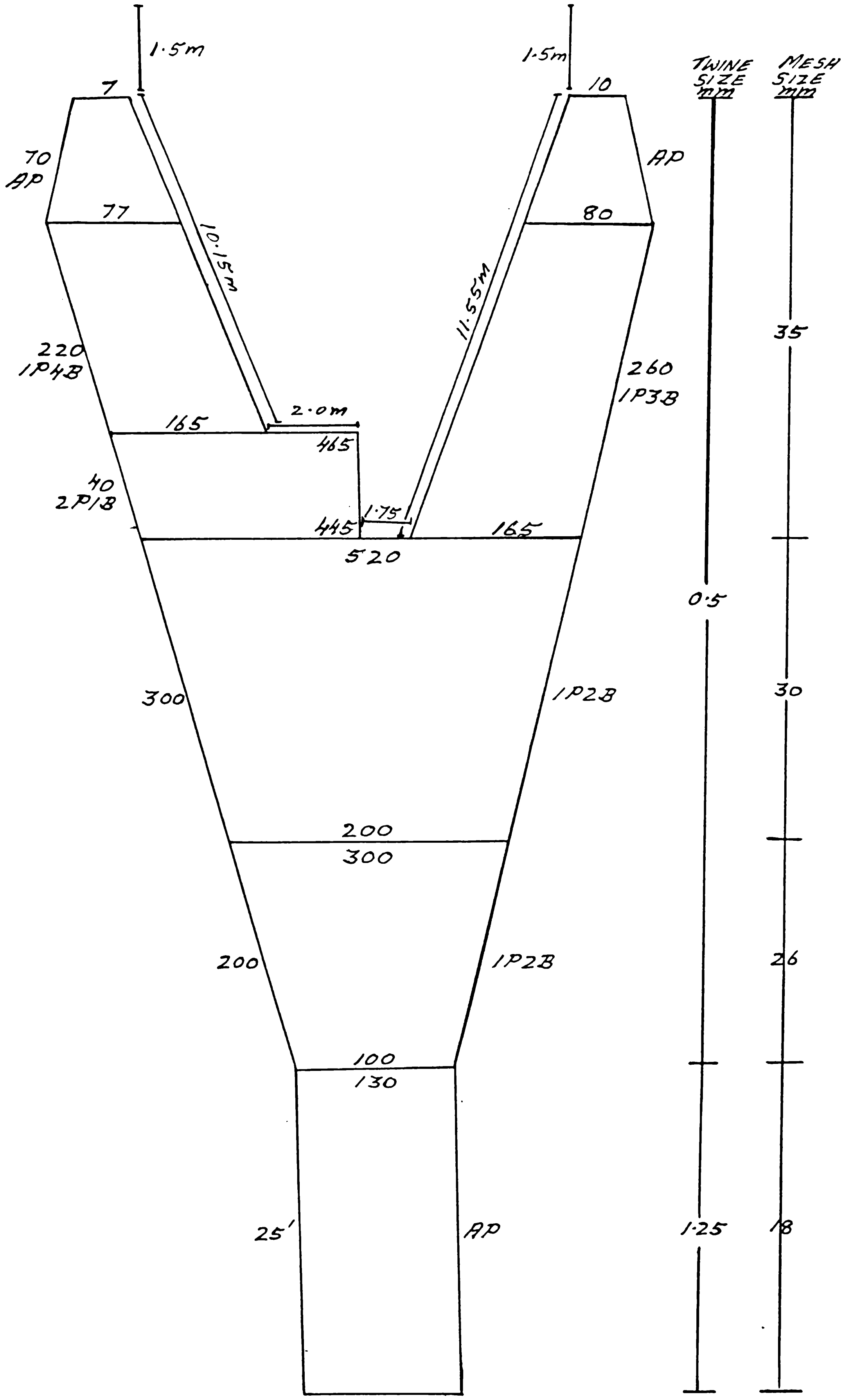


Fig.3.5.f SHRIMP TRAWL USED BY ALM 370 ENGINE FITTED TRAWLERS.

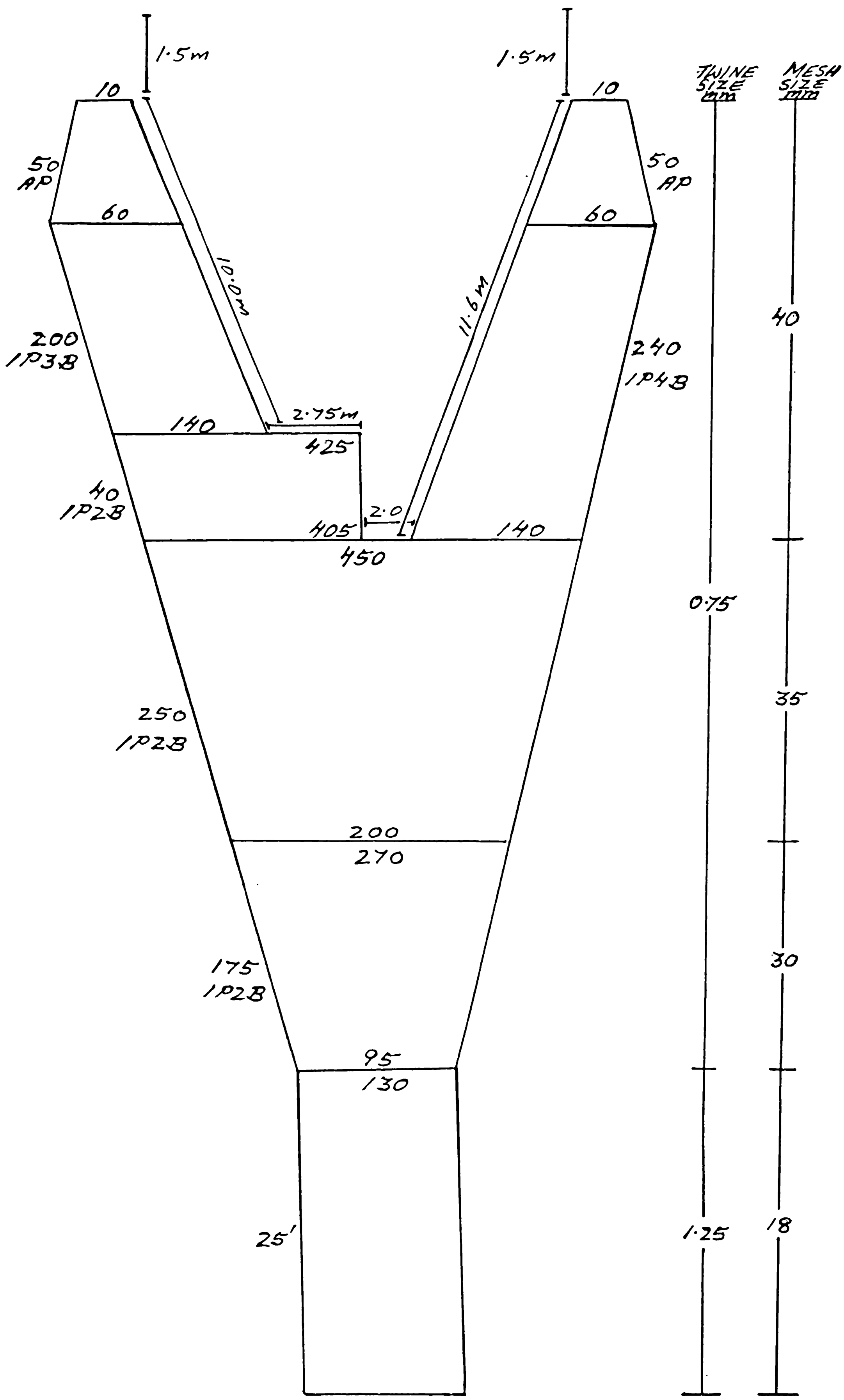


Fig.3.5.g SHRIMP TRAWL USED BY ALM 370 ENGINE FITTED TRAWLERS.

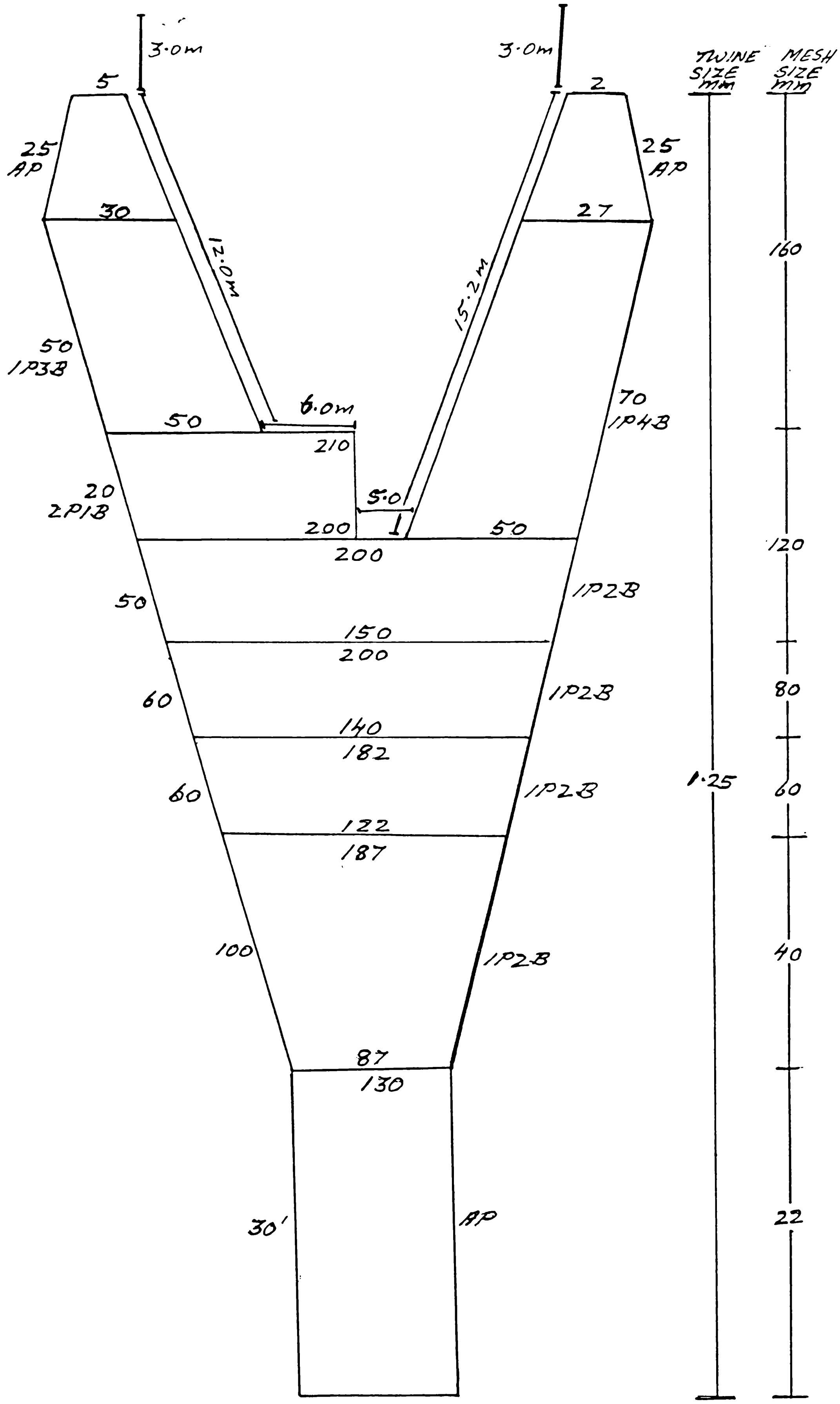


Fig.3.5.h FISH TRAWL USED BY ALM 370 ENGINE FITTED MEDIUM TRAWLERS.

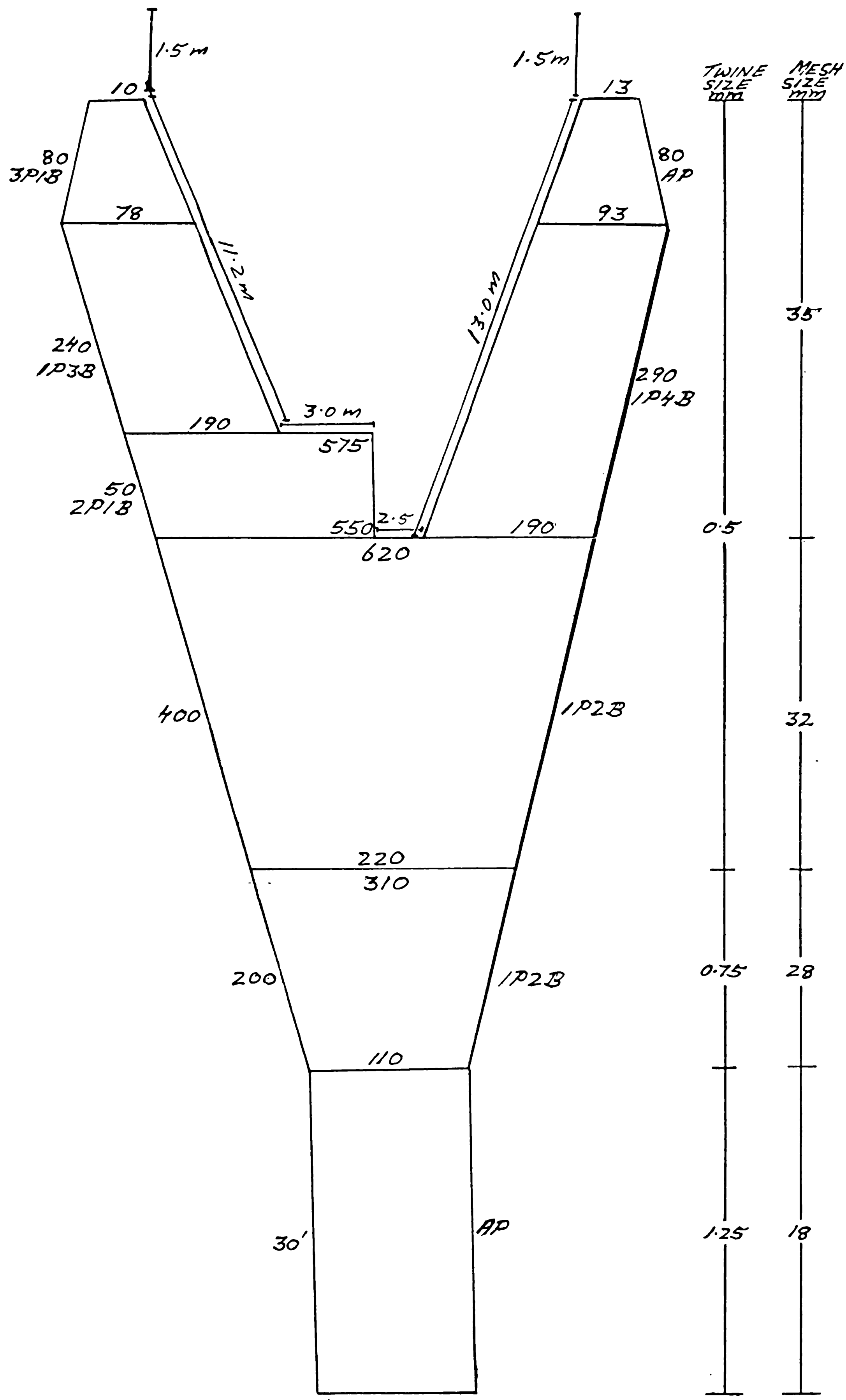


Fig.3.5.i SHRIMP TRAWL USED BY ALM 400 AND ALM 402 ENGINE FITTED MEDIUM TRAWLERS.

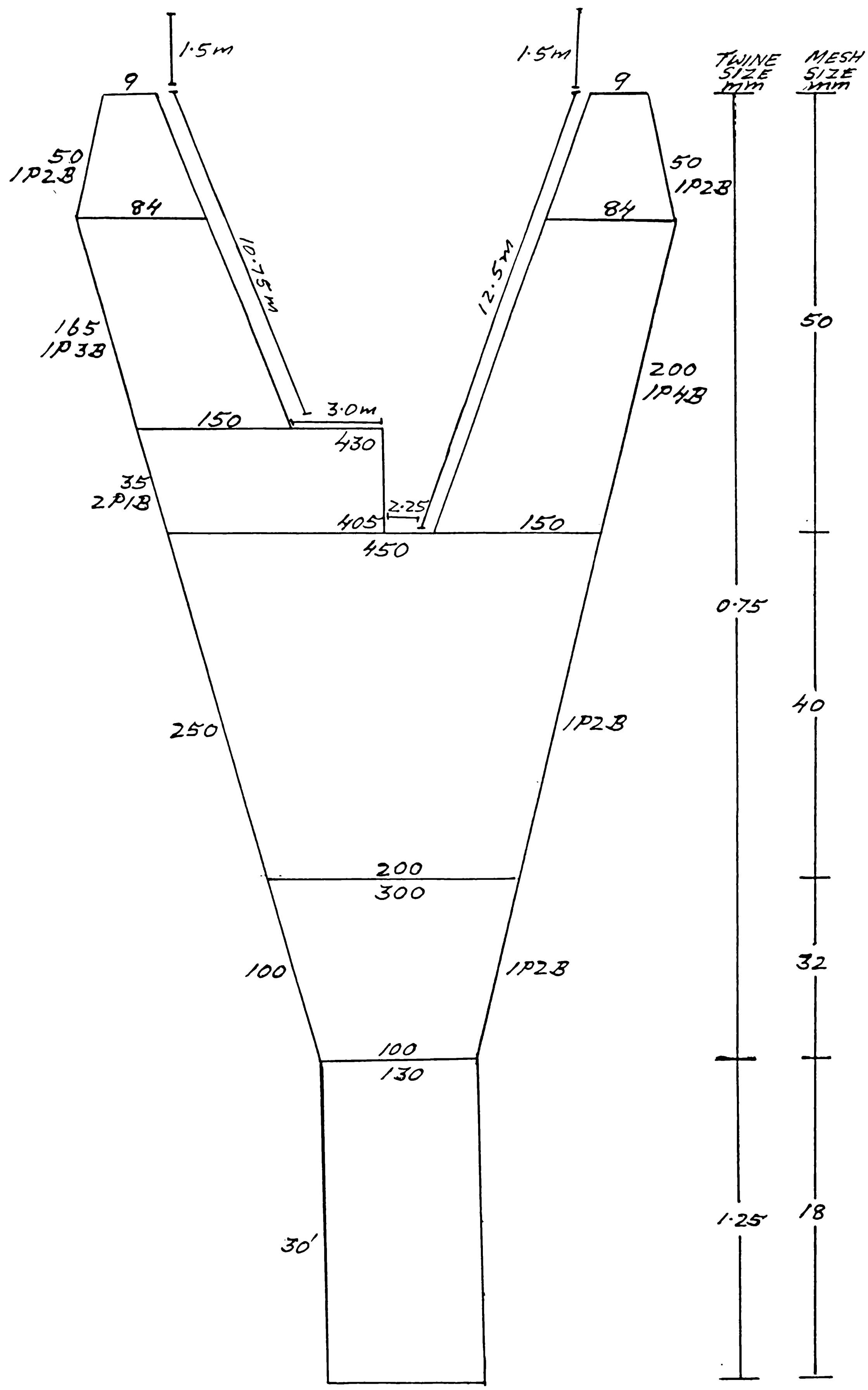


Fig.3.5.j SHRIMP TRAWL USED BY ALM 400 AND ALM 402 ENGINE FITTED MEDIUM TRAWL.

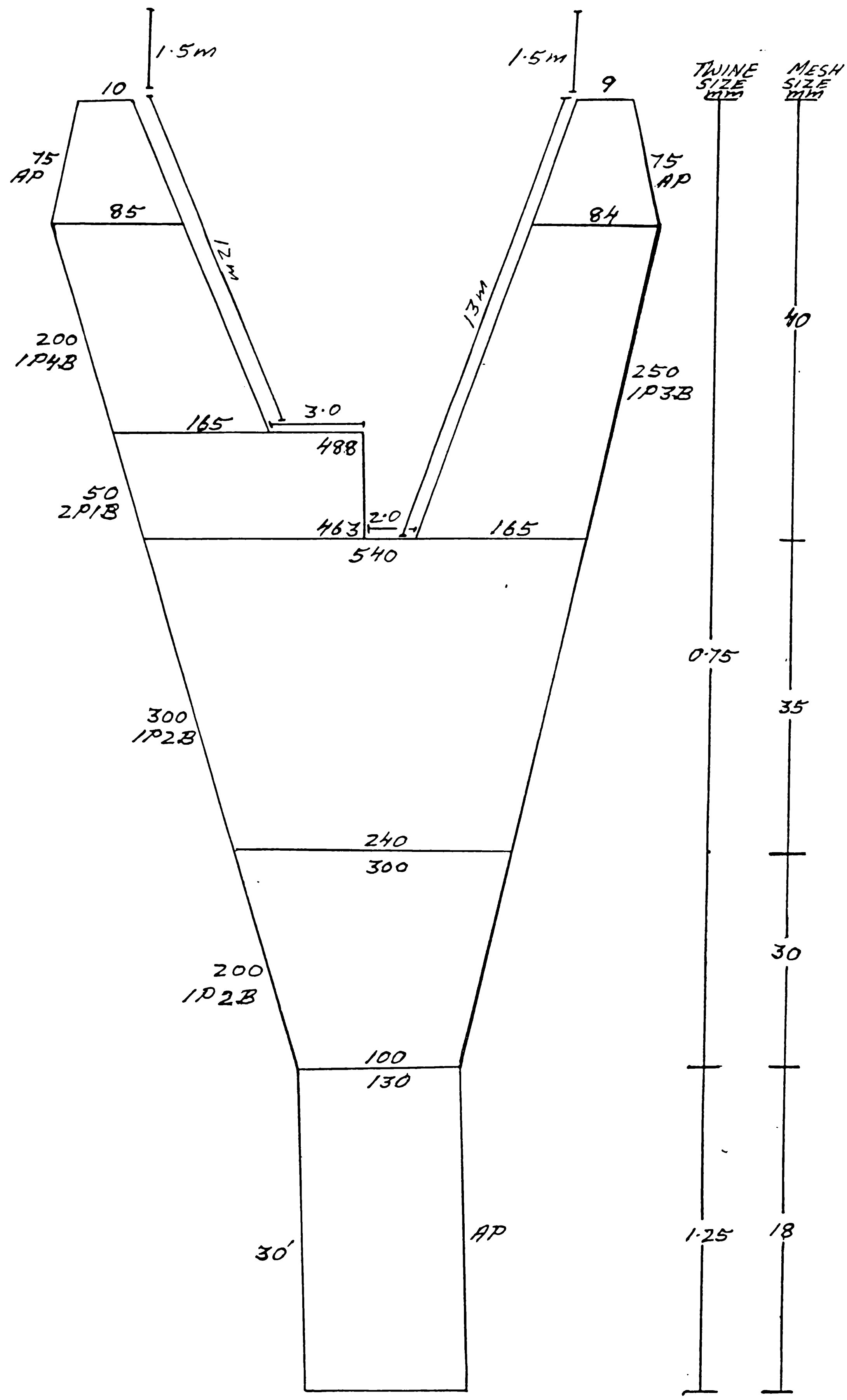


Fig.3.5.k SHRIMP TRAWL USED BY ALM 400 AND ALM 402 ENGINE FITTED MEDIUM TRAWLERS.

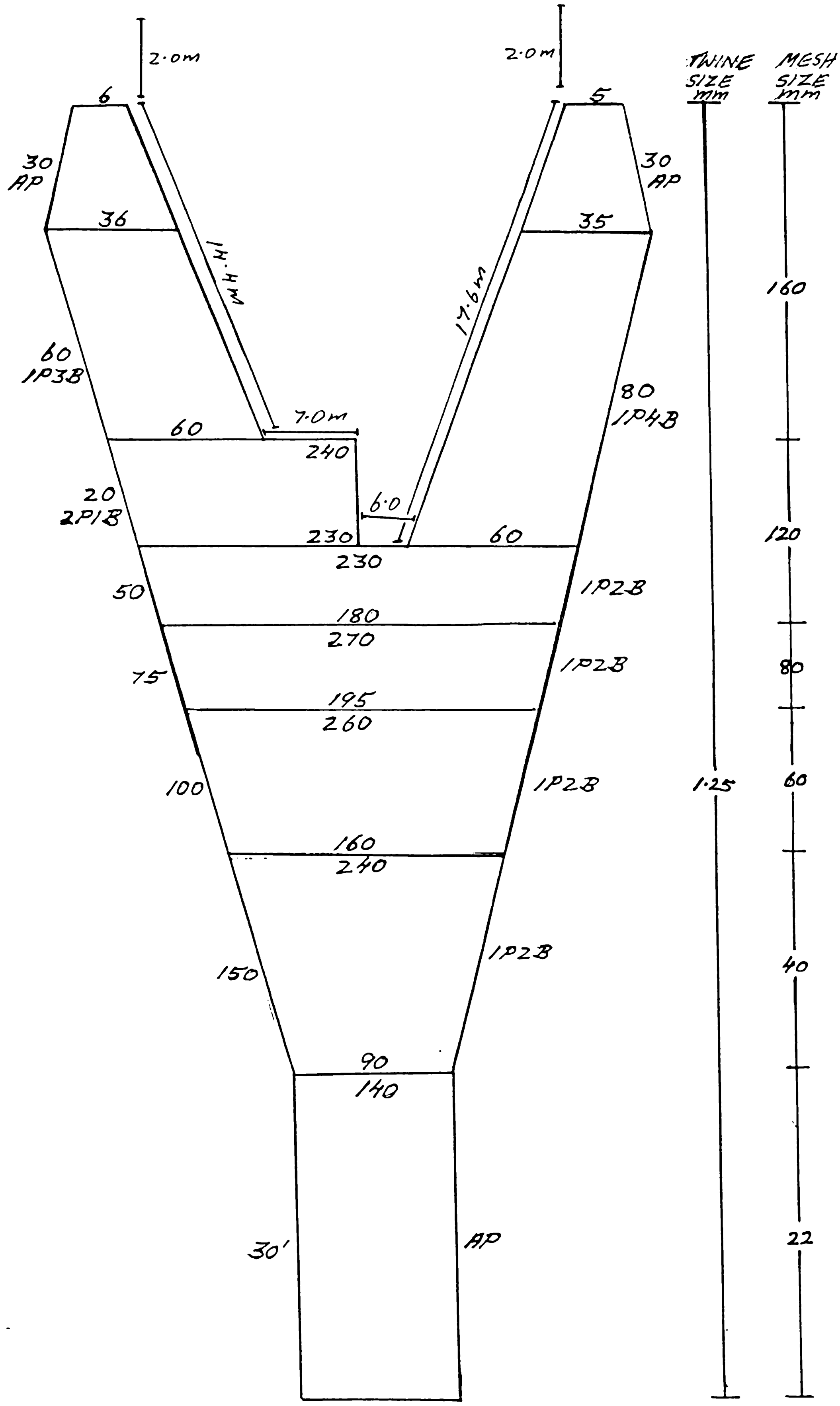


Fig.3.5.1 FISH TRAWL USED BY ALM 400 AND ALM 402 ENGINE FITTED MEDIUM TRAWLERS.

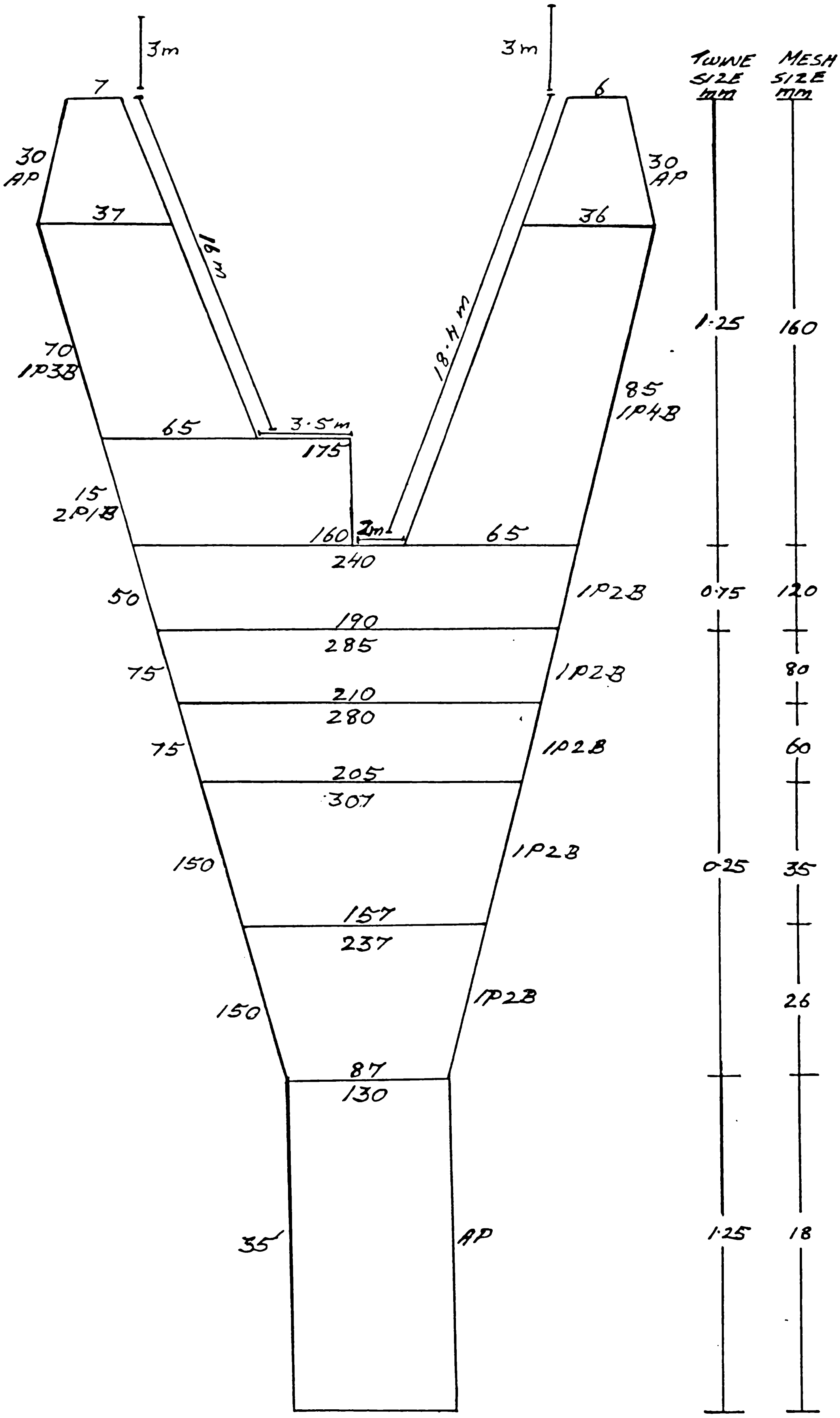


Fig.3.5.m FISH TRAWL USED BY ALM 400 AND ALM 402 ENGINE FITTED MEDIUM TRAWLERS

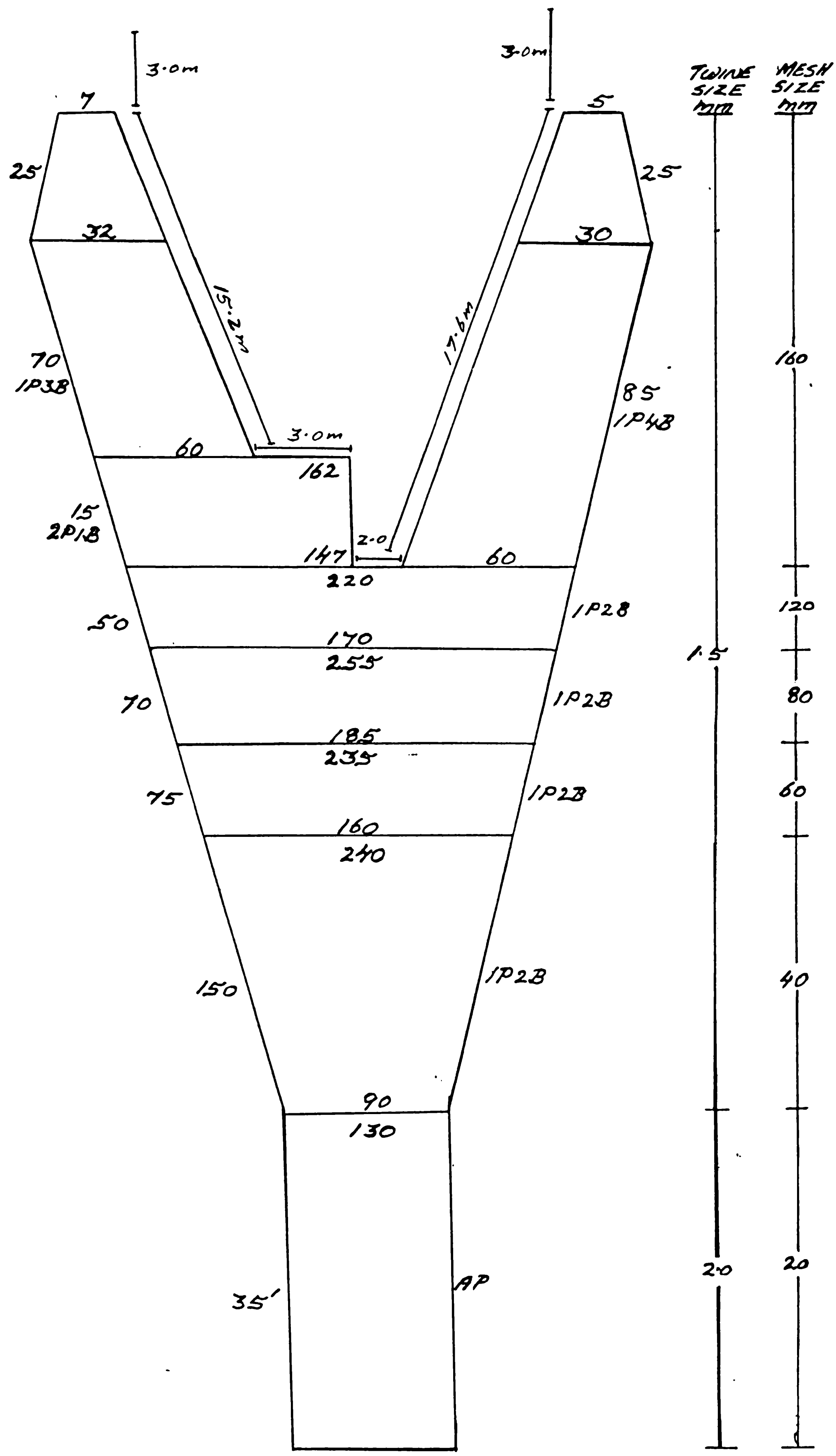


Fig.3.5.n FISH TRAWL USED BY ALM 680 ENGINE FITTED MEDIUM TRAWLER.

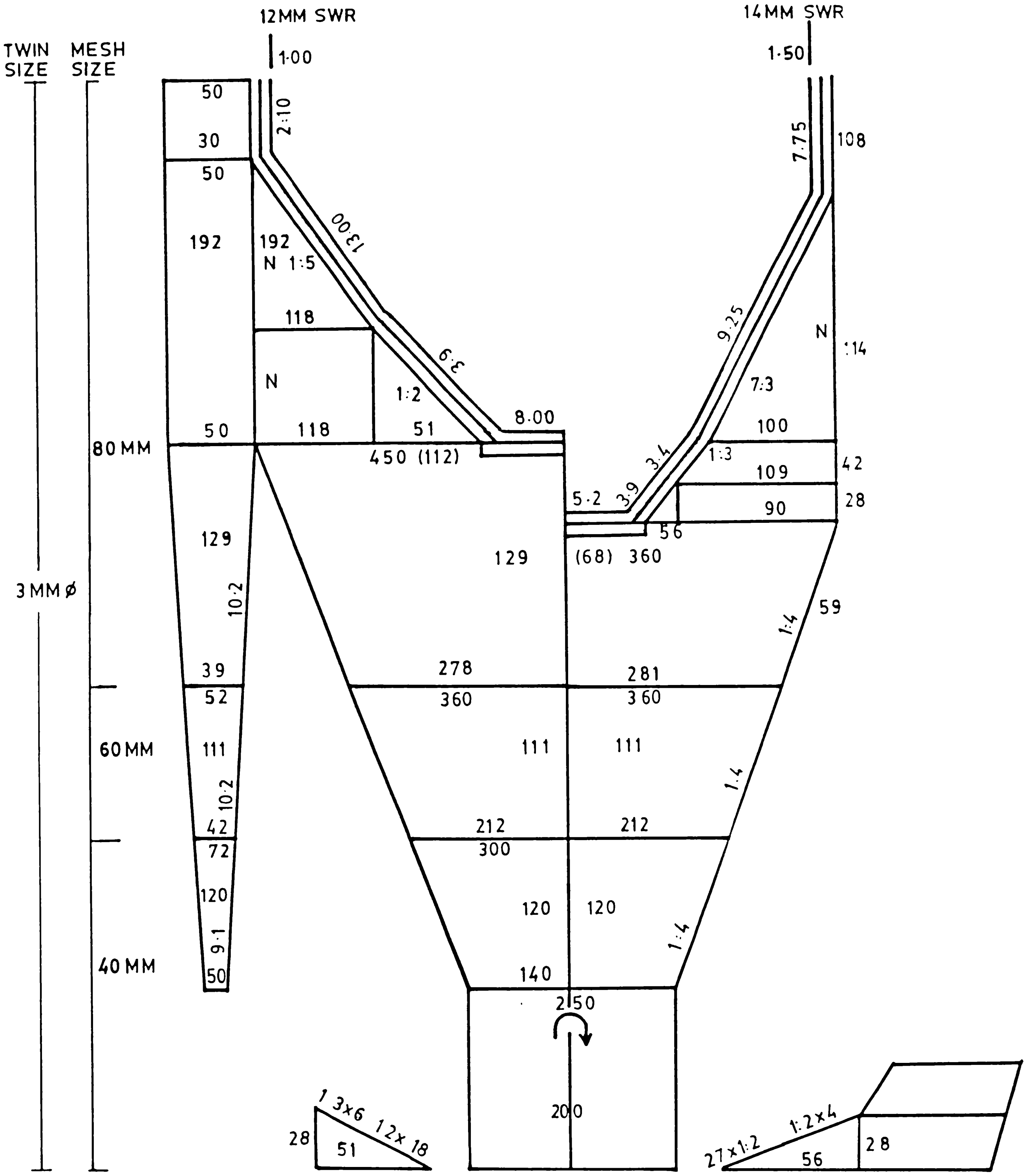


Fig.3.5.a FOUR SEAM DEEP SEA SHRIMP TRAWL NET.

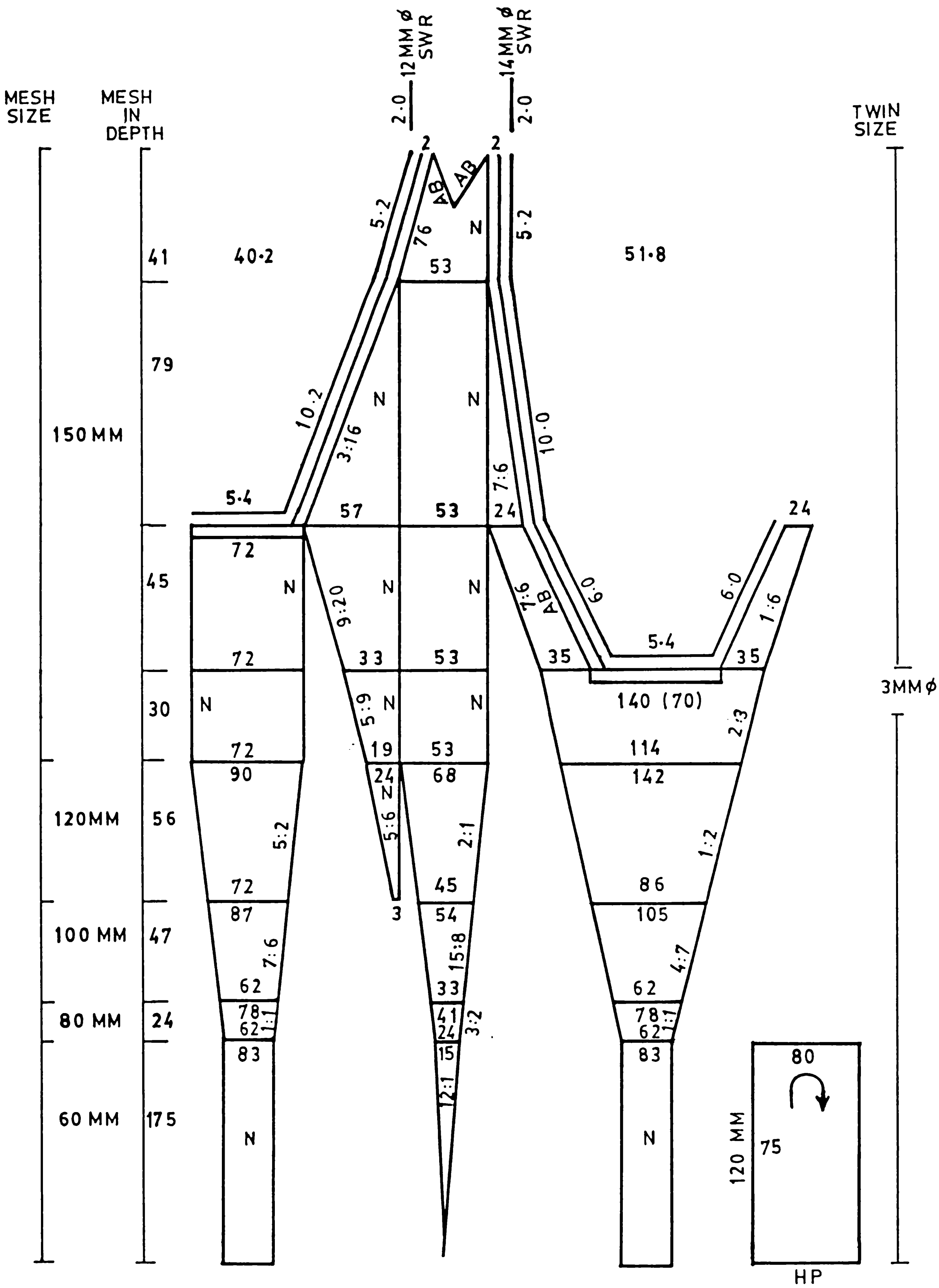


Fig.3.5.p SIX SEAM DEEP SEA TRAWL NET.

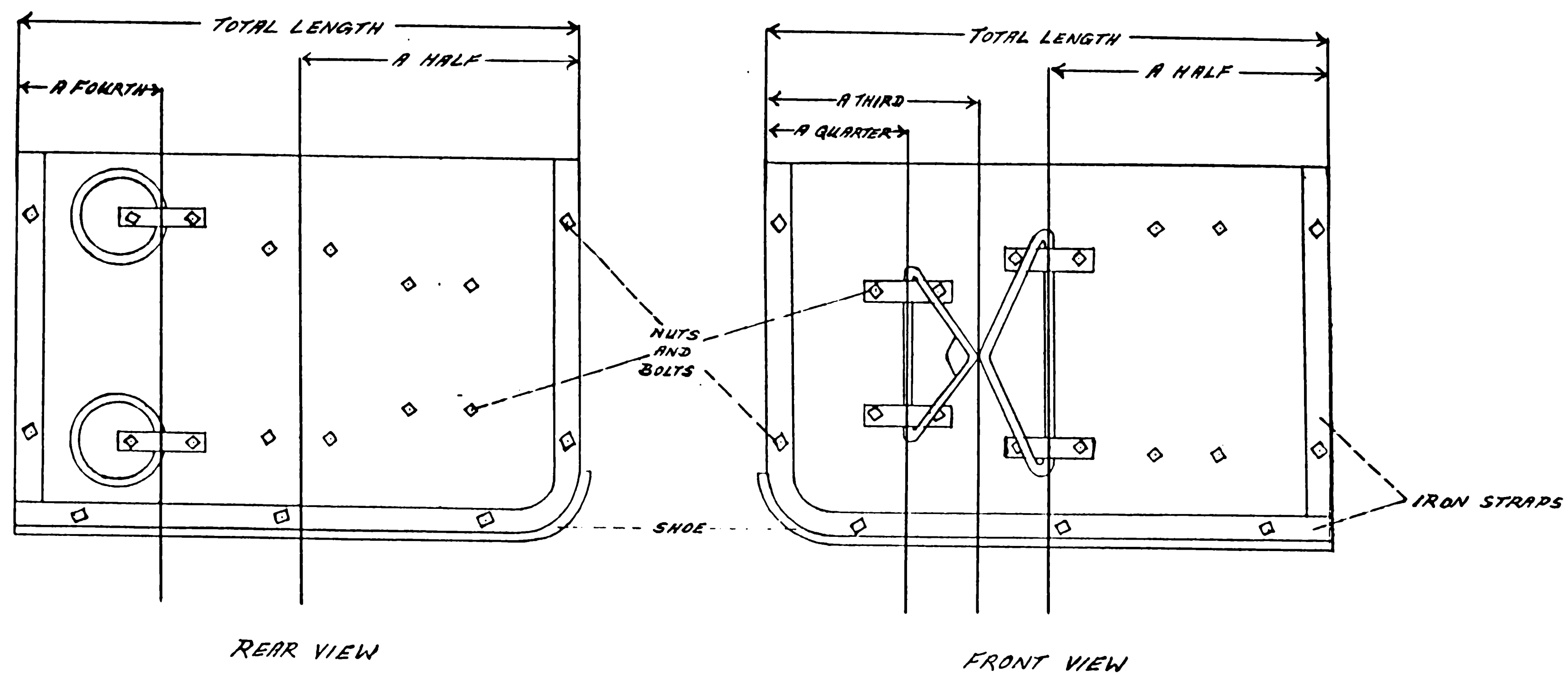
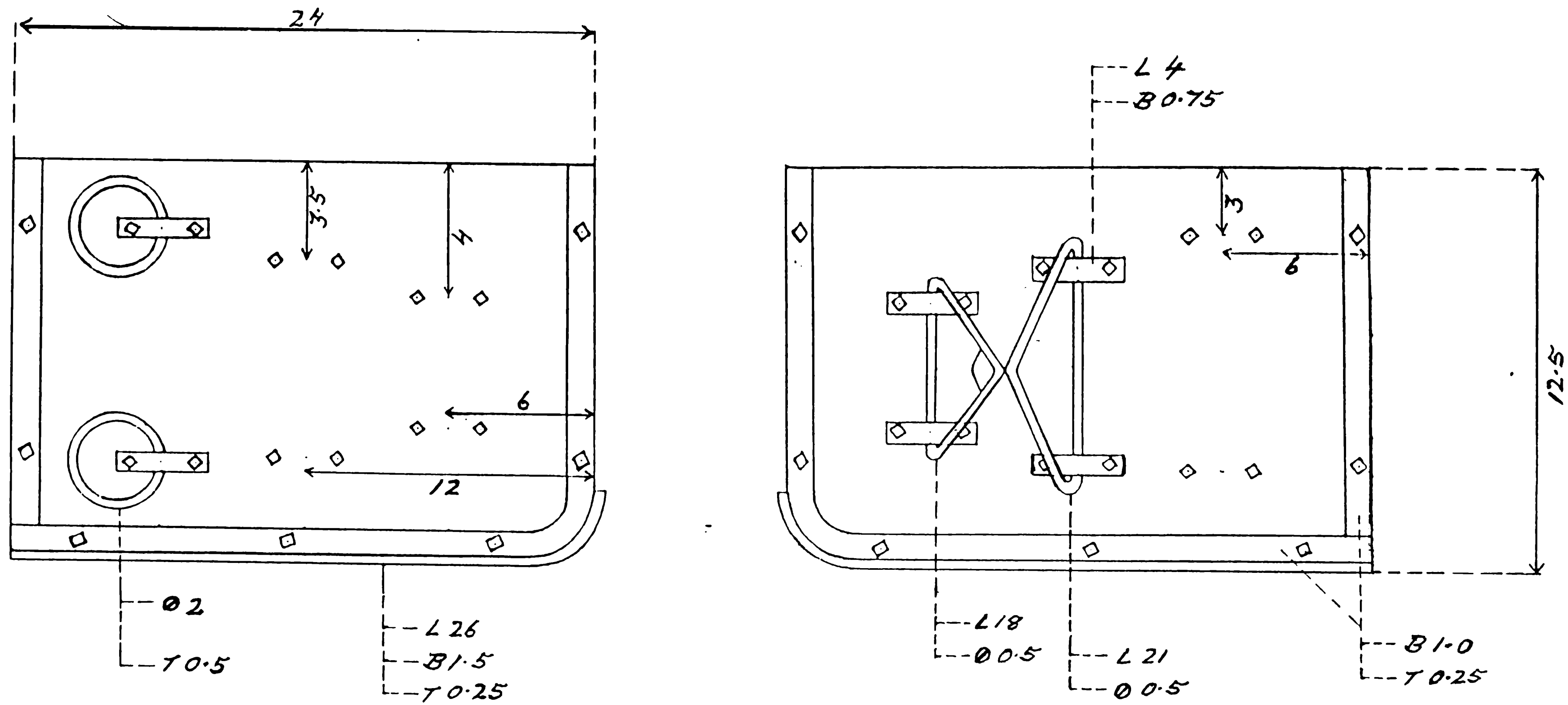


Fig.3.7.2a DESIGN PROPORTIONS OF CONVENTIONAL FLAT RECTAGULAR OTTER BOARDS ATTACHED TO MINI TRAWL NETS

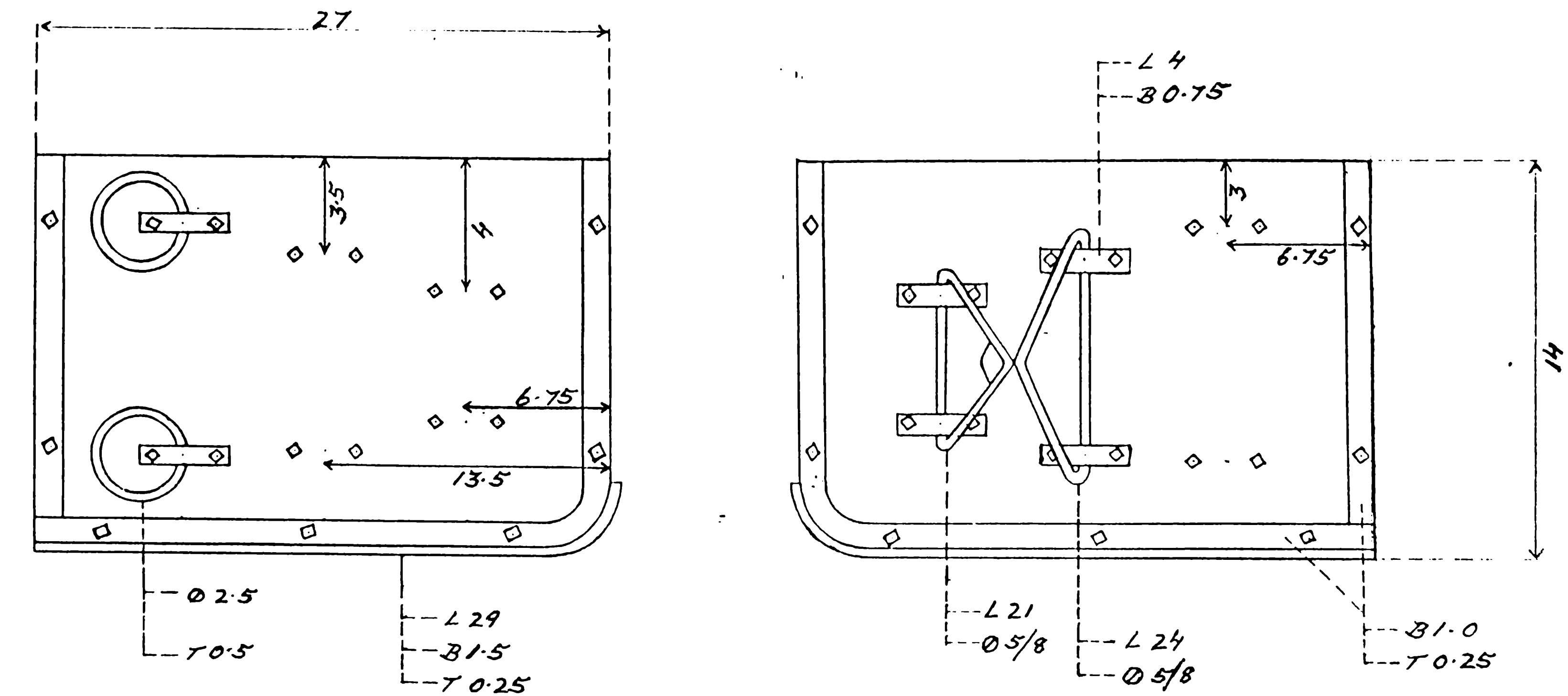


L - LENGTH
B - BREADTH
T - THICKNESS
Ø - DIAMETER

ALL DIMENSIONS IN INCHES

PLANK THICKNESS - ONE INCH

Fig.3.7.2b . 4 OTTER BOARD ATTACHED TO MINI TRAWL NET OPERATED FROM 7.5HP OBM FITTED CRAFT.

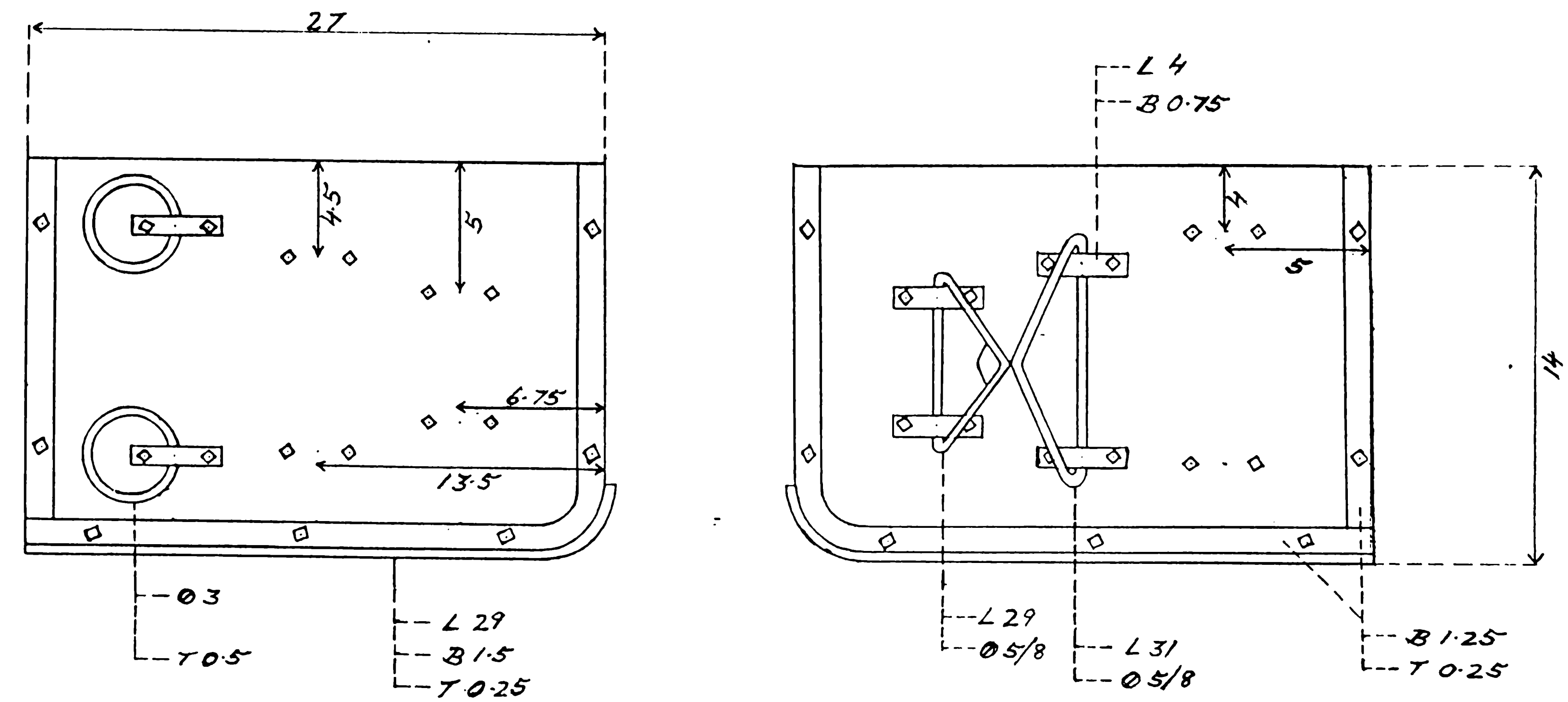


L - LENGTH
B - BREADTH
T - THICKNESS
Ø - DIAMETER

ALL DIMENSIONS IN INCHES

PLANK THICKNESS - ONE INCH

Fig.3.7.2c .5 OTTER BOARD ATTACHED TO MINI TRAWL NET OPERATED FROM 15HP OBM FITTED CRAFT



L - LENGTH
B - BREADTH
T - THICKNESS
Ø - DIAMETER

ALL DIMENSIONS IN INCHES

PLANK THICKNESS - ONE INCH

Fig.3.7.2d OTTER BOARD ATTACHED TO MINI TRAWL NET OPERATED FROM 20 HP OBM FITTED CRAFT

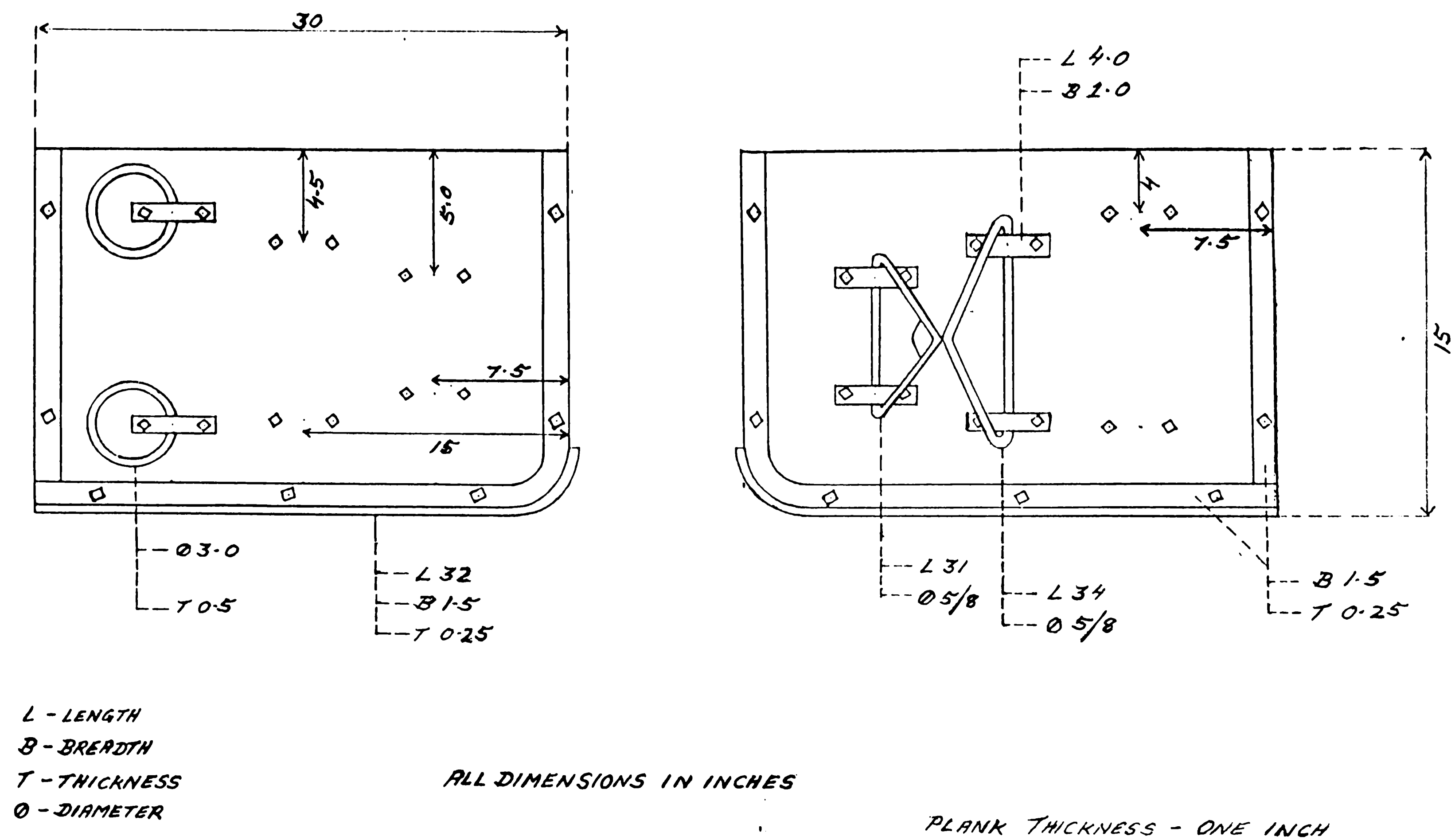


Fig.3.7.2e OTTER BOARD ATTACHED TO MINI TRAWL NET OPERATED FROM 25 HP OBM FITTED CRAFT

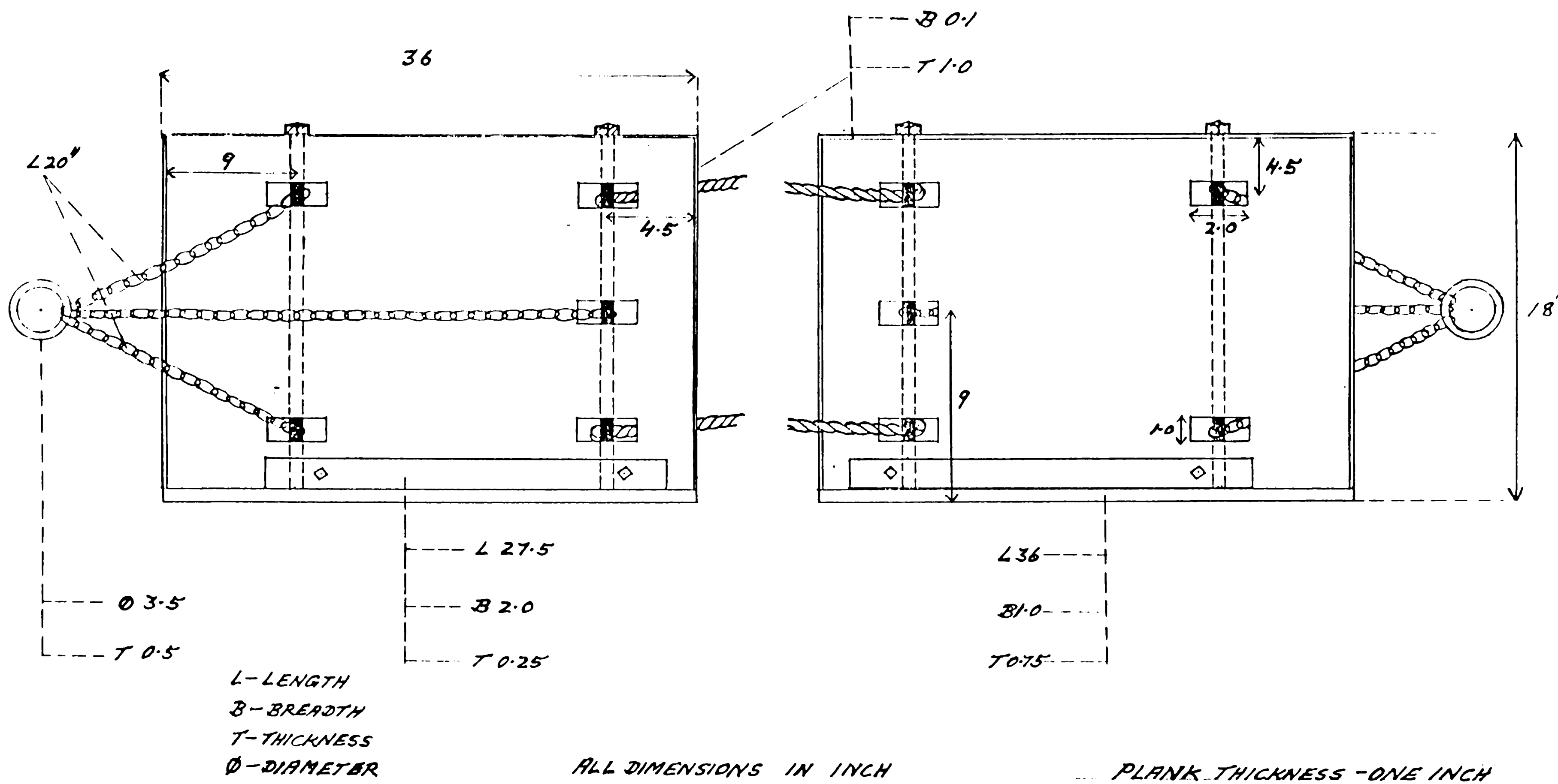


Fig.3.7.2f FLAT RECTANGULAR OTTER BOARDS OF 28' MEDIUM TRAWLERS

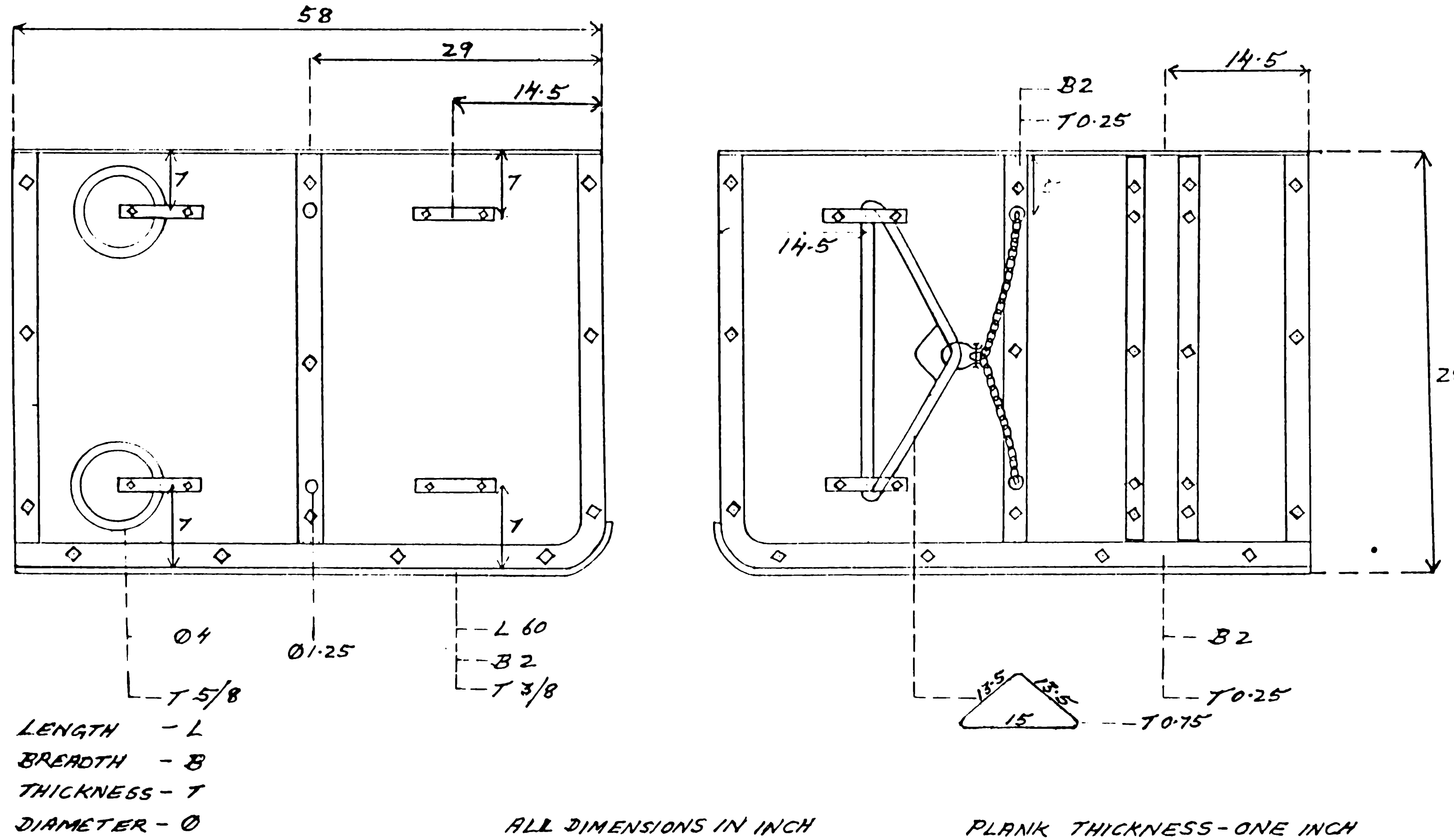


Fig.3.7.2g OTTER BOARD DESIGN OF ALM 370, ALM 400 AAND ALM 402 ENGINE FITTED MEDIUM TRAWLERS

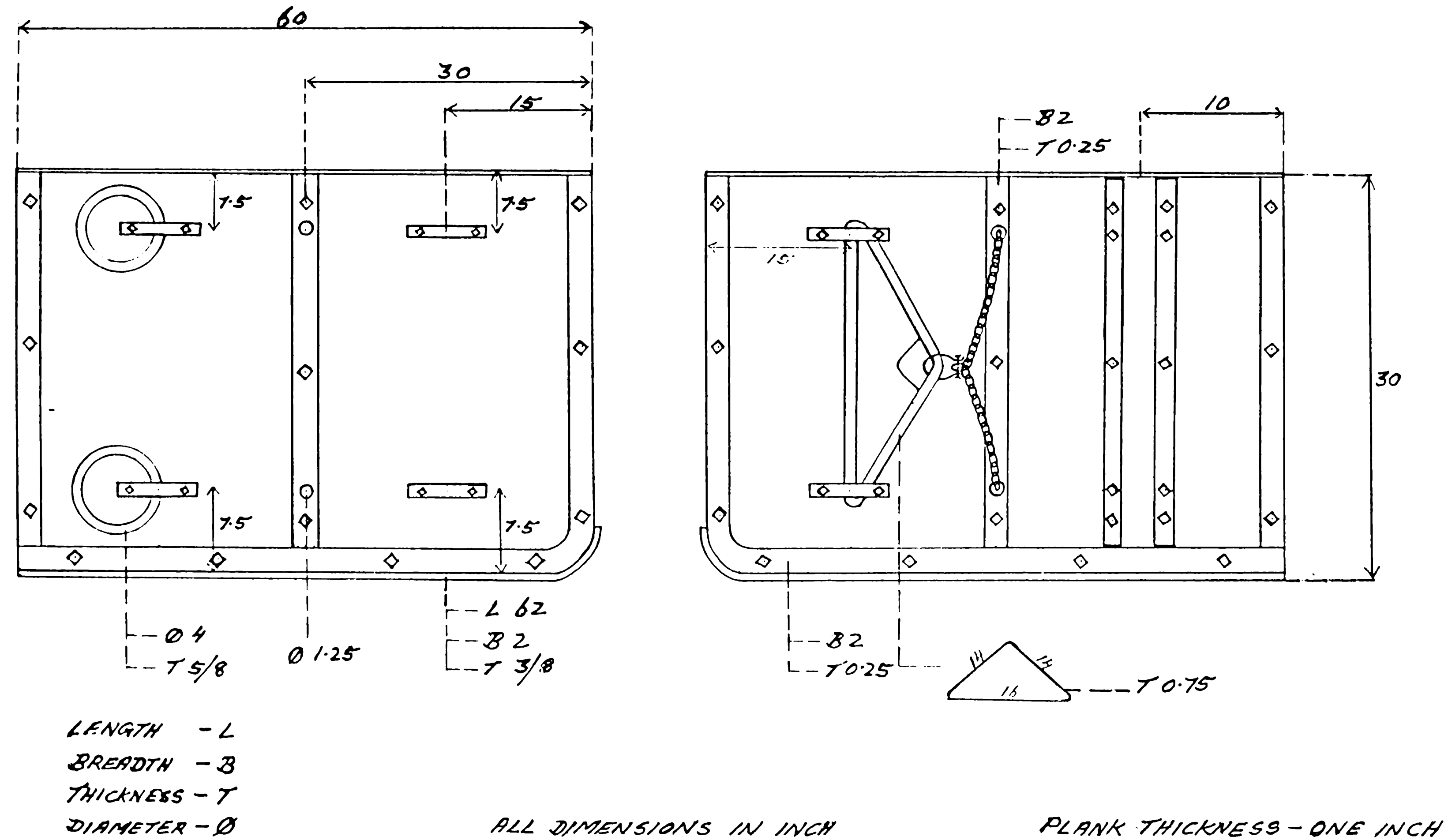


Fig.3.7.2h OTTER BOARD DESIGN OF ALM 680 ENGINE FITTED MEDIUM TRAWLERS

Plate. 3.7.1.b FLAT RECTANGULAR OTTER BOARD OF MEDIUM TRAWLERS.

Plate. 3.7.1.a FLAT RECTANGULAR OTTER BOARD OF SMALL TRAWLERS.

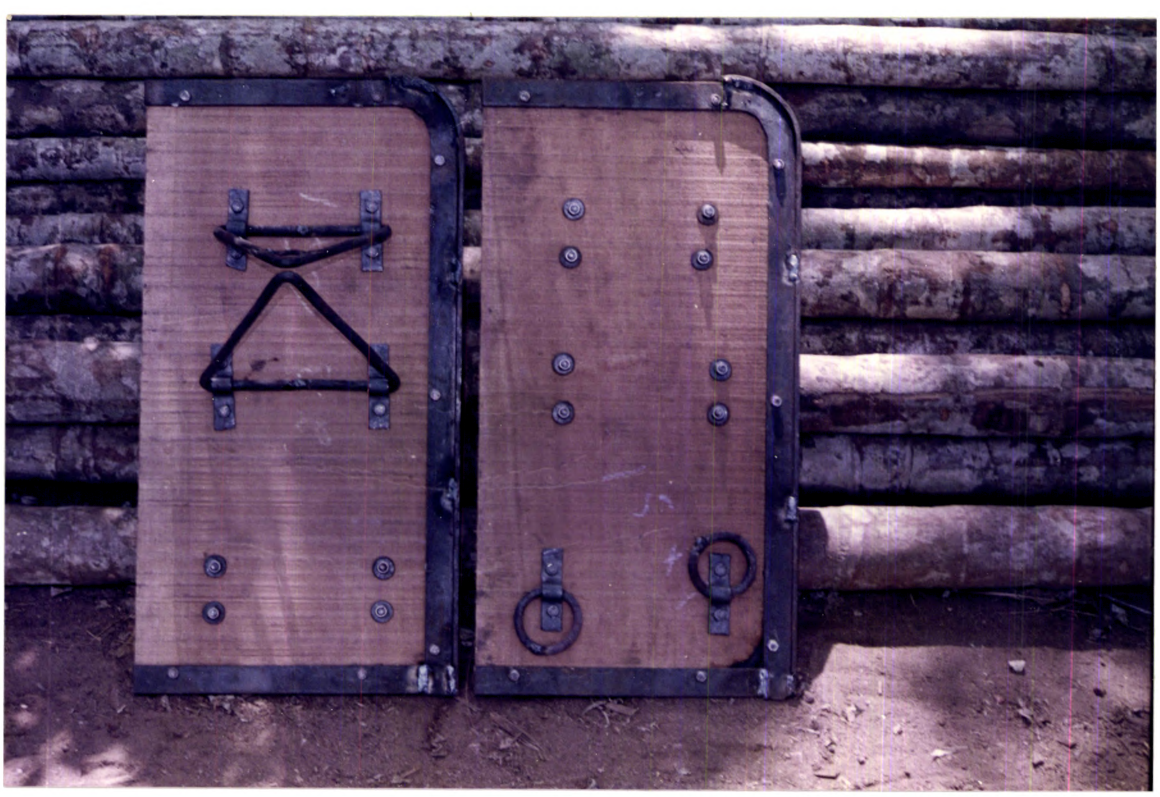


Plate. 3.7.1.c POLYVALENT OTTER BOARD DESIGN OF DEEP SEA TRAWLERS.

CHAPTER 4

FUEL CONSUMPTION, PROPELLER EFFICIENCY AND OVERPOWERING IN MEDIUM TRAWLERS

4.1 INTRODUCTION

The propulsion of a fishing vessel fitted with an internal combustion engine is effected by the movement of the propeller due to the power transmitted to it through the propeller shaft from the main engine. Some of the important considerations in selecting the main engine for a fishing vessel are the cost levels and the technical efficiency of the engine to be installed. Under technical efficiency the main factor is the fuel consumption level of the engine. Moreover the propeller that is installed should be matching to the power delivered to the propeller. Fyson, 1985, elaborates that the type of engine, required power, weight and bulk of the engine, ease of maintenance, fuel consumption and main and auxiliary power take-off requirements are the major considerations for selecting the main engine of a fishing vessel.

Traung (1963), in "Efficient propeller selection", provides a text on how to select efficient propellers for fishing vessels without getting involved in difficult mathematics, but still keeping to established engineering principles. According to him, a random check of fishing boat propellers reveal that there efficiency can be improved by 5 to 10%. The general procedure for the selection of a propeller, the selection of maximum power and the selection of the power required for towing are presented.

Fouling of vessels results in a reduction of speed, an increased cost in fuel and further it incurs a loss of time and money for the application of necessary remedial measures. The immediate effect of fouling is an increase in the resistance in the movement of the hull through the water - a phenomenon known as frictional resistance. Anon (1952), details that as a result of experience over a number of years, the British Admiralty makes an allowance for design purposes for an increase of frictional resistance of 0.25 percent per day out of dock in temperate waters and 0.5 percent per day in tropical waters. Gulbrandsen, 1986, in "Reducing the fuel costs of small fishing boats", says that removal of foulers from a badly fouled hull can reduce the fuel consumption by around 40%. He further adds that, in the tropics the increase in surface friction due to fouling has been estimated to be between 0.6% and 1.5% per day. Assuming 0.7% as the average frictional increase per day and that the frictional resistance is around 35% of the total resistance at the normal operating speed of fishing vessels, he estimated the increase in fuel consumption due to fouling at 7%, 44% and 88% after 1, 6 and 12 months respectively.

The importance of the initiation of a fuel conservation programme can be assessed from the results of a project initiated by the New Zealand Energy Research and Development Committee and the New Zealand Government (Billington, 1988). In 1983, the New Zealand Fishing Industry Board carried out a fuel monitoring/propulsion efficiency pilot project from a random sample of fishing vessels in one port. The objective of the project was to determine the value of fuel flow measurement on a range on vessels of differing size and fishing methods, and to investigate the effect on fuel consumption of hull fouling and propeller repitching where this appeared to be required. Eight fishing vessels in the port of Tauranga were involved in the project. Of the eight vessels five were capable substantial fuel economy without impairment of fishing efficiency. The remaining three could not afford to burn less fuel without accepting a significant loss of performance.

Following the pilot study, the New Zealand Fishing Industry Board introduced an advisory programme for commercial fishing operators throughout the industry. Ninety vessels were included in the programme and a standard evaluation questionnaire was sent to the skipper of each of these vessels. Compilation of the results from this survey indicated that for 35.5% of the vessels, opportunities for improving propulsion efficiency had been identified. Of these the skippers of 84.4% of the vessels had made changes in their normal operating rpm to either decrease fuel consumption or improve speed or bollard pull in relation to fuel used. For 15.5% of the vessels change in propeller pitch had been recommended, and in 85% of the cases these changes had been implemented. Overall 24% of the skippers of the ninety-vessel survey had been able to calculate fuel savings achieved as a result of fuel flow testing coupled with bollard pull and vessel speed management.

A survey of the medium and deep sea trawlers showed that the propeller types existing on the medium trawlers of Kerala included the controllable pitch propellers on a small scale and fixed pitch propellers on a large scale. Three blade fixed pitch propeller was the most common type of propeller installed on the medium trawlers. On the deep sea trawlers there were controllable pitch propellers, fixed pitch propellers and also fixed pitch propellers provided with Kort nozzle. In the medium trawlers, gun metal was the most common type of material used in propeller construction though there were isolated cases of usage of manganese bronze. In the deep sea trawlers the propellers were constructed only in manganese bronze. The propellers of deep sea trawlers were all four blade versions.

The main engines fitted on the medium trawling fleet of Kerala are the medium speed engines. The most common engine type installed on the medium trawlers operating along the Kerala coast is the Asok Leyland Marine diesel engines. The other engines installed include Kirloskar, Ruston, Yanmar, and Bukh. Other MWM type constituted a negligible percentage. The ALM models installed include ALM 370, ALM 400, ALM 402 and ALM 680. The ALM 412, a new model is also picking up in the market.

It was evident from the works mentioned above that fouling of the hull, propeller repitching and efficiency of the installed propeller are important factors affecting the fuel consumption of a vessel. Further instances of overpowering of the fishing vessels of the Kerala fleet is put forward in the studies conducted by Hameed et al., 1988. Here an attempt is made to study the effect of engine RPM, hull fouling and construction material on the fuel consumption of medium trawlers fitted with ALM diesel engines. Further, the efficiency of the propellers installed on the medium trawlers is worked out following the method of Traung (1963) and Fyson (1985). Instances of overpowering of medium trawlers is also dealt with as per the method followed by Traung (1963).

4.2 OBJECTIVES

- to study the fuel consumption levels of the medium trawlers in relation to
  - i) Hull fouling
  - ii) Engine RPM
  - iii) Construction material

- to study the efficiency of propellers installed on medium trawlers.

- to assess the percentage of overpowering of the medium trawlers in terms of
  - i) Determination of engine torque and propeller torque
  - i) Efficiency in propeller use

4.3 MATERIALS AND METHODS

4.3.1 Observations on fuel consumption

Fuel consumption measurements have been done on selected medium trawlers operating from the Cochin Fisheries Harbour. The fuel consumption was measured using a fuel flow measurement tank (Plate. 4.3.1a). The measurement tank was designed and constructed with the aim of measuring the fuel consumption of fishing trawlers operating with different horse power of engine. The tank was constructed in 3mm perspex sheet of size 4" x 4" x 24" (LxBxH). It is provided with a quarter inch one-way stop cock, half inch above the bottom level on one side. A nut secures it to the perspex sheet on the inside. A rubber bush in between the nut and the perspex sheet prevents any leakage of fuel. A four inch thick square perspex sheet is screwed on to the top of the tank so that it can be removed should there be any repair for the stop cock. This sheet is provided at it's center with a one inch diameter lid with locking mechanism, which can be opened to fill the tank with fuel.

The tank is capable of holding six liters of fuel and is graduated to five and a half liters, leaving space on top and bottom to ensure proper measurement. The long lines going around the tank show the graduations at one thousand milli liter (liter) graduations and the shorter lines the one hundred milli liter (0.1 litre) graduations. Small pieces of transparent plastic with values written on it highlight the graduations every five hundred milli liter. A flexible quarter inch hose fifteen feet long is attached to the one way stop cock. This hose at the other end is connected directly to the fuel pump during measurement (Plate 4.3.1b).

Since Ashok Leyland Marine (ALM) diesel engine was the most common type of engine installed on the medium trawlers operating from Cochin, trawlers fitted with this model of engine was selected for fuel consumption measurement. Out of the different models of ALM diesel engines the main models which were installed on the medium trawlers were ALM 370, ALM 400, ALM 402 and the ALM 680. From these, there was limited installation of the ALM 680 engine. Hence the study was concentrated on the other three engine models.

4.3.1.1 Fuel consumption and hull fouling

For measuring the fuel consumption in relation to hull fouling two medium trawlers each, of 32ft fitted with ALM 370 engines, of 38ft fitted with ALM 400 engines and of 43ft fitted with ALM 402 engines were selected. In all the cases the trawlers were not more than one year old. The first fuel consumption measurement was done on each trawler immediately after cleaning (Plate 4.3.1.1a) and painting the hull. Observations were made at different RPM levels of the engine to include the towing RPM of 1600 and 1700 and the steaming RPM of 1800 and 1900. Four observations were made at each RPM on each trawler. These measurements were repeated at 3 and 6 month (Plate 4.3.1.1b) intervals on each of the trawlers selected and the results were computed.

4.3.1.2 Fuel consumption in relation to engine RPM

The fuel consumption measurement on each of the trawlers selected for 4.3.3.1 above, at the 0 month at different RPM levels of 1600, 1700, 1800 and 1900 were taken as fuel consumption levels of the different engine models in relation to engine RPM.

4.3.1.3 Fuel consumption in relation to construction material

In order to study the fuel consumption levels of trawlers built in wood and steel, two 43ft medium trawlers each of wood and steel fitted with ALM 400 engines were selected and fuel consumption measurements were conducted at 1600, 1700, 1800 and 1900 RPM of the engine on a clean hull. Four observations were made at each RPM level on each of the four trawlers.All the trawlers selected were one year old.

4.3.2 Propeller efficiency

To study the efficiency of the propellers fitted to the medium trawlers operating along the Kerala coast data was collected from 80 medium trawlers fitted with Ashok Leyland marine diesel engines. The method followed by Fyson, 1985 is adopted to study the efficiency of the installed propellers. Data on the following parameters (Table 4.3.2) were collected from the trawlers.

i) Effective horse power (EHP)

The horse power of the engine at 1800 RPM is taken as EHP (Table 4.3.2).

ii) Reduction gear ratio

This denotes the ratio of the reduction gear attached between the propeller shaft and engine of a trawler (Table 4.3.2).

iii) Propeller RPM

This is the rotations per minute of the propeller based on the reduction gear ratio available on the trawler. Since the EHP has been taken at 1800 RPM, the propeller RPM is the product of the RPM of engine at EHP and the reduction gear ratio (Table 4.3.2).

iv) Propeller diameter (D)

This denotes the total diameter of the propeller measured in feet (Table 4.3.2).

v) Length over all (LOA)

This is the length over all (LOA) of the trawler measured in feet (Table 4.3.2).

vi) Length at water line (LWL)

The length at water line (LWL) of the trawler measured in feet (Table 4.3.2).

Other parameters which were calculated (Table 4.3.2) include

vi) Speed V

This is the speed of the vessel in knots and has been estimated according Fyson (1985), who states that the speed length ratio ($V/L^{1/2}$) values lie in the range of 0.9 to 1.2 for fishing boats up to 30m in length. The speed of the vessel at a speed length ratio of 1.2 has been taken because the EHP and propeller RPM has been estimated at 1800 RPM (Table 4.3.2).

vi) Speed of advance V_A

This has been calculated as per the method of Fyson, 1985. It is expressed by the formula

$$V_A = V\ (1-w)$$

Where V_A - speed of advance

V - speed of the trawler

w - wake fraction

The wake fraction has been taken as a constant at 0.21 (Fyson, 1985) (Table 4.3.2).

vii) P/D

This is the pitch/diameter(P/D) ratio (Table 4.3.2).

viii) Propeller efficiency (η)

Propeller efficiency is given by the ratio of thrust power developed by the propeller to the power delivered to the propeller, ie., P_T / P_D. The efficiency was measured from the

$B_P - \delta$ diagram (Fyson, 1985).

In many of the cases the EHP and RPM are the same and the V_A values and D values were not varying very much. Hence only 25 cases (Table 4.3.2) out of the eighty trawlers from which data was collected were analysed, ensuring that all the length types of trawlers were represented.

According to the method followed by Fyson, 1985, the selection of optimum propeller variables have been computed from the Taylor propeller coefficients B_P and δ. The Taylor propeller coefficients are represented by the following formula

$$B_P = (n \times P_D^{0.5}) / V_A^{2.5})$$
$$\delta = (n \times D) / V_A$$

where,

n = propeller RPM

P_D = delivered horse power

V_A = speed of advance

D = propeller diameter

The delivered horse power (P_D) (Table 4.3.2) was estimated by giving an allowance of 5% for bearing and shaft losses from the EHP. B_P, has been calculated after arriving at the P_D and V_A. From the installed diameter of the propeller measured in feet, the Taylor propeller coefficient δ has been calculated. After arriving at the Taylor coefficient δ, the optimum propeller diameter on the vessel was arrived at as follows.

From the B_P-δ diagram, P/D and δ values are read off at the line of maximum efficiency. The optimum efficiency (η_O) (Table 4.3.2), at this point is also read off. The optimum diameter D_O may be found from

$$\delta = \frac{(n \times D)}{V_A}$$

Therefore $$D = \frac{(V_A \times \delta)}{n}$$

Since the optimum propeller diameter calculated as above was larger than the available propeller aperture, a propeller with smaller diameter had to be installed. Here also the P/D and η_i (Table 4.3.2) of the installed propeller is read off from the B_P- δ diagram as follows.

$$\delta = \frac{(n \times D)}{V_A}$$

In this calculation, D is the diameter of the propeller installed. The B_P value is not changed. From the charts, corresponding to these B_P and δ values, the P/D and η_i are obtained. From this P/D and D_i values, the pitch was calculated. The results of this calculation is presented in Table 4.3.2.

4.3.3 Overpowering

Overpowering is a phenomenon in which a large increase in power is required for a small increase in speed. Overpowering has been studied from three view points

i) By the determination of engine torque and propeller torque of selected medium trawlers

ii) Through an analysis of the propeller efficiency calculations in the case of the medium trawlers

iii) Based on the horse power of the engine installed

4.3.3.1 Determination of engine torque and propeller torque

Here overpowering is calculated by determining the torque developed by the engine and the torque delivered by the propeller.

If there is any difference between the two, it is quantified as wasted torque, which in other words is the excess power developed by the engine and not absorbed by the propeller installed. The method followed here is that of Traung, 1963, the same method is followed by Fyson, 1985. Data was collected on the following parameters to arrive at the torque developed by the engine and the torque developed by the propeller of the 25 medium trawlers (Table 4.3.3.1) for which propeller efficiency calculation was done.

i) Effective horse power (EHP)

The horse power of the engine at 1800 RPM is taken as EHP (Table 4.3.3.1). ii) Delivered horse power (P_D)

The delivered horse power (P_D) was estimated by giving an allowance of 5% for bearing and shaft losses from the EHP (Table 4.3.3.1). iii) Reduction gear ratio

This denotes the ratio of the reduction gear attached between the propeller shaft and engine of a trawler (Table 4.3.3.1).

iv) Propeller RPM

This is the rotations per minute of the propeller at free running based on the reduction gear ratio available on the trawler.

Since the P_D has been taken at 1800 RPM, the propeller RPM is the product of the RPM of engine at P_D and the reduction gear ratio (Table 4.3.3.1).

v) RPS (n)

This is the rotations per second of the propeller, arrived at from the RPM (Table 4.3.3.1).

vi) Diameter (D) (ft)

The diameter of the propeller measured in inches is converted to feet (Table 4.3.3.1).

vii) Speed V

This is the speed of the vessel in knots and has been estimated according Fyson (1985), who states that the speed length ratio ($V/L^{1/2}$) values lie in the range of 0.9 to 1.2 for fishing boats up to 30m in length. The speed of the vessel at a speed length ratio of 1.2 has been taken because the EHP and propeller RPM has been estimated at 1800 RPM (Table 4.3.3.1).

viii) Speed of advance V_A (ft/sec)

The speed of advance (Table 4.3.3.1) has been calculated as per the method of Fyson, 1985. It is expressed by the formula

$$V_A = V\ (1-w)$$

Where V_A - speed of advance

V - speed of the trawler

w - wake fraction

The wake fraction has been taken as a constant at 0.21 (Fyson, 1985).

The speed of advance V_A which was calculated in knots is converted to feet per second.

ix) Trawling RPM

This is the Rotations Per Minute of the propeller at trawling based on the reduction gear ratio available on the trawler. The engine RPM at trawling is taken at an average of 1600 from observations and the trawling RPM is the product of the RPM of engine at trawling and the reduction gear ratio (Table 4.3.3.1).

x) RPS (n1)

The trawling RPM is converted to rotations per second of the propeller (Table 4.3.3.1).

xi) Engine torque (Q_e)

According to Fyson, 1985, marine diesel engines have constant torque over their working range of RPM and the permissible torque can easily be determined from the given engine rating data. The permissible engine torque is determined (Table 4.3.3.1) from the following formula

$$\text{Torque } Q = (550 \times P_D) / 2\Pi n$$

Where, Q (Q_e) - Torque (Engine torque)(ft, lb)

P_D - delivered horse power determined from the calculations for propeller efficiency

n - is the RPS of the propeller

xii) Speed coefficient (J)

This is the non-dimensional speed coefficient. According to the formula used by Fyson, 1985, (Table 4.3.3.1) is calculated as follows.

$$J = V_A / n \times D$$

Where V_A - is the speed of advance (ft/sec)

n - is the propeller revolutions (revs/sec)

D - is the propeller diameter (ft)

xiii) P/D ratio

This value is arrived from the analysed optimum propeller values propeller efficiency calculations (Table 4.3.3.1).

xiv) K_Q

This is another non-dimensional coefficient, torque (K_Q), arrived at from the K_T, K_Q diagram for three bladed propellers (Fyson, 1985) (Table 4.3.3.1).

xv) ρ

This is the density factor for sea water in feet system.

xvi) Propeller torque (Q_p)

According to the formula presented by Fyson, 1985, the torque of the propeller (Q_P) (Table 4.3.3.1) can be worked out from the formula.

$$K_Q = Q / \rho \times n^2 \times D^5$$

From this formula Q can be calculated as follows

$$Q_P = K_Q \times \rho \times n^2 \times D^5$$

Where, Q - torque (ft, lb)

K_Q - non-dimensional coefficient of torque

ρ - density of sea water

n - propeller revolutions (revs/sec)

D - propeller diameter (ft)

After calculating all these parameters the difference between the engine torque (Q_e) and the propeller torque (Q_p) is arrived at. The difference is then computed as a percentage of Q_p

(Table 4.3.3.1).

4.3.3.2 Analysis of propeller efficiency calculation of medium trawlers

The propeller efficiency calculation has been analysed for presenting the case of overpowering by selecting the following parameters from the propeller efficiency calculation.

i) LOA (ft)

ii) EHP

iii) Optimum propeller values

iv) Installed propeller values

v) Do - Di

vi) $\eta_o - \eta_i$

From this output presented in (Table 4.3.3.2) , the reason for a high difference in optimum and installed propeller values is discussed in the context of overpowering.

4.4 RESULTS AND DISCUSSION

4.4.1 Fuel consumption and hull fouling

The effect of hull fouling on the fuel consumption of ALM 370 engines of 81 horse power at 1800 RPM, fitted to wooden trawlers of average length 32ft is shown in Fig.4.4.1a. It was observed that the total average increase in fuel consumption for this length type was 13.7% by the end of the third month, at all the four RPM levels on an average, at which observations were made, and by the end of the sixth month the increase in fuel consumption averaged 33.4%. Between the third and sixth month the total average increase in fuel consumption was 17.25%.

Hull fouling and its influence on the fuel consumption of ALM 400 engines of 89 hp at 1800 RPM, fitted to wooden trawlers of average length 38ft is presented in Fig.4.4.1b. By the end of the third month the total average increase in fuel consumption was 14.1% and by the end of the sixth month the total average increase was 33.8%. The total increase between the third and sixth month averaged 17.1% for all the four RPM levels of the engine.

The influence of hull fouling on the fuel consumption of ALM 402 engines of 100 hp at 1800 RPM, fitted to wooden trawlers of average length 43ft is presented in Fig.4.4.1c. The end of the third month saw a total average increase in fuel consumption by 14.4% and by the end of the sixth month, the total average increase in fuel consumption was 34.25%. Between the third and sixth month the total average increase was recorded at 17.56% for all the four RPM levels of the engine at which measurements were done.

If the fuel consumption levels of all the three types of engines on which measurements were done is considered together, it can be inferred that on an average the fuel consumption in medium trawlers is increasing on an average by 13.73% due to hull fouling at the end of the third month and by 33.8% at the end of the sixth month for the medium trawlers operating along the Kerala coast. This has been taken as a overall average since not much variation in fuel consumption is observed between the trawlers fitted with different horse power of engines.

4.4.2 Fuel consumption in relation to engine RPM

The effect of engine RPM on the fuel consumption of wooden medium trawlers of average length 32ft, fitted with ALM 370 engines at four different RPM levels is presented in Fig. 4.4.2a. The total average percentage increase in fuel consumption from 1600 to 1900 rpm was recorded as 34.83%. The percentage increase in fuel consumption between the RPM levels 1600-1700, 1700-1800 and 1800-1900, were not found to be proportionate (Fig. 4.4.2a).

Engine RPM and its influence on the fuel consumption of ALM 400 engines fitted to wooden medium trawlers of average length 38ft at the four RPM levels at which measurements were recorded is presented in Fig. 4.4.2b. The total average percentage increase in fuel consumption in this case was estimated as 31.9%. In this case also the percentage increase in fuel consumption between the four RPM levels was not proportionate (Fig. 4.4.2b).

Influence of engine RPM on the fuel consumption of ALM 402 engines fitted to wooden medium trawlers of average length 43ft at four different RPM levels is presented in Fig. 4.4.2c. A total average percentage increase in fuel consumption of 30.08% was recorded between 1600 and 1900 rpm. Here also the percentage increase in fuel consumption between the four RPM levels at which recordings were done were not found to be proportionate (Fig. 4.4.2c).

4.4.3 Fuel consumption in relation to construction material

The comparative fuel consumption of wooden and steel medium trawlers of average length 43ft fitted with ALM 400 engines at four different RPM levels of 1600, 1700, 1800 and 1900 is presented in Fig. 4.4.3. The average fuel consumption was observed to be lower for the steel medium trawlers by 5.93% at 1600rpm, 6.35% at 1700 rpm, 8.33% at 1800 rpm and 9.72% at 1900 rpm. Though it is encouraging that in the operational analysis of medium trawlers (Section : 6.4.9; Table 6.4.9), the average fuel consumption of steel trawlers (45ft) in the 45-50 ft length class fitted with ALM

400 engines were estimated at 23.4 % lower than wooden trawlers of average length 43ft. The high average fuel consumption per hour of the medium trawlers of average length 43ft was due to the fact that the average was contributed by ALM 400 and ALM 680 engine fitted trawlers. Here since the wooden trawlers were more than one year old than the steel trawlers in which fuel consumption measurements were done, there is a possibility that the increased fuel consumption levels of the wooden trawlers may be due to the age of the trawler.

4.4.4 Propeller efficiency

The results (Table 4.3.2) obtained on the twenty five medium trawlers on which propeller efficiency calculations were conducted, were grouped into five based on the EHP of the engine installed. Each group is discussed below.

Group I (cases 1-4)

In this group the medium trawlers of 81 hp, ranging in LOA from 32 to 34ft were found to be installed with a propeller diameter ranging from 34 to 39" and had a free running speed range of 6.46 to 6.68 knots. The propeller efficiency for the 34ft boats averaged 47.5% when compared to the efficiency of the 32ft boats, for which the efficiency was as low as 42%. This is because the difference between the diameter of the optimum and installed propeller values

(Table 4.3.2) of 34ft boats are lower than that of the 32ft boats.

Group II (cases 5 to 11)

Medium trawlers of 90 hp in this group with an LOA ranging from 32 to 42ft, installed with propeller diameter ranging from 34 to 40" had a free running speed range of 6.46 to 7.3knots. In cases 5, 7 and 9 (Table 4.3.2) the efficiency of the installed propeller is low because of the low installed propeller diameter. For cases 3, 6, 8 and 10 (Table 4.3.2), the efficiency of the installed propeller does not vary much from the optimum propeller efficiency. The difference in the values as a percentage of the installed propeller values is only a maximum of 6.12% (Table 4.3.2). This is due to the low variation in the installed and optimum propeller diameters.

Group III (cases 12 to 18)

The medium trawlers of this group vary in length from 38 to 52ft and are installed with a 100 hp engine having propellers ranging in diameter from 41 to 42" and with a free running speed range of 6.89 to 8.18 knots. The propellers installed in all the boats of this group gives good efficiency values (Table 4.3.2). This is due to two reasons, one is that the diameter of the installed propeller is not varying much from the optimum propeller diameter. The second is that the propellers are matching to the engine horse power installed. The propeller diameters of the boats are varying only by one inch (Table 4.3.2).

Group IV (cases 19 and 20)

The two cases 19 and 20 in this group had an LOA of 53ft and 47ft respectively and were installed with a 110 hp engine, a new ALM model. The propeller diameters were equal at 42" but the free running speeds were 8.23 knots and 7.78 knots respectively for the two cases. The efficiency of this group is not as good as the previous group because the optimum and installed propeller diametre (Table 4.3.2) vary by 4.8" and 4.4" respectively.

Group V (cases 21 to 25)

The medium trawlers in this group are installed with 148 hp engines, LOA ranging from 43ft to 53ft, propeller diameter ranging from 42" to 45" and with free running speed ranging from 7.3 to 8.23 knots. In cases 21, 23 and 24, the efficiency values of the installed propeller are much lower when compared with cases 22 and 25 (Table 4.3.2). This is mainly due to the difference in gear ratio. The 4:1 gear ratio proved to be better for this group since the installed propeller efficiency for cases 22 and 25 are 48% and 54% respectively, while for the boats with 4.5:1 gear ratio, the efficiency values are only 47, 47.5 and 48% respectively for the cases 21, 23 and 24 (Table 4.3.2).

The maximum efficiency of installed propeller in all the cases was 54% for the case numbers 19 and 25. This is the result of the proper matching of the engine horse power, gear ratio and propeller diameter. In all the five groups analysed, group number III was found to be performing best with the lowest percentage difference of optimum and installed propeller efficiencies. Hence the medium trawling boats of LOA 38 to 52ft (Table 4.3.2 , Group III), powered with 100 hp engine at 1800 RPM, are recommended to install 4:1 gear ratio, since the efficiency of the installed propellers are very high in Group III, compared to the other groups. In the medium trawlers of the above mentioned specifications (Table 4.3.2Group III), those with OAL ranging from 38ft to 43ft are recommended to be installed with 41" diameter propeller and pitch/diameter ratio 0.61 to 0.73, while the medium trawlers with OAL of 43ft to 52ft are recommended to be installed with a 42" diameter propeller with a pitch/diameter ratio of 0.71.

4.4.5 Overpowering

4.4.5.1 Overpowering in relation to engine torque and propeller torque

From the results of the calculation to determine the engine torque and propeller torque of 25 medium trawlers operating from Cochin Fisheries Harbour, it can be seen that in all the 25 cases with LOA ranging from 32ft to 53ft overpowering was observed. Qe-Qp (engine torque - propeller torque), (Table 4.3.3.1), shows the difference between the engine developed torque and the torque absorbed by the propeller, which can otherwise be said to be wasted torque, indicating the level of overpowering. When Qe-Qp was taken as a percentage of Qe, the minimum overpowering was 10.16% (case No. 16, Table 4.3.3.1) and the maximum was 80.92% (case No. 25, Table 4.3.3.1). Based on the percentage of overpowering, the 25 medium trawlers can be classified into two groups as given below.

Group A - 10.16% to 27.83% overpowering
Group B - 73.97% to 80.92% overpowering

The reasons for the high percentage of overpowering in Group B (Table 4.3.3.1), is the very high installed power of engine compared to OAL. In the 25 cases analysed the boat with 43ft, LOA was found to be the least overpowered (10.16%) (Case No. 16, Table 4.3.3.1).

Overpowering results in wastage of fuel. For example, in case number 25 of Group B (Table 4.3.3.1), if the installed 148 hp (ALM 680) engine is replaced with a 100 hp (ALM 402) engine, the saving in fuel can be calculated as follows.

4.4.5.2 Overpowering in relation to propeller efficiency

From the Table 4.3.3.2, it can be seen that in all the cases for which propeller efficiency calculation was done there is a difference between the optimum propeller diameter and the installed propeller diameter. The difference shown by Do - Di ranged from a minimum of 2.3" for case number 23 (Table 4.3.3.2) and a maximum of 11" for case number 5 (Table 4.3.3.2). In simple terms,the optimum propeller diameter calculated, indicates a larger propeller diameter than the installed propeller, showing that the installed propeller is too small for the boat, resulting in a loss of efficiency of the installed propellers ($\eta_o - \eta_i$) (Table 4.3.3.2). In other words, the EHP (Table 4.3.3.2) of the trawlers are suitable for the optimum propeller values and not for the installed propeller values, indicating a loss of energy or power, reflected in the loss of efficiency of the installed propellers. Thus it can certainly be concluded that all the medium trawlers of different OAL and EHP, subjected to propeller efficiency calculations are overpowered.

Table 4.3.2 PROPELLER EFFICIENCY CALCULATIONS

INPUT DATA

BOAT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
LOA (ft)	32	33	34	34	32	34	38	40	40	40	42	38	40	42	43	43	47	52	53	47	43	45	45	48	53
LWL (ft)	29	28.5	31	30	29	31	34	35	35	35.5	37	33	34	36	38.5	37	42	46.5	47	42	37	39	39	41	47
SPEED (V)	6.46	6.41	6.68	6.57	6.46	6.68	7.00	7.1	7.1	7.15	7.3	6.89	7	7.2	7.45	7.3	7.78	8.18	8.23	7.78	7.3	7.49	7.49	7.68	8.23
SPEED OF ADVANCE Va	5.1	5.1	5.3	5.2	5.1	5.28	5.53	5.61	5.61	5.85	5.77	5.44	5.53	5.69	5.89	5.77	6.15	6.46	6.5	6.1	5.77	5.92	5.92	6.07	6.5
EHP	81	81	81	81	90	90	90	90	90	90	90	100	100	100	100	100	100	100	110	110	148	148	148	148	148
RPM	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	400	450	400	400	400
GEAR RATIO	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4.5:1	4:1	4.5:1	4.5:1	4:1
DIAMETER (D) (inch)	34	34	39	39	34	40	38	40	34	39	39	41	41	41	41	42	42	42	42	42	45	45	45	45	42

OUTPUT VALUES

BOAT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
OPTIMUM PROPELLER VALUES																									
P/D Ratio	0.56	0.57	0.575	0.57	0.56	0.56	0.57	0.59	0.59	0.58	0.59	0.56	0.56	0.58	0.58	0.58	0.59	0.60	0.60	0.59	0.57	0.56	0.58	0.59	0.61
Pitch (Po) (inch)	24.60	25	25.2	25.1	25.00	25.20	25.70	26.30	26.30	25.30	26.30	25.60	25.60	26.40	26.50	27.00	27.07	27.20	28.08	27.4	31.00	27.80	27.70	30.90	30.30
Diameter (Do) (inch)	44	43.8	43.8	44	45	45	45	44.9	44.9	43.7	44.6	45.7	45.7	45.5	45.6	46.2	45.5	45.3	46.8	46.4	54.5	49.7	47.7	52.8	49.7
Efficiency no (%)	48.90	49	50	49	48.00	49.00	52.00	51.50	51.50	51.00	52.00	49.00	50.30	51.50	52.50	51.50	54.00	56.00	55.00	53.00	50.60	49.70	51.50	52.50	56.50
INSTALLED PROPELLER VALUES																									
P/D Ratio	1.03	1.023	0.75	0.75	1.07	0.73	0.83	0.74	1.10	0.80	0.79	0.73	0.61	0.73	0.73	0.71	0.71	0.71	0.76	0.73	0.83	0.70	0.84	0.84	0.78
Pitch (Pi) (inch)	35.00	35	29.3	29.3	36.50	29.20	31.50	29.60	37.40	31.20	31.00	29.80	25.00	30.00	30.00	30.00	30.00	30.00	32.00	30.7	37.40	31.50	37.80	38.00	35.00
Diameter (Di) (inch)	34	34	39	39	34	40	38	40	34	39	39	41	41	41	41	42	42	42	42	42	45	45	45	45	45
Efficiency ni (%)	42.00	42	48	47	41.00	47.00	47.00	49.20	43.30	48.60	49.00	47.80	50.00	49.00	51.00	50.00	52.00	54.00	52.50	51	47.00	48.00	47.50	48.00	54.00
Do - Di	10	9.8	4.8	5	11	5	7	4.9	10.9	4.7	5.6	4.7	4.7	4.5	4.6	4.2	3.5	3.3	4.8	4.4	9.5	4.7	2.7	7.8	4.7
no - ni	6.9	7	2	2	7	2	5	2.3	8.2	2.4	3	1.2	0.3	2.5	1.5	1.5	2	2	2.5	2	3.6	1.7	4	4.5	2.5
no - ni as % of no	16.43	16.67	4.17	4.26	17.07	4.26	10.64	4.67	18.94	4.94	6.12	2.51	0.60	5.10	2.94	3.00	3.85	3.70	4.76	3.92	7.66	3.54	8.42	9.38	4.63

Table 4.3.3.1 OVERPOWERING IN MEDIUM TRAWLERS

SERIAL NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
EHP	81	81	81	81	90	90	90	90	90	90	90	100	100	100	100	100	100	100	110	110	148	148	148	148	148
5% SHAFT LOSSES	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
LOA (ft)	32	33	34	34	32	34	38	40	40	40	42	38	40	42	43	43	47	52	53	47	43	45	45	46	53
Pd	76.95	76.95	76.95	76.95	85.50	85.50	85.50	85.50	85.50	85.50	85.50	95.00	95.00	95.00	95.00	95.00	95.00	95.00	104.50	104.50	140.60	140.60	140.60	140.60	140.60
GEAR RATIO	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	4.5:1	4:1	4.5:1	4.5:1	4:1
PROPELLER RPM	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	400	450	400	400	400
RPS (n)	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	6.67	7.50	6.67	6.67	6.67
DIAMETER (D) (inch)	34	34	39	39	34	40	38	40	34	39	39	41	41	41	41	42	42	42	42	42	45	45	45	45	42
DIAMETER (D) (feet)	2.83	2.83	3.25	3.25	2.83	3.33	3.17	3.33	2.83	3.25	3.25	3.42	3.42	3.42	3.42	3.50	3.50	3.50	3.50	3.50	3.75	3.75	3.75	3.75	3.50
SPEED OF ADVANCE Va(knots)	5.1	5.1	5.3	5.2	5.1	5.28	5.53	5.61	5.61	5.65	5.77	5.44	5.53	5.69	5.89	5.77	6.15	6.46	6.5	6.1	5.92	5.92	5.92	5.92	6.5
Va (ft/sec)	8.61	8.61	8.95	8.78	8.61	8.92	9.34	9.47	9.47	9.54	9.74	9.19	9.34	9.61	9.95	9.74	10.39	10.91	10.98	10.30	10.00	10.00	10.00	10.00	10.98
TRAWLING RPM	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	355.56	400.00	355.56	355.56	400.00
RPS (n1)	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	6.67	5.93	6.67	5.93	5.93	6.67
ENGINE TORQUE (Qe)	898.57	898.57	898.57	898.57	998.41	998.41	998.41	998.41	998.41	998.41	998.41	1109.3	1109.3	1109.3	1109.3	1109.3	1109.3	1109.3	1220.3	1220.3	1847.1	1641.8	1847.1	1847.1	1847.1
SPEED COEFFICIENT J	0.4053	0.4053	0.3672	0.3603	0.4053	0.3567	0.3932	0.3790	0.4459	0.3915	0.3998	0.3565	0.3645	0.3750	0.3882	0.3712	0.3957	0.4156	0.4182	0.3925	0.3999	0.3555	0.3999	0.3999	0.4705
P/D Ratio (INSTALLED)	1.03	1.023	0.75	0.75	1.07	0.73	0.83	0.74	1.1	0.8	0.79	0.73	0.61	0.73	0.73	0.71	0.71	0.71	0.76	0.73	0.7	0.7	0.7	0.7	0.78
Kt, Kq Diagram (Kq)	0.465	0.46	0.245	0.245	0.51	0.215	0.287	0.22	0.535	0.27	0.26	0.215	0.155	0.22	0.212	0.217	0.205	0.187	0.23	0.225	0.2	0.215	0.2	0.2	0.22
Kq/10	0.0465	0.046	0.0245	0.0245	0.051	0.0215	0.0287	0.022	0.0535	0.027	0.026	0.0215	0.0155	0.022	0.0212	0.0217	0.0205	0.0187	0.023	0.0225	0.02	0.0215	0.02	0.02	0.022
DENSITY OF SEAWATER p(rho)	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988	1.988
PROPELLER TORQUE (Qp)	750.20	742.13	784.90	784.90	822.80	781.75	807.47	799.93	863.13	865.00	832.96	884.47	637.64	905.04	872.13	1007.0	951.32	867.79	1067.3	1044.1	1035.4	1408.7	1035.4	1035.4	1020.9
Qe - Qp	148.37	156.44	113.66	113.66	175.61	216.66	190.94	198.48	135.28	133.41	165.45	224.87	471.70	204.30	237.21	102.33	158.02	241.55	152.94	176.14	811.64	233.09	811.64	811.64	826.12
Qe - Qp as % of Qp	19.78	21.08	14.48	14.48	21.34	27.71	23.65	24.81	15.67	15.42	19.86	25.42	73.97	22.57	27.20	10.16	16.61	27.83	14.33	16.87	78.39	16.55	78.39	78.39	80.92
	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A	A	A	A	A	B	A	B	B	B

A - Group A
B - Group B

Table 4.3.3.2 OVERPOWERING IN MEDIUM TRAWLERS IN RELATION TO PROPELLER EFFICIENCY

BOAT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
LOA (ft)	32	33	34	34	32	34	38	40	40	40	42	38	40	42	43	43	47	52	53	47	43	45	45	48	53
EHP	81	81	81	81	90	90	90	90	90	90	90	100	100	100	100	100	100	100	110	110	148	148	148	148	148
OPTIMUM PROPELLER VALUES																									
P/D Ratio	0.56	0.57	0.575	0.57	0.56	0.56	0.57	0.59	0.59	0.58	0.59	0.56	0.56	0.58	0.58	0.58	0.59	0.60	0.60	0.59	0.57	0.56	0.58	0.59	0.61
Pitch (Po) (inch)	24.60	25	25.2	25.1	25.00	25.20	25.70	26.30	26.30	25.30	26.30	25.60	25.60	26.40	26.50	27.00	27.07	27.20	28.08	27.4	31.00	27.80	27.70	30.90	30.30
Diameter (Do) (inch)	44	43.8	43.8	44	45	45	45	44.9	44.9	43.7	44.6	45.7	45.7	45.5	45.6	46.2	45.5	45.3	46.8	46.4	54.5	49.7	47.7	52.8	49.7
Efficiency η_o (%)	48.90	49	50	49	48.00	49.00	52.00	51.50	51.50	51.00	52.00	49.00	50.30	51.50	52.50	51.50	54.00	56.00	55.00	53.00	50.60	49.70	51.50	52.50	56.50
INSTALLED PROPELLER VALUES																									
P/D Ratio	1.03	1.023	0.75	0.75	1.07	0.73	0.83	0.74	1.10	0.80	0.79	0.73	0.61	0.73	0.73	0.71	0.71	0.71	0.76	0.73	0.83	0.70	0.84	0.84	0.78
Pitch (Pi) (inch)	35.00	35	29.3	29.3	36.50	29.20	31.50	29.60	37.40	31.20	31.00	29.80	25.00	30.00	30.00	30.00	30.00	30.00	32.00	30.7	37.40	31.50	37.80	38.00	35.00
Diameter (Di) (inch)	34	34	39	39	34	40	38	40	34	39	39	41	41	41	41	42	42	42	42	42	45	45	45	45	45
Efficiency η_i (%)	42.00	42	48	47	41.00	47.00	47.00	49.20	43.30	48.60	49.00	47.80	50.00	49.00	51.00	50.00	52.00	54.00	52.50	51	47.00	48.00	47.50	48.00	54.00
Do - Di	10	9.8	4.8	5	11	5	7	4.9	10.9	4.7	5.6	4.7	4.7	4.5	4.6	4.2	3.5	3.3	4.8	4.4	9.5	4.7	2.7	7.8	4.7
$\eta_o - \eta_i$	6.9	7	2	2	7	2	5	2.3	8.2	2.4	3	1.2	0.3	2.5	1.5	1.5	2	2	2.5	2	3.6	1.7	4	4.5	2.5

HULL FOULING AND FUEL CONSUMPTION - ALM
370 ENGINE

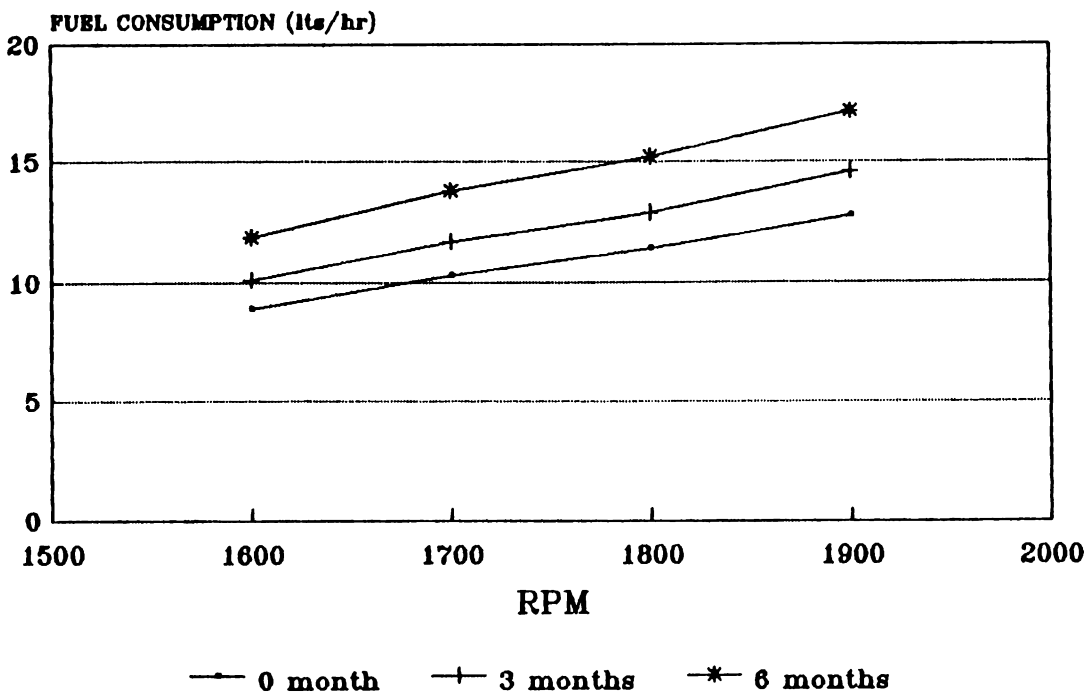


Fig.4.4.1a

HULL FOULING AND FUEL CONSUMPTION
ALM 400 ENGINE

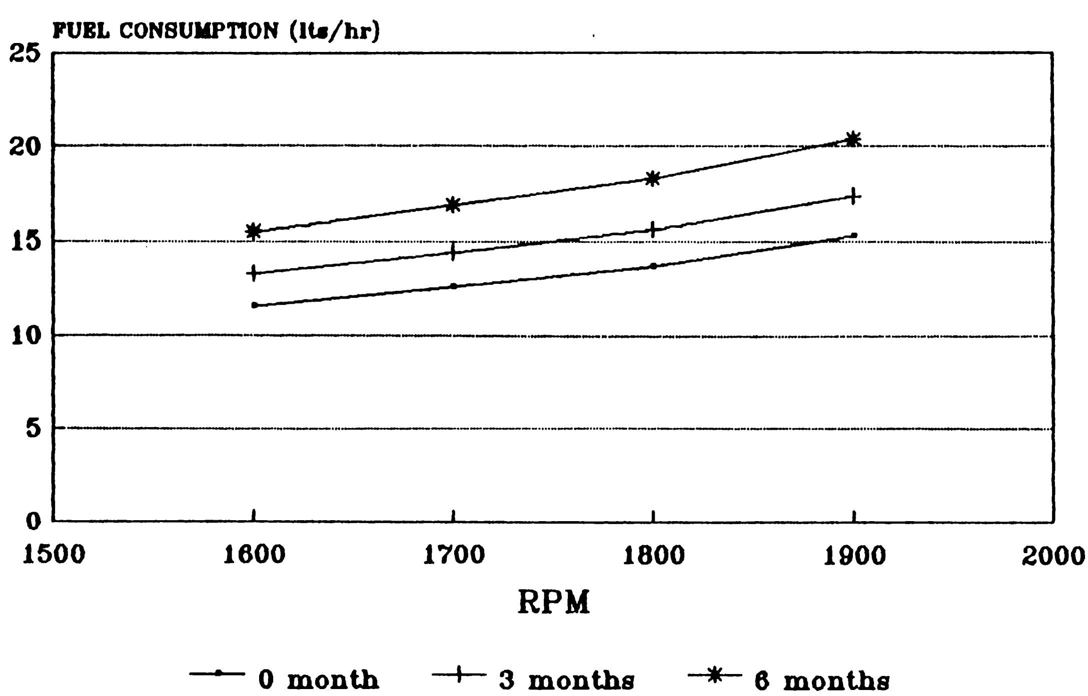


Fig. 4.4.1b

HULL FOULING AND FUEL CONSUMPTION ALM 402 ENGINE

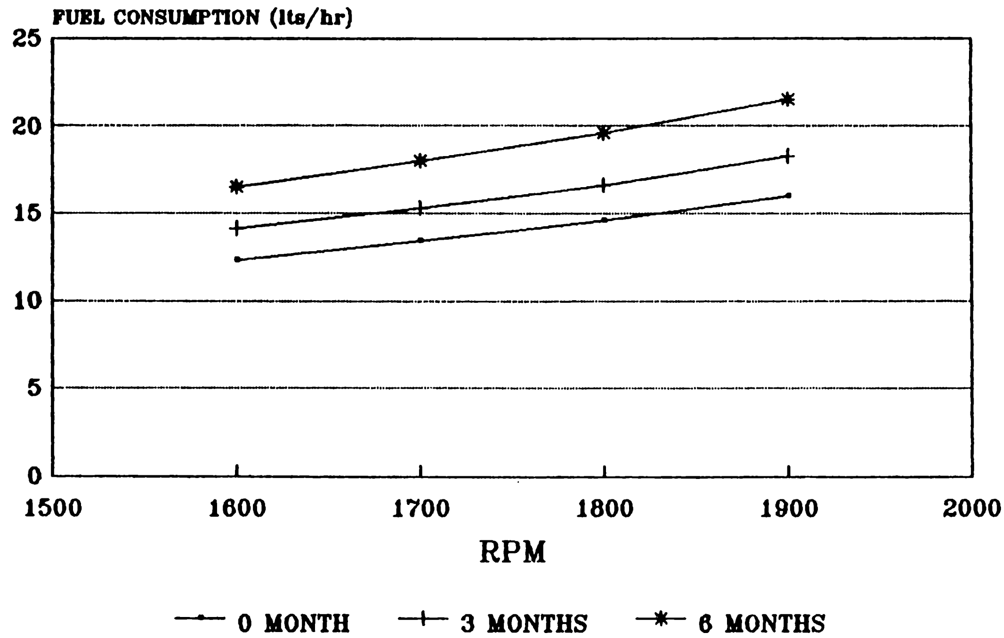


Fig. 4.4.1c

RPM AND FUEL CONSUMPTION FOR 32' WOODEN TRAWLERS FITTED WITH ALM 370 ENGINE

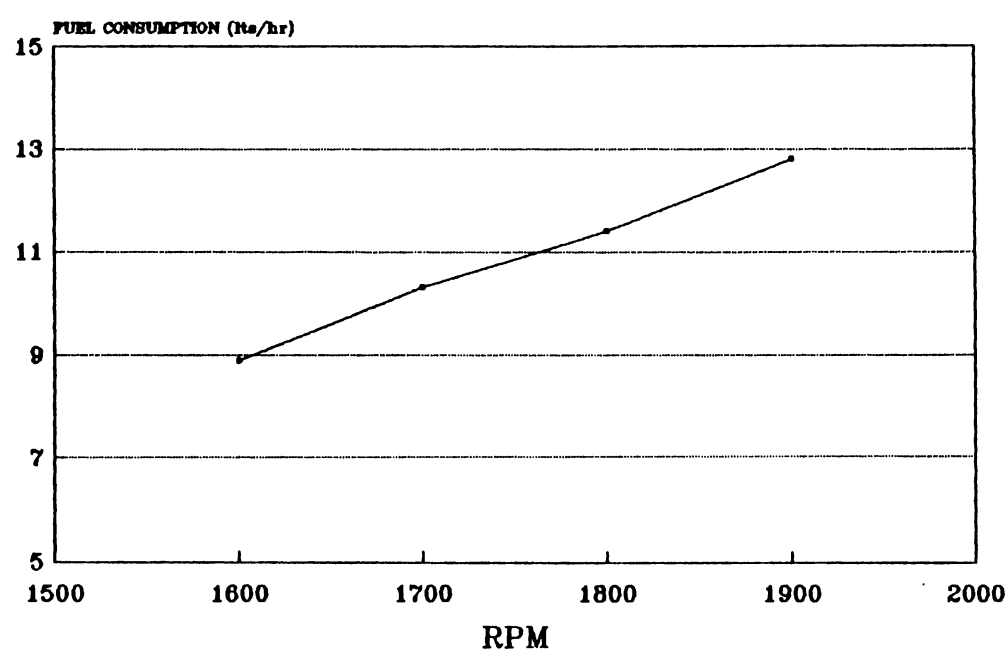


FIG. 4.4.2a

RPM AND FUEL CONSUMPTION FOR 38' WOODEN TRAWLERS FITTED WITH ALM 400 ENGINE

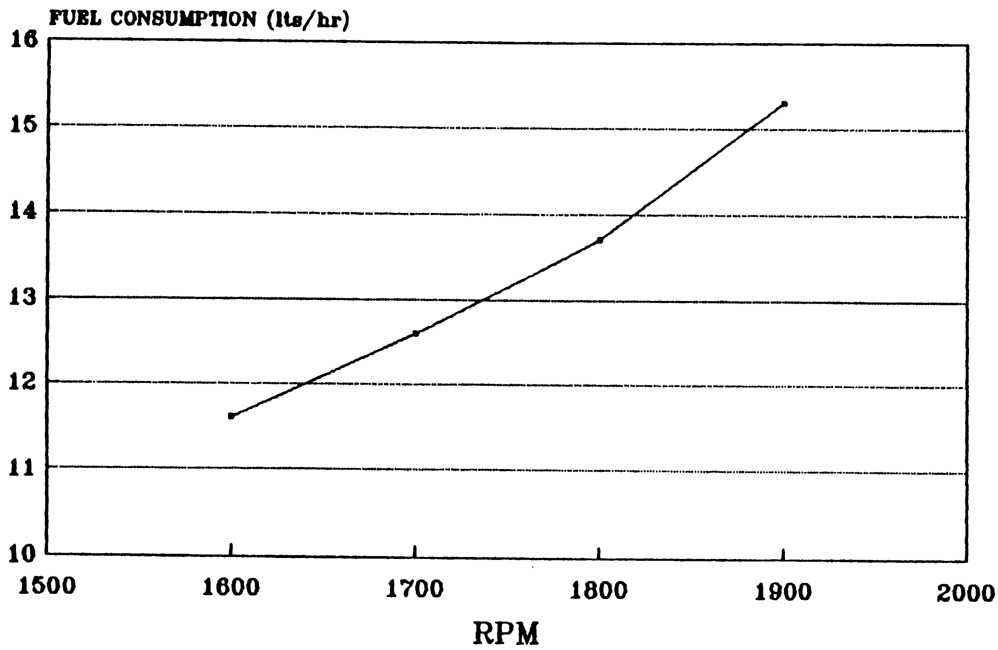


FIG. 4.4.2b

RPM AND FUEL CONSUMPTION OF 43' WOODEN TRAWLERS FITTED WITH ALM 402 ENGINE

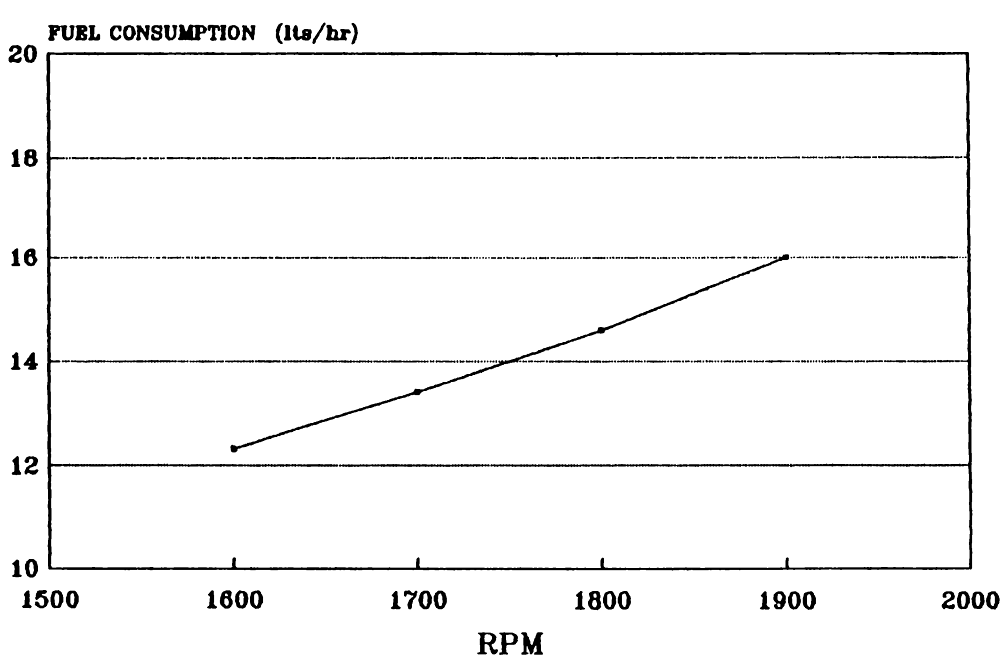


Fig. 4.4.2c

COMPARISON OF FUEL CONSUMPTION OF 43' WOODEN AND STEEL TRAWLER FITTED WITH ALM 400 ENGINE

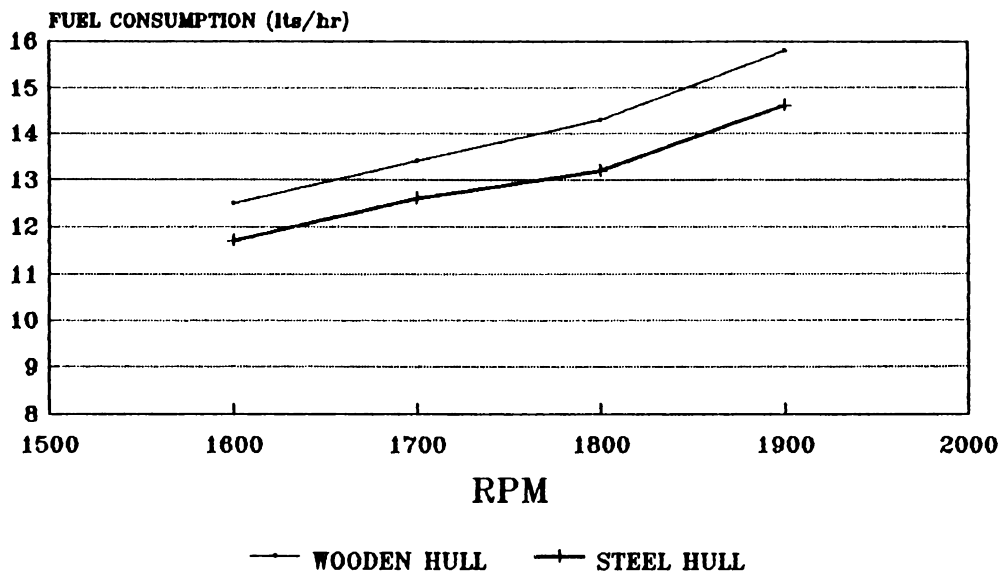


Fig. 4.4.3

Plate. 4.3.1.a FUEL FLOW MEASUREMENT TANK

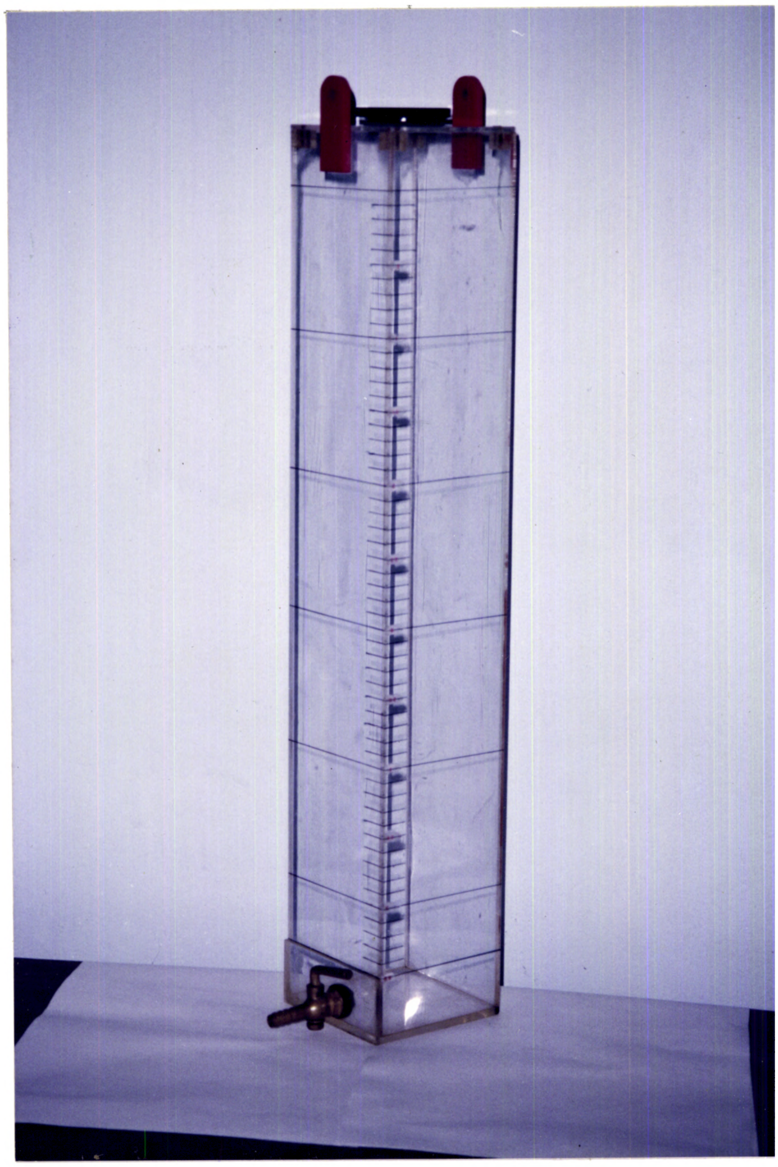


Plate. 4.3.1.b FUEL CONSUMPTION MEASUREMENT ON A MEDIUM TRAWLER.

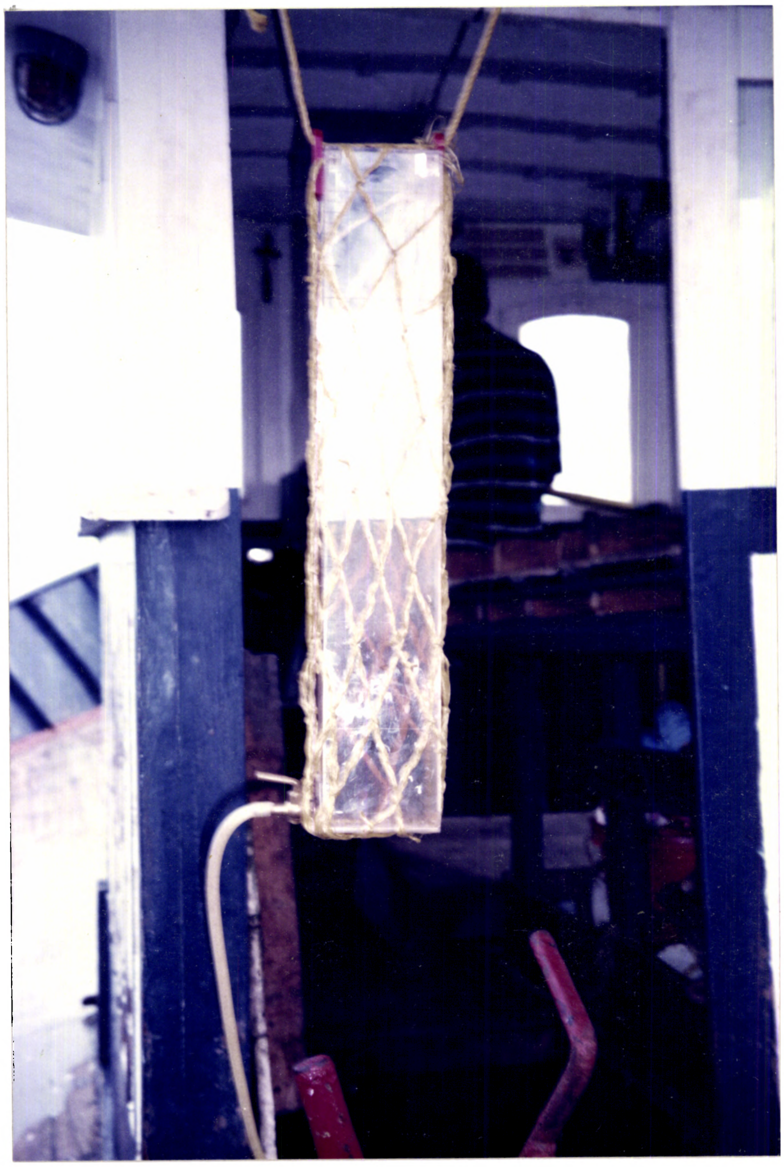


Plate. 4.3.1.1.a CLEANED HULL OF A MEDIUM TRAWLER.

Plate. 4.3.1.1.b A BADLY FOULED HULL.

CHAPTER 5

PERFORMANCE OF SMALL MOTORIZED BOATS - A SURVEY FINDING

5.1 INTRODUCTION

The state of Kerala is strategically located on the south-west coast of the Indian sub-continent between $8^{0}04'$ and $37^{0}06'$ north latitude. The coast line of 590kms supports a fishermen population of 7.63 lakhs as per 1993-'94 estimates. With a rich background of traditional fishing the state accounts for about 25% of the total marine fish landings in India. Three classes of fishing vessels contribute to the marine fish production of Kerala, the artisanal sector comprising traditional fishing crafts of a variety of sizes engaged in a number of fishing methods, the mechanised sector consisting of the deep sea trawlers above 23m in length and medium sized boats ranging from 7.69m to 20.8m. The main technological difference between the two sectors is that the mechanised sector use inboard marine diesel engines as their propulsion units with larger and more sophisticated fishing gears while the fishing crafts in the artisanal sector use/do not use out board motors (OBM's) with smaller fishing gears. The frequent instances of conflict between the artisanal sector and the mechanised sector over their respective areas of fishing along the coast forced the Government of Kerala to protect the traditional sector through the enactment of the Kerala Marine Fisheries Regulation Act, 1980, reserving the coastal waters upto a 10kms exclusively for the traditional sector.

Among the traditional fishing methods along the coast of Kerala, the mini purse seine or the ring seine is most popular. With the introduction of the out board motors the efficiency of these units and also their operational area increased considerably. Though gill netting and line fishing are other important artisanal fishing methods carried out along the coast, the higer productivity of the ring seine lead to a rapid increase in number of these units. The pelagic resources at which these gears were aimed at could not sustain their economic operation and consequent to the ban in mechanised trawling within 10km of the coastline the demersal resources could not be fully exploited in this area. This resulted in a diversification of fishing method by a large number of out board motor fitted canoes and plank built boats to operate mini trawl nets. This method of fishing came to be specifically called as mini trawling in some areas along the coast where the original country craft, a plank built canoe of 15m LOA used for mini purse seining was cut transversely to form two mini trawlers (Hameed et al. 1988).

Thus it was observed that there are three types of artisanal fishing craft that are operating mini trawl nets, the dug out canoes(Plate 5.1a), plank built canoes and the mini trawlers (Plate 5.1b and Plate 5.1c). All the three types of crafts operating mini trawl nets are powered by means of out board motors of 8hp to 25hp depending on the size of the craft and the size of the mini trawl net used (John and Hameed, 1995).

According to South Indian Federation of Fishermen Society, 1991, there are a total of 1648 mini trawl net units operating along the coast of Kerala (Anon, 1991a). Further the mini trawl nets have been grouped under the 'Other Gears' category. The district-wise split up of 'Other Gears' as per SIFFS census is shown in Table 5.1.1. Since these gears were exploiting the demersal resources of the Kerala coastline by trawling, a study of the operating expenses pattern of these units was deemed necessary to throw light into a hitherto unexplored fishing method.

6.2 OBJECTIVES

- To study the method of operation
- To analyse the operational expenses pattern of traditional fishing crafts fitted with out board motors operating mini trawl nets from selected centers along the Kerala coast.
- To ascertain the possibilities of energy optimisation in these units.

5.3 MATERIALS AND METHODS

A survey was conducted selecting 84 artisanal craft fitted with out board motors from five centers along the Kerala coast during the period 1994-'95. Care was taken to ensure that the different horse power of out board motors installed were properly represented. The centers which were selected for the survey included Chaliyam, Parappanangadi, Ambalapuzha, Valanjavazhi and Azhikode. From Chaliyam 16 crafts fitted with out board motors were surveyed, all of which were dug-out canoes .Information was collected from 16 plank built boats fitted with OBM's from Parappanangadi. All the OBM fitted crafts surveyed from Ambalapuzha (23), Valanjavazhi (16) and Azhikode (13) were mini trawlers.

The survey was conducted using an interview schedule divided into three sections

i) General information
ii) Economics of operation
iii) Operation details

The various heads under which information was collected under the three sections have been discussed. The 'General information' part helped in arriving at the fixed cost structure of these units as well as other technical details of the craft and gear. The variable cost structure of the units selected was arrived at using the 'Economics of operation' part. Details of the daily operations from the different centers were obtained from the 'Operation details' part.

5.4 DISCUSSION

5.4.1 General details and fixed cost structure

From the 'general information' section of the interview schedule the general details of the craft and gear and the heads and estimates of the fixed cost structure of the were arrived at from five centers along the Kerala coast.

Regarding the general details of the craft, at Chaliyam the 16 crafts surveyed were all dug-out canoes. The surveyed crafts were one year old to eleven years old. Two types of wood Chini and Mango were used for the construction. The length of these dug out canoes ranged from 7.5m to 9m. All the crafts were using 7.5hp Yamaha engines. The crew strength was two to three persons. Sixteen crafts were surveyed from Parappanangadi. All the crafts surveyed were plank built boats ranging in length from 8.5m to 9.0m. Of the sixteen boats surveyed three were fitted with Mariner OBM while the remaining had Yamaha OBM. Aini and Chini were the main types of wood used for the construction. All the crafts surveyed were more than six years old. All the crafts in the region were fitted with 7.5hp engine. From Ambalapuzha 24 mini trawlers were surveyed. All were plank built. Some of the craft were new constructions while others were earlier large boats used for mini purse seining earlier but cut into two at the middle to form two mini trawlers. The craft surveyed were one year old to nine years old. The OAL ranged from 6.5m to 7.2m. Aini wood was the chief type of material used in the construction. The crew strength per craft was 3-4 and Yamaha 15hp was the most common OBM used. At Valanjavazhi also the common type of OBM fitted mini trawl net operating craft was the mini trawler. 14 mini trawlers were surveyed from this region. All the craft were mini purse seine (ring seine) vessels cut into two to form mini trawlers. Hence the length of the craft varied from 7.5m to 10m. Aini wood was the material of the craft. 3-4 persons was the crew strength of each craft. One notable feature in this region was that as the size of the craft increased the hp of the OBM used also increased and it was observed that 15hp, 20hp and 25hp OBM's were used. At Valanjavazhi, 13 mini trawlers commonly known as 'muri valloms' were surveyed. All the vessels in the region was repurchases with only very few new constructions. The length of the vessel ranged from 8.0m to 8.5m with a crew strength of 4 persons per craft. Suzuki 9.9 (12hp) and Yamaha 15hp were the most common types of OBM used.

The components which consitute the capital costs or the investment costs of this fishery include

i) Cost of craft
ii) Cost of OBM
iii) Cost of net
iv) Cost of otter board

The cost of the craft varied with the wood used for the construction. Chini, Aini and Mango can be seen as the chief types of wood used in the construction. Chini and Mango were the only material used for the construction of dug out canoes, while aini was used in the construction of plank built canoes. At Chaliyam a 9m long dug out cost around 28,000 rupees while the same plank built canoe at Parappanangadi cost around 30,000 rupees. The plank built mini trawlers of 9m at Ambalapuzha cost around 32,000 rupees. Aini was used the main building material for mini trawlers. Yamaha OBM is the most widely used OBM for the traditional craft. This is followed by Suzuki and Mariner in that order. The rise in prices for different horse power of Yamaha OBM during 1993-1994 is given below.

HORSE POWER/MODEL	1993 - 1994 (Rs.)
8hp/DK/7	45880
15hp/HK/15	57365
25hp/AK/25	71995

Source : Yamaha Sevice Center, Cochin.

The fixed costs are constituted by the following components

i) Interest on investment

ii) Depreciation

a) Depreciation on fishing craft

b) Depreciation on the OBM

c) Depreciation on the fishing net

d) Depreciation on the otter board

The annual interest for all types of OBM fitted craft is calculated at the rate of 15%, this is higher than the bank interest of 12% because the artisanal fishermen often take loans from outside sources including the auctioning agent to meet the investment expenses. Thus even in the case of own money invested, interest is included in the fixed cost as the opportunity cost of the capital.

Depreciation on the craft, OBM, net and otter board can been computed by straight line method dividing the initial investment by the life expectancy of the equipment. In the case of the dug-out canoes from Chaliyam the expected life of the craft can be taken as 20 years, for the plank built canoes from Parappanangadi and the mini trawlers from Azhikode, Ambalapuzha and Azhikode the avrage life of the craft can be fixed at 15 years. The life of the OBM in all the cases in all the centers can be fixed at 3 years. For the mini trawl nets used at the all the centers the average life worked out to 3 years. In the case of the otter boards attached to the mini trawl nets the average life could be fixed at five years.

5.4.2 Variable cost structure

The "Economics of operation" part of the interview schedule gave necessary information on the variable cost structure of the units surveyed from the five centers along the Kerala coast.

The repair and maintenance of OBM worked out to about Rs.7000 per year at Chaliyam and Parappanangadi for the 7.5hp OBM while it was around Rs.10,000 per year at the other three centers for the 15hp OBM. For the 25hp OBM observed at Valanjavazhi, the maintenance expenditure worked out to 12,000 per year.

Repair and maintenance expenditure of the net including the otter board worked out to around Rs.800 per year at Chaliyam and Parappanangadi for the net used on a 7.5 OBM fitted craft. At Ambalapuzha, Valanjavazhi and Azhikode it was around Rs.1000 per year for the larger nets used on 15hp and 25hp OBM's. At all the centers except Azhikode a new net had to be replaced every year.

The consumption of lubrication oil was around 1litre per 30 litres of Kerosene for the 7.5hp OBM's and for the 15hp and 25hp engines it was around 1 litre per 35 litres and 1 litre per 40 litres of Kerosene respectively. Kerosene the main fuel of the OBM was obtained at Chaliyam and Parappanangadi at the Government control price of Rs.2/85 per litre. At the other centers Kerosene was bought at Rs. 2/70 per litre. Since they used petrol for starting the OBM and Kerosene for running, on an average 1 litre of petrol was consumed per day at all the centers. The gear oil consumption for the OBM's worked out to 1litre per month at all the centers.

Since baskets were used to land the catches on an average Rs.30 per week was spend on baskets at all the centers.

Batta in the form of incentive to the crew was absent at Chaliyam and Parappanangadi. But at Ambalapuzha, Valanjavazhi and Azhikode each crew got Rs.10 per day as incentive.

The number of crew on the dug out canoes surveyed from Chaliyam was mostly two and rarely three. On the plank built boats operating from Parappanangadi three persons went for fishing on a craft. At Ambalapuzha it was four persons per craft while at Valanjavazhi three persons went for fishing on the 7.5m mini trawlers and four persons on the 10m mini trawlers. At Azhikode the number of crew was four as in Ambalapuzha.

Sale of the catch was done at the landing center by auctioning. At all the centers except Azhikode 5% of the sale proceeds had to be given as commission to the auctioning agent. At Azhikode the commission was 6% of the catch value.

At all the centers except Azhikode the sales proceedings less the commission given to the auctioning agent was shared equally between the owner and the crew. At Azhikode it was 40% to the owner and 60% to the crew of the total sales value less commission.

Miscellaneous expences worked out to Rs.30 per week at Chaliyam and Parappanangadi and Rs.40 per week at the other centers.

The average value of the catch landed per day at Chaliyam and Parappanangadi worked out to Rs.550/-. But the quantity landed per day in kilograms varied slightly and was estimated at 30kgs/day to 35kgs/day respectively at the two centers. At Ambalapuzha and Valanjavazhi the average value of catch per day was Rs.700 and Rs.800 respectively and the quantity landed per day was 40kgs and

60kgs respectively. At Azhikode the quantity and value of catch landed per day was 15kgs and Rs.500 respectively for the mini trawl net operating season and 20 to 25kgs and Rs.400 respectively for the gill net operating season.

5.4.3 Fishing operations

From the "Operation details" part of the Interview Schedule, all the details regarding the daily fishing operations were collected from the five fishing centers selected for survey along the Kerala coast.

At Chaliyam the daily fishing operation started around 4 AM. Within half an hour of steaming the first net was shot. On an average each day four hauls were done at an average hauling time of one hour per haul. Along with each haul on a average 15 kgs of trash fish was also caught which was thrown back into the sea. The depth of operation ranged from 3 to 13 fathoms. The length of warp payed out for fishing at this depth range worked out to 20 to 75 fathoms. Between 11.00 am and 12.00 amthe fishermen were back at the base, managing a total operating time of 7.5 hrs per day on the average. The fishermen went on full throttle to the fishing ground and back. While towing the net, when aimed at shrimps it was full throttle and when fishing for the flat fish the speed of tow was maintained at

3/4th of the full throttle. As a result during shrimp season the fuel consumption was 4.0 litres of Kerosene per hour and while fishing for flat fish the consumption was 3.5 litres of kerosene per hour for the 7.5hp OBM fitted dug-out canoes. At Chaliyam the OBM fitted craft operated six days a week only for 8 months in an year. Annually 4 months was lost due to inclement weather. The average value of the catch per day was Rs. 550 and the average quantity worked out to 25kg. The average number of fishing days at Chaliyam was around 166 days per year.

At Parappanangadi the fishermen set out for daily fishing around 5 AM. Since the productive grounds were a bit far off, it took on an average 45 minutes to reach the fishing ground. Three to four hauls were done on one days operation at one hour per haul. About 10 to 15 kg of trash fish got per haul was thrown back into the sea. The average depth of operation was 7 fathoms with a range of 2 to 12 fathoms. A warp length of 10 fathom to 60 fathom was payed out at the respective depth of operation. The average operating time per day worked out to 7 hrs and the fishermen were usually back at the base by 12.00 PM. The speed of steaming and trawling was maintained as it was at Chaliyam but the 7.5hp OBM fitted plank built canoes of Parappanangadi operated at an average fuel consumption of 4 liters of kerosene per hour. The units surveyed from Parappanangadi operated six days a week for 10 months in an year, showing that only 2 months was lost due to inclement weather. The average quantity and value of catch realised was 30 kg and Rs. 500 respectively. The average number of fishing days at Parappanangadi worked out to 188 days per year.

At Ambalapuzha, the fishing operation started around 5 am and within an hour of steaming the first net was shot. Between four to five hauls were done per day at slightly above one hour per haul and of the approximately 10 kg of trash per haul, around 10 kg to 15 kg was brought ashore to be dryed for use as manure. Usually 6-60 fathom length of warp was payed out to trawl at a depth range of 2-20 fathom respectively. Reaching back to the base by around 2.00 pm the average operating time per day worked out to approximately 10 hours. The steaming and towing speeds were similar to the operations at Chaliyam and Parappanangadi, with the 15 hp OBM fitted mini trawlers of Ambalapuzha giving a fuel consumption of 4.5 to 5 litres per hour. Fishing operations could be conducted only for 8 months in an year with the remaining month days standing lost due to bad weather. Thus on an average the total number of fishing days at this center was estimated at 170 days per year. The catch value realised per day was around Rs.700 to Rs.800 per day for an average quantity of 30kg.

Valanjavazhi was a fishing center very close to

Ambalapuzha, hence the operating hours were similar to that at Ambalapuzha. Though there were a number of mini trawlers fitted with higher horse power OBM's operating larger nets, the depth of operation, number of hauls and warp length payed out was comparable to Amablapuzha. The trash fish quantity was also comparable to that of the above mentioned center. At the steaming speeds as mentioned for the above centers, the 20 hp OBM fitted mini trawler consumed on an average 5 litres per hour, while for the 25 hp OBM fitted craft it was 6 liters per hour. The catch value realised, the quantity of catch and the number of operating months were also comparable to that obtained at Ambalapuzha. The average number of fishing days per unit at this center was estimated at 174 daysper year.

Fishing operation at Azhikode started around 5.00 AM, but unlike the other centers within half an hour of steaming the fishing ground was reached. On an average 5 to 6 hauls were towed per day at one hour per haul and the fishermen were back at their base by around 3.00 pm. The quantity of trash per haul was higher at this center at around 15 kg to 20kg per haul, of which around 20kg was brought back to shore for use as manure. The depth of operation was very low at this center ranging between 2 fathom and 8 fathom, and a scope ratio of 1:5 was maintained on the warp payed out. The Suzuki 12hp OBM's fitted on the mini trawlers surveyed at this center consumed on an average 5 liters of kerosene per hour. Of the total 8 months fished at this center, trawling was conducted only for 3 months while the remaining months the fishermen went for gill netting on the same boat. The averge revenue per day and quantity per day for trawling and gill netting was Rs.500 and 15kg and Rs.300 and 20 to 25 kg respectively.

Table 5.1.1 DISTRICTWISE OTHER GEARS (MOTORISED)

District	Boat Seines Vattavala	Boat Seines Thattumadi	Trammel Net	Mini Trawl	Hook & Line	Others	Total
Kasaragod	--	--	--	6	12	--	18
Cannanore	--	--	--	113	18	36	187
Calicut	--	--	--	464	131	--	595
Malappuram	197	--	--	399	--	--	596
Trichur	90	--	--	--	17	--	107
Ernakulam	15	--	--	2	5	--	22
Alleppey	--	--	--	644	27	11	682
Quilon	--	61	262	--	505	--	828
Trivandrum	--	400	750	--	1,400	--	2,550
Total	302	461	1,012	1,648	2,115	47	5,585

Source: SIFFS

Plate. 5.1.a DUG OUT CANOE (FOR MINI TRAWL NET OPERATION).

Plate. 5.1.b A MINI TRAWLER UNDER CONSTRUCTION.

Plate. 5.1.c MINI TRAWLER RETURNED TO BASE.

CHAPTER 6

OPERATIONAL ANALYSIS OF MEDIUM TRAWLERS

6.1 INTRODUCTION

The introduction of motorisation and mechanisation by the Food and Agricultural Organisation in the fifties was a boost in the arm for the development of the fishing industry of India. Step by step advancements in the mechanisation process lead to the introduction of twenty three new designs of fishing craft by the Central Institute of Fisheries Technology in collaboration with the FAO. These fishing craft were meant for different types of fishing like gill netting, line fishing and stern trawling. Later on purse seining was introduced into the Indian fishing industry in the seventies. Today fishing has become highly energy intensive and of the different fishing methods trawling has been confirmed to be the most energy expensive method. While stressing the need for encouraging low energy fishing methods, steps to conserve the energy expenditure of existing methods have reached high priority in the research and development establishments of the country.

Export statistics of the country over the years show that shrimps continue to hold the primary status in terms of value of the marine products exported from India. The cephalopods, squid and cuttlefish are not far behind in contributing to the marine products export earnings of our country. These products are landed by the trawl net operating boats especially the mechanised ones, operating all along the coasts of the maritime states. The medium trawlers landing these catches range in length from 8.5m (28 ft) to 16.2m (53 ft). In addition to the wooden trawlers of different over all length (OAL) from 28ft to 53ft there are steel trawlers above 40ft OAL operating along the coast. As per the CMFRI census 1980, the total medium trawlers operating along the Kerala coast numbered 2630 constituting 86.6% of the total mechanised fishing craft in the state. According to the Expert Committee on marine fisheries management in Kerala (1989), as on March 1989, the total number of registered and unregistered medium trawling boats operating in Kerala waters numbered 3497 constituting 82.8% of the total mechanised craft.

There are very few works on the economic efficiency of the medium trawlers operating along the Kerala coast. Iyer et al. 1968, studied the catch per unit effort, total effort per year, yearly landings and crew remuneration of fishing vessels of sizes 9.15m(30'), 9.76m(32') and 10.97m(36') designed by the Central Institute of Fisheries Technology. Iyer et al. 1983, studied the effect of increase in the number of fishing trips on the economic efficiency of 9.82(32') and 11m(36') fishing trawlers along the

Kerala coast. Iyer et al., 1985, worked out the economics of operation of 9.75m(32') and 10.97m(36') wooden trawlers operating along the Kerala coast. Devaraj M. and Smitha P. (1988), studied the economics of mechanised shrimp trawlers in Kerala of OAL 28' to 32' to create an economic model to provide estimates of economically optimum catch and effort. Panikkar et al. 1990, made a study on the comparative economic efficiency of purse seiners, trawlers and drift gill netters operating along the Kerala coast from 1982-1986. In this study all the sample units of trawlers were 32' with 65hp engine. Panikkar et al. 1991, made a study on the economics of purse seiners, trawlers and gill netters along the Kerala coast with special reference to fuel efficiency. In this study also the sample of trawlers selected were 9.8m(32') to 10.9m(36') with 60hp to 68hp engine.

Due to lack of supportive study on all the length classes of trawlers along the Kerala coast a comprehensive study has been attempted integrating the technical, economical and operational aspects of the different length classes of medium trawlers (Plate 6.1) operating along the Kerala coast with special emphasis on fuel consumption, to suggest measures to reduce the energy consumption levels.

6.2 OBJECTIVES

To analyse the economics of operation of different length classes of medium trawlers operating along the Kerala coast.

To suggest measures to optimise the energy consumption pattern.

6.3 MATERIALS AND METHODS

The study was carried out from three centers, namely, Beypore, Cochin and Neendakara, along the Kerala coast, during the period September 1992 to October 1994.

The medium trawlers operating along the Kerala coast were classified into six length classes, namely, 25-30, 30-35, 35-40, 40-45, 45-50 and 50-55ft. Since preliminary survey of the type and sizes of the medium trawlers of the Kerala coast proved that the trawlers operating from the three centers were similar, the study was concentrated from the Cochin Fisheries Harbour and the representative samples drawn from Cochin. Through stratified random sampling giving proportional allocation to each length class, 22 medium trawlers were selected for the study. The selection was also based on access to authentic data on economics of operation of the units under study. An interview schedule was prepared and divided into three parts as follows.

i) General Information

Using this section information was collected on the technical details of the boat, engine, propeller, net and it's accessories.

ii) Economic Analysis

The economic analysis part was divided into four sections.

a) Capital Costs

This covered the capital investment costs incurred for the owner. It included the cost of boat, net and otter boards and the depreciation of the same.

b) Variable Costs

This is the operational costs incurred on each fishing trip. The details collected and recorded for variable costs of the selected units include:

1. Maintenance of boat/engine/propeller
2. Maintenance of net including otter board
3. Cost of engine oil

4. Cost of diesel
5. Harbour toll
6. Cost of ice
7. Cost of basket
8. Batta/ration/food
9. Crew share
10. Agent's commission
11. Miscellaneous expenses

c) Revenue

This is total returns on catch per fishing trip.

d) Catch

This is the quantity landed per fishing trip recorded in kilograms.

iii) Operation Details

The heads under which details on the fishing operation of the selected boats were collected and recorded include:

1. Vessel name
2. Horse power
3. Starting time/date
4. Shooting time
5. No. of hauls
6. Kgs trash per haul
7. Time of return/date
8. Depth of operation
9. Warp length paid out
10. Steaming engine RPM

11.Towing engine RPM

12.Diesel consumed (lts)

13.Catch (kgs)

In the case of Economic Analysis, weekly statements collected and recorded at the end of the weekend. The fishing operation details were collected and the recordings were done at the rate of 8 observations per month for each of the sampled boats. The recorded details were cross-checked by regular visits to the landing centers. Occasional fishing trips on selected boats helped in understanding the operation method in depth.

The collected data were used to analyse the economics of operation as well as to assess the trawling trip cycle and to determine the diesel consumption rates at different steaming and towing RPM levels of the engine. Data on the operation details of the boat was used to calculate the catch per unit effort (CPUE), revenue per unit catch, fuel expenses per unit catch etc.

Since the medium trawlers under study, except those in the 25-30 feet length class were capable of undertaking fishing trips of more than one day duration, an analysis was done to assess the fuel consumption pattern of the trawlers in the 30-35 feet to 50-55 feet length class, from the fuel conservation perspective to undertake fishing trips of different durations of one day, two day, three day and one week fishing trips.

6.4 RESULTS AND DISCUSSIONS

6.4.1 General details

The general details were collected using the 'General information' part of the interview schedule. It was observed that most of the trawlers operating from the Cochin Fisheries Harbour were wooden trawlers with the exception that there were a few trawlers in the 40-45ft class and 45-50ft class made of steel. The timber used for the construction was Aini and in the case of the steel trawlers mild steel was used instead of marine grade steel. The most common engine model installed on the trawlers from 30-35ft to 50-55ft length class was Ashok Leyland Marine (ALM) diesel engine, in the 25-30ft length class the Maarna and Ruston engines were most prevalent. The Maarna diesel engine was of 24hp and the Ruston engine had a horse power of 37.5. The horse power of the different ALM engines models installed on the medium trawlers sampled include, 89hp for ALM 370, 99hp for ALM 400, 106hp for ALM 402 and 156hp for ALM 680. This is the horse power of the engine models at 2000 RPM, continuous rating. Of these, 89hp and 99hp were found in the trawlers of 30-35ft length class. Only 99hp trawlers were present in the 35-40 ft length class, while for the 40-45 ft length class the trawlers sampled were fitted with 99hp, 106hp and 156hp engines. In the 45ft-50ft and 50ft-55ft length class the trawlers sampled were fitted with 99hp and 106hp ALM engines respectively. The common reduction gear ratio of the ALM engines was 4:1. The propellers installed on the 30-35ft to 50-55ft length class trawlers under study were three blade fixed pitch propellers (Plate. 6.4.1a), but in the case of the 25-30ft length class many boats were found to be installed with variable pitch propellers. The material of construction of the propellers of 30-35ft to 50-55ft was gun metal.

The trawlers of 25-30ft length class had no winches while for the trawlers above this length class double drum winches were found to be installed. Each drum had a capacity of holding 500m to 700m of wire rope. The gallows were absent in the 25-30ft length class but for the trawlers above this length class the gallows installed were all center gallows (Plate. 6.4.1b). The otter boards used all the trawlers sampled were found to be flat rectangular otter boards. The details of the otter boards used and the types of nets used as relevant to each length class is given in Chapter 3 (Section 3.7).

In none of the wooden trawlers of any length class class fuel saving devices like Kort nozzle and fuel flow meter were found to be installed. The steel trawlers above 40ft length (Plate 6.4.1c) were also not installed with a Kort nozzle. Fuel flow was measured by the use of dip-sticks or from the diesel level tube provided at the side of the diesel tank. Blind fishing was the most common method of fishing and in none of the trawlers operating from Cochin Fisheries Harbour, aimed trawling using the assistance of electronic instruments like echosounder was used.

6.4.2 Fishing operations

Except the trawlers in the 25-30ft length class which resorted to only one day fishing, all the trawlers in the other five length classes undertook fishing trips of longer duration. The fishing trawlers in the 30-35ft went mostly for one day fishing and rarely for two day fishing. In the 35-40ft and 40 -45 ft class, two day fishing was resorted to at a larger extent. The fishing trawlers in 45-50ft and 50-55ft length classes went mostly for two day fishing and also for occasional three day fishing trips. The fishing gears employed included three types of shrimp trawls and two types of fish trawls. Of these gears the trawlers in the 20-30ft length class use only one type of shrimp trawl. The vessels in the 30-35ft length class operated only three types of nets, two types of shrimp trawls and one type of fish trawl. The trawlers fitted with ALM 400 and ALM 402 engines operated all the five types of nets. The trawlers fitted with ALM 680 engine operated only one type of fish trawl. The design of the net used depended on the horse power of the engine used and not on the length class of vessel Chapter 3 (Section 3.5, Figs. 3.5e to 3.5n) The fish trawls were also directed at the cephalopod resources during the post-monsoon season. It was observed from the details collected from the operation details part of the interview schedule and from occasional fishing trips that these medium trawlers in all the length classes maintained a very high steaming RPM of 1900 and above. Fuel consumption studies Chapter 4 (Section 4.4.2) have proved that the fuel consumption is highest at these RPM levels.

The catch emptied onto the deck was sorted species wise and the trash fish which averaged between 20-30kg per haul was thrown back into the sea. Ice boxes of 100kg capacity were present in the 25-30ft trawlers, while for the 30-35 ft trawlers, the ice boxes had a capacity of 200-250kgs. The trawlers in 35-40ft length class had fish hold of 1.5tonne capacity along with two 200kg ice boxes and for the trawlers in 40-45ft the fish holds were of 2 to 2.5t capacity. The 45-50ft and 50-55ft trawlers did not possess ice boxes but their fish holds had a capacity of 3-5t. The trawlers of the 25-30ft did not take any ice with them due to the short duration of their fishing trip. The 30-35ft trawlers took 2-3 blocks of ice. Above this length class the trawlers took 5, 10 or 15 blocks of ice depending upon the capacity of the fish hold. The fish catches were usually spread out on the aft deck and covered with polythene. In Cochin Fisheries Harbour the trawl catches are usually auctioned only in the afternoon which is quite convenient for the one day and two day trip going fishing trawlers but inconvenient for the three-day-fishing trawlers as they return on the morning of the third day and have to wait till afternoon to dispose off the catch.

Night fishing is not prevalent in the trawlers operating from Cochin and fishing trawlers anchor at night. Fishing operations were carried out on all days of the week except Sunday with the exception that few operators do work on Sundays during good season.

It was observed that on reaching the base the catch was auctioned off, during which time the trawlers idled at the wharf with their engines running at 500 or 700RPM. The idling time varied between half an hour to one hour with an average of 45 minutes for all the trawlers. The ice and water required for the next trip is loaded during this time. The trawlers refuelled the same evening and minor maintenance requirements immediately attended to before the coming day's fishing.

6.4.3 Catch disposal

Immediately after reaching the harbour the fish catches which were spread out on the deck was auctioned off. In the case of the shrimp and cephalopod landings, they are dumped on the floor of the auctioning area in lots and through bidding and counter bidding the highest bidder will buy the lot. The right to auction the catch of a particular boat rested with an auctioning agent, each of whome has several boats under him and he gets a commission of six percent of the total catch value. The proceeds of a sale are collected by the auctioning agent and usually he also finances the boats under his control. Though the accounts are settled usually at the weekend, depending on the requirement of owner/crew he will make partial payments. An auctioning agent who is doing substantially well will even provide financial support for the building of new boats, but the money was loaned without any interest since the amount could slowly be adjusted from the auctioning revenue.

6.4.4 Repair and Maintenance

It was observed that repairs to the net due to instances of torn fishing net were many and the major expense for fishing gears was due to this in the medium trawlers. The maintenance schedule of all the trawlers under study were found to be highly irregular. Repair and maintenance to the engine was found to be done as a when a problem arises, preventive maintenance was not resorted to. In the case of the hull, chipping and scrapping of the fouling organisms was found to be done at an interval of six months for the trawlers under study. The preliminary survey on this aspect proved that in many cases cleaning of the hull extended even upto 8 months. Painting of the hull and super structure was done once a year for all the trawlers under study. It was observed that none of the trawlers including the steel trawlers used antifouling paints, insteads enamel paints were preferred due to their low cost. In the case of the propeller, maintenance was done when the trawlers were dry docked for cleaning of the hull. Maintenance due to propeller repitching was found to be a common incidence and due to cavitation on the blades to a lesser extent in all the trawlers sampled and in most trawlers operating from the harbour.

6.4.5 Capital Costs

The sub-costs coming under this head include :

i) Fishing boat including accessories
ii) Fishing nets
iii) Otter boards

The 25-30 ft boats were 15years old, the 30-35ft, 35-40ft and 40-45ft trawlers were one to two years old while the 45-50ft and 50-55ft boats were one year old. The 45-50ft trawlers were constructed in steel while all the others were wooden trawlers. The current market value of the boats in all classes were taken to calculate the fixed costs. For the fishing nets and otter boards the cost of new purchases were recorded. The split-up of the total capital costs for the different length classes is given in Table 6.4.5.

6.4.5.1 Cost of fishing boat including accessories

The cost of the boat varied with the age of the boat, with the 15 year old 28' boats coming under the 25-30 feet length class costing Rs.1,80,000 and the new 53' trawlers in the 50-55 feet length class costing above Rs.15,00,000. The cost of boat with accessories for the different classes of medium trawlers sampled is given in Table 6.4.5.

6.4.5.2 Cost of fishing nets

The cost of the net varied with the type of the net used by the horse power of engine installed on the vessel. Each boat was boat was observed to have one or two substitutes for each type of net used. There was no standard for the number of substitutes and hence the cost of all the nets owned by a fishing vessel were taken together. The total cost of different types of fishing nets used by the different length classes is given in Table 6.4.5.

6.4.5.3 Otter boards

The cost of the otter boards also varied, as the design of board changed with the horse power of engine installed. The cost of the flat rectangular otter boards used by the different length classes are given in Table 6.4.5.

6.4.6 Fixed Costs

The fixed costs of the different length classes of trawlers sampled include

6.4.6.1 Interest on capital

This was taken at the rate of 12% per annum which was the bank interest rate at that time (Table 6.4.5).

6.4.6.2 Depreciation

After a certain period of time the existing unit becomes superannuated and the depreciation costs provide the owner with the income to purchase a new unit. The total depreciation of the boat has been worked out using the following relation

Total depreciation = Cost of boat - Expected salvage value

where Expected salvage value = $C \times (1 - D)^n$

C = Cost of boat

D = Rate of depreciation

n = age of boat

$$\text{Depreciation per year} = \frac{\text{Total depreciation}}{\text{Age of boat}}$$

The useful service life of a wooden medium trawler is taken as 15 years and that of a steel medium trawler at 12 years, hence the rate of depreciation for the two is 6.6% and 8.3% respectively. In the case of the nets and otter boards, which had a service life of 2 and 5 years respectively, the rate of depreciation was estimated at 50%, 20% per annum respectively (Table 6.4.5).

6.4.7 Variable Costs

The variable costs of a fishing vessel is constituted by the costs incurred by the vessel for each fishing trip i.e. the operating costs. The operating costs of trawling per fishing trip includes

- i) Repair and maintenance costs
- ii) Fuel expenditure
- iii) Harbour toll
- iv) Ice
- v) Basket
- vi) Batta/Ration/Food
- vii) Crews share
- viii) Agent's commission
- ix) Miscellaneous expenses

6.4.7.1 Repair and maintenance costs

The repair costs of repairing/replacing the net and accessories and the maintenance costs incurred for the boat/engine /propeller/electrical system etc. have been taken together under the head repair and maintenance costs. The annual average percentage of repair and maintenance costs of the different classes of trawlers studied are given in Table 6.4.5. On an average it forms 9.57% (Table 6.4.7) of the total variable costs for medium trawlers.

6.4.7.2 Fuel expenditure

The cost of lubricating oil and diesel constituted a major share of the operating costs and is considered together under the head fuel expenditure. The percentage share of fuel expenditure on the operating costs of the different length class of trawlers is presented in Table 6.4.5. This consumed the highest percentage share, 45.42% (Table 6.4.7) on an average of the operating costs of medium trawlers.

6.4.7.3 Harbour toll

The toll had to be paid to the harbour authorities by the trawlers for each visit to the harbour. At the beginning of the study period the toll charge was Rs.9/= per visit which increased to Rs.11/= per visit by the end of the study period. The expenditure incurred for harbour toll for the different length classes of medium trawlers is given in Table 6.4.5. Harbour toll expenses worked out to 0.15% (Table 6.4.7) of the total operating costs on an average for the medium trawlers.

6.4.7.4 Cost of ice

The cost of ice varied depending on the availability of water and during summer months the cost per block of ice shot up to as high as 175%. The trawlers belonging to different length classes took ice blocks depending on the season and also the storage facilities on board. The cost incurred for ice by the different length classes of trawlers is given in Table 6.4.5. The cost percentage of ice on the total operating costs for the different length classes of trawlers is given in Table 6.4.7. On a average for medium trawlers it formed 2.62% (Table 6.4.7) of the total operating costs.

6.4.7.5 Cost of basket

Though a low priced commodity the baskets in a trawler had to be replaced every two weeks. The cost incurred for basket by the different length classes of medium trawlers is given in Table 6.4.5. The percentage cost of basket on the total operating costs for the different length classes is given in Table 6.4.7. This cost formed 0.17% (Table 6.4.7) of the total operating costs for the medium trawlers on an average.

6.4.7.6 Batta/ration/food

This is the allowance given to the crew members as a whole for food. It worked out to Rs.150/= per day for the total crew of the trawler. Since the trawlers do not go for fishing on Sundays from Cochin, Sunday bata was also given which worked out to Rs.90/= for the whole crew. Bata constituted 5.98% of the total operating costs of the medium trawlers on an average.

6.4.7.7 Crews share

On an average 31% of the total value of sales value realised per trip less the expenses incurred for fuel and oil, ice, basket, batta, agent's commission and miscellaneous expenses was split up between the crew as crew share. Usually for a medium trawler the crew strength was 5 people per boat but rarely six people also used to go on a trip. The crews share in the case of a crew strength of five people and six people per boat is as given below

CREW STRENGTH	- SIX	FIVE
Syrang (1)	- 8%	8.5%
Driver (1)	- 6%	7.5 %
Dech hands (3-4)	- 4.25%	5%
Total	-31.00%	31.00%

On an average crew share accounted for 27.07% of the operating expenses of the medium trawlers. The percentage share of crew share on the total operating expenses for the different length class of medium trawlers is given in Table 6.4.7.

6.4.7.8 Agent's commission

Six percent of the total value realised on a trip's sales was given to the auctioning agent as commission. On an average the expenses for commission accounted for 8.17% of the operating costs for medium trawlers. The percentage share of agent's commission on the total operating costs for the different length classes of medium trawlers is given in Table 6.4.7.

6.4.7.8 Miscellaneous expenses

These expenses included presentations/ donations to church/crew, water expenses, cost of battery compound used on the wire rope, medical expenses on accidents etc. and it formed on an average 0.84% of the total operating costs of the medium trawlers (Table 6.4.7).

6.4.8 Economic analysis of medium trawlers

The economic analysis of the six length classes sampled is presented in Table 6.4.5. Except for the 25-30 ft length class the total operating costs worked out to 68.84% of the total catch value realised on an average for the other five length classes. In the 25-30 ft length class the operating costs came to 46.49% of the total catch value, this is mainly due to the exceptionally low fuel expenditure of these trawlers attributed to the low horse power of engine fitted on them, the average horse power coming only to 30.5. The repair expenditures incurred to the boat, engine and nets was the owners liability and in the 25-30 ft class it took up only 10.15% of the owner's gross profit, since only one type of net was operated by this length class. In the other length classes 30-35ft, 35-40ft and 50-55ft it took up more than 25% of the owner's gross profit, these percentage levels being higher since four types of nets are being operated in these length classes. In the 40-45ft class the net profit went on the negative side due to the low output. In the 45-50ft class, the steel trawlers sampled used only one type of net, hence the repair expenditures consumed only 19.16% of the owner's gross profit. In the operating costs, the major share of the operating expenses was borne by fuel expenditure and the average for all the six length classes coming to 45.42% of the total operating costs. In all the length classes the percentage cost of fuel expenditure on the total operating costs was above 40%. The next major share of the operating expenses went for crew share, which consumed on an average 27.07% of the total operating expenses for all the length classes together.

The operating costs as a percentage of the total catch value realised for each length class of vessel is presented in Table 6.4.8.

6.4.9 Operational analysis of medium trawlers

An operational analysis worked out for all the length classes and is presented in Table 6.4.9. This analysis was done to arrive at the fuel cost per kilogram catch, average value realised per kilogram catch, actual trawling hours per year, the fuel consumption per trip, fuel consumption for actual trawling, fuel consumption per hour and the average number of days per fishing trip for each length class of medium trawlers studied. The fuel cost per kilogram catch was highest for the 40-45ft length class and lowest for the 25-30ft length class, due to the highest and lowest percentage share of fuel expenditure to the total operating costs respectively. The average value realised per kilogram of catch for medium trawlers during the period 1992-'94 worked out to Rs.26.17. The actual trawling hours for all length classes together worked out to 65.54% of the total fishing hours. The fuel consumption per trip increased according to the increase in the duration of the trip and it was also proportionate to the increasing length class from 30-35 to 50-55ft class, with the 45-50 and 50-55ft classes recording the highest levels. The fuel consumption per trip was lowest for the 25-30ft length class, since the trip duration was lowest for this class, the trawlers resorting to only one day fishing. The fuel consumption for actual trawling was corresponding to the percentage of actual trawling hours per year. The average fuel consumption per hour was highest for the length class 40-45. The average number of days fished per year for all the length classes worked out to 237 days, the highest being for the 50-55ft length class (264) due to their better ability to withstand rough weather conditions and the lowest (215) for the medium trawlers in the 25-30ft length class.

6.4.10 Measures for fuel conservation

6.4.10.1 General measures

From Section 6.4.2 on "Fishing operations", it is clear that all the medium trawlers in the 30-35ft to 50-55ft were steaming at a high speed of 1900 RPM and above. Many earlier works like Gulbrandsen (1986) and Billington (1988) have proved that speed is an important factor contributing to the increased fuel consumption in fishing vessels. From results (Chapter 4:Section 4.4.2) of the "Observations on fuel consumption" Chapter 4 (Section 4.3.1), it can be inferred that if the medium trawlers of the length classes from 30-35ft to 50-55ft reduce their free running (steaming) RPM from 1900 to 1800 the percentage reduction in fuel consumption is of the order of 11.13%. Hence all the medium trawlers are recommended to steam at 1800 RPM.

Further it is evident form Section 6.4.2 on "Fishing operations", the medium trawlers are idling at the harbour for an average period of 45 minutes at which time their engine is running at 500 to 700 RPM. It is recommended that the idling time be reduced to 15mins., through quick measures for auctioning, or conversely, that the medium trawlers stop their engines while auctioning is going on. It can be made compulsory by the Harbour Authority's all over the state that the fishing vessels stop their engines while idling in the harbour, thereby saving precious fuel which otherwise go wasted and also reducing the pollution levels around the Fishing Harbours of the state.

Section 6.4.1 on "General information", reveals that the medium trawlers operating from the Harbour scrap the hull for removing the fouling organisms at a minimum interval of six months interval. From results (Chapter 4:Section 4.4.1) of the "Observations on fuel consumption" Chapter 4 (Section 4.3.1), it is evident that if the medium trawlers change the interval between scrapping of foulers from 6 months to 3 months, a potential fuel saving of 17.3% is possible per trawler. Hence it is recommended that the medium trawlers scrap their hull at a minimum interval of 3 months or lower.

Section 6.4.1 on "General information", it can be seen that instances of repairs occurring due to propeller repitching are many. This may be due to the fact that in almost all the medium trawlers, the propeller is constructed in gun metal, a material of lower strength than manganese bronze. Hence it is recommended that all the medium trawlers use propellers of manganese bronze.

Since the fuel consumption measurements on board the medium trawlers were done in a crude method without the aid of any flow monitoring devices, the operators were often totally unaware of the exact fuel consumption at any particular time. The New Zealand Fishing Industry Board, in a pilot project (Billington, 1988) to determine the value of fuel flow monitoring on a number of vessels, concluded that on an average an annual saving of 10% was possible through fuel monitoring of a fishing vessel. It is evident from this the importance of installing fuel flow devices on our medium trawlers. Hence it is recommended the the medium trawlers operating along the Kerala coast install fuel flow monitoring devices.

The installation of Kort nozzle to an open propeller can give additional thrust of around 20 to 25% at the towing speed condition, hence it is most suitable for trawlers since it can bring in an additional fuel saving of 10 to 14%. The steel medium trawlers operating along the coast were not found to be fitted with Kort nozzles, hence it is recommended that the steel trawlers be fitted with Kort nozzles.

Repairs due to tearing of the net in the medium trawlers are frequent and occurs on every trip or by the haul. This occurs mainly because of the blind fishing method practised along the coast without the use of any electronic devices like echosounders. It is recommended that the medium trawlers above 40ft length capable of going for longer fishing trips be installed with echosounders so that they can understand the terrain and direct their tow towards a school of fish thereby reducing the hauling time and increasing the number of hauls.

6.4.10.2 Fuel saving and fishing trip duration

The average fuel consumption pattern and the fuel costs involved by the medium trawlers in the length classes 30-35, 35-40, 40-45, 45-50 and 50-55 while going for fishing trips of different durations according to their respective endurance levels is presented in Table 6.4.10.2a, Table 6.4.10.2b, Table 6.4.10.2C, Table 6.4.10.2d and Table 6.4.10.2e respectively. From the operation details of the medium trawlers operating from the Cochin Fisheries Harbour it was observed that the time duration varied on an average from 14-16 hours, 26-28 hours, 36-38 hours and 68-72 hours for one day, two day, three day and one week fishing respectively. From the data collected from Port authorities on 317 medium trawlers from Calicut, 230 medium trawlers from Cochin and 581 medium trawlers from Quilon, including all the length types of trawlers operating from the respective centers, it was observed that the medium trawlers in the 25-30 feet, 30-35 feet, 35-40 feet, 40-45 feet, 45-50 feet and 50-55 feet length classes constituted around 14%, 27%, 24%, 21%, 11% and 3% of the total trawler fleet of Kerala. As per the Expert committee on marine fisheries management in Kerala (1989), the total number of medium trawling boats in Kerala numbered 3497.

The medium trawlers in the 30-35 feet length class are capable of going for fishing trips of upto two day duration. The comparative economics of these trawlers in terms of fuel cost while undertaking one day and two day fishing trips is presented in Table 6.4.10.2a. The fuel saving of two day fishing over one day fishing of this length class trawlers per trip is 37 liters and in terms of value it is Rs.265.29 per trawler. At an average number of fishing days 243 (Table Operational analysis) per year for the trawlers in this length class, the number of days per trip worked out to 1.28 (Table Operational analysis). Here the figure in excess of 1 i.e. .28 is taken as a percentage of the total fishing days and is considered as the total number of two day trips undertaken. Thus the total number of two day trips worked out to 53 on an average out of the total of 243 fishing days for this length class. It is estimated that 137 one day trips are being made on an average by the trawlers of this length class. If these one day trips are converted to two day fishing the total number of trips saved works out to 68 and the total saving per year per trawler in this length class works out around Rs.18,000. The total number of trawlers in this length class is estimated at 874 and the total saving in fuel cost by converting to two day fishing for this length class works out to around 1.5 crores per year.

The medium trawlers in the 35-40ft length class are capable of going for fishing trips of upto three day duration. Therefore a comparative economics of these trawlers in terms of fuel cost while undertaking one day and two day and three day fishing trips has been worked out and is presented in Table 6.4.10.2b. The fuel saving of two day fishing over one day fishing of this length class trawlers per trip is 44.7 liters and in terms of value it is Rs.320.50 per trawler. In the case of three day fishing over one day fishing the fuel saving per trip is 119.2 liters and in terms of value Rs.854.66 per trawler per trip. For three day fishing over two day fishing the fuel saving per trip is 52 liters and in terms of value it is Rs.372.84 per trawler per trip. The average number of days per trip for this length class of trawlers came to 1.44. At an average of 236 fishing days per year, the total average number of two day trips came to 52. Thus 132 one day fishing trips are being made by the trawlers on an average. If these one day trips are converted to two day trips the total saving for this length class of trawlers at a total of 874 trawlers in Kerala works out to (66 (trips saved) x 320.5 x 874) around 1.85 crores. If the two day trips are converted to three day trips, the total saving works out to (52-35 x 372.8 x 874) around 0.55 crore. Thus the total saving for making two day and three day fishing for this length class of trawlers works out to 2.4 crore. If the one day trips are converted to three day trips, the total saving works out to (132-44 x 855.5x 874) around 6.58 crores for the trawler fleet of this length class in Kerala.

Fishing trips of upto one week duration can be undertaken by the medium trawlers of 40-45 feet length class. The comparative economics of these trawlers in terms of fuel cost while undertaking one day and two day three day and one week fishing trips has been worked out and is presented in Table 6.4.10.2c The fuel saving of two day fishing over one day fishing of this length class trawlers per trip is 52 liters and Rs.380/= in terms of quantity and value respectively. In the case of three day fishing over one day fishing the fuel saving per trip is 140 liters and in terms of value Rs.1003.8 per trawler per trip. For three day fishing over two day fishing the fuel saving per trip is 62 liters and in terms of value it is Rs.444.54 per trawler per trip. In the case of two day fishing over one week fishing, the fuel saving per trip worked out to 193 liters and Rs.1383.81. The average number of days per trip for this length class of trawlers came to 1.85. At an average of 228 fishing days per year, the total average number of two day trips came to 97. Thus 34 one day fishing trips are being made by the trawlers on an average. If these one day trips are converted to two day trips the total saving for this length class of trawlers at a total of 734 trawlers in Kerala works out to (17 (trips saved) x 380 x 734) around 0.47 crore. If the two day trips are converted to three day trips, the total saving works out to (97-64 x 444 x 734) around 1.07 crore. For two day trips over one week trips, the total savings came to (97-39 x 1383 x 734) around 5.88 crores.

The fishing trawlers studied under the 45-50 ft had an endurance capacity of going for upto one week fishing. The comparative economics of these trawlers in terms of fuel cost while undertaking two day, three day and one week fishing trips has been worked out and is presented in Table 6.4.10.2d. The fuel saving of three day fishing over two day fishing of this length class trawlers is 47.5 liters and Rs.340.5/= in terms of quantity and value respectively, per trawler per trip. In the case of one week fishing over three day fishing the fuel saving is 53 liters and in terms of value Rs.380/= per trawler per trip. In the case of one week fishing over two day fishing the saving in terms of fuel is 148 liters and in terms of value it comes to Rs.1061/=. The average number of days per trip for this length class of trawlers came to 2.98. At an average of 238 fishing days per year, the total average number of three day trips came to 77. The two day trips were negligible at 3.75% of the total number of trips made. If the three day trips are changed over to one week trips trips, the total number of trips saved works out to 39 and at an average of 385 trawlers in this length class in Kerala the total savings came to (77-38 x 380 x 385) around 0.57 crore.

The 50-55 ft medium trawlers also had an endurance capacity of going for fishing upto one week. The comparative economics of these trawlers in terms of fuel cost while undertaking two day, three day and one week fishing trips has been worked out and is presented in Table 6.4.10.2e. The fuel saving of three day fishing over two day fishing per trawler of this length class per trip is 61.5 liters and Rs.441/= in terms of quantity and value respectively. In the case of one week fishing over three day fishing the fuel saving per trawler per trip is 70 liters and in terms of value Rs.501/=. In the case of one week fishing over two day fishing the saving in terms of fuel is 193 liters and in terms of value it comes to Rs.1384/=. The average number of days per trip for this length class of trawlers came to 2.16. At an average of 264 fishing days per year, the total average number of three day trips came to only a meager 14 while the two day trips numbered 111. On changing over the two day trips to three day the total number of trips saved was estimated at 37, at 104 trawlers in this length class in Kerala the total saving works out to 0.17 crore. If the two day and three day trips are changed over to one week fishing, the total number of trips saved works out to 44 (37 + 7) and the total savings comes to (1384 x 37 x 104 + 501 x 7 x 104) 0.57 crore.

Table 6.4.5. ECONOMIC ANALYSIS OF MEDIUM TRAWLERS OPERATING FROM COCHIN FISHERIES HARBOUR

LENGTH CLASS (ft)	25-30	30-35	35-40	40-45	45-50	50-55
CAPITAL COSTS						
COST OF FB	158000	408333.33	468750	960000	1112500	1500000
COST OF FN	19583.33	39556.66	57149	55664	59000	71426
COST OF OB	1700	2866.66	2800	3120	3000	3000
TOTAL CAPITAL COSTS	179283.33	450756.65	528699	1018784	1174500	1574426
FIXED COSTS (FC)						
INTEREST ON CAPITAL	21514	54090.8	63444	122254	140940	188931
DEPRECIATION OF FB	6946.76	24397.41	28007.23	61269.12	92337.5	99000
DEPRECIATION OF FN	7343.75	19778.33	21430.88	20874	29500	35713
DEPRECIATION OF OB	260.27	573.33	560	624	600	600
TOTAL FIXED COSTS	36064.78	98840.07	113442.11	205021.12	263377.5	324244
VARIABLE COSTS (VC) OR OPERATING COSTS						
REPAIR AND MAINTENANCE COSTS (RMC)	22171	71335	99932.5	94437.2	42698.5	92909
FUEL EXPENDITURE	90038.55	329786.33	374506.75	426260	357876	487246
HARBOUR TOLL	0	2046	1804	1252.8	924	1705
ICE	0	15217	20802.75	21549.8	47070.5	29856.5
BASKET	391.68	1156	1277.5	1816	1432.5	1297.5
BATTA/RATION/FOOD	23775	39161.66	38713.75	43222	44775	46497.5
CREWS SHARE	70754.84	198703.61	198872.88	163309.11	243282.85	317363.25
AGENTS COMMISSION	12794.34	65405.73	69726.76	54772.24	78973.5	101993.7
MISCELLANEOUS EXPENCES	1192.17	3261.33	5635.75	9051	12981.5	7545.5
TOTAL VARIABLE COSTS	221117.58	726072.66	811272.64	815670.15	830014.35	1086413.95
TOTAL COSTS (FC+VC)	257182.36	824912.73	924714.75	1020691.27	1093391.85	1410657.95
TOTAL REVENUE	475645.17	1071190.66	1162117.5	1069331.4	1316232	1699895
OWNERS GROSS PROFIT (OGP)	218462.81	246277.93	237402.75	48640.13	222840.15	289237.05
NET PROFIT (OGP - RMC)	196291.81	174942.93	137470.25	-45797.07	180141.65	196328.05
CATCH DETAILS						
QUANTITY (Rs.)	19100	39720	43700	40580	50550	64940
VALUE (Rs. LACS)	4.76	10.71	11.62	10.69	13.16	17

Table 6.4.7 PERCENTAGE SHARE OF EACH OPERATING COST ON THE TOTAL VARIABLE COSTS OF MEDIUM TRAWLERS OPERATING FROM COCHIN FISHERIES HARBOUR

LENGTH CLASS (ft)	25-30	30-35	35-40	40-45	45-50	50-55	Avarage
REPAIR AND MAINTENANCE COSTS (RMC)	10.03	9.82	12.32	11.58	5.14	8.55	9.57
COST OF ENGINE OIL AND DIESEL	40.72	45.42	46.16	52.26	43.12	44.85	45.42
HARBOUR TOLL	0.00	0.28	0.22	0.15	0.11	0.16	0.15
ICE	0.00	2.10	2.56	2.64	5.67	2.75	2.62
BASKET	0.18	0.16	0.16	0.22	0.17	0.12	0.17
BATTA/RATION/FOOD	10.75	5.39	4.77	5.30	5.39	4.28	5.98
CREWS SHARE	32.00	27.37	24.51	20.02	29.31	29.21	27.07
AGENTS COMMISSION	5.79	9.01	8.59	6.71	9.51	9.39	8.17
MISCELLANEOUS EXPENSES	0.54	0.45	0.69	1.11	1.56	0.69	0.84

Table 6.4.9. OPERATIONAL ANALYSIS OF MEDIUM TRAWLERS OPERATING FROM COCHIN FISHERIES HARBOUR

LENGTH CLASS (ft)	25-30	30-35	35-40	40-45	45-50	50-55
FIXED COST PER KG OF CATCH (Rs.)	1.89	2.49	2.60	5.05	5.21	4.99
OPERATING COST PER KG OF CATCH (Rs.)	11.58	18.28	18.56	20.10	16.42	16.73
TOTAL COST PER KG OF CATCH (Rs.)	13.47	20.77	21.16	25.15	21.63	21.72
FUEL COST PER KG OF CATCH (Rs.)	4.71	8.30	8.57	10.50	7.08	7.50
AVG. VALUE REALISED PER KG CATCH (Rs.)	24.90	26.97	26.59	26.35	26.04	26.18
PROFIT PER KG CATCH (Rs.)	11.44	6.20	5.43	1.20	4.41	4.45
TOTAL FISHING HOURS/YEAR	2426.98	3628.2	3407.43	3118	3243.48	3671.6
ACTUAL TRAWLING HOURS/YEAR	1728.27	2036.86	1851.8	1823.09	2319.48	2335.1
FUEL CONSUMPTION (FC)/TRIP	48.64	234.87	309.65	445.08	545.45	531.86
TOTAL FC (LITERS/YEAR)	10458	44625	50783	54745	43636	64621
TOTAL FC FOR ACTUAL TRAWLING (LTS/YR)	7447.22	25052.33	27598.50	32009.32	31205.01	41098.29
TOTAL FC FOR STEAMING (LTS/YR)	3010.78	19572.67	23184.50	22735.68	12430.99	23522.71
TOTAL NUMBER OF TRIPS	215	190	164	123	80	121.5
AVERAGE FUEL CONSUMPTION PER HOUR	4.31	12.30	14.90	17.56	13.45	17.60

Table 6.4.10.2a FUEL CONSUMPTION LEVEL WITH REFERENCE TO TRIP DURATION OF MEDIUM TRAWLERS IN THE 30-35 FEET LENGTH CLASS OPERATING FROM COCHIN FISHERIES HARBOUR

FISHING TRIP		ONE DAY			TWO DAY	
TRIP DURATION (hrs)	14	15	16	26	27	28
AVERAGE FC* (lt/hr)	12.3	12.3	12.3	12.3	12.3	12.3
TOTAL FC (lt)	172.2	184.5	196.8	319.8	332.1	344.4
TOTAL AVERAGE FC (lt)		184.5			332.1	
COST PER LITER OF FUEL (Rs.)		7.17			7.17	
TOTAL FUEL COST (Rs.)		1322.87			2381.16	

* FC - FUEL CONSUMPTION

Table 6.4.10.2b FUEL CONSUMPTION LEVEL WITH REFERENCE TO TRIP DURATION OF MEDIUM TRAWLERS IN THE 35-40 FEET LENGTH CLASS OPERATING FROM COCHIN FISHERIES HARBOUR

FISHING TRIP		ONE DAY			TWO DAY			THREE DAY	
TRIP DURATION (hrs)	14	15	16	26	27	28	36	37	38
AVERAGE FC* (lt/hr)	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
TOTAL FC (lt)	208.6	223.5	238.4	387.4	402.3	417.2	536.4	551.3	566.2
TOTAL AVERAGE FC (lt)		223.5			402.3			551.3	
COST PER LITER OF DIESEL (Rs.)		7.17			7.17			7.17	
TOTAL COST (Rs.)		1602.50			2884.49			3952.82	

* FC - FUEL CONSUMPTION

Table 6.4.10.2c FUEL CONSUMPTION LEVEL WITH REFERENCE TO TRIP DURATION OF WOODEN MEDIUM TRAWLERS IN THE 40-45 FEET LENGTH CLASS OPERATING FROM COCHIN FISHERIES HARBOUR

FISHING TRIP		ONE DAY			TWO DAY			THREE DAY			ONE WEEK	
TRIP DURATION (hrs)	14	15	16	26	27	28	36	37	38	68	70	72
AVERAGE FC* (lt/hr)	17.56	17.56	17.56	17.56	17.56	17.56	17.56	17.56	17.56	17.56	17.56	17.56
TOTAL FC (lt)	245.84	263.4	280.96	456.56	474.12	491.68	632.16	649.72	667.28	1194.08	1229.2	1264.32
TOTAL AVERAGE FC (lt)		263.4			474.12			649.72			1229.2	
COST PER LITER OF DIESEL (Rs.)		7.17			7.17			7.17			7.17	
TOTAL COST (Rs.)		1888.58			3399.44			4658.49			8813.36	

* FC - FUEL CONSUMPTION

Table 6.4.10.2d FUEL CONSUMPTION LEVEL WITH REFERENCE TO TRIP DURATION OF STEEL MEDIUM TRAWLERS IN THE 45-50 FEET LENGTH CLASS OPERATING FROM COCHIN FISHERIES HARBOUR

FISHING TRIP		TWO DAY			THREE DAY			ONE WEEK	
TRIP DURATION (hrs)	26	27	28	36	37	38	68	70	72
AVERAGE FC* (lt/hr)	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45
TOTAL FC (lt)	349.7	363.15	376.6	484.2	497.65	511.1	914.6	941.5	968.4
TOTAL AVERAGE FC (lt)		363.15			497.65			941.5	
COST PER LITER OF DIESEL (Rs.)		7.17			7.17			7.17	
TOTAL COST (Rs.)		2603.79			3568.15			6750.56	

* FC - FUEL CONSUMPTION

Table 6.4.10.2e FUEL CONSUMPTION LEVEL WITH REFERENCE TO TRIP DURATION OF WOODEN MEDIUM TRAWLERS IN THE 50-55 FEET LENGTH CLASS OPERATING FROM COCHIN FISHERIES HARBOUR

FISHING TRIP		TWO DAY			THREE DAY			ONE WEEK	
TRIP DURATION (hrs)	26	27	28	36	37	38	68	70	72
AVERAGE FC* (lt/hr)	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
TOTAL FC (lt)	457.6	475.2	492.8	633.6	651.2	668.8	1196.8	1232	1267.2
TOTAL AVERAGE FC (lt)		475.2			651.2			1232	
COST PER LITER OF DIESEL (Rs.)		7.17			7.17			7.17	
TOTAL COST (Rs.)		3407.18			4669.10			8833.44	

* FC - FUEL CONSUMPTION

Plate. 6.1 MEDIUM TRAWLER

Plate. 6.4.1.a THREE BLADE FIXED PITCH PROPELLER.

Plate. 6.4.1.b CENTER GALLOWS OF MEDIUM TRAWLERS.

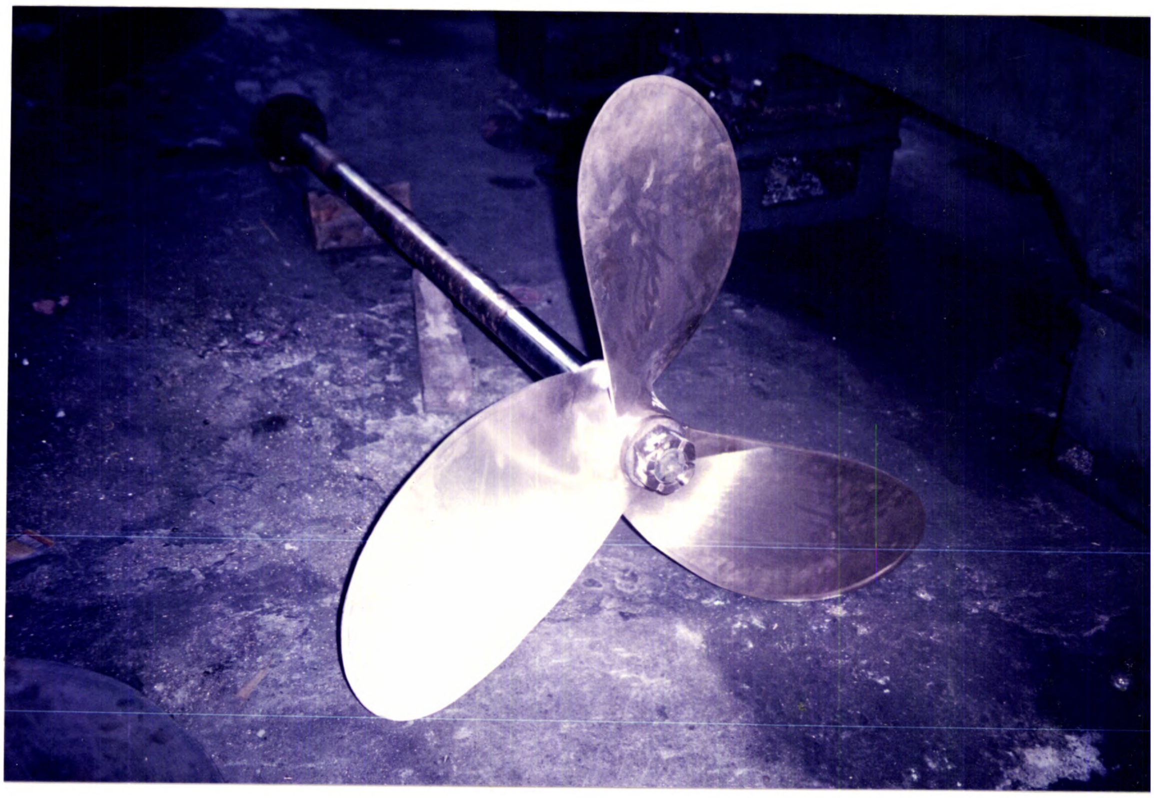


Plate. 6.4.1.c A 45' STEEL TRAWLER.

CHAPTER 7

OPERATIONAL ANALYSIS AND ENERGY CONSUMPTION LEVELS OF DEEP SEA TRAWLERS

7.1. INTRODUCTION

Indigenous craft mechanisation in the North West Coast of India and introduction of small mechanised stern trawling boats of 9–13m OAL within the South West Coast in the late fifties, increased the productive capacity of the Indian fishing industry. This lead to increased production of shrimps from the South West Coast and quality fin fishes from the North West Coast. Since then the fisheries development has been shrimp oriented and shrimp was the major item of export, both in volume (33.1%) and in value (70.2%) in 1994-'95.

Beyond 50m depth, the resources are largely unexploited or under-exploited. The fishery resources in the outer continental shelf and slope and the oceanic regions in the Indian EEZ has been estimated as 1.64 million tonnes (Sudarsan et. al. 1990). Of this, the demersal stocks form about 0.65 million tonnes, the coastal pelagic stocks 0.74 million tonnes and oceanic resources 0.25 million tonnes. Coast-wise, west coast supports 56.4% of the resources, east coast 16.4%, Lakshadweep sea 3.8%, Andaman and Nicobar Seas 8.5% and the oceanic waters 15% of the fishery potential. Depth-wise 8..3% of the resources are supported by the outer shelf areas (50-200m depth) whereas the continental slope and oceanic regions represent 1.7% and 15% of the resource potential.

The economic viability of catching prawns in the 'Sandheads' area of the Upper East Coast by large trawlers in the mid seventies paved the way for the development of marine fishing by deep sea trawlers. Though the Central Marine Fisheries Research Institute had assessed the resource potential of prawns in this area to be about 600 tonnes/annum which can sustain only 105 trawlers, the increase in number of trawlers went on unabated, touching a total of 180 trawlers besides about 150 mini trawlers and sona boats. These vessels were introduced between 1970 and 1990. During the fourteen year period, 1970-1983, the number of deep sea fishing vessels grew slowly at a average pace of 4.8 units per year and reached 68 trawlers in 1983. Except for the introduction of six units of 850 hp in 1976, the average power of 58 remaining vessels was 380 hp. All these vessels operated viably along the North East Coast (Sandheads), with an average catch per vessel of 24-35 tonnes. The second period from 1984 to 1990 saw a drastic change in the deep sea fishing industry and the number of deep sea fishing vessels added during the period was 112 with an average increase of 16 units per annum. The increase in fishing power was 468 hp per boat on the average. In 1988 a large number of deep sea trawlers migrated from Visakhapatnam to Cochin to exploit the deep sea lobster and deep sea prawn potential of the South West Coast. Oommen (1980, 1985), estimated the standing stock and potential yield of deep sea lobsters and shrimps separately for the Quilon Bank, Gulf of Mannar and South West Coast (7^{o}N to 13^{o}N). He estimated the potential yield of 3168t, 1116t and 7765t of deep sea lobsters for the above three regions respectively. He also estimated potential of 975t and 3123t of deepsea shrimps for the Quilon bank and South West Coast respectively. After a few years of operation the catch rates of deepsea resources and shrimps came down and the operation of these vessels became unviable and most of the vessels returned to their base in Visakapatnam. But a few vessels retained their base of operation as Cochin and fished along the west coast of India.

The new deepsea fishing policy was announced by the Government of India in 1991. The policy involves three new schemes namely i) Leasing of foreign fishing vessels for operation in the Indian EEZ ii) Test fishing and iii) Joint ventures between Indian and foreign companies, in deep sea fishing, processing and marketing. During the first year of operation of the new Deep Sea Fishing Policy, though nearly 300 vessels were permitted to be acquired under various schemes only 64 vessels joined the Indian fishing fleet.

As for the landing facility of deep sea fishing vessels, there are at present four deep sea fishing harbours in operation in India and two are under construction. These fishing harbours have a design capacity for accommodating 200 deep sea fishing vessels and 2200 mechanised fishing vessels. All the harbours except Vizhag are used mostly by mechanised fishing boats. Vizhag deep sea fishing harbour accommodates nearly 150 of the 180 deep sea trawlers in the country.

Here an attempt is made to study the energy consumption levels with the aim of energy optimisation in deep sea trawlers operating along the Kerala coast. With this end in view an an in depth economic analysis is done. With the aid of the economic analysis and the operational parameters, the operational analysis worked out and the energy consumption levels with emphasis on fuel use assessed. Finally suggestions are made towards reducing the fuel consumption with the aid of economic and operational parameters.

7.2 OBJECTIVES

Analyse the economics of operation of the deep sea trawlers operating along the Kerala coast.

Work out an operational analysis to assess the fuel consumption levels

Suggest measures to optimise the energy consumption pattern.

7.3 MATERIALS AND METHODS

In Kerala the deep sea fishing trawlers operated only from the Cochin Fisheries Harbour. Hence the study was conducted on the deep sea fishing trawlers operating from Cochin Fisheries Harbour during the period 1992 -1993, 1993-1994 and 1994-1995. According to the Marine Products Export Development Authority only five trawlers were operating with Cochin as their base, but according to the Cochin Fisheries Harbour Authorities 12 deep sea trawlers were paying occasional visits to the harbour with seven of them having their base at vizhag. Out of the remaining five deep sea trawlers, one is a Factory Stern Trawler of OAL, 104.32m and a main engine of 5700hp and three auxiliary engines of 1120hp each. The remaining four trawlers were of the same length (Plate 7.3a) and horse power of main engine and the study was concentrated on these trawlers. The data from these trawlers were collected using a pre-tested Interview Schedule divided into three parts

i) General information

ii) Economic analysis

iii) Operational analysis

The "General information" part gave necessary information on the fixed costs of all the four trawlers selected for the study as well as the technical details of the vessel and the gear. The various heads under which information was collected using the "General information" part of the Schedule is given in Annexure7.3a. The technical details of these trawlers are furnished in Table 7.3a. The selected trawlers were of approximately the same age.

The economics of operation of these units was collected using the "Economic analysis" part of the Interview Schedule. Economic analysis of the units selected for the study was done after collecting and recording data on :

1. Payments and Benefits to crew
2. Maintenance expenditure
3. Fuel expenditure
4. Miscellaneous expenditure

Details on the above expenditures were collected and recorded as pooled data at the quarter of each year. The analysis was done on an yearly basis as an average for the four trawlers. The results of the analysis is presented in Table 7.4.7a.

The Operational Analysis of the deep sea trawlers was worked out by computing data under several heads which are presented in the results of the analysis given in Table 7.4.8. Here also the analysis was worked out for the years 1992-'93, 1993-'94 and 1994-'95 as an average for the four trawlers.

7.4 RESULTS AND DISCUSSIONS

7.4.1 Fishing operations

All the four trawlers were outrigger-cum-stern trawlers. The number of voyages made by each vessel, the total number of fishing days and the average number of days per voyage is presented in Table 7.4.8 for the three years 1992-'93, 1993-'94 and 1994-'95. The fishing voyages were aimed at two main species i.e. the deep sea shrimps and cuttle fish. Along with deep sea shrimp, deep sea lobsters were also caught, while along with cuttle fish fish was also caught. The area of operation for the deep sea shrimp was Alleppey to Kasargod, 9^{o} to 12^{o} and for cuttle fish it was from Cochin to Ratnagiri, 10^{o} to 12^{o}. Two types of nets were used by all the four vessels, a four seam net aimed at deep sea shrimp and a six seam net aimed at cuttle fish. The otter boards used were the polyvalent otter boards (Plate 7.4.1), each weighing 500kg. Deep sea shrimps were found to be abundant at 380 - 420ms depth while the cuttle fish was abundant at 60 to 120ms depth. A scope ratio of 1:2.3 to 2.5 was maintained. The steaming speed of the vessels ranged from 7 to 8.5 knots at an engine RPM of 1100 to 1200. The trawling speed was maintained between 2.5 to 3.0 knots at an engine RPM of 820 to 900 for the deep sea shrimp and 2.3 to 2.6 knots at an RPM of 740 to 820 for cuttle fish. The average fuel consumed per hour worked out to 75 to 80lt per hour while steaming and 60 to 65lt per hour while trawling. While going for deep sea shrimp fishing the trawlers operated 24 hrs a day, but in the case of cuttle fish fishing the trawlers anchored about 8hrs a day at night. The average number of hauls per day worked out to 6-7 in the case of deep sea shrimp with a time duration per haul of 2.5 to 3.0 hours, and for cuttle fish also it was 6-7 hauls per day at 2.0 to 2.5 hours per haul. Around half an hour is taken for hauling and for shooting each net.

7.4.2 Catch details

The catches include deep sea shrimp, lobster, cuttle fish and fish. The catch details have been recorded as shrimp (deep sea shrimp), lobster (deep sea lobster) and other fish (cuttle fish and fish). The percentage of shrimp, lobster and other fish to the total catch for the years 1992-'93, 1993-'94 and 1994-'95 are shown in Fig.7.4.2a, Fig.7.4.2b and Fig.7.4.2c, respectively.

7.4.3 Catch Disposal

In the case of deep sea shrimp and deep sea lobster the catch landed is immediately sorted and graded. The catch is then treated in sodium meta bisulphite. After treatment the graded catch is finger-layed in baby cartons grade-wise at 2kg per carton in the case of deep sea shrimp and 1.5kg per carton in the case of deep sea lobster. The cartons are then dipped in immersible quick freezer at $-18^{o}C$ to $-21^{o}C$ for 10 minutes. The baby cartons are then closed and placed in a polythene cover. It is then kept in the fish hold for 24 hrs at $-25^{o}C$. After 24 hrs, 8 baby cartons are packed in a master carton and kept inside the cold storage till ready for export.

For cuttle fish the catch is first sorted and graded. Different lots of 9kg are weighed out and placed as such in a freezer tray which is inserted into a plate freezer for one and a half hours. The frozen cuttle fish is then wrapped in ploythene sheet and kept in the fish hold for 24hrs at $-25^{o}C$. Three slabs of 9kg are packed in a master carton and the master cartons are kept in the cold storage till ready for export.

The fish that are caught as a by-catch are sorted and kept in the fish hold, which are finally sold at the wharf.

7.4.4 Capital Costs

The sub-costs under this head include

i) Fishing vessel including accessories
ii) Fishing net (nets and accessories)
iii) Otter boards

All the four trawlers selected for the study were four years old. The present market value of the vessels were taken to calculate the fixed costs. For the fishing gear the cost of new net and otter board were recorded.

7.4.5 Fixed Costs

The various fixed costs include

7.4.5.1 Interest on capital

It was taken at the rate of 12 percent per annum on the capital costs so that it will also include the opportunity cost of capital investment.

7.4.5.2 Interest on loan

The company took a loan of Rs.78,27,553 on each of the four vessels at an interest payable at the rate of 6.75% from the Shipping Development Fund Committee.

7.4.5.3 Insurance

The hull and machinery of all the four vessels was insured and the fishing company had to pay a depreciating amount each year to the insurance company.

7.4.5.4 Depreciation

The total depreciation for each of the components; vessel, net and otter board was worked out using the following equation.

Total depreciation = Cost of vessel - Expected salvage value

Where expected salvage value = $C \times (1-D)^n$

C = cost of vessel

D = rate of depreciation

n = age of vessel

$$\text{Depreciation per year} = \frac{\text{Total depreciation}}{\text{Age of boat}}$$

The useful service life of the steel trawlers has been taken as 20 years, hence the rate of depreciation of these vessels was 5% per annum. In the case of nets, each vessel had to replace two new nets each season, hence the rate of depreciation in this case was estimated at 100%, the service life being only one year. For the otter boards, the rate of depreciation was 20%, the service life taken as 5 years.

The percentage share of each component of the fixed costs on the total fixed cost for the three years 1992-'93, 1993-'94, 1994-'95 as an average of the four vessels is shown in Fig.7.4.5a, Fig.7.4.5b and Fig. 7.4.5c respectively.

7.4.6 Variable Costs

The variable costs of a deep sea trawler constitutes the annual costs incurred by the trawler for the fishing voyages i.e. the operating expenses. The annual operating expenses of a trawler can be grouped under the following heads

i) Maintenance expenditure

ii) High Speed Diesel(H.S.D.) and Lube oil expenses

iii) Miscellaneous expenses

iv) Payments and Benefits to crew

7.4.6.1 Maintenance expenditure

7.4.6.1.1 Fishing nets and allied material

Under this head the expenses incurred for webbing material, cod end, wire ropes, otter boards and twine. The percentage share of this component on the total variable costs of the four trawlers for the three years 1992-'93, 1993-'94, 1994-'95 are 9.68%, 10.2% and 11.37% respectively, as shown in Table 7.4.6a. This component consumed 7.04% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown Table 7.4.6b.

7.4.6.1.2 Deck spares and consumables

A number of items like daily consumables, gally items, electronic items like Echo sounder paper, stationary etc. are purchased each year under this head. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 are 5.65%, 5.46% and 4.91% respectively (Table 7.4.6a). This component consumed 3.64% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.1.3 Trawler maintenance

Immediate maintenance expenditure to the trawler, engine, propeller, electrical system etc. are included under this head. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 are 7.81%, 9.65% and 10.1% respectively as shown in Table 7.4.6a. On an average, this component consumed 6.24% of the total revenue for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.1.4 Imported spare parts and Clearing and forwarding charges

Since a number of components on board the vessel are imported, repairs to the same can be done only by importing the spare parts. The imports incur clearing and forwarding charges and this is also included under this head. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 are 6.1%, 9.98% and 7.45% respectively as shown in Table 7.4.6a. This component consumed 5.46% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.1.5 Dry docking expenses

The dry docking frequency of these deep sea trawlers is once every two years. During dry docking painting is done to the hull and super structure. Details of the dry docking of each of the four vessels during the three years of survey is shown in chart 7.4.6.1.5. The expenses incurred for a deep sea trawler of 27m length for dry docking including the estimate of the expenses for hull and super structure painting is shown in Chart 7.4.6.1.5. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 are 0%, 1.89% and 2.63% respectively as shown in Table 7.4.6a. This component consumed 1.53% of the total revenue on an average for the two years 1993-'94, 1994-'95. The percentage share of this component on the total revenue for the three years 1992-'93, 1993-'94 and 1994-'95 is shown in 7.4.6b.

7.4.6.2 H.S.D. and Lube oil expenses

This forms a major component of the operating expenses of a trawler. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 is shown in Fig. 7.4.6.2. This component consumed 31.74% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6a. As part of the Deep Sea Fishing Policy of the Government of India, the Government is providing diesel subsidy each year to those company's engaged in deep sea fishing. Thus the vessels surveyed got as subsidy of 12.14%, 12.48% and 12.84% of the Freight On Board (FOB) value for the years 1992-'93, 1993-'94 and 1994-'95 respectively. It consumed 31.46%, 38.57% and 24.89% of the total revenue for the three years 1992-'93, 1993-'94 and 1994-'95 respectively as shown in Table 7.4.6b.

Here a special note is added to say that the Government of India has withdrawn the diesel subsidy given for the promotion of deep sea fishing in the Indian waters from April 1st 1996.

7.4.6.3 Miscellaneous expenses

Under this head of operating expenses is taken two components, the crew mess and port charges.

7.4.6.3.1 Crew mess

This component takes care of the food allowance to the crew. Mess allowance is given to the crew at the rate of Rs.35 per day to each floating officer and Rs. 30 per day to each floating crew per sea day. This expence is incurred by the company even when there is no fishing. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 is shown in Table 7.4.6a. This component consumed 2.1% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.3.2 Port charges

This includes the berthing charges and wharfage that the company has to pay to the port authorities. It comes to Rs. 250 per day per vessel at the Cochin Port. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average was 1.35% as shown in Table 7.4.6a. This component consumed 0.92% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.4 Payments and Benefits to crew

This is another major head of the operating expenses of a deep sea trawler and a number of components like crew salaries, incentives, out-station allowance, sea allowance, crew medical and leave transfer allowance and crew welfare are included.

7.4.6.4.1 Crew salaries

Salary is payed to the crew at an average of 15 crew per trawler. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average was 5.45% as shown in Table 7.4.6a. This component consumed 3.67% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b. The percentage split-up of the crew salary per month on the total salary is as follows

Designation		% share
Skipper	-	25.60
Chief engineer	-	24.39
Bosun	-	13.01
IInd Engineer	-	10.58
Cook	-	6.09
Oilman	-	6.09
Senior deckhand	-	5.28
Deckhand Grade II	-	4.88
Junior deckhand	-	4.08
Total	-	100.00

7.4.6.4.2 Incentives

Incentive is given to the officers and crew of each trawler. In addition to this a packing allowance is also given to the officers and crew at the rate of Rs.1 per kg, Rs.4 per kg and Rs. 2 per kg for cuttle fish, shrimp and lobster packing respectively. The expenditure for these two are considered together under this head. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average worked out to 5.43%. This component consumed 3.6% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b. The average incentive split-up for the officers and crew of the trawlers surveyed is presented below.

Designation		% share
Skipper	-	21.00
Chief engineer	-	18.00
Bosun	-	11.50
IInd Engineer	-	09.50
Cook	-	40.00
Oilman	-	
Senior deckhand	-	
Deckhand Grade II	-	
Junior deckhand	-	
Total	-	100.00

7.4.6.4.3 Out-station allowance

The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average came to 1.01% as shown in Table 7.4.6a. respectively. This component consumed 0.62% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b. The percentage share of out-station allowance per month for the crew of the trawlers surveyed are given below.

Designation		% share
Skipper	-	18.185
Chief engineer	-	18.185
Bosun	-	13.64
IInd Engineer	-	13.64
Cook	-	07.27
Oilman	-	07.27
Senior deckhand	-	07.27
Deckhand Grade II	-	07.27
Junior deckhand	-	07.27
Total	-	100.00

7.4.6.4.4 Sea allowance

An allowance is paid to the floating crew for each sea going day at the rates shown below

Amount	Crew designation
Rs. 110	Skipper and Chief Engineer
Rs. 65	Bosun
Rs. 50	II Engineer
Rs. 20	Senior deck hand, Oil man, Cook
Rs. 15	Second Grade and Junior deck hand

The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 is shown in Table 7.4.6a. This component consumed 1.42% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.6.4.5 Crew medical and LTA

The medical expenses of the floating crew is met by the company and in addition to this a medical allowance of Rs.800 per year for the Officers and Rs.400 per year for the remaining crew is paid by the company. The other component under this head, Leave Transfer Allowance is paid to the Officers and crew at the rate Rs.1500 per year for the Officers and Rs.750 per year for the crew. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average worked out to 0.56% as shown in Table7.4.6a. This component consumed 0.37% of the total revenue on an average for the three years

1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

8.4.6.4.6 Crew welfare

This includes the uniform allowance, magazine allowance, presentations etc. given to the crew. A uniform allowance of Rs. 450 per year is given to the crew equally. Magazine allowance comes to Rs.200 per voyage. The percentage share of this component on the total variable costs for the three years 1992-'93, 1993-'94, 1994-'95 on an average was 0.11%, as shown in Table 7.4.6a. This component consumed 0.08% of the total revenue on an average for the three years 1992-'93, 1993-'94, 1994-'95 as shown in Table 7.4.6b.

7.4.7 Economic analysis

The economic analysis of the four deep sea trawlers has been worked out as an average for each of the three years 1992-'93, 1993-'94 and 1994-'95 and is presented in Table 7.4.7. The results for each year is presented below.

i) *1992-1993*

The economic analysis of the four trawlers as an average for the year 1992-'93 is presented in Table 7.4.7a. In 1992-'93 the total operating costs worked out to 64.59% of the total catch value realised. The percentage share of each of the major components to the total operating costs is presented in Table 7.4.7b. H.S.D. and lube oil expenses was as high as 48% of the total variable costs. The next major share was for maintenance expenditure, 29.24 %, of this the percentage expenditure for net and allied material was the highest, 9.68%. Trawler maintenance was close behind at 7.81%. Dry docking expenses was absent during 1992-'93 since none of the trawlers were dry docked during this period. Crew welfare took up as much as 17.25% of the total operating costs while miscellaneous expenses came to 4.81%. The operating profit for 1992-'93 came to 20.03% of the total revenue.

ii) *1993-1994*

The total operating costs for 1993-'94 worked out to 81.88% of the total catch value realised. The percentage share of each of the major components to the total operating costs is presented in Table 7.4.7b. H.S.D. and lube oil expenses came to 47.47% of the total variable costs. The next major share was for maintenance expenditure, 37.18%, of this, Net and allied materials, Trawler maintenance and, Imported spare parts and Clearing and forwarding charges contributed around 10% each. Expenses for dry docking was incurred during this year as two of the four vessels were dry docked. Crew welfare came to 11.51% of the total operating costs while miscellaneous expenses came only to 3.84%. Since the operating profit for this year was very low, 3.26% of the total revenue, the company was at a loss in 1993-'94.

iii) *1994-1995*

In 1994-'95 the total operating costs worked out to 57.32% of the total catch value realised. The percentage share of each of the major components to the total operating costs is presented in Table 7.4.7b. Of this H.S.D. and lube oil expenses came to 43.41% of the total variable costs. Maintenance expenditure for 1994-'95 came to 36.47%, of this the percentage expenditure for Net and allied material was highest at 11.37%. Crew welfare came to 15.22% of the total operating costs while miscellaneous expenses was only 4.9%. The operating profit was very high in 1994-'95, constituting 32.32% of the total revenue.

The profit shown for each year is the profit on fishing operations, from this the company incurred administrative expenses which worked out to an average of 50% of the total average profit for the years under study.

7.4.8 Operational analysis

The operational analysis of the four deep sea trawlers has been worked out as an average for each of the three years 1992-'93, 1993-'94 and 1994-'95 and is presented in Table 8.4.8. The results for each year is presented below.

i) *1992-'93*

The operational analysis worked out as an average for the four trawlers for the year 1992-'93 is presented in Table 8.4.8. The total cost cost per kilogram of catch came upto Rs.110/47. Out of this fixed costs and operating costs per kilogram of catch worked out to 19.23% and 80.77% respectively. During this year out of the average value realised per kilogram of catch, Rs.138/14, 15.37% was consumed by the fixed costs, 64.59% was consumed by the variable costs and only 20.03% went as profit. Of the total fishing hours in this year 96.4% was used for trawling and only 3.6% for steaming. On an average only four voyages were made and the total average number of fishing days for all the four trawlers during 1992-'93 was 148, the remaining days being lost in Port for maintenance work and other technical delays. The average fuel consumption per hour was for the year 1992-'93 was estimated at 66.57 liters.

ii) *1993-'94*

The operational analysis worked out as an average for the four trawlers for the year 1993-'94 is presented in Table 8.4.8.

Out of the total cost per kilogram of catch which came upto Rs.106.17, the percentage share for fixed costs and operating costs per kilogram of catch worked out to 15.35% and 84.64% respectively. During this year out of the average value realised per kilogram of catch, Rs.109.75, 14.84% was consumed by the fixed costs, 81.88% was consumed by the variable costs and only 3.28% went as profit. Of the total fishing hours in this year 96.34% was used for trawling and the rest for steaming. On an average only four voyages were made and the total average number of fishing days for all the four trawlers during 1993-'94 was 152. The average fuel consumption per hour during this year worked out to 73.54 liters.

iii) *1994-1995*

The operational analysis worked out as an average for the four trawlers for the year 1994-'95 is presented in Table 8.4.8. The total cost per kilogram of catch came upto Rs.45.34. The percentage share of fixed costs and operating costs on the total cost per kilogram of catch worked out to 15.3% and 84.69% respectively. During this year out of the average value realised per kilogram of catch, Rs.66.99, 10.35% was consumed by the fixed costs, 57.32% was consumed by the variable costs and only 32.33% went as profit. Of the total fishing hours in this year 96.32% was used for trawling and only 3.68% for steaming. On an average 4.5 voyages were made this year and the total average number of fishing days for all the four trawlers during 1994-'95 was 170. The fuel consumption per hour for the trawlers worked out to 67.78 liters.

7.4.9 Fuel use and operational profitability

From the economic analysis it is evident that in the case of deep sea trawlers also the expenditure incurred for fuel was constituting the highest percentage of operating expenses, the average for the three years coming to 46.53%. The operating profit was highest during 1994-'95 due to the high catches of cuttle fish and also because an average of 4.5 voyages were made during this year. Thus it is clear that by increasing the number of voyages the profit levels can be increased. The total value realised per kilogram of catch was high during 1992-'93 and 1993-'94 because the percentage of deep sea shrimp and deep sea lobster catches were high during these years, while for 1994-'95 the cuttle fish voyages were predominant which is evident from the high landings of cuttle fish. Due to the lower value per kilogram of catch of this commodity, the returns per kilogram of catch for 1994-'95 was very low compared to the other years. Inspite of the high quantity of catches, due to the low fuel consumption per hour during 1994-'95, the fuel cost per kilogram of catch was lowest. If the fuel cost per kilogram is high, it will affect the profit on operations. Here it is evident that by lowering the fuel consumption the profit levels can be increased. The profit per kilogram of catch for 1993-'94 was low due to the low quantity of catches and the increased number of voyages aimed at the lower priced cuttle fish. The profit per kilogram of catches for 1992-'93 was highest inspite of the low quantity of catch, because the voyages were aimed at the high priced deep sea shrimp and deep sea lobster resources. Though the deep sea shrimp and lobster resources are located farther than the cuttle fish resources, from the operational analysis for 1992-'93 it is clear that the average steaming time during this year in which the voyages were aimed at the shrimp and lobster resources was only .3.7.%. Hence no cause for concern regarding increase in fuel expenditure for voyages directed towards shrimp and lobster resources. Thus concentrating more on the deep sea shrimp and deep sea lobster resources can increase the profit levels of the company.

7.4.10 Energy saving measures

The fact that fuel expenditure is constituting the highest percentage of operating expenses, highlights the importance of energy conservation measures aimed at reducing the fuel consumption. Since hull fouling is a major contributing factor towards increase in fuel consumption, it is felt that the dry docking frequency of the trawlers be reduced to one year interval from the present two years, as it is clear from the economic analysis that dry docking expenses constituted only 2.26% of the operating expenses on an average for the two years 1993-'94 and 1994-'95. It is highly encouraging that all the deep sea trawlers under study were fitted with Kort nozzle (Plate 7.4.10). It has been proved that the propeller nozzle can reduce the fuel consumption on an average between 10-14% and also improve the thrust at lower speeds. Thus at a conservative estimate of 10% fuel saving on an average, considering the high fuel consumption levels of the deep sea trawlers and also due to the fact that for more than 90% of the total time spent for fishing operations the trawlers are operating at a low RPM level for trawling purposes, the fitting of propeller nozzle for these trawlers is most appropriate. The quantification of fuel saving levels with respect to the Kort nozzle requires further studies. None of the trawlers studied were found to be using a fuel flow meter. The measurement of fuel consumption on these trawlers was done by noting marks on a transparent tube at the side of the diesel tank and it was usually quantified as fuel consumption rates at the end of a voyage. Thus the exact fuel consumption levels or any increase in the fuel consumption at a particular time from the earlier noted figures from the previous voyage could not be quantified accurately due to the lack of a flow meter. Studies conducted in New Zealand using flow meters have proved that the use of flow meters can reduce the fuel consumption levels by an average of 10%. Hence it is recommended that the deep sea trawlers be fitted with fuel flow meters.

TABLE 7.3a TECHNICAL DETAILS OF DEEP SEA TRAWLERS SAMPLED

1	TYPE OF TRAWLING	OUTRIGGER/ STERN TRAWLER	OUTRIGGER/ STERN TRAWLER	OUTRIGGER/ STERN TRAWLER	OUTRIGGER/ STERN TRAWLER
2	LENGTH (m)	27	27	27	27
3	BREADTH (m)	7.4	7.4	7.4	7.4
4	DRAUGHT (m)	3.5	3.5	3.5	3.5
5	GRT	180	180	180	180
6	BHP (Main Engine)	550	550	550	550
7	MAKE	YANMAR(JAPAN)	YANMAR(JAPAN)	YANMAR(JAPAN)	YANMAR(JAPAN)
8	No. OF AUX. ENGINES	2	2	2	2
9	MAKE	CATERPILLAR	CATERPILLAR	CATERPILLAR	CATERPILLAR
10	HP	77	77	77	77
11	BOLLARD PULL	ABT 6 TONS	ABT 6 TONS	ABT 6 TONS	ABT 6 TONS
12	PROPELLER				
a	No. OF LEAFS	4	4	4	4
b	MATERIAL	Mn BRONZE	Mn BRONZE	Mn BRONZE	Mn BRONZE
c	BLADE AREA	2.0106 sq. mts	2.0106 sq. mts	2.0106 sq. mts	2.0106 sq. mts
d	DIAMETER	1600mm	1600mm	1600mm	1600mm
e	PITCH	1696mm	1696mm	1696mm	1696mm
13	FISHING EQUIPMENTS				
a	NO. OF NETS	3	3	3	3
b	TYPE	TRAWL	TRAWL	TRAWL	TRAWL
c	WIRE ROPE L (m)	1000 mts	1000 mts	1000 mts	1000 mts
d	DIAMETER	16mm	16mm	16mm	16mm
f	WINCH CAPACITY	10 TONNES	10 TONNES	10 TONNES	10 TONNES
14	OTTER BOARD				
a	TYPE	POLYVALENT	POLYVALENT	POLYVALENT	POLYVALENT
b	MATERIAL	M.S.	M.S.	M.S.	M.S.
c	WEIGHT	500 kgs	500 kgs	500 kgs	500 kgs
15	FISH HOLD CAPACITY(cu. m.)				
a	FOR FISH	100 cu. m.	100 cu. m.	100 cu. m.	100 cu. m.
b	FOR SHRIMP	65 T	65 T	65 T	65 T
16	ENDURANCE (DAYS)	45	45	45	45
17	EXISTING INSTALLATION/RIGGING	OUTRIGGER/STERN-TRAWLING	OUTRIGGER/STERN-TRAWLING	OUTRIGGER/STERN-TRAWLING	OUTRIGGER/STERN-TRAWLING
18	FREEZING MACHINERY ON BOARD				
a	BOCK COMPRESSOR (No.)	3	3	3	3
	(CAPACITY)	10 TONNES EACH	10 TONNES EACH	10 TONNES EACH	10 TONNES EACH
b	IQF (CAPACITY)	1T	1T	1T	1T
c	PLATE FREEZER (CAPACITY)	1.5 T/D	1.5 T/D	1.5 T/D	1.5 T/D
19	CREW COMPLIMENT	15	15	15	15

Table 7.4.6a PERCENTAGE SHARE OF EACH OPERATING COST ON THE TOTAL VARIABLE COSTS OF DEEP SEA TRAWLER OPERATING FROM COCHIN FISHERIES HARBOUR FOR THE PERIOD 1992 - 1995

	1992-1993	1993-1994	1994-1995
MAINTENANCE EXPENDITURE			
FISHING NET AND ALLIED MATERIAL	9.68	10.20	11.37
DECK SPARES AND CONSUMABLES	5.65	5.46	4.91
TRAWLER MAINTENANCE	7.81	9.65	10.10
IMPORTED SPARES & C AND F CHARGES*	6.10	9.98	7.45
DRY DOCKING EXPENCES	0.00	1.89	2.63
H.S.D. AND LUBE OIL EXPENCES	48.71	47.47	43.41
MISCELLANEOUS EXPENCES			
CREW MESS	3.47	2.51	3.49
PORT CHARGES	1.33	1.32	1.41
PAYMENTS AND BENEFITS TO CREW			
CREW SALARIES	6.22	4.88	5.24
INCENTIVES	6.35	4.10	5.83
OUT-STATION ALLOWANCE	1.43	0.10	1.50
SEA ALLOWANCE	2.51	1.80	2.02
CREW MEDICAL AND LTA*	0.61	0.53	0.53
CREW WELFARE	0.13	0.10	0.10

Table 7.4.6b PERCENTAGE SHARE OF EACH OPERATING COST TO THE TOTAL REVENUE

FISHING NET AND ALLIED MATERIAL	6.25	8.35	6.52
DECK SPARES AND CONSUMABLES	3.65	4.47	2.82
TRAWLER MAINTENANCE	5.04	7.90	5.79
IMPORTED SPARES & C AND F CHARGES*	3.94	8.17	4.27
DRY DOCKING EXPENCES	0.00	1.55	1.51
H.S.D. AND LUBE OIL EXPENCES	31.46	38.87	24.89
MISCELLANEOUS EXPENCES			
CREW MESS	2.24	2.06	2.00
PORT CHARGES	0.86	1.08	0.81
PAYMENTS AND BENEFITS TO CREW			
CREW SALARIES	4.02	4.00	3.00
INCENTIVES	4.10	3.35	3.34
OUT-STATION ALLOWANCE	0.93	0.08	0.86
SEA ALLOWANCE	1.62	1.48	1.16
CREW MEDICAL AND LTA*	0.39	0.43	0.30
CREW WELFARE	0.08	0.09	0.06

Table 7.4.7a ECONOMIC ANALYSIS OF 27m DEEP SEA TRAWLERS OPERATING FROM COCHIN FISHERIES HARBOUR FOR THE PERIOD 1992

CAPITAL COSTS			
COST OF FB	9226337.5	9226337.5	9226337.5
COST OF FN	600000	600000	600000
COST OF OB	600000	600000	600000
TOTAL CAPITAL COSTS	10426337.5	10426337.5	10426337.5
FIXED COSTS (FC)	1992-'93	1993-'94	1994-'95
INTEREST ON CAPITAL	1107160.5	1107160.5	1107160.5
INTEREST ON LOAN	528359.83	528359.83	528359.83
INSURANCE	551397	518587	506216
DEPRECIATION OF FB	427857	427857	427857
DEPRECIATION OF FN	600000	600000	600000
DEPRECIATION OF OB	1182.06	1182.06	1182.06
TOTAL FIXED COSTS	3215956.39	3183146.39	3170775.39
OPERATING COSTS OR VARIABLE COSTS (VC)			
MAINTENANCE EXPENDITURE			
FISHING NET AND ALLIED MATERIAL	1307940.75	1790947.56	1995860.48
DECK SPARES AND CONSUMABLES	763534.22	959166.95	861895.98
TRAWLER MAINTENANCE	1055193.1	1694632.7	1772869.99
IMPORTED SPARES & C AND F CHARGES*	823462	1752001	1307059
DRY DOCKING EXPENCES	0	331782	462330
H.S.D. AND LUBE OIL EXPENCES	6580714	8335405	7618656
MISCELLANEOUS EXPENCES			
CREW MESS	469293	441553.25	612213.48
PORT CHARGES	179987	232523	247015
PAYMENTS AND BENEFITS TO CREW			
CREW SALARIES	840275	856784	919836
INCENTIVES	857293.5	719345.48	1022860
OUT-STATION ALLOWANCE	193605	17400	263605
SEA ALLOWANCE	339635	316855	354045
CREW MEDICAL AND LTA*	82318	92754	93283
CREW WELFARE	17175	18285	17144
TOTAL VARIABLE COSTS	13510425.57	17559434.94	17548672.93
TOTAL COSTS (FC+VC)	16726381.96	20742581.33	20719448.32
TOTAL REVENUE	20916000.00	21443000.00	30614000.00
NET PROFIT	4189618.04	700418.67	9894551.68
CATCH DETAILS			
QUANTITY (Kg.)	151415.00	195377.00	456992.00
VALUE (Rs. LACS)	209.16	214.43	306.14

Table 7.4.7b PERCENTAGE SHARE OF EACH OF THE MAJOR COMPONENTS ON OPERATING COST OF DEEP SEA TRAWLERS OPERATING FROM COCHIN FISHERIES HARBOUR FOR THE PERIOD 1992 - 1995

	1992-1993	1993-1994	1994-1995
MAINTENANCE EXPENDITURE	29.24	37.18	36.46
H.S.D. AND LUBE OIL EXPENCES	48.71	47.47	43.41
MISCELLANEOUS EXPENCES	4.80	3.83	4.90
PAYMENTS AND BENEFITS TO CREW	17.25	11.51	15.22

Table 7.4.8 OPERATIONAL ANALYSIS OF DEEP SEA TRAWLERS (27M) OPERATING FROM COCHIN FISHERIES HARBOUR FOR THE PERIOD 1992 - 1995

YEAR	1992-'93	1993-'94	1994-'95
FIXED COST PER KG OF CATCH (Rs.)	21.24	16.29	6.94
OPERATING COST PER KG OF CATCH (Rs.)	89.23	89.87	38.40
TOTAL COST PER KG OF CATCH (Rs.)	110.47	106.17	45.34
FUEL COST PER KG OF CATCH (Rs.)	43.46	42.66	16.67
AVERAGE VALUE REALISED PER KG CATCH(Rs.)	138.14	109.75	66.99
PROFIT PER KG CATCH (Rs.)	27.67	3.58	21.65
TOTAL FISHING HOURS/YEAR (AVG.)	3404	3496	3400
TRAWLING HOURS/YEAR (AVG.)	3282	3368	3275
STEAMING HOURS/YEAR (AVG.)	122	128	125
TOTAL FISHING HOURS/VOYAGE (AVG.)	851.00	874.00	755.56
FUEL CONSUMPTION (FC)/VOYAGE (AVG.)	56651.75	64269.75	51207.78
TOTAL FC (H.S.D. LITERS/YEAR) (AVG.)	226607	257079	230435
TOTAL FC FOR TRAWLING (LTS/YR) (AVG.)	218485.36	247666.50	221963.13
TOTAL FC FOR STEAMING (LTS/YR) (AVG.)	8121.64	9412.50	8471.88
TOTAL AVERAGE NUMBER OF VOYAGES	4	4	4.5
FUEL CONSUMPTION PER HOUR (AVG.)	66.57	73.54	67.78
TOTAL AVERAGE NUMBER OF FISHING DAYS	148	152	170
NUMBER OF DAYS PER VOYAGE	37	38	38

PERCENTAGE SHARE OF SHRIMP, LOBSTER AND OTHER FISH TO THE TOTAL CATCH FOR 1992-93, 1993-94 AND 1994-95

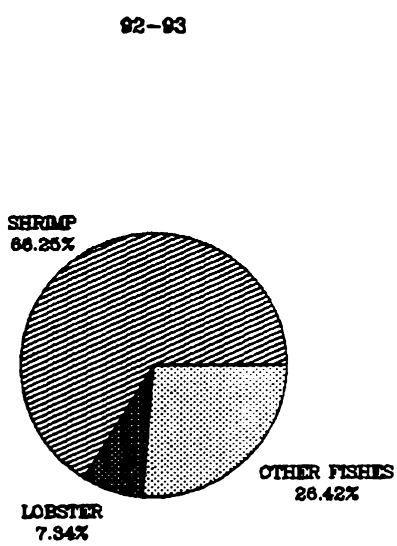


Fig.7.4.2a

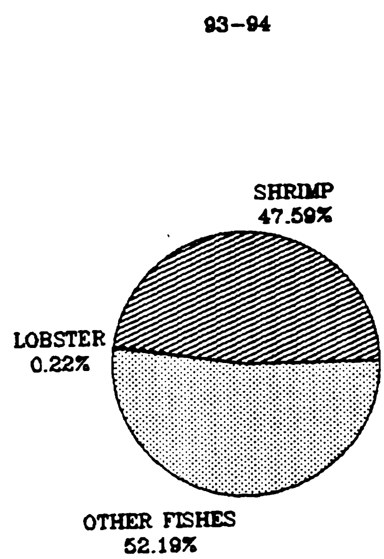


Fig.7.4.2b

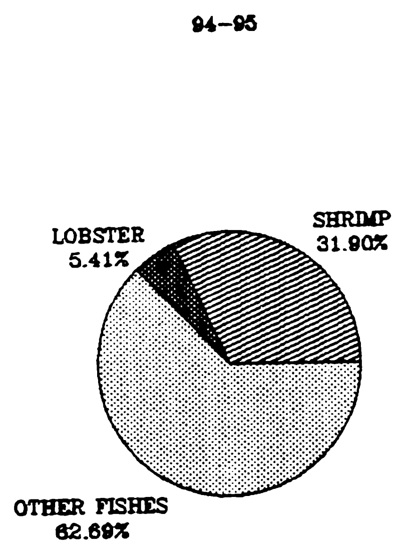


Fig.7.4.2c

PERCENTAGE SHARE OF EACH COMPONENT
OF FIXED COST TO THE TOTAL FIXED COST.

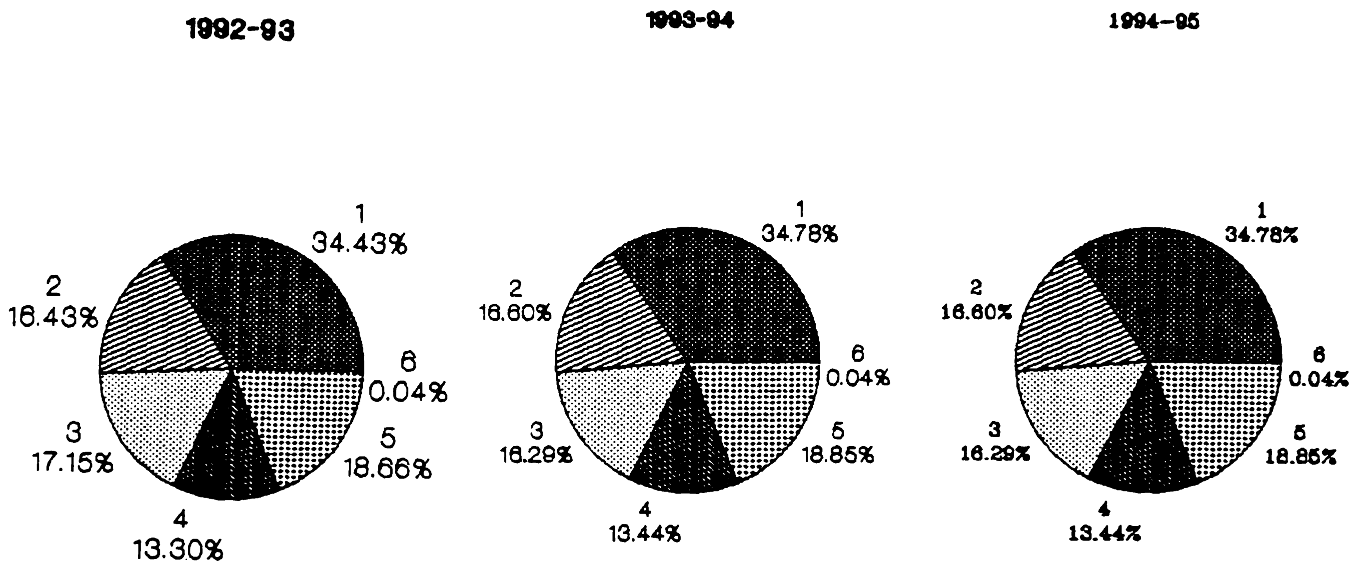


Fig.7.4.5a Fig.7.4.5b Fig.7.4.5c

1- INTEREST ON CAPITAL

2- INTEREST ON LOAN

3- ISURANCE

4- DEPRECIATION OF FB

5- DEPRECIATION OF FN

6- DEPRECIATION OF OB

ANNEXURE 7.3a PROFORMA FOR THE COLLECTION OF GENERAL INFORMATION OF DEEP SEA TRAWLERS

A. DETAILS OF COMPANY

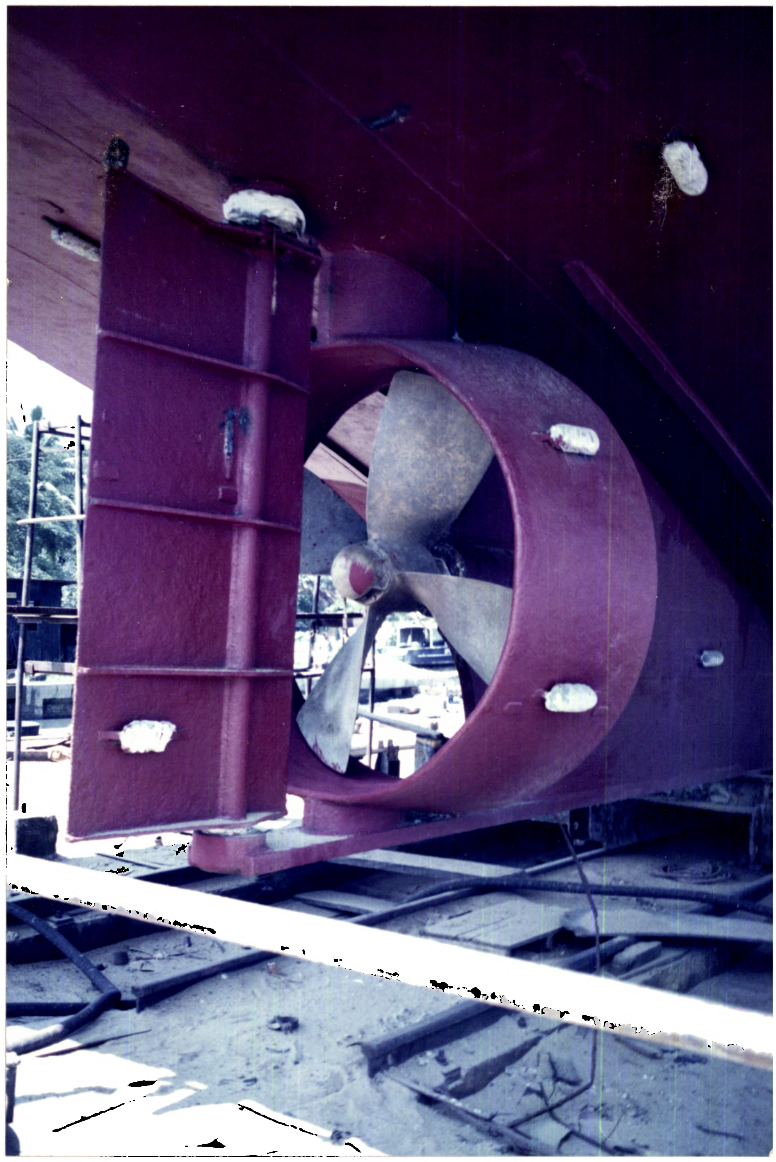
1 NAME OF THE COMPANY
2 ADDRESS
3 TELEPHONE NUMBER
4 DATE OF INCORPORATION
5 DATE OF COMMENCEMENT OF BUSINESS

B. DETAILS OF VESSELS OWNED

1 NAME OF THE VESSEL
2 MONTH AND YEAR OF BUILD
3 YARD/COUNTRY OF BUILD
4 DATE OF AQUISITION
5 TOTAL LANDED COST (Rs. IN LACS)
6 BASE OF OPERATION
7 DATE OF FIRST VOYAGE
8 TECHNICAL DETAILS
9 TYPE OF TRAWLING
10 LENGTH (m)
11 BREADTH (m)
12 DRAUGHT (m)
13 GRT
14 BHP (Main Engine)
15 MAKE
16 No. OF AUX. ENGINES
17 MAKE
18 HP
19 BOLLARD PULL
20 PROPELLER
a No. OF LEAFS
b MATERIAL
c BLADE AREA
d DIAMETER
e APERTURE
f PITCH
21 FISHING EQUIPMENTS
a NO. OF NETS
b TYPE
c COST OF EACH
d LENGTH OF HEAD ROPE
e WIRE ROPE L (m)
f DIAMETER
g WINCH CAPACITY
22 OTTER BOARD
a TYPE
b COST (ONE PAIR)
c MATERIAL
d WEIGHT
23 FISH HOLD CAPACITY(cu. m.)
24 ENDURANCE (DAYS)
25 EXISTING INSTALLATION/RIGGING
26 FREEZING MACHINERY ON BOARD WITH
27 CAPACITY
28 FUEL CONS. (L/Hr)
29 CREW COMPLIMENT
30 DATE OF RETURN FROM LAST VOYAGE

Plate. 7.3.a DEEP SEA TRAWLER(27m).

Plate. 7.4.1.0 KORT NOZZLE OF A 27m DEEP SEA TRAWLER.



CHAPTER 8

PRODUCTION FUNCTION ANALYSIS AND ENERGY EFFICIENCY OF MEDIUM TRAWLERS

8.1 PRODUCTION FUNCTION ANALYSIS

8.1.1 INTRODUCTION

Production is concerned with the way in which resources or inputs are employed to produce products or outputs. The concept of production is quite broad and encompasses both manufacture of physical goods and provision of services. A firm attempts to combine various inputs in such a way that minimum resources are committed to produce a given product or that maximum production results from a given input. Production analysis focuses on the efficient use of inputs to create outputs (Pappas and Hirschey, 1990). It examines the technical and economical characteristics of systems used to provide goods and services, with the aim of determining the optimal manner of combining inputs so as to minimize costs.

A production function expresses the technological or engineering relationship between the output of a product and its inputs. In other words, the relationship between the amount of various inputs used in the production process and the level of output is called a production function. Technology also contributes to output growth, as the productivity of the factors of production depends on the state of technology. The point which needs to be emphasised here is that the production function describes only efficient levels of output : that is, the output associated with each combination of inputs is the **maximum** output possible, given the existing level of technology. Production function changes as the technology changes.

Production function can be estimated by statistical techniques using historical data on inputs and output. One can hypothesise several alternative forms i.e., linear, quadratic,cubic etc., for this function. Though there are various forms of production function, empirical studies on the subject have found the Cobb-Douglas form to be the most appropriate.

8.1.1.1 The Cobb-Douglas production function

The most popular form of production-function to appear in economic literature is the Cobb-Douglas function.

Suppose $Q = f(N,K)$

This means that the physical output level, Q, depends upon, or is a function of the quantities of labour, N and capital, K, used. Given this, Cobb-Douglas form is

$Q = AN^{\alpha}K^{1-\alpha}$, where $0< \alpha < 1$, and A and α are constants.

The Cobb-Douglas is the most widely used production function in empirical work. The function is expressed by

$$Q = A\ L^{a}K^{b}$$

where Q is output and L and K are inputs of labor and capital, respectively. A, a (alpha) and b (beta) are positive parameters determined in each case by the data. The greater the value of A, the more advanced is the technology (Salvatore, 1983). The parameter a measures the percentage increase in Q resulting from a one percent increase in L while holding K constant. Similarly b measures the percentage increase in Q resulting from a one percent increase in K while holding L constant. Thus a and b are the output elasticity of L and K, respectively.

8.1.1.2 The fisheries production function

The fisheries production function (Anon, 1991) combines both biology and technology : biology is represented by fish stock (K) and technology by fishing effort (E). The functional relationship between these variables is as :

A model of fisheries economics should include both a biological unit and an economic unit. The biological unit consists of a growth function relating to natural growth (reproduction + individual growth - mortality) to the fish population size or stock.

In the logistic growth curve , G(X), point Xmsy is the fish stock that gives rise to maximum growth, K is the equilibrium population towards which a fishery tends to move, in the absence of fishing, given food availability and other environmental parameters.

The economic unit shows a relationship between output(catch) and input(effort). This is the production function.

$$Y = f\ (E); \quad f/E > 0; \quad f/E < 0 \quad \text{for } X = X$$

For a given X, the larger the effort, the greater is the catch. Conversely for any given X, the larger the value of X, the greater is the value of Y.

$$Y = h\ (X); \quad h/X > 0; \quad h/X < 0 \quad \text{for } E = E$$

Along the h(X) curve, E remains constant; shifts of the curve imply changes in effort.

Fishing effort (E) itself is a composite input that can be broken down into its component elements; capital, labour, materials and time spent. Capital itself is composite in character; it include the boat (including the engine) and the net. Factors such as, hp of the engine, length and tonnage of boat, mesh size of net and headrope length of net, influence the performance of the boat and net.

The fishery production function has some peculiar characteristics. Unlike other firms, the fishery unit produces not fish, but effort. Effort itself is collective in nature. The catching power thus produced, when multiplied by the time spent fishing, gives the amount of effort spent. On the other hand the time spent fishing determines the rate of capacity utilisation.

The fishery production function is characterised by positive but diminishing marginal products of stock and effort. Therefore the crux of managerial decision making is to find an optimum.

Effort which is a composite can be expressed as follows;

$E = (Ei)$

where i = 1, 2, 3,.........'n', stands for different components of effort such as

E1 - OAL of boat

E2 - horsepower of the engine

E3 - total fixed cost

E4 - maintenance expenditure

E5 - Fuel expenditure

E6 - Other expense

E7 - Wages

E8 - total man-hours spent on fishing

E9 - total running time of the vessel

E10- depth of operation of the fishing ground

E11- length of gear

E12- steaming time

We may state that : $Y = f(E) = f[(h(Ei))]$;...........

Where Y is the total output expressed in financial terms.

A translog production function of the Cobb-Douglas variety can give a more meaningful expression of the relation between the dependant variable on one hand and the independant variables. The form of the function is :

$$Y = B\ E1^{b1}\ E2^{b2} \ldots\ldots\ldots\ldots\ldots\ldots E12^{b12}$$

For estimates of the parameters, it is rewritten in following log-linear form :

$$Y = b0 + b1 \log E1 + b2 \log E2 + \ldots\ldots\ldots b12 \log E12$$

Here b0 is the log of B.

This equation is fitted to the sample data on catch and effort. The estimated values (Snedecor and Cochran, 1967), of the parameter 'bi' (b1, b2, b3,.......b12) supply the necessary information for the calculation of the marginal products of fishing inputs.

8.1.1.3 Overall elasticity

A crucial purpose of the production function estimates is to analyse elasticity of production. The marginal product of input i (MPi) gives the increase in catch contributed by an additional unit of input i. A meaningful measure of each input's contribution at the margin is it's production (catch) elasticity. It is defined as the percentage change in catch due to a percentage change in the quantity of input used. In a Cobb-Douglas model, the parameters 'bi' themselves are the production elasticities. The elasticity of production of input (i) is less than, equal to, or greater than unity as MPi is relatively less than, equal to, or greater than average product of input (APi). It will be positive as long as both APi and MPi are positive.

From the economic analysis of medium trawlers worked out in Chapter 6, it is clear that fuel expenditure is consuming on an average around 45% of the total variable costs of a medium trawler. Economic rationality demands a progressive reduction of the unit cost of fuel, inorder to arrive at greater productivity and profitability. To put alternatively, the value of 'b' with respect to fuel should show a figure, greater than unity (Anon, 1991). In this study a production function model was fitted with the aim of evaluating the economic efficiency of input utilisation in trawler operation and also to determine the effect of fuel expenditure on the output of medium trawlers.

8.1.2 Materials and methods

The data used in this study pertained to 22 trawlers operating from the Cochin Fisheries Harbour. The data collected for working out the economic and operational analysis of the medium trawlers operating from the Cochin Fisheries Harbour was utilised for this study. Thus the average of cost and earnings, technical and operation details recorded for the period September 1992 - October 1994 was used in this analysis.

The statistical approach of cross-sectional analysis (Anon, 1991) has been adopted for this study. Cross-sectional analysis deals with data collected at one particular time. The data thus might be linked to a snapshot, frozen in time. Instead of making observations of the variables for each year, the variables are observed for each boat sampled during a particular year.

The Cobb-Douglas production function (Panikkar and Srinath. 1990) was used for analysis which is given below.

$$Y = b0 \quad E1^{b1} \; E2^{b2} \; E3^{b3} \ldots\ldots\ldots\ldots E12^{b12}$$

Where Y is the dependant variable and E1, E2, E3 etc. are the independant variables. b0 is a constant and b1, b2, b3 etc. are regression coefficients.

The definitions of variables used in this study and the relevant concepts are discussed below.

Y (E13) - is the dependant variable and it is the output in financial terms. The output (revenue) of each vessel is the value of its total catch.

E1 - is the overall length of each vessel in feet. The length of the boat was measured from the tip of the bow to the stern.

E2 - is the horse power of the engine. The horse power of the engine at 1800 RPM was taken as standard since it is approximately the steaming RPM of the engine.

E3 - this is the total fixed costs. It includes the interest on the total capital costs and the depreciation cost of the boat net and otter board.

E4 - is the maintenance expenditures inclusive of the expense incurred in repairing the boat, engine, propeller and net in rupees.

E5 - is the fuel expenditure and includes both the total expenses for lubrication oil and diesel in rupees.

E6 - other expenses including the expenses for harbour toll, ice, basket and miscellaneous expenses in rupees.

E7 - wages inclusive of batta, crews share and agent's commission in rupees.

E8 - total man-hours spent on fishing. This has been calculated by multiplying the total number of days fished by average number of hours working per day by the average number of crew.

E9 - total running time of the vessel. Computed by multiplying the total number of days fished by the average number of hours working per day.

E10- depth of operation of the fishing ground. Since the boats operated with three types of nets, each having a different average operating depth, the depth of operation had three values for each boat. Hence the multiple regression is repeated for each average depth. The depth of operation has been taken in fathoms.

E11- length of gear. Since three types of nets were operated, similar to the E10 variable the length of the gear also had three values corresponding to the depth of operation of each. The length of the gear is taken in meters.

E12- steaming time. This is the time taken by the vessel to reach and come back from the fishing ground. This is computed by multiplying the total number of days fished by each boat by the average number of hours taken to go and come back from the fishing ground.

8.1.3 Results and Discussion

The estimated production equation, for the three multiple regression outputs (Table 8.1.3.1, Table 8.1.3.2 and Table 8.1.3.3), is given below

8.1.3.1 Production equation fitted for average depth of operation

19 fathoms and average length of net 33 meters (Table 8.1.3.1.)

$$Y = 1.4231\ E1^{.4587}\ E2^{.1323}\ E3^{.004}\ E4^{.0364}\ E5^{-.0101}\ E6^{.014}$$
$$E7^{.0984}\ E8^{-.2111}\ E9^{1.0251}\ E10^{-.3026}\ E11^{.314}\ E12^{-.022}$$
$$R^2 = 97.85\%$$

In this equation figures representing bi (b1, b2, ... b12), for the effort parameters except E5, E8, E10 and E12 are positive. Here, while considering each parameter separately, a respective percentage increase of these parameters by the figures represented by b1, b2, b3, b12, will lead to a respective percentage increase in output (Y) while holding the other parameters constant. But in the case of E5, E8, E10 and E12, it will lead to a respective percentage decrease in output while holding the other parameters constant.

8.1.3.2 Production equation fitted for average depth of operation 24 fathoms and average length of net 31 meters (Table 8.1.3.2)

$$Y = 2.6132\, E1^{.4398}\, E2^{.1867}\, E3^{-.1711}\, E4^{.0225}\, E5^{.0194}\, E6^{.021}\, E7^{.2863}\, E8^{.4660}\, E9^{-.5014}\, E10^{-.527}\, E11^{.6879}\, E12^{.2790}$$

R^2 = 98.19%

From the equation it is evident that the figures representing bi (b1, b2, ... b12), for the effort parameters except E3, E9, and E10 are positive. Here, while considering each parameter separately, a respective percentage increase of these parameters by the figures represented by b1, b2, b3, b12, will lead to a respective percentage increase in output (Y) while holding the other parameters constant. But in the case of E3, E9, and E10, it will lead to a respective percentage decrease in output while holding the other parameters constant.

8.1.3.3 Production equation fitted for average depth of operation 45 fathoms and average length of net 47 meters (Table 8.1.3.3

$$Y = 4.3465\ E1^{.7982}\ E2^{.1427}\ E3^{-.1814}\ E4^{-.019}\ E5^{.0016}\ E6^{.0861}\ E7^{.955}\ E8^{-1.0301}\ E9^{.0041}\ E10^{-.7238}\ E11^{.1586}\ E12^{.2733}$$

$R^2 = 97.12\%$

The figures representing bi (b1, b2, ... b12)in the equation, for the effort parameters except E3, E4, E8 and E10 are positive. Here, while considering each parameter separately, a respective percentage increase of these parameters by the figures represented by b1, b2, b3, b12, will lead to a respective percentage increase in output (Y) while holding the other parameters constant. But in the case of the effort parameters E3, E4, E8 and E10, it will lead to a respective percentage decrease in output while holding the other parameters constant.

The R-squared (multiple correlation coefficient) calculated for fitting the three production models fitted averages 97.72%, which indicates that a very substantial part of variability is explained by the 12 factors taken for forming all the three models. The very high value of R-squared also indicates that the fitted models are a good fit for the data.

In all the three production models the variance ratio (F ratio), as seen from the Analysis of Variance tables (Table 8.1.3.1, Table 8.1.3.2 and Table 8.1.3.3), for regression coefficients shows a very high significance ($p < 0.001$).

Comparing the three production equations, the value of the constant b0, though in all cases higher than unity, is highest (4.3465) in the case of the equation fitted for average depth of operation 45 fathoms and average length of net 47 meters. This implies that technology imparted for fishing effort is highest in this case. The high depth of operation and length of net influenced by the improved technology of using boats of higher overall length installed with higher horse power of engine. In the three production equations fitted it can be seen that the value of b with respect to fuel (b5) i.e. fuel expenditure is -0.0101, 0.0194 and 0.0016 respectively. For higher productivity and profitability, it is necessary that this figure be greater than unity. But, here, in the first case it is negative and in the second and third cases it forms a meagre 0.01% and 0.001% of unity respectively. From this it becomes evident that fuel expenditure is creating a negative influence on the productivity and profitability of the medium trawlers sampled. Thus the production model fitted here highlights the importance and urgency of implementing energy optimisation measures with respect to fuel use control in the medium trawlers operating along the Kerala coast.

8.2 Energy efficiency of medium trawlers

8.2.1 Introduction

Energy conservation and fuel saving have been given a very high priority since the dramatic price increase of fuel in the seventies. Major programmes for better energy housekeeping have been undertaken by many nations and many fishing nations have carried out studies and research and development programmes for fuel saving in the fisheries. The interest in such activities both from fishermen and from the authorities, appears to be related to the fuel prices.

In 1980, Norway launched a major energy saving programme. The fuel price and consumption per kilogram of fish landed for different fishing methods assessed. Purse seining for schooling fish is very efficient in terms of kilogram of fuel per kilogram of fish, and even more so energy-wise, due to the high fat content of this type of fish. Offshore trawling for groundfish shows the highest consumption. In the late seventies most Norwegian wetfish trawlers used 1kg of fuel per kg of fish caught. At that time trawling used about three times as much fuel as longlining and three to four times more than coastal fishing. Inshore fishing at that time used about 0.1kg of fuel per kilogram of fish. An important factor in a high cost country like Norway is the productivity of labour. Expressed in landed fish per man-year, the trawlermen are twice as efficient as the longliners and three times more so than the coastal fishermen (Endal, A. 1988).

The fuel saving of medium trawlers in relation to fishing trip duration has been worked out in Chapter 6 based on the length class of boats, but it was observed that the fuel consumption levels of the medium trawlers in the different length classes for which analysis has been done is influenced by the horse power of the engine installed. Moreover, the fuel consumption observations on medium trawlers presented in Chapter 4, proved that the fuel consumption levels of fishing trawlers are influenced by the horse power of the engine installed, hence an attempt is made here to classify the medium trawlers based on the engine horse power installed and an analysis is done to arrive at the actual level of fuel saving of a medium trawler in relation to the duration of the fishing trip. Further based on this classification of the medium trawlers the energy yield of the trawlers, for which economic and operational analysis has been done in Chapter 6, is worked out.

8.2.2 Objectives

i) To analyse the energy efficiency of the medium trawlers in terms of the fuel consumption of the engine type installed.

ii) To study the energy efficiency of the medium trawlers with reference to the energy yield.

8.2.3 Materials and Methods

8.2.3.1 Energy efficiency and fuel efficiency of engine installed

To study the energy efficiency with reference to the fuel efficiency of the engine type installed, the data of the economics of operation and operation details of the 22 medium trawlers sampled were recomputed according to the engine type installed. The engine type installed on these 22 medium trawlers were of three types, Maarna, Ruston and Ashok Leyland Marine diesel engines. Of these, Maarna and Ruston were low horse power engines installed on 28' trawlers coming under the 25-30 feet length class while all the other trawlers were installed with higher horse power Ashok Leyland engines. The Ashok Leyland engines installed included the models; ALM 370, ALM 400, ALM 402 and ALM 680. Thus the 22 trawlers were grouped under six engine types. The heads under which the data were recomputed include

Engine type/Model
Engine horse power
Average length of boat
Total average fishing hours per year
Total average steaming time per year
Total average trawling hours per year
Average number of trips per year
Average number of days fished per year
Average number of days per trip
Total average fuel consumption per year(liters)
Average fuel consumption per trip (liters)
Average fuel consumption per day/trip day (liters)
Total average fuel consumption for trawling (liters/year)
Total average fuel consumption for steaming (liters/year)
Average fuel consumption per hour (liters)

The fuel consumption analysis for the medium trawlers according to the engine type installed is presented in Table 8.2.3.1. The analysis for the medium trawlers fitted with ALM 400 engines was done in two ways, one grouping the wooden trawlers together and the other grouping the steel trawlers. In the case of the analysis of the fuel consumption of the ALM 402 engines, the analysis was repeated for the medium trawlers above 50 feet.

8.2.3.2 Energy efficiency and energy yield

Energy yield is the kilogram of catch per liter of fuel consumed. In order to study the energy efficiency of the medium trawlers, the economic and operational analysis of the 22 medium trawlers sampled has been utilised. The trawlers were classified under six engine types as in 9.5.3.1 and the energy yield has been worked out. The energy yield is worked out by dividing the total average catch per year by the total average fuel consumption per year. The various heads under which data were computed for this calculation include

Engine type
Engine horse power
Average length of trawler (ft)
Total average fuel consumption per year (lts)
Total average catch (kg/yr)
Kilogram catch per liter of fuel

As in the case of fuel consumption analysis (8.2.3.1), the engine types have been grouped and the energy yield worked out is presented in Table 8.2.3.2.

8.2.4 Results and Discussion

8.2.4.1 Energy efficiency and fuel efficiency of engine type installed

From the Table (8.2.3.1) on fuel consumption analysis it is evident that there is clear increase in the average fuel consumption per hour with the increase in engine horse power. For the ALM 400 and ALM 402 engines the average of the two fuel consumption values have been taken. The increase in fuel consumption was not observed to be proportional to the increase in over all length of the boat. In the case of ALM 400 engine fitted to steel hull of average length 45', the fuel consumption was lower by 10% from the same engine model fitted to a wooden hull of average length 38.5'. It was observed that the wooden hull was older by more than a year compared to the steel hull. Similarly, in the case of ALM 402 engine fitted to a wooden hulls of average length 52', the lower fuel consumption, though negligible, came to 3.25%. From the observations it is clear that the horse power of the engine installed is not proportionate to the overall length of the boat. The wooden trawlers of average length 38.5', being fitted with a 90hp engine, while the same engine fitted on steel trawlers of average length 45' was performing at a lower fuel consumption level. Similarly, the ALM 402 model engine was observed to be fitted on trawlers of average length 52' and 49', the fuel consumption slightly lower in the first case. These can be considered as clear cases of over powering, as proved earlier from the studies conducted by Hameed et al. 1988.

8.2.4.2 Energy efficiency and energy yield

The results of the analysis is presented in Table 8.2.3.2. For comparison purposes, the average of the values for kilogram catch per liter of fuel for the Maarna and Ruston engines are taken. Similarly the two values for ALM 400 engine fitted trawlers are taken as an average while for the ALM 402 engine fitted trawlers also the same is repeated. Thus it can be observed from the table that the kilogram catch per liter of fuel consumed was highest at 2.95 kilogram per liter of fuel consumed, for the low horse power engines fitted to trawlers of average length 28'. In the case of ALM engine fitted trawlers, the energy yield is close to unity for the ALM 370, 400 and 402 engine model fitted trawlers, but for the ALM 680 model fitted trawlers it was the lowest at 0.66 kilogram per liter of fuel consumed. Thus the energy efficiency of the medium trawlers with reference to energy yield can be said to be highest for the trawlers fitted with engines of horse power around 30 and lowest for the trawlers fitted with a 148 hp engine.

Table 8.1.3.1 MULTIPLE REGRESSION OUTPUT FOR AVERAGE DEPTH OF OPERATION 19 FATHOMS AND AVERAGE LENGTH OF NET 33 METERS

VARIABLES	DESCRIPTION	REGRESSION COEFFICIENT (bi)	PROBABILITY	PARTIAL r^2
E1	OAL OF BOAT	0.4587	0.46726	0.0602
E2	HORSE POWER OF ENGINE	0.1323	0.36383	0.0923
E3	TOTAL FIXED COSTS	0.004	0.97798	8.95E-05
E4	MAINTENANCE EXPENDITURE	0.0364	0.37734	0.0874
E5	FUEL EXPENDITURE	-0.0101	0.90785	0.0016
E6	OTHER EXPENCES	0.014	0.8129	0.0066
E7	WAGES	0.0984	0.77332	0.0097
E8	TOTAL MAN-HOURS SPENT ON FISHING	-0.2111	0.92298	0.0011
E9	TOTAL RUNNING TIME OF VESSEL	1.0251	0.6516	0.0239
E10	DEPTH OF OPERATION	-0.3026	0.02135	0.4623
E11	LENGTH OF GEAR	0.314	0.62119	0.0283
E12	STEAMING TIME	0.022	91744	0.0013
CONSTANT	OUTPUT	1.4231		

STD. ERR. OF EST. = 0.0432

R SQUARED = 0.9785

ANALYSIS OF VARIANCE TABLE

SOURCES	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
REGRESSION	0.7648	12	0.0637	34.159	5.157E-06
RESIDUAL	0.0168	9	0.0019		
TOTAL	0.7816	21			

Table 8.1.3.2 MULTIPLE REGRESSION OUTPUT FOR AVERAGE DEPTH OF OPERATION 24 FATHOMS AND AVERAGE LENGTH OF NET 31 METERS

VARIABLES	DESCRIPTION	REGRESSION COEFFICIENT (bi)	PROBABILITY	PARTIAL r^2
E1	OAL OF BOAT	0.4398	0.45582	0.0632
E2	HORSE POWER OF ENGINE	0.1876	0.17387	0.195
E3	TOTAL FIXED COSTS	-0.1711	0.37607	0.0879
E4	MAINTENANCE EXPENDITURE	0.0225	0.54338	0.0424
E5	FUEL EXPENDITURE	0.0194	0.80884	0.0069
E6	OTHER EXPENCES	0.021	0.6934	0.0181
E7	WAGES	0.2863	0.32676	0.1067
E8	TOTAL MAN-HOURS SPENT ON FISHING	0.466	0.82514	0.0057
E9	TOTAL RUNNING TIME OF VESSEL	-0.5014	0.82889	0.0055
E10	DEPTH OF OPERATION	-0.527	0.01364	0.5094
E11	LENGTH OF GEAR	0.6879	0.24899	0.1444
E12	STEAMING TIME	0.279	0.32214	0.1087
CONSTANT	OUTPUT	2.6132		

STD. ERR. OF EST. = 0.0397

R SQUARED = 0.9819

ANALYSIS OF VARIANCE TABLE

SOURCES	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
REGRESSION	0.7675	12	0.064	40.633	2.432E-06
RESIDUAL	0.0142	9	0.0016		
TOTAL	0.7816	21			

Table 8.1.3.3 MULTIPLE REGRESSION OUTPUT FOR AVERAGE DEPTH OF OPERATION 45 FATHOMS AND AVERAGE LENGTH OF NET 47 METERS

VARIABLES	DESCRIPTION	REGRESSION COEFFICIENT (bi)	PROBABILITY	PARTIAL r^2
E1	OAL OF BOAT	0.7982	0.29426	0.1211
E2	HORSE POWER OF ENGINE	0.1427	0.52826	0.0456
E3	TOTAL FIXED COSTS	-0.1814	0.14749	0.2182
E4	MAINTENANCE EXPENDITURE	-0.019	0.70183	0.0171
E5	FUEL EXPENDITURE	0.0016	0.98815	2.59E-05
E6	OTHER EXPENCES	0.0861	0.21461	0.1653
E7	WAGES	0.955	0.10852	0.2607
E8	TOTAL MAN-HOURS SPENT ON FISHING	-1.0301	0.67844	0.0200
E9	TOTAL RUNNING TIME OF VESSEL	0.0041	0.99887	2.35E-07
E10	DEPTH OF OPERATION	-0.7238	0.04869	0.3658
E11	LENGTH OF GEAR	0.1586	0.81903	0.0061
E12	STEAMING TIME	0.2733	0.15031	0.2155
CONSTANT	OUTPUT	4.3465		

STD. ERR. OF EST. = 0.0500

R SQUARED = 0.9712

ANALYSIS OF VARIANCE TABLE

SOURCES	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
REGRESSION	0.7591	12	0.633	25.287	1.872E-05
RESIDUAL	0.0225	9	0.0025		
TOTAL	0.7816	21			

Table 8.2.3.1 FUEL CONSUMPTION ANALYSIS OF MEDIUM TRAWLERS ACCORDING TO ENGINE TYPE INSTALLED

ENGINE TYPE/MODEL	MAARNA	RUSTON	ALM 370	ALM 400 (WOOD)	ALM 400 (STEEL)	ALM 402	ALM 402 (› 50')	ALM 680
ENGINE HORSE POWER	24	37.5	81	90	81	100	100	148
AVERAGE LENGTH OF BOAT (ft)	28	28	32	38.5	45	49	52	43
TOTAL AVERAGE FISHING HOURS PER YEAR	2503	2350.67	3647	3329.29	3243	3561.67	3671	3078.5
TOTAL AVERAGE STEAMING TIME	745.33	652	1684	1441	924	1465	1336.5	1146
TOTAL AVERAGE TRAWLING HOURS PER YEAR	1757.67	1698.67	1963	1888.29	2319	2096.67	2334.5	1932.5
AVERAGE NUMBER OF TRIPS PER YEAR	213	217.33	210.5	151.71	84	135.67	121.5	95.5
AVERAGE NUMBER OF DAYS FISHED PER YEAR	213	217.33	241	231.43	238	254.33	264.5	238.5
AVERAGE NUMBER OF DAYS PER TRIP	1	1	1.15	1.54	2.84	1.93	2.18	2.5
TOTAL AVERAGE FUEL CONSUMPTION PER YEAR (lts)	9427.33	11488.67	40420	49907.71	43636.5	55768.33	55690.5	62338.5
AVERAGE FUEL CONSUMPTION PER TRIP	44.27	53.06	168.71	332.24	519.59	421.22	461.33	654.12
AVERAGE FUEL CONSUMPTION PER DAY/TRIP DAY	44.27	53.06	147.27	215.42	183.14	220.38	211.07	261.35
TOTAL AVERAGE FUEL CONSUMPTION FOR TRAWLING (lts/yr)	6621.18	8302.65	19096.46	28326.18	31203.41	32678.01	35458.42	39140.78
TOTAL AVERAGE FUEL CONSUMPTION FOR STEAMING (lts/yr)	2806.15	3186.02	16403.54	21581.54	12433.09	23090.32	20232.08	23197.72
AVERAGE FUEL CONSUMPTION PER HOUR (lts)	3.77	4.9	11.08	14.98	13.46	15.7	15.19	20.28

Table 8.2.3.2 ENERGY YIELD OF MEDIUM TRAWLERS ACCORDING TO THE ENGINE TYPE INSTALLED

ENGINE TYPE	MAARNA	RUSTON	ALM 370	ALM 400 WOOD	ALM 400 STEEL	ALM 402	ALM 402 (› 50')	ALM 680
ENGINE HORSE POWER	24	37.5	81	90	81	100	100	148
AVERAGE LENGTH OF TRAWLER (ft)	28	28	32	38.5	45.00	49	52	43
TOTAL AVERAGE FUEL CONSUMPTION PER YEAR (lts)	9427	11489	40420	49908	43636	55768	55690	62338
TOTAL AVERAGE CATCH (kg/yr)	18264	45391	39672	35333	50545	59160	64944	41211
KG CATCH PER LITER OF FUEL	1.94	3.95	0.98	0.71	1.16	1.06	1.17	0.66

SUMMARY

Energy optimisation has become inevitable in the fisheries sector of the developed and developing countries especially after the rapid fuel price rise of the seventies. A large number of research and development activities and fuel conservation programmes aimed at reducing the fuel consumption levels in fishing have been initiated many developed and developing countries. Trawling has been confirmed to be a highly energy intensive fishing method. An analyse of the energy consumption levels of the trawlers operating along the Kerala coast has been conducted aimed at fisheries energy optimisation.

Chapter 1

The first chapter reviews the works related to energy optimisation both in the International context and the Indian context. The energy optimisation researches underway in most developed countries is directed towards energy conservation and the use of alternative energy sources in fishing. In India energy inefficiencies which has lead to excessive fuel consumption in fishing is attributed to overpowering of the vessels, obsolete designs, excessive fouling of the hull leading to increased frictional resistance of a vessel and the inefficiency in propeller use.

Chapter 2

Resource estimates are important in assisting and directing the effort to particular resource locations leading to effective fish capture. The resource estimates for the Indian EEZ as suggested by various authors are discussed. The unexploited and underexploited resources beyond 50m depth is projected as the resource for future developmental strategy. The exploited marine fishery resources of Kerala, contributing on an average to the tune of around 25% of the annual marine fish landings of India, is presented in detail. Statistical enumerations on the exploitation of the marine fishery resources from 1950 to 1993 are discussed.

Chapter 3

The trawl net designs of the state of Kerala have been surveyed from a very broad perspective. The net designs used by three classes of vessels; the artisanal craft fitted with OBM (small trawler), mechanised fishing boats fitted with inboard diesel engines and the deep sea trawlers, were surveyed. The results of the survey showed that the net designs varied with the horse power of the propulsion system in the case of the artisanal and the medium trawlers. In the case of the deep sea trawlers the net designs of a 550 horse power of vessel was surveyed. In the case of the artisanal craft the most common net design of 7.5hp, 15hp, 20hp and 25hp OBM fitted craft along the Kerala coast is presented. Regarding the design of trawl nets operated by the medium trawlers, the designs could be grouped into four classes depending on the type of net and horse power of the engine installed. Basically five types of nets are found to be operated by the medium trawlers, three types of shrimp trawls and two types of fish trawls. The deep sea trawlers of 27m length powered with a 550 hp engine were found to be using two designs of nets: one was a four seam net aimed at the deep sea shrimp resources and the other a six seam net aimed at cuttle fish. The data sheet is presented for all the designs and discussed in detail.

The trawl net resistance of all the designs surveyed were calculated. The results of the computation indicate that in the case of the trawl net designs of the artisanal craft the resistance values varied from 6.9kgf to 12.9kgf. For the net designs of the medium trawlers the resistance varied from 27.28kgf to 305.76kgf. The trawl resistance values of the two deep sea trawl net designs were 603.25kgf for the four seam net and 414.24kgf for the two seam design. In all the cases it was observed that the resistance values varied with the speed of tow and the mesh size of the various sections of the net.

Flat rectangular otter boards were found to be the most popular otter boards used by the small trawlers as well as the medium trawlers. Hence the design of these flat rectangular otter boards along the Kerala coast has been surveyed. The designs are illustrated and discussed. The small trawlers were found to be using three different dimensions of otter boards, depending upon the length of the net and the horse power of the OBM used. The dimensions were 24 x 12.5" for 8hp OBM fitted crafts, 27 x 14" for 15hp and 20hp OBM fitted crafts and 30 x 15" for the 25hp OBM fitted crafts. In the case of the 15hp and 20hp OBM fitted craft though the dimensions were same the weights varied. In the medium trawlers the design of the flat rectangular otter boards used by the 25-30ft length class varied from a common design used by the trawlers above this length class. The design of flat rectangular otter boards of the medium trawlers indicated a similar design for all the length classes of trawlers except that the weights varied in the case of ALM 370, 400 and 402 engine fitted trawlers while for the ALM 680 engine fitted trawlers the dimension was slightly bigger.

Chapter 4

The fuel consumption levels of medium trawlers were assessed in relation to RPM of the main engine, hull fouling and material of construction of the hull by direct measurements. The efficiency of the installed propellers of selected medium trawlers were worked out. The overpowering in medium trawlers were calculated in relation to the torque developed by the engine and the efficiency of the installed propellers. Fuel consumption tests showed that the average percentage increase in fuel consumption between 0 to 3 months was 14.06% and between 0 to 6 months the total average increase was recorded at 33.8%. Fuel consumption tests revealed that the average increase in fuel consumption of ALM 370 engine fitted trawlers was 34.83% between 1600 and 1900 RPM. In the case of the ALM 400 engine fitted trawlers the increase was recorded at 31.9% and for the ALM 402 engine fitted trawlers at 30.08%.. In the case of fuel consumption in relation to hull fouling it was observed that for the steel medium trawlers of average length 43' the total average fuel consumption was lower by 7.58% than the wooden medium trawlers of the same length. Propeller efficiency tests conducted on twenty five steel medium trawlers indicate that the installed propeller efficiency of all the cases analysed was lower than the optimum. In all the twenty five cases analysed the maximum difference in installed and optimum efficiency values came to 6.9% and the minimum difference 1.2%. This means that on an average the efficiency of propellers installed on medium trawlers can be improved by around 5%. Overpowering when studied in relation to the torque developed by the engine and the propeller, it was observed that all the twenty five cases in which propeller efficiency calculation was done were overpowered. The average percentage of overpowering in medium trawlers worked out to around 10%. When overpowering was studied in relation to the efficiency of propeller use it could be confirmed that all the samples representing the medium trawlers of length 32' to 53' were overpowered.

Chapter 5

The performance of the small trawlers in relation to the fuel consumption levels of the out board motors installed were surveyed from five centers along the Kerala coast. The survey indicated that the mini trawl nets are operated mainly by three horse powers of out board engine fitted crafts, the 7.5hp, 15hp, 20hp and 25hp. the length of the craft varied from 7.5 to 10m. The average fuel consumption per hour for the different OBM's was observed at 3.5 to 4 liters per hour for 7.5hp, 4.5 to 5 liters per hour for the 15hp OBM, 5liters per hour for the 20hp and 6 liters per hour for the 25hp OBM.

Chapter 6

The medium trawlers of Kerala were grouped in to five length classes and an operational analysis worked out to study the economics of operation of the various length classes and assess the fuel efficiency of operations in relation to the fishing trip duration of the various length classes. The percentage cost of fuel expenditure over the total operating costs worked out to 45.42% on an average for the trawlers in all the length classes.The fuel consumption per hour for the medium trawlers varied from 4.3 liters per hour for the 25-30 ft length class to 17.6 liters per hour for the 50-55ft length class. An average saving of 1.5 crores per year was possible for the medium trawlers in the length class 30-35 ft operating along the Kerala coast in converting the one-day trips to two day trips. The instances for energy inefficiency occurring in these trawlers have been assessed and suitable remedial measures suggested.

Chapter 7

In this chapter the operational analysis of the deep sea trawlers has been worked with the aim of assessing the operational efficiency in terms of fuel use for the deep sea fishing vessels. The average percentage share of fuel expenditure to the total operating expenses worked out to 46.29% for all the deep sea trawlers. Average fuel consumption for a 27m steel trawler fitted with 550 hp main engine worked out to 69.3 liters per hour. The fuel use and operational profitability of the deep sea trawlers have been worked out and the energy saving measures to be implemented for deep sea vessels are suggested.

Chapter 8

A production function analysis has been worked out for the 22 medium trawlers for which operational analysis has been worked out in chapter 6. Three production models were fitted based on the depth of operation and length of fishing net used. Based on the results of the analysis it has become evident that fuel expenditure is creating a negative influence on the productivity and profitability of the medium trawlers sampled.

The energy efficiency of the medium trawlers has been studied in terms of the fuel efficiency of the engine type installed and the energy efficiency of the medium trawlers with reference to energy yield worked out.

RECOMMENDATIONS

1. From the design survey on trawl nets it was observed that the net designs used by the medium trawling fleet of Kerala were two seam nets, but is evident that a four seam net is capable of better mouth opening and filtering more quantity of water, which can result in higher catch rates per haul. It is recommended that four seam net designs be used by the medium trawling fleet of Kerala.

2. Another fact observed from the survey of net designs is that the cod-end mesh size was as low as 18mm. This calls for immediate attention towards mesh regulation in trawl fishing. It is recommended that the mesh size at the cod end of the trawl nets be fixed at 35mm aimed at resource conservation.

3. Since speed of the vessel or conversely running at a high engine RPM is identified to cause excessive fuel consumption in fishing vessels, it is recommended that the medium trawling fleet reduce their steaming RPM from 1900 to 1800.

4. It was observed that, in the propellers installed on the medium trawling fleet of Kerala that the efficiency of the installed propellers was lower by an average of 5%. This can lead to lower speed of the vessel as a result of which the operators are forced to increase the RPM leading to higher fuel consumption. Hence a new propeller design model should be installed on the medium trawling fleet of Kerala.

5. It is further recommended that the medium trawlers with OAL ranging from 38ft to 43ft be installed with 41" diameter propeller and P/D ratio of 0.61 to 0.73. The medium trawlers of OAL 43ft to 52ft are recommended to be installed with a 42" diameter propeller with P/D ratio of 0.71.

6. A maximum of 100hp at maximum continuous RPM of 2000 is recommended for the trawlers in the 40ft to 45 and for the trawlers between 45ft to 55 ft length range a maximum of 110hp at a maximum continuous RPM of 2000 is recommended.

7. The artisanal fishing craft fitted with 7.5 hp OBM were found to performing the best among the mini trawl net operating crafts with regard to fuel consumption. Hence 7.5hp is recommended as the horse power of OBM for the artisanal craft operating mini trawl nets.

8. The medium trawlers operating along the Kerala coast were not observed to be using anti-fouling paints to the under water surfaces of the hull resulting in excessive attachment of fouling organisms. It is recommended that the medium trawlers use CIFT specified anti-fouling paints and reduce the level of attachment of fouling organisms.

9. It is recommended that the average idling time at the harbour for the medium trawlers be reduced to 15 mins from the present average of 45 mins, through quick measures for auctioning or conversely that the medium trawlers stop their engines while auctioning is going on.

10. Instances of propeller repitching were many on the medium trawlers fitted with the propellers made of gun metal. Propeller repitching can cause increased fuel consumption due to reduced efficiency of the propeller wereby the operators are forced to increase the RPM of the engine leading to increased fuel consumption. Hence it is recommended that the medium trawlers use manganese bronze a stronger and reliable material than gun metal in propeller construction.

11. None of the medium trawling fleet of Kerala are installed with a fuel flow meter as a result of which the operators are unable to know the exact fuel consumption at any particular time and he is also not aware as to the RPM at which his engine will burn the optimum amount of fuel. Hence it is recommended that the medium trawlers along the Kerala coast use fuel flow monitors on their vessels for precise fuel measurement.

The deep sea trawlers were also not using fuel flow metering devices, hence the deep sea trawlers are also recommended to install fuel flow meters.

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