ECHNO ECONOMIC STUDIES ON INDUSTRIAL FISHING IN THE UPPER EAST COAST OF INDIA

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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 C.P. Verghese, M.Sc., under my supervision and guidance in the Department 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

I, C.P. Verghese, do hereby declare that the work presented in this thesis is the result of my own investigations and neither the thesis nor any part thereof has been accepted nor is being submitted for any other degree. All the sources of information have been duly acknowledged.

(C.P. VERGHESE)

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PREFACE

Industrial Shrimp fishing in the East coast of India was initiated by the Union Carbide trawlers in the Sixties. However, organised commercial shrimp exploitation was started in the upper East coast after the location of potential shrimp resources by Fishery Survey of India vessels (Sudarsan and Joseph, 1975). Discovery of shrimp fishery from the Sandheads down to Andhra Pradesh Coast triggered many industrialists, technocrats and Skippers to introduce outrigger trawlers. No one disclosed the real profit in the venture, but the number of outriggers increased year after year showing the fortune in the enterprise.

Exploitation of shrimp resources in the North east coast went on unabated. Number of Trawlers from 37 in 1978-79 increased to 155 in 1991-92. Slowly the fishery began to feel the pressure from all sectors - traditional, mechanised and large vessels. Unit output began to reduce showing economic crisis. Although the rate of return was enough to run the show, the less efficient, especially on fuel front, began to crumble. Failure of repayment of loan to credit and investment agencies ended up in confiscation of vessels.

This necessitated the regulation of fishery in the region. The entrepreneurs themselves volunteered for a ban of Shrimp trawling from 15 April to 15 June. This was not based on any scientific studies. The operators also tried to diversify the operation for other lucrative dollar earners like deep sea lobster, cuttle fish etc. But the modification and diversification could not be implemented in many vessels, as they were basically not intented for such changes. There came an awareness among Scientists that regulation based on scientific studies are essential. Studies conducted later showed that Upper east coast of India cannot bear further input of additional large vessels which would endanger the very survival of shrimp fishery in the region and rational exploitation is the only solution for the growth of the industry.

In this background a study on techno economic aspects of the industrial fisheries was keenly felt as to know what are the resources in the region, whether the existing industrial vessels can survive, whether there is any over capitalisation of the scarce financial resources.

These issues are discussed in the chapters one to seven reviewing various works carried out from fishing technology to modelling. Chapter one discusses the Bio industrial scenario of Upper East coast of India tracing from the exploratory trawling carried out by R.V. Anton Brunn to FORV Sagar Sampada. The potential of shrimp and fish resources, topography, productivity, oceanic circulation and shrimp concentration of the ground have been highlighted in the chapter.

Chapter two deals with research carried out on demersal trawl as the Outrigger vessel specifically fish in the bottom for Shrimp. Tracing from the history of trawl, going through the technology of trawling, reaching the evolution of Outriggers the section reviews research work carried out on gear and accessories.

Chapter three describes the operation of the trawl and trawler under investigation. The specification of investigation and industrial fleet have been described in detail. The factors such as productivity and preservation have also been covered under this section.

Chapter four explains the results of industrial and investigation vessels. The data collected for a period of one year during 1991-92 have been processed using Harvard Graphics computer programme. The results cover voyage wise and annual production of investigation vessels. Species wise composition of the production has been presented for all voyages. Fuel expense is found to be the most decisive factor in the cash out flow while operating all types of investigation vessels.

Chapter five is on techno-economic synthesis of both Industrial fleet and investigation fleet. Analysis of Industrial vessels have been carried out after surveying 135 industrial vessels operated in the region for their rigging, propeller assembly, type of main engine, correlation between LOA and HP and fuel consumption. The investigation vessels have been subjected to the analysis of cash inflow and out flow. The catch per unit effort of six different types of investigation vessel have also been synthesised.

On the economic analysis side, Chapter six covers the trawler operation based on four methodologies such as simple rate of return, Internal Rate of Return, Break even analysis and Sensitivity analysis. These analyses testify how efficient the investigation vessels are from economic point of view. From the economic analysis the most economical optimum size of the vessel for industrial fishing also emerged.

Chapter seven encompasses the economic model of industrial fishing starting from an open access equilibrium prevalent in the present case. The study evolved Econometric model regressing the results of production output, operating expenses, Vessels, fishing season and CPUE. To avoid capitalisation, Log linear model clearly showed how many vessels the region can withstand taking into account fuel efficiency, optimum size of vessel, season of fishing and various dependant factors.

Chapter eight is the summary of all seven individual chapters giving an abstract of contents and recommendations.

CHAPTER 1

THE UPPER EAST COAST - BIO INDUSTRIAL SCENARIO

Organised fishing using mechanical propulsion in India started only in the early fifties, although sporadic attempts of exploratory fishing surveys have been made by the turn of this century. Fishing from mere existence level has grown to the level of an Industry during the last fifty years. This is revealed from the increase in fish production from 0.53 million tonnes in 1950-51 to 2.44 million tonnes in 1991-92 against 3.90 million tonnes fishery potential estimated for the entire EEZ (Anon, 1991), Even during the last fifty years only 180 large vessels (vessels above 20 m. OAL) have been introduced, although it was planned for introduction of larger number through five year plans.

1.1. INDUSTRIAL FLEET

The upper East coast of India with wide continental shelf of 76360 sq. km. forming 63% of the total East coast shelf area and influx of large rivers and tributaries has rich potential of shrimp ground known as the Sandheads. Outrigger fishing started in the North East coast in 1972 with the import of two 24 m. (Gulf of Mexico type) outrigger trawler from USA (Rao, 1988). The economic viability of these vessels paved way for the steady increase of fishing fleet. Out of 180 vessels introduced, 155 vessels have been active in fishing during 1991-92 in the region. These vessels were considered as industrial vessels which were mainly rigged with outrigger booms or stabilizers for shrimp fishing from Kalingapatnam upto the Sandheads (84°10'E 18°20'N to 89°E 21°N) (Figure 1). The industrial fleet is operated by companies, sometimes under contract to processing plants, marketing organisations or export organisations. They are based at Visakhapatnam because of proximity to the Sandheads.

1.2. MINI TRAWLERS

The small scale mechanised fishing fleet of about 23,000 boats exploiting shrimp, Cephalopods and miscellaneous fish by stern trawling throughout the Indian coast witnessed the introduction of 15 m. 'Mini trawlers' in 1985, adopting outrigger trawling. Mini trawlers are a miniature version of 23 m. outrigger trawlers having an endurance of 18 - 20 days. They had refrigerated fish hold, consume less fuel compared to 23 m. trawler and operated by certified fishing second hands. They were owned by Technocrats and fishery entrepreneurs.

1.3. SONA BOATS

Simultaneously, the small scale fishermen who were operating small mechanised boat for prawn in the inshore waters started enlarging the size of their boats from 43' to 48' (13.0 m. to 14.63 m.). These boats are called 'SONA' boats after the name of the first enlarged version of small mechanised boat. These boats are stern trawlers and carry ice for preservation. The endurance of the vessel is 10 - 12 days. Experienced Tindel commands the vessel with mostly artisanal fishermen as the crew. These boats are fitted with engine having lesser HP than that of Mini trawlers and thereby lesser fuel consumption operating in the same area.

Though Mini trawlers and Sona boats were introduced almost simultaneously for commercial exploitation of shrimp resources alongwith outrigger trawlers, the cost of Mini trawlers were around Rs 20 to 25 lakhs while that of Sona boats were only Rs 4 to 5 lakhs due to the expensive refrigeration system auxiliary engines and other sophisticated gadgets on board Mini trawlers.

Both the types of boats were financed by Agriculture Refinance Programme. The repayment of Mini trawlers was heavy due to higher project cost. Moreover the refrigeration system on board Minitrawlers had constant failures and they had to switch over to ice fishing. The running cost of Mini trawlers was much higher than that of Sona boats for almost the same output and hence the introduction of Sona boats picked up year after year pushing back the Mini trawlers.

1.4. BOTTOM TOPOGRAPHY AND METEOROLOGICAL CONDITIONS

The sea bottom of the North east coast within 100 m. isobath, generally favourable for trawling. In zone A, grounds are muddy and sandy, whereas zone B grounds are mostly rocky (Figure 1). However, these areas are trawlable with heavy ground rope. There are no big variations in depth within the 100 m. isobath in the Mahanadi - Godavari area (FAO, 1962). The width of the continental shelf is only 25 to 40 nautical miles. Meteorological conditions in the area on the whole are favourable for fishing operations, though the region is cyclone prone, when the trawlers enter Paradeep or any nearby ports for shelter.

1.5. CURRENT

There are two kinds of active currents in Bay of Bengal; ebb and flow currents during monsoon season. In the Godavari - Mahanadi area, the monsoon current runs along the coast changing its direction by 180° twice in a year (South east and north east winds). Both ebb and flow currents and monsoon current change periodically, not only their direction but also their speed. Interferences of one current with the other creates a fairly complicated and varying picture of a resultant current. While trawling, the flow of current should be taken into account and the skipper should operate with the current as sometimes the current speed in Bay of Bengal exceeds three knots and trawling against current will result in minimum catch. When the current speed is low and fish concentration is good, it is advisable to conduct trawling at counter courses and thus avoid loss of time required for steaming without the trawl against the current (FAO, 1962).

1.6. PRODUCTIVITY

Primary productivity studies along the seas around India had shown that east coast had an average value of $0.63 gC.m.^{-2} day^{-1}$ against $1.19 g C.m.^{-2} day^{-1}$ for Arabian Sea (Nair *et al.*, 1973). Trawl surveys conducted using *R.V. Anton Brunn* at different stations in Bay of Bengal and Arabian Sea had shown that the West coast is about 2.5 tonnes more productive than the East coast (Pruter, 1964). However, based on primary productivity studies, it is reported that there is not much difference in point to point productivity in Bay of Bengal and Arabian Sea (Radhakrishna et al., 1978; Battathiri et al., 1980). Therefore, Sudarsan and Somvanshi (1988) concluded that difference in landing vis-a-vis fish production would be due to the extent of continental shelf in each of zones in East and West coasts.

1.7. OCEANIC CIRCULATIONS AND SHRIMP CONCENTRATION

Thermal signature derived from enhanced Satellite data showed cyclonic and anticyclonic circulation pattern of water masses in pair or in isolation in 10° - 20° latitude belt of the Bay of Bengal during the period February - March, 1991 (fig.2). Time series sea surface temperature (SST) images generated from NOAA - AVHRR satellite data repeatedly showed this circulatory motion in the above area during February - March. Although this is a lean season, fishing data indicated that shrimp catches from the areas of rotating waters were found to be unusually high (Dwivedi and Mini Raman, 1993).

1.8. FISH RESOURCES

It is estimated that North east coast of India can sustain a potential 143,000 tonnes of demersal fishery resources from 0 - 50 m. and beyond (Anon, 1991). George et al. (1977) and Sudarsan and Joseph (1978) have opined that upper East coast share in marine fish production could be substantially increased through developmental efforts. Exploratory fishing off Andhra Pradesh, Orissa and West Bengal coasts have also shown abundance of Nemipterids and cat fishes in this region (Krishnamoorthi, 1973; Shekharan, et al., 1973). The trend in marine fish production and share of North east coast in the total fish landings reveal that there has been perceptible increase in contribution from upper East coast over the years.

1.8.1. Trawling Operations by Kalyani

The result of trawling operations in the Bay of Bengal from 1959-60 to 1961-62 by Kalyani I - V have been studied by Kuthalingam et al. (1973) and observed that 90.53% of the catch consists of Sciaenids Clupeids, Leognathids, Nemipterids, Lactarids, Muraenids, Carangids and Percoids. Of the various fishing grounds in the Bay of Bengal, the Sandheads, off Mahanadi, Devi and Prachi rivers have been found to be very productive and catch rates and quality fishes were high from these regions. The analysis of depth-wise distribution showed that Stomatids (*Pampus* spp.), Pomadasids and prawn occurred between 5 - 15 fathom,Sciaenids, Clupids, Leognathids, Nemipterids etc. between 15 - 25 fathom and shark, rays and skates between 30 - 35 fathom. Experimental night trawling showed that in general, yield in night trawling was less than that in day trawling.

1.8.2. Resources located by FORV Sagar Sampada

The cruise reports of FORV Sagar Sampada (Anon, 1987) indicate that the bottom trawling carried out at 9 stations off Orissa and West Bengal using a 400 mesh bottom trawl has brought out that catch rate was better (237 - 360 kg/hr) in shallow water of 30 - 40 m. compared to deeper areas. *Pennahia macrophthalmus* (23.5%) *Decapterus dayi* (21%), *Pampus argenteus* (8%) and *Tachysurus thalassinus* (4.6%) were important component of bottom trawl. In these region *Pennahia macrophthalmus* followed by *Pampus argenteus* were landed in appreciable quantities at shallow regions. *Decapterus dayi*, *Nemiterus delagoae*, *Loligo duvaucelli* and *Rastrelliger kanagurtha* dominated at 40 m. depth operations. *Ilisha filigera* was the dominent species at 51 m. At 60 m. *Nemipterus japonicus*, *Arius thalassinus* and *N.lutens* were dominent. The trawling operations of FORV Sagar Sampada revealed rich ground for Sciaenids and white pomfrets in the north Orissa coast at 33 m. depth. Potential of prawn was reported to be much less compared to fish resources. Dominent species off Paradeep at 51 - 71 m. were Metapenaeus monoceres and Solenocera crassicornis. Bottom trawling at 50 m. indicated the presence of prejuvenile Trichurus russelli indicating the feeding ground of these species.

During FORV Sagar Sampada cruise from 1985 - 88 spacial distribution and species composition of various demersal fishes of depth range from 27 to 100 m. in the North east coast (16°00' to 22°00N; 77°30' to 89°00'E) showed that CPUE of 315 to 430 kg was obtained with species composition of Nemipterids, Carangids, mackerel silver bellies, Psenes etc. (Sivakami, 1990) Sudarsan and Somvanshi (1988) reported that the Sandheads appear to be an area of abundance for mackerel where catches as much as 5 to 10 tonnes were caught in 2 to 3 hours of trawling.

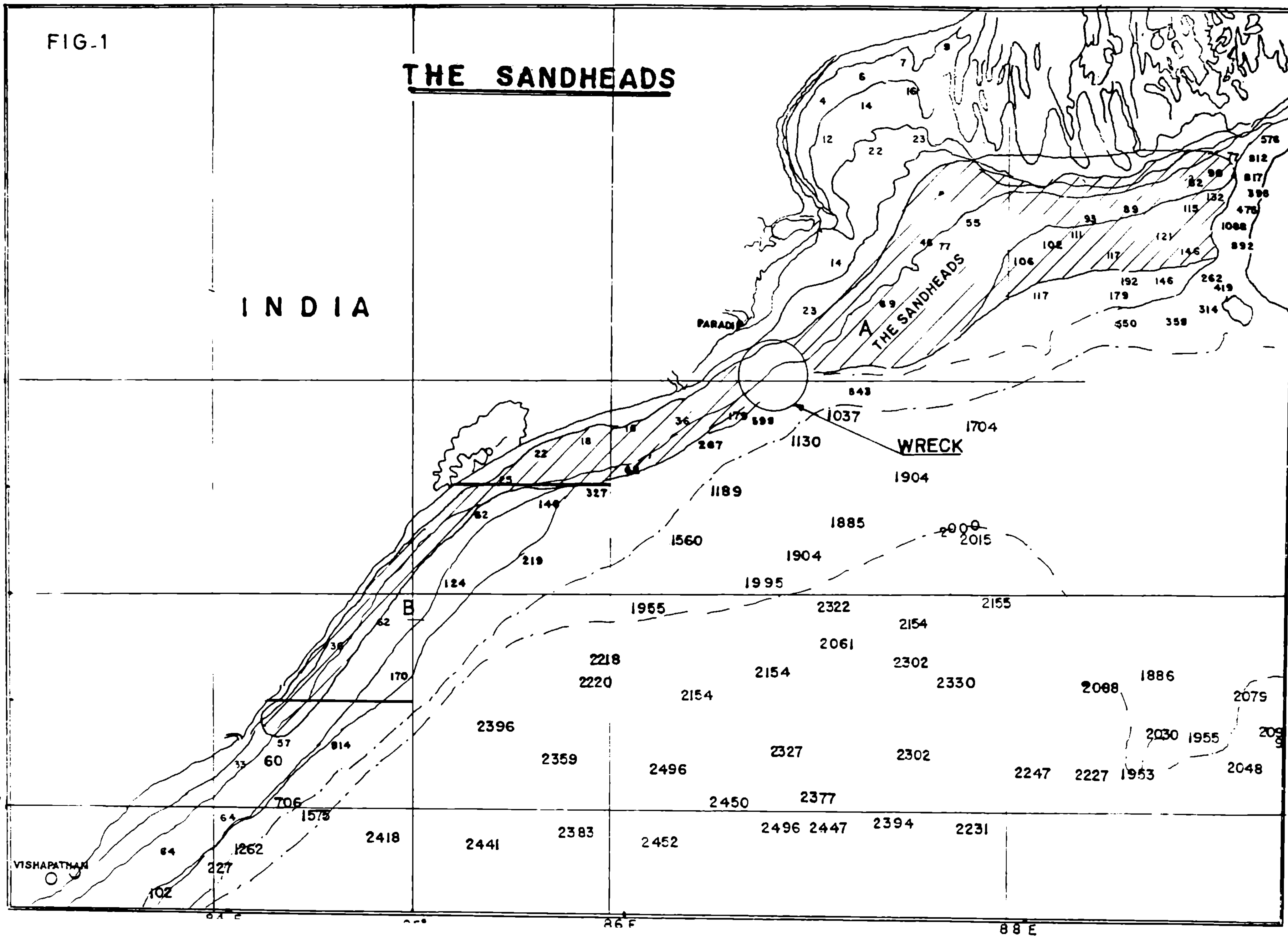
1.8.3. Penaeid prawn resources

Penaeid prawns form an important constituent of marine fisheries resources of North east coast of India. The species of prawn generally caught in the trawl are categorised as Tiger (Penaeus monodon, P.semisulcatus and P.japonicus), White (P.indicus, P.merguiensis and

P.penicillatus), Brown (Metapenalus monoceros, M.ensis and M.affinis) and Flower (M.brevicornis and M.dobsoni). The abundance of various commercial species of prawn was Tiger 8%, White 30% and Brown 62% (Rao, 1987 and 1988). There was a gradual increase in abundance of Tiger from 11 m. depth to 60 m. depth and a gradual decrease thereafter. The Whites were more abundant in 11 - 40 m. depth. The abundance of Brown gradually increase from 11 m. to 100 m. depth. Sandhead I, off Paradeep and Chilka are good grounds for Tigers, while off Paradeep, Gopalpur, Kalingapatnam and Sandheads II are productive grounds for Whites. Browns are dominent off Anchorage, Sunderbans and Gopalpur (Rao, 1987). Fishery Survey of India have located rich prawn grounds along Orissa and West Bengal coasts during its survey in seventies (Sudarsan, 1977; Sudarsan and Joseph, 1979).

Out of a total potential of 178,000 tonnes of Penaeid prawns estimated for the entire EEZ of India, their production during 1978 was estimated at 179,856 tonnes as compared to 144,069 tonnes during 1990-91 (Anon, 1979 and Anon, 1992). The catchable potential of Penaeid prawn from 0 - 50 m. depth zone in the upper East coast is estimated to be 11,849 tonnes (George et al., 1977; Anon, 1991). The MSY of prawn derived by employing Relative response method is 16,059 tonnes of which large trawlers contribute 4,478 tonnes. The share of West Bengal, Orissa and Andhra Pradesh from mechanised and non mechanised sectors is in the order 666, 2,277 and 8,638 respectively (Rao, 1993). The maximum production of large trawlers during 1989-90 was 5,313 tonnes. If this value is taken as Maximum contribution approach (Alagaraja, 1987), the MSY of the upper east coast will be 16,894 tonnes. This shows that Penaeid prawns are exploited at their MSY. The study group set up by Government of India to examine the status of marine shrimp fishery also concluded that prawns are exploited at the maximum sustainable yield (Anon, 1989). In this scenario, it is of paramount importance to study the techno-economics of industrial fishing in the upper East coast of India.

FIG-1


THE SANDHEADS
INDIA
THE SANDHEADS
A
B
WRECK
PARADIP
VISHAPATHAM
20°
19°
18°
88 E

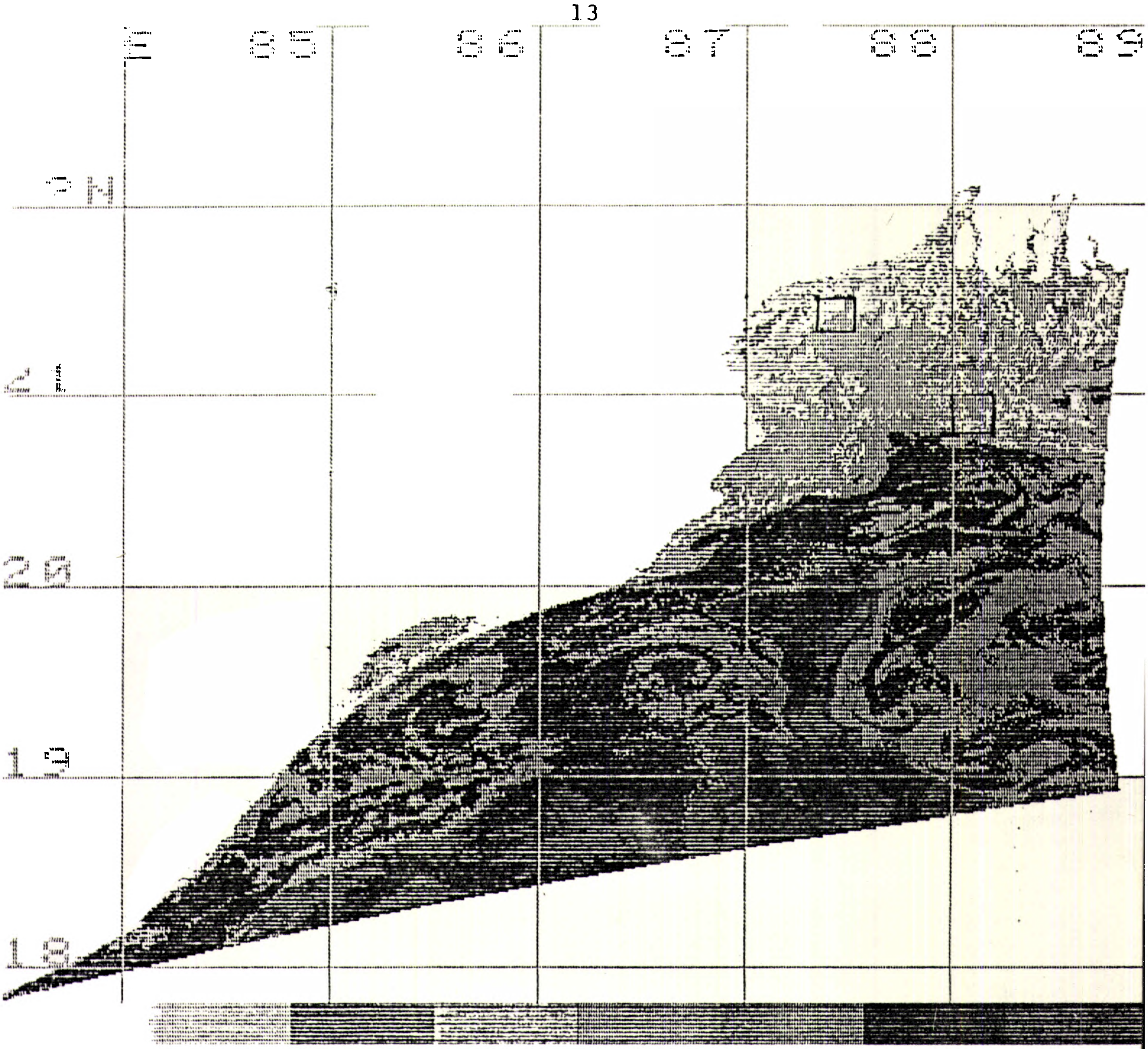


Fig.2 A satellite thermal image of SST, 6-2-1991, in the bay of Bengal obtained from NOAA - AVHRR
Spatial distribution of SST in steps of 0.5 deg. C

CHAPTER 2

DEMERSAL TRAWL GEAR AND OUTRIGGER

2.1. BOTTOM TRAWL

Industrial Vessels operate Bottom trawl which is an important and effective implement for the capture of demersal fish resources. It is a conical shaped bag, made of different pieces of webbing. The mouth of the bag is kept horizontally opened by otter boards, which move obliquely when towed by a vessel. The vertical mouth is formed by buoyancy of floats on the headline and weight on the foot rope.

2.2. HISTORY OF TRAWL

It is not exactly known when and where the trawl has developed. Iversen (1937) recorded that a small trawl called 'Keitel' was in use in the brackish waters on the Baltic coast of Germany. A trawl 'Wondyrchoun' was operated in Thames (England) for salmon in 1376 (Anon, 1921). The predecessors of otter trawls are beam trawls, where the mouth is kept opened by beam which gives a fixed mouth area. The length of beam increased when power came into trawling. The idea of otter trawling came from Sport fishing gear 'the otter' and trawl with doors was first used by Sportsmen in Ireland in 1870 (Iverson, 1937). Initially the trawl was towed by a single line and with the introduction of gallows, the two warp system came into practice. In 1893, completely a new type of trawl was introduced in Scotland, namely, the Granton Otter Trawl and it is still used in European waters with modifications. An important development of otter trawl is the French or Vigneren Dahl (V.D.) system. V.D. trawl is an improved method of rigging the net with the doors providing a sweep line (Hickling, 1923). They are believed to guide the fish into the advancing trawl.

Trawling was first attempted in Indian seas in 1902 by S.T. Premier (Herdman, 1903) and was followed by the exploratory trawling of Ceylon Company of Pearl Fisheries (Hornell, 1916). But the earlier trials ended in economic failures. The operations conducted by the Japanese trawler Taiyo Maru 17 were quite encouraging (Chidambaram, 1952) and later attempts were taken up by many Government and Private agencies.

2.3. SIZE OF TRAWL

Generally the size of trawl is given by the length of headline. This leads to confusion as the length provides no comparative size of the trawl and the long wing trawl need not be bigger. The explanation given by Percier (1959) is that wings are only extension from the net and are really no part of the funnel. In Poland size of the net is referred by a fraction, the numerator being the length of head rope in metres and the denominator being the length of half the circumference of the stretched length of front edge of the bellies (Szatybelke, 1959). In the former USSR the size of the net include the length of the legs (Andreev, 1962). In certain trawls, the size is named by the number of meshes around the mouth with mesh size. In India size of the trawl is designated by the length of head rope.

2.4. SCOPE RATIO

The length of warp to be paid out in bottom trawling is dependant on various factors such as nature and depth of fishing ground, weight of gear, speed of vessel and direction of tow. The relationship between the depth of ground and the length of warp to be paid out for effective trawling is called scope ratio. To release a warp length from three to five times the depth of ground is the general practice followed by many Skippers. Kullenberg (1953) has experimentally found that the thicker wire runs more vertically and need not therefore be as long as thinner wire. Wathne (1959) observed that a scope ratio of 3:1 is not adequate for obtaining the maximum spread of the gear in shallow waters. The scope ratio increases according to the decrease in depth and ratio decreases according to increase in size of the net. (Nair *et al.*, 1966)

2.5. TRAWL AND TRAWLER

Trawl has to be designed so as to match the resistance of the net with that of the pull of the trawler for effective utilization of power installed. But in large trawler the engine power is governed by factors other than towing the gear. So it is not surprising that a large trawler may operate comparatively small net. However, for small trawler Miyamoto (1959) has worked out the following formula to relate engine power (P) and the size of trawl head line length (L) in feet.

$$L = \sqrt{43.6\ P + 660} \qquad (1)$$

Koyama (1966) also has worked out a similar relation between engine power (P) (ps) and length of head rope length H (in)

$$H = 42 + 0.006\ P \qquad (2)$$

The relation between the length of head rope HR (ft) and horse power of engine P has been worked out by Nair and George (1964) after surveying various designs of small trawl.

$$HR = 0.5\ P + 28.1 \qquad (3)$$

2.6. TRAWL DESIGNING

The size of different parts of trawl depend upon factors like trawler, fishing condition, expected catch, material, mesh size etc. The general principles of design of trawl have been described by Nair (1969). The correlation of the various sections of small trawl from India has been worked out by Nair and George (1964) as,

$L = 0.7\ HR + 6$ (ft) (4)

$D = 0.7\ L + 2.3$ (") (5)

$Bm = 0.5\ L - 2.87$ (") (6)

$B = 0.24\ L + 0.92$ (") (7)

$W = 0.4\ L - 4$ (") (8)

$J = 0.22\ L + 2.46$ (") (9)

Where L is the maximum length of belly, HR is the head rope length, D is the belly depth, S is the size of square Bm is the loength of bosum, B is maximum weidth of belly, W is the width of side wedge and J is the length of jib.

2.7. MATERIALS OF TRAWL

Trawl is made of synthetic fibres like Nylon (Polyamide), Polyethylene, Terelene etc. because of its high breaking strength, less resistance and easy handling. Comparative fishing carried out with hemp and Kapron (Soviet equivalent of nylon) showed the efficiency of the latter in using a thinner twine, higher towing speed at same RPM and higher catch (Ovchinnikov, 1958). Norwegian trawling experiments showed that the catch with nylon trawls were about four to five times as large as that of cotton trawls of exactly the same type (Firth, 1950). However, Kuriyan (1965) observed that there is no apparent effect on the catch of prawn by substituting nylon for cotton. Comparative trawling conducted with identical nylon and manila nets showed that resistance to progression is less for nylon than manila, the difference being 20% (Percier, 1956). Okonski (1969) has reported that trawl made of Polyethelyene was operationally better than nylon on the Wadge Bank. The advantage of synthetic material allows either an increase of speed or decrease of fuel consumption of the trawler.

Twisted and plaited synthetic yarns are used for construction of bottom trawls. While twisted netting yarns are cheaper, braided yarns are stronger and therefore preferred for cod ends. Among different degrees of twist for trawl twine, medium twist is taken for bottom trawl construction.

2.8. TWINE SIZE

The diameter of the twine and the net sections are related to the strength of trawl. In the bellies meshes are fabricated with thinner twine than cod end. But some of the Russian designs do not follow this pattern (Vinogradov, 1960, Andreev, 1962). Meshes at the edge of hanging rope and cod end are fabricated with double twine or thicker twine to support high strain.

2.9. MESH SIZE

Mesh size in trawl depends on the size of fish to be caught. Mesh size will be high in upper bellies where more filteration has to be effected and the size will be decreased towards cod end in two to four intermediaries. Mesh sizes in the forward parts are some what dependant on the size and taper of the trawl (Dickson, 1971). The netting infront part of trawl especially wing and square only frighten the fish and therefore those parts can be large mesh netting.

Ever since the introduction of trawling, mesh size particularly cod end has been receiving much attention. Selective fishing with regulated mesh size would not only prevent depletion of population, but also ensure filteration of water through the meshes, thereby effecting the efficiency of the gear. Cod end mesh size in the North Atlantic trawls operated from large trawlers are regulated as 120 m.m. (Personal observation). To avoid depletion of shrimp fishery in South west coast of India, Panicker and Sivan (1965) stress the necessity of increasing the cod end mesh size from 24.5 mm to 41.64 mm.

2.10. SELECTIVE SHRIMP TRAWL

With the increasing demand for shrimp in the export market and consequent increase in introduction of large number of shrimp vessels including outriggers, huge quantities of bycatch are caught in the trawl. Since most of the shrimp trawlers cannot carry the low value bycatch due to lack of space in the fish hold, they preserve only shrimp and throw the bycatch. It is estimated that about 130,000 tonnes of bycatch were discarded in the North east coast of India alone by the large vessels in 1988 (Rao and Murthy, 1993). These bycatch contain large quantities of juveniles and young ones. The discarding of bycatch has created not only depletion of fish resources in the coastal waters, but also many socio-economic problems to the fishing communities. Therefore, most of shrimp trawlers all over the World have started selective fishing for prawn. Although several countries have conducted research to evolve selective shrimp fishing (Karlsen and Larsen, 1988; Valdemarsen, 1988; Isaksen et al., 1992), such works have not been undertaken in India. Attempts have been made in the Mozambique waters to transfer the bycatch from outrigger trawlers to the collector boats for utilisation ashore (Ames, 1993).

2.11. TRAWL DESIGN

The different sections of trawl are estimated to the required size and shape and it is drawn on graph. Shape is determined to have a smooth contour of the bag. To give comparable size and shape of the net, the width of the panel is drawn at half the stretched width and the length is drawn at the stretched length (Dickson, 1959). Although designs are studied by making models and tested in experimental tanks, successful trawls are evolved after extensive field trials. There are many standard designs now used in various countries. Garner (1967) describes the design and construction of Granton trawl operated by British trawlers. Ben-Yami (1956 a, 1956 b, 1959) gives the details of hybrid and Italian trawl net. Poliakov (FAO, 1962) operated a 15 m. Russian design in the Bay of Bengal for exploratory trawling. Details of some Russian designs are presented by Andreev (1962). FAO (1965) published a Catalogue of Fishing Gear describing commonly used gear in various countries. Designs on shrimp trawls from various countries have been presented by Kristjonson (1968). Okonski (1969) experimented four trawl designs to improve trawling on Wadge Bank. The designs of otter trawls for shrimps in India have been described by various workers (Satyanarayana et al., 1963; Kuriyan et al., 1963, 1966). A new design called bulged belly trawl has been developed in the South west coast of India (Verghese et al., 1968; Nair et al., 1971).

2.12. CONSTRUCTION OF TRAWL

Trawl is constructed from the approved design. When fully assembled and rigged, it take the shape of a huge funnel. Trawl funnel is formed by two or four seams. However net with six and eight panels are also designed (Koyama, 1965). Efficient performance of the net depends on proper and precise assembly of the webbing and rigging. If the trawl is improperly assembled the twine in the net webbing will be subjected to unduly distortion and breakage. Prawn catches from India were noticed to increase by about 50% when additional wings were provided (Kuriyan, 1965). In some Japanese design the lower belly is constructed 75 to 90 cm. longer than the upper belly in order to lift the cod end above the muddy bottom. When towing the trawl along a sandy bottom, the upper and lower bellies are constructed in the same length (Miyazaki, 1966). Special cod end locking devices, which facilitate quick release of cod line have been developed in United States (High, 1966) and former Soviet Union (Kostunin, 1968).

2.12.1. Trawl catenary

The lower wing is shaped 10% more in length and is laced to the upper side giving slack to lower wing. The allowance of slack in the lower net depends on the type of fishing for which the net is designed. The quarter region of trawl has to be properly constructed to conform a close catenary shape to the head line and ground rope. Corner gussets are therefore constructed to relieve unnatural strain at the quarter region (Garner, 1962). Three rows of bosum meshes and three rows of wing hanging sides are fabricated with double twine in the corner gussets of big trawl (Verghese, 1972). The wing meshes are also doubled where more strain is expected.

2.12.2. Hanging of webbing

The ratio of hanging may be expressed as the length of line by the length of stretched webbing. The ratio termed as 'hanging' coefficient (W)

$$W = \frac{l}{S} \qquad (10)$$

Where l is the length of line and S is stretched length of webbing.

The percentage of 'hang-in' (P) is expressed by the ratio

$$P = \frac{(S-l) \times 100}{S} \qquad (11)$$

Both are reciprocal values but the second expression gives the direct proportion of the looseness in the net (Lusyne, 1959).

The hanging of webbing at bosum is effected by a hang-in coefficient of 0.4 to 0.5. In the top wing where tapering is done all bars, the rope length is equal to the stretched netting. The lower wing meshes are hung to the fishing line with a looseness of 15%. The looseness is given two third at the bunt region below the square and one third at the wing ends. This allows the square to lift hydrodynamically (Garner, 1967). In Granton trawl, Garner (1967) states that the length of ground rope may be half of the length of head line plus two third of the stretched length of square which added together are doubled.

2.12.3. Wing side hanging

When horizontal co-efficient increased the vertical co-efficient decreases. The relation between the vertical and horizontal co-efficient may be expressed by the equation (Andreev, 1962).

$$Uv = \sqrt{1 - \frac{2}{Uh}} \qquad (12)$$

Where Uv is the hanging co-efficient along vertical and Uh is hanging co-efficient along the horizontal. So if the vertical hanging is known, the wing side hanging can be calculated.

2.12.4. Weight and buoyancy

The weight to be used on foot rope depends on factors like weight of the gear, types of fishes to be caught, speed of operation etc. However, Nair and George (1964) have worked out the relation of total weight (W) on small four seam shrimp trawl foot rope (FR) as

$$W = 0.8\ FR - 9.65\ (lbs) \qquad (13)$$

In larger trawlers, the ground rope weight is decided by trial and error as many of the underwater factors and conditions cannot be estimated. At higher towing speed the weight on ground rope is increased. If the weight is inadequate it can be observed from the absence of abrasion markings on bobbins (Kostyunin, 1968).

In small four seam shrimp trawls, the relationship of extra buoyancy of floats (F) and the length of head rope (HR) is expressed (Nair and George, 1964) as

$$F = 0.75\ HR - 15\ (lbs) \qquad (14)$$

Floats are not evenly distributed along the head rope. They are closer in the bosum and wider on wing region.

2.13. TICKLER CHAIN

Shrimp are sometimes hidden in the mud on the bottom and so the ground rope will not be able to bring them out of it to catch. So long chains are attached to the ground rope to tickle them out of mud to engulf by the advancing trawl. These chains are called tickler chain. Some of the initial experiments with trawl gear to improve the catch of shrimp was done in the Gulf of Mexico (Bullis, 1956). Miyamoto (1957) and Davis (1958) report the advantages of using tickler chain to improve the shrimp catch. Deshpande and Sivan (1962) used tickler chain in their beam trawl to improve shrimp catches. In shrimp trawl, catch increased when the ground rope is rigged with tickler chain (Deshpande and George, 1965). Deshpande and Kartha (1967) reported that the chains attached to foot rope do not alter the fish catch or the spread of the net.

2.14. TRAWL OPENING

One of the major factors influencing the catch of trawl is the vertical and horizontal opening. The vertical opening of the mouth depends upon the rigging of the head line and ground rope (Okonski and Sadowski, 1959). The shape of the trawl is also depend on the resistance of trawl. For practical purpose of understanding the trawl performance, vertical and horizontal openings are taken into consideration.

2.14.1. Horizontal Spread

The spread of wings caused by the horizontal diversion of the trawl door is termed as horizontal opening. The fishing spread of trawl between danlenos is approximately 0.5 to 0.6 l (where l is the head line length) and while in operation the head line and foot rope acquire a chain curve. An approximate distance between the doors (B) may be calculated by the method given by Deshpande (1960).

$$B = \frac{b \times L}{l} \qquad (15)$$

Where b is the horizontal distance between the warps at two particular point, L is the length of warp while trawling and l is the marked length of warps from particular point to gallow. Takayama and Koyama (1961) give a measuring device to obtain the opening breadth of wing nets. A more reliable calculation of the distance between the frontal ends of wing (W) may be done by the angle subtended by the warp (Koyama, 1965).

$$W = \frac{2lw\ ln}{lh+ln} \sin\frac{\theta}{2} + \frac{Fln}{lh+ln} \qquad (16)$$

Where, lw is the length of warp (m) paid out, Ln is the length of net measured between the frontal end of the wing and the cod end (m), lh is the length of Sweep line (m), θ is angle subtended of a pair of warp and F is the internal between two top rollers (m).

The above equation has not taken into consideration, the underwater factors effecting the trawl spread. The true value of horizontal spread is therefore measured by using instruments.

Among three dimensions ie, horizontal opening, vertical opening and length of trawl net, the most important factor to catch shrimp is horizontal opening because prawn usually live in the mud and jump up from sea bed not more than a height of 1 m. when disturbed by trawling.

2.14.2. Vertical height

The vertical opening is the height of head line from ground rope. It is an important factor for the potential catch of high swimming fish. The method to increase the height is the addition of buoyancy on head line. At higher speed, the drag of the buoyant material overcome the lift and the lifting component become useless. So at higher speed hydro-dynamic floats and kites are recommended to increase the head line height. When the trawl is in action, the stream of water exert pressure on all direction and cause the body to swell. Some times the external pull of the door tries to bring the head line down (Binns, 1959).

The practical way to raise the head line is to decrease the strain on it and increase the length of danlenos (Ben-Yami, 1959; Taniguchi, 1961). Decrease of towing tension on head line is achieved by making the bosum sections longer than the corresponding section of ground rope (Vinogradov, 1960). The tension on the head line is also released by shortening the ground rope leg (Ben-Yami, 1959; Vinogradov, 1960). Vertical opening is increased by means of providing sufficient height to wings and making it pennon shape (Vinogradov, 1960). Decrease in fishing spread cause increase in fishing height. So it is preferable to increase the fishing height by suitably designing the trawl using hydrodynamic devices, so that horizontal spread is not affected. As the measuring instruments are cumbersome and expensive, the constructional vertical opening may be calculated by the method explained in the geometrical analysis of trawl (Okonski, 1967 and 1968). Instrumentation in fishing technology has been advanced and the performance of trawl underwater such as horizontal spread, vertical spread, catch indication etc. can be monitored using Net monitoring systems (Sivadas and Ramakrishnan, 1988). The Scanmar gear monitoring system with several sensors on the net is without cable connecting the net and the boat and therefore easy to operate(Larsen, 1988).

2.15. TRAWL RESISTANCE

The net drag is largely determined by the area of netting in different parts, the relationship between twine diameter and mesh size and the extent to which the mouth of the trawl is opened (Crewe, 1964). Rational improvement of trawl, stipulate a thorough knowledge of the load imposed on different parts of the net. Although instruments are employed to measure the resistance of the trawl (de Boer, 1959; Hamuro and Ishi, 1964; Satyanarayana and Nair, 1965; Carrothers, 1966; Sivadas, 1970) total net drag (Dn) may be estimated theoretically (Foster, 1965; Dickson, 1966).

$$Dn = S \frac{d}{a} \frac{1}{125} + \left(\frac{6.6 \; x2yg \; x \; 5}{S} \right) \qquad (17)$$

Where S is the total surface area of netting in sq. ft. $\frac{d}{a}$ is the ratio of twine diameter, 1 bar length, 2 yg is the ground rope spread at wing ends in ft. and h is the head line height in feet.

Fridman (1986) states that the permissible drag of a trawler is equal to the available towing pull of the vessel Ft (Kg f) which can be estimated approximately from equation

$$Ft \quad P. (K_f - 0.7\ V) \qquad (18)$$

Where, P is equal to engine horse power, K_f is an empirical towing force Coefficient which ranges from 10 for trawlers with conventional propeller to 15 for trawlers fitted with C.P. propeller in nozzle and V is the vessel speed.

Out of the total drag of the gear system, a major share is caused by the net body alone. During experimentation Dickson (1966) obtained a share of 58%, for trawl and 10% for net appendages like bobbins, floats and ground rope friction, while FAO (1957) recorded net drag of 68% for Italian bottom trawl.

2.16. DOUBLE RIG TRAWL

The most effective method of catching shrimp is by double rig trawling which tows 2 trawls by one boat through outrigger or stabilizer booms. In twin rigging four trawls are operated using a sledge in between the twin rig.

The basic principle of trawling is that the total resistance of gear should be matched to towing force of the trawler whether the boat tows one net, two nets or four nets. The resistance of a net in a double rig trawling corresponds to half of the towing force of the outrigger. The opening width of net mouth will be proportional to the principal dimension of the net. The opening width of a net in a double rig trawling will be 0.7 time that of a single rig trawling and the total opening width of two nets in a double rig trawling will be 1.4 times of wingle rig trawling (Anon, 1993). That is why the double rig trawl is efficient for catching shrimp world wide. Imai and Marin (1978) conducted experiments on double rigged scale model balloon type shrimp trawl net to determine the physical characteristics. Many theories have been advanced for explaining the superiority of double rig over single trawl; the most likely explanation is that a smaller trawl inherently fishes better because it adjusts to irregularities in the bottom more easily. Gonzalez and Vanjen (1982) report that the double rig system surpassed the twin trawl system when trials were conducted in the nearshore waters of Cuba. Success of double rig trawling has been reported from China and it has now become popular and achieved economic efficiency (Xinghui, 1988). Varhoest and Maton (1964) compared double rig beam trawl with single rig otter trawl and observed that the double rig catch can be increased by 30%. It is reported from the North sea that double rig trawl catch 1½ to 2 times as much as a boat towing single conventional trawl (Anon, 1985). However, this method was regarded as ineffective in Korean waters as the topography of the sea bed is steeply slopped from coast (Anon, 1993).

Outrigger trawling was introduced for exploiting shrimp from the upper East coast of India in 1972 (Rao, 1988). Not much works on technological aspects of outrigger trawler have been carried out in India. However, investigation has been carried out by surveying outriggers and their nets at Visakhapatnam. Kartha et al. (1990) have worked out emperical relationship between engine power and size of double rig trawl as well as the interrelationship of its different parts and accessories. Panicker et al. (1977) have found that double rig trawling is more productive as a whole and its efficiency in shrimp catching is almost double of single rig. Shrimp fishery in the upper East coast of India operating outrigger vessels has been studied by Rao (1987, 1988 and 1993).

2.17. TRY NET

Since the shrimp live in mud, it may be difficult to detect them by Echo sounder with white line. Productivity of shrimps normally by all outriggers are tested by operation of a third net called Try net. Richness of ground can be observed by assessing the content of try net which is occasionally hauled up while the main nets are towed.

2.18. OTTER DOOR

Otter doors are devices to keep the trawl net horizontally open while towing. Although there are several types and designs of doors, such as rectangular, oval, L-shaped, cambered, polyvalent etc. are available for bottom trawling, the most widely used type is flat rectangular. The popularity of this board is due to its simplicity in construction and operation. The most common pattern of this board is 2:1 length breadth ratio.

Flat rectangular boards are made of wood and reinforced with iron stuts. Each board is provided with pair of brackets, the forward one is shorter than the rear. These brackets are connected to the towing warp while fishing. On the reverse side, two rings are provided to connect the head rope and foot rope (ground rope) of the trawl net. This arrangement allows the board to move in an oblique outwardly direction. While towing, the board always stays at an angle. The force of flowing water then keep the board apart and keep the net horizontally open.

Several studies have been undertaken in India on the various aspects of otter boards. Some of the important works were on setting of angle of the board, different shape of board such as rectangular, oval and horizontal curved and aspect ratio (Satyanarayana and Mukundan, 1963; Mukundan et al., 1967; Deshpande et al., 1970).

Four outrigger trawling flat rectangular boards are used. This is mainly because it matches with the special character of operation. Flat rectangular board used in outrigger fishing has comparatively more length ratio than conventional boards. The height to length ratio of the board is called aspect ratio. The aspect ratio of such boards is considerably low at 0.5 - 0.3. Although a higher ratio has greater hydrodynamic efficiency, a long board is preferred for outrigger trawling because of its capability for a greather sweeping area and positive effects on the fishing efficiency. A higher breadth otter door is not required as horizontal opening is more important in shrimp fishing rather than vertical opening. outriggers prefer bridle chains for brackets instead of iron brackets, as the latter are inconvenient when a pair of boards are hung up. Area of the board for outrigger net is large in comparison with that of common trawl. The area of otter board of a 350 HP double rig trawler is usually 2 to 2.5 m^2. Thus the total area of four boards will be about 8 to 10 m^2. It can thus give a wider mouth area than a stern trawler.

2.19. OUTRIGGER

The first attempt to develop double rig method of fishing was started in the Gulf of Mexico by shrimp fishermen from Texas late in 1955. Following these initial efforts, others in the Industry became interested and many have subsequently contributed to the successful development of the method. The evolution of double rig method while necessarily one of trial and error has progressed by free exchange of ideas. The benefits inherent in this method of shrimp trawling were early and rapidly recognised and accepted, and by 1957 a major trend towards conversion of many stern trawlers was under way at Texas ports. The popularity and acceptance of conversion soon spread to Florida and Mexico where many conversions to double rig have been made (Knake, et al., 1958). Robas (1959) explained conversion of a 67 ft. trawler from single trawl operation to two trawls operation using longer outrigger booms producing more shrimp per unit effort.

There are many variations of these basic designs of outrigger. But the most well designed booms are built around used or discarded oil-field drill stem pipes. In Texas and nearby states, oil-well drilling companies use 7.3 m. heavy-walled pipes of 102 mm dia. After the walls are worn down to about 13 mm, they are discarded. Such pipes make fine outrigger booms when properly braced and they were found to be quite inexpensive (Ringhaver, 1960). Although double rig method of shrimp trawling has reached fairly advanced stage of development, it is still evolving. A recent innovation has been the introduction of stabilizer planes which will be suspended mid point of the outriggers during fishing operations. The stabilizers will help considerably to reduce the rolling of the vessel.

The deck lay out of shrimp trawl using outriggers varies very little from boat to boat except in some boats that have been converted from other types of fishing to shrimp trawling. Invariably the wheel house is situated forward. There are generally three parallel winch drums on the same unit in order to make best use of the drive. With hydraulics, the winch can now have two drums, each oriented to pass cable directly to the block on the end of each outrigger. The third (try net) which can now be separated and placed in any convenient location as an independent unit. Easiness in turning is one of the important aspects of double rig trawling. It is easy to manoeuvre a single rig than a twin rig outrigger.

CHAPTER 3

TRAWL TRAWLER AND OPERATION

3.1. TRAWL

The outrigger trawling vessels operated four seam shrimp trawl of head rope (HR) length ranging from 19.8 m. (65 ft) to 36.6 m. (120 ft.). The basic design and mesh sizes remain uniform and only the head rope and foot rope (FR) length varied according to the towing power of the engine. Except the Australian built vessel (vessel D) all the other types operated single rig trawl (figure 3). Wh[illegible] the vessel D (Figures 14, 15) operated twin ri trawl of 18.4 m. HR (figures 4, 6) the similar size HP (500 HP) of Indian built vessel E (figures 16, 17) towed single rig 36.6 m. HR length trawl (figure 5). The head rope length of vessels A and B were 27.4 m., while the vessel C had HR length 32 m. The net of mini trawl being the smallest had HR only 19.8 m. All the outrigger vessels operated try net to test the productivity of the ground and to enable the vessel remain on the productive shrimp ground. The try net was a reduced scale version of the main net in the ratio of 1:7 to 1:10.

3.2. OTTER BOARD

The outrigger boards were of flat rectangular type with wide keel. The aspect ratio of outrigger boards was different from that of flat rectangular boards used for spreading single bottom trawl. The basic design of otter boards remain same for all the 6 vessels. The weight of otter board of twin rig trawl (vessel D) was 280 kg., whereas the otter board of single rig trawl of vessel E was weighing 300 kg. The vessel A and B operated otter boards weighing 180 kg. each, while the vessel C towed otter boards weighing 200 kg. each. The weight of otter boards of Mini trawler was only 80 kg. when the twin rig trawls were operated, a sledge weighing 200 kg. was rigged in between 2 trawls (figures 4, 6).

3.3. DIVERSIFIED GEAR

Vessel D and E diversified their operation for deep sea lobster. Both the vessels operated 40 m. four seam trawl (figure 7) with 'V' form otter board of 265 cm. x 161 cm. weighing 500 kg. each (figures 8, 9). For deep water trawling oval otter boards have advantages to ride over obstacles more easily than flat rectangular boards (Foster, 1966). For deep water trawling Russian fleet operate slotted oval otter board which was found to be more convenient not only for increasing side thrust (Cy) but for producing longitudinal stability in relation to vertical axis under all regimes of trawling (Matrosov, 1953). However, for deep sea lobster trawling, the commercial vessels preferred 'V' form otter boards due to its convenience in operation besides they do not hook at the bottom when encountered with obstacles (Hu, 1961).

Depending upon the availability of lobster the trawling grounds of deep water lobster were in different regions such as off Andaman, outer edge of Wadge Bank, off Quilon, off Cochin and off Ponnani generally at a depth range of 240 to 300 m. While conducting trawling in deep water, the warp of the vessels was changed into 18 m. galvanised steel wire rope (SWR) and the scope ratio ranged from 1:2.5 to 1:3.

3.4. TRAWLER

The large industrial vessels operated in the upper East coast were built in India, Mexico, Australia, Holland, Korea, U.S.A., Hongkong and Singapore with varying OAL from 21.39 m. (104 GRT) to 27 m. (180 GRT). In 1991-92 large outrigger vessels numbering 155 operated in the upper East coast based at Visakhapatnam. Although these vessels were built in different Shipyards, for the study purpose, vessels built in India, Mexico and Australia were taken as representative, as they constitute the major fleet. Accordingly, common category of 21.94 m. (104 GRT) and 21.39 m. (115 GRT) outrigger trawlers built in Mexico (Vessel A and B), 21.59 m. (116 GRT) outrigger (vessel C) and 27 m. (180 GRT) combination trawler (vessel E) built in India and 22.34 m. (155 GRT) combination trawler (vessel D) built in Australia have been selected for the study. Since Mini trawlers are commonly operated, a 15.85 m. outrigger Mini trawler (vessel F) has also been included in the investigation. The technical details of six types of vessels A, B, C, D, E and F chosen for the study are given in table 1. The design details (both profile and main deck) of the vessels are given at figures 10 to 19. The specifications of outrigger boom and stabilizer plane stabilizer plane are given at figures 20 and 21. Stabilizer plane is used only in vessels D and E.

3.5. WINCH

Power transmission to the winch installed on board the selected vessels of study except vessel F was by means of hydraulic devices, whereas, vessel F had only a mechanical winch. Since the vessels were primarily meant for shrimp fishing using outrigger, the winch capacity was restricted to trawling upto 120 m. depth. Accordingly, most of the vessels rigged for outrigger were having only warp length of 350 m. of 16 mm dia approximately in each drum (lifting capacity 3 tonnes). However, vessels operated for deep sea lobster trawling upto 300 - 350 m. depth had wire rope capacity of 1000 m. with dia of 16/18 mm galvanised SWR (lifting capacity 5 tonnes). Vessels A, B and C had 3 drum parallel winches with drum axis parallel to centre line of vessel (Figure 22). Vessel D and E had split type winches of 2 number of either side for main warps (Figure 23). While Mexican vessels positioned the winch in amidship, winches of Australian built vessels were situated near the gunwale. The split winches were provided with separate winch drum for try net which is also being used for anchoring. However, the try net winch and anchor winch in case of Australian built vessels were separate. The advantages of split winch in case of vessels D and E are that it can be turned to have the drive direct towards stern trawling, when they are engaged in deep sea lobster fishing.

Galvanised SWRs are predominently used for longivity and better tenacity. The warp carrying capacity of winch drum plays a role in determining the size of warp. Vessel D and E use same size of warp for both outrigger and deep sea trawling so as to avoid additional expenditure of changing the warp. The longivity of the warp is affected by the bends which the warp is forced in the 3 drum winch.

3.6. WHEEL HOUSE

All large vessels (vessels A, B, C, D and E) were equipped with modern fish finding and navigational equipments such as Echo sounder, Fish finder with colour display, Satellite Navigator, Radar, Auto pilot, RT and VHF. However, Mini trawler (vessel F) had only Fish finder.

3.7. OPERATION

The operation of trawls from the outrigger is as shown in figures 3, 4. The outrigger trawling operations were carried out at a depth range upto 100 m. in the area 84°10'E, 18°20'N to 89°E 20°N. With the aid of Satellite Navigator and Radar coupled with recording of colour display fish finder, the exact position of productive ground for trawling is chosen. Try net observation also helped to check the productivity of the ground. Once the position is fixed the skipper concentrates on the area till haul landing reduces below the economic level. Operation of try net at intervals of 30 minutes facilitates in retaining the vessel at the productive ground. Generally a day haul lasts 3 to 4 hours while night haul lasts for 6 hours. The low price fishes in the haul are generally discarded. Only quality fishes such as Pomfrets, Perches, Polynemids, big Sciaenids etc. are preserved in the fish hold.

3.8. PRODUCTIVITY AND LUNAR PHASE

It has been observed that the eighth day 'Ashtami' from New moon and Full moon are observed to be good fishing periods. From New moon day, the catches shows an increasing trend upto the eighth day when it is maximum and then reduces. The maximum or the eighth day from Full moon is less than that of New moon. Skippers schedule their departure from port to be in the fishing ground on the eighth day from Full moon so as to have continuous 15 days productive fishing.

The relationship between productive fishing and lunar phase has not been studied in detail. However, study on lunar, diurnal and tidal periodicity in relation to prawn abundance and migration in the Godavari estuarine system observed that the catches were higher during the darker half of the month than in the brighter fortnight. The landings during low tides were generally higher than those during high tides and usually heavier catches were made in stake nets during nocturnal low tides than during the day low tides (Subramanyan, 1965).

3.9. PRESERVATION

Shrimp and lobster immediately after catching are beheaded and stored in refrigerated sea water (RSW). RSW is a pre cooling process where sea water is chilled and the material in the shrimp bags to be frozen is immersed. The material is than taken out and stored in the fish hold where blast freezers are used and the material is frozen to -20°C. The size of the RSW tank is 5' x 6' x 4' (1.5 x 1.8 x 1.2 m). RSW processing is a handicap when the voyage is extended depending on the catch and diesel consumption. IQF is rapid compared to that of RSW. The temperature is lowered to -18°C within 20 - 30 minutes. This is achieved by the brine in the tank, longer coil, and an agitator. The agitator is normally provided to maintain flow of brine over the cooling coil and also to maintain uniform temperature of sea water brine. The catch contained in the bag made of Nylon normally called as shrimp bag will be kept immersed in the brine. Within 20 - 30 minutes the material will be quick frozen individually depending on the quantity immersed, the size of the product and the brine temperature. It has been observed that the products frozen by this method have minimum weight loss during thawing at the processing plants on shore and the quality is found to be better. The products after immersion freezing are transferred to the refrigerated fish hold where the temperature is maintained around -25°C and stored. IQF is a pre processing technique. IQF tanks are insulated and normally of size 6' x 6' x 5' to 8' x 6' x 5' (1.8 x 1.8 x 1.5 m to 2.4 x 1.8 x 1.5 m.) filled with sea water brine.

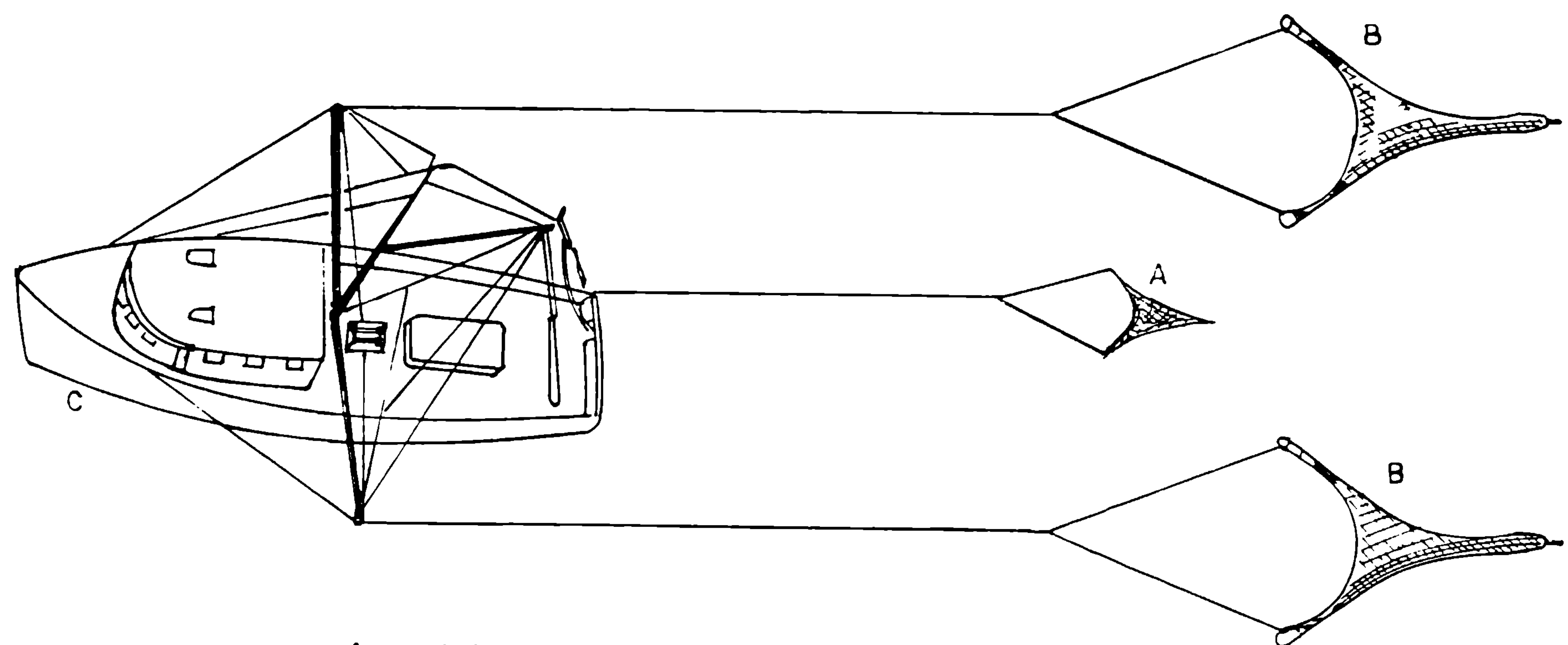
TABLE 1. SPECIFICATION OF VESSELS

Name of vessel	A	B	C	D	E	F
OAL (m)	21.94	21.39	21.59	22.34	27.00	15.85
Type of vessel	Outrigger (Steel)	Outrigger (Steel)	Outrigger (Steel)	Combination (Steel)	Combination (Steel)	Outrigger (Mini trawler) (Wood)
Outrigger length(m)	9.0	9.0	12.0	13.5	13.0	8.2
Year of built	1974	1977	1987	1986	1988	1986
Price (Rs lakh)	45	23*	60.5	92	95	17
Country of built	Mexico	Mexico	Bhavnagar India	Australia	Ratnagiri India	Mangalore India
GRT	104	115	116	155	180	-
Engine (Main)	CAT D353	CAT D353	CAT 3408	CAT DT3412	CAT DT 3412	Ruston MWM D232
HP	380	380	402	500	500	145
Aux.Engine	Lister	Lister	Lister	CAT 3304	CAT 3304	Kirloskar
HP	37.5 (2)	37.5(2)	62(2)	77(2)	77(2)	25
Fuel con/hr/Eng(l)	7	7	12	12	12	-
Fuel con/day/hr(kl/l)	1.2/55	1.2/55	1.6/65	2.0/85	2.0/85	0.53/25
Lub oil con/voy (l)	300	300	300	400	400	60
Kort Nozzle	No	No	Yes	Yes	Yes	No
Propeller	Fixed	Fixed	Fixed	CP	Fixed	Fixed
Winch	HYD Athward	HYD Athward	HYD Athward	HYD split	HYD split	Mechanical
Fuel cap. (kl)	40	40	56	65	65	11.5
Fresh water cap.(t)	10	10	10	15	15	6
Fish hold (m^3)	75	75	75	80	100	28
Storage Temp.(°C)	-20	-20	-24	-30	-30	Iced
Trawl HR (m)	27.4	27.4	32.0	18.4x2	36.6	19.8
Otter board wt.kg.each	180	180	200	280	300	80
Endurance(days)	28	28	30	35	35	11
No. of crew	10	10	10	12	12	9

*Second hand purchase

DOUBLE RIGGING:

FISHING RIG COMPRISING THE TWO MAIN TRAWLS AND A TRY NET



A – TRY NET B – MAIN NET
C – OUT RIGGER TRAWLER

FIG. 3

TWIN TRAWL

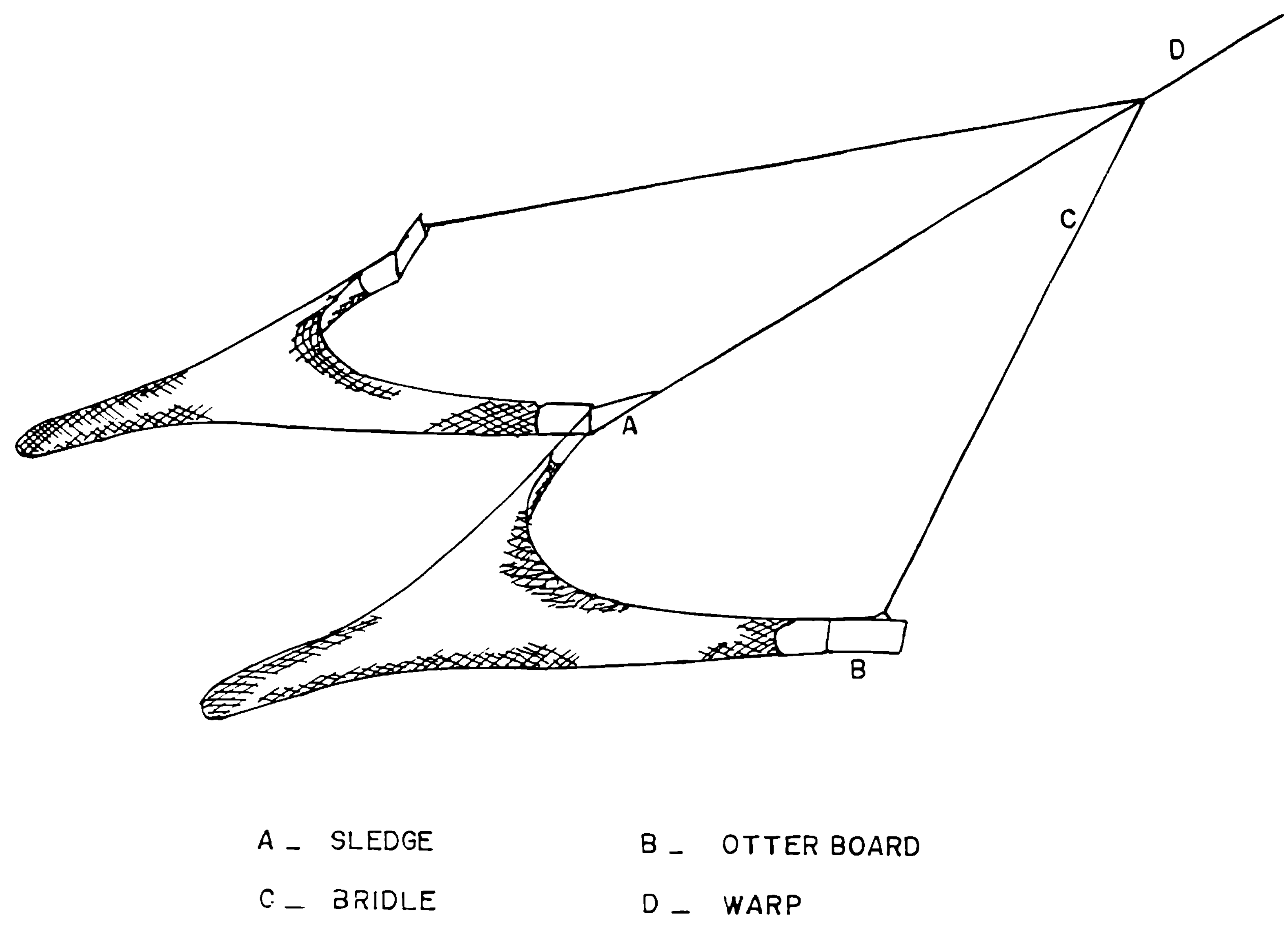


FIG. 4

FIG. 5

SINGLE RIG OUT RIGGER TRAWL

VESSEL - E

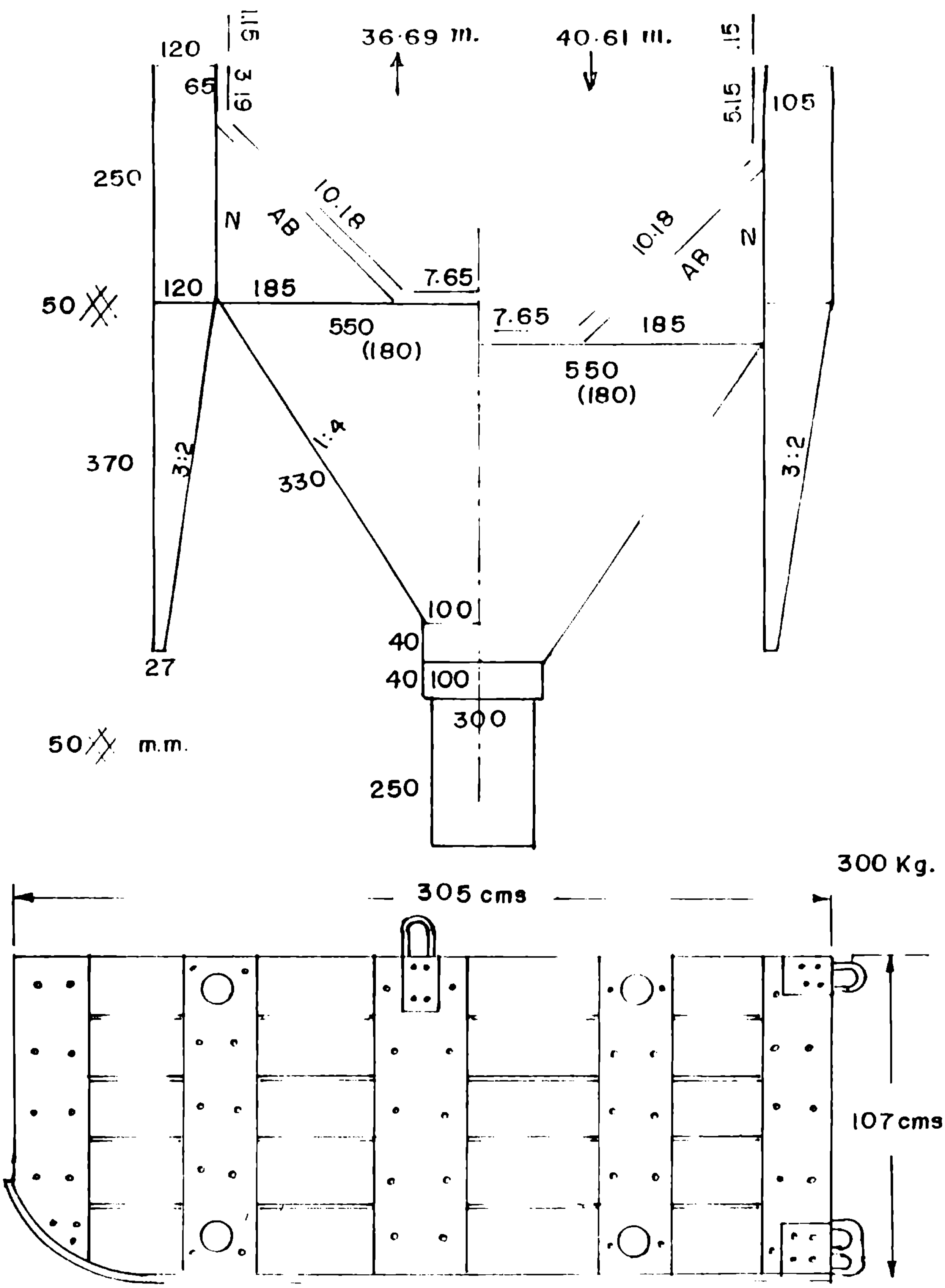


FIG. 6

TWIN RIG OUTRIGGER TRAWL

VESSEL - D

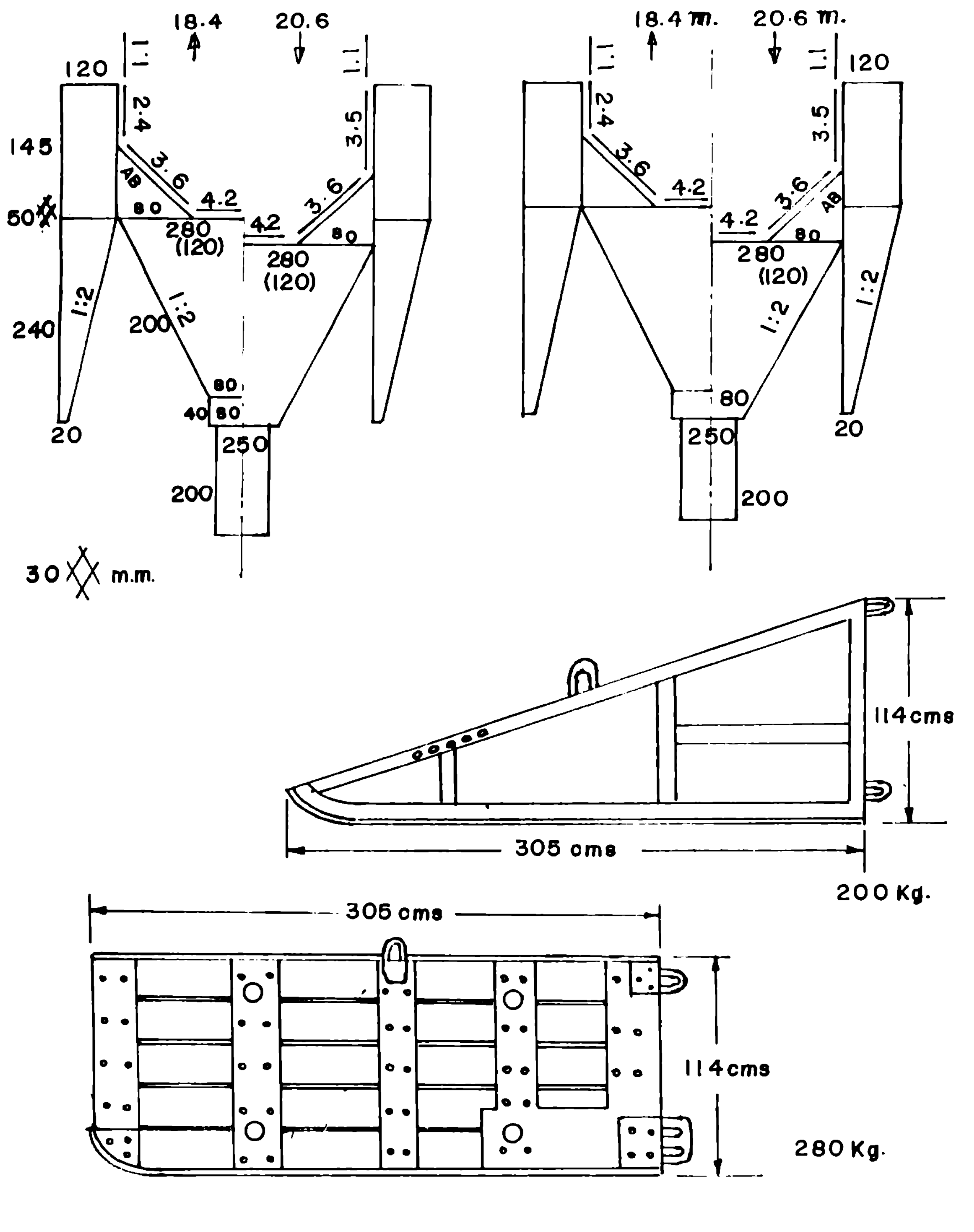
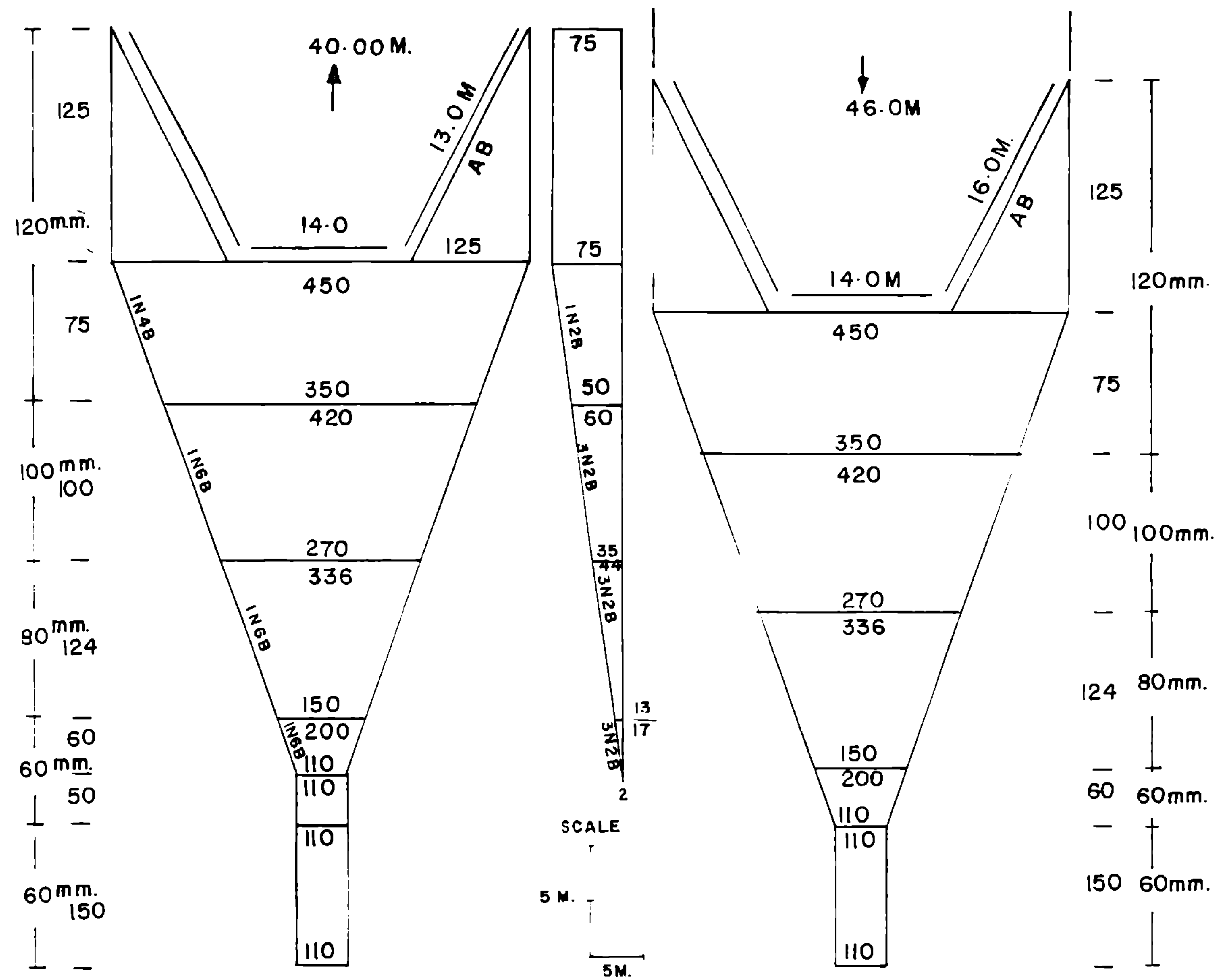
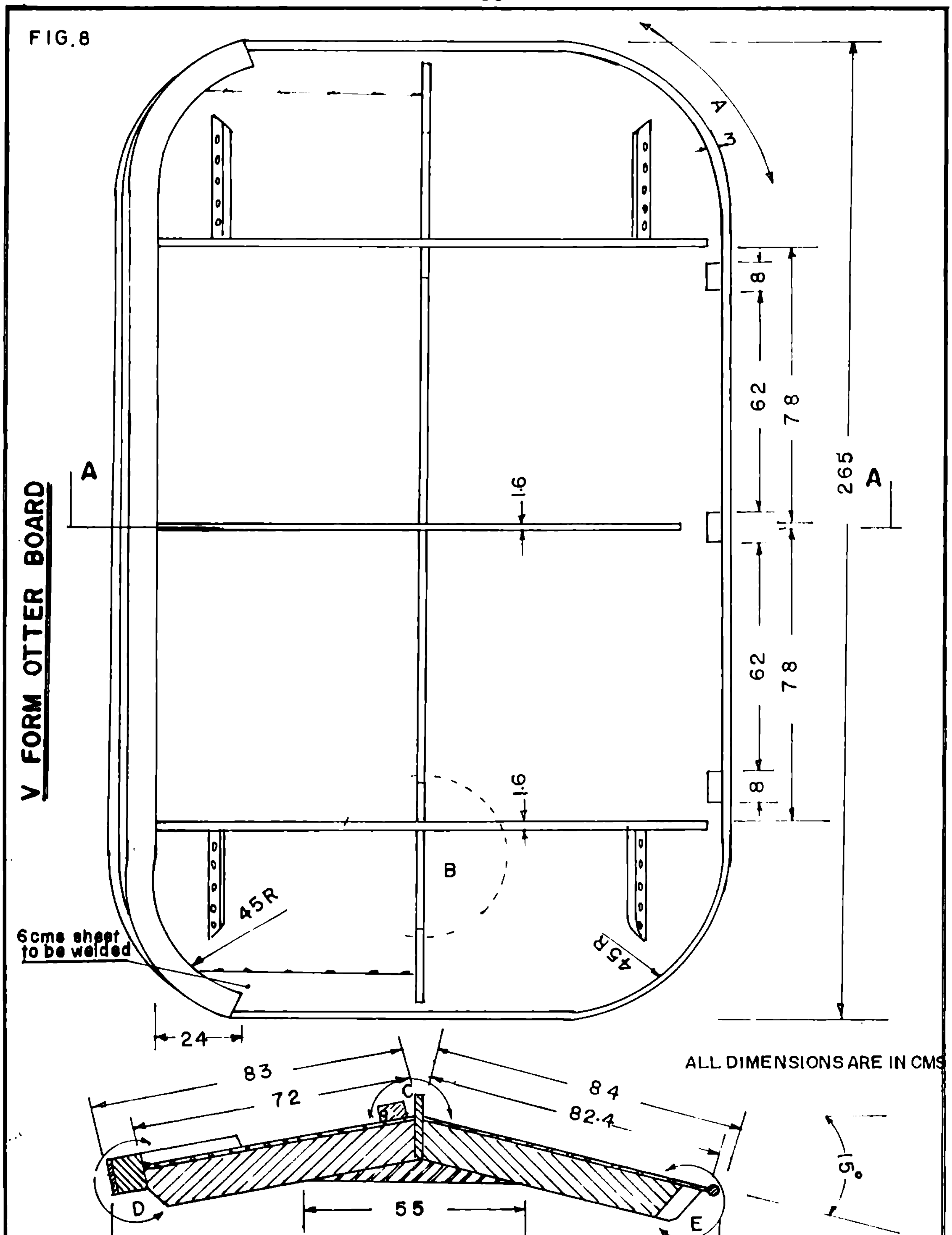


FIG. 7

FOUR SEAM DEEP SEA LOBSTER TRAWL

VESSEL D & E





SECTION AT A.A

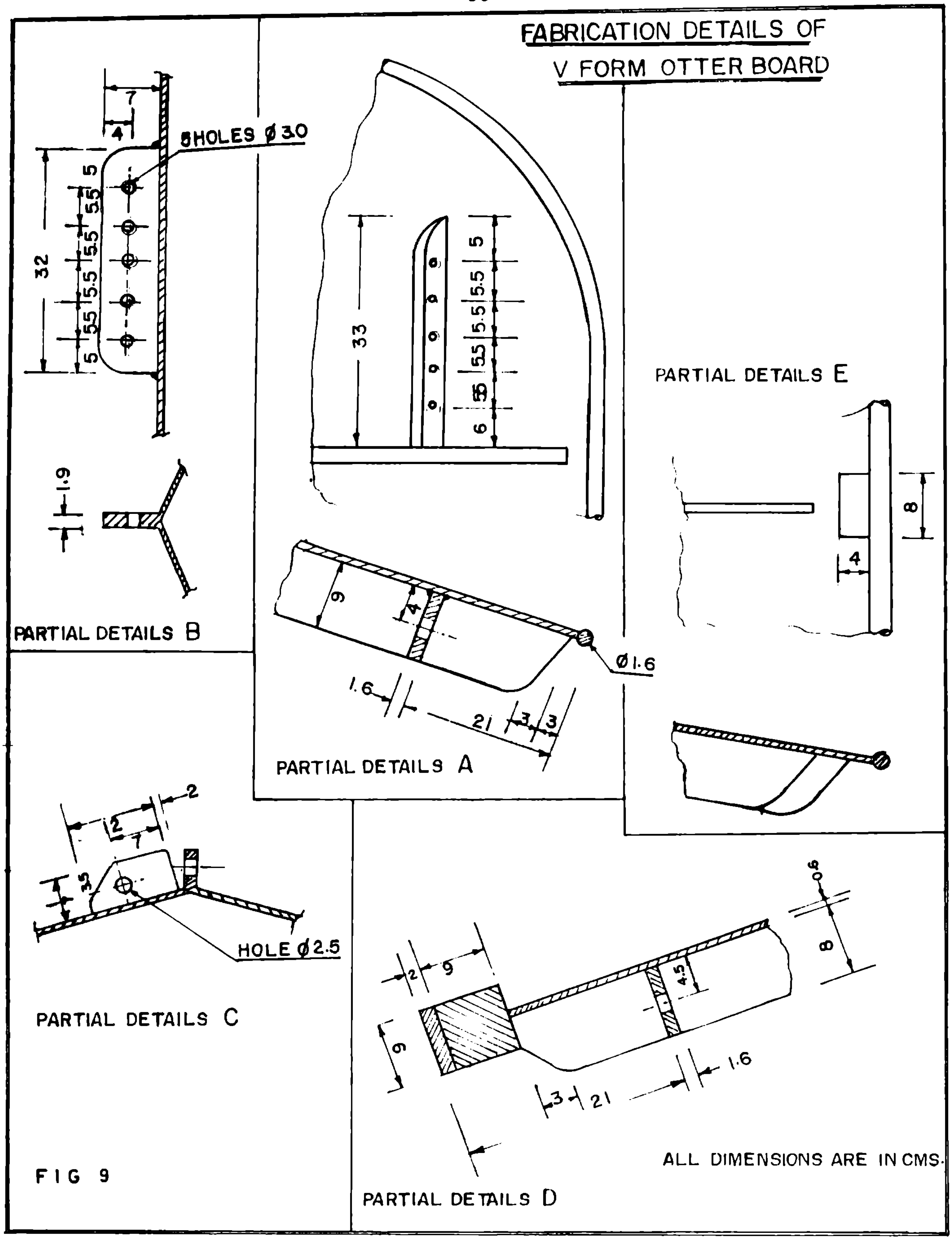

FABRICATION DETAILS OF
V FORM OTTER BOARD
5HOLES Ø 3.0
PARTIAL DETAILS B
PARTIAL DETAILS A
Ø1.6
PARTIAL DETAILS E
HOLE Ø 2.5
PARTIAL DETAILS C
PARTIAL DETAILS D
ALL DIMENSIONS ARE IN CMS.

FIG 9

FIG 10

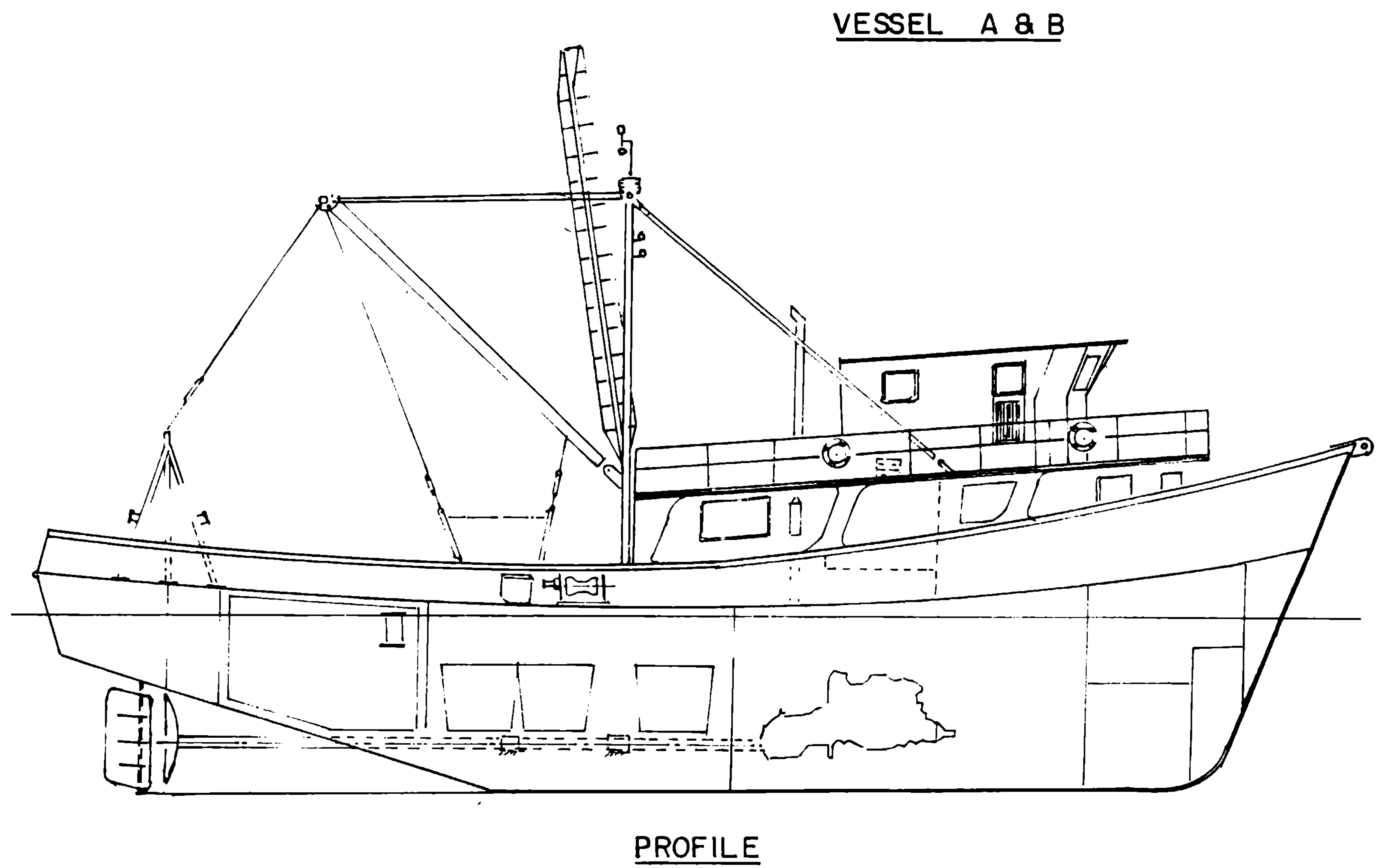
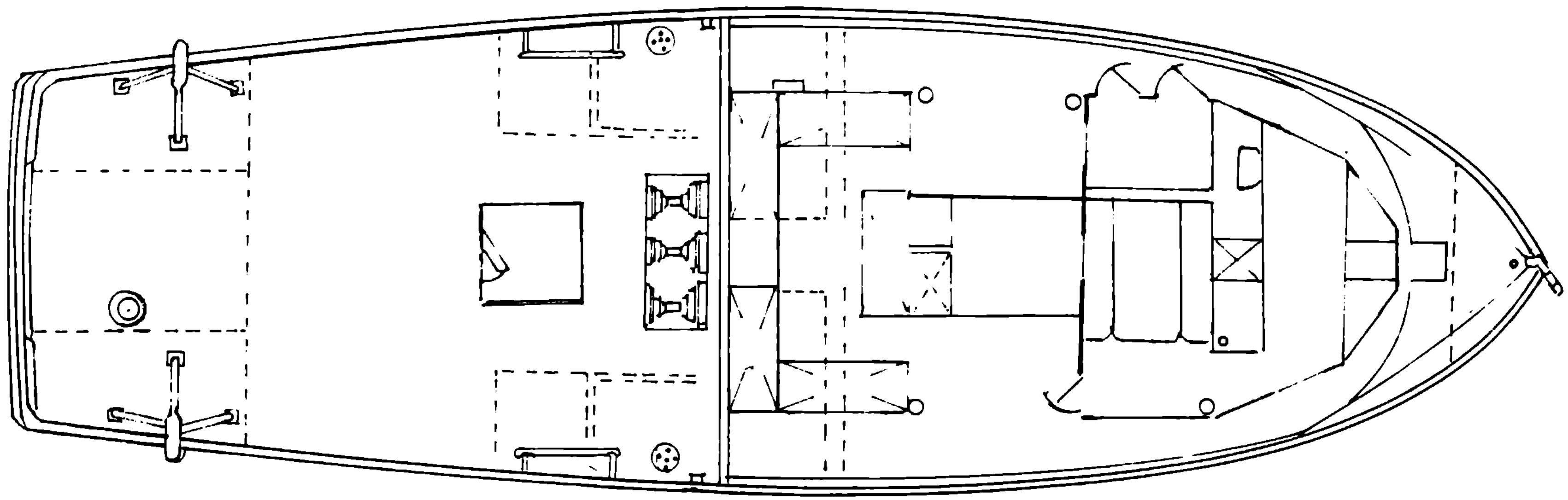


FIG. 11

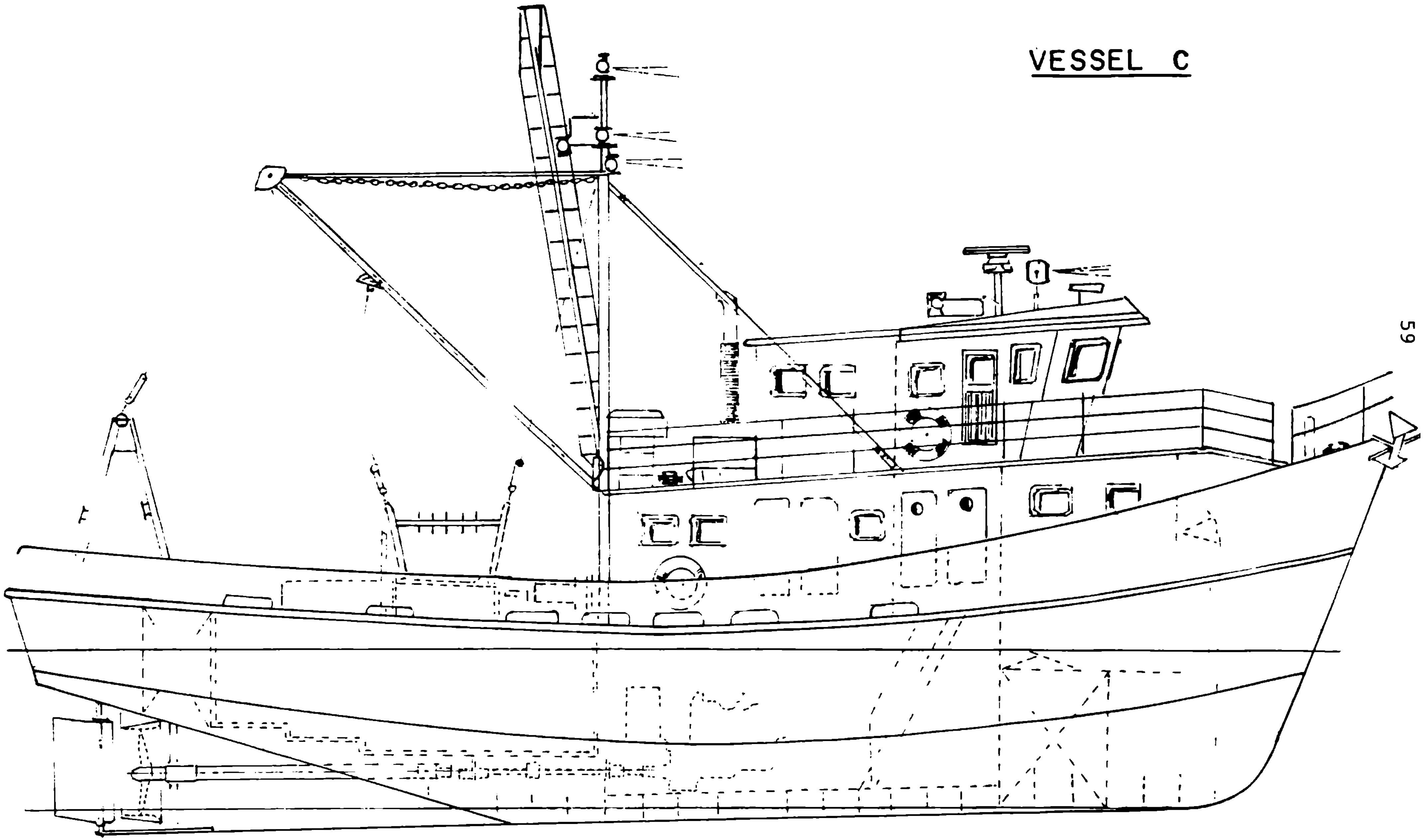
VESSEL A & B



MAIN DECK

FIG. 12

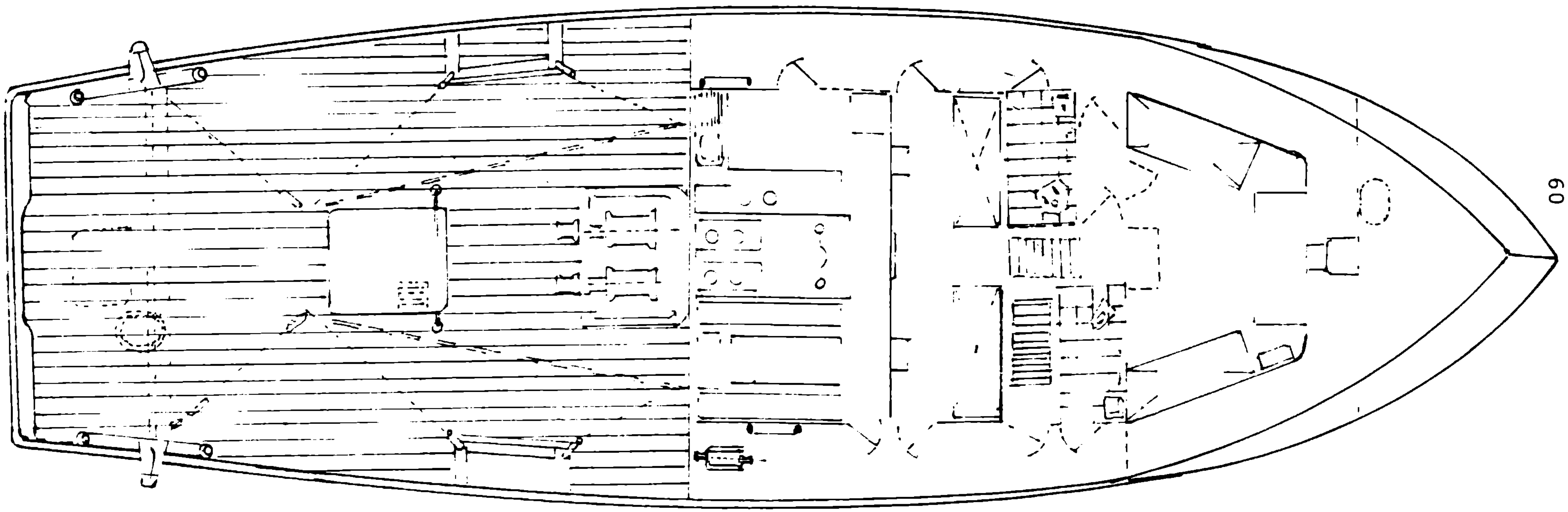
VESSEL C



PROFILE

FIG. 13

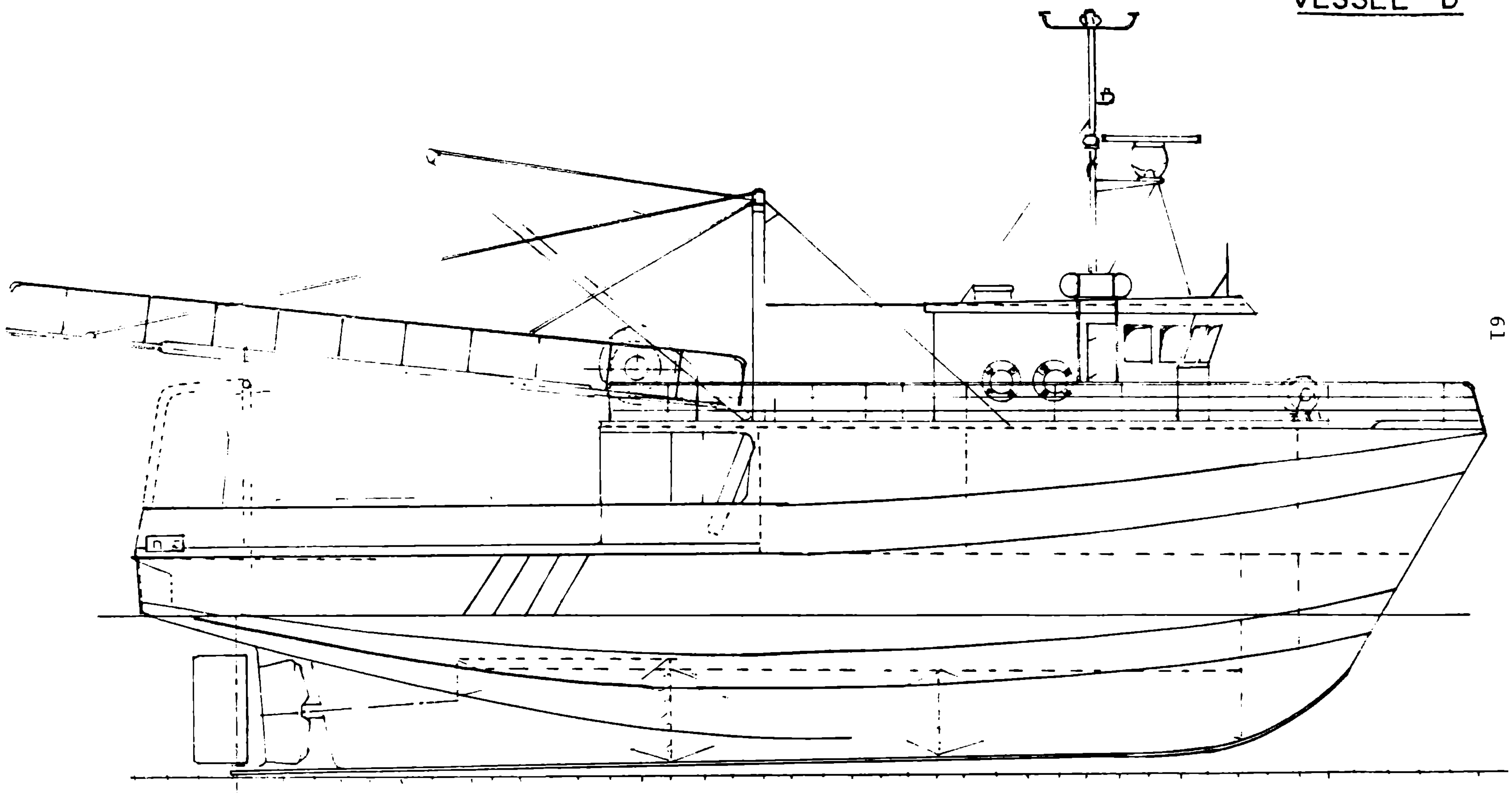
VESSEL C



MAIN DECK

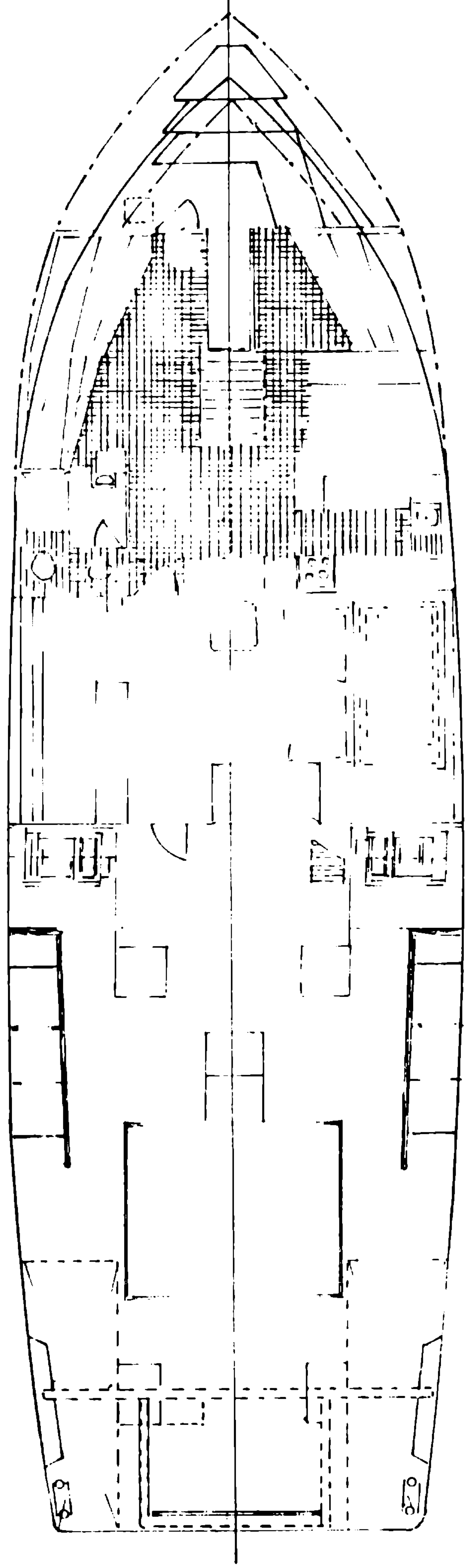
FIG.14

VESSEL D



PROFILE

VESSEL D

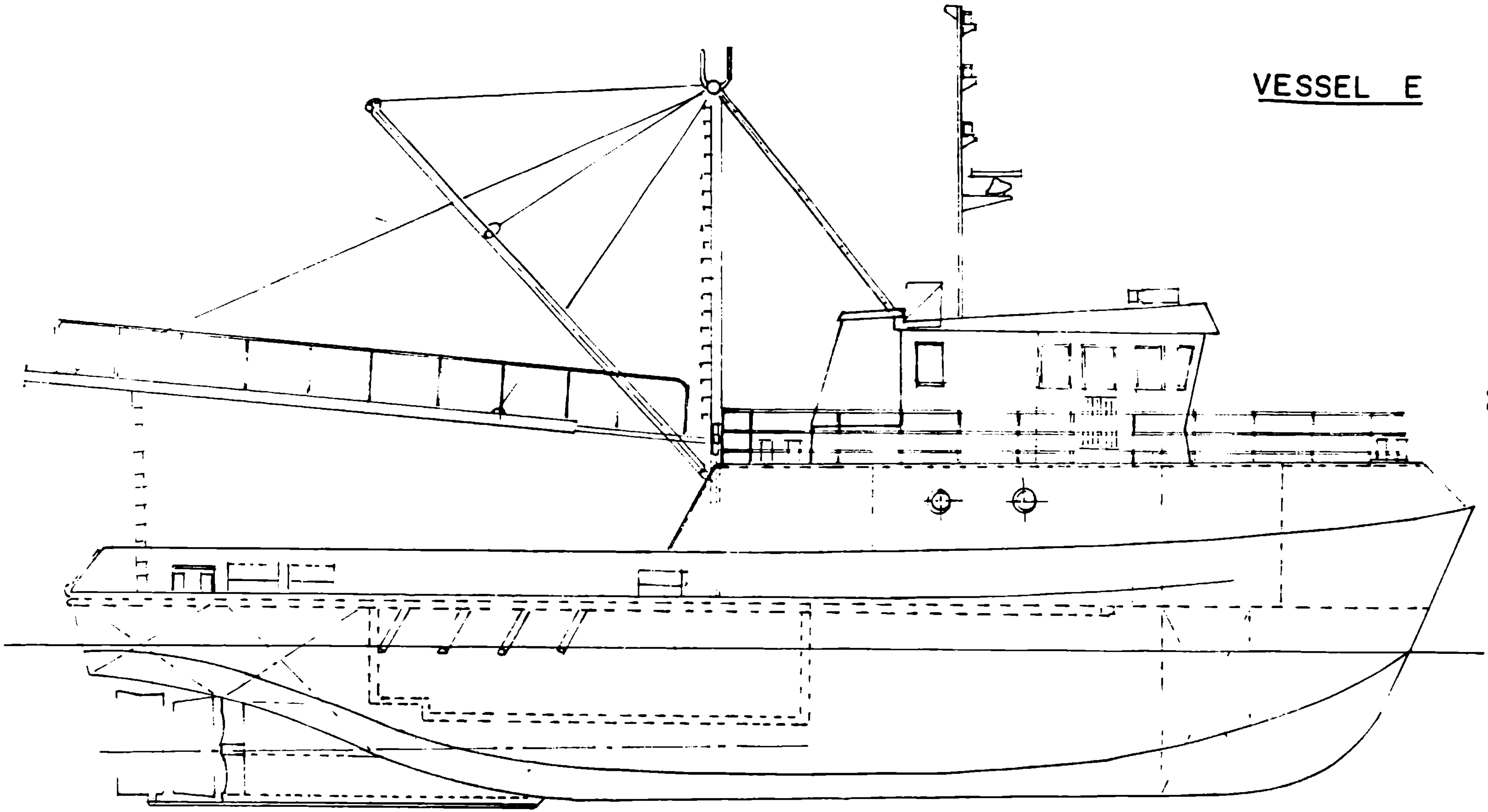


MAIN DECK

FIG 15

FIG 16

VESSEL E



PROFILE

VESSEL E

MAIN DECK

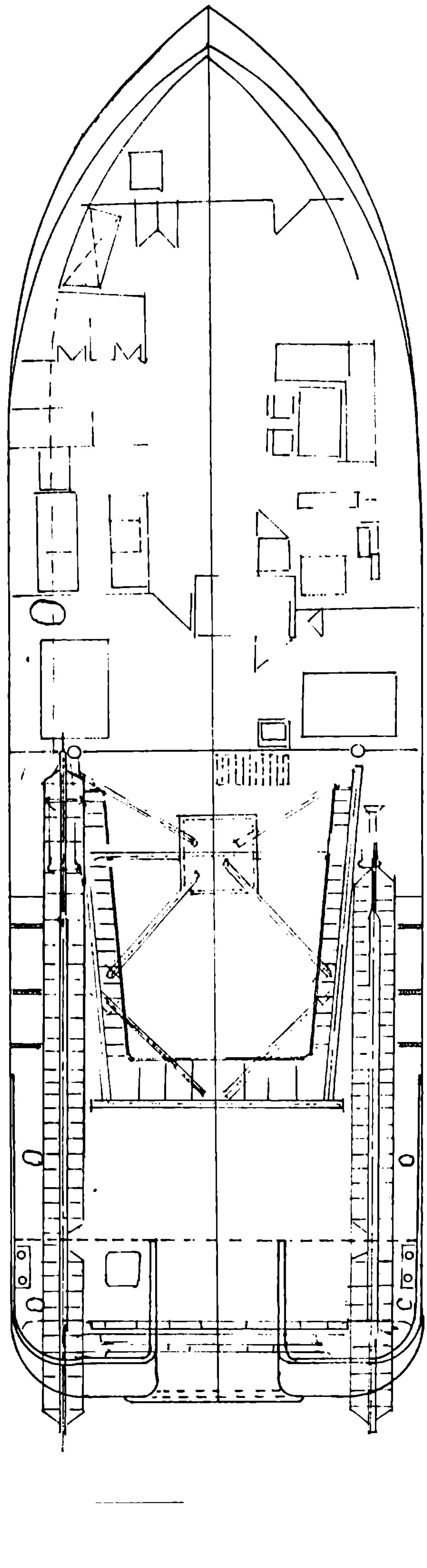
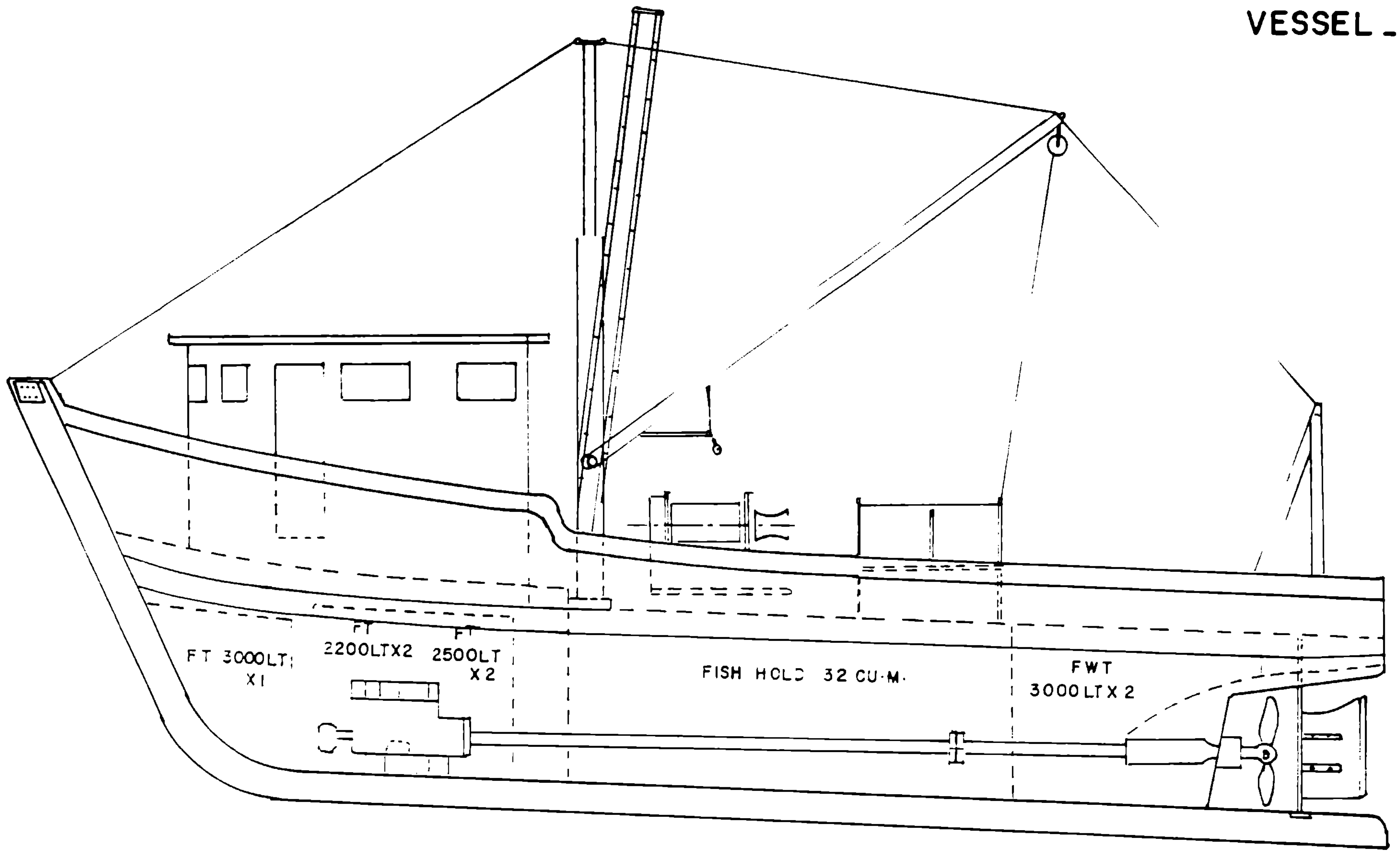


FIG.17

FIG. 18

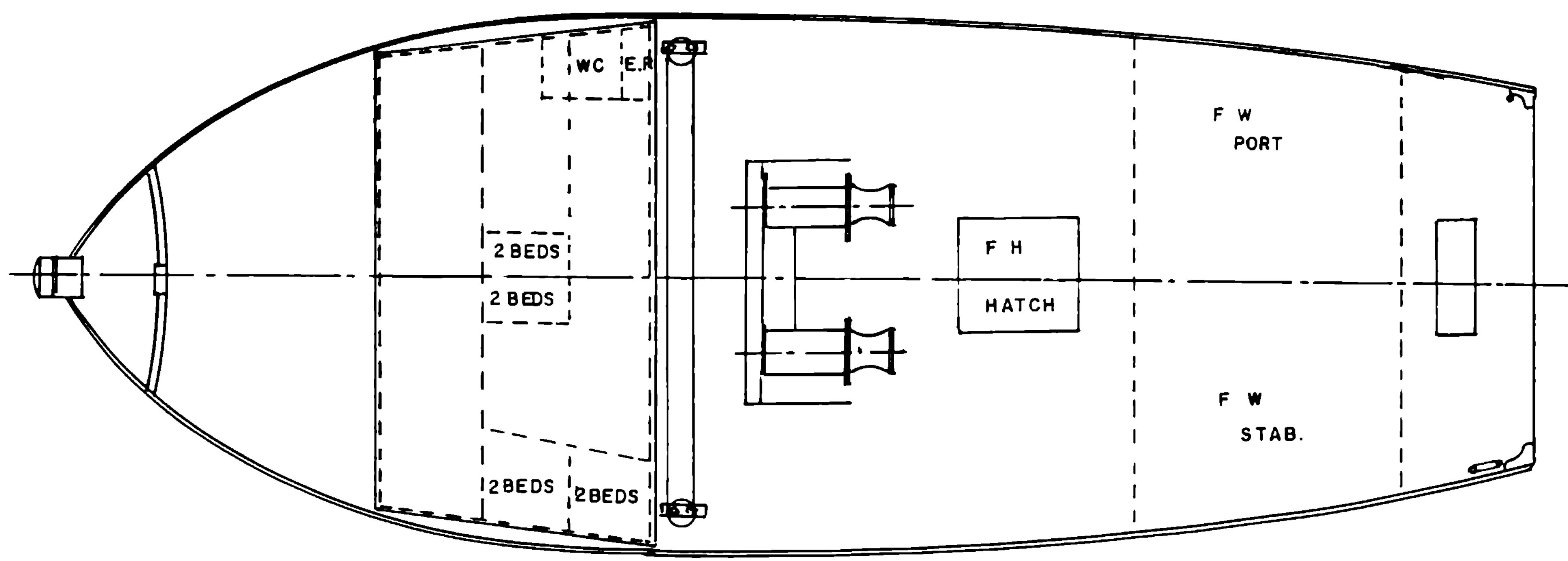
VESSEL _ F



PROFILE

FIG.19

VESSEL_ F



MAIN DECK

FIG. 20

OUTRIGGER STABILIZER BOOM

(SIDE ELEVATION TOWARDS PORT SIDE)

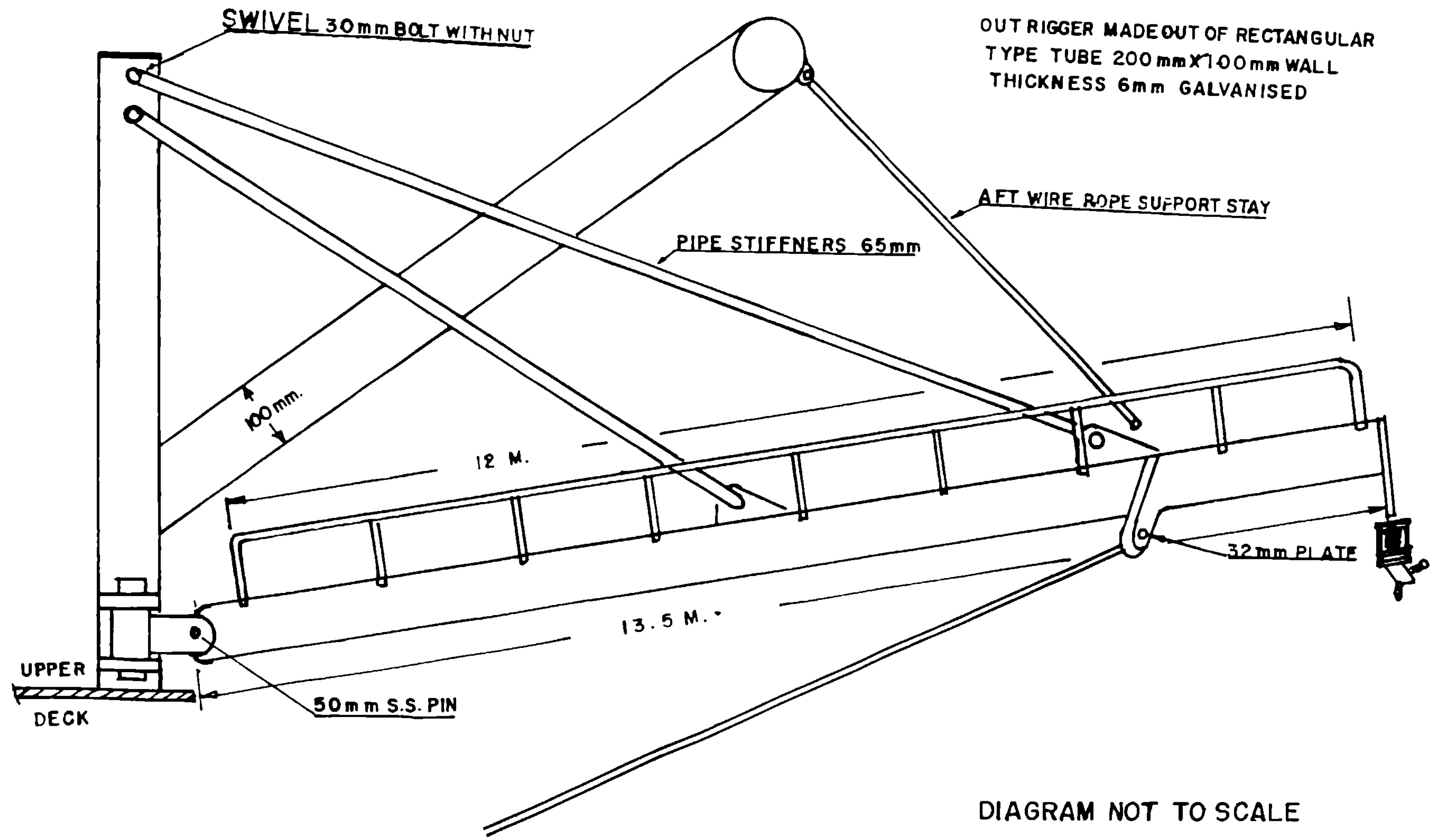
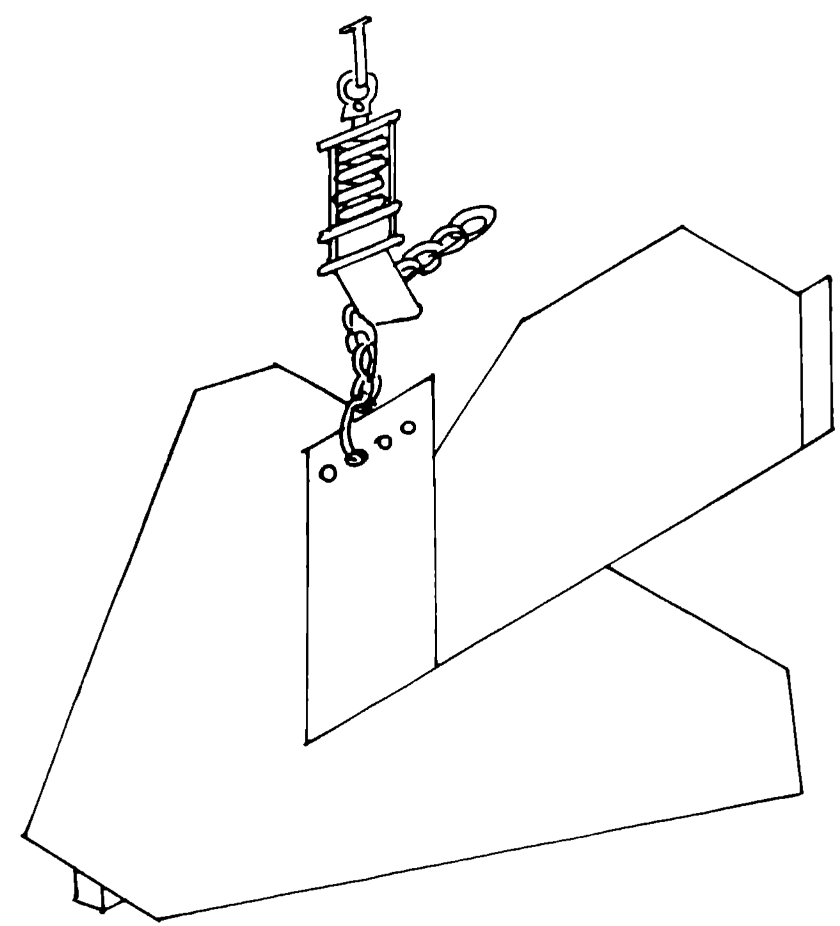


DIAGRAM NOT TO SCALE

FIG - 21

STABILIZER PLANE

(SIDE VIEW)



WEIGHT — 61 Kg.
PLATE — 8mm.thk.

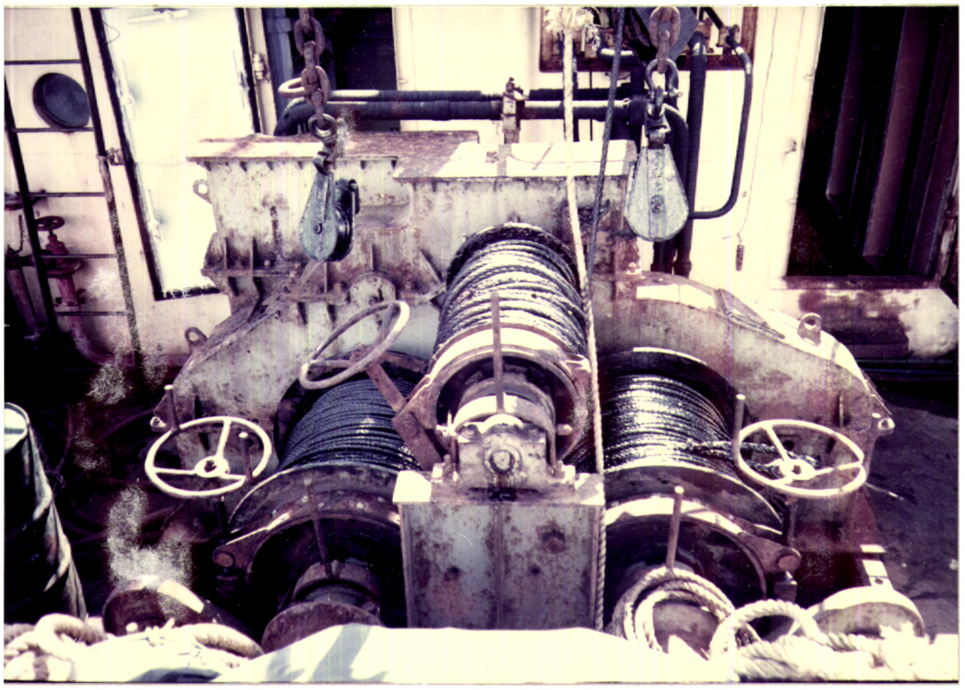
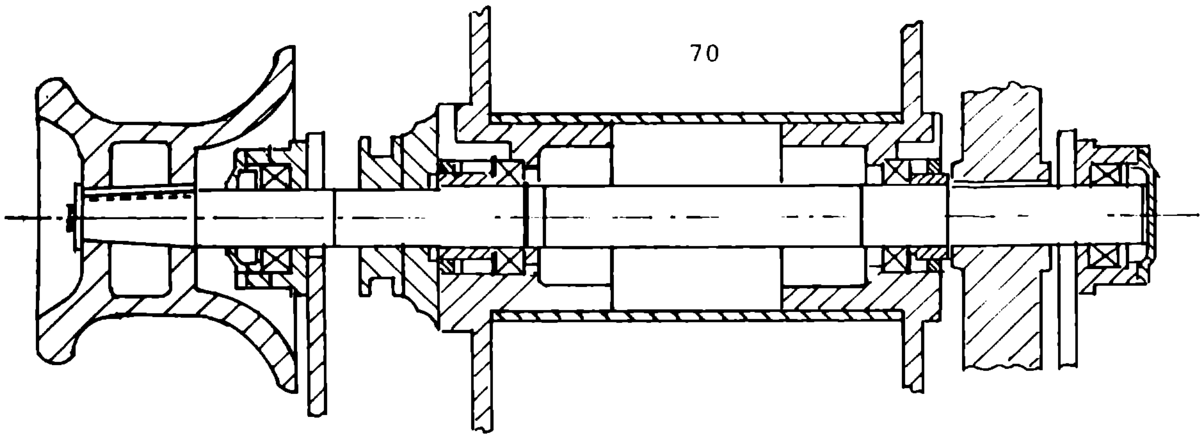
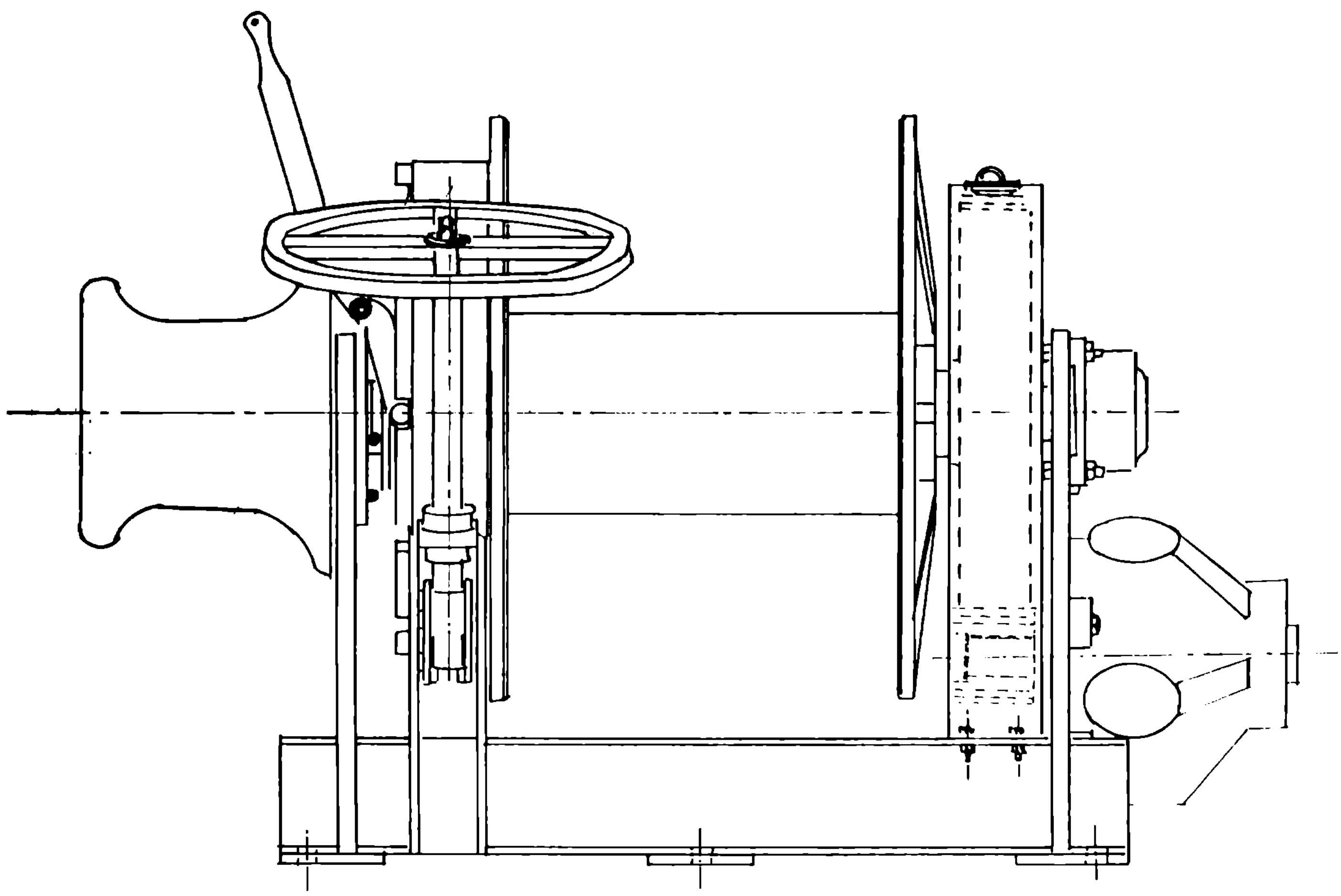


Fig 22. Three drum winch Vessels A, B & C



SECTION ON SHAFT ℄



ELEVATION

Fig. 23 SPLIT WINCH OF VESSELS D & E

CHAPTER 4

RESULTS OF INDUSTRIAL FISHING

During 1991-92, 155 industrial vessels of 20 m. and above operated from Visakhapatnam base (CMFRI, Personal Communication). Almost all these were outrigger vessels operated for shrimp. Five parameters such as number of vessels operated, fishing days, fishing hours, total prawn catch and CPUE have been ploted to indicate effort and production of these vessels (Figure 57).

Out of 155 vessels, 135 have been surveyed in detail to study the parameters such as LOA - HP relationship, HP - fuel consumption correlation, countries of construction of Industrial vessels, age of vessels, propeller assembly, types of engine installed, types of rigging, availability of power on board and types of engines installed in the vessels. The results of analysis of these factors are stated in figures 24 to 29.

Out of 135 vessels surveyed, 6 different types of vessels (Vessels A, B, C, D, E and F) have been selected to collect fishing details such as type of fishing, voyage duration, fishing days, number of hauls taken, fishing effort, depth at which the vessel fished, species of shrimp caught, CPUE and Cash inflow and outflow.

4.1. VESSEL 'A'

Vessel A conducted 5 voyages of 88 fishing days expending 1293 hours in 309 hauls. The duration of fishing voyage varied from 7 to 23 days. The fishing has been carried out at a depth range of 30 to 80 m. and the vessel has landed a total of 8247 kg. of prawn valued at Rs 1,401,762. (The various species of shrimp landed have been recorded as headless weight throughout the study). She has also landed fish catch worth Rs.87,037. Voyagewise production of different species of shrimp is given from figures 30 - 35. The cash inflow and outflow of vessel A is given in figure 36. The average CPUE of the vessel was calculated as 5.54.

4.2. VESSEL 'B'

Vessel B conducted 7 voyages of 199 fishing days expending 3760 hours at a fishing depth ranging from 35 - 90 m. The duration of the voyage varied from 27 to 30 days and landed 28282 kg. of prawns valued at Rs 4,339,402. The vessel also landed fish worth Rs 315,178 and consumed 278 kilo litres of fuel costing Rs 1,464,610. The vessel was in operation throughout the year from June to March. The voyagewise production of different species of shrimp is furnished in figure 31. The cash inflow and outflow of this vessel is seen from figure 37 and the average CPUE of this vessel was 7.49.

4.3. VESSEL 'C'

Vessel C conducted 6 voyages of 210 fishing days expending 3,212 hours at a fishing depth ranging from 30 to 82 m. depth. The duration of fishing voyage varied from 30 to [illegible] [illegible] The voyages [illegible] as seen from [illegible] this vessel [illegible]

[illegible]

Vessel [illegible] which 3 [illegible] were for [illegible] and [illegible] the [illegible] shrimp [illegible] number of [illegible] and [illegible] trawling were [illegible] of fishing voyage [illegible] 9,80[illegible] shrimp expe[illegible] [illegible] fish worth Rs 343,625. The total running expenditure of this vessel for catching the above quantity of lobster, shrimp and fish was Rs 2,310,737 consuming 279.5 kilo lites of diesel oil. The species-wise shrimp landed is given at Figure 33 and the Cash inflow and outflow of the vessel is given at Figure 39.

4.5. VESSEL 'E'

Vessel 'E' could not operate the first 2 voyages due to maintenance and engineering repairs. She conducted only 4 voyages starting from October 1991. The vessel conducted only 1 voyage of 45 days for shrimp expending 365 hours in 147 hauls. Shrimp trawling has been carried out at a depth range 40 to 80 m. The vessel landed 4,100 kg. of shrimp valued Rs 1,004,699. She conducted 3 voyages having a duration of 15 to 45 days for Deep sea lobster producing 6,325 kg. of lobster. The production of lobster during third voyage was not significant as this was a break voyage due to engineering snags and she made frequent entry into the port. This vessel altogether spent 145 fishing days and 1080 hours of fishing. During deep sea fishing trawling was carried out at a depth range of 240 - 300 m. while shrimp trawling was done at a depth of 40 - 80 m. Besides shrimp and lobster, fish worth Rs 207,900 was also landed. Total value of shrimp, lobster and fish was Rs 3,378,161. She consumed 199.79 kilo litres of diesel oil and spent Rs 1,737,683 as operational expenses. The voyagewise landing of shrimp and lobster is seen from figure 32. The figure 40 gives the details regarding the cash inflow and outflow of the vessel.

4.6. VESSEL 'F'

The vessel F operated for 9 voyages expending 176 fishing days. She exclusively did shrimp trawling and caught 7,381 kg. of shrimp and caught fish worth Rs 59,130. Thus the total inflow of cash was Rs 1,207,818. The specieswise landing of vessel F is seen from Figure 35. The cash inflow and outflow of this vessel is given in Figure 41. This vessel had no freezer and she was carrying ice for preservation. Her voyages were staggered for the convenience of unloading catch in order to avoid spoilage on board.

Monthly production of shrimp of vessel A, B, C, D, E, F may be seen from table 2. The annual shrimp and lobster production trend of different types of vessel is given in Figure 42. The annual cash flow of different vessels is furnished in Figure 43. The annual percentage composition of lobster and shrimp landed by different types of vessels is seen in Figures 44 to 49. The CPUE in different months for different types of vessels have been plotted and given in Figure 50. Average CPUE for different vessels has been plotted (Figure 51). Figure 52 gives average unit cost of production of different types of vessels. The average unit cost of production (a) and unit price of shrimp/lobster (b) and shrimp/lobster and fish (c) is given in Figure 53.

Shrimp catch landed by the above vessel were headless and it was not possible to give the exact specieswise break-up. To derive the head on weight of these landings, headless weights are multiplied by a factor of 1.4925 (Rao, 1993). Only commercial identification was done utilising common names such as Tiger, White, Brown and Flower, since their scientific names have been explained already.

TABLE 2 MONTHLY PERCENTAGE COMPOSITION OF LOBSTER AND SHRIMP LANDED BY DIFFERENT TYPES OF VESSEL

Month/ Vessel		6	7	8	9	10	11	12	1	2	3	4	5
	L	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	9.8	9.8	5.0	3.1	3.1	8.0	8.0	3.0	3.0	-	-
A	W	-	23.6	23.6	15.7	18.3	18.3	13.6	13.6	5.7	5.7	-	-
	F	-	0.8	0.8	2.0	-	-	-	-	0.3	0.3	-	-
	B	-	65.8	65.8	77.3	78.6	78.6	78.4	78.4	91.0	91.0	-	-
	L	-	-	-	-	-	-	-	-	-	-	-	-
	T	8.9	8.9	3.6	4.4	4.4	4.0	4.0	2.1	2.1	3.8	-	-
B	W	12.0	12.0	4.1	13.2	13.2	18.6	6.6	9.4	9.4	5.0	-	-
	F	0.7	0.7	0.1	0.2	0.2	-	0.1	-	-	0.2	-	-
	B	78.4	78.4	92.2	82.2	82.2	77.4	89.3	88.5	91.0	-	-	-
	L	-	-	-	-	-	-	-	-	-	-	-	-
	T	8.0	8.0	12.5	12.5	6.0	3.6	3.6	3.6	4.8	4.8	-	-
C	W	10.0	10.0	28.5	28.5	16.6	7.5	7.5	7.0	1.6	1.6	-	-
	F	0.6	0.6	0.8	0.8	0.4	0.3	0.3	0.2	-	-	-	-
	B	81.4	81.4	58.2	58.2	77.0	88.6	89.2	93.6	93.6	-	-	-
	L	-	-	-	-	-	-	100.0	100.0	10.0	100.0	100.0	100.0
	T	-	-	9.7	9.7	2.8	2.8	-	-	-	-	-	-
D	W	-	-	41.4	41.4	28.0	28.0	-	-	-	-	-	-
	F	-	-	0.7	0.7	0.3	0.3	-	-	-	-	-	-
	B	-	-	48.2	48.2	68.9	68.9	-	-	-	-	-	-
	L	-	-	-	-	-	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	T	-	-	7.0	7.0	7.0	-	-	-	-	-	-	-
E	W	-	-	47.7	47.7	47.7	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	45.3	45.3	45.3	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-	-	-	-	-
	T	5.4	5.4	4.7	5.2	3.0	3.7	3.7	2.0	11.1	12.0	3.6	-
F	W	36.6	36.6	43.3	45.3	18.7	21.0	21.0	4.5	2.2	0.4	-	-
	F	-	-	-	2.7	1.3	0.6	0.6	-	-	-	-	-
	B	58.0	58.0	52.0	46.8	77.0	74.6	74.6	93.5	86.7	87.6	96.4	-

INDEX L.Lobster, T.Tiger, W.White, F.Flower, B.Brown

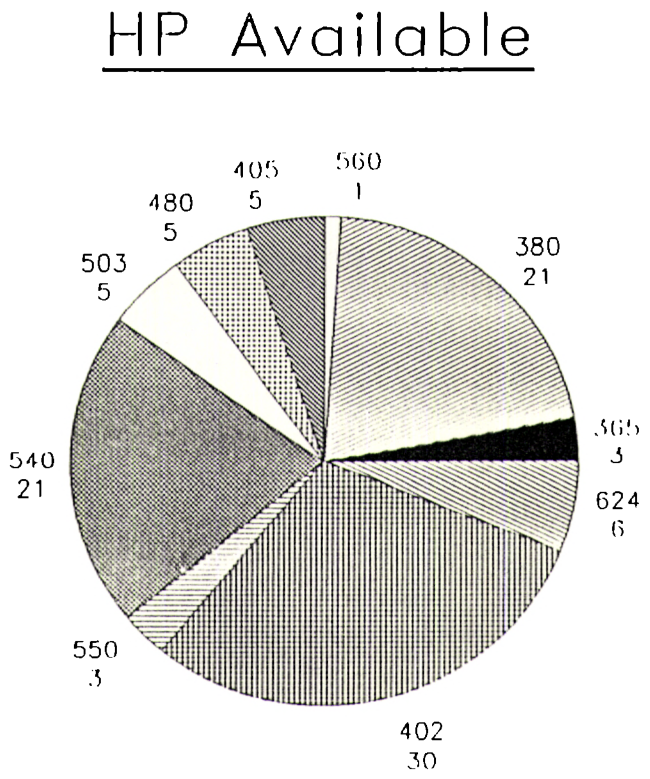

HP Available
560
1
380
21
365
3
624
6
402
30
550
3
540
21
503
5
480
5
405
5

FIG 24

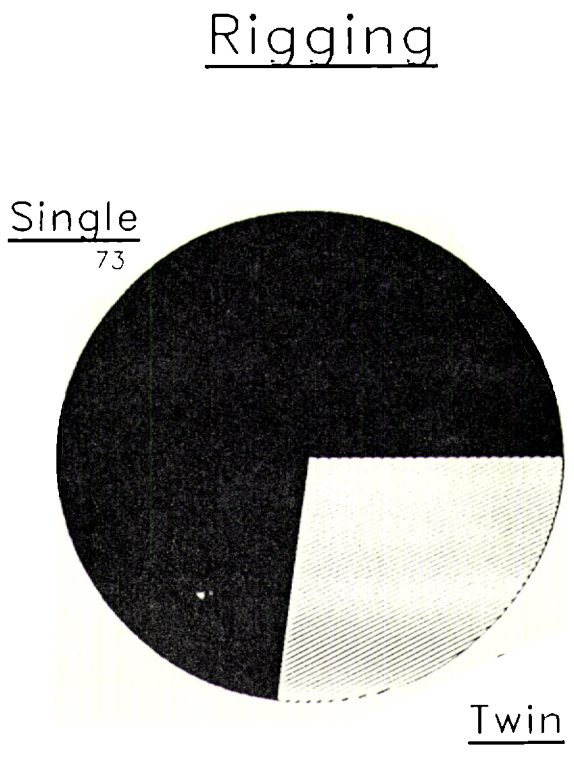


FIG. 25

PROPELLER ASSEMBLY

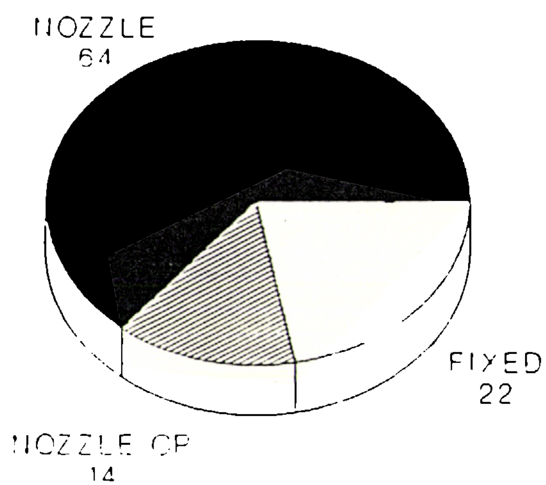


FIG 26

TYPE OF MAIN ENGINE

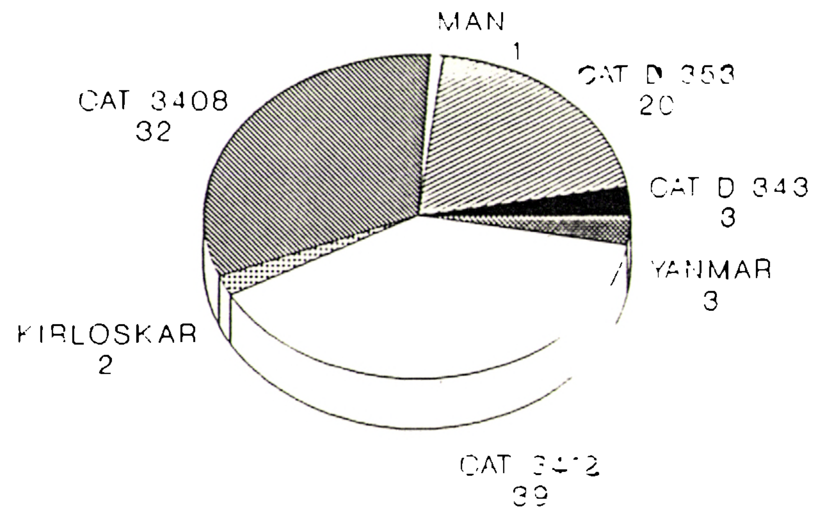


FIG. 27

VESSELS BUILT IN VARIOUS COUNTRIES

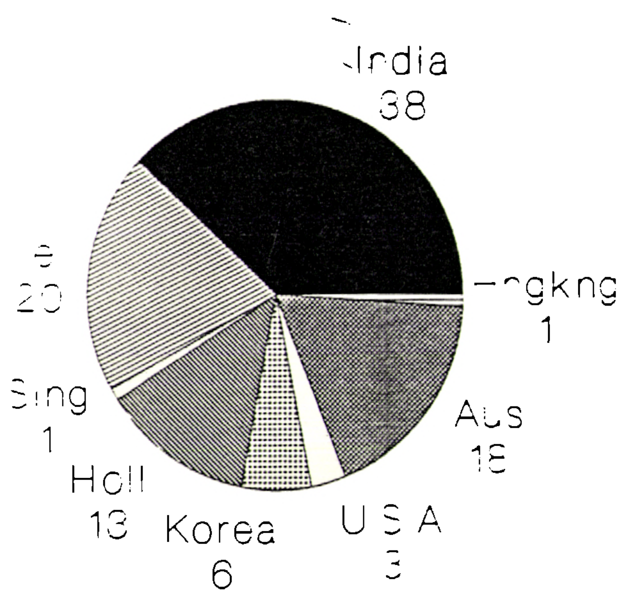


FIG 28

OLDAGE OF VESSELS

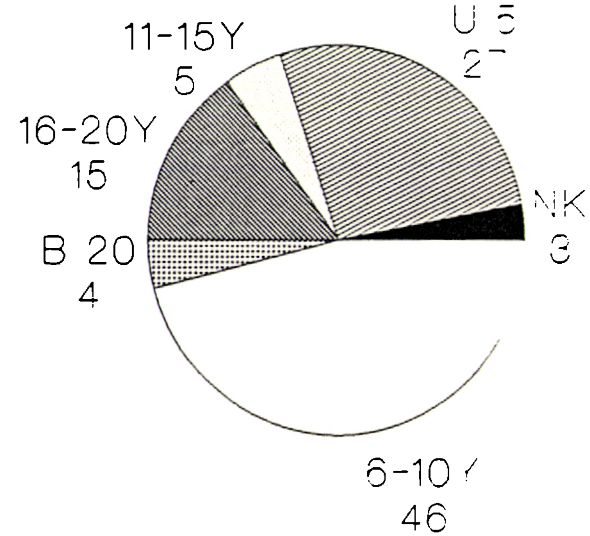
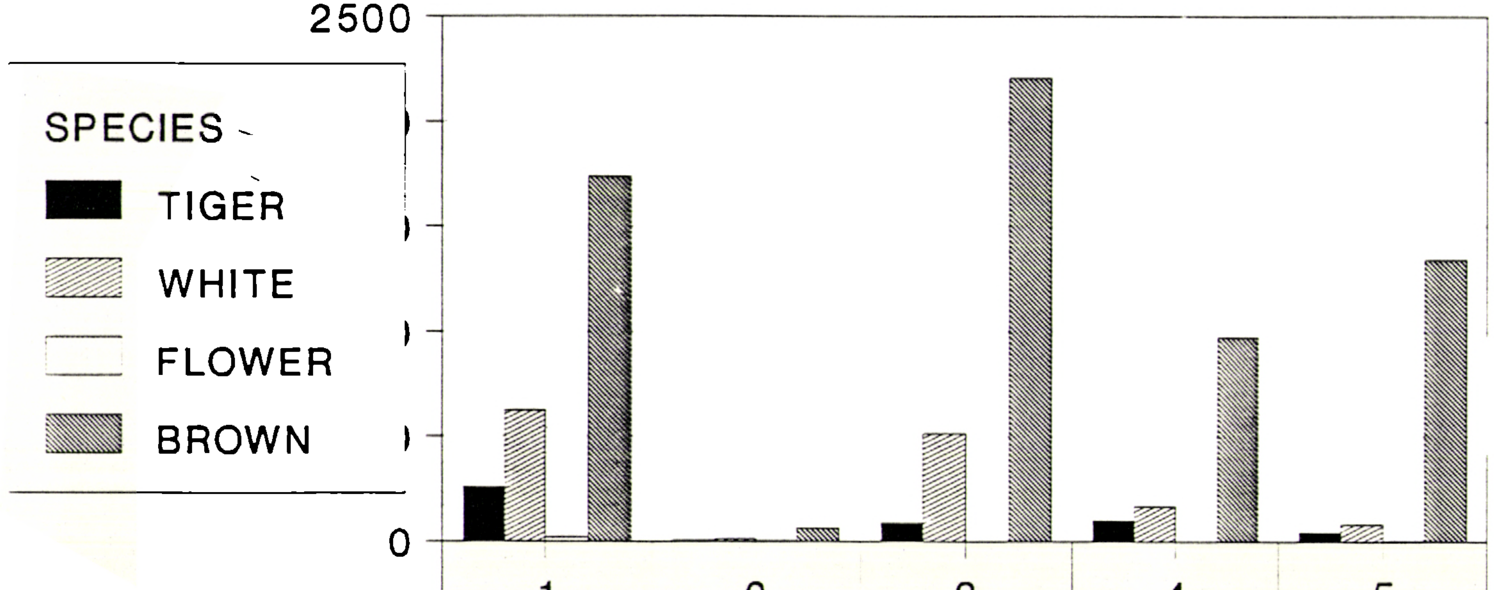


FIG.29

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES - VESSEL A

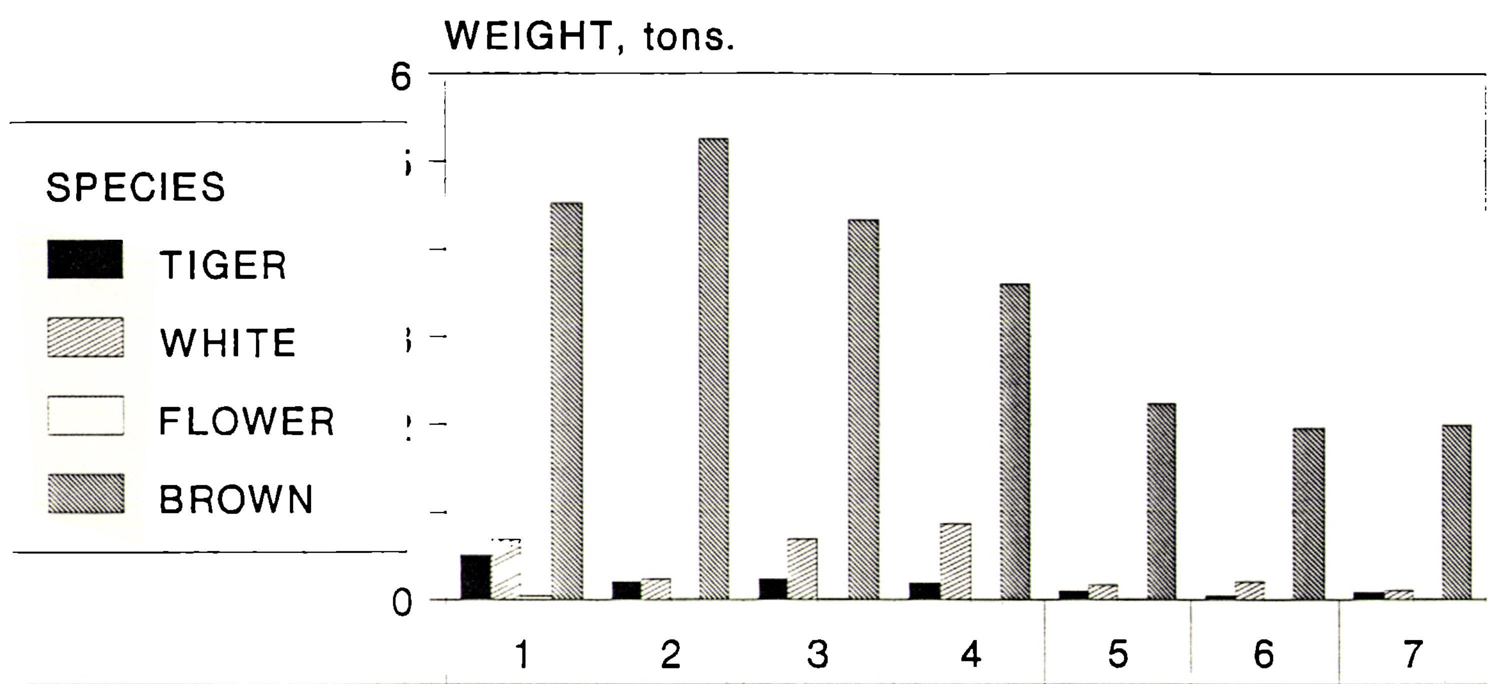


	1	2	3	4	5
TIGER	259.2	4.2	87.56	100.07	44
WHITE	622.9	13.1	513.99	168.43	83.45
FLOWER	20.78	1.65			4
BROWN	1737.52	64.35	2204.13	975.08	1342.9

VOYAGE

FIG. 30

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES - VESSEL B

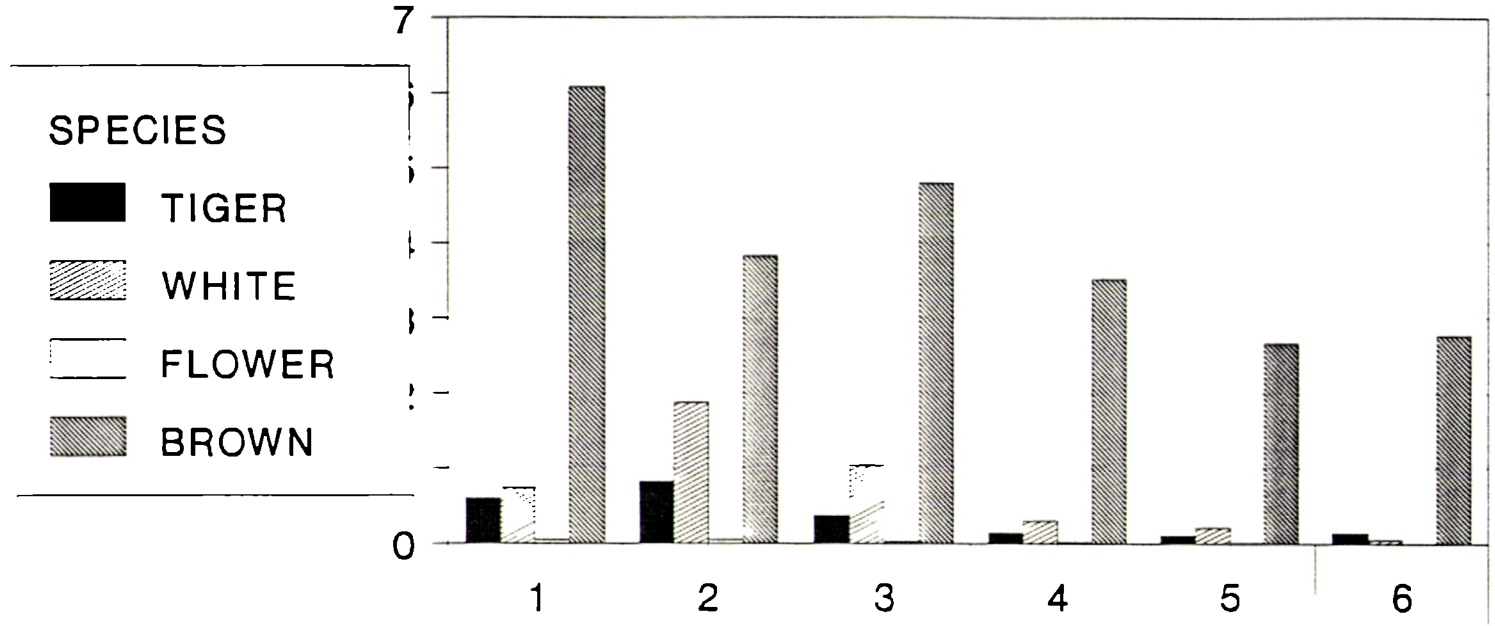


	1	2	3	4	5	6	7
TIGER	0.512	0.204	0.232	0.187	0.101	0.046	0.082
WHITE	0.691	0.236	0.695	0.865	0.164	0.207	0.108
FLOWER	0.04	0.003	0.009		0.003		0.004
BROWN	4.524	5.256	4.33	3.602	2.237	1.958	1.984

VOYAGE

FIG. 31

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES - VESSEL C

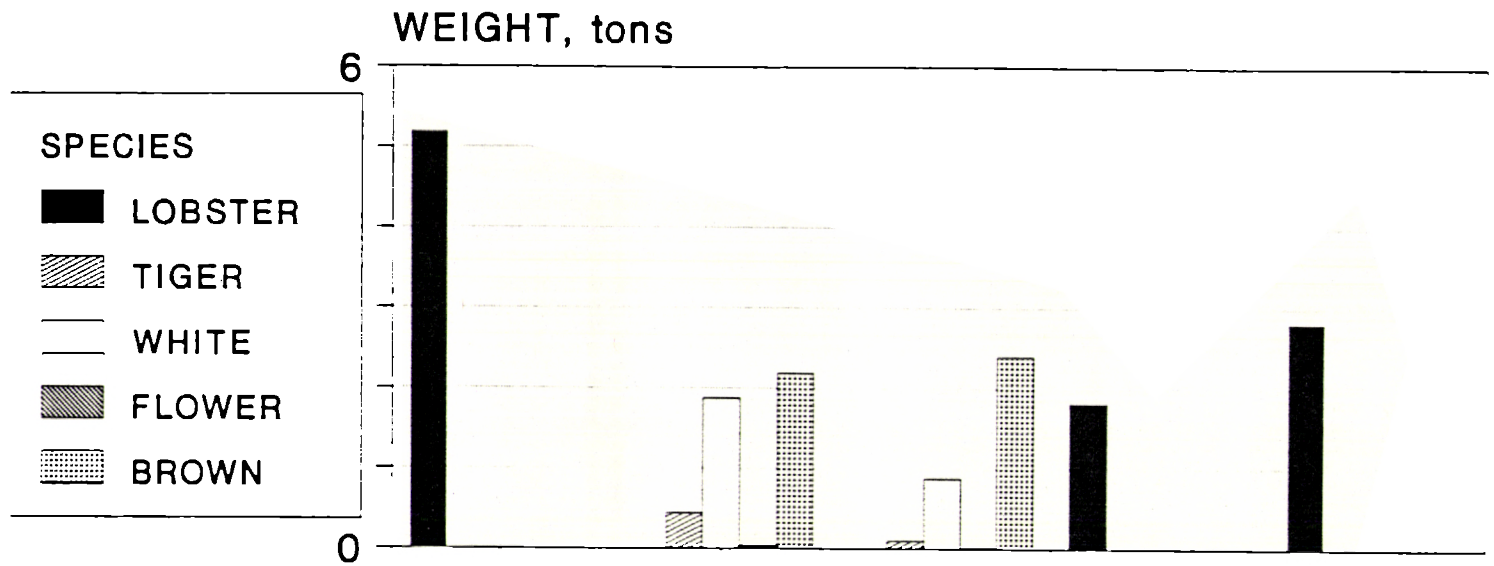


	1	2	3	4	5	6
TIGER	0.599	0.821	0.368	0.141	0.108	0.142
WHITE	0.745	1.872	1.036	0.297	0.208	0.048
FLOWER	0.048	0.049	0.025	0.014	0.004	
BROWN	6.071	3.831	4.801	3.515	2.66	2.769

VOYAGE

FIG. 32

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES -VESSEL D

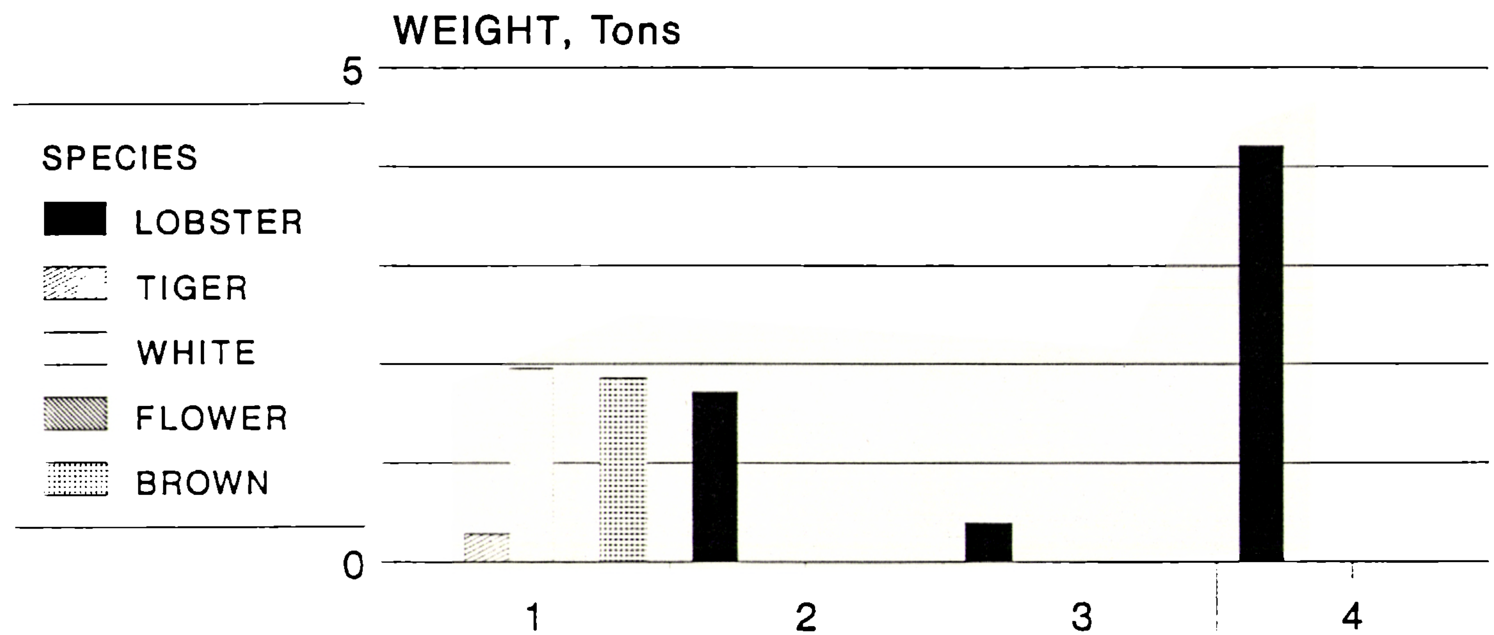


	1	2	3	4	5
LOBSTER	5.182	0	0	1.815	2.805
TIGER	0	0.436	0.098	0	0
WHITE	0	1.871	0.871	0	0
FLOWER	0	0.033	0.012	0	0
BROWN	0	2.179	2.391	0	0

VOYAGE

FIG. 33

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES - VESSEL E

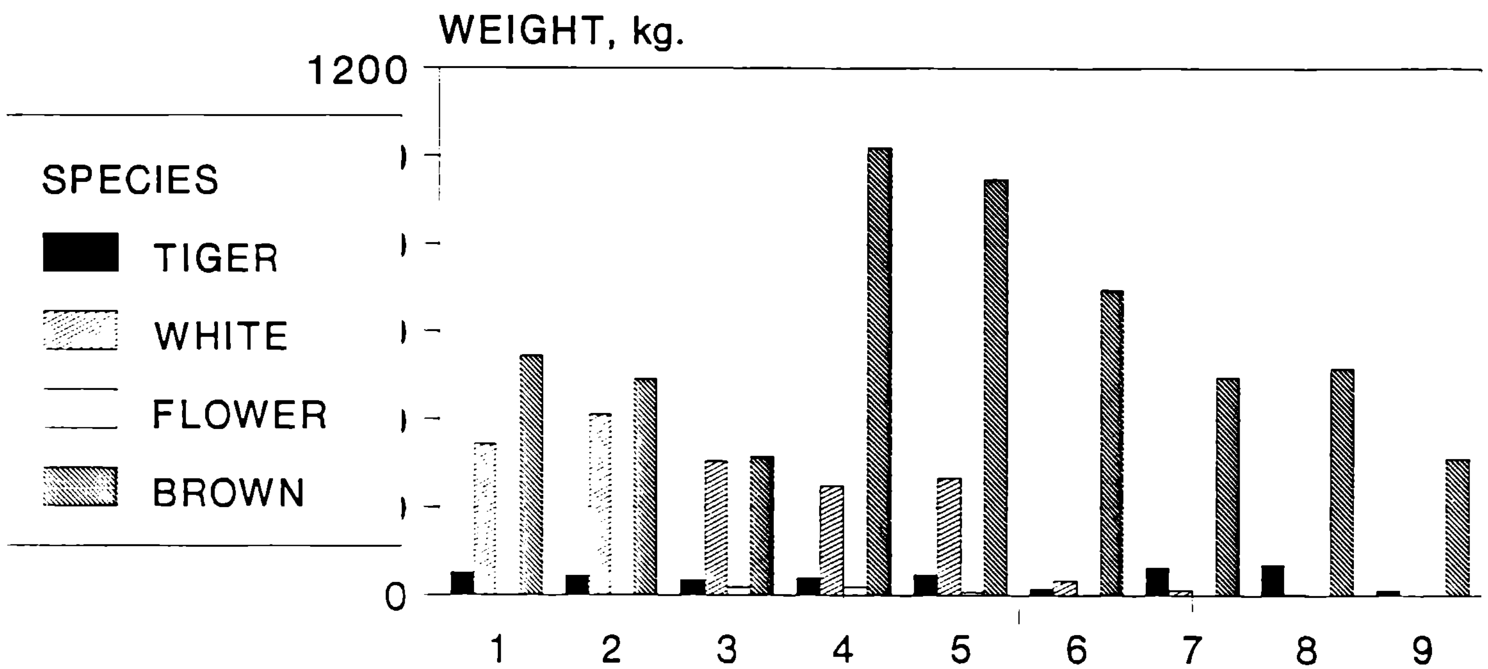


	1	2	3	4
LOBSTER	0	1.721	0.394	4.21
TIGER	0.285	0	0	0
WHITE	1.957	0	0	0
FLOWER	0	0	0	0
BROWN	1.858	0	0	0

VOYAGE

FIG. 34

VOYAGE WISE PRODUCTION OF DIFFERENT SPECIES - VESSEL F

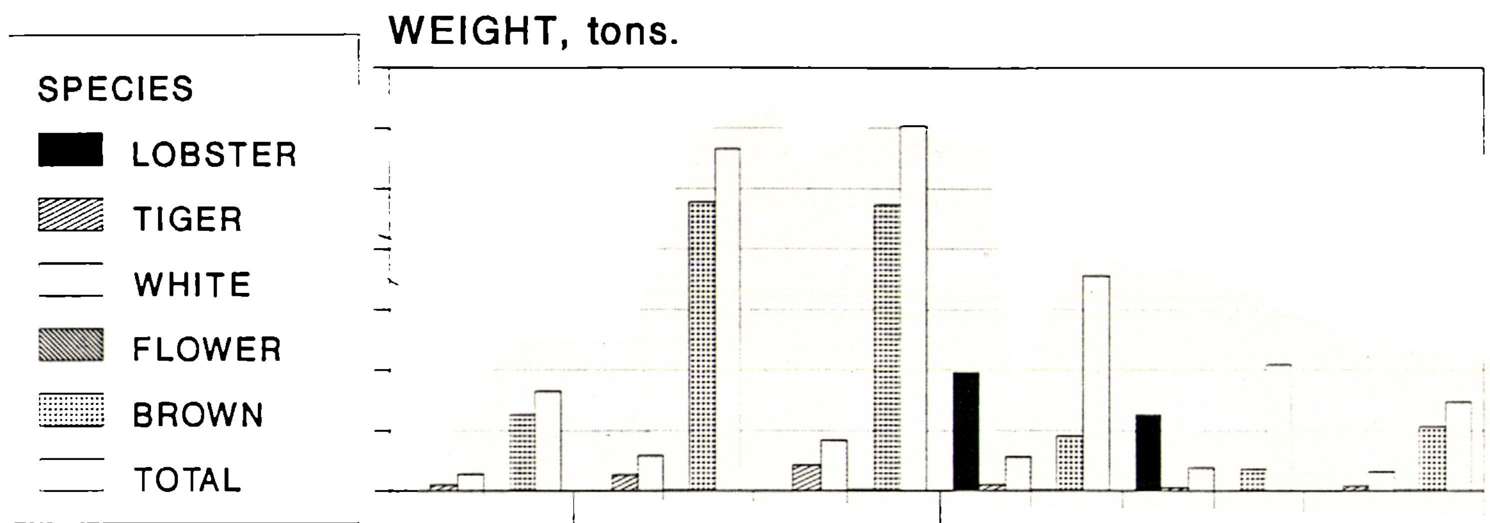


	1	2	3	4	5	6	7	8	9
TIGER	51.1	44.1	34.8	39.7	47.2	15.5	63.7	70.9	11.5
WHITE	343.5	410.9	305	247.3	266.1	32.7	12.4	2.5	
FLOWER			18.3	18.3	7.3				
BROWN	545.4	491.9	314.8	1019.7	946.9	696.1	496.1	515.7	311.8

VOYAGE

FIG. 35

ANNUAL SHRIMP/LOBSTER PRODUCTION TREND OF DIFFERENT TYPES OF VESSEL



	A	B	C	D	E	F
LOBSTER				9.802	6.325	
TIGER	0.495	1.364	2.18	0.534	0.285	0.379
WHITE	1.402	2.967	4.206	2.842	1.957	1.62
FLOWER	0.026	0.059	0.141	0.045	0	0.044
BROWN	6.324	23.892	23.648	4.57	1.858	5.338
TOTAL	8.247	28.282	30.174	17.794	10.425	7.381

VOYAGE

FIG.36

CASH INFLOW AND OUTFLOW VESSEL A

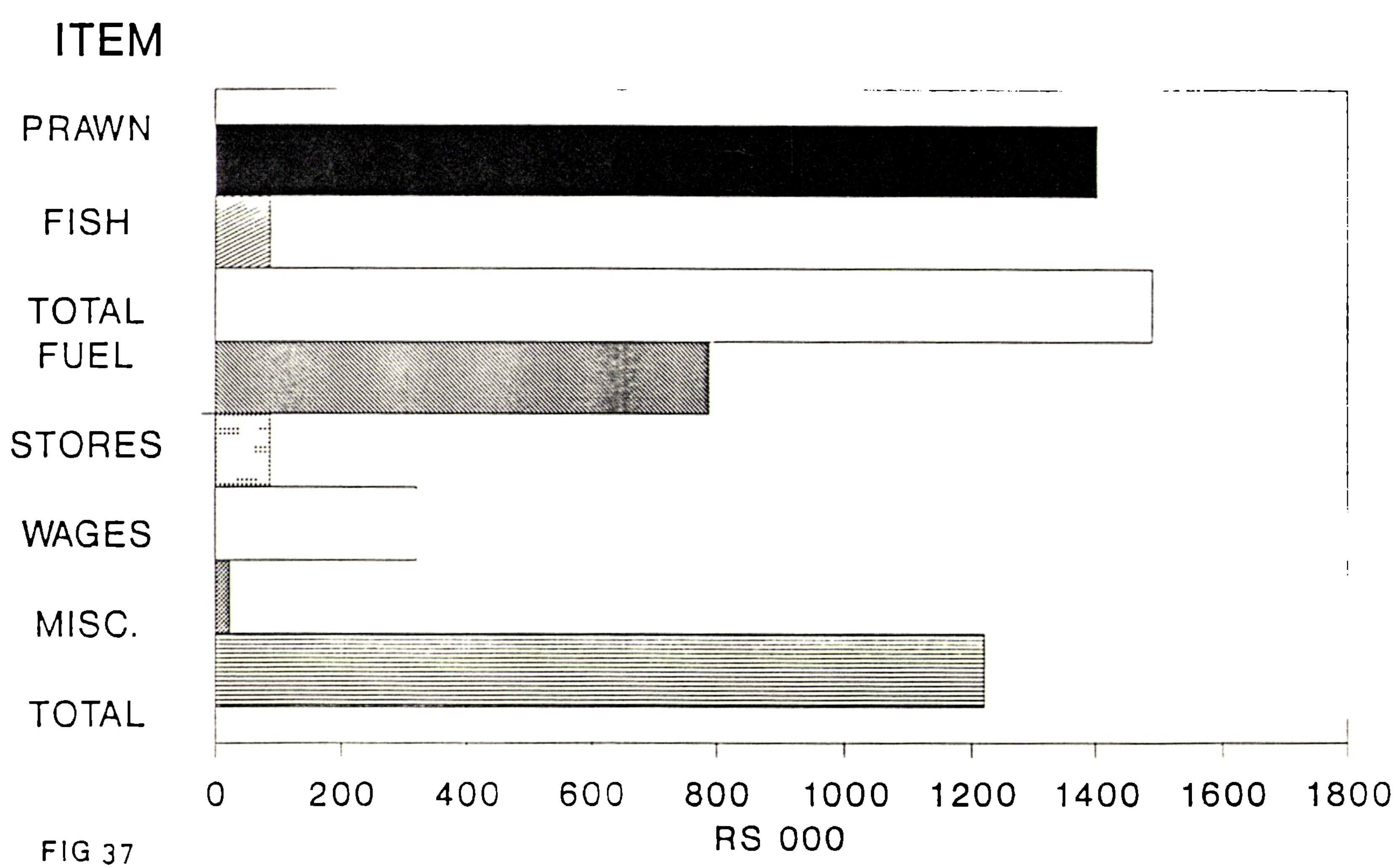


FIG 37

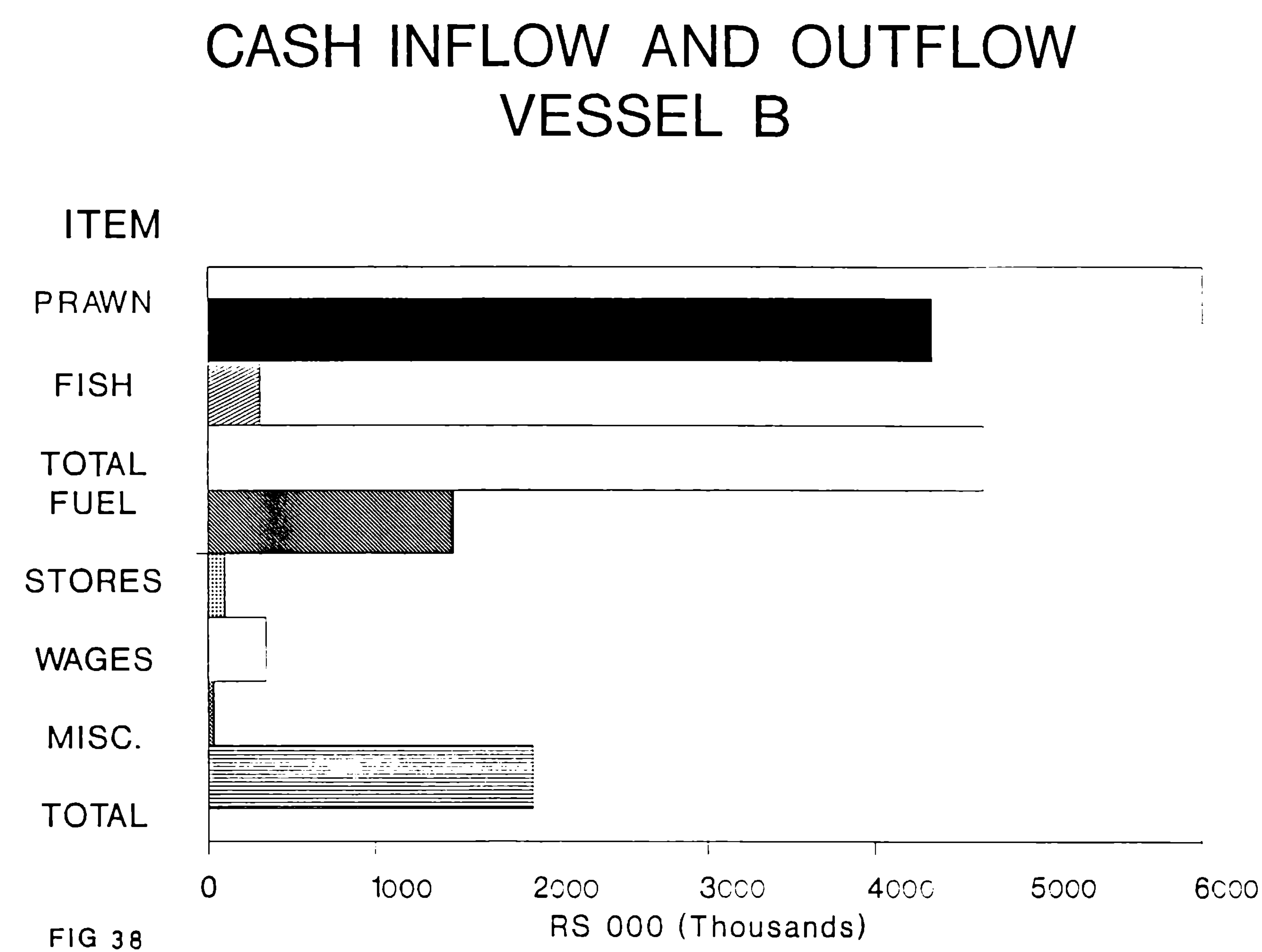

CASH INFLOW AND OUTFLOW
VESSEL B
ITEM
PRAWN
FISH
TOTAL
FUEL
STORES
WAGES
MISC.
TOTAL
0
1000
2000
3000
4000
5000
6000
RS 000 (Thousands)

FIG 38

CASH INFLOW AND OUTFLOW
VESSEL C

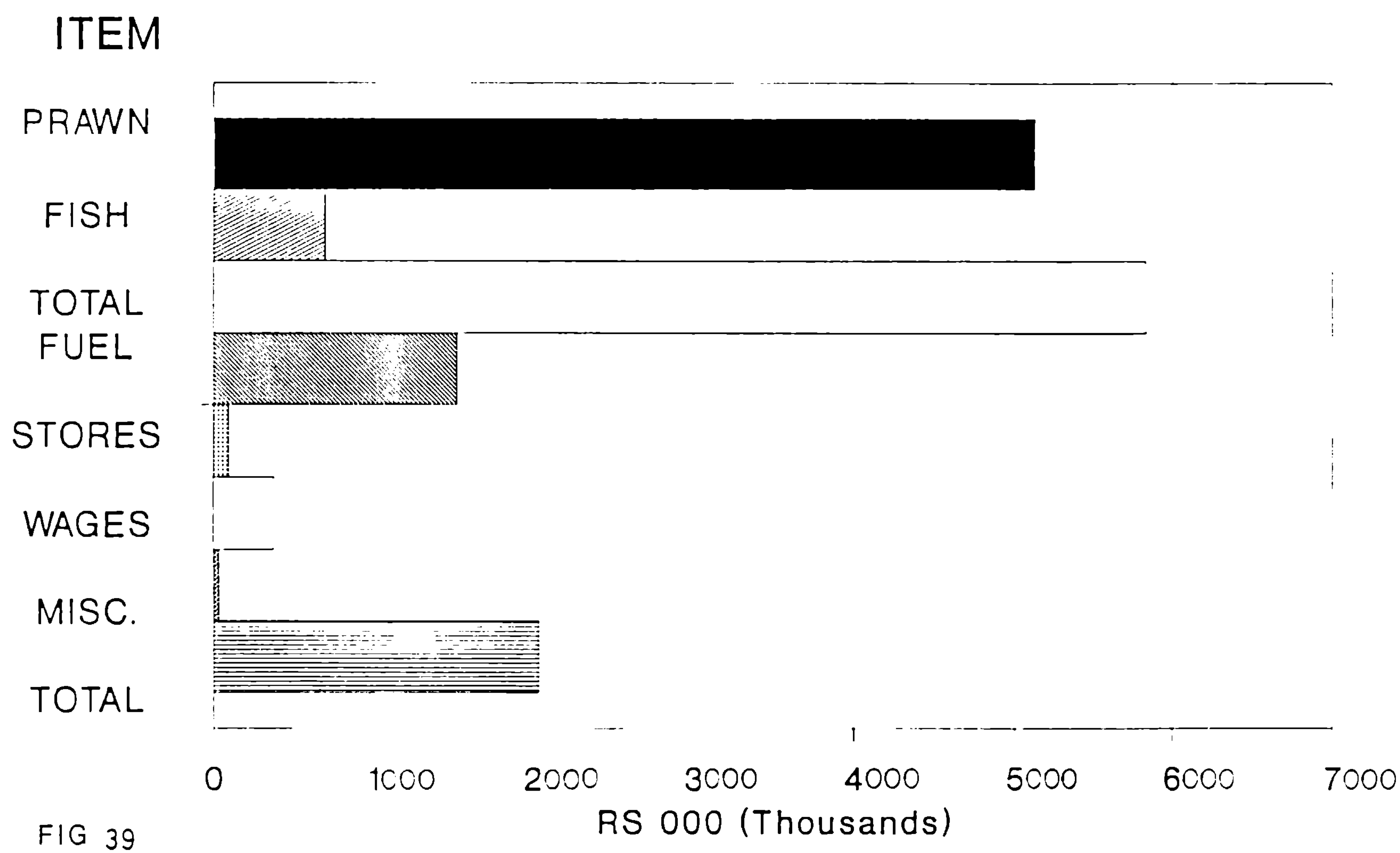


FIG 39

CASH INFLOW AND OUTFLOW
VESSEL D

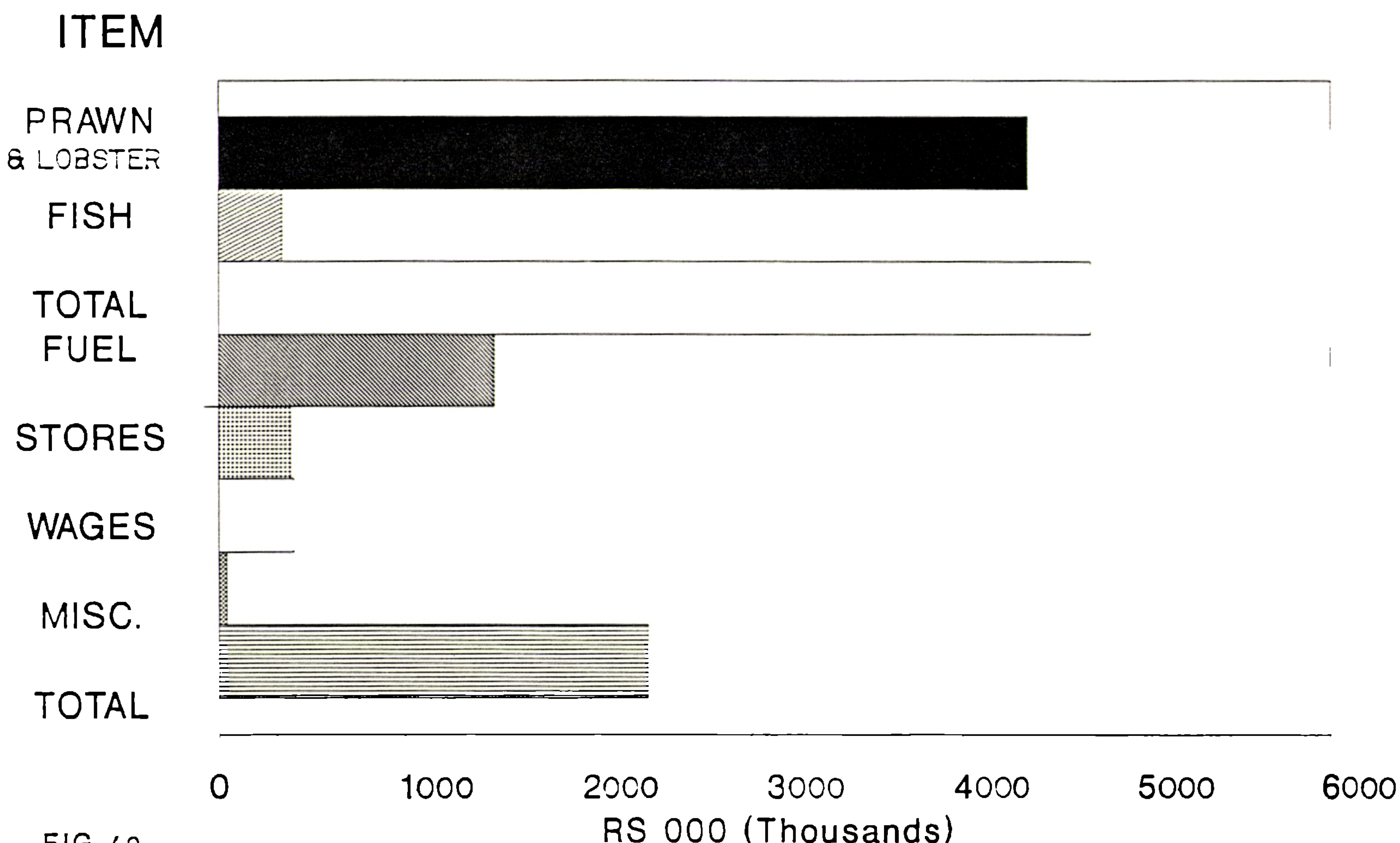


FIG 40

CASH INFLOW AND OUTFLOW VESSEL E

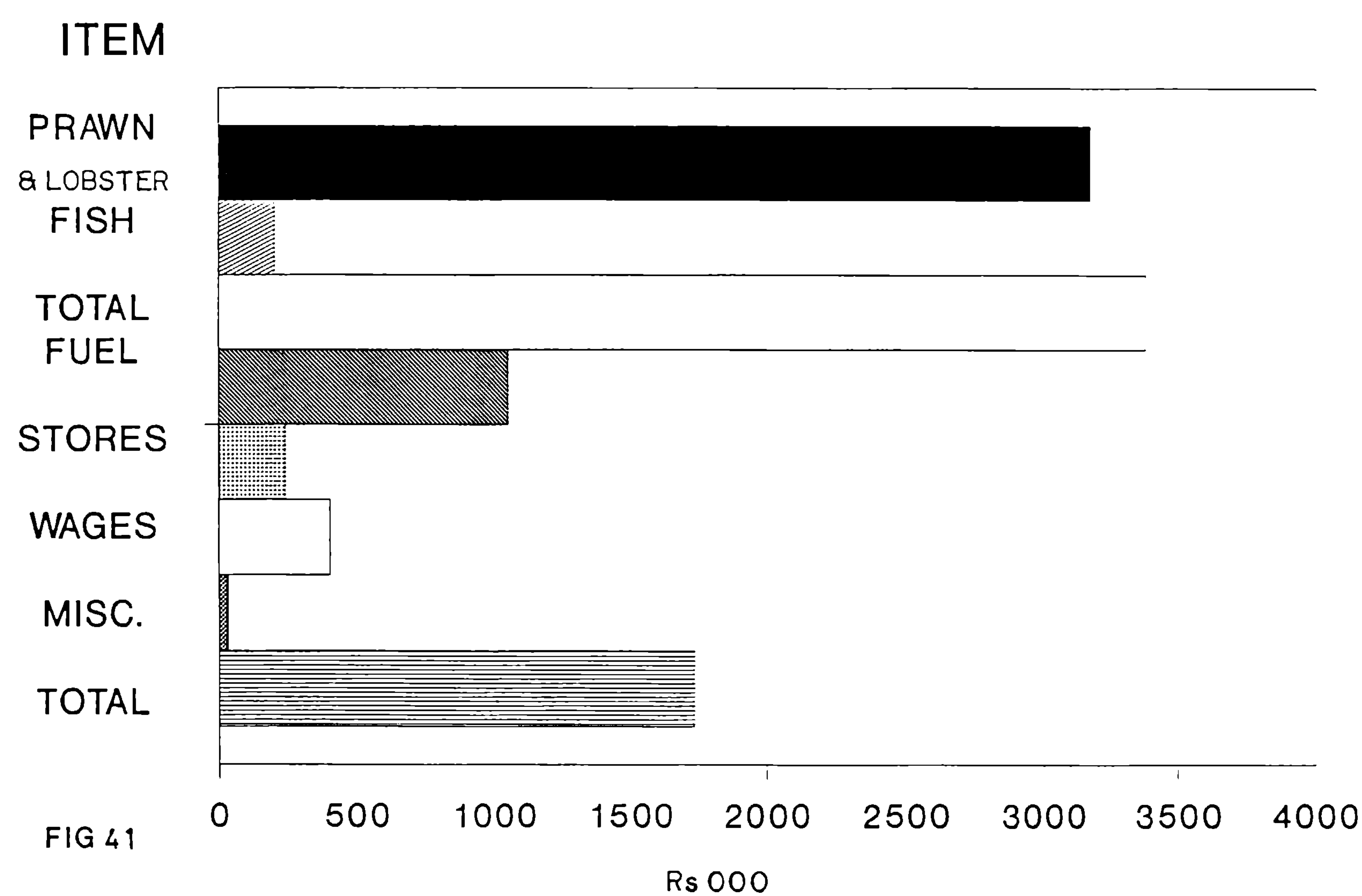


FIG 41

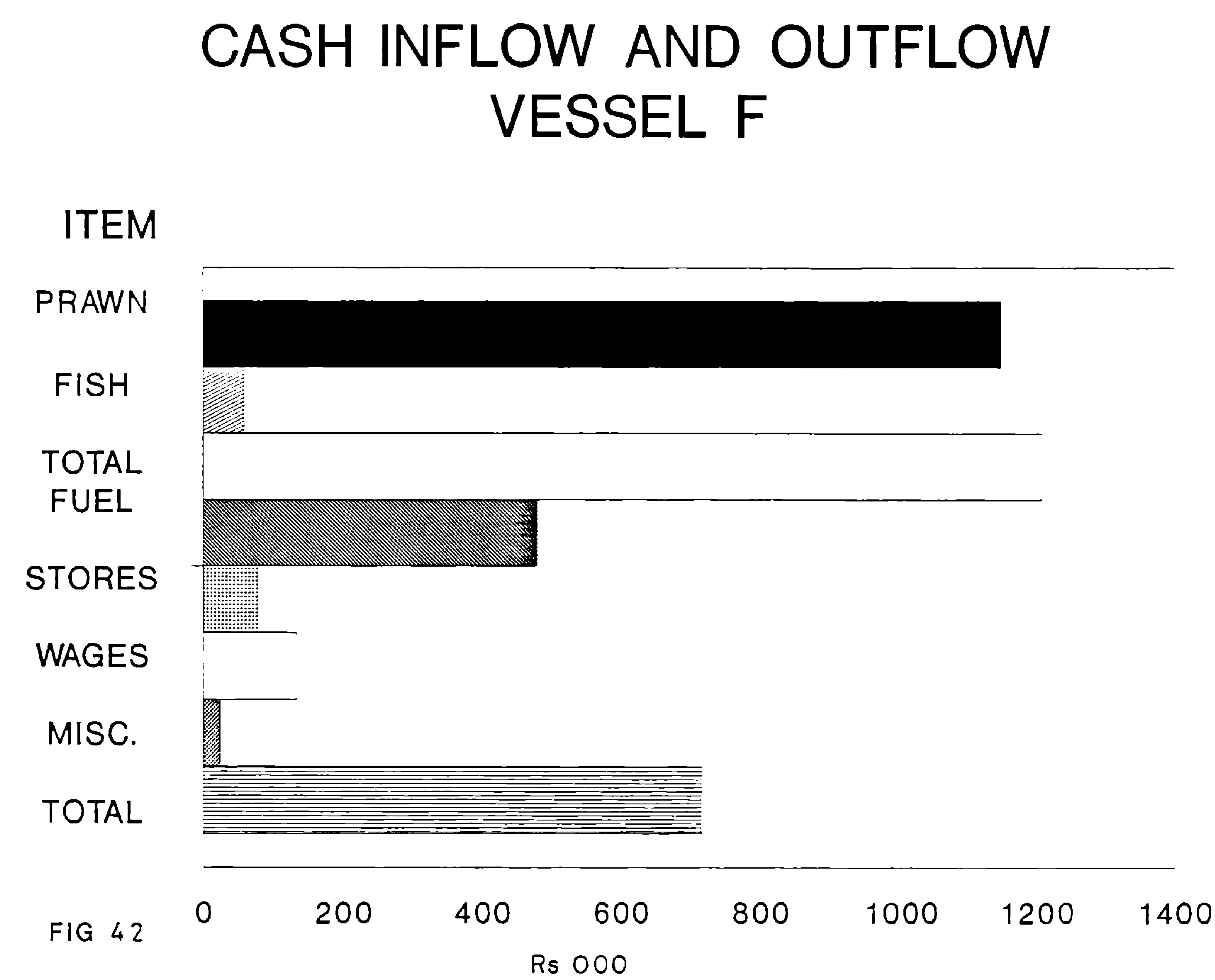
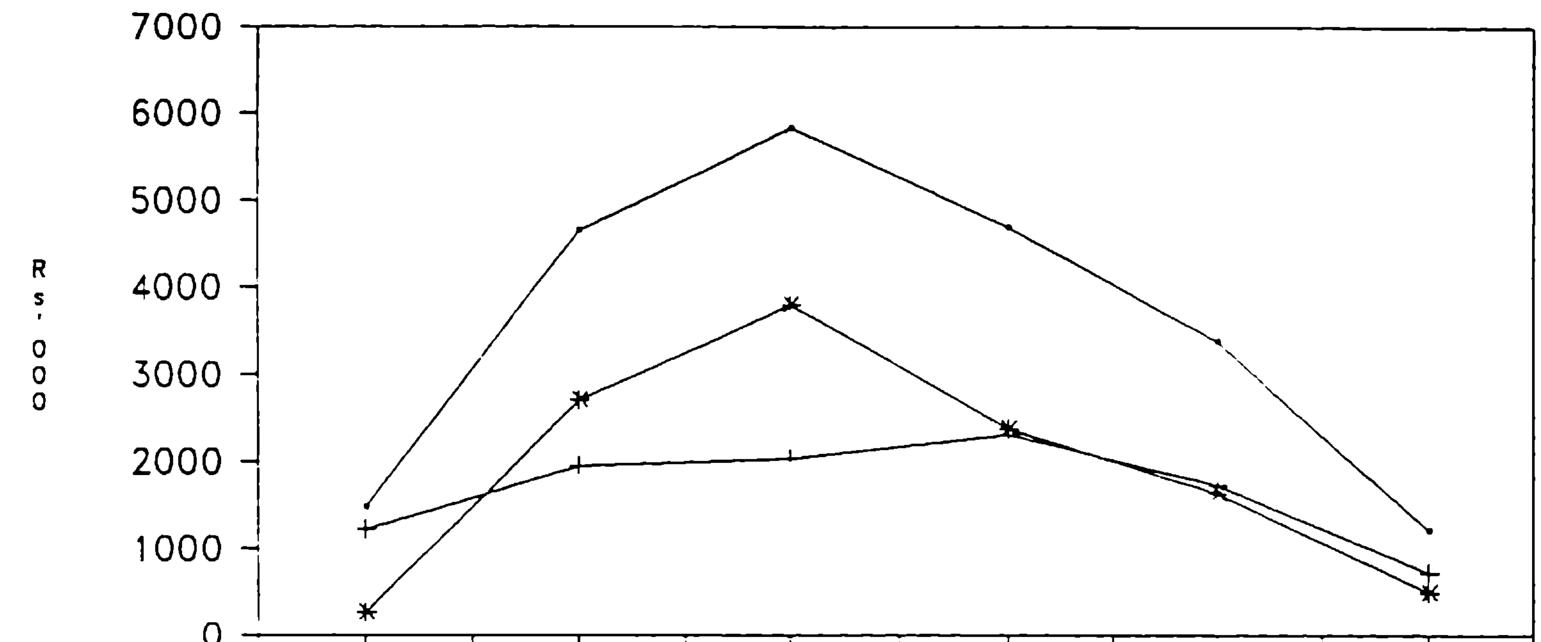

CASH INFLOW AND OUTFLOW
VESSEL F
ITEM
PRAWN
FISH
TOTAL
FUEL
STORES
WAGES
MISC.
TOTAL
0
200
400
600
800
1000
1200
1400
Rs 000

FIG 42

ANNUAL CASH FLOW OF DIFFERENT VESSELS



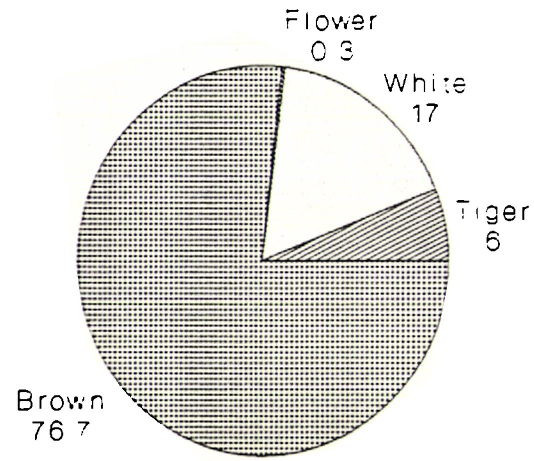
	A	B	C	D	E	F
INFLOW	1488.799	4654.58	5831.451	4693.219	3378.'61	1207.818
OUTFLOW	1220.5	1951.91	2038.741	2310.737	1737.683	715.895
NET PROFIT	268.299	2702.67	3792.709	2382.482	1640.478	491.923

VESSEL

INFLOW — OUTFLOW — NET PROFIT

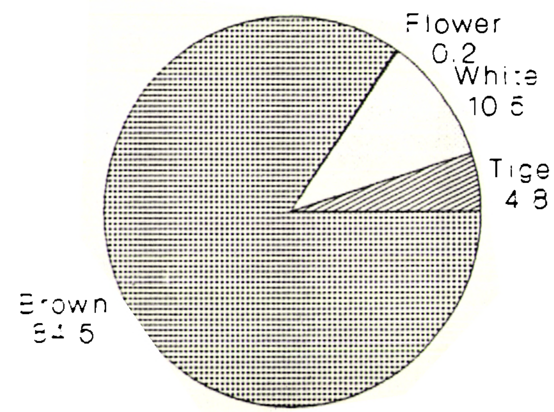
FIG.43

Annual percentage composition of Lobster and Shrimp landed by different types of vessel



Vessel A

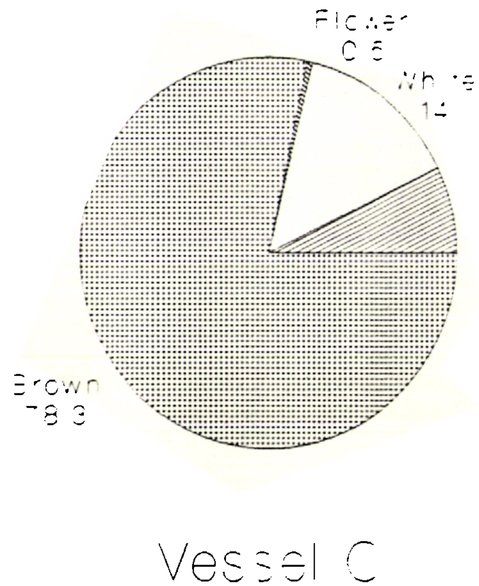
FIG. 44



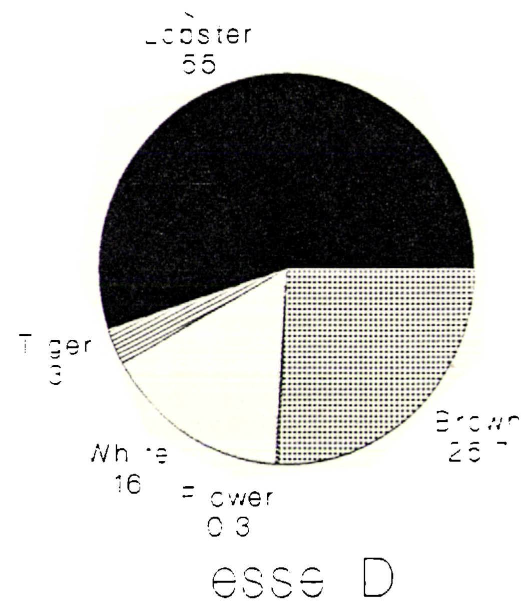
Vessel B

FIG. 45

Annual percentage composition of Lobster and Shrimp landed by different types of vessel



F I G· 46



F I G·47

Annual percentage composition of Lobster and Shrimp landed by different types of vessel

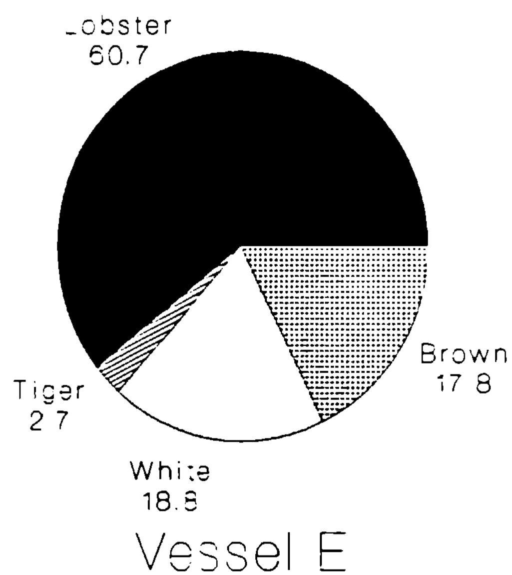


FIG.48

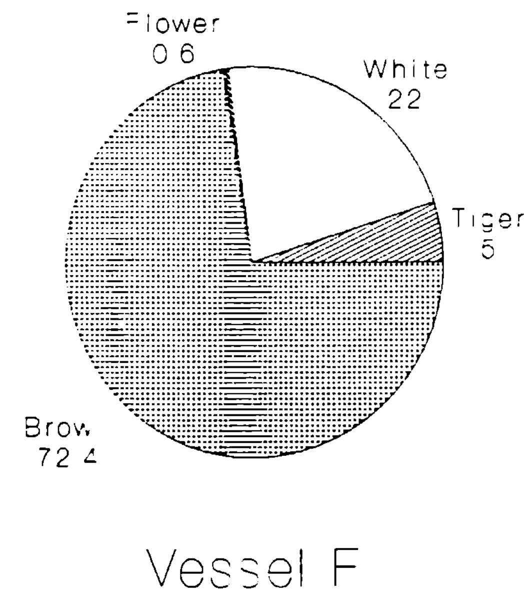


FIG.49

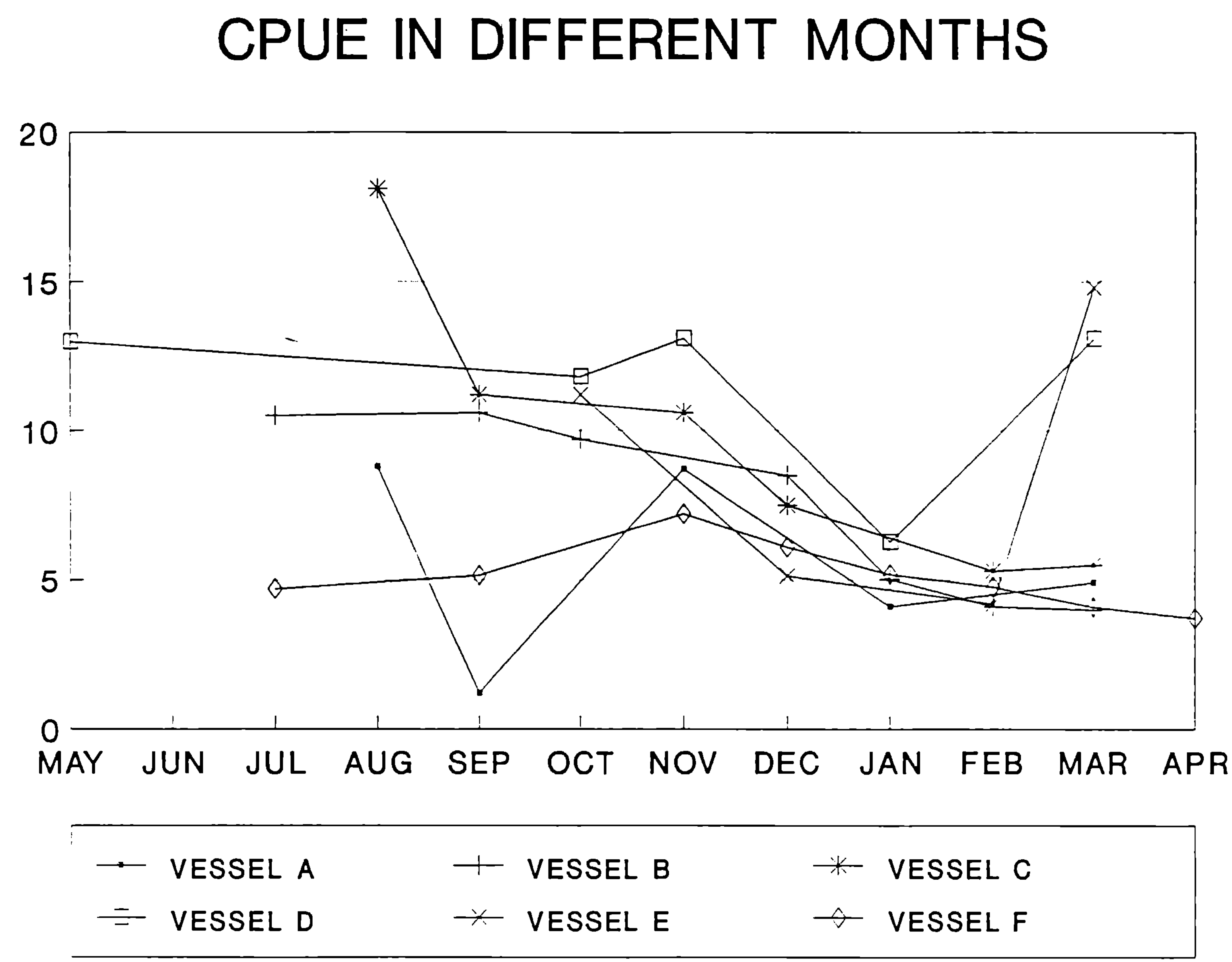
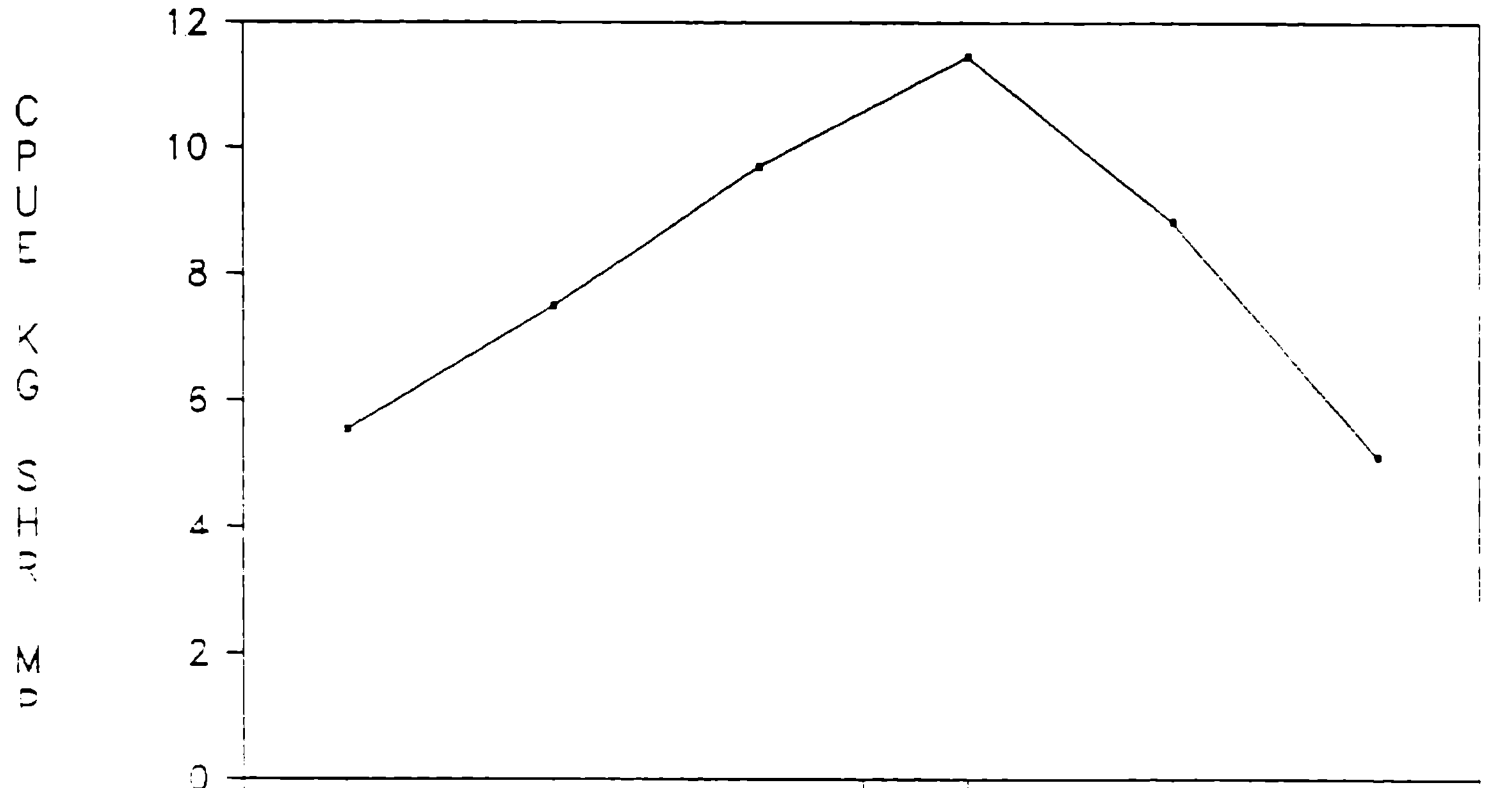

CPUE IN DIFFERENT MONTHS
20
15
10
5
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
VESSEL A
VESSEL B
VESSEL C
VESSEL D
VESSEL E
VESSEL F

FIG.50

AVERAGE CPUE OF DIFFERENT VESSELS



	A	B	C	D	E	F
CPUE	5.54	7.49	9.7	11.45	8.83	5.1

VESSELS

FIG.51

AVERAGE UNIT COST OF PRODUCTION OF DIFFERENT TYPES OF VESSEL

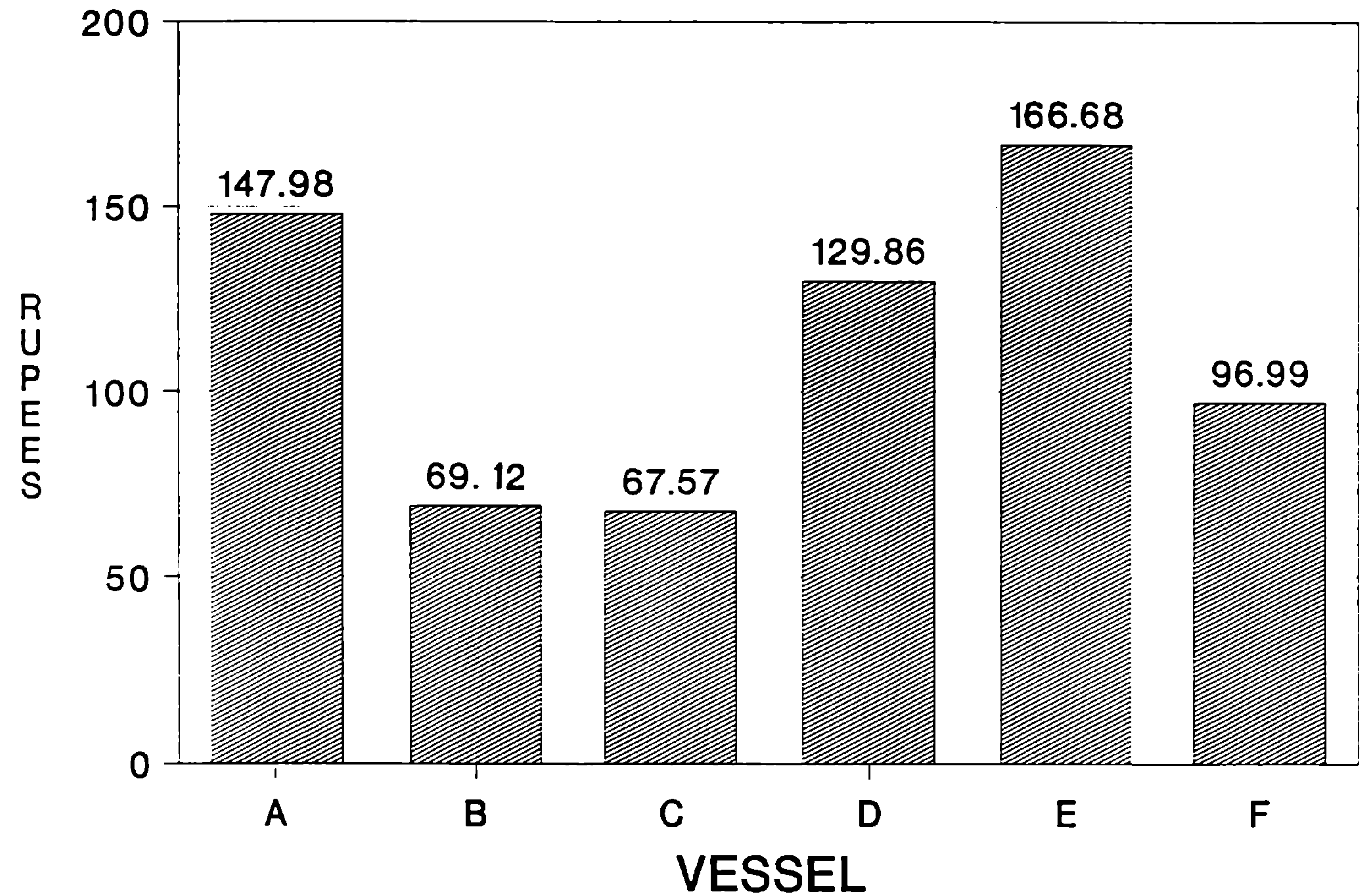
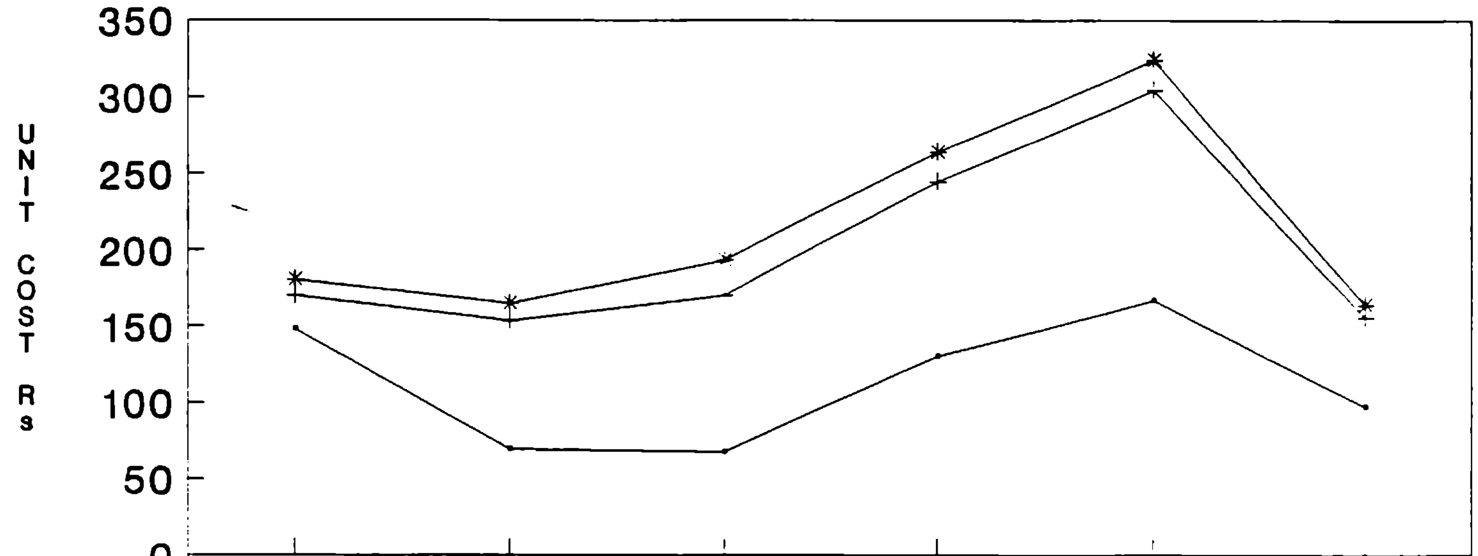


FIG.52

AVERAGE UNIT COST OF PRODUCTION (a) AND UNIT PRICE

OF SHRIMP/LOBSTER (b) AND SHRIMP/LOBSTER AND FISH (c)



	A	B	C	D	E	F
a	147.98	69.12	67.57	129.86	166.68	96.99
b	170	153.43	170	244.44	304.1	155.63
c	180.53	164.58	193.26	263.75	324.14	163.64

VESSEL

FIG.53

CHAPTER 5

TECHNO-ECONOMIC SYNTHESIS

5.1. INDUSTRIAL FLEET

Analysis of data collected from 135 industrial vessels operated in the upper East coast of India reveals that the large commercial vessels are in the range OAL 20.94 m. to 27 m. OAL. The preference class of vessels for industrial fishing was analysed with a frequency distribution of 2 using a Microstat computer programme and finds that 45.31 percent formed between 20 to 22 OAL and 20.31 percent constituted 22 to 24 OAL. While 26 to 28 OAL vessels operated 22.66 percent 24 to 26 class limit was only 11.72 percent (Table 3). Of these vessels, about 51% are in the range of 380 to 402 HP., 21% constitute 540 HP and the remaining category of HP are not in significant contribution (Figure 24). Frequency distribution of HP with a class limit of 10 also showed the same result (Table 4).

5.1.1. Rigging

The most preferable type of rigging is that of single rig trawl which forms 73%. The remaining vessels were rigged with double rig trawl (Figure 25).

5.1.2. Propeller assembly

Analysis also shows that the propeller assembly of the industrial vessels consists of 64% with fixed propeller and nozzle, while 22% was without nozzle. Propeller with controlable pitch (CP) and nozzle constituted 14% (Figure 26). Each engine has a desired RPM by which optimum thrust is obtained in the propeller. Any RPM beyond or below this point shall increase the fuel consumption. With CP propeller the RPM can be maintained and propeller pitch varied to obtain lowest fuel consumption. In the vessels having CP propeller fuel consumption can be reduced increasing the fishing effort by increasing the number of hauls. By reducing the pitch without reducing the RPM, the winch can be operated whose speed of hauling can be increased without giving momentum to the vessel. However, vessel with CP propeller is expensive and has to be carefully handled. Probably from this, fixed propeller with nozzle is the most desired installation in the industrial vessels.

5.1.3. Type of main engine

Most of the engines of industrial vessels installed are CAT 3412 and CAT 3408 which forms 71% (Figure 27), while Kirloskar, Man, Yanmar and other Caterpillar type constituted negligible percentage. Although there are many engines installed in industrial vessels, from the maintenance point of view the abundance of CAT 3408 and CAT 3412 is advantageous, as critical spares can be easily maintained for the fishing industry due to less variation in abundance. Even in the latest construction of large vessels by Indian Yards, the indigenous engines installed were 2% only.

5.1.4. Shipyards

Analysis further indicates that Indian Shipyuards have the capability to construct vessels suitable for industrial fishing especially with outrigger shrimp trawling. Since out of the total fleet, 35% form vessels from Indian Yards and the next highest country of construction was Mexico. The vessels built in Yards in India, Mexico and Australia form the major fleet (76%). (Figure 28)

5.1.5. Age of Fleet

From the oldage of vessels operated in the upper East coast, it was indicated that 46% comes in the group 6 to 10 years old and 27% is under 5 years old (Figure 29) which is an indication that even after 10 years majority of the existing fleet will sustain.

5.1.6. Type of Auxiliary engine

Analysis of auxiliary engine installed on industrial vessels showed that 46% engines was Lister and 35% was CAT 3304. Indian auxiliary engines such as Kirloskar and Ruston installed were only 13% inspite of the difficulties in getting spares for the imported engines. Other category of auxiliary engines such as CAT 330, OM 616 Benz, Perkings and Ford constituted only 6%. The HP of these engines varied generally from 33.7 to 77.

The fuel consumption of these engines was within the range from 6 litre per hour to 16 litre per hour.

5.1.7. LOA and HP

To test the significance of the relationship between length overall and horse power and between horse power and fuel consumption of main engine, a scatter plot for the 128 outrigger fishing vessels is given at Figure 54. (Out of 135 vessels data, 7 vessels data were discarded as they were lying in the extreme end of the regression).

Using the straightline equation,

$$Y = mx + C$$

Where Y represents the horse power, x the length overall in metres, m - the slope and c - the intercept, the value obtained for intercept is - 180.85502788515 and slope is 27.206953495703.

The plot of length overall versus the horse power fits the regression equation

$$HP = 27.207 \times LOA - 180.855 \qquad (19)$$

With a regression coefficient of r = 0.7515 which shows that the relationship between length overall and horse power is highly significant.

5.1.8. HP versus $FClh^{-1}$

5.1.8.1. Main engine

In the case of plot main engine horse power versus fuel consumption litre/hr. ($Fclh^{-1}$) (Figure 55), the regression equation for 135 vessels data is

$$FClh^{-1} = 0.176 \times HP - 8.56 \qquad (20)$$

It is found to hold good with r = 0.9485 which is also highly significant (the value of intercept is -8.563861733637 and slope is 0.17591051586837)

5.1.8.2. Auxiliary Engine

In case of plot of auxiliary engine, horse power versus $FClh^{-1}$ (Figure 56) the regression equation for 145 cases is

$$FClh^{-1} = 0.122 \times HP - 2.41 \qquad (21)$$

It is found to be highly significant with r = 0.9387. The value of intercept is 2.4113094084646 and slope is 0.12224692586361.

5.1.9. $FClh^{-1}$

From the above regression equations for main engine operated for towing power and auxiliary engine used for service, the $FClh^{-1}$ can be assessed at 0.15 to 0.16 and 0.06 to 0.10 per HP respectively.

The empirical equations referred to above are to be applied with caution and are valid only within the ranges with which the relationships are derived.

5.2. INVESTIGATION FLEET

5.2.1. Vessel A

The voyagewise production of different species of shrimp landed indicates that for the first voyage, the maximum catch was Brown while the remaining species landed in the descending order were White, Tiger and Flower (Figure 30). During the second voyage of the vessel which was a brake voyage, the catch was poor having a total of 83.30 kg. Out of this the maximum production was for Brown which was 64.35 kg. and the remaining species were in the order of White, Tiger and Flower. The abundance of 4 commercial varieties of shrimp noted in the same order in voyage 3 which caught a total shrimp catch of 2805.68 kg. Out of this quantity the maximum catch was again Brown which amounted 2204.13 kg. Similar trend was observed in voyage 4 and 5 which caught a total production of shrimp of 1243.58 kg. and 1474.35 kg. respectively. Thus the total landing of vessel A during the year was 8247.31 kg. of which 76.3% (6323.98 kg.) was Brown while the remaining commercial species were in the order White (17%), Tiger (6%) and Flower (0.3%) (Figure 44).

5.2.2. <u>Vessel B</u>

Vessel B conducted 7 voyages which also caught the same pattern of abundance of commercial varieties as in the case of vessel A. Out of a total production of shrimp of 28281.95 kg., 84.5% (23891.96 kg.) was Brown and White, Tiger and Flower were in the order 10.5% (2966.80 kg.), 4.8% (1363.75 kg.) and 0.2% (59.45 kg.) respectively (Figure 45).

5.2.3. Vessel C

The same trend was also observed in the case of shrimp production of vessel 'C'. Out of a total weight of 30174.20 kg., production of Brown was 78.3% while White, Tiger and Flower was in the order 14.0% (4205.85 kg.) 7.2% (2179.60 kg.) and 0.5% (141.0 kg.) respectively (Figure 46).

5.2.4. Vessel D

Vessel D carried out 5 voyages of which 3 voyages were for deep sea lobster and 2 voyages for shrimp. Voyages 1, 4 and 5 were for deep sea lobster producing 5182 kg., 1815 kg. and 2805 kg. respectively (Figure 33). Thus total production of lobster during the year for the vessel D was 9802 kg. During the voyages 2, and 3 the trend of abundance of varieties of shrimp was same as that of vessel A, B and C i.e. the highest production was Brown followed by White, Tiger and Flower. In general for vessel D, out of lobster and shrimp production, 55% was lobster, 25.7% Brown, 16% White, 3% Tiger and 0.3% Brown (Figure 47).

5.2.5 Vessel E

Vessel E also carried out operations for deep sea lobster. Out of 4 voyages, she spent 3 voyages for deep sea lobster catching a total of 6325.4 kg. deep sea lobster which constituted 60.7% of total lobster and shrimp. Out of the remaining, Flower constituted 18.8% (1957.5 kg.) Brown constituted 17.8% (1858 kg) was White formed 2.7% (1957.5 kg). There was no catch of Flower in this voyage (Figures 32, 46). Thus in percentage composition there was slight variation for vessel E from vessel A, B, C and D.

5.2.6. Vessel F

This is a Mini trawler conducting short voyages because of her limitation of freezer/RSW storage. She conducted 9 voyages of days ranging from 11 - 25. Out of the total quantity of shrimp, 7381.2 kg. (72.4%) was Brown, 1620.4 kg. (22%) was White, 378.5 kg. (5%) was Tiger and 43.9 kg. (0.6%) was Flower (Figures 35, 49). This vessel also showed the similar pattern of landing of different varieties of shrimp like vessel A, B and C. The pattern of month-wise abundance of different varieties of shrimp was also in the order Brown, White, Tiger and Flower (Table 2).

5.3. CASH INFLOW AND OUTFLOW

The total receipt and expenditure of operation of vessel A showed that while the total value of fish was only Rs 87037.93, the value of shrimp was Rs 1,401,761.63. Thus out of total cash inflow, the maximum inflow was from the shrimp and the income from fish was negligible. Out of the expenditure of vessel A, the maximum outflow was for fuel (65%) followed by wages, stores and miscellaneous expenditure (Figure 37). Similar was the pattern of cash inflow outflow of vessel B where the income generation from Brown was the highest and from the fish the least (Figure 38). Fuel constituted the major expenditure (75%) followed by wages, stores and miscellaneous. In case of vessel C the cash inflow and outflow pattern was the same as vessel A and B and expenditure on fuel constituted 75%. Vessel D had 64% of fuel expenditure, while the expenditure of Stores and Wages remain almost the same pattern. In case of vessel E expenditure on fuel constituted the 61%, while wages was higher than the expenditure on stores. Similar was the trend of cash inflow and outflow of vessel F where fuel constituted 67% of cash outflow. Thus the expenditure on fuel for the six category of vessels varied from 61 to 75 percent.

When compared the annual cash inflow, outflow and net profit of vessel A, B, C, D, E and F, it was found that the maximum inflow and net profit was for vessel C followed by vessel B. The pattern of the net profit for the remaining vessels were in the order D, E, F and A (Figure 43). From the above, it is seen that vessel C (OAL 21.59 m. GRT 116, HP 402) was making the maximum profit of all the vessel. It may be noted that this vessel was exclusively fishing for shrimp and not engaged on any diversified fishing operation. As far as the maximum cash outflow is concerned, vessel D expenditure was more than vessel C probably because this was engaged in deep sea lobster fishing.

5.4. CPUE

When examined the average catch per unit effort (CPUE) for different vessels, it was observed that vessel D had the highest (11.45) CPUE followed by vessel C (9.7) (Figure 51). The CPUE of vessel D and E were very high during the lobster fishing which was during the period from Jan. - March. From Jan. to April it was noted that the catch of all the 4 vessels (A, B, C and F) were generally declining (Figure 50). During this period vessel D and E have diverted for diversified fishing for deep sea lobster. The industry was observing a closed season by themselves during 15th April - 15th June and therefore there was no operation of large vessels. During the declining shrimp season (Jan. - April), had the vessel C went for diversified operations for deep sea lobster, she should have performed much better showing a greater net cash inflow. However, it was not possible for such a diversified operation for vessel C due to mainly the winch installation intending the vessel exclusively for outrigger operation and not oriented for stern deep sea trawling. If there was a provision for diversified fishing with winch power capable of switching over to stern trawling for deep sea lobster, vessel C should have been an ideal industrial vessel with greater productivity and the highest net profit.

5.5. UNIT COST OF PRODUCTION

The unit cost of production of shrimp and lobster was the lowest in case of vessel C (Figure 52) followed by vessel B even with 75% expenditure for fuel. If the vessel could reduce the fuel consumption at the rate of other vessels (other than B), unit cost of shrimp production of vessel C should have come down. The third unit cost of production was that of vessel E mainly because of lowest purchase price of Mini trawler. Although vessel D had the highest CPUE, the unit cost of production of one kg. shrimp/lobster was higher than vessels C, B and F. The highest cost of Unit production was for vessel E mainly because of the highest purchase price of the vessel and low production of lobster/shrimp compared to vessel D.

TABLE - 3
FREQUENCY DISTRIBUTIONS - CORRELATION OF HP VS LOA

Number of cases 128

Number of variables: 2

Variable: 2. LOA (m)

CLASS LIMITS		FREQUENCY	PERCENT	....CUMULATIVE...	
				FREQUENCY	PERCENT
20.00	22.00	58	45.31	58	45.31
22.00	24.00	26	20.31	84	65.63
24.00	26.00	15	11.72	99	77.34
26.00	28.00	29	22.66	128	100.00
	TOTAL	128	100.00		

CLASS LIMITS		FREQUENCY
20.00	22.00	58
22.00	24.00	26
24.00	26.00	15
26.00	28.00	29

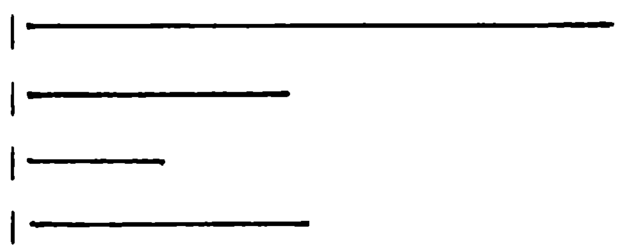


TABLE - 4

FREQUENCY DISTRIBUTIONS - HP VS FC FOR OUTRIGGER VESSELS

Number of cases: 135 Number of variables: 2 Variable: 1.HP

CLASS LIMITS		FREQUENCY	PERCENT	....CUMULATIVE...	
				FREQUENCY	PERCENT
365.00	375.00	4	2.96	4	2.96
375.00	385.00	29	21.48	33	24.44
385.00	395.00	0	.00	33	24.44
395.00	405.00	41	30.37	74	54.81
405.00	415.00	6	4.44	80	59.26
415.00	425.00	0	.00	80	59.26
425.00	435 00	0	.00	80	59.26
435.00	445.00	0	.00	80	59.26
445.00	455.00	0	.00	80	59.26
455.00	465.00	0	.00	80	59.26
465.00	475.00	0	.00	80	59 26
475 00	485 00	6	4.44	86	63.70
485.00	495.00	0	.00	86	63.70
495.00	505.00	7	5.19	93	68.89
505.00	515.00	0	.00	93	68.89
515.00	525.00	0	.00	93	68.89
525 00	535.00	0	.00	93	68.89
535.00	545.00	28	20.74	121	89.63
545.00	555.00	4	2.96	125	92.59
555.00	565.00	2	1.48	127	94.07
565.00	575.00	0	.00	127	94.07
575.00	585.00	0	.00	127	94.07
585.00	595.00	0	.00	127	94.07
595.00	605.00	0	.00	127	94.07
605.00	615.00	0	.00	127	94.07
615.00	625.00	8	5.93	135	100.00
	TOTAL	135	100.00		

TABLE 4. Continued.

CLASS LIMITS		FREQUENCY
365.00	375.00	4
375.00	385.00	29
385.00	395.00	0
395.00	405.00	41
405.00	415.00	6
415.00	425.00	0
425.00	435.00	0
435.00	445.00	0
445.00	455.00	0
455.00	465.00	0
465.00	475.00	0
475.00	485.00	6
485.00	495.00	0
495.00	505.00	7
505.00	515.00	0
515.00	525.00	0
525.00	535.00	0
535.00	545.00	28
545.00	555.00	4
555.00	565.00	2
565.00	575.00	0
575.00	585.00	0
585.00	595.00	0
595.00	605.00	0
605.00	615.00	0
615.00	625.00	8

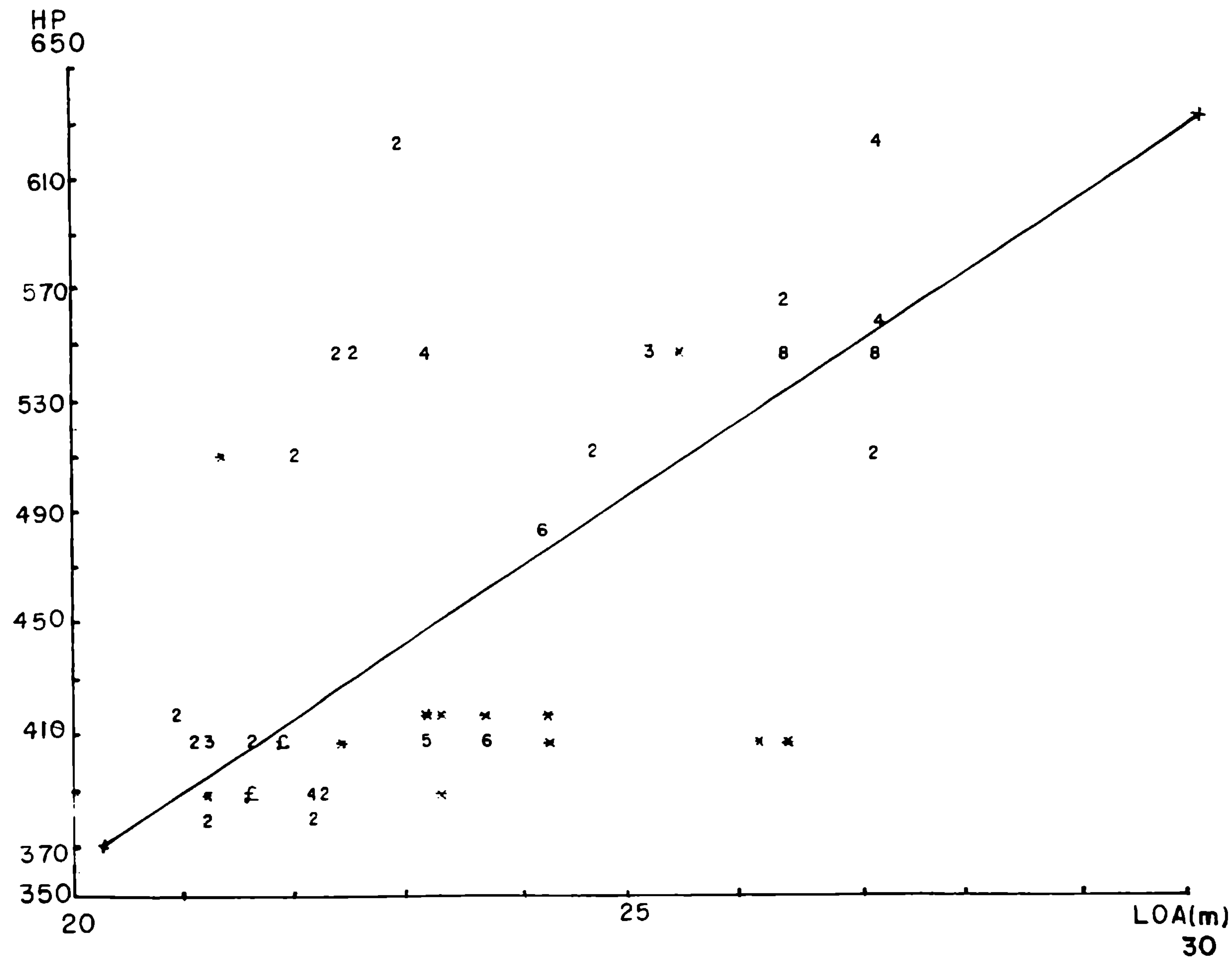


FIG.54 CORRELATION BETWEEN LOA AND HP FOR OUTRIGGER VESSELS

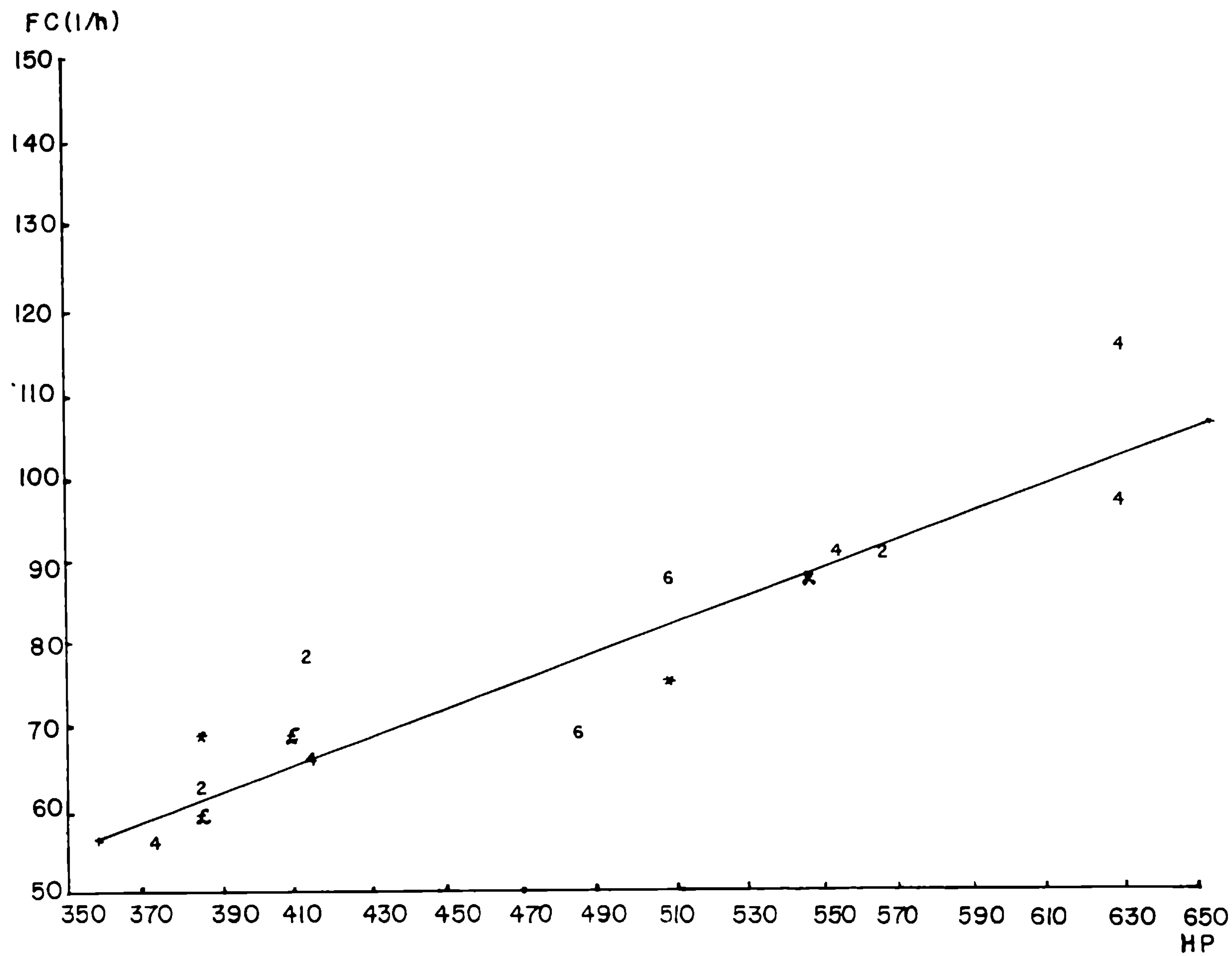


FIG.55 MAIN ENGINE HP vs FC $l\,h^{-1}$

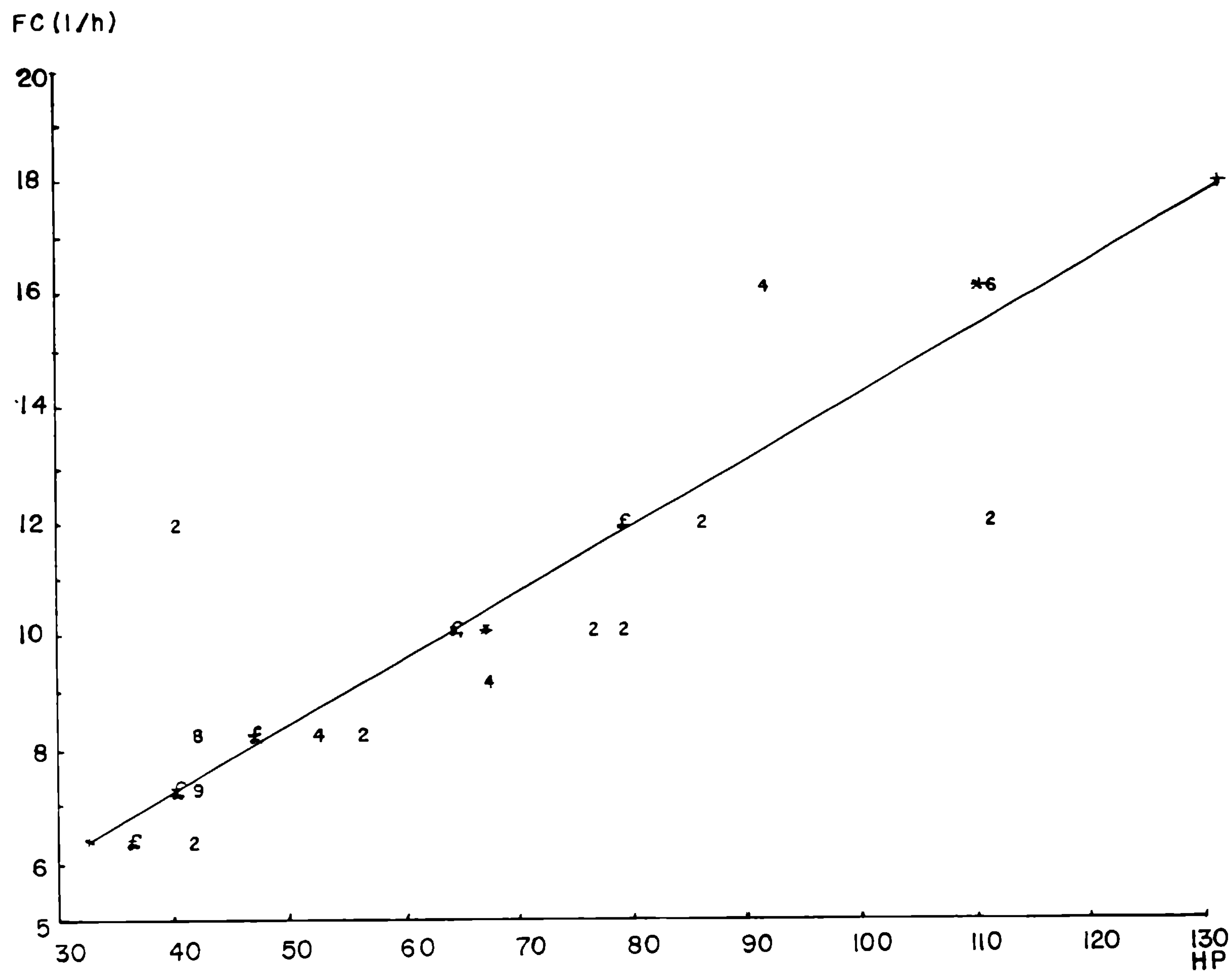


FIG.56 **HP OF AUXILIARY ENGINE vs FC $l h^{-1}$**

EFFORT AND PRODUCTION OF INDUSTRIAL VESSELS OPERATED IN THE UPPER EAST COAST OF INDIA

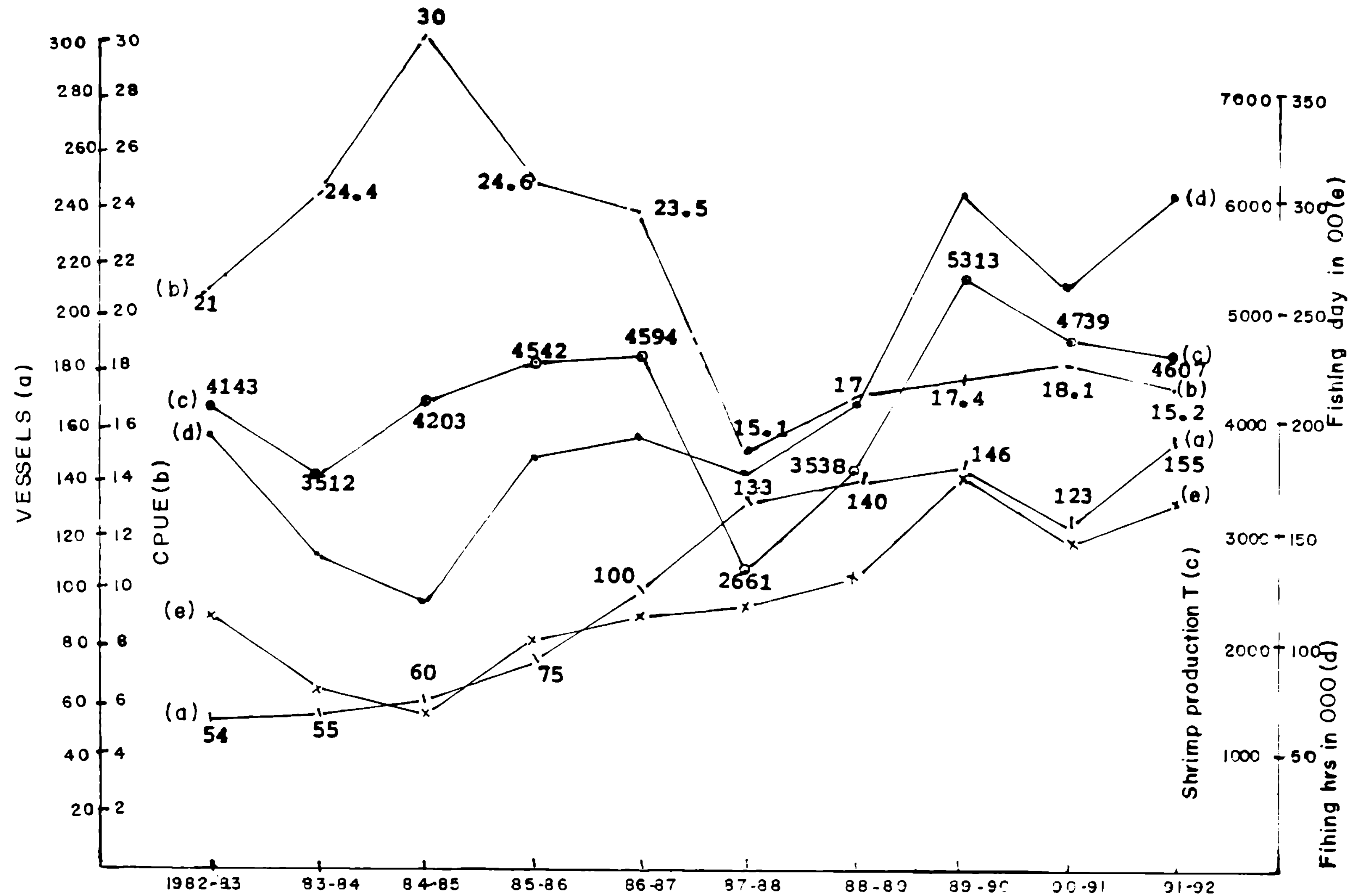


FIG.57

CHAPTER 6

ECONOMIC ANALYSIS

6.1. TRAWLER OPERATIONS

Visakhapatnam is one of the major fishing harbours in the country where sufficient infrastructure facilities are available for operation of large vessels. Most of the large vessels belong to various private and public sector companies are operating from here. These trawlers vary in size from 21.39 m. to 27 m. OAL. Most of the trawlers are outrigger steel vessels operated for shrimp. Each trawler undertakes on an average ten voyages spread over 3 to 5 weeks during the period from June to March. The average annual catch per trawler ranges from 8 to 30 tonnes of prawns. The Maximum Sustainable Yield (MSY) of shrimp in the upper East coast of India comprising West Bengal, Orissa and Andhra Pradesh is estimated at 16,059 tonnes of which only 4,478 tonnes are available for large trawlers and the remaining are exploited by non-mechanised and mechanised boats (Rao, 1993). The MSY estimates were derived by employing 'Relative Response' and 'Swept area' methods.

6.2. METHODOLOGY

The most important aspects involved in the operation of industrial vessels is the study on economic performance concerning cost and returns. A number of methods are available to measure the financial and economic performance of fishing vessels. In the present study four standard methods of evaluation viz. a) Simple return on investment, b) Internal rate of return, c) Break even analysis and d) Sensitivity analysis are adopted.

6.2.1. Return on Investment

Out of the total 155 trawlers, a sample of 6 various types of vessels have been taken into account for detailed study of their economics of operation. The annual income and expenditure statement of these trawlers is given at Table 5. Among the 6 trawlers selected for detailed study, trawlers B gives maximum returns of 116% over the investment followed by trawlers C, F, D, E and A in the order. One of the important reasons for highest return on investment for vessel B was that it was a second hand vessel refitted and its capital investment was much less than most of the other. As far as production and income point of view, vessel C has faired well.

6.2.2. Internal Rate of Return (IRR)

The basic issue of investment is that what the project has to pay back should not be less than what it cost. Since pay back is in future, it is to be equated to the present by discounting at a suitable rate of compound interest which will make the two equal. The sum now which is equal to a sum received or spent in future is called Present Value (PV). Net Present Value (NPV) of future cash flows are found by discounting. The Discounted Cash Flow (DCF) at 35% for 1 Rupee for the first year will be Re.0.74 which was obtained by applying the formula

$$DCF = \frac{P}{(P+i)^n} \qquad (22)$$

Where P is the value of amount, i is the interest and n is the number of years (Chandra, 1980).

Applying the value $(1 + 0.35)^1 = 0.74$

$$IRR = \text{Percentage of Positive DCF} + \text{Difference in percentage of positive and negative DCF} \times \frac{\text{Positive NPV}}{\text{Positive NPV} + \text{Negative NPV}} \qquad (23)$$

IRR for all the six vessels from the production data has been worked out calculating the Cash flow for ten years assuming the same income and operating cost, using discounting factor. It was found that vessel A had no returns since the total net positive Cash flow is lower than the negative flow (Table 6). While the vessel B had the highest IRR of 115.74% (Table 7), the vessel C had an

IRR of 60.68% (Table 8). Vessels D and E although deployed for deep sea lobster fishing during lean season, their IRR were only 20.68% and 9.27% respectively (Table 9, 10). This was mainly due to higher HP of the engine installed and hence higher operating cost on fuel. Since the vessel F was installed with a smaller HP main engine and its fuel consumption was lower than all other vessels, her IRR was higher than few of the selected vessels (Table 11).

6.2.3. Break-Even Analysis

Break - Even Analysis inspite of its limitations provides a simple and effective method of indicating effects of costs and evenue at varying levels of output. For the purpose of this analysis cost revenue relation QS-F-QV is used (Chandra, 1980).

Q - yearly quantity of production (Kg)

S - unit selling price per Kg

F - fixed cost

V - variable cost per Kg

At break-even point, Profit P will be zero

then $$Q = \frac{F}{S - V} \qquad (24)$$

Table 12 details the break-even point analysis for the 6 trawlers wherein an attempt has been made to ascertain as to what quantity of prawn these trawlers have to produce to meet at least the operating cost of the vessels. It will be seen that vessel A has a negative returns while B and C vessels have fairly large surplus and it reduces for vessels D, F and E in the order.

6.2.4. Sensitivity Analysis

Sensitivity Analysis shows that how sensitive is the internal rate of return, when uncertainties in the project come in. When the number of trawlers increases, they have to share the total sustainable yield available in the area. As a result CPUE will come down and a stage will emerge when trawlers will not be able to even meet the obligatory operating expenses such as fuel, wages, spares and stores.

In order to find out the variation in IRR a situation has been assumed when 5% reduction in income happens every year due to increase in number of vessels year after year. It was found that the IRR of vessel A has a negative cash flow and the operation of the vessel will be at loss. IRR of vessels B, C, D, E and F has been reduced from 115.74% to 106.55%, 60.68% to 51.31%, 20.68% to 7.23%, 9.27% to nil and 24.32% to 4.80% respectively (Tables 13, 14, 15). This will indicate that vessels A, F, E and D will not withstand the adverse condition of increase in number of trawlers happening year after year.

In order to find out upto which year the trawler will be able to recover the operating costs, a situation has been assumed wherein the number of vessels operating in the area goes up by 5% and the catches of the trawlers also come down by 5% every year over the period of next 10 years. The details regarding the income, operating costs and surplus/deficit in respect of the above exercise is given in Tables 16, 17. Trawlers B, C and D will be able to meet the operating costs fully throughout the ten year period even if there is 5% reduction in income every year while vessel A will lose from fourth year onwards and vessels E and F can garner profit upto ninth and eighth year respectively. The operating costs does not include the interest and' loan instalment payments and depreciation. If these items are included, only trawlers B and C can prolong their fishing upto ninth and seventh year respectively. It may be worth mentioning here that the trawler B was purchased second hand and it had cost the owner only Rs 23 lakhs. Hence the commitments on account of depreciation, interest and instalment payment are comparatively lower than other trawlers.

6.3. PRODUCTION AND RETURN OF INDUSTRIAL VESSELS

The number of large outrigger vessels operated in the upper East coast have been increasing year after year. While there was only 54 vessels in 1982-83, it increased to 155 vessels in 1991-92, although there was a decline in 1990-91. Correspondingly the CPUE of the vessels operating in the region has also gone down substantially from the highest of 30 to 15. In 1982-83, 54 large vessels harvest 4143 tonnes of shrimp, while 155 vessels could produce only 4607 tonnes (figure 53). In 1986-87, 100 vessels caught 4594 tonnes, whereas 155 vessels could produce only 4607 tonnes. This indicate that 55 vessels could marginally add up only 13 tonnes. During 1984-85 the maximum CPUE was 30 operating only 60 vessels producing 4203 tonnes. In 1989-90 the all time production of 5313 tonnes was recorded by 146 vessels dropping the CPUE from 30 to 17.4. This indicate that an additional 86 vessels could harvest only 1110 tonnes! which reduced the CPUE drastically. Thus there is an over capitalisation of rare financial resources in the region. Even with the operation of 155 large vessels in 1991-92, vessels B (115.74%), C (60.68%), D (20.68%) and F (24.32%) obtained an IRR of over 20%. This indicate that although there is over-capitalisation, some of the optimum size vessels could sustain in the region.

However any further addition of large vessels in the region may add up only conflicts in the socio-economic front with traditional and mechanised fishermen, because additional input may reduce their share. It may even upset the ecosystem and the very existence of shrimp industry in the region as it had happened for the shrimp fishery in the Kerala coast (Achary, 1987). So restricting the input effort is the best possible approach for management of fishery (George et al., 1980; Kalawar et al., 1985 and Nair et al., 1989).

6.4. OPTIMUM SIZE OF VESSEL

The choice of a specific type of a trawler suited for a given fishery encompasses factors such as distance to fishing ground, fishery resources to be exploited, type of fishing to be conducted, oceanographic conditions of the area, infrastructural facilities for processing, storage and marketing, requirement of processing and storage on board, space for operation of fishing gear, accommodation for the crew, cost of vessel and vessel economy and technological skill of the statutory personnel manning the vessel. It is impossible to design a hull which satisfy all the above conditions. Therefore, a compromise of the above factors are required without sacrificing the economy of operation. An improved hull form incorporating a lower prismatic coefficient (Cp) and block coefficient C_B reduce fuel cost greatly (Dai and Lee, 1975 quoted by Jiang, 1982). Utmost caution need to be exercised in order to ensure that the vessel is not over-capitalised in an effort to get the most advanced vessel.

Based on the considerations of fishery resources, oceanographic conditions, distance of the ground to the harbour and infrastructural facilities, Joseph (1985) suggested that combination trawlers in the range 200 - 300 GRT capable of carrying out different types of trawling are suitable for Indian waters. For the estimated catch and the distance to the fishing ground a vessel of minimum 20 m. is considered suitable according to Sheshappa and Digernes (1985). For the existing and potential trawling grounds in India, vessels of size 18 m., 30 m. and 40 m. OAL appear most suitable (Roy Choudhury, 1973). The observation of comparative performance of large deep fishing vessel indicated that ideal types of vessel suited for trawling including deep sea lobster fishing along South-west coast of India is 20 m. OAL (GRT 61.28) with 220 HP (Oommen, 1985). Considering the cost of operation and unit cost of production of shrimp and lobster, the present study indicates that a vessel of the size (C) 21.59 m. - 402 HP

- 116 GRT performed much better than of other 5 vessels. Her IRR of 60.68% was very impressive and should have shown a much higher percentage, had the vessel been basically a combination trawler diversifying for deep sea lobster during the lean shrimp season.

TABLE 5. RETURN ON INVESTMENT OF DIFFERENT TYPES OF VESSEL

Particulars	Vessels					
	A	B	C	D	E	F
1.0 INVESTMENT						
1.1. Fishing vessel	45,00,000	23,00,000	60,50,000	92,00,000	95,00,000	17,00,000
2.0 INCOME (Rs)						
2.1. Prawns	14,01,762	43,39,402	51,27,294	43,49,594	31,70,261	11,48,688
2.2. Fish	87,038	3,15,178	7,04,157	3,43,625	2,07,900	59,130
2.3. Total	14,88,800	46,54,580	58,31,451	46,93,219	33,78,161	12,07,818
3.0 OPERATING COSTS (Rs)						
3.1. Fuel	7,88,500	14,64,610	15,33,421	14,78,597	10,54,633	4,78,819
3.2. Stores & Spares	87,800	1,00,190	97,220	3,86,400	2,46,500	79,600
3.3. Wages & Allowances	3,21,200	3,50,400	3,74,400	4,05,600	4,05,600	1,33,470
3.4. Insurance 1.5%	67,500	34,500	90,750	1,38,000	1,42,500	25,500
3.5. Miscellaneous	23,500	36,710	33,700	40,140	30,950	24,006
3.6. Total	12,88,500	19,86,410	21,29,491	24,48,737	18,80,183	7,41,395
4.0 RETURNS (Rs)						
4.1. Surplus	2,00,000	26,68,170	37,01,960	22,44,482	14,97,978	4,66,423
4.2. Return on Inv. %	4.45	116.01	61.19	24.40	15.77	27.44

TABLE 6. CASH FLOW AND CALCULATION OF IRR - VESSEL A

Year	Income (Rs)	Investment (Rs)	Operating costs (Rs)	Balance to be discounted (Rs)	Discounting Factor 1%	NPV (Rs)
'0'		4500000		(4500000)		(4500000)
1	1488800		1288500	200300	0.990	198297
2					0.980	196294
3					0.971	194491
4					0.961	192488
5					0.951	190485
6					0.942	188683
7					0.933	186880
8					0.923	184877
9					0.914	183074
10					0.905	181272
						(4500000)
						1896841

Since the total net positive Cash flow is lower than the negative flow, there would be no returns.

TABLE 7. CASH FLOW AND CALCULATION OF IRR - VESSEL B

Year	Income	Investment	Operating cost (Rs)	Balance to be discounted	Discounting 114%	NPV	Discounting 116%	NPV
'0'		2300000		(2300000)		(2300000)		(2300000)
1	4654580		1986410	2668170	0.467	1246035	0.462	1232695
2					0.218	581661	0.214	570988
3					0.102	272153	0.099	264149
4					0.048	128072	0.046	122736
5					0.022	58700	0.021	56032
6					0.010	26682	0.010	26682
7					0.005	13341	0.005	13341
8					0.002	5336	0.002	5336
9					0.001	2668	0.001	2668
10					0.000	-	0.000	-
						(2300000)		(2300000)
						2334648		2294627
						34648		(5373)

$$IRR = 114 + 2\left(\frac{34648}{34648+5373}\right) = 115.74\%$$

TABLE 8. CASH FLOW AND CALCULATION OF IRR - VESSEL C

Year	Income (Rs)	Investment (Rs)	Operating costs (Rs)	Balance to be discounted (Rs)	Discounting 60%	NPV	Discounting 61%	NPV
'0'		60,50,000		(6050000)		(6050000)		(6050000)
1	5831451		2129491	3701960	0.625	2313725	0.621	2298917
2					0.391	1447466	0.386	1428957
3					0.244	903278	0.240	888470
4					0.153	566400	0.149	551592
5					0.095	351686	0.092	340580
6					0.060	222118	0.057	211012
7					0.037	136973	0.036	133271
8					0.023	85145	0.022	81443
9					0.015	55529	0.014	51827
10					0.009	33318	0.009	33318
						(6050000)		(6050000)
						6115638		6019387

$$IRR = 60 + 1 \left(\frac{65638}{65638 + 30613}\right) = 60.68\%$$

TABLE 9. CASH FLOW AND CALCULATION OF IRR - VESSEL D

Year	Income (Rs)	Investment (Rs)	Operating cost (Rs)	Balance to be discounted (Rs)	Discounting 20%	NPV	Discounting 21%	NPV
'0'		9200000		(9200000)		(9200000)		(9200000)
1	46923219		2448737	2244482	0.833	1869654	0.826	1853942
2					0.694	1557671	0.683	1532981
3					0.579	1299555	0.564	1265888
4					0.482	1081840	0.466	1045929
5					0.402	902282	0.386	866370
6					0.335	751901	0.319	715990
7					0.279	626210	0.263	590299
8					0.233	522964	0.219	491542
9					0.194	435430	0.180	404007
10					0.162	363606	0.149	334428
						(9200000)		(9200000)
						9411113		9101376

$$IRR = 20 + 1 \left(\frac{211113}{211113+98624} \right) = 20.68\%$$

TABLE 10. CASH FLOW AND CALCULATION OF IRR - VESSEL E

Year	Income (Rs)	Investment (Rs)	Operating cost (Rs)	Balance to be discounted (Rs)	Discounting 9%	NPV	Discounting 10%	NPV
'0'		9500000		(9500000)		(9500000)		(9500000)
1	3378161		1880183	1497978	0.917	1373646	0.909	1361662
2					0.842	1261297	0.826	1237330
3					0.772	1156439	0.751	1124981
4					0.708	1060568	0.683	1023119
5					0.650	973686	0.621	930244
6					0.596	892795	0.564	844860
7					0.547	819394	0.513	768463
8					0.502	751985	0.467	699556
9					0.460	689070	0.424	635143
10					0.422	632147	0.386	578220
						(9500000)		(9500000)
						9611027		9203578

$$IRR = 9+1\left(\frac{111027}{111027+296422}\right) = \underline{9.27\%}$$

TABLE 11. CASH FLOW AND CALCULATION OF IRR - VESSEL F

Year	Income (Rs)	Investment (Rs)	Operating cost (Rs)	Balance to be discounted (Rs)	Discounting 24%	NPV	Discounting 25%	NPV
'0'		1700000		(1700000)		(1700000)		(1700000)
1	1207818		741395	466423	0.806	375937	0.800	373138
2	"				0.650	303175	0.640	298511
3					0.524	244406	0.512	238809
4					0.423	197297	0.410	191233
5					0.341	159050	0.328	152987
6					0.275	128266	0.262	122203
7					0.222	103546	0.210	97949
8					0.179	83490	0.168	78359
9					0.144	67165	0.134	62501
10					0.116	54105	0.107	49907
						(1700000)		(1700000)
						1716437		1665597

$$IRR = 24 + 1 \left(\frac{16437}{16437+34403}\right) = 24.32\%$$

TABLE 12. BREAK-EVEN ANALYSIS

Sl. No.	Particulars	Vessel A	B	C	D	E	F
1.	Investment (Rs)	45,00,000	23,00,000	60,50,000	92,00,000	95,00,000	17,00,000
2.	Operating costs (Rs)	12,88,500	19,86,410	21,29,491	24,48,737	18,80,183	7,41,395
3.	12% Return on Investment 12% of 1	5,40,000	2,76,000	7,26,000	11,04,000	11,40,000	2,04,000
4.	Total (2 + 3)	18,28,500	22,62,410	28,55,491	35,52,737	30,20,183	9,45,395
5.	Actual prawn catch (kg)	8,427	28,282	30,174	17,794*	10,425*	7,381
6.	Value (Rs)	14,01,762	43,39,402	51,27,294	43,49,594	31,70,261	11,48,688
7.	Weighed average price for all the vessels (Rs/kg)	190	190	190	190	190	190
8.	Quantity of prawn catch required to make the vessel break-even(4 ÷ 7) kg.	9,625	11,910	15,030	18,700	15,900	4,980
9.	Value (8x Rs 190)(Rs)	18,28,750	22,62,900	28,55,700	35,53,000	30,21,000	91,46,200
10.	Actual performance in relation to break-even (6-9)(Rs)	(-) 4,26,988	20,76,502	22,71,594	7,96,594	1,49,261	2,02,488

*This includes deepsea Lobster

TABLE 13

SENSITIVITY ANALYSIS - IRR WHEN 5% REDUCTION IN INCOME EVERY YEAR DUE TO INCREASE IN NUMBER OF VESSELS YEAR AFTER YEAR

Year	Vessel A				Vessel B				
	Income	Investment	Operating costs	Balance to be discounted	Income	105%	NPV	110%	NPV
'0'	-	45,00,000		(45,00,000)	(2300000)		(2300000)		(2300000)
1	14,88,800	-	12,88,500	2,00,300	2668170	0.488	1302067	0.476	1270049
2	14,14,360	-		1,25,860	2435441	0.238	579635	0.227	552845
3	13,39,920	-		51,420	2202712	0.116	255515	0.108	237893
4	12,65,480	-		(23020)	1969983	0.057	112289	0.051	100469
5	11,91,040	-		(97460)	1737254	0.028	48643	0.024	41694
6	11,16,600	-		(171900)	1504525	0.014	21063	0.011	16550
7	10,42,160	-		(246340)	1271796	0.007	8903	0.005	6359
8	9,67,720	-		(320780)	1039067	0.003	3117	0.002	2078
9	8,93,280	-		(395220)	806338	0.001	806	0.001	806
10	8,18,840	-		(469660)	573609	0.000		0.000	000
	Net Negative flow		(62,24,380)				(2300000)		(2300000)
	Net positive flow		3,77,580				2332038		2228743
	Loss No Returns								

$$IRR = 105 + 5\left(\frac{32038}{32038+71257}\right) = \underline{106.55\%}$$

TABLE 14

SENSITIVITY ANALYSIS - IRR WHEN 5% REDUCTION IN INCOME EVERY YEAR DUE TO INCREASE IN NUMBER OF VESSELS YEAR AFTER YEAR

Vessel C						Vessel D					
Income	Invest.	Operating costs	Balance to be discounted	Disc. 45%	Disc. 52%	Income	Invest.	Op.cost	Balance to be discounted	Disc.7%	Disc. 12%
	6050000		(6050000)	(6050000)	(6050000)		9200000		(9200000)	(9200000)	(9200000)
5831451	-	2129491	3701960	2554352	2435889	4693219	-	2448737	2244482	2098591	2004322
5539878	-		3410387	1623344	1476698	4458558	-		2009821	1754574	1601827
5248305	-		3118814	1022971	888862	4223897	-		1775160	1448531	1263914
4956732	-		2827241	638956	528694	3989236	-		1540499	1175401	979757
4665159	-		2535668	395564	311887	3754575	-		1305838	931062	740410
4373586	-		2244095	242362	118937	3519914	-		1071177	713404	543087
4082013	-		1952522	144487	103484	3285253	-		836516	521149	378105
3790440	-		1660949	84708	58133	3050592	-		601855	350280	243149
3498867	-		1369376	47928	31496	2815931	-		367194	199754	132557
3207294	-		1077803	25867	16167	2581270	-		132533	67327	42676
				(6050000)	(6050000)					(9200000)	(9200000)
				6780539	5970247					9260073	7929804
				730539	(79753)					60073	(1270196)

$$IRR = 45+7\left(\frac{730539}{730539+79753}\right) = \underline{51.31\%}$$

$$IRR = 7+5\left(\frac{60073}{60073+1270196}\right) = \underline{7.23\%}$$

TABLE 15

SENSITIVITY ANALYSIS - IRR WHEN 5% REDUCTION IN INCOME EVERY YEAR DUE TO INCREASE IN NUMBER OF VESSELS YEAR AFTER YEAR

Year	Vessel E					Vessel F					
	Income	Invest.	Operating cost	Balance to be discounted	Disc. 2%	Income	Invest.	Operating cost	Balance to be discounted	Disc. 3%	Disc. 5%
'0'		9500000		(9500000)	(9500000)		1700000		(1700000)	(1700000)	(1700000)
1	3378161	-	1880183	1497978	1468018	1207818	-	741395	466423	452897	444035
2	3209253	-		1329070	1277236	1147427	-		406032	382888	368271
3	3040345	-		1160162	1092873	1087036	-		345641	316262	298634
4	2871437	-		991254	915919	1026645	-		285250	253587	234761
5	2702529	-		822346	745045	966254	-		224859	194053	176289
6	2533621	-		653438	580253	905863	-		164468	137824	122693
7	2364713	-		484530	422026	845472	-		104077	84615	73999
8	2195805	-		315622	269226	785081	-		43686	34468	29575
9	2026897	-		146714	122800	724690	-		(16705)	(12796)	(10775)
10	185989	-		(22194)	(18199)	664299	-		(77096)	(57359)	(47337)
					(9518199)					(1770155)	(1758112)
					6893396					1856594	1748257
										86439	- 9855

IRR - Nil

$$IRR = 3+2 \left(\frac{86439}{86439 + 9855}\right) = 4.80\%$$

TABLE 16

SENSITIVITY ANALYSIS - WHEN CATCH/INCOME REDUCED BY 5% EVERY YEAR UPTO WHICH YEAR TRAWLER WILL BE ABLE TO RECOVER THE OPERATING COSTS

Year	Vessel A			Vessel B			Vessel C		
	Income	Operating costs	Surplus/ Deficit	Income	Operating costs	Surplus/ Deficit	Income	Operating costs	Surplus/ Deficit
1	1488800	1288500	200300	4654580	1986410	2668170	5831451	2129491	3701960
2	1414360	1288500	125860	4421851	1986410	2435441	5539878	2129491	3410387
3	1339920	1288500	51420	4189122	1986410	2202712	5248305	2129491	3118814
4	1265480	1288500	(23020)	3956393	1986410	1969983	4956732	2129491	2827241
5	1191040	1288500	(97460)	3723664	1986410	1737254	4665159	2129491	2535668
6	1116600	1288500	(171900)	3490935	1986410	1504525	4373586	2129491	2244095
7	1042160	1288500	(246340)	3258206	1986410	1271796	4082013	2129491	1952522
8	967720	1288500	(320780)	3025477	1986410	1039067	3790440	2129491	1660949
9	893280	1288500	(395220)	2792748	1986410	806338	3498867	2129491	1369376
10	818840	1288500	(469660)	2560019	1986410	573609	3207294	2129491	1077803

Figure in ( ) indicate deficit.

This vessel can continue operation till 3rd year only and thereafter if it continues its operation it will face losses only as indicated above.

For a 5% reduction in income in each year upto the next 10 years, this vessel will continue to get surplus.

For a 5% reduction in income in each year upto the next 10 years, this vessel will continue to get surplus.

TABLE 17

SENSITIVITY ANALYSIS - WHEN CATCH/INCOME REDUCED BY 5% EVERY YEAR UPTO WHICH YEAR THE TRAWLER WILL BE ABLE TO RECOVER THE OPERATING COSTS

Year	Vessel D			Vessel E			Vessel F		
	Income	Operating costs	Surplus/ Deficit	Income	Operating costs	Surplus/ Deficit	Income	Operating costs	Surplus/ Deficit
1	4693219	2448737	2244482	3378161	1880183	1497978	1207818	741395	466423
2	4458558		2009821	3209253		1329070	1147427		406032
3	4223897		1775160	3040345		1160162	1087036		345641
4	3989236		1540499	2871437		991254	1026645		285250
5	3754575		1305838	2702529		822346	966254		224859
6	3519914		1071177	2533621		653438	905863		164468
7	3285253		836516	2364713		484530	845472		104077
8	3050592		601855	2195805		315622	785081		43686
9	2815931		367194	2026897		146714	724690		(16705)
10	2581270		132533	1857989		(22194)	664299		(77096)

Vessel D: For a 5% reduction in income in each year upto the next 10 years, this vessel will continue to get surplus.

Vessel E: This vessel will lose only during 10th year from now.

Vessel F: Deficit will occur from 9th year onwards.

CHAPTER 7

MODELLING

7.1. BIO-ECONOMIC MODEL OF INDUSTRIAL FISHING

The basic bio-economic model of fishing was prepared by Schaefer (1957). This is the logistic growth rate of fish stock as shown in the biological productivity curve (figure 58). The growth rate will depend on population size of biomass of the stock. When the stock is small it will grow fast, as the density of fish increased the growth slows down. The peak is reached at population size that gives the growth marked by Maximum Sustainable Yield (MSY). Beyond this point the population will reduce its growth until a point is reached where the

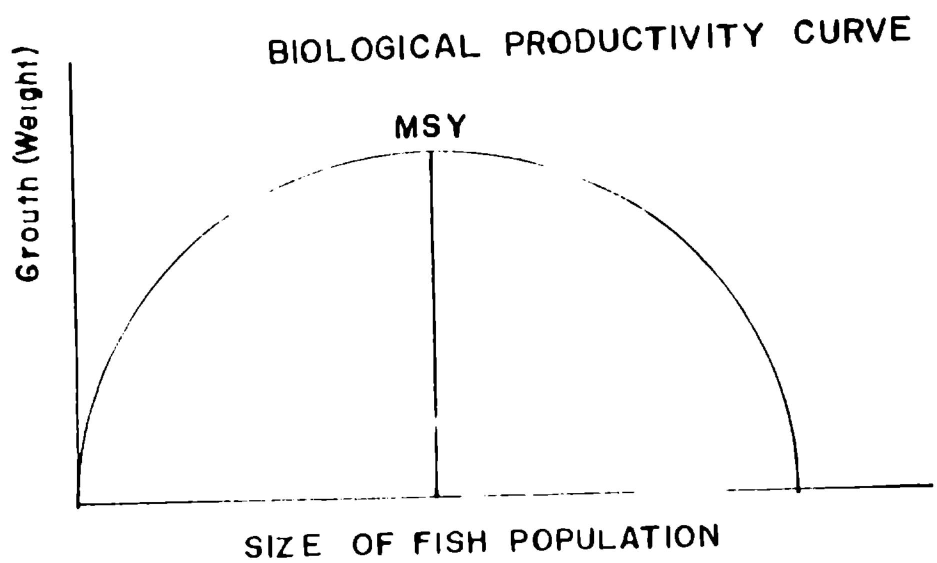


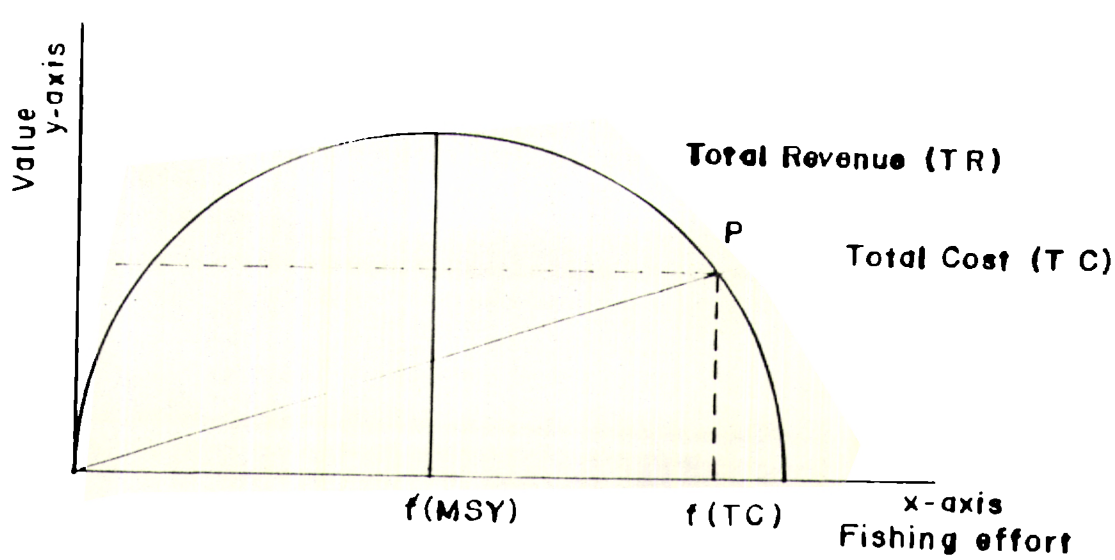
FIG.58

environmental carrying capacity is saturated and the fish stock stops growing.

If the stock is subjected to fishing the population will be reduced; the extent of reduction will depend on the magnitude of fishing effort. When the fish stock has been reduced to a given size, it may be kept at that level if the quantity of catch is equal to the growth at that size of the stock. This balance of catch and growth is called the sustainable yield. MSY is thus obtained at the stock size corresponding to the top of the curve where the growth is highest.

7.1.1. Economic Model

The economic aspects of the model (figure 59) looks



OPEN-ACCESS EQUILIBRIUM

FIG.59

similar to the previous one, there are fundamental differences. Here the Y axis measures monetary values; both the aggregated cost of fishing effort (TC - total costs) and the value of the catch that constitutes the sustainable yield for any given size of population (TR - total revenues). The X axis describes the magnitude of the fishing effort, increasing to the right. It also implies the size of the population, but here it is important to note that the increase goes the opposite way. That is, at the point of origin, there is no fishing effort and the fish stock is at its maximum size, with zero growth since it is in the natural balance of saturated environmental capacity. As the fishing effort increases the stock diminishes thereoretically to be annihilated at zero size where the curve intersects the X axis on the right side.

7.1.2. Open Access Equilibrium

The extent of stock reduction will depend on the cost of the total fishing effort. This cost is described by the line TC in figure. For the sake of illustration, the cost is assumed to be a linear function of the number of effort units (measured in number of vessels, fishing hours etc.). If the total effort stays at f(MSY), the total cost of fishing is considerably less than the total value of the sustainable catch (total revenue at MSY). There is thus profit in the fishery. But when there is open access to the fishery, new trawlers will be attracted by the profit. Then the Open Access Equilibrium (OAE) at point P may be beyond the vessel that is optimum for the economic as a whole. The total effort is raised and the total cost, TC, rises accordingly. This process will go on until the costs of the fishery are equal to its revenues, that is, at the point where the line TC intersects the curve of the value of sustainable yield. The profit has become zero; new trawlers will not be tempted to enter and the size of the fish stock and the effort will have to be found a new equilibrium indicated by (TC).

This size of the fish stock is far below that which would have given MSY. The process described has two consequences:

- there is no profit in the fishery; the costs are equal to the revenues
- the total harvest is less than it would have been with less effort

This situation is rather the rule than the exception in the major commercial fisheries. When the total fishing effort on a species is beyond the optimum, both the input resources (such as fuel) and the fish resources are being wasted.

7.1.3. Shifting cost function on OAE

In an open-access unregulated fishery, it is the cost of the effort that determines its magnitude given the same price of fish. If the effort is beyond the optimum level, an increase in the unit cost will eventually force the effort down; the operations are run at a loss and boats will leave the fishery until a new balance is reached. This is illustrated in figure 60. The line TC is original cost function from figure 55. Two more lines have been added. TC_T indicates a raised level of cost, for instance brought about by taxing the input (increased fuel price etc.). The increased unit

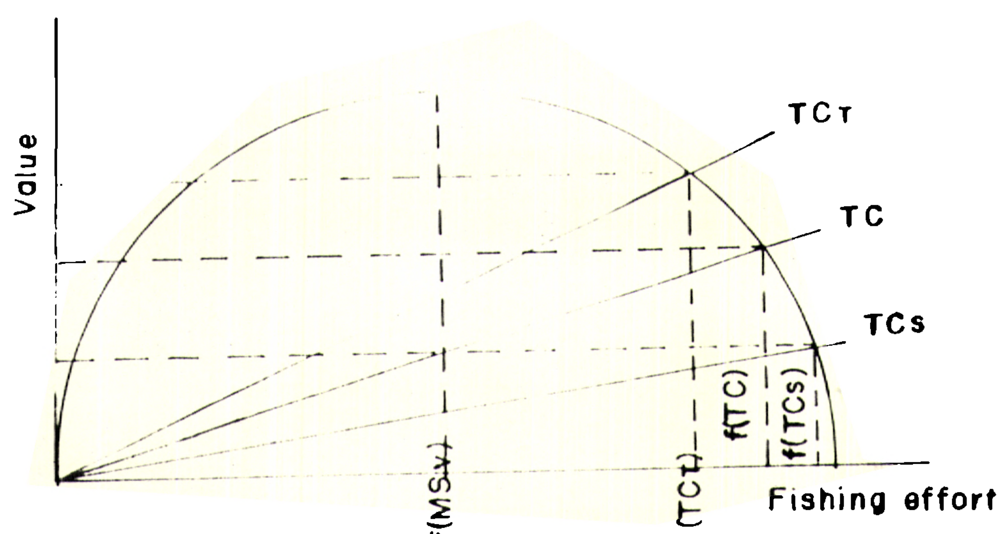


FIG.60 EFFECT OF SHIFTING COST FUNCTIONS ON THE OPEN-ACCESS EQUILIBRIUM

cost means that the fishery becomes nonprofitable at a lower level of effort, f (TC). The fish stock is exploited less intensely than before the growth and thereby the sustainable harvest increases. The result is that more output is produced with less input. The trawlers are, however, not making more or less income than at the previous equilibrium of f (TC). What has been gained is on the macrolevel; there is more production of fish and less fuel is being spent because the effort has been lowered.

The opposite will happen if the unit cost of effort is reduced, for example by subsidies on fuel. This case is represented by the cost line TC_S. Lowered costs mean increased profitability; the total effort will go up and a new equilibrium will be reached at $f(TC_S)$, where more input is producing at less output. Subsidies are not the only mechanism that may lower the cost of unit effort. Improved technology, properly managed operation, fishing according to Lunar phase avoiding fishing during lean season, selection of proper vessel, diversification of fishing etc. raise the efficiency of the input and thus increases profitability and thereby the total effort. The line TC_S in figure 60 can therefore also be taken to represent the above factors. The conclusion is that without any restraints on the fishery, reduced cost per unit effort will lower the total costs and increase the output.

7.1.4. Limitations of the model

The Schaefer model is an extremely useful method for explaining the principles of bio-economic fisheries analysis. Morever it usually seems to fit the facts reasonably well. Nonetheless, like all models, it does suffer from various drawbacks.

On the biological side, it shares the weakness of most growth models in that it seems the fish stock leading an existence on its own, in isolation from others. In practice, the growth curve and the MSY are evasive concepts. Where there are different fisheries exploiting different fish stocks in the same ecological environment, they will affect each other. The various species of fish all have their place in the food chain and what happens with one link will influence the growth of other. Also it assumes a stable marine environment, but in practice, changes in environmental parameters (oceanographic conditions) may have an extremely important bearing on the state of the stocks. MSY estimates have for long been a cornerstone of fisheries management, but nevertheless a number of fish stocks are over exploited. Time and again the estimates have been off the mark. Fisheries managers are becoming more aware of this and the tendency is now to keep well on the safe side of the estimates.

On the economic side, the model has the shortcomings of most macroeconomic long-run equilibrium models. Namely, the assumption that industrial actors will respond smoothly to variations in external parameters. In the fishery context this means that the total effort is supposed to adapt flexibly to changes in economic and biological variables; that boats will leave or enter the fishery relatively easily. In reality, this may not hold true. The capital in fisheries tends to have a very long working life, and various institutional factors, such as the share system of crew payment tend to cushion the return to capital with the consequences that the adjustment period may be very long. Also, the model assumes the unit effort to be relatively constant over time. But in practice, unit effort may change, either through technological improvement or through change in the operating intensity of the units.

This is illustrated by a process observed in the present context. When there is a profit in the fishery, new boats enter and the total yield gradually approaches

MSY. By this time the investments and the employment in the fishery have created powerful interests, often of political consequence. This makes it difficult to arrest the growth. New boats are being contracted and the total effort is pushed beyond the level for optimal yield. The expansion of fishing fleet and harvesting of the existing stock will lead to overcapitalisation in relation to the sustainable yields of which the fishery is capable. This is what has happened to the industrial fishing in the upper East coast of India which is explained in the model. Subsequent depletion of stock can lead to severe social and economic problems as happened in the case of Kerala (Achary, 1987). Such socio-economic factors have rarely been incorporated in the fishery management models.

7.2. ECONOMETRIC MODEL OF INDUSTRIAL FISHING

This is an attempt to develop a simple econometric model based on the data available pertaining to the large vessels operating in the upper East coast of India. The aim of the model is to assess the critical variables that are relevant in finding the maximum shrimp and fish catch in the said region. It is understood that the amount of fish and shrimp harvested by a vessel at a particular point of time depends on various factors including physical, chemical and biological nature of the sea apart from the specification of the vessel and technological skill of the crew.

However, the model now developed is only an exploratory model and would establish the nature of relationship between the variables. It suffers from all the limitations of Ordinary Least Square estimates (OLS) and do not ensure two-way causation (Gujarati, 1985). The basic idea for the model has been borrowed from Clark and Kirkwood (1979), though the data restrictions do not permit the level of sophistication achieved in their model.

The independent variable, namely, total value of shrimp and fish caught during an year by two different vessels has been viewed as dependant on the following variables:

Operating expenses, (TE)
Nature of vessel, (D1)
Fishing season chosen,(D2)
Expenditure on fuel, (F) and
Catch per unit effort,(U)

The value of output (Total value of fish production - V) is thus projected to have a linear relationship with the said variables. That is:

$V = f$ (TE, D1, D2, F, U) (25)

A brief explanation of the variables follows:

7.2.1. Operating Expenses

The data available on operating expenses includes the expenditure on stores and spares, wages, messing allowances and miscellaneous expenses incurred. The amount do not include the expenditure on fuel. A level of TE is required to maintain the minimum level of fish catch. Thereupon, the TE may have to be minimised to maximise net return.

7.2.2. Nature of the vessel

The specification of the vessel would affect the level of fish catch. Given a sample of five vessels, two vessels have been selected for the purpose of the model. The vessel A was found to be the least productive in terms of value of catch, returns and IRR over a period of 10 years. Similarly, vessel C was found to be the most productive, with the most impressive IRR (Table 8). These have been regarded as dummy variables (D1) and the data for five trips for the vessel A and six trips for vessel C have been made use of.

7.2.3. Fishing season

Based on the available data, the total fishing season has been divided into two parts namely, lean and non-lean periods. The period from January till May has been regarded as lean period of fishing. Accordingly, dummy values have been assigned to this variable over 11 voyages.

7.2.4. Expenditure on fuel

The relation between fuel expense and fish catch would show a backward being curve (figure 61) indicating a decreasing function after the peak utilisation limit has been reached. In a way, the degree of expenses on fuel would serve as a measure of the Skippers skill in handling the vessel in the most efficient manner. This

BACKWARD BENDING

YIELD CURVE

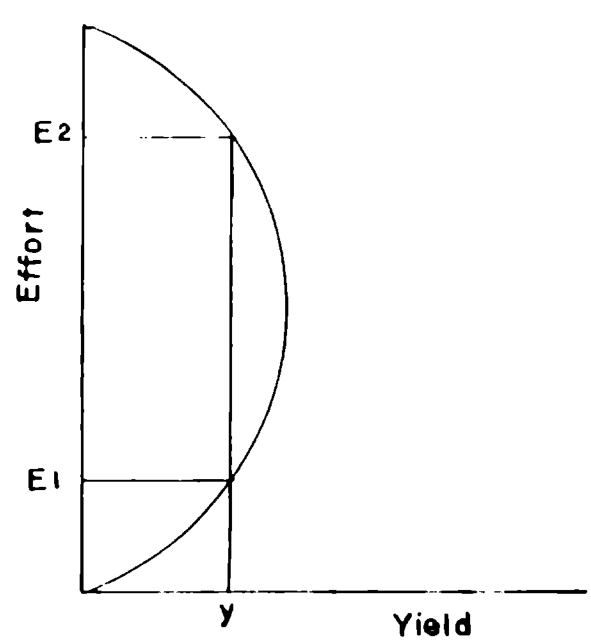


FIG.61

variable is likely to capture the most elusive 'skill' variable.

7.2.5. Catch per unit effort

CPUE would also be another measure of skill and efficiency provided the catch is uniformally spread over the fishing ground. In reality, this rarely does happen and thus the variable would serve as a measure of productivity. At an extreme, this may even be regarded as a measure of luck!

7.2.6. Assumptions

Apart from the usual assumptions of any least square estimates, the following specific assumptions may be listed:

a) Fish stock is assumed to be self replenishing and not diminished by additional introduction of vessels.

b) Entry and exit into the fishing fields are restricted overtime, thus limiting the number of operating vessels.

7.2.7. Regression Results

The results of regression analysis has been presented below:

V -543741* +2.11TE +333782.4* D1+349036.9* D2+2.25* F+17074.24U

(3.55) (1.06) (1.99) (2.03) (1.84) (0.71)

No. of observations (N) = 11

Degrees of freedom 5 R^2 = 0.98

The results are significant at 5 - 10% confidence interval.

* - Significant variables.

Figures in the brackets indicate t-values

R^2 - goodness of fit.

The large intercept with a negative value makes the model somewhat vulnerable. This would imply that some variation in the dependant variable has not been fully explained by the existing variables. The model may have to be expanded to capture the 'unseen' variable.

Dummy variable for the type of vessel indicates a positive significant relationship. But, the estimate is biased to the extent that there was an element of bias in selecting the two vessels (the lowest and highest IRR) from the total sample itself.

Dummy variable on the fishing season clearly brings out the advantage of working during the non-lean season. It would be highly unprofitable/unproductive to fish for shrimp during the months from January to April. It also emphasise the necessity of diversification to other fishing grounds as done by vessels D and E for deep sea lobster.

Fuel consumption measured by the expenditure on fuel has proved to be a significant variable influencing the catch. It may not be considered as a measure of efficiency of boat operations because of the positive sign. That is, more fuel consumption does not mean more catch. However, the degree of uncertainty as to the available stock would also make it an imperfect measure of efficiency. At best, it may be assumed that the productivity would go on raising until a particular level alongwith the raising fuel consumption.

CPUE may also be regarded as a significant variable including the value of catch. This indicates the level of experience and skill to some extent assuming that the catch is not uniformally distributed over the entire area. Therefore in reality, the results may vary given a bigger sample ($N > 11$).

7.2.8. Conclusions

It is a fact that the model suffers from various limitations imposed by the data constraint. However, it is indicative as to certain possible conclusions towards maximising the total catch. It may be concluded with a fair degree of confidence that a right kind of vessel, a particular fishing season, diversification during lean season and effort to minimize expenditure on fuel are important factors that would result in maximum yield.

The step-wise regression details which are appended* indicate that TE does not have a stable coefficient. This would strip the model of yet another measure of efficiency. In short, the model fails to capture the impact of efficiency, skill, experience and learning-by doing over yield.

7.3. EXTENSION OF MODEL

An extension of the model may require more data on a few more variables. The sample size may also need to be expanded to look beyond an year. In this context, it may not be out of place to present the model developed by Clark and Kirkwood (1979). The model had simplified the choice between only two kinds of vessels, namely, freezer trawlers and brine trawlers. It includes both biological and economic parameters (Pitcher and Hart, 1982) namely:

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*APPENDIX:

Details of step-wise Regression:

(1) $V = 39950.8 + 2.550\ TE \quad R^2 = 0.05$

(2) $V = 54329.12 + 2.817\ TE + 591957\ D1 \quad r^2 = 0.64$

(3) $V = -214273 + 3.433\ TE + 629200\ D1 + 359007\ D2 \quad R^2 = .85$

(4) $V = -635265 + 3.15\ TE + 394262\ D1 = 447736\ D2 + 2.48 \quad R^2 = .92$

CPUE - Y

Catchability coefficient - Q

Boat serviceability - S

Landed price of prawn - P

Operating costs - C

Fixed costs - K

Number of boats - Z

Number of prawns in stock - X

Average weight of a prawn - W

Natural mortality rate of prawn - M

Average recruitment of prawn - R

The model has made use of modern maximising techniques to arrive at the optimum number of boats, type of boats and season for fishing, thus maximising the catch. However, trying such a model would require sophisticated and precise-data for few years.

However, a double log model at the macro level has been attempted to enable to assess the relevant elasticities to determine the optimum fleet size. Given that the MSY for the large vessels may be fixed at 5313 tonnes, the optimum number of vessels to be operated in the region need to be calculated. Although Rao (1993) has estimated the MSY for large trawlers as 4478 tonnes, these vessels from the area have produced 5313 tonnes.

(Figure 57) and therefore this figure has been taken as the MSY for the model.

7.4. LOG-LINEAR MODEL

The following variables have been incorporated in the log-linear model:

(1) Number of vessels in operation (V)

(2) Average catch per unit of effort (C)

Time series data from 1978-79 to 1991-92 have been made use of, while estimating the OLS coefficient for the model. Total catch for the year (TP_t) has thus been envisages to be determined by the number of boats and average effort:

$$TP_t = \# (V_t, C_t)$$

Where # is function, V-number of vessels, C-CPUE and t- t value. In terms of the logarithmic specification, the model would be the following:

$$\ln TP_t = \ln b_0 + b_1 \ln V_t + b_2 \ln C_t + u_t$$

Where, ln = log to the base e, and e = 2.718

The above model may be further simplified by substituting, i.e., $\ln b_0 = a$

Thus we have,

$$\ln TP_t = a + b_1 \ln V_t + b_2 \ln C_t + u_t \qquad (26)$$

7.4.1. Results

The regression results of the above model have been presented below: (See Table 18)

$$\ln TP_t = 2.38649 + 0.5746 V_t + 1.1054\ C_t$$

$$(3.6625) \qquad (3.0004)$$

No. of observations = 14

Degrees of freedom = 11 $R^2 = 0.57$

The results are significant at 5% level.

Figures in the bracket indicate t-values.

Making use of the elasticity now estimated, the optimum boats needed to maximise the catch upto the MSY level can be projected. The CPUE achieved was the highest during the year 1984-85, during which period 60 vessels were operating (Figure 57). This year has been taken as the bench mark for the calculations.

The coefficient of the variable, V (0.574604) (i.e., number of vessels in operation) is the relevant elasticity for the calculation. In other words, it implies that the total catch would increase from the existing level by 0.5746%, if the number of vessels increase by 1%. During the above mentioned bench-mark year, the number of vessels in operation were 60 (1984-85) and the total catch for the year was 4202.8

tonnes. The catch has to increase by 26.42% in order to reach the MSY level of 5313 tonnes. This would also mean that the number of vessels need to be increased by 45.97%. In actual numbers, this entails an increase in the number of vessels by 28. Thus, calculations have revealed that it would be optimal to operate only 88 industrial vessels in order to reach a maximum feasible catch of 5313 tonnes.

The data for the year 1989-90 shows that there were about 146 vessels operating, and the catch was 5313 tonnes. As per the results obtained from the model, 58 vessels were redundant. The overpopulation may be explained in terms of inefficiency of operation and/or using the vessels of non optimal specifications.

These results need to be analysed in the light of the linear regression model presented in the Chapter. In a way, the results strengthened the conclusions already arrived at. It is already stated that the results of the linear regression model suggest that certain kind of vessels, a particular fishing season, reasonable amount of expenditure on fuel and fair amount of operating capital would result in maximum yield. On the otherhand, the results of the log-linear model at the macro-level have brought us to the conclusion that about 58 vessels were redundant when the total catch was tending to the MSY level. This would intuitively mean that the vessels were operating below capacity due to all or any of the reasons mentioned above. That is, a few of them might not be of the right specification or, a few of them might not have been operated during the non-lean season or, they might not have used the fuel efficiently or a combination of these factors and so on.

In sum, the above exercise, when taken in totality, draws attention to the fact that the vessels operating in the said region may optimise their catch provided they pay due regards to the efficiency norms. In terms of policy prescription, the logical conclusion could be to curtail the fleet size, exploit the area during non-lean season and use the vessels of right specification.

High value fisheries and harvesting of the stock has often led to over capitalisation in relation to sustained yield. Subsequent depletion of the stocks can lead to severe social and economic problems as the crafts and gears will be laid up creating unemployment and economic strain to the fishing industry. Mere limitation of access is not an adequate management but a detailed, precise and enforceable control appropriate to each resource based on the biology of stock will ensure a sustained fishery.

TABLE 18
TIME SERIES DATA FROM 1978-79 TO 1991-92 FOR REGRESSION ANALYSIS

TP	V	C	LNTP	LNV	LNC
1950.7	37	22.85	7.5759	3.61	3.13
1935.7	50	15.68	7.5682	3.91	2.75
4290.9	50	22.09	8.3643	3.91	3.1
3888.0	53	21.47	8.2657	3.97	3.07
4143.2	54	20.98	8.3292	3.99	3.04
3511.8	55	24.39	8.1639	4	3.19
4202.8	60	30.04	8.3435	4.09	3.4
4541.6	75	24.57	8.421	4.32	3.2
4593.9	100	23.52	8.4325	4.61	3.16
2661.1	133	15.09	7.8865	4.89	2.71
3537.7	140	16.92	8.1712	4.94	2.83
5313.0	146	17.40	8.5779	4.98	2.86
4739.0	123	18.10	8.4636	4.81	2.9
4607.0	155	15.20	8.4353	5.04	2.72

TP - Total production, V - Vessels, C - CPUE,

LN - Log Value, LNTP - Y axis (dependent variable)

LNV & LNC - X axis (independent variable)

Regression Output

Constant	2.38649	
Std Err of Y Est	0.227752	
R Squared	0.569509	
No. of Observations	14	
Degrees of Freedom	11	
X Coefficient (s)	0.574604	1.105487
Std Err of Coef.	0.156886	0.368437

CHAPTER 8

SUMMARY AND RECOMMENDATIONS

SUMMARY

The present scenario of industrial fishing in India is that most of large trawlers are based at Visakhapatnam and congregate in the potential shrimp ground in the upper East coast of India commonly known as the Sandheads. These are outrigger vessels operating two or four trawl nets along with a testing trawl called try net. In the early Seventies these vessels were operating on a very high economic return which was evident from the steady increase in number of outriggers, over a period of twenty years. Since the total allowable catch has to be shared by all vessels including the increasing fleet, reduction per vessel output is bound to happen. Therefore some of them could not survive the competition and withdrew from the scene. The number of outriggers did not increase subsequently. However, there arose a doubt whether the existing fleet of about 180 vessels are fishing economically or whether there is any scope for further introduction of industrial vessels in the region. This study is focussing to the techno economic aspects of industrial fishing in the upper East coast of India.

Chapter 1

The shrimp and fish resource potential as assessed by various exploratory surveys are explained in the chapter. Alongwith mechanised trawlers in the region, when large outriggers were introduced, an innovative design of trawler called Mini trawler sprang in the scene. Simultaneously small fishermen introduced a less capital intensive boat called Sona boat which could survive in the region compared to the Mini trawlers.

Chapter 2

Tracing the history of trawl from the brackish waters on Baltic coast of Germany, the various Scientific works carried out in India and abroad on various aspects of trawl have been reviewed. Attempts have been made to explain the technology of design, construction and operation of bottom trawl gear and otter door used in the outrigger vessels. Specific details such as research on materials of trawl, twine size, mesh size, selective shrimp trawl and configuration of trawl have been incorporated. The origin of outrigger vessels and its development have been traced from Texas in 1955. The superiority of double rig trawl over single trawl has been explained with reference to fishing capability.

Chapter 3

Craft and Gear used by the investigation fleet has been described in detail giving specifications. Six types of vessels have been chosen from various category of industrial vessels operated and they have been named A (21.94 m.), B (21.39 m.), C (21.59 m.), D (22.34 m.), E (27.0 m.) and F (15.85 m.). Out of the above, D and F were combination trawlers and the remaining four were outrigger vessels. The net used was similar in design scaled up according to increase in HP. Flat rectangular otter boards were used in case of single rigged trawl and a sledge was assembled when twin rigged outrigger trawl was operated. The combination vessels used for diversified fishing for deep sea lobster during lean season during which time four seam deep sea lobster trawl was operated with V form otter board. Operations were carried out utilising electronic and navigational equipments and only shrimp and quality fishes were preserved. Skippers scheduled their operation on the eighth day of New moon and Full moon during which period there was substantial increase in catch. This showed there is relationship between shrimp production and lunar phase.

Chapter 4

The results of industrial vessels as well as investigation vessels have been analysed for the HP availability, types of rigging, propeller assembly, vessel built in various Shipyards and age of vessels. In the Cash outflow fuel constituted a major item. When the CPUE was examined, the maximum was for vessel D (22.34 m. GRT - 155, HP - 500), although average unit cost of production was the least for the vessel C (21.59 m. GRT - 116, HP - 402).

Chapter 5

This Chapter provides techno-economic synthesis of both industrial fleet and investigation fleet. It was seen that HP ranging from 380 - 402 covered 51% of the total industrial fleet. Out of various kinds of rigging, 73% was of single rig type. During the analysis it was found that 64% of the vessel had propeller nozzle and majority (71%) of engines belong to CAT 3408 and CAT 3412. Out of all the industrial vessels 35% vessels were built in Indian Shipyards and 73% of the vessel could sustain another 10 years in the region. Out of the various species constituted, the catch of Brown formed the major variety.

The regression equation arrived at after survey of

135 industrial vessels indicated HP - LOA relationship as HP = 27.207 x LOA - 180.855. From the regression equation for main engine and auxiliary engine the fuel consumption litre/hour has been assessed at 0.15 to 0.16 and 0.06 to 0.10 per HP respectively. When the Cash inflow and out flow was examined the pattern was same for all the six types of vessel. The expenditure on fuel for the six category of vessels varied from 61 - 75%. The optimum size of the vessel out of investigation fleet was vessel C, which was making maximum profit out of all. If this vessel had diverted for diversified deep sea lobster, the return on investment should have been much more than the present level.

Chapter 6

The performance of investigation vessels has been evaluated working out the IRR for the year. While the IRR of vessel C was very impressive (60.68%), vessel B (21.39 m., GRT - 104, HP - 380) had the highest IRR - 115.74%. The main reason for the highest IRR for vessel B was that it was a second hand vessel with least capital cost among large vessels. The sensitivity analysis indicated that vessel A, F, E and D will not withstand adverse conditions of increase in number of trawlers happening year after year. Analysis further indicated that trawlers B, C and D will be able to meet the operating cost fully throughout another 10 year period, if there is 5% reduction in income year after year. While analysing production of return of industrial vessel, it was found that there is over capitalisation of rare financial resources and likely conflicts on socio-economic front even without further addition of large vessels in the region.

Chapter 7

The growth rate of fish population depends on biomass of the stock. At the peak of fish population, it gives the maximum sustainable level of production. The value of catch constitutes the sustainable yield for any given size of population. When there is an open access to the fishery, new trawlers are attracted by the profit. The total effort then is pushed beyond the level of optimum yield. This expansion of fishing fleet beyond optimum yield leads to over capitalisation which has been explained in the model.

The Econo-metric model of industrial fishing evolved assess the critical variables that are relevant in finding the maximum shrimp and fish catch. This has been evolved after the independent variables such as operating expenses (TE), nature of vessel (D1), fishing season (D2), expenditure on fuel (F) and CPUE (U) are analysed. The vessel output (V) has been projected to have a linear relationship.

$$V = f(TE), D1, D2, F, U)$$

The regression results concluded with a fair degree of confidence that certain kind of vessel, a particular fishing season, diversification during lean season and effort to save on fuel would result in maximum yield.

Through Log linear model the optimum boats needed to maximise the catch upto MSY level have been evolved.

$$TP_t = a+b_1 \ln V_t + b_2 \ln C_t + u_t$$

The calculations have revealed that it would be optimal to operate only 88 large vessels in order to reach MSY in the region. The remaining vessels are redundant and the over population of vessels is explained in terms of inefficiency and over capitalisation of financial resources.

RECOMMENDATIONS

1. Fuel constitute the major outflow of the industrial vessels. Each engine has a desired RPM by which optimum thrust is obtained from the propeller. Any RPM beyond or below this point shall increase fuel consumption. Therefore, utmost care should be taken to maintain optimum RPM and maximum production should be ensured during the time for the best economic return.

2. Although double rig trawls have more opening width than single rig trawl, for the best manoeuvring of the optimum size vessel, single rig trawl is preferred in the upper East coast of India.

3. Analysis of the data collected from 135 industrial vessels revealed that vessels with CP propeller is expensive and fixed propeller with nozzle is the most desired installation.

4. Ther is over capitalisation of large vessels in the upper East coast of India. Such over capitalisation apart from wasting rare financial resources, upset the ecosystem and the very existence of shrimp fishery. Therefore, for the healthy growth of shrimp and fish industry, the fleet size has to be brought to the optimum level.

5. When taken in totality, the maximum shrimp resources available for the large vessels are only 5313 tonnes and this could be most economically exploited by the operation of 88 industrial fishing vessels against the present fleet of about 180 vessels. The remaining vessels should be shifted for diversification of other resources.

6. Considering the cost of operation and requirement of diversification during lean season, a combination outrigger and deep sea stern trawler of the size 21 to 23 m. with 400 HP is suitable for industrial fishing in the upper East coast of India. In such vessel split winch will be more suitable than three drum winch. Such vessel will reduce considerably the unit cost of production of shrimp/lobster and fish.

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