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A DESIGN STUDY OF TURKISH BLACK SEA FISHING VESSELS

A thesis submitted for the Degree of Master of Science in Engineering at the University of Glasgow.

By

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DEDICATION

TO MY PARENTS, BROTHERS AND SISTERS FOR THEIR ENDLESS SUPPORT AND ENCOURAGEMENTS

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SUMMARY

This thesis presents a design study of Turkish Black Sea fishing vessels, which are mostly built by traditional methods. These vessels provide the highest catch rate of Turkey's total, and their numbers and sizes are increasing year by year. The Black Sea fishing vessels rely heavily upon anchovy stocks for their survival. In this study it has been assumed that the anchovy stocks are reasonably abundant to exploit. Because of the growing importance of the Black Sea fishing vessels in Turkey's fishing structure, it was considered to be worthwhile carrying out such study on this particular type of vessels. This thesis, therefore, contains detailed information on the Black Sea fish and fish stocks and it covers the general aspects of Turkey's fishery structure.

This thesis provides a basic understanding of the design of a fishing vessel and outlines the factors that influence the design in general. A number of formulae of practical use are presented to estimate the main dimensions and group masses for preliminary design purposes. The thesis then focuses on the Black Sea fishing vessels which are of major interest to the study. A representative fishing vessel of the Black Sea type, called the parent vessel, was chosen to be analysed on the basis of the data collected from Turkey. The lines plan of the parent vessel has been redrawn to build a model, whose scale was 1/12.5. The towing experiment, on which basis the speed-power curve of the parent vessel has been evaluated, was conducted in the Hydrodynamic Laboratory of Glasgow University. The hydrostatic and stability characteristics of the parent vessel have been determined by using a computer program from the WOLFSON UNIT, which is available in the Department of Naval Architecture and Ocean Engineering.

Having analysed the parent vessel it was possible to improve certain features of the traditional design. In accordance with the improvements made within the parent vessel, two sets of general arrangement plans have been produced. On the structural side of the study, a comparison of midship sections between the parent vessel and the proposed vessel based on the Lloyd's Rules has been made. The proposed design has also been checked for longitudinal strength and stability based on IMO criteria.

An economic model of the Black Sea fishing for anchovy has been included. In this study, all costs are expressed in US$ and decisions about loans, interest rates and inflation rate reflect Turkish Government's policy as it was at the time of writing of this thesis.

CHAPTER 1

INTRODUCTION

For many thousands of year, living creatures of the sea have provided man with one of his principal sources of food. This is true today, and food from the sea continues to grow in importance as efforts are made to establish sufficient resources to feed the multiplying world population, production being unable to keep up with growing demands for protein.

Many years ago man made the change from hunting to farming animals, so achieving a much greater supply of food than was possible from hunting the natural wild stocks. This sophistication has not yet been achieved so far as sea life is concerned, although aquaculture is now developing rapidly and supplying a significant proportion of the fish protein consumed in a number of countries, especially through the farming of freshwater and shellfish species. The bulk of the world's sea food supply continues to come from the stocks of ocean fish and other sea creatures, whose boundaries of movement are governed by natural characteristics of individual species and the ocean environment.

As the naturally occurring ocean stocks of fish are not yet fully utilized, commercial fishermen are hunters and likely to remain so for the foreseeable future. While fish farming will grow rapidly in importance, it would appear that there will be a place for the commercial fisherman for a great many years in the future.

To many eyes the methods and equipment used by fishermen appear crude and unsophisticated; in fact, so far as modern commercial fishing is concerned, the opposite is true in most of the world's important fisheries. Technology, sophistication, complexity and investment in vessel and equipment, together with techniques of finding and bringing fish to port, are showing rapid growth.

Increasing investment in research and development is continually improving the efficiency of operation and conditions under which fishermen work.

In order for a fishing operation to be successful, it must be economically viable within the structure in which it operates; if a fisherman does not achieve sufficient financial reward, then he cannot continue fishing. Any technological development that does no more than pay for itself is unlikely to be of benefit to the fisherman or to be used by him.

Many different methods of fishing and types of fishing gear for catching commercially important sea life have emerged over the centuries; their continued use and development to meet local conditions in many parts of the world has led to the sophistication of today's operation.

When one looks at the composition of the fishing fleet of the world, one can see that the majority of fishing boats are of less than 30m in length overall. Most of them are in fact very much smaller than this, with many inshore fishing craft ranging in size from 6 to 15m. It is these numerous small craft fishing off the coasts of all the fishing countries of the world which have tended to be neglected by the naval architect, boat designer and engineer and it is these craft, because they account for a very high proportion of annual fish catches, which most can benefit from improved design, engineering, studies in fuel energy saving, etc. However, in this lower range of design requirements formal courses and study texts are not readily available.

The variety of fishing boats is vast. Even restricting the selection of the smaller types, there is still a wide choice, and it is in the field of small fishing boats that many specialized types of craft have been developed over time to meet local conditions. Some of these craft have been developed over hundreds of years, and represent the finest seagoing craft in existence.

The choice facing the fisherman is bewildering today. Traditional craft are still built but their costs are rising because they are designed to be built by traditional methods. Some of these designs have been adapted to modern materials such as glass-reinforced plastic (GRP) and ferro-cement, whilst at the same time a new range of designs specifically suited to these new materials has emerged. In addition, there are many designs which are aimed to take advantage of steel and aluminium construction.

Electronic equipment is playing an ever increasing role, both for navigation and for fish finding. Fishermen are having to become more and more cost conscious as the profit margins from fishing are narrowed. No longer can machinery and equipment be fitted regardless of cost; each item must be considered on its merits.

Boats are complex pieces of equipment. The multitude of systems, mechanical, electrical, hydraulic and electronic, all present their particular difficulties. When one considers that these systems are fitted to a craft which may have to operate under severe weather conditions, one has some idea of the magnitude of the problem. Boats can, and do, operate successfully. Faults, when they do occur, are usually the result of lack of attention to small details.

1.1 Aim of the thesis

The main aim of this thesis is to propose an alternative design to the existing traditional design of Turkish fishing vessels by means of modifications evaluated from a parent vessel. Special consideration is given to the Black Sea type of fishing vessels as being of major importance from fishing point of view. Because of their relatively large sizes and capabilities of capturing anchovy fish, which is available in large quantities, makes this particular type of vessels significant to be examined .

One of the purpose of this study is to investigate the weaknesses of the traditional design and examine their impacts on economy.

1.2 Layout of the thesis

The contents of the thesis explain how the main areas of interest within the context of the thesis were undertaken.

In Chapter 2, a literature review on the Black Sea fish and fish stocks is presented along with a review of the existing fisheries structure of Turkey. Some 15 species of commercial importance among over a hundred fish species of the Black Sea are introduced individually and the maps concerning distribution and migration of those species are presented.Certain fish species as anchovy, sprat and horse mackerel have been found to be the most abundant fish species of the Black Sea.This led to the main consideration to be given to multi purposed (seiner/trawler) vessels of the Black Sea, hunting these particular species. Furthermore, general information on Turkey's fishery structure is presented. this contains the fleet classification and production by regions and years as well as the fish consumption and utilisation.In addition, fishing vessels of Turkey are presented by regions, years and horse power along with a number of tables.

In Chapter 3, some preliminary design methods of fishing vessels are presented and factors influencing the design of a fishing vessel are outlined.This chapter contains a number of formulas of practical use to estimate the main dimensions and group weights of fishing vessels for the preliminary purposes. Some of these formulas are based on the previous studies carried on the Black Sea type of fishing vessels.

In Chapter 4, the analysis of the existing design is carried out on the basis of data collected from various organizations, fishermen and shipyards of Turkey. The majority of the data relating to fishing vessel building was obtained from Surmene Shipyard near Trabzon, which is the largest fishing vessel yard of Turkey. In the concept of analysing the existing design, a parent fishing vessel being representative of her family has been chosen and others derived by making use the data mentioned above. Analysing the existing design enabled to make a comparison between the traditional fishing vessels of the Black Sea and modern fishing vessels of the world.

Chapter 5 deals with the modifications of general arrangements made within the parent vessel and presents a comparison of midship sections between the parent vessel and the proposed vessel, which has been based on the Lloyd's Rules. The proposed design has also been checked for longitudinal strength and stability based on IMO stability criterion.

In Chapter 6, economic evaluation of purse seine fishing vessels of the Black Sea is presented. A comparison of the profitabilities of vessels of three different sizes, which were evaluated from the parent vessel, has been made.Internal rate of return has been taken to be the comparison method of profitability. As a complementary tool or measure for fishing vessel calculations break-even analysis has been applied. Furthermore, to examine the impact of variation of the annual catch rate and machinery on the internal rate of return sensitivity analysis has been carried out.

In Chapter 7, the conclusions drawn from this study are presented and some recommendations are made.

CHAPTER 2

LITERATURE REVIEW

2.1 THE STRUCTURE OF TURKISH FISHERIES

In this chapter, it is aimed to present a general information on the structure of Turkish fisheries. Figures and tables given in this section are only representative to the situation until 1984. This arises from lack of collection of reliable data as well as the unavailability of recent statistics.

Turkey is surrounded by the seas from three sides: the Black Sea from the North the Aegean-Marmara from the West, and the Mediterranean from the South. Hence the marine potential of Turkey is composed of the production from these regions. Inland waters, which account for 8.2 percent to the total water products of Turkey, are not included. Table 2.1 below shows total marine potential of Turkey by the regions. As can be computed from this table the total length of the coastlines of Turkey is 8333 km.

SEA	Coastline (Km)	Area of sea (Km^2)	Coastline of islands (Km)
Black Sea	1695	12500	6
Marmara	1189	11300	252
Aegean	2805	96880	679
Mediterranean	1577	30400	130

Table 2.1 Coastlines and areas of the seas of Turkey[3]

The Turkish fisheries industry, composed entirely of small scale owner-operators, exploits the coastal waters of the country's extensive coastline. there has as yet been no attempt to venture into more distant waters. It is true that this would involve sending vessels as far away as the Atlantic (though it should be mentioned that the neighbouring countries of Rumania, Greece, Israel, have vessels for fishing in distant waters).In Turkey, fishing mainly is based on coastal fishing, in which fishing grounds are relatively close to the ports and land, and the total fishing time (voyage, searching, actual fishing, etc.) is limited to around 24 hours.

2.1.1 Fleet Classification and Production

Turkey's total sea-fish production, which is subject to considerable fluctuations, is greater now than it was before 1939 and in the early post war years. Catch distribution and total amount of catch of Turkey by regions and years are presented in Table 2.2.

REGION	CATCH (tonnes)		
	1980	1981	1982
Black Sea	335779	363247	416880
Marmara	30369	40649	41970
Aegean	18176	18231	14268
Mediterranean	7876	12117	10613
TOTAL	392196	434244	474731

Table 2.2 Catch distribution by regions and years.[35].

To see the individual contributions of each region as a percentage of total catch a nondimensional table is also given below (Table 2.3).

Year	Black Sea (%)	Marmara (%)	Aegean (%)	Mediterr. (%)
1980	84.8	10.6	2.6	2.0
1981	83.8	9.2	4.2	2.8
1982	85.9	8.8	3.0	2.3
1983	85.2	8.5	3.4	2.9
1984	85.7	7.5	4.4	2.4

Table 2.3 Percentage catch distribution by regions and years. [35]

As can be seen from the above table, the Black Sea provides the highest catch rate of the total amount with the average percentage of 85.7, and followed by Marmara and the Aegean and the Mediterranean with far less proportions of 7.5%, 4.4%, 2.4% respectively.

In Turkey's seas, there are over 400 fish species, some of the important ones are: anchovy, horse mackerel, atlantic bonito, bluefish, dogfish, grey mullet, sardine, turbot, chub mackerel, ray, striped mullet, red mullet, gar fish, snoek, european Seabas ~~asebas~~.

Fishing is practised in the inshore waters all around the Turkish coast, particularly in Bosphours and the sea of Marmara with Istanbul as the major landing centre. While there are a number of species caught in this area, various types of bonito mackerel account for major percentage of total landings. Important fisheries also exist in the waters of the eastern end of the Black Sea centred on Trabzon. Substantial stocks of anchovy, horse mackerel, turbot and bonito, as well as less important species, occur in the Black Sea. It should be mentioned that the anchovy is the most important fish resource, being available in large quantities.

Fishing in the Mediterranean is carried out in the Iskenderun Gulf and, while landings are not large in relation to total production, this area is important because of abundant shrimp and red mullet resources. The fishing ground in the Aegean Sea, which rank last in importance are mainly in the Izmir and Saroza Gulf areas.

From the point of view of reward, Turkish fishermen can be classified into two main categories: firstly, those employed on small rowing/engine boats using hand lines (this usually involves 3 to 4 men), and secondly, fishermen engaged on seiner boats, called "girgir" employing usually 15 to 20 men, or some cases as many as 30 to 35. In the former category, fishermen, other than the owners, generally receive a share of the catch and their returns are considered to be low. In the case of "girgir" seiner, three members of the crew are semi-skilled and receive a higher share of the catch than the others who also receive a small fixed wage. No exact information is available on the level of earnings in the fisheries as compared with other occupations.

2.1.2 Fishing vessels of Turkey

The Turkish fishing vessels, the powered section of which has expanded fairly steadily over the last few years, may be categorised into three main groups according to their tonnages:

a) Small size fishing vessels (under 3 tons)
b) Medium size fishing vessels (3 to 40 tons)
c) Large size fishing vessels (40 to 60 tons)

Table 2.4 shows the number of fishing vessels, by power and size for the years 1976 to 1982. As can be seen from this table there is an increase in the number of vessels and sizes. Machinery, equipment, etc. for the vessels are mainly imported. because of the government's legislation these items are duty-free. This encourage fishermen to have their own boats.

Years	No of vessel	Horse power			Length (m)			
	Total	1 - 50	51-100	101-(+)	1 - 5	6 - 10	11 - 20	21-(+)
1976	4599	3911	195	493	326	3860	395	18
1977	5616	4900	286	430	211	4532	560	83
1978	5945	5236	251	458	215	4945	661	124
1979	5707	4968	227	512	166	4672	728	141
1980	6764	6007	259	498	197	5647	762	158
1981	7392	6539	258	595	110	6241	875	166
1982	14658	11884	363	758	4182	9122	1195	159

Table 2.4 Turkey's fishing vessels; number, size and power.[35]

The distribution of the fishing vessels by region is also presented in Table 2.5. It can be seen from the table that the greater concentration is located in the regions of the Black Sea and the Sea of Marmara.

Summarizing the tables 2.4 and 2.5; 62% of total number of vessels of 14,658 has varying lengths of 6 to 10 meters. The average horse power is under 50HP (37kW). The number of vessels in the power range of 51HP to 100HP is 363, and 758 vessels have the engine power of above 101HP (75kW).

Recent developments have enabled Turkish fishermen to use such modern vessels as the capacity of 100 tons and 24 meters long by 7 meters beam. These vessels are uquipped with such modern fish finding and navigation equipment as sonar, net-sounder, radar, wireless. The purse seine operated by one of those types of vessel may have a length of 1000 meters, and be able to catch up to 150 tonnes anchovy per shot.

Region	No of vessel	Horse power			Length (m)			
		1 - 50	**51-100**	**101-(+)**	**1 - 5**	**6 - 10**	**11 - 20**	**21-(+)**
Black Sea	4239	3128	95	262	1624	2121	414	80
Marmara	4238	3301	138	346	1103	2513	554	68
Aegean	2433	2075	82	61	774	1548	104	7
Mediterranean	1070	940	46	83	180	776	110	4
TOTAL	**11980**	**9444**	**361**	**752**	**3681**	**6958**	**1182**	**159**

Table 2.5 Distribution of fishing vessels [3,5]

Figure 2.1 Typical Black Sea seiners

In Turkey, fishing vessels are mostly built by traditional method. Because of being the major shipyard in which traditional vessels are built Sürmene Shipyard is going to be introduced in general:

Sürmene is a town, located on the North-East coast of the Black Sea, being 40km apart from the central city Trabzon.The shipyard was founded on a sandy ground, just beside the sea, protected by a number of breakwaters from the force of waves. The area of the shipyard is relatively small (2000m^2). However, this area is not only for building fishing vessels but also for yachts and small cargo ships.The method of shipbuilding carried out in Sürmene is based on the skill passed from father to son. The concept is applied by expert people trained with practice, no naval architecture and engineering skill are involved.

The shipyard facilities are not more than a couple of simple workshops, such material handling equipment as crane, winch, sledge, etc. do not exist. In this shipyard both wood and steel crafts can be manufactured. The sizes of ships may be up to 36 meters long for fishing vessels, 56 meters long for cargoships, and 16 meters for yachts. It is possible to continue working on 3 or 4 ships at a time. The productivity can be up to 10 to 12 fishing vessels a year.

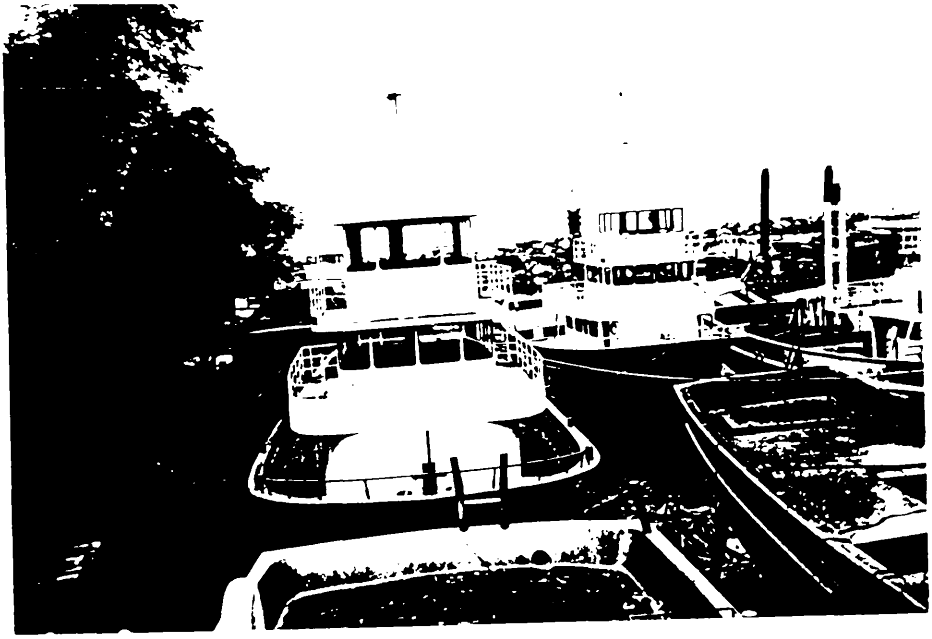


Figure 2.2 A view of Sürmene Shipyard

Because a ship an expensive investment, the manufacturer cannot take the risk of building a vessel and then declare her for sale without an order. Before starting any kind of vessel, the owner and the manufacturer discuss the requirements for the vessel in question, then the manufacturer must say ~~that~~ whether the requirements are able to be met or not. As regard to the manufacturing process, detailed information such as project, lines plan may not be necessary; a representative picture of the vessel to be built taken possibly from a magazine or orally description given by the customer in many cases can be enough for the manufacturer.It can be said that the design is very much based on the builder's imagination and skill. However, the actual outcome does not seem to be much different from modern built vessels.

In the shipyard conditions it is not possible to carry out any kind of experiment. Problems and weaknesses of the design, if any, can only be recognised by means of complaints coming from the fisherman, who is very often the owner of the vessel, after a period of experience with vessel. The builders considers the disadvantages of the design and tries to make sure that such undesirable occurances will not continue on the next design. In other words, the experience gained from the previous vessel is evaluated for the next one. This is also the way to create rather different vessel in accordance with new requirements being a result of changes taking place in fishing technology.

2.1.3 Transportation

There are not many good quality roads linking every residential area to where the catch is landed. The number of railways are also very limited. Therefore unequal distribution and consequently nonuniform fish consumption becomes unavoidable.It has been estimated[35] that 70 percent of total marine products are transported by means of primary carriage roads. Depending upon the distance and the product to be moved, ice can either be applied or not. Transporters that have refrigeration system on board are mainly used for exportation purposes, thus for the inland market fish is carried by ordinary lorries, without a cooling system. As a result of this fish may be ruined in a short period of time. This leads to distribution to district areas as quickly as possible often exceeding the speed limit.

It is estimated[35] that 1% to 10% of total product is transported by ships that have a cooling system on board, 4% to 7% of it is again carried by ships that have no cooling system on board, and 1% of the total fish is carried by aircraft in spite of being the most expensive way of transport. It would seem that transport is mainly based on conventional land carrying system.

2.1.4 Trade

2.1.4.1 Organisation of Internal Trade

Most of the fish landings are sold by auction in the major ports, while in the smaller ports, where no organised market exists, fishermen sell their catches directly to the customer or other buyers, if any. The auction markets are supervised and managed by the local municipalities. While a small proportion of the total landings in these ports is sold directly to the customers, canners, salters and exporters, the majority of the fish is sold at the auction markets.

There also exist, however, a number of hawkers selling fish, especially in coastal districts. Most of the retail fish shops sell fruit and vegetables in summer time. While retail prices on fish are reported to be 50 per cent higher than first-hand value, fish prices are, on the whole, competitive with those of meat.

Inland districts are supplied directly by coastal whole-salers or commission salesman. No inland wholesaler exists in inland consumption centres. Fresh fish in these centres is sold at retail fish shops.

2.1.4.2 Foreign Trade

The main products exported are fresh fish, for which Italy, Greece, Yugoslavia, and Romania are the main customers. With the expansion of freezing plants, export of frozen fish have been steadily increasing in recent years. Almost all fish frozen in Turkey is exported. Salted, smoked and dried fish is also exported to Greece, Bulgaria, Israel and Romania. In the total regional trade of

Turkey fish exports play an insignificant role. Turkey being a fishing net exporting country, imports negligible quantities of fish and fish products.

2.1.5 Fish Consumption and Utilisation

Fish consumption in Turkey is comparatively low, averaging 10 kg (landed weight) per inhabitant per year. Consumption varies considerably between coastal regions and interior. In the region east of the Black Sea, containing Istanbul and Marmara, where a large proportion of the catch is sold, average consumption is twice as high as in coastal areas of the Aegean and Mediterranean, While in inland areas consumption is of negligible quantity (1 to 1.5 kg. per inhabitant), and no fish at all is consumed in most rural districts.

To see Turkey's place in a world-wide comparison, fish consumption figures of some countries are given in Table 2.6. As can be seen from this table that in developed countries, average fish consumption varies between 60 to 100 kg per head, whereas in Turkey it is only about 10 kg per head according to most optimistic calculations.

Country	Fish consumption (Kg/head)
Iceland	100
Norway	61
Japan	60
Spain	50
Portugal	42
France	20
Greece	15
Turkey	9.5

Table 2.6.Fish consumption of some countries [40]

The main factors to which the low fish consumption in some regions may be attributed are the lack of organisation in selling, the inadequacy of means of communication, the absence of refrigerated transport, the high cost of fish compared with other foodstuffs, the abundance and variety of fruits, vegetables, cereals and farm products, and the very low wage level. Certain technical or psychological factors must also be taken into account in this respect; for instance, the fact that housewives do not know how to clean and prepare fish, the peculiar fish smell, and the difficulty of washing plates and cooking utensils that have been used for fish.

2.1.6 Fish Farming

Natural conditions for fish farming are only available for the Aegean, the Marmara and the Mediterranean seas. However, due to inadequate technical knowledge fish farming at sea has not been introduced yet, but in the case of fresh water farming, there are a number of farms working quite efficiently.

It would be said that the idea of fish farming at sea seems to require further knowledge and developments to be materilized. The matter however, is still being discussed among the concerned scientists.Therefore the objectives of fishery policy of Turkey, for the time being, should be concentrated on more fish hunting than fish farming at sea.

2.1.7 Policy Objectives

Fishing has been carried out for centuries in all Turkish waters which are fairly abundant in fish stocks. In spite of this, production was until recently at a low level and the industry remained one of the less important sectors of the national economy with very little supervision or guidance from the authorities. On various considerations the Turkish authorities have felt that they are justified in taking steps to expand fish production in Turkey to the fullest possible extend. Fish resources, particularly in the Black Sea, are considered to be capable of sustaining considerable further exploitation. Many small communities along the extensive coastline are largely dependent upon the fisheries for their livelihood. Fish is considered to be an important supplementary source of protein for the growing population.

On this background, the objectives of fishery policy in recent years have been redefined along the the following lines:[5]

a) To reorganise all phases of the catching, handling, processing and distribution of fish in such a way that as much will be caught and marketed as is to the greatest advantage of the national economy and of those engaged in the fishing industry;

b) To develop and promote new fishing methods, products and markets so as to encourage the expansion of fishing activities:

c) To provide assistance to the fishing industry through the provision of technical information and market research;

d) To establish pilot enterprises to encourage the catching and distribution of fish;

e) To provide other general services to assure a continued development of the fisheries and to conserve the resources of the sea of the Turkish coast.

2.2 ASSESSMENT OF THE COMMERCIAL FISH RESOURCES OF THE BLACK SEA

2.2.1 General Information on the Black Sea

The basic dimensions of the Black Sea are as follows:[37]

Total surface (in square kilometers)	423×10^3
Volume (in cubic kilometers)	537×10^3

Volume of the oxygenated zone (0-200 m depth) (cubic kilometers)	68847
Average depth (meters)	1271
Maximum depth (meters)	2245

One hundred and sixty-five species and subspecies of fish have been found in the Black Sea, of which 119 are exclusively marine, 24 are anadromous or semi-anadromous, and 22 are freshwater species. Some 15 other freshwater species are found rarely (Dehnik, 1979).[37]

There are some 15 species or species groups of commercial importance, of which some 3 or 4 are dominant.
The following 14 species , reviewed in this report, are illustrated here :

(1) Picked dogfish
(2) Thornback ray
(3) Sturgeons
(4) Sprat
(5) Anchovy
(6) Shad
(7) Whiting
(8) Mullet
(9) Bluefish
(10) Mediterranean horse mackerel
(11) Red mullet
(12) Mackerel
(13) Atlantic bonito
(14) Turbot

On this list, sprat, anchovy and horse mackerel are referred to as major species and the remainder are referred to as minor species. The following summaries of the species of commercial importance are presented.

2.2.2 Picked Dogfish (*Squakis acanthias L.*) (Map 1, See Addendum)

The species is carnivorous, feeding on fish and to a lesser extent on molluscs. It reaches a maximum length of 150 cm. It is caught mainly by trawl and fixed nets. The length of the fish caught ranges from 45-150 cm, the weight from 1-19 kg (average 3 - 7 kg).

2.2.3 Thornback Ray (*Raja clavata L.*) (Map 2)

The species is carnivorous, feeding on fish, molluscs and crustacea. There are specialized fisheries for this ray in the Soviet Union and Turkey. It is also caught incidentally in the turbot fishery.

2.2.4 Sturgeons (*Fam. Acipenseridae*) (Map 3)

They have a long life cycle and can only support a low level of exploitation. They feed on fish, sturgeon are caught by bottom - set gear such as trammel nets and baited and unbaited longlines. Like picked dogfish, sturgeon are also caught as a by - catch in the bottom trawl fishery for sprat.

2.2.5 Sprat (*Sprattus sprattus phalericus*) (Map 4)

This is the one of the most abundant species in the Black Sea. It reaches sexual maturity at one year old and reproduces during the whole year with a maximum between November and March. Prior to 1970, the commercial fishery for sprat used only traps and beach - nets. Bulgarian fishermen were the first to introduce bathy - pelagic trawls, followed later by the USSR and Romania. Pelagic and bathypelagic trawls now account for 95% of the commercial catches of sprat.

2.2.6 Anchovy (*Engraulis encrasicolus ponticus*) (Map 5)

The anchovy is the most abundant fish species in the Black Sea. Purse seine is the predominant gear used for anchovy, accounting for over 95% of the total

Black Sea catch. The remainder is caught by trap - nets (Romania) and mid - water trawl (Turkey).

2.2.7 Shad (*Alosa kessleri pontica Eichw*) (Map 6)

The fishery for shad is carried out mainly during the spawning migration using trapnets in the sea and fixed or floating nets and beach nets in the rivers.

2.2.8 Whiting (*Odontogadus merlangus euxinus Norden*) (Map 7)

The whiting is distributed over the whole continental shelf in the Black Sea but until 1978 had not been the object of a fishery, except perhaps in Turkey. In Bulgaria it appears as by - catch in the sprat fishery with bathypelagic trawl. With trapnets, the largest catches have been obtained on the Romanian coast.

2.2.9 Mullet~~s~~ (*Fam. Mugilidae*) (Map 8)

There is no substantial fishery for mullet, this fish being caught in small numbers in many coastal regions.

2.2.10 Bluefish (*Pomatomus saltatrix*) (Map 9)

The fishery for bluefish is carried out with beach nets, trapnets and purse seines. This last method is particularly efficient in years when the stocks are abundant.

2.2.11 Mediterranean Horse Mackerel (*Trachurus mediterraneus ponticus, Aleev*) (Map 10)

This relatively abundant species lives its whole life in the Black Sea. It is fished with trapnets and beach nets by all countries bordering the Black Sea, and also with purse seines (USSR, Turkey and Bulgaria), with lights (USSR) and with bathypelagic trawl (Bulgaria and Turkey).

2.2.12 Striped Mullet (*Mullus barbatus L.*) (Map 11)

The fishery for striped mullet is carried out with beach nets, trapnets, setnets on the bottom, and in the past with trawls.

2.2.13 Mackerel (*Scomber scombrus L.*) (Map 12)

Fishing for mackerel is carried out with a variety of gears, mainly traps, sea nets and purse-seines.

2.2.14 Atlantic Bonito (*Sarda sarda Block*) (Map13)

This is a pelagic species being found during the warm season only. Fishing for bonito is carried out mainly by purse-seine, with trap-nets and drift-nets used to a lesser extent.

2.2.15 Turbot (*Scophthalmus maeoticus pall*) (Map 14)

The turbot is the most important commercially of the benthonic fishes of the Black Sea. It is caught by conventional demersal trawls and other gear.

The Table 2.7 below shows average annual catch of the main fish species or species groups obtained by the countries bordering the Black Sea from that sea and the Sea of Marmara, with a rough evaluation of the level of exploitation (the Sea of Azov excluded).

Nominal catches of all species from the Mediterranean, the Sea of Marmara, the Black Sea and the Sea of Azov by Bulgaria, the USSR, and Turkey in the period 1971-1980 (in 10^3 tons) are given in Table 2.8.

Period	1961-65	1966-70	1971-75	1976-80	Exploitation level	Catches 1980
Species (group)					1976-80	
Anchovy	69	98	191.3	262.3	2 - 3	394.3
Sprat	6.2	3	6.1	44.1	1 - 2	84.5
Horse mackerel	18.4	22.8	29.9	42.1	2 - 3	53
Atlantic bonito	20.1	29.4	4.5	7.4	3	14.9
Mackerel	9.8	2.1	+	+	3	+
Bluefish	0.8	5.9	2.3	9.8	2 - 3	10.5
Shad	1.9	1.4	3	2.5	3	1.8
Turbot	3.6	3.7	3.7	2.9	4	2.9
Picked dogfish	-	2.7	0.8	1.7	1	1.7
Thornback ray	-	1.6	1.2	2.4	1	1.8
Mugils	3.6	4.8	2.7	7.8	3	6.9
Striped mullet	1.1	3.2	1.7	2	3	1.8
Sturgeons	0.6	0.4	0.3	0.3	3	0.3
Whiting	-	3.8	15.5	16.1	1	10.5
Total	**135.1**	**182.8**	**253**	**401.3**		**584.9**

Table 2.7.Assessment of the total fish ~~resources~~ catch of the Black Sea.(1=little exploited, 2=moderately exploited, 3=fully exploited, 4=over exploited).[37]

Year **Country**	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bulgaria	4.2	4.2	5.3	7.5	8.6	9.9	10.2	12	15.1	17.9
Romania	5.9	7.9	6.3	5.6	6.3	7.7	6.1	7.1	7.6	10.3
USSR	263.8	283.7	285.9	371.5	349.8	369.2	244.1	290.9	326.1	403.6
Turkey	146.9	172.6	150.3	241.2	182.7	133.7	146.2	222.3	327.4	397.3
Total	**420.8**	**468.4**	**447.8**	**625.8**	**547.4**	**520.5**	**406.6**	**532.3**	**676.2**	**829.1**

Table 2.8.Nominal catches of all species by the countries bordering the Black Sea.[37]

2.2.16 Regulations in Force in the Black Sea Fisheries

Until 1958, not much attention had been given in the fishery regulations of the countries around the Black Sea. Regulations concerning marine fish were first introduced in the Soviet Union in 1954. governing the minimum legal size of commercially important fish caught with trawls.

When the convention on fishing in the Black Sea between the Governments of Bulgaria, Romania and the Soviet Union became effective in 1959, the following regulatory measures were adopted by the sessions of the Joint Commission set up to implement that convention:[37]

(a) Minimum fish size landed, measured from the tip of the snout to the end of the peduncle of the tail and the maximum permitted percentage of under-sized fish as accidental catch;

Species	Length (cm)	Accidental catch (%)
Beluga	170	-
Danube sturgeon	110	-
Starry sturgeon	100	-
Turbot	35	5
Shad	16	8
Mullets	20	20
Horse mackerel	10	20
Mackerel	15	20

(b) Total prohibition of the fishery for the species acipenser nudiventrus, which species is to close to extinction;

(c) Prohibition of fishing for other sturgeons with all types of gears in the River Dniestr, and with longlines in the whole of the Black Sea except in the delta of the Danube;

(d) Experimental fishing for sturgeons with baited longlines; the curved part of the hooks should not be less than 23 mm long and the total weight of 1000 hooks should not be less than 4 kg;

(e) A minimum mesh size of the gear used for turbot of 180 mm (knot to knot);

(f) Prohibition of commercial hunting for dolphins.

In Turkey, which does not adhere to the Convention on Fishing in the Black Sea, the following regulatory measures have been introduced (GFCM/CGPM, 1979).[37]

(a) Prohibition of trawling within a distance of 3 miles from the coast;

(b) Prohibition of fishing for turbot between 25 April and 25 August (in 1979); this period changes each year depending on the meteorological conditions;

(c) Minimum size of turbot (standard length) of 36 cm;

(d) Minimum mesh size of the trawl codends of 20 cm.

2.2.17 Summary of Assessment of the Black Sea Fish Resources

On the background given in the previous sections, some important conclusions may be as follows:

The Black Sea provides the highest amount of fish of total catches of Turkey, with an average percentage of 85.7 (Table 2.3).

The most abundant fish species of the Black Sea are, respectively, anchovy, sprat, and horse mackerel (Table 2.7). Therefore, these are the fish species of our most interest in the research.

2.2.17.1 Anchovy

Anchovy is a winter seasonal fish, available at the densest concentration in the period from November to March. It descends during the day to a depth of 70-90m, and rises during the night to the higher water layers thereby moving toward the coast into depths of 10-40m. Purse seine is the predominant gear, accounting for 95% of total anchovy catches, mid-water trawl is also possible.

2.2.17.2 Sprat

Sprat is supposed to be a spring seasonal fish (April-October), although, this period may change slightly. Maximum concentration being found 30-80m depth. Commercial fishing gear is pelagic and bathypelagic trawls account for 95% of sprat catches.

2.2.17.3 Horse mackerel

Horse mackerel is an essentially a coastal living fish, being found at 20-70m depth. It appears in the same period as anchovy (October-May). Common fishing gear for horse mackerel are mid-water trawls and purse seines.

Fish species, fishing methods and gears summarized above are ~~the~~ some of the important factors which influence the design of a fishing vessel. So it can be concluded that the vessel type will be a multi-purpose one (combination of trawling and seining).

CHAPTER 3
FISHING VESSEL DESIGN

3.1.INTRODUCTION

The scope of fishing vessel design is to build the vessel and put it into operation. It must be based on realistic and sound economic assumptions, otherwise it will be a failure. A failure of the design may also be purely technical in character and this kind of failure is always combined with particular operational drawbacks: if, for example, the insulation of fish hold is not properly designed the quality of catch will be lower than anticipated; if the propeller is wrongly selected the fuel consumption will be increased or speed and pull insufficient. These must be borne in mind when accepting outlines and general requirements for a fishing vessel design. The designer must be able to discuss them in a reasonable way to achieve the "optimum design."

As far as considering a design for existing fishing grounds the design consists mostly of fishing vessel types already operating on these grounds. The design process of a fishing vessel may be subdivided into 8 different stages:

1) Outlines and general requirement
2) Preliminary design
3) Contract design
4) Classification drawings
5) Working drawings
6) Evaluation of tests and trials
7) Drawings and calculations necessary for operation of the vessel
8) Evaluation of operational results.

A fishing vessel is a specialized vessel which is intended to perform certain well defined task. Its size , carrying capacity, accommodation and machinery and equipment are all related to its function in carrying out its planned operations.

Factors which influence the design of a fishing vessel may be grouped under the following headings:

(1) The available resources
(2) Fishing gear and methods
(3) Geographical characteristics of the fishing area
(4) Seaworthiness of the vessel and crew safety.
(5) Laws and regulations applicable to fishing vessel design
(6) Choice of construction material
(7) Handling and stowage of the catch
(8) Economics.

3.1.1 The available resources

Information on the resources, fish species available to be caught, the desired fishing method, and expected catch rates, is normally made available to the naval architect by the owner or operator of the vessel to be designed. However, in order to provide his own estimates, the designer should have a good knowledge of local conditions, fish types and species caught, fishing methods and gear currently being employed in his area.

3.1.2 Fishing gear and methods

The principal methods operated from fishing vessels may be divided into three main types:

1) Towed and dragged gear
a) Bottom trawling: otter, pair, multi-rig

The bottom trawl is towed across the sea bed so that fish pass through the open mouth at the large end and become trapped at the point (Fig.3.1). This net may be towed by one or a pair of vessels depending upon its rigging (Fig.3.2).

In multi-rig bottom trawling, a single vessel tows two (or more) trawls from outriggers on each side of the hull (Fig.3.3).

b) Mid-water trawling: single, pair

A net similar to, but larger than a bottom trawl is towed in the water column between sea bed and the surface(Fig.3.4).

c) Dredging

A heavy steel frame with teeth scrapes or digs the sea bed for shellfish such as scallops or clams.

d) Trolling

The vessel tows a number of lines on, or at various depths below the surface using artificial lures or bait to attract fish (Fig.3.5).

2) Encircling gear
a) Purse seine

This is a general name given to the method of surrounding a dense fish school on, or near the surface, by a large wall of net. The net is then drawn together underneath the fish to make an artificial pond (Fig.3.6).

b) Seine netting

This is a bottom fishing method where fish are surrounded by warps laid out on the sea bed with a trawl-shaped net at mid length. As the warps are pulled in, the fish are herded into the path of the net and caught.

3) Static gear
a) Set gill nets and drift gill nets

walls or compounds of netting are set out in a particular pattern so that fish are gilled, tangled or trapped. The gear may be set anywhere between the surface and the sea bed, and either anchored or allowed to drift freely (Fig.3.7).

b) Long lines

Long lines often several miles in length, with many short branch lines carrying baited hooks. They are set out in a particular pattern so that fish are attracted by the bait and hooked. This type of gear may be set on the sea bed using anchors, or at various depths beneath the surface (Fig.3.8).

c) Lift nets

Framed nets are operated in a scooping manner over the side of a stationary vessel. This is surface method utilizing light attraction techniques.

d) Pots and fish traps

These are constructed of wood, steel and wire mesh, plastic or plastic coated wire. They may be set either on the sea bed or at various depths.

There are also several miscellaneous methods which are difficult to fit into a specific category, eg, pole and line fishing.

In the following pages, illustrations of some fishing techniques are presented[15,38].

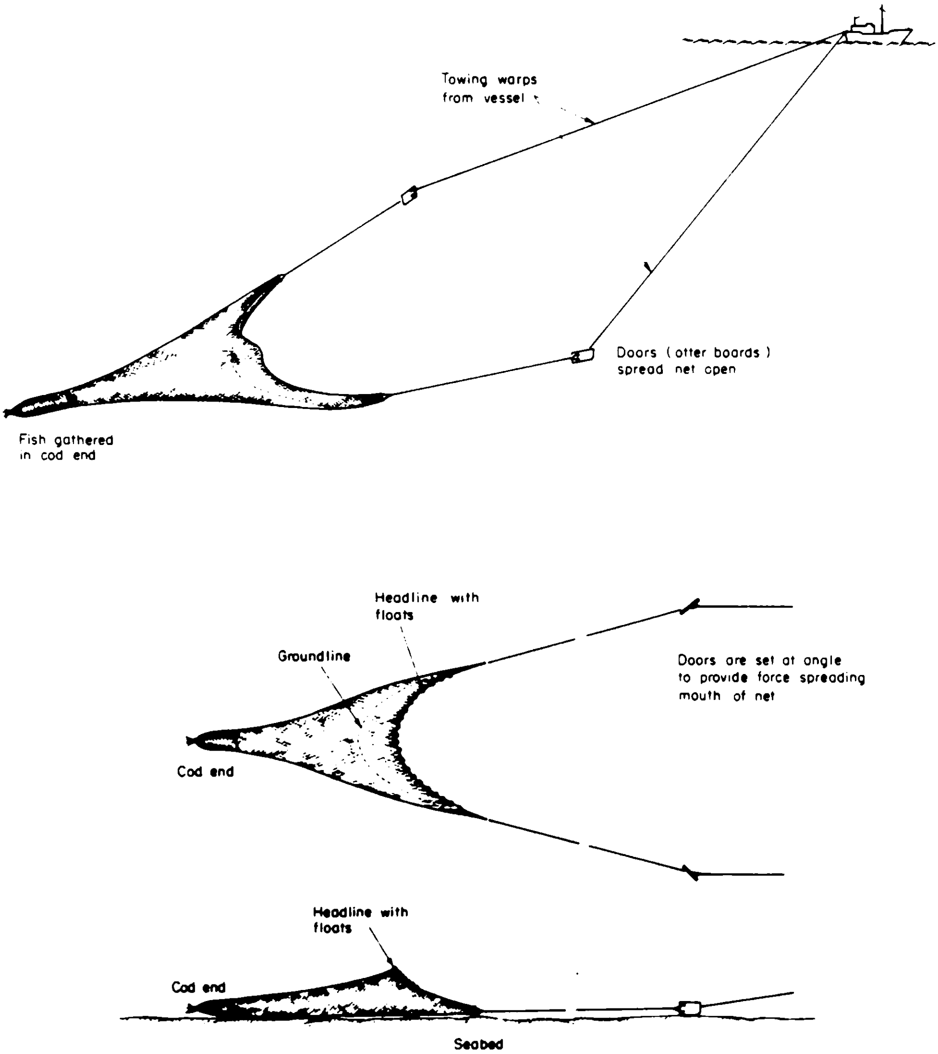


Fig.3.1 Bottom trawling

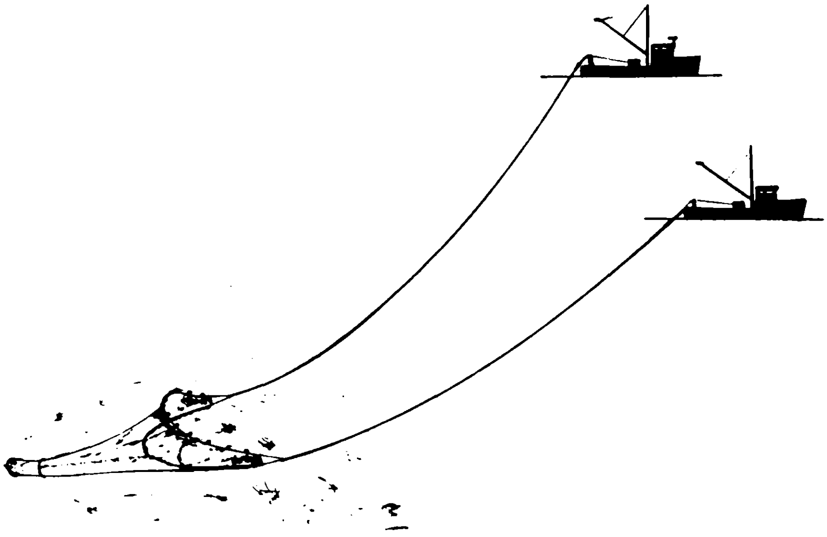


Fig.3.2 Two boat bottom trawling

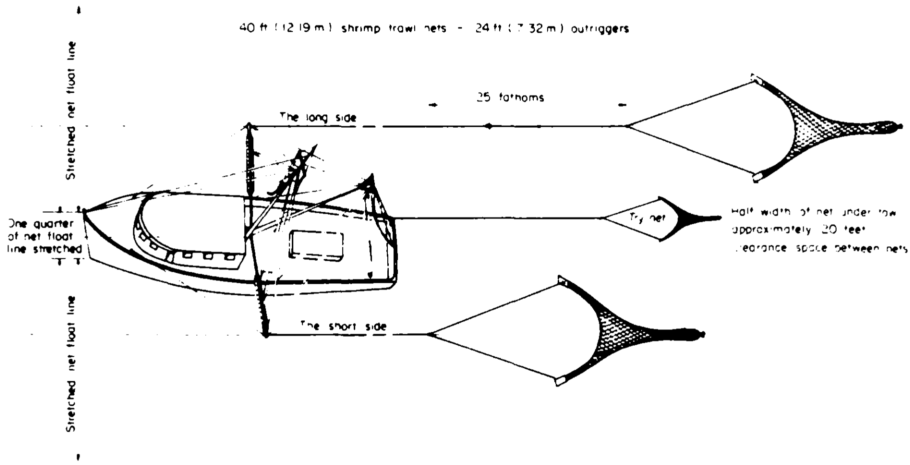


Fig.3.3 A diagrammatic representation of a double-rigged shrimp trawler

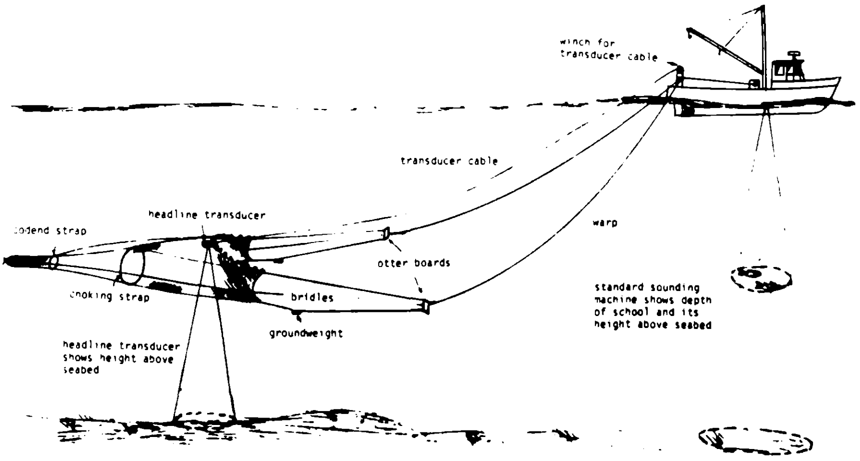


Fig.3.4 One boat mid-water trawling

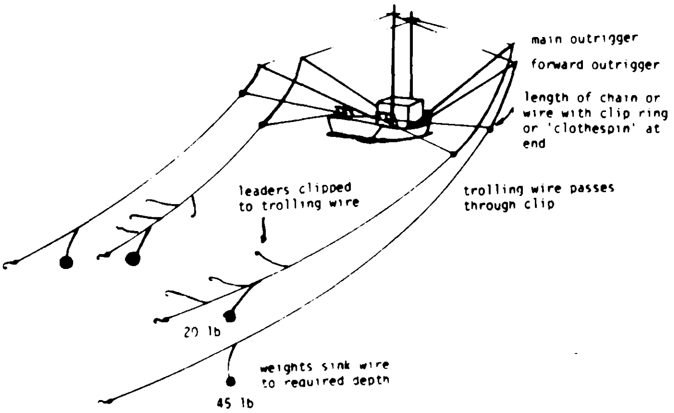
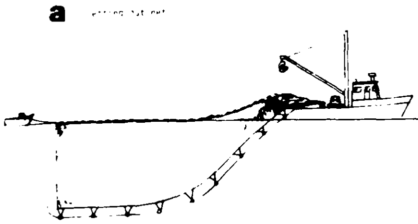
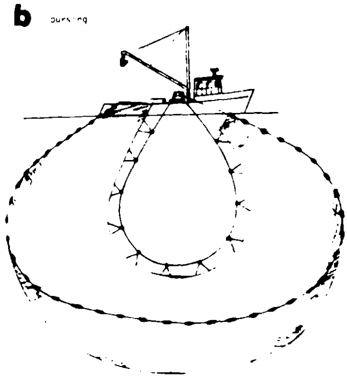


Fig.3.5 Trolling operation

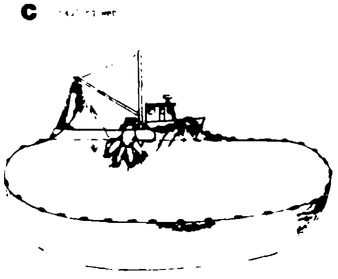
Fig 68 Western one boat method of purse seine operation



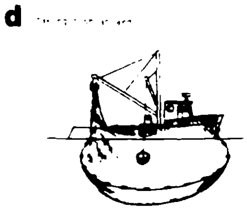
(a) Setting the net; vessel moves ahead, drops skiff or buoy with net attached and moves in circular path paying out net over stern



(b) Pursing; the floatlines and purse lines have been brought aboard; each end of the purse line is taken to the purse winch and both ends pulled in together drawing the bottom of the net together

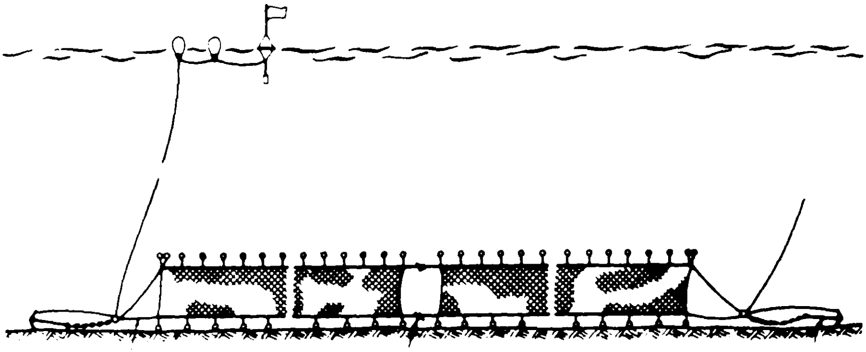


(c) Pursing completed; web being hauled, the purse rings have been pulled up and are hanging over the side. The bunt is secured forward so that the fish cannot leave the net

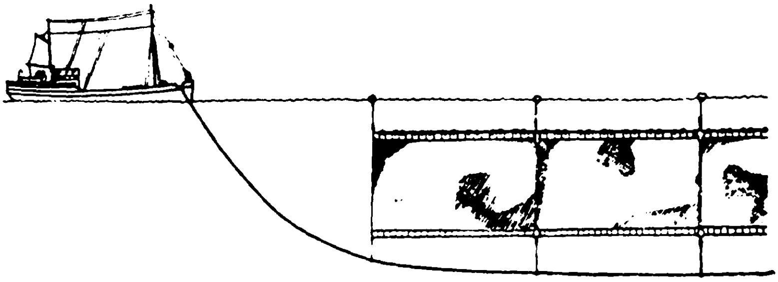


(d) Ready to remove the fish; the net has been hauled until the fish are gathered close to the ship's side; brailing or pumping can now begin

Fig.3.6 Western one boat method of purse seine operation



Bottom set gill nets



Drift gill nets

Fig.3.7 Method of setting gill nets

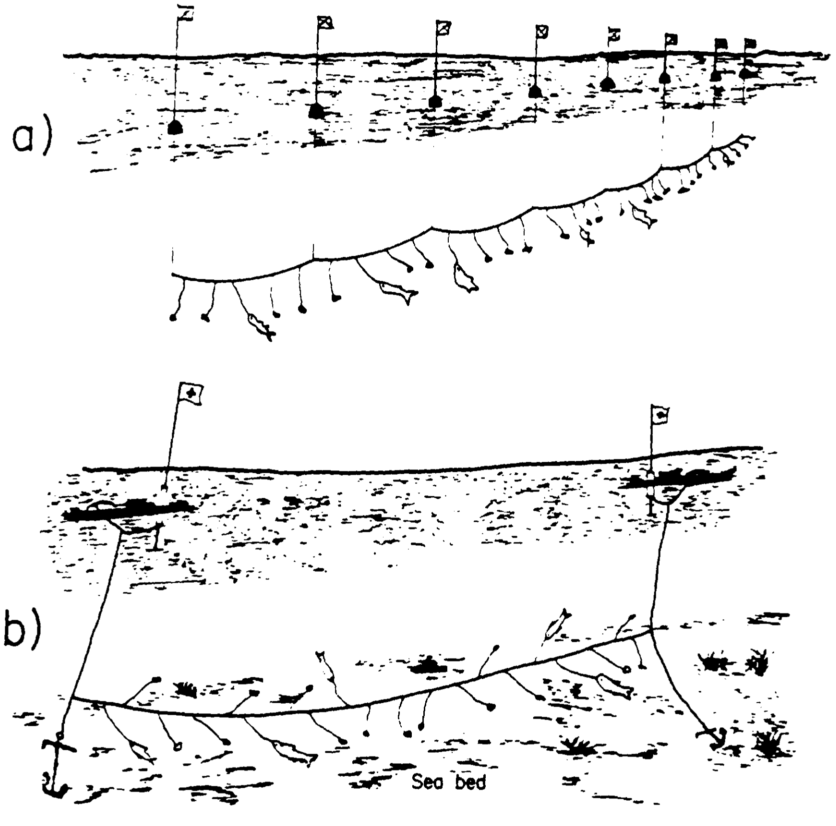


Fig.3.8 Longline gear

3.1.3 Geographical characteristics of the fishing area

The physical characteristics of the area have an influence on design decisions. For example, for trawlers dragging nets over the ground, the condition of the bottom will have a considerable effect on the weight of gear to be handled. Rough grounds require heavier gear, with a consequent effect on handling methods on deck, the deck space needed to accommodate the gear and the number of crew or complexity of mechanized handling needed. Weather conditions also influence design.Rough weather conditions may require greater freeboard to keep the decks reasonably dry, or even an increase in vessel size to allow fishing to continue in adverse conditions. Strong winds and heavy rain over long periods require good visibility from the bridge and more extensive navigational gear for position finding. Tropical climates with high temperature and humidity require special care in planning for good ventilation, particularly of engine room spaces and in the siting of crew accommodation. All these items should be taken into consideration by the designer.

3.1.4 Seaworthiness of the vessel and crew safety

Special consideration must be given to the stability of the ship during the design stage to ensure that it will be capable of surviving the variety of weather and operating condition likely to be encountered during the ship's life time.

Seakindliness, namely, a comfortable motion, dry decks, good working conditions, as distinct from the actual ability to withstand the weather and operating requirements, is more a matter of hull shape and careful weight distribution.

Crew safety is an important consideration and the designer should have a knowledge of working conditions required for the fishing methods to be used in the vessels. He designs so that such things as warp leads on deck, areas where heavy weights are lifted and handled are still planned with the greatest possible safety to crew members working on deck.

3.1.5 Laws and regulations applicable to fishing vessel design

Many countries have laws intended to make certain that specific classes of vessels built are seaworthy and crew are safeguarded; and that in the event of accidents or breakdowns at sea necessary safety measures are available for the protection and rescue of human life.

Laws concerning vessel design, construction and operation, will differ from country to country, and the designer must be familiar with both the laws of his own country and those of neighbouring countries within whose waters his designs might operate. He should also be aware of the international conventions which his country has signed.

3.1.6 Choice of construction material

The building material from which the vessel is to be built has, of course, a most important effect on design. What should be considered in the preliminary design stages is the relative weight of each construction material, the volume and hence displacement which must be designed into the hull to cover the weight of its component materials and equipment and consequently what space will be available as catch carrying capacity as well as the cost of the material. and construction.

In the size range, 10m to 30m, the principal materials will be wood, steel, fibre-reinforced plastic (FRP), ferro cement and aluminium.

In this range, wood is in general somewhat lighter than steel, but because of the greater thickness of the hull construction, requires a larger hull for the same internal capacity.

Ferro cement will in general be heavier than steel if near equivalent strengths are to be obtained and, although there can be a slight increase in size for equivalent internal capacity, the increased weight should ~~should~~ be allowed for in the design calculation.

FRP will be some 70% of the weight of steel construction in the medium size range; so increased internal capacity and/or reduced vessel size for the same internal capacity must be balanced against the cost increase per unit weight of this material compared with steel or wood.

3.1.7 Handling and stowage of the catch

Activity on deck is a considerable factor in design decisions. The bringing of the catch aboard and in particular the means of handling and stowing it can have a considerable effect on the economics of the whole operation; the size of crew needed for these operations, and the mechanical devices adopted to reduce this labour content requiring considerable thought on the part of both naval architect and owner.

3.1.8 Economics

Uppermost in the designer's mind must be the question of what the final design will cost to build. Will the vessel be able to repay its building cost? Will she go on to complete a useful operational life with profit to its owner, while providing a satisfactory living to its crew in conditions of maximum possible comfort and safety?

3.2 PRELIMINARY DESIGN OF FISHING VESSELS

3.2.1 Introduction

Preliminary design establishes the main characteristics of the vessel but stops short of the preparation of working drawings for construction. The cost of the preliminary design study may be important. The first step is to formulate operational (owners, staff) requirements. The naval architect has the responsibility for ~~of~~ ensuring that requirements are feasible and meeting them, but will be only one member of the group that decides them. Others will be economists, agents, directors and superintendents.

Requirements are translated into main dimensions, hull form, powering, arrangement specification and cost. This must be done quickly and cheaply and is obviously iterative During the preliminary design process, changes may be needed and should be possible without serious penalty. The work may be done by the owner's staff, prospective builders, or consultants. Usually all three are involved today. They certainly must agree on the final proposals. A good preliminary design has the foresight to accept alterations as the design is developed without major penalty. Its cost is the wages of a small team and computing. Alterations during construction are very expensive.

The calculations of preliminary design may be computerised but it is not necessarily worth programming the decisions; it is considered later. Initial errors in iterative procedures lead to the same results, but the design spiral takes longer.

Main dimensions include length, breadth, draught and block coefficient.

3.2.2 ESTIMATION OF MAIN DIMENSIONS

To evaluate the main dimensions of a fishing vessel for preliminary purpose~~s~~, two methods are presented; one is to make use of the following empirical formulae and Fig.39 based on ~~the~~ previous studies[50,38], the other, as a common practice, is to use the statistical data established from ~~the~~ a list of similar vessels.

3.2.2.1 Method 1

3.2.2.1.1 Beam

To improve the stability and to have a large deck area, beam is chosen to be comparatively large.The suggested relationship between beam and length is:[50]

$$B=0.762+L/4 \ (m) \tag{3.1}$$

3.2.2.1.2 Breadth-Draught Ratio

Breadth-draught ratio is a factor in resistance considerations, but also has influence on stability. The value of this ratio may be chosen in the following range:[50]

$$B/T = 2.25 \text{ to } 3.25 \text{ (generally 2.5)} \qquad (3.2)$$

3.2.2.1.3 Depth and Freeboard relationship

The deck edge should not immerse at an angle of less than 12.5 degree[28]. This is the same as saying:

$$f \geq 0.111 \cdot B \qquad (3.3)$$

$$D = T + f \qquad (3.4)$$

3.2.2.1.4 Length-Displacement Ratio

This ratio is used to express the volume of displacement in proportion to length of a vessel. The displacement length ratio was originally used by Admiral D.W. Taylor for recording of resistance of ships. The coefficient was: $\nabla / (L_{pp} / 100)^3$ and in this form it has been used widely in calculating power of ships.

$$\frac{L}{\Delta^{1/3}} = 12 \,\text{to}\, 15 \qquad (3.5)$$

Where, L is in feet and Δ is in tonnes

3.2.2.1.5 Length-Speed-Displacement Relationship

This relationship is expressed by using formula of the Posdunine type. Although empirical they are based on existing vessels and include practical considerations.

$$L = C\left(\frac{V}{V+2}\right)^2 \Delta^{1/3} \tag{3.6}$$

The value V of speed in knots is intended to be the trial speed about 1/2 to 1 knot above the service speed. Δ is the summer load displacement in tonnes. L is L_{BP} in meters. The constant C comes from one or many existing vessels, however, for fishing vessels it may be estimated from the equation below, and its value is around 21[50].

$$C = 10 + 8(V / \sqrt{L}) \cong 21 \tag{3.7}$$

Where V is in knots and L is in feet.

3.2.2.1.6 Coefficients of Form

The values of the most typical coefficients of form, for fishing vessels, may be taken as in the following ranges[50]:

$$\begin{aligned} C_b &= 0.40 \text{ to } 0.45 \\ C_p &= 0.55 \text{ to } 0.60 \\ C_m &= 0.65 \text{ to } 0.85 \\ C_w &= 0.09 + 1.07 \cdot C_p \end{aligned} \tag{3.8}$$

In addition, a list of C_b, C_p, and C_m coefficients for fishing vessels are included in Table 3.1 for guidance in preliminary design evaluation[38].

C_b	C_p	C_m
0.30	0.550	0.545
0.40	0.554	0.722
0.42	0.554	0.758
0.44	0.554	0.794
0.46	0.556	0.827
0.48	0.560	0.857
0.50	0.566	0.883
0.52	0.574	0.906
0.54	0.583	0.926
0.56	0.595	0.942
0.58	0.608	0.954
0.60	0.623	0.968
0.62	0.639	0.970
0.64	0.656	0.975
0.66	0.674	0.978
0.68	0.693	0.981
0.70	0.712	0.983
0.72	0.731	0.985
0.74	0.750	0.988
0.76	0.769	0.988
0.78	0.788	0.990

Table 3.1 Coefficients of form for fishing vessels

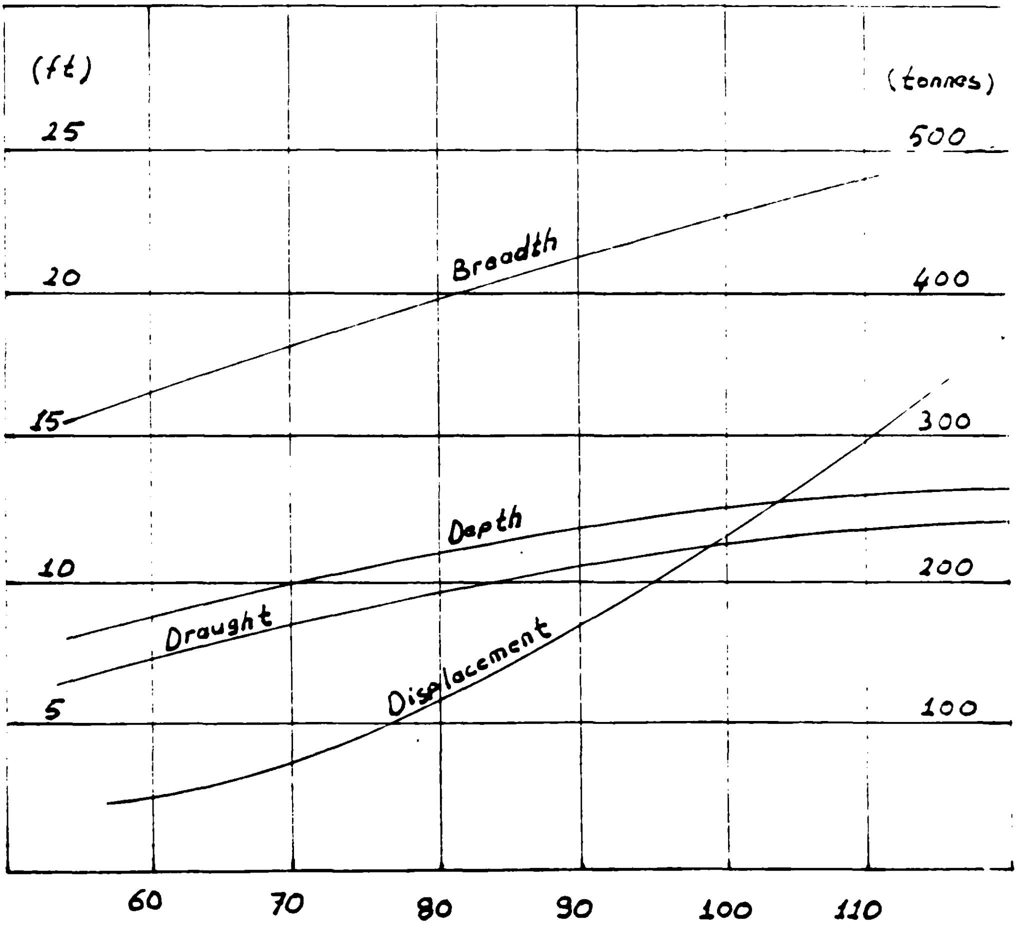


Figure 3.9 Length, breadth, depth and displacement relationship [50]

3.2.2.2 Method 2

To evaluate the main dimensions, the following numerical values are established from the list of similar vessels:

L_{WL}/B_{WL}
B_{WL}/T
B_{WL}/D
C_b

Knowing the displacement volume, ∇, it can be written:

$L_{WL}/B_{WL}=a_1$

$B_{WL}/T=a_2$
$B_{WL}/D=a_3$

$L_{WL}=a_1 x B_{WL}$
$T=B_{WL}/a_2$
$D=B_{WL}/a_3$

$\nabla=C_b x L_{WL} x B_{WL} x T$
$\nabla=C_b x a_1 x B_{WL} x B_{WL} x B_{WL}/a_2$

$$B_{WL}=\sqrt[3]{\frac{a_2\times\nabla}{a_1\times C_b}} \qquad (3.9)$$

The other dimensions are then calculated from the above equations.

3.2.3 GROUP MASSES

3.2.3.1 Hull Weight

For steel fishing vessels[50]:

$$W_{hull} = C_s \cdot N \text{ (tonnes)} \tag{3.10}$$

$$C_s = \frac{0.24}{1.3^{LogN}} \cdot \left[1 + \tfrac{2}{3}(C_b - 0.5)\right] \cdot \left[1 + 0.4 \cdot l_{ss} / L\right]$$
$$l_{ss} \cong (0.10 \text{to} 0.15) \cdot L \tag{3.11}$$

This formula gives a useful check on the actual approach taken for the evaluation of steel mass in this thesis.

For wooden fishing vessels[50]:

$$W_{hull} = 0.072 \cdot N \text{ (tonnes)} \tag{3.12}$$

Where, Cubic Number N=LBD (m^3), and l_{ss} is the length of superstructure

3.2.3.2 Weight of Equipment and Deck Machinery

For such fishing vessels as trawler and seiner deck machinery and equipment weight may be estimated as a function of cubic number[50]

$$W_E = C_E \cdot N$$
$$C_E \cong 0.00173 \cdot N \cdot \sqrt{N + 100} \tag{3.13}$$

3.2.3.3 Weight of Fishing Gear

Even though fishing gear weight may vary depending upon the type of gear and type of vessel, it can be estimated approximately by the empirical formula given below[50];

$$W_{f_g} \cong 0.065 N^{0.6} \tag{3.14}$$

3.2.3.4 Weight of Main Machinery

Admiralty coefficient is defined by the equation below:

$$C = \frac{\Delta^{2/3}.V^{3}}{BHP} \cong (100\,\text{to}\,110) \qquad (3.15)$$

Having chosen the Admiralty coefficient and knowing the displacement and the speed the required engine power and machinery weight can be computed from the following formulas[50].

$$W_{m} \cong \frac{20}{\text{LogBHP}} \cdot \frac{BHP}{n} \qquad (3.16)$$

BHP=Brake Horse Power
n=Rev/Min

3.2.3.5 Weight of Auxiliary Machinery[50]

$$W_{aux} = 0.0018 \times N^{1.32} \qquad (3.17)$$

3.2.3.6 Weight of Outfitting[50]

$$W_{out} \cong 0.025 \times N \qquad (3.18)$$

3.2.3.7 Weight of Fuel

For preliminary purposes a consumption of 0.19kg/HP/hr may be estimated for diesel installations of small fishing vessels.

$$W_{fuel} = 0.0046 \times BHP \times n \ \text{(tonne)} \qquad (3.19)$$

n= Number of days of steaming

3.2.3.8 Weight of Fish & Ice

To compare fishing vessels of various sizes and obtain figures enabling an approximation of displacement for design purposes, it is logical to use fish hold capacity as the principal factor influencing the size of the vessel. The hold capacity is related to the displacement and this ratio is assumed to remain constant for a particular type and size ranges of fishing vessels. That ratio is expressed by: V_{fh}/Δ (m^3/t). The range for this ratio is generally[38];

$$V_{fh} / \Delta = (0.55 \text{ to } 0.75)(m^3 / \text{tonne}) \qquad (3.20)$$

In Table 3.2, some examples of fish hold-displacement ratio values are presented in relation to size and type of vessel

Weight of fish is related to the fish hold capacity by means of stowage factor

$$W_{fish} = C_s \times V_{fh} \qquad (3.21)$$

Where C_s is the stowage factor (t / m^3), which is dependant on fish type and size, stowage method adopted. Approximate stowage factors for preliminary calculations may be as follows[38]:

Fresh fish on ice in bulk	0.50 (t/m^3)
Fresh fish on ice in shelves	0.30 (t/m^3)
Fresh fish on ice in boxes	0.25 (t/m^3)
Frozen tuna in bulk	0.60 (t/m^3)
Refrigerated sea water	0.75 (t/m^3)

Ice weight can be taken to be 50 % of fish weight for non tropical climate conditions.

Type of vessel	Dimensions L_{OA}/L_{WL}xBxD	V_{fh}/Δ
Shrimp trawler/wood	9.76/8.58x3.9x1.27	0.508
Fishing boat/wood	9.76/8.89x2.9x1.26	0.56
Shrimp trawler/wood	10.98/10.13x3.5x1.64	0.55
Trawler/wood	11.63/10.71x3.66x1.64	0.565
Fishing boat/wood	12.8/11.7x3.96x1.96	0.23
Trawler/wood	13/12x3.8x1.75	0.63
Stern trawler/wood	15.95/14.61x3.98x2.05	0.84
Purse seiner/wood	16/14.85x4.7x2.5	0.463
Trawler/wood	18.48/16.16x5.6x2.2	0.38
Trawler/wood	20.1/18.15x6.1x2.44	0.26
Stern trawler/steel	25.9/23.2x6.86x3.73	0.538
Catcher boat/wood	/8.00x2.06x0.86	0.46
Mothership/wood	/16.00x3.4x1.6	0.44
Tuna longliner/wood	/10.85x4.37x2.09	0.568 light cond. 0.353 full load cond.
Tuna longliner/steel	/19.85x4.50x1.89	0.646 light cond. 0.408 full load cond.
Tuna longliner/steel	/72.8x12.8x5.7	0.178 light cond. 0.69 full load cond.

Table 3.2 Examples of V_{fh}/Δ values[38]

3.2.3.9 Weight of provisions

It may be assumed to be 5kg/person/day

3.2.3.10 Weight of Fresh Water

It may be assumed to be 10kg/person/day

3.2.3.11 Weight of Crew

It may be assumed to be 100kg/person with effects

3.3 DISPLACEMENT-WEIGHT EQUATIONS

The buoyancy criteria requires that the sum of weights should be equal to the displacement defined by the designer. It is common practice to split the displacement into two main components; light ship weight (W_{1sh}) and dead weight (W_d).

$$\Delta = W_{1sh} + W_d \qquad (3.22)$$

In various loading conditions, the total dead weight of the vessel comprises:

- –Weight of crew and its effect (W_{crew}) which is largely constant
- –Weight of fishing gear (W_{fg}) also a constant figure
- –Weight of fresh water (W_{fw})
- –Weight of fuel and lubricating oil (W_{flo})
- –Weight of ice (W_{ice})
- –Weight of fish (W_{fish})
- –Weight of provisions (W_{prv})

In the form of an equation;

$$W_d=W_{crew}+W_{fg}+(W_{fw}+W_{flo}+W_{ice}+W_{fish}+W_{prv}) \qquad (3.23)$$

The weights in brackets vary in quantity during the operation of the vessel as before reaching the fishing grounds part of fresh the water, provisions, fuel and lubricating oil and ice are consumed, the consumption continuing during the fishing operation and on the way back to harbour. In the mean time the hold is partially or fully loaded with fish during the fishing trip and it is therefore necessary to ascertain some characteristic load conditions for calculating purposes: These conditions are, ~~the~~ at most, the following:

- –Leaving for fishing grounds
- –Arriving at the fishing grounds
- –Leaving fishing grounds
- –Arriving at port.

The maximum weight among these four typical conditions is used to define the maximum displacement (and the maximum draught) with the corresponding minimum freeboard.In practical operation, the probability that the fish hold will be fully loaded with fish at the assumed point of "leaving fishing grounds" is not very high. For small fishing vessels it is therefore customary to base the first design concept on an assumed "half load displacement" which corresponds to weight of light ship plus weight of crew with effects plus weight of fishing gear plus 1/2(weight of fresh water, weight of provisions, weight of fuel and lubricating oil, weight of ice and fish). In other words, It is assumed that the consumables have been 50 % utilized and that the amount of fish corresponds to the hold being filled to 50 % of its capacity. in form of an equation;

$$\Delta 1/2\text{load}=W_{lsh}+W_{crew}+W_{fg}+1/2(W_{fw}+W_{flo}+W_{ice}+W_{fish}+W_{prv}) \qquad (3.24)$$

This equation cannot be solved in an exact analytical way. It is therefore necessary to apply certain approximate methods. Using the formulas 3.10 to 3.19, the equation 3.24 can be converted into a form ~~of displacement dependant only~~ dependant only on displacement as shown below:

$$Ax\Delta^{2/3}-\Delta+B=0 \qquad (3.25)$$

Where A and B are the constants

Then by an appropriate numerical technique (i.e. Newton-Raphson) the above equation can be solved.

CHAPTER 4

ANALYSIS OF EXISTING TURKISH DESIGNS

On the basis of the data collected from the Sürmene Shipyard, the existing design of Turkish Black Sea fishing vessels has been analysed.

4.1 Parent vessel

A fishing vessel has been chosen to be a representative one of the existing design. The offset table and the corresponding body plans of this parent vessel are presented in Table 4.1 and Figure 4.1.

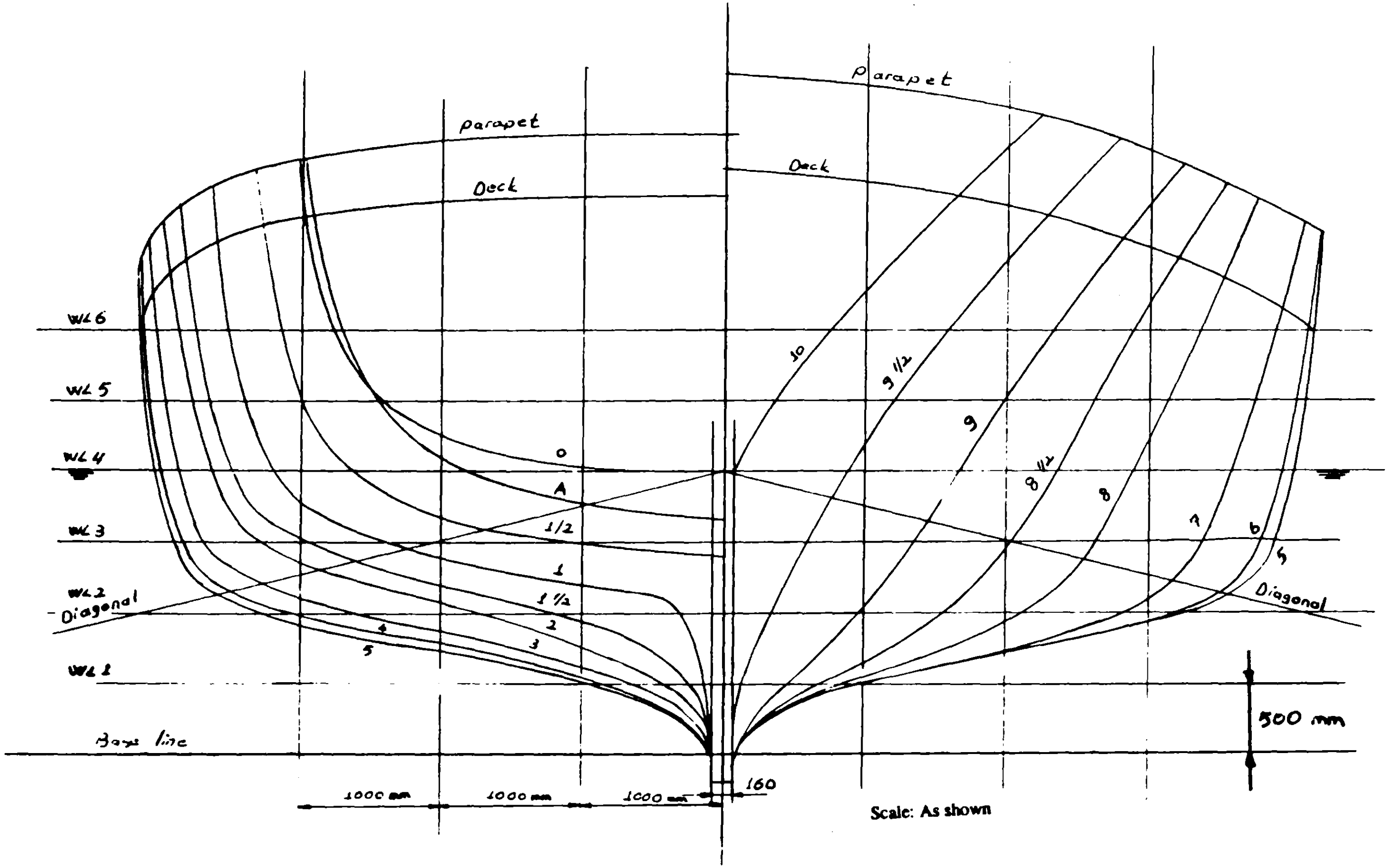
Main particulars of the parent vessel are as follows:

Length over all	L_{OA}=30m
Length water line	L_{WL}=27m
Length between perpendicular	L_{BP}=26.02m
Beam water line	B_{WL}=7.92m
Beam moulded	B=8.25m
Displacement to DWL, 2.00 m draught	Δ=197.3 tonnes
Main engine	BHP=550 HP
Midship is taken a midlength of L_{WL}	
Depth	D=3.00m

SECTION	HALF BREADTHS (mm)							
NO	WL1	WL2	WL3	WL4	WL5	WL6	DECK	PARAPET
A	-	-	-	-	2460	2970	2910	2950
0	-	-	-	0	2430	2760	2960	3030
1/2	-	-	1000	2560	3010	3150	3290	3350
1	120	300	2350	3150	3400	3500	3600	3650
1 1/2	240	1190	2950	3475	3650	3750	3830	3880
2	450	1750	3280	3650	3800	3880	3950	4000
3	660	2580	3700	3880	3980	4040	4050	4110
4	850	3050	3850	3990	4070	4130	4130	4200
5	980	3250	3900	4030	4100	4140	4140	4200
6	1010	3170	3800	3950	4040	4110	4110	4200
7	1010	2810	3390	3600	3750	3890	3930	4080
8	850	2130	2640	2910	3150	3360	3510	3780
8 1/2	690	1560	2060	2360	2630	2910	3200	3540
9	460	950	1350	1680	1980	2330	2800	3230
9 1/2	160	350	600	900	1200	1560	2280	2780
10	-	-	-	-	360	740	1880	2260

Distance (mm)	WL1	WL2	WL3	WL4	WL5	WL6
BOW (From Sec.9)	1610	1950	2330	2700	3080	3500
STERN (From Sec.1)	430	450	1880	2700	2810	2930

Table 4.1 Offset table of the parent vessel



Scale: As shown

Figure 4.1 Body plan of the parent vessel

4.2 Estimation of steel weight

In this paragraph, two ways of estimating of the steel weight are presented and a comparison between the results of those methods is made.

1) Rough estimation (based on the data collected from Sürmene Shipyard)
2) Builder's estimation (based on builder's experience)

4.2.1.Rough estimation

An overall estimate of steel weight has been made by knowing the total amount of steel consumed in a year and the number of vessels produced.

In 1986, six fishing vessels were built in Sürmene Shipyard and 445 tonnes steel (invoiced weight) was used up. It has been assumed that 3% of this amount was scrap, so net steel weight was 432 tonnes.

It has been assumed that weight is proportional to deck area and hence $(L \times B)$. Thus the calculation procedure simply consists of evaluating $L \times B$ for each vessel and dividing by the sum. This gives the proportion of total material "c" used by each vessel. Multiplication of the proportion "c" by the total amount of steel consumed in the year gives the steel weight for each vessel, which is donated as W_1. The process is illustrated in Table 4.2.

4.2.2 Builder's estimation

However, the builder's estimation of plate weight is rather different. He again uses the deck area concept as a base but includes the specific gravity of steel and the plate thickness "t". They assume that the total plate area is three times the deck area. So plate weight can be written as:

$$W_p = (L \times B) \times t \times \gamma \times 3 \qquad (4.1)$$

In the above formula, W_p is the plate weight in tonnes, γ is the specific weight of steel (7.8t/m^3), t is the plate thickness in meters, which can be taken as 0.008m an average. Thus this equation becomes

$$W_p = 0.192(L \times B) \qquad (4.2)$$

Stiffening is with angle bars. The weight of stiffeners can be taken as a percentage of plate weight. For fishing vessels, it may be assumed to be 40% (W_{stif}=0.40W_p). So steel weight of the hull will be:

$$W_{hull} = W_p + W_{stiff}$$

$$W_{hull} = 1.4W_p \qquad (4.3)$$

Substituting equation (4.2) and (4.3):

$$W_{hull} = 0.269(L \times B) \qquad (4.4)$$

It has been estimated that superstructure weight is approximately 20% of hull weight (W_{ss}=0.20W_{hull}).

Thus:

$$W_{ss} = 0.054(L \times B) \qquad (4.5)$$

So total steel weight will be the sum of hull weight and superstructure weight, which is represented by W_2.

$$W_2 = W_{hull} + W_{ss} \qquad (4.6)$$

Substituting (4.4) and (4.5) into (4.6) we arrive at the total steel weight as:

$$W_2 = 0.323(L \times B) \qquad (4.7)$$

Where W_2 is in tonnes, L and B are in meters.

The results of the above formula for a range of length are shown in Table 4.2. As can be seen from this table, the results of W_1 and W_2 show a good agreement with each others.

The conclusion that may be drawn from the equation (4.7) is that steel weight is directly proportional to the product of L and B.

For comparison, steel weight can be expressed as a function of overall length of vessel. Using the data values in Table 4.2, the weights have been plotted against lengths in Figure 4.2.and an exponential curve has been fitted to the points.

It should be mentioned however, that the validity of Figure 4.2 and related formulas are valid only for lengths of 25 to 32 meters.

L (m)	B (m) (m)	LxB (m^2)	c=(LxB)/1355	W1=cx432 (tonnes)	W2=0.323(LxB) (tonnes)
25	7	175	0.129	55.73	56.53
26	7	182	0.134	57.89	58.79
27	8	216	0.159	68.69	69.77
28	8	224	0.165	71.28	72.35
30	9	270	0.199	85.97	87.21
32	9	288	0.213	92.02	93.02
Total		1355	1.000	431.57	437.67

W1=Rough estimation
W2=Builder's estimation

Table 4.2 Estimation of steel weight

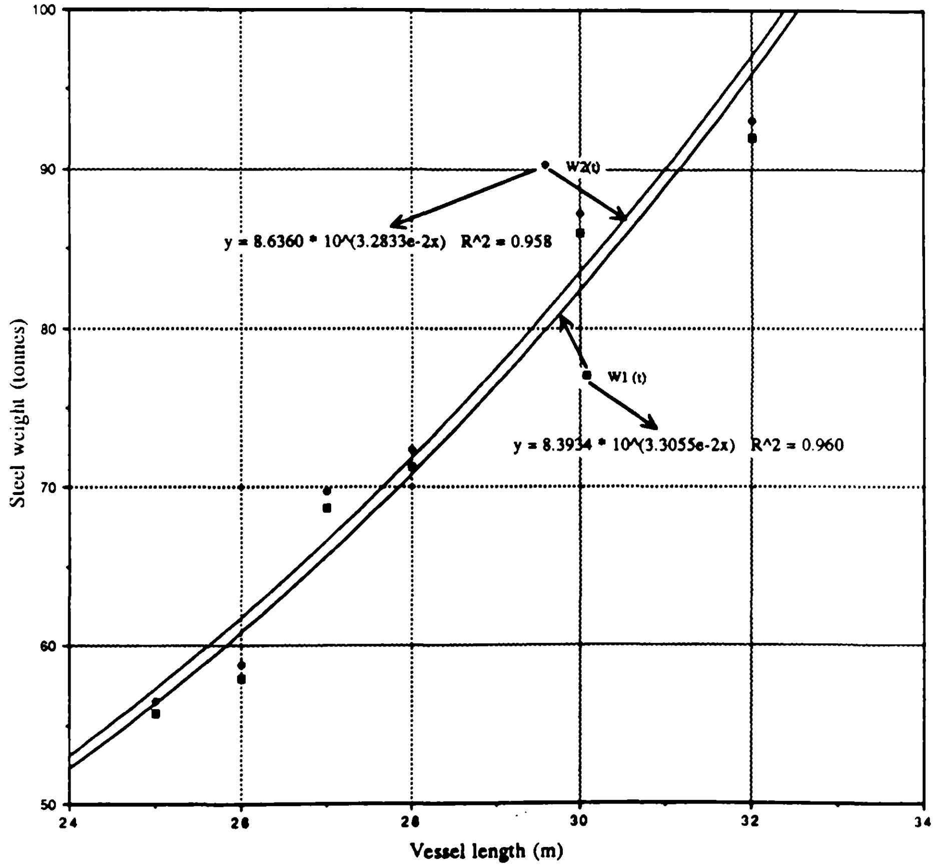


Figure 4.2 Steel weight estimation of Black Sea fishing vessels

4.3 Hydrostatic and stability characteristics

A representative fishing vessel of the existing design has been chosen and corresponding lines plan have been produced. The origin of the hull form came from one of the seining/trawling fishing vessel designed by traditional method in Sürmene Shipyard. The sizes of this particular type of fishing vessels may vary from 20 meters to 32 meters. By using the "WOLFSON UNIT" computer suite, which is available in the Department of NA&Ocean Eng., the hydrostatic and stability characteristics of the parent vessel have been determined. Values of these characteristics are presented in the form of tables (Table 4.3 and Table 4.4).

WL (m)	MLD DISP (tonnes)	FULL DISP (tonnes)	LCB (m)	LCF (m)	VCB (m)	TPC (Tonnes/cm)	WSA (m^2)
1.400	96.635	98.073	0.595	-0.271	0.977	1.472	175.318
1.425	100.341	101.800	0.562	-0.348	0.993	1.492	177.863
1.450	104.107	105.588	0.527	-0.446	1.009	1.515	180.681
1.475	107.924	109.426	0.491	-0.518	1.025	1.535	183.180
1.500	111.788	113.310	0.455	-0.583	1.041	1.553	185.596
1.525	115.695	117.236	0.419	-0.641	1.057	1.570	187.909
1.550	119.642	121.202	0.383	-0.693	1.072	1.587	190.148
1.575	123.629	125.206	0.347	-0.740	1.088	1.602	192.326
1.600	127.653	129.247	0.312	-0.777	1.104	1.616	194.368
1.625	131.709	133.319	0.278	-0.808	1.120	1.629	196.324
1.650	135.794	137.420	0.245	-0.836	1.135	1.642	198.225
1.675	139.909	141.549	0.213	-0.860	1.151	1.653	200.068
1.700	144.053	145.708	0.182	0.880	1.166	1.664	201.851
1.725	148.225	149.894	0.152	-0.897	1.182	1.674	203.576
1.750	152.425	154.108	0.123	-0.910	1.197	1.683	205.241
1.775	156.650	158.346	0.095	-0.919	1.212	1.691	206.856
1.800	160.894	162.603	0.068	-0.927	1.227	1.700	208.447
1.825	165.157	166.880	0.042	-0.933	1.242	1.707	210.018
1.850	169.438	171.173	0.017	-0.938	1.357	1.715	211.574
1.875	173.738	175.485	-0.005	-0.943	1.272	1.722	231.112
1.900	178.054	179.814	-0.028	-0.946	1.287	1.729	214.641
1.925	182.386	184.159	-0.050	-0.948	1.302	1.736	216.160
1.950	186.736	188.521	-0.071	-0.950	1.317	1.743	217.667
1.975	191.101	192.898	-0.091	-0.951	1.331	1.749	219.163
2.000	195.482	197.292	-0.110	-0.951	1.346	1.756	220.638
2.025	199.889	201.716	-0.129	-0.993	1.361	1.768	222.710
2.050	204.322	206.163	-0.149	-1.017	1.376	1.777	224.519
2.075	208.776	210.631	-0.167	-1.034	1.390	1.786	226.239
2.100	213.250	215.118	-0.186	-1.044	1.405	1.793	227.871
2.125	217.742	219.623	-0.203	-1.048	1.419	1.800	229.419
2.150	222.251	224.145	-0.221	-1.052	1.434	1.806	230.953
2.175	226.774	228.680	-0.237	-1.056	1.449	1.812	232.495
2.200	231.312	233.231	-0.252	-1.058	1.463	1.819	234.023
2.225	235.864	237.796	-0.269	-1.060	1.477	1.824	235.537
2.250	240.432	242.376	-0.284	-1.060	1.492	1.830	237.036
2.275	245.015	246.971	-0.298	-1.060	1.506	1.836	238.520
2.300	249.611	251.579	-0.312	-1.058	1.521	1.841	239.990
2.325	254.221	256.201	0.326	-1.055	1.535	1.846	241.447
2.350	258.845	260.837	-0.339	-1.051	1.549	1.850	242.891
2.375	263.482	265.486	-0.351	-1.046	1.563	1.855	244.322
2.400	268.130	270.146	-0.363	-1.042	1.578	1.860	245.758

WL (m)	BMT (m)	GMT (m)	BML (m)	MCT (tm/cm)	CB	CP	CM	CW
1.400	5.602	3.869	54.661	1.894	0.302	0.646	0.468	0.645
1.425	5.512	3.795	54.437	1.959	0.308	0.648	0.476	0.654
1.450	5.425	3.724	54.567	2.038	0.314	0.650	0.484	0.664
1.475	5.339	3.654	54.252	2.101	0.320	0.652	0.491	0.672
1.500	5.255	3.586	53.850	2.160	0.326	0.654	0.499	0.681
1.525	5.170	3.517	53.359	2.215	0.332	0.657	0.506	0.688
1.550	5.089	3.452	52.805	2.267	0.338	0.659	0.513	0.695
1.575	5.010	3.389	52.207	2.316	0.344	0.662	0.520	0.702
1.600	4.932	3.327	51.496	2.358	0.349	0.664	0.526	0.708
1.625	4.855	3.266	50.740	2.397	0.355	0.666	0.533	0.714
1.650	4.780	3.206	49.969	2.433	0.360	0.669	0.539	0.719
1.675	4.707	3.148	49.183	2.467	0.366	0.671	0.545	0.724
1.700	4.633	3.090	48.384	2.499	0.371	0.674	0.551	0.729
1.725	4.560	3.032	47.575	2.527	0.376	0.676	0.557	0.733
1.750	4.486	2.974	46.756	2.554	0.381	0.678	0.562	0.737
1.775	4.413	2.916	45.937	2.578	0.387	0.680	0.568	0.741
1.800	4.342	2.860	45.138	2.601	0.391	0.683	0.574	0.745
1.825	4.272	2.805	44.361	2.623	0.396	0.685	0.579	0.748
1.850	4.204	2.752	43.608	2.645	0.401	0.687	0.584	0.751
1.875	4.138	2.700	42.874	2.666	0.406	0.689	0.589	0.754
1.900	4.074	2.652	42.162	2.686	0.410	0.691	0.594	0.758
1.925	4.013	2.605	41.473	2.706	0.415	0.693	0.599	0.761
1.950	3.953	2.560	40.803	2.725	0.419	0.695	0.604	0.764
1.975	3.895	2.517	40.152	2.744	0.424	0.697	0.608	0.766
2.000	3.838	2.475	39.518	2.762	0.428	0.698	0.613	0.769
2.025	3.784	2.435	39.372	2.815	0.432	0.700	0.617	0.774
2.050	3.731	2.397	39.027	2.852	0.437	0.702	0.622	0.779
2.075	3.680	2.360	38.624	2.884	0.441	0.704	0.626	0.782
2.100	3.630	2.325	38.167	2.911	0.445	0.706	0.630	0.786
2.125	3.580	2.290	37.663	2.933	0.449	0.708	0.634	0.789
2.150	3.532	2.257	37.167	2.954	0.453	0.709	0.638	0.791
2.175	3.486	2.225	36.693	2.976	0.457	0.711	0.642	0.794
2.200	3.440	2.194	36.226	2.996	0.461	0.713	0.646	0.797
2.225	3.396	2.164	35.764	3.016	0.464	0.714	0.650	0.799
2.250	3.353	2.135	35.307	3.035	0.468	0.716	0.654	0.802
2.275	3.310	2.107	34.855	3.053	0.472	0.718	0.657	0.804
2.300	3.268	2.079	34.407	3.071	0.475	0.719	0.661	0.806
2.325	3.227	2.052	33.965	3.087	0.479	0.721	0.664	0.809
2.350	3.186	2.026	33.529	3.103	0.482	0.722	0.668	0.811
2.375	3.147	2.001	33.098	3.118	0.486	0.724	0.671	0.813
2.400	3.108	1.976	32.683	3.133	0.489	0.725	0.675	0.815

Table 4.4 Hydrostatic characteristics of parent vessel

4.4 Resistance and propulsion

A model of the parent vessel has been built on the basis of the offset table presented in Table 4.3. The scale of the model is 1/12.5. The model has been run in the tank of Department of Naval Architecture and Ocean Eng. of Glasgow University at various speeds and corresponding resistance values (total drag) measured. These figures are shown in ~~the below~~ Table. 4.5

Model speed (m/s)	Model resistance (Kg)
0.50	0.0549
0.75	0.1917
1.00	0.3294
1.25	0.6589
1.50	1.5374
1.75	2.7173
2.00	5.6004
2.25	8.5601
2.50	9.5516

Table 4.5 Resistance values of the ~~parent~~ model vessel

On the basis of the above information, the coefficients of the resistance components for the model and full size vessel have been calculated to compute the effective power required for the parent vessel. These values are presented in Table 4.6 and Table 4.7. based on the ITTC skin friction line.

MODEL						
Speed (m/s)	Resist. (kg)	Resist. (N)	Re	Ct	Cf	Cr
0.50	0.0549	0.539	948000	0.0030505	0.0047423	-0.0016919
0.75	0.1917	1.881	1422000	0.0047340	0.0043487	0.0003853
1.00	0.3294	3.231	1896000	0.0045757	0.0040984	0.0004773
1.25	0.6589	6.464	2371000	0.0058578	0.0039185	0.0019393
1.50	1.5374	15.082	2845000	0.0094915	0.0037805	0.0057111
1.75	2.7173	26.657	3319000	0.0123252	0.0036694	0.0086558
2.00	5.6004	54.940	3793000	0.0194487	0.0035770	0.0158717
2.25	8.5601	83.975	4267000	0.0234880	0.0034985	0.0199895
2.50	9.5516	93.701	4741000	0.0212289	0.0034303	0.0177986

Table 4.6 Resistance particulars for the model

VESSEL						
Speed (m/s)	Re	Cf	Cr	Ct	Resist. (kN)	Power (kW)
1.7681	40227000	0.0023877	-0.0016919	0.0006959	0.2460	0.43
2.6522	60227000	0.0022451	0.0003853	0.0026305	2.0924	5.55
3.5363	80455000	0.0021505	0.0004773	0.0026278	3.7161	13.14
4.4203	100455000	0.0020820	0.0019393	0.0040212	8.8850	39.27
5.3044	120455000	0.0020283	0.0057111	0.0077394	24.6248	130.62
6.1884	140682000	0.0019841	0.0086558	0.0106399	46.0775	285.15
7.0725	160682000	0.0019473	0.0158717	0.0178190	100.7915	712.85
7.9566	180682000	0.0019158	0.0199895	0.0219053	156.8188	1247.74
8.8406	200909000	0.0018878	0.0177986	0.0196865	173.9902	1538.18

Table 4.7 Resistance particulars for the full size vessel

In Figure 4.3, the effective horse power for the parent vessel calculated in Table 4.7 has been plotted against speed (knots) along with the power curve of Model 149A[4] for comparison purpose. The Model 149A of 75 ft.(22.86m), 100 ton, 10 knot was designed from a hydrodynamic point of view, incorporating a bulbous bow, 2-bladed propeller, and steerable nozzle which replaces the rudder. Tests of this model showed exceptionally low resistance, exceptionally high propulsive efficiency, and a high efficiency when trawling. Test results were expanded to all sizes for ready comparison with existing vessel. To facilitate comparisons with existing vessel of all sizes, the effective powers and speeds for model 149A were plotted on a log-log basis versus displacement from 10 tons to 1,000 tons in Fig.4.4 to 4.6. Each figure refers to a different load condition, and secondary scales along the bottom show the waterline lengths, in feet and meters, for salt water.

Speed(Knots)	EHP
6.5	20
7.0	26
7.5	33
8.0	41
8.5	55
9.0	70
9.5	90
10.0	105
10.5	140
11.0	165
11.5	240
12.0	350
12.5	495
13.0	650
13.5	850

Table 4.8 Effective power values for Model 149A read off from Fig.4.6

For comparison, the power curve for Model 149A was evaluated from Fig.4.6, which most nearly fits the displacement and length of the parent vessel (197.3 ton, 27m). At this displacement and length (from the bottom scale) powers and speeds, which are shown in Table 4.8, were read off and plotted in Fig.4.3. As can be seen from this figure that effective powers of parent vessel and Model 149A show a good agreement with each other. Maximum difference between effective powers of these curves is round about 55HP (32%) and occurs around at 11knots speed. Outside of this speed the discrepancy between the two curves gets gradually smaller.

The required engine power has been calculated on the basis of the effective power curve (Fig.4.3) for a chosen free running speed of 10 knots with a single screw propeller. The propulsion calculations are demonstrated in Chapter 5. It has been found that the required engine power (350HP) is far below the engine power that the parent vessel has got already on board (550HP). It has also been found that the engine power for the Black Sea fishing vessels is relatively high in comparison to similar fishing vessels of the world. In Fig.4.7, curves of engine power for typical fishing vessels are shown. It generally may be said that there is a strong tendency among the Black Sea fishermen to increase the power in relation to size with not much respect to economy. The effect of variation of machinery size on the economy is dealt with in Chapter 6.

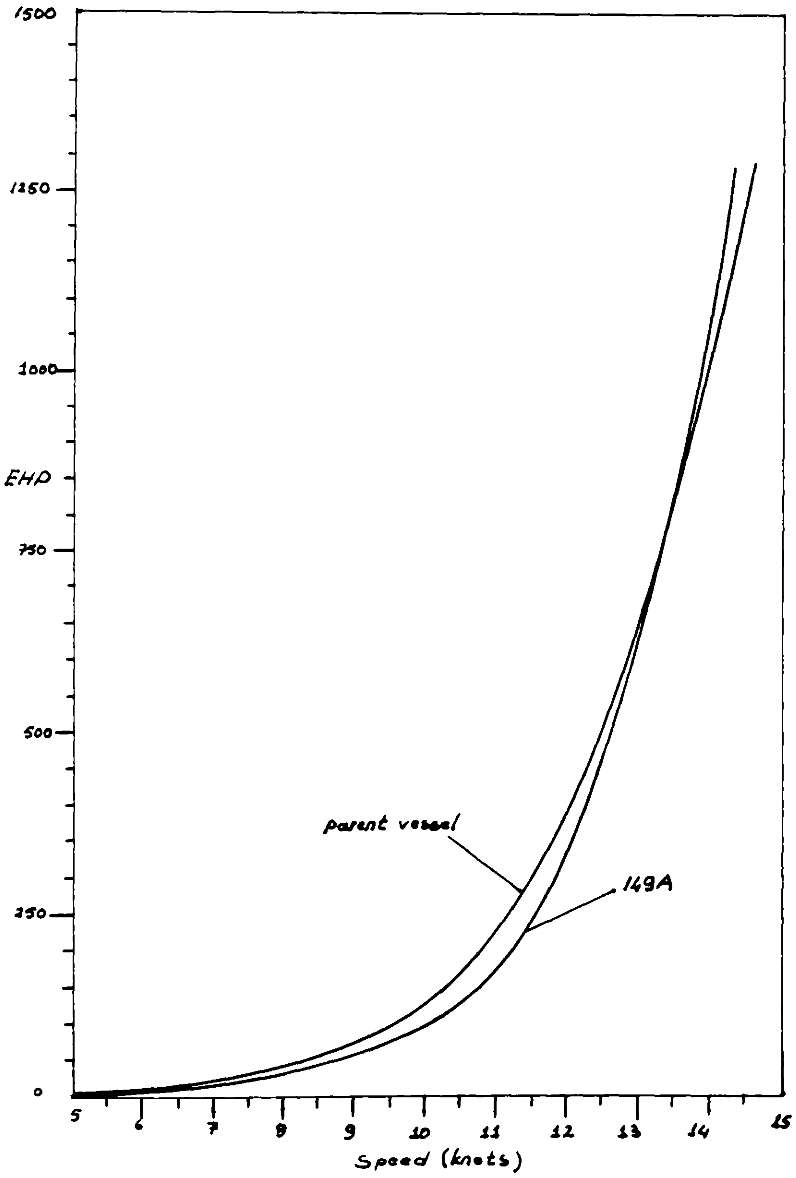


Figure 4.3 Effective power curves for parent vessel and Model 149A

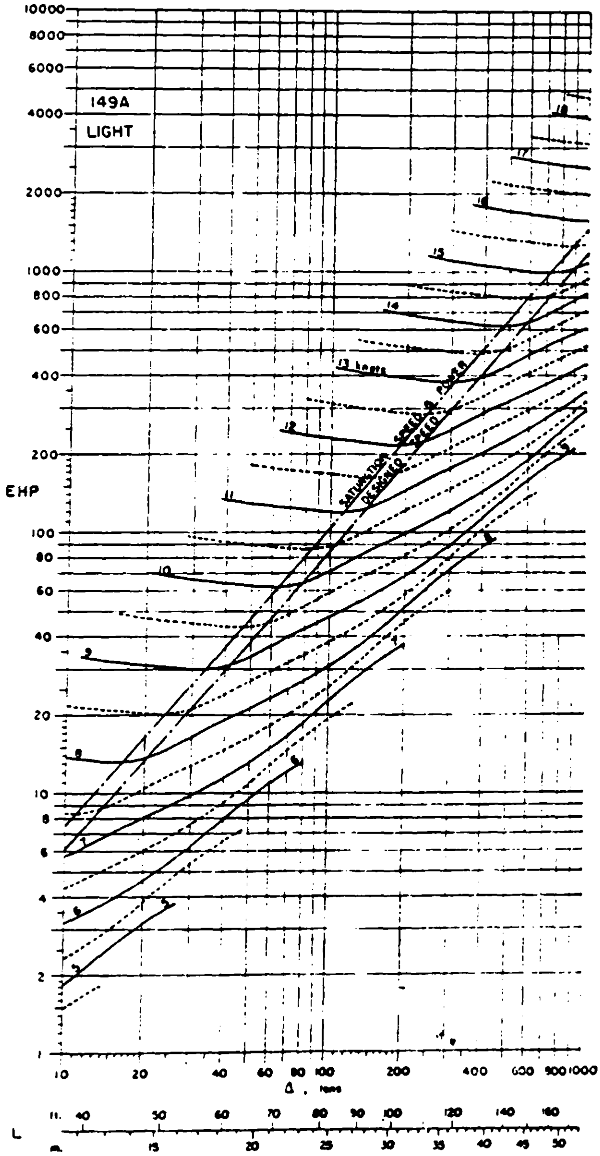


Fig.4.4 Effective power for Model 149A at even speeds in light condition

(Ref.: Fishing Boats of the World 2, P 357)

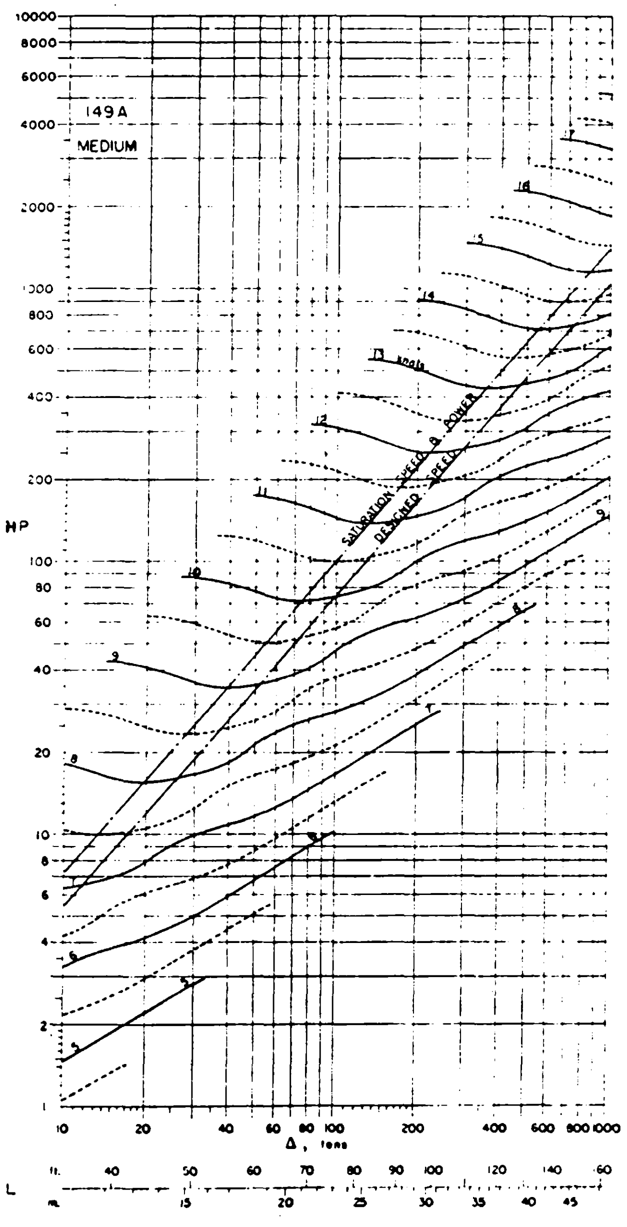


Fig.4.5 Effective power for Model 149A at even speeds in medium condition

(Ref.: Fishing Boats of the World 2, P 358)

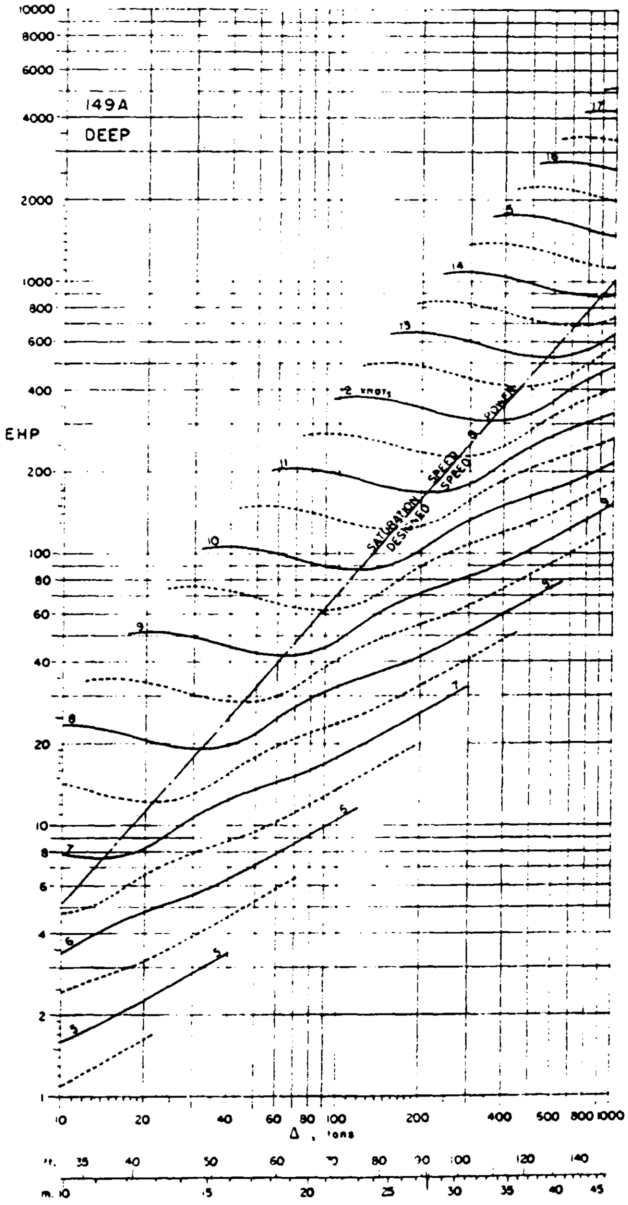


Fig.4.6 Effective power for Model 149A at even speeds in deep condition

(Ref.: Fishing Boats of the World 2, P 358)

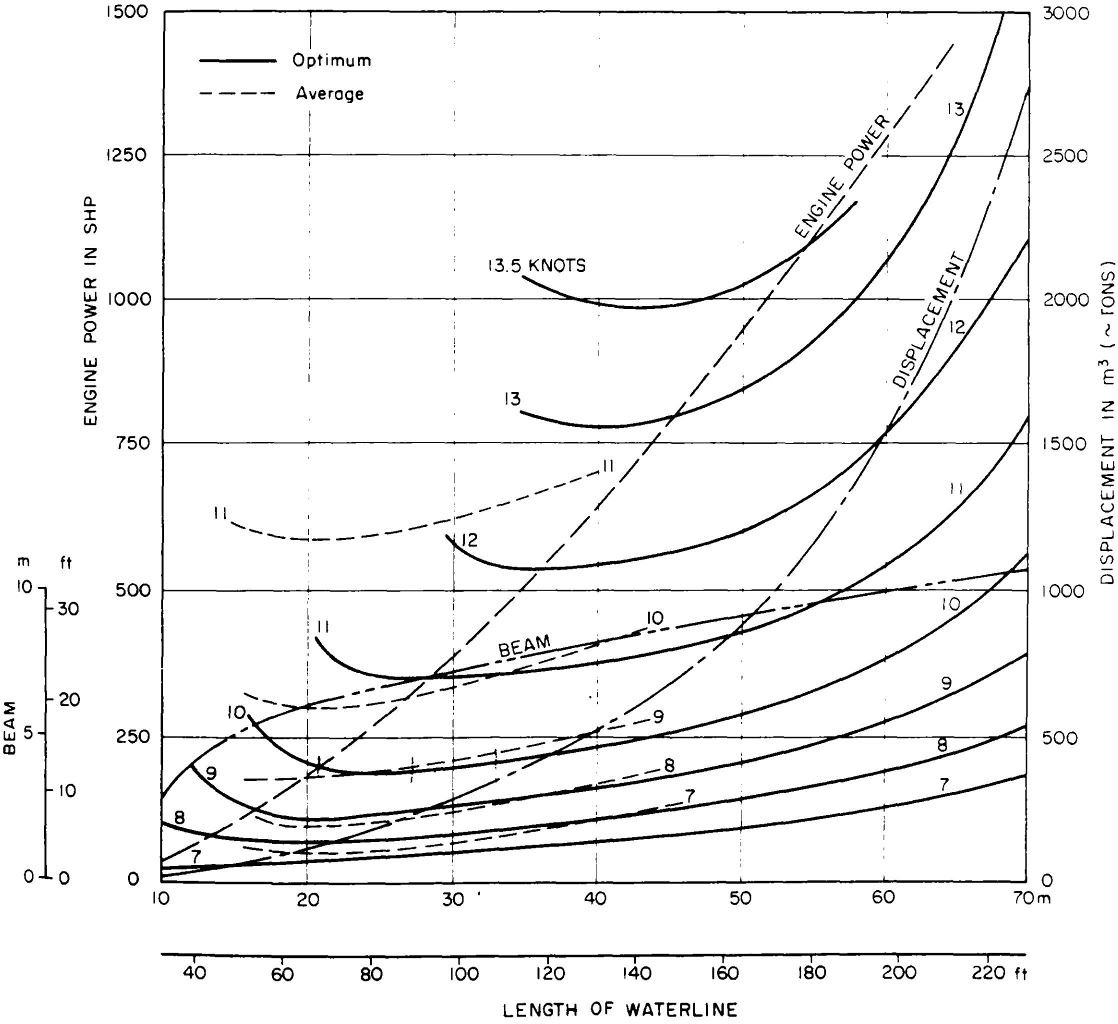


Figure 4.7 Curves of engine power for typical fishing vessels

(Ref.:FAO, Design of Small Fishing Vessels,Page 188)

CHAPTER 5

PROPOSED DESIGN OF THE BLACK SEA FISHING AND VARIATION OF SIZE OF THIS VESSEL

5.1 Variation of the vessel sizes and powering calculations

In this section, powering calculations of vessels of three different sizes are presented:

1) The 21m vessel
2) The 27m vessel (parent vessel)
3) The 33m vessel

The 21m vessel and the 33m vessel were evaluated from the parent vessel respectively, shortening and extending the length (fish hold length) of the parent vessel by 6 meters. Draught (2 meters) and speed (10 knots) were assumed the same for those three vessels.

Displacement, effective horse power and the midship section coefficient for the parent vessel are:

Δ_{27}=197.3 tonnes (from the hydrostatic table presented in Chapter 4)
P_E=135 HP (from Fig.4.3)
C_m=0.61 (same for all vessels since the midship section has not been subjected to any variation)

It is first necessary to work out the displacement and the effective horse power for the 21m vessel and the 33m vessel from the parent vessel. The decrement and the increment in displacement induced by shortening and extending the length of fish hold of the parent vessel can be calculated as:

$\pm\Delta \doteq A_m \times L_{fh} \times \rho$

Where

A_m is the midship section area $=C_m \times B \times T=0.61 \times 8 \times 2=9.76$ cm^2

L_{fh}= length of fish hold=6 meters

ρ=density of salt water=1.025 tonne/m^3

$\pm\Delta=9.76 \times 6 \times 1.025=60$ tonnes

Therefore;

$\Delta_{21}=\Delta_{27}-60=197.3-60=137.3$ tonnes

$\Delta_{33}=\Delta_{27}+60=197.3+60=257.3$ tonnes

Since power is proportional to $(\text{displacement})^{2/3}$ and $(\text{speed})^3$, and assuming the speed is constant, for the effective power it can be written:

$P_{E(21)}=135 \times (137.3/197.3)^{2/3}=106$ HP

$P_{E(33)}=135 \times (257.3/197.3)^{2/3}=161$ HP

5.2 Propeller selection

The following symbols and definitions are applicable to this section unless otherwise stated:

P_E=effective horse power; this is the power required to overcome the calculated total resistance at a certain speed.

P_D=delivered horse power; this is the power at the tail-end of the propeller shaft

P_S or SHP=shaft horse power; this is the power delivered to the propulsion shafting. It is the sum of power required to overcome the resistance of the vessel, the losses at the propeller and the losses in shaft bearings.

P_B or BHP=brake horse power; this denotes the power delivered at the engine coupling. It is greater than the SHP by any bearing and transmission losses.

V=ship speed

V_A=speed of advance=V(1-w)

w=Taylor wake fraction=$(V-V_A)/V$

t=thrust deduction factor

η_H=hull efficiency=(1-t)/(1-w)

η_O=open water propeller efficiency

η_R=relative rotative efficiency (this varies little from unity and in practice can be ignored)

η_S=shaft efficiency

η_D=quasi-propulsive coefficient=$\eta_H \times \eta_O \times \eta_R = P_E/P_D$

η_T=overall efficiency=$\eta_D \times \eta_S = P_E/P_B$

Very few of smaller fishing vessels have propellers specially designed for them. It is usual to fit stock propellers and the selection process involves determining the most appropriate propeller from those available.

Data for selection of optimum propeller variables are available in different forms of presentation resulting from systematic tests with families of model propellers in various research establishments throughout the world. These tests involve running propeller models of varying pitch ratio, blade area, number of blades and section shapes in open water in a towing tank over a range of slip from 0 to 100%, and measuring the required torque input and thrust produced. Many such series have been tested but the most often used data for propellers of smaller boats designed for the free running condition are those produced by the Netherlands Ship Model Basin (NSMB) between 1937 and 1964. These data are presented in the form of what are known as B_p-δ charts (Fig. 5.2). The Taylor propeller coefficients B_p and δ are given by:

$$B_p=(n\times P_D^{0.5})/(V_A^{2.5})$$

$$\delta=(n\times D)/V_A$$

Where,

n=propeller RPM

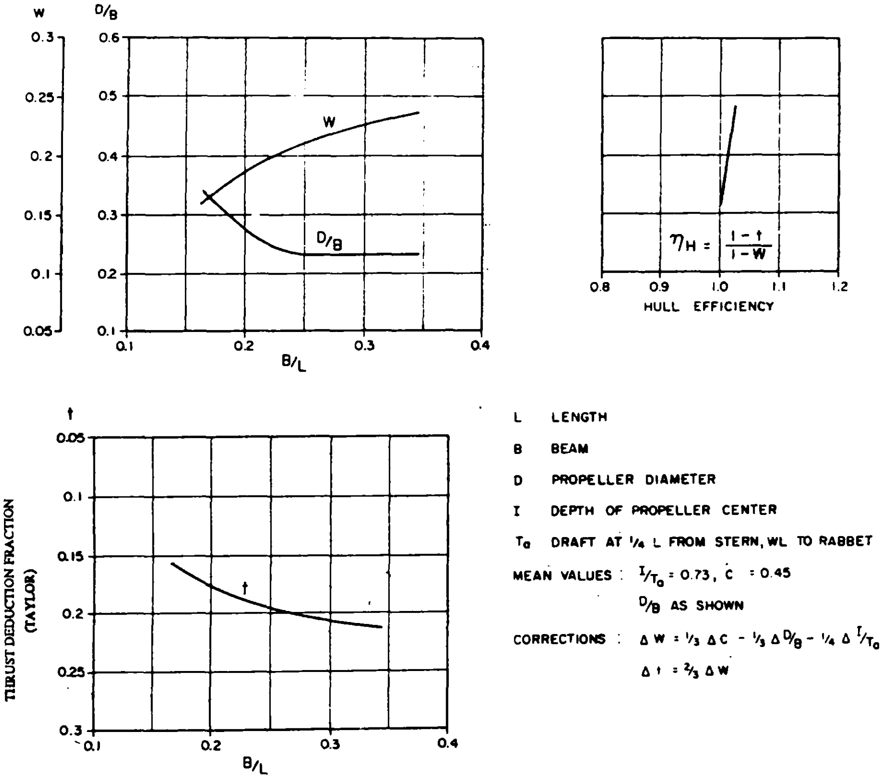
P_D=delivered horse power

V_A=speed of advance, knots

D=propeller diameter, feet

Speed (knots)	Disp=137.3 tonnes 21m vessel		Disp=197.3 tonnes 27m vessel		Disp=257.3 tonnes 33m vessel	
	PE (kW)	PB (kW)	PE (kW)	PB (kW)	PE (kW)	PB (kW)
7	12	29	15	38	18	46
8	24	59	30	76	36	92
9	47	115	60	151	72	185
10	79	194	100	252	120	308
11	135	331	170	428	203	521
12	228	559	290	731	346	888
13	385	944	490	1235	585	1501

Table 5.1 P_E and P_B values for the vessels of three different sizes



L LENGTH

B BEAM

D PROPELLER DIAMETER

I DEPTH OF PROPELLER CENTER

T_a DRAFT AT 1/4 L FROM STERN, WL TO RABBET

MEAN VALUES : $I/T_a = 0.73$, $C = 0.45$

D/B AS SHOWN

CORRECTIONS : $\Delta W = \frac{1}{3} \Delta C - \frac{1}{3} \Delta D/B - \frac{1}{4} \Delta I/T_a$

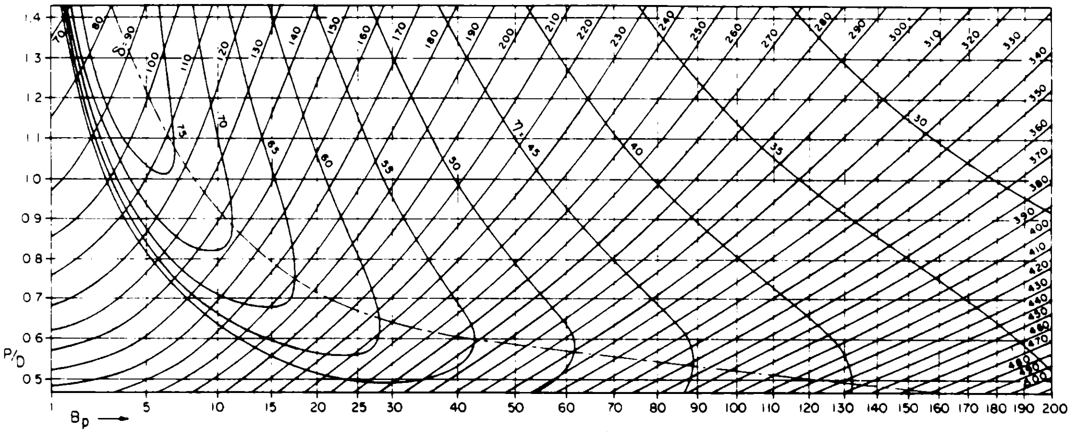
$\Delta t = \frac{2}{3} \Delta W$

Figure 5.1 Thrust deduction factor and hull efficiency for fishing vessels

(Ref.: FAO, Design of Small Fishing Vessels, 1985)

Type B 3 blades $\frac{A_f}{A_0} = 0.50$

$t_a/D = 0.05$ $d/D = 0.18$ P = pitch (constant)



Type B 4 blades $\frac{A_f}{A_0} = 0.55$

$t_a/D = 0.045$ $d/D = 0.167$ P = pitch at blade tip reduced 20% at root

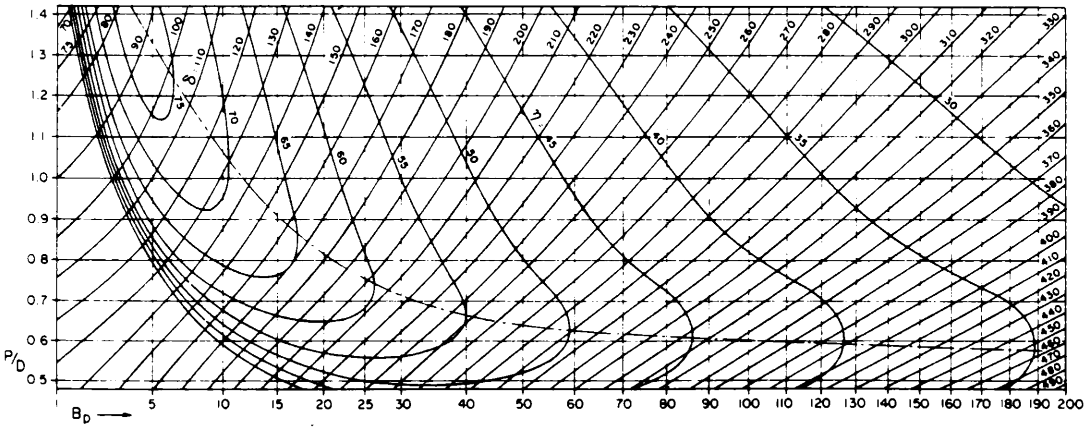


Figure 5.2 B_p-δ diagram for 3 and 4 bladed propellers

(Ref.: FAO, Design of Small Fishing Vessels, 1985)

Returning to our vessels, propeller selection procedure may be demonstrated as fellow:

1) The 21m vessel

$V=10$ knots
$L=21m$
$B=8m$
$B/L=0.379$
$t=0.215$ (from Fig.5.1)
$w=0.240$ (from Fig.5.1)
$\eta_H=(1-t)/(1-w)=(1-0.215)/(1-0.240)=1.033$
$V_A=V(1-w)=10\times(1-0.240)=7.60$ knots
$P_E=106$ HP (calculated in previous section)
Engine revolution=2100 RPM
Ratio=3:1
Propeller shaft revolution=700 RPM

$$\eta_D=\eta_H\times\eta_O\times\eta_R$$

First shot:

$\eta_D=1.033\times\mathbf{0.44}\times1=0.455$ (Assuming $\eta_O=0.44$)

$P_D=P_E/\eta_D=106/0.455=233$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times233^{0.5})/(7.6^{2.5})=67.10$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=67$ we read off: $\delta=310$ and $\eta_O=0.46$

Second shot:

$\eta_D=1.033\times\mathbf{0.46}\times1=0.475$

$P_D=P_E/\eta_D=106/0.475=223$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times223^{0.5})/(7.6^{2.5})=66$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=66$ we read off: $\delta=307$, $\eta_O=0.462$ and P/D=0.58 (Pitch-Diameter Ratio)

Third shot:

$\eta_D=1.033\times\mathbf{0.462}\times1=0.477$

$P_D=P_E/\eta_D=106/0.477=222$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times222^{0.5})/(7.6^{2.5})=65.5$ (accurate enough)

$D=(\delta\times V_A)/n=(307\times7.6)/700=3.333ft=39.998$in

$P=39.998\times0.58=23.199$in

The nearest stock size will probably be **40in×23in** or (1016mm×584mm).

Stock sizes are usually in one inch intervals up to 36in diameter and in two inch intervals above both diameter and pitch.

$\eta_T=\eta_D\times\eta_S=0.477\times0.95=0.453$
$P_B=P_E/\eta_T=106/0.453=234$ HP
Weather allowance:10%
BHP=234×1.10=257.4
BHP=257 HP

2) The 27m vessel

V=10 knots

L=27m

B=8m

B/L=0.295

t=0.207 (from Fig.5.1)

w=0.227 (from Fig.5.1)

$\eta_H=(1-t)/(1-w)=(1-0.207)/(1-0.227)=1.026$

$V_A=V(1-w)=10\times(1-0.227)=7.73$ knots

$P_E=135$ HP (From Fig.4.3)

Engine revolution=2100 RPM

Ratio=3:1

Propeller shaft revolution=700 RPM

$\eta_D=\eta_H\times\eta_O\times\eta_R$

First shot:

$\eta_D=1.026\times\mathbf{0.44}\times1=0.451$

$P_D=P_E/\eta_D=135/0.451=299$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times299^{0.5})/(7.73^{2.5})=72.86$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=73$ we read off: $\delta=320$ and $\eta_O=0.451$

Second shot:

$\eta_D=1.026\times\mathbf{0.451}\times1=0.463$

$P_D=P_E/\eta_D=135/0.463=292$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times 292^{0.5})/(7.73^{2.5})=71.95$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=72$ we read off: $\delta=317$, $\eta_O=0.452$ and $P/D=0.575$

Third shot:

$\eta_D=1.026\times\mathbf{0.452}\times 1=0.464$

$P_D=P_E/\eta_D=135/0.464=291$ HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times 291^{0.5})/(7.73^{2.5})=71.88$ (accurate enough)

$D=(\delta\times V_A)/n=(317\times 7.73)/700=3.501\text{ft}=42\text{in}$

$P=42\times 0.575=24.15\text{in}$

The nearest stock size will probably be **42in×24in** or (1067mm×610mm).

$\eta_T=\eta_D\times\eta_S=0.464\times 0.95=0.441$

$P_B=P_E/\eta_T=135/0.441=306$ HP

Weather allowance:10%

BHP=306×1.10=336.7

BHP=337 HP

3) The 33m vessel

V=10 knots

L=33m

B=8m

$B/L=0.241$

$t=0.190$ (from Fig.5.1)

$w=0.205$ (from Fig.5.1)

$\eta_H=(1-t)/(1-w)=(1-0.190)/(1-0.205)=1.018$

$V_A=V(1-w)=10\times(1-0.205)=7.95$ knots

$P_E=161$ HP (calculated in previous section)

Engine revolution=2100 RPM

Ratio=3:1

Propeller shaft revolution=700 RPM

$$\eta_D=\eta_H\times\eta_O\times\eta_R$$

First shot:

$$\eta_D=1.018\times\mathbf{0.44}\times1=0.448$$

$$P_D=P_E/\eta_D=161/0.448=359\ \text{HP}$$

$$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times359^{0.5})/(7.95^{2.5})=74.5$$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=74.5$ we read off: $\delta=324$ and $\eta_O=0.447$

Second shot

$$\eta_D=1.018\times\mathbf{0.447}\times1=0.455$$

$$P_D=P_E/\eta_D=161/0.455=354\ \text{HP}$$

$$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times354^{0.5})/(7.95^{2.5})=74$$

Using Fig.5.2 chart for 4-bladed propeller of DAR (Disc Area Ratio) 0.55, for $B_p=74$ we read off: $\delta=323$, $\eta_O=0.448$ and $P/D=0.572$

Third shot:

η_D=1.018×**0.448**×1=0.456

$P_D=P_E/\eta_D$=161/0.456=353 HP

$B_p=(n\times P_D^{0.5})/(V_A^{2.5})=(700\times 353^{0.5})/(7.95^{2.5})$=73.8 (accurate enough)

$D=(\delta\times V_A)/n$=(323×7.95)/700=3.668ft=44in

P=44×0.572=25.18in

The nearest stock size will probably be **44in×25in** or (1118mm×635mm).

$\eta_T=\eta_D\times\eta_S$=0.456×0.95=0.433
$P_B=P_E/\eta_T$=161/0.433=372 HP

Weather allowance:10%

BHP=372×1.10=409
BHP=409 HP

5.3 Cavitation control

After determining the propeller diameter it is necessary to do a simple check on the pressure on the back of the blades to ensure that propeller is not overloaded, in which case there can be a break down in flow and consequent loss of thrust. This phenomenon is usually referred to as cavitation, and its onset is recognized by erosion of propeller blades, vibration and noise emanating from the propeller.

Generally, the thrust loading for free running conditions should not exceed about 8psi (55kN/m^2)[38]. This may be determined from:

Blade pressure=(thrust developed–lbs)/(blade area–in^2)

Thrust developed=$(326\times P_T\times \eta_B)/V_A$

Where,

η_B=propeller efficiency behind hull=$\eta_R\times \eta_O$

V_A in knots

For practical purposes the hull efficiency and the relative rotative efficiency can be taken as unity and $P_T=P_D$, $\eta_B=\eta_O$

For the 21m vessel:

Thrust developed=(326×222×0.462)/7.6=4399lbs

Blade area=$(\pi\times 40^2\times 0.55)/4=691.15$in^2

Blade pressure=4399/691.15=**6.365psi** (44kN/m^2)

For the 27m vessel:

Thrust developed=(326×291×0.452)/7.73=5547lbs

Blade area=$(\pi\times 42^2\times 0.55)/4=762$in^2

Blade pressure=5547/762=**7.279psi** (50kN/m^2)

For the 33m vessel:

Thrust developed=(326×353×0.448)/7.95=6485lbs

Blade area=$(\pi\times 44^2\times 0.55)/4=836.29$in^2

Blade pressure=6485/836.29=**7.75psi** (53kN/m^2)

5.4 Derivation of brake horse power curves

Effective power values for the 27m vessel can be read off from Fig.4.3 and then can be used to compute the effective power values for the 21m vessel and the 33m vessel by means of power-displacement relationship ($P=C\times\Delta^{2/3}\times V^3$).

Once the effective power values has been computed, they then can be converted into brake horse power (BHP or P_B) values since they are related to each other by means of overall efficiency (η_T), and including the weather allowance of 10% it can be written:

$$BHP=(P_E/\eta_T)\times 1.1$$

In above expression η_T has been assumed to remain constant for practical reason.

Values of P_E and P_B for the vessels are presented in Table 5.1 and P_B values are plotted versus speed in Fig.5.3.

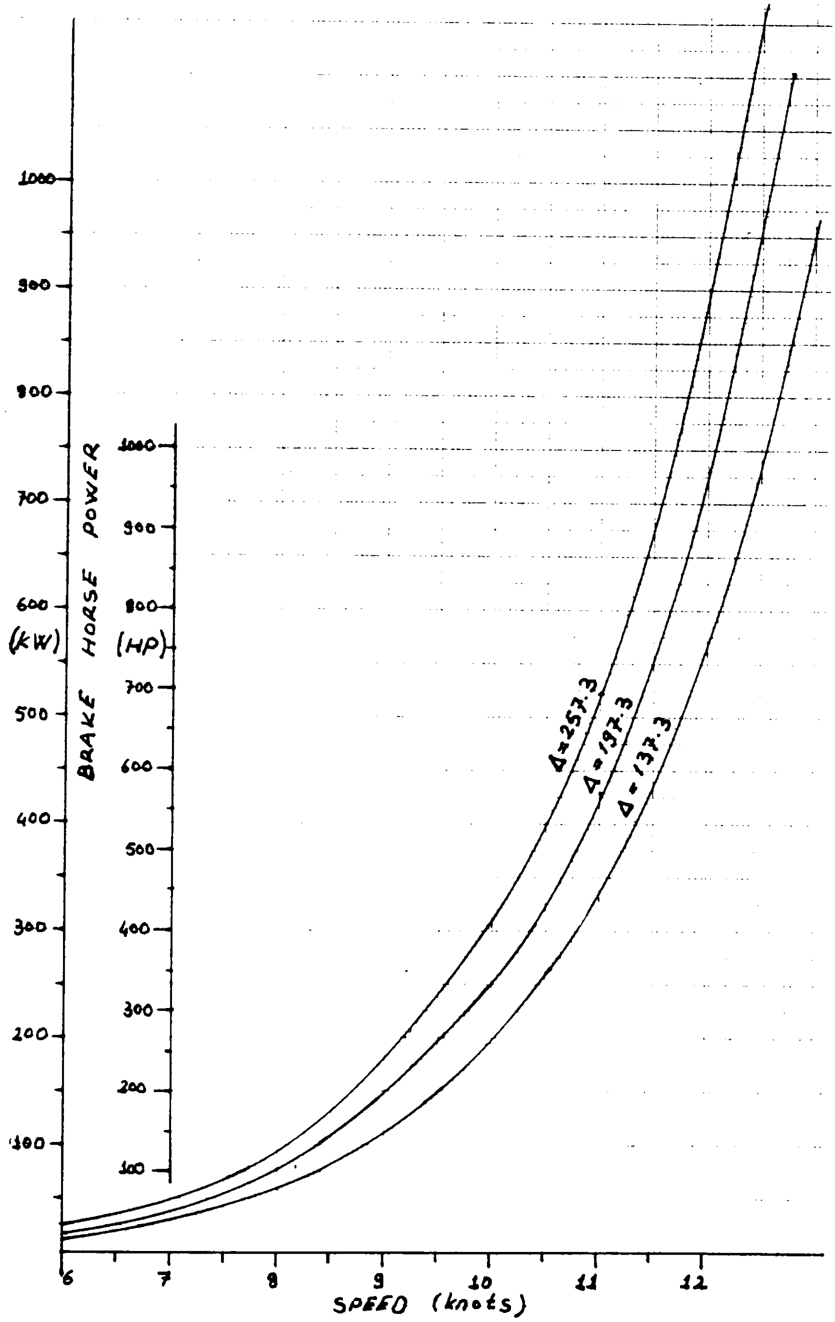


Fig.5.3 Brake horse power curves for the vessels of three different sizes

5.5 Proposed design and general arrangements

In accordance with the general requirements of the Turkish fishery and the availabilities of the natural resources as well as the facilities of the shipyards, two proposed design (PD1 and PD2) based on the parent hull form have been proposed.

5.5.1 Weight and centre of gravity calculations

In this section, more sensitive calculations for weight and centre of gravity are presented. The vessel has been sub divided into a number of sections each weight and centre of gravity of which has been taken into consideration individually. Throughout the weight calculations, 8 mm has been taken as an average thickness of plating and the midship section calculations on P98 to P100 confirm that this is a reasonable value. In calculations of the position of centre of gravity, all moments have been taken about amidships, which is based on L_{WL}, and, "+" represents the forward of amidships and "-" represents the aft of amidships.

In the concept of calculating the weight and centre of gravity for the Proposed Design 1 (PD1) and Proposed Design 2 (PD2) and evaluating the general arrangements four typical loading conditions have been considered; light ship condition, departure condition, half load condition and 100% fish hold load condition.

After examining the traditional general arrangement on the parent vessel it has been found that some features of it can be improved. The major change made is the increment of the fish hold capacity (approx.by 40%) within the same length. Increasing the fish hold capacity caused a trim problem in particular in the half and fully loaded conditions. The magnitude of the trim was about 50 cm by the bow, which was totally undesirable. In order to overcome this trim problem, the fresh water tanks have been moved to as far aft as possible and raised up to the deck head as far as possible. In addition the engine room has been moved aft by about 2 meters, and the fuel tanks have been divided into two parts transversely, which allows use of the forward part of the fuel first to minimize the trim effect in loading conditions. The arrangement plans and the calculation tables related to above modifications are named as the Proposed Design 1 (PD1)

Having produced the PD1, It has been seen that some of the forward part of the hull volume is not able to be used. In order to make as much use of the available volume of the hull as possible, another set of calculation tables and drawing plans, named as the Proposed Design 2 (PD2).has been produced. The PD2 may be distinguished from the PD1 by the fact that its accommodation has been located in the forward hull under the deck, whereas the PD1 has its accommodation on the second deck.

SECTION "0"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2AxKg (cm^3)
8x2920	233.60	376	87833.60
8x640	51.20	348	17817.60
8x600	48.00	286	13728.00
8x600	48.00	240	11520.00
8x1000	80.00	214	17120.00
8x1000	80.00	200	16000.00
200x200x10	39.00	374	14586.00
200x200x10	39.00	212	8268.00
	618.80		186873.20
	KG=	301.99 cm	

SECTION " 1/2"

Scantling (mmxmm)	1/2A (cm^2)	Kg (cm)	1/2AxKg (cm^3)
8x3220	257.60	372	95827.20
8x1220	97.60	312	30451.20
8x600	48.00	222	10656.00
8x660	52.80	182	9609.60
8x1000	80.00	156	12480.00
8x1000	80.00	145	11600.00
200x200x10	39.00	371	14469.00
200x200x10	39.00	155	6045.00
	694.00		191138.00
	KG=	275.41 cm	

SECTION " 1"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3540	283.20	360	101952.00
8x1640	131.20	280	36736.00
8x500	40.00	182	7280.00
8x900	72.00	152	10944.00
8x1000	80.00	128	10240.00
8x740	59.20	112	6630.40
8x1000	80.00	66	5280.00
200x200x10	39.00	358	13962.00
200x200x10	39.00	128	4992.00
	823.60		198016.40
	KG=	240.43 cm	

SECTION "1 1/2

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x2740	219.20	350	76720.00
8x1360	108.80	282	30681.60
8x440	35.20	196	6899.20
8x400	32.00	164	5248.00
8x2080	166.40	120	19968.00
8x520	41.60	84	3494.40
8x380	30.40	62	1884.80
8x500	40.00	30	1200.00
200x200x10	39.00	348	13572.00
200*200*10	39.00	104	4056.00
	751.60		163724.00
	KG=	217.83 cm	

SECTION "2"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3900	312.00	338	105456.00
8x1440	115.20	276	31795.20
8x480	38.40	178	6835.20
8x440	35.20	146	5139.20
8x2060	164.80	106	17468.80
8x600	48.00	62	2976.00
8x380	30.40	36	1094.40
8x260	20.80	14	291.20
200x200x10	39.00	336	13104.00
200x200x10	39.00	92	3588.00
	842.80		187748.00
	KG=	222.77 cm	

SECTION "3"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3980	318.40	328	104435.20
8x1840	147.20	242	35622.40
8x800	64.00	126	8064.00
8x2400	192.00	84	16128.00
8x500	40.00	40	1600.00
8x300	24.00	13	312.00
200x200x10	39.00	326	12714.00
200x200x10	39.00	76	2964.00
	863.60		181839.60
	KG=	210.56 cm	

Table 5.2 Calculation of the hull plate weight and its centre of gravity

SECTION "4"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x4100	328	320	104960
8x1480	118.4	230	27232
8x360	28.8	142	4089.6
8x660	52.8	110	5808
8x2040	163.2	78	12729.6
8x740	59.2	42	2486.4
8x320	25.6	14	358.4
200x200x10	39	318	12402
200x200x10	39	66	2574
	854		172640
	KG=	202.15 cm	

SECTION "5"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x4100	328	322	105616
8x1490	119.2	228	27177.6
8x380	30.4	136	4134.4
8x700	56	104	5824
8x2050	164	74	12136
8x720	57.6	38	2188.8
8x320	25.6	14	358.4
200x200x10	39	320	12480
200x200x10	39	64	2496
	858.8		172411.2
	KG=	200.76 cm	

SECTION "6"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x4060	324.8	302	98089.6
8x1560	124.8	224	27955.2
8x340	27.2	136	3699.2
8x500	40	110	4400
8x2240	179.2	74	13260.8
8x680	54.4	42	2284.8
8x200	16	16	256
200x200x10	39	300	11700
200x200x10	39	60	2340
	844.4		163985.6
	KG=	194.20 cm	

SECTION "7"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3880	310.4	312	96844.8
8x2060	164.8	220	36256
8x600	48	114	5472
8x2100	168	66	11088
8x420	33.6	34	1142.4
8x300	24	14	336
200x200x10	39	310	12090
200x200x10	39	60	2340
	826.8		165569.2
	KG=	200.25 cm	

SECTION "8"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3480	278.4	336	93542.4
8x2200	176	234	41184
8x600	48	118	5664
8x1380	110.4	72	7948.8
8x540	43.2	40	1728
8x360	28.8	18	518.4
200x200x10	39	334	13026
200x200x10	39	60	2340
	762.8		165951.6
	KG=	217.56 cm	

SECTION" 8 1/2"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x3180	254.4	350	89040
8x2300	184	250	46000
8x700	56	124	6944
8x1000	80	74	5920
8x480	38.4	40	1536
8x320	25.6	16	409.6
200x200x10	39	348	13572
200x200x10	39	90	3510
	716.4		166931.6
	KG=	233.01 cm	

Table 5.3 Calculation of the hull plate weight and its centre of gravity

SECTION "9"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x2780	222.4	364	80953.6
8x3160	252.8	230	58144
8x760	60.8	76	4620.8
8x620	49.6	34	1686.4
200x200x10	39	362	14118
200x200x10	39	160	6240
	663.6		165762.8
	KG=	249.79 cm	

SECTION" 9 1/2"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x2240	179.2	380	68096
8x2100	168	300	50400
8x1880	150.4	140	21056
8x540	43.2	30	1296
200x200x10	39	378	14742
200x200x10	39	280	10920
	618.8		166510
	KG=	269.09 cm	

SECTION " 10"

Scantling (mmxmm)	1/2 A (cm^2)	Kg (cm)	1/2 AxKg (cm^3)
8x1640	131.2	396	51955.2
8x1320	105.6	350	36960
8x1200	96	254	24384
200x200x10	39	394	15366
	371.8		128665.2
	KG=	346.06 cm	

SECTION" 10 1/2"

1/2 A= 212.09 cm^2

KG= 364 cm

Section No	1/2 A (cm^2)	KG (cm)	1/2 AxKG (cm^3)
0	618.80	301.99	186871.4120
0.5	694.00	275.41	191134.5400
1	823.60	240.43	198018.1480
1.5	751.60	217.83	163721.0280
2	842.80	222.77	187750.5560
3	863.60	210.56	181839.6160
4	854.00	202.15	172636.1000
5	858.80	200.76	172412.6880
6	844.40	194.20	163982.4800
7	826.80	200.25	165566.7000
8	762.80	217.56	165954.7680
8.5	716.40	233.01	166928.3640
9	663.60	249.79	165760.6440
9.5	618.80	269.09	166512.8920
10	371.80	346.06	128665.1080
10.5	212.09	364.00	77200.7600
	11323.89		2654955.8040
	KG=	234.46 cm	
	KG= 2.34 m		

Table 5.4 Calculation of the hull plate weight and its centre of gravity

Sec. No	Weight/Len. (kg/m)	Av.Weig./Len. (kg/m)	Lenght (m)	Av.Weight (kg)	Mom. Lev. (m)	Moment (kgm)
S	80.00					
		485.80	0.50	242.90	-13.75	-3339.88
0	891.60					
		950.25	1.35	1282.84	-12.825	-16452.39
0.5	1008.90					
		1110.00	1.35	1498.50	-11.475	-17195.29
1	1211.10					
		1154.85	1.35	1559.05	-10.125	-15785.36
1.5	1098.70					
		1169.85	1.35	1579.30	-8.775	-13858.34
2	1241.00					
		1257.35	2.70	3394.85	-6.75	-22915.20
3	1273.50					
		1266.00	2.70	3418.20	-4.05	-13843.71
4	1258.50					
		1262.25	2.70	3408.08	-1.35	-4600.90
5	1266.00					
		1254.75	2.70	3387.83	1.35	4573.56
6	1243.50					
		1229.80	2.70	3320.46	4.05	13447.86
7	1216.10					
		1166.15	2.70	3148.61	6.75	21253.08
8	1116.20					
		1080.00	1.35	1458.00	8.775	12793.95
8.5	1043.80					
		1002.65	1.35	1353.58	10.125	13704.97
9	961.50					
		926.55	1.35	1250.84	11.475	14353.42
9.5	891.60					
		717.35	1.35	968.42	12.825	12420.02
10	543.10					
		437.00	1.35	589.95	14.175	8362.54
10.5	330.90					
		225.45	1.15	259.27	15.44	4003.09
B	120.00					
			30	32120.65		-3078.56
				LCG=	**-0.096 m**	

Table 5.5 Calculation of LCG of the hull plate

HULL STRUCTURE	WEIGHT (tonnes)
Plate	32.00
Frame	15.00
Keel	0.88
Brackets	0.10
Stem	0.32
Stern Post	0.12
Concrete	2.11
	50.53
Fastening (5%)	2.53
TOTAL	**53.05**

SUPER STRUCT.	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
DECK 1	6.735	4.00	5.15	26.940	34.685
DECK 2	5.725	6.50	5.85	37.213	33.491
DECK 3	3.839	8.50	7.80	32.632	29.944
	16.299				
Fast.(5%)	0.815				
TOTAL	**17.114**			96.784	98.121
		KG=	**5.66 m**		
		LCG=	**5.73 m**		

HULL FITTING	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Rudder Stock	0.260	1.00	-12.70	0.26	-3.302
Steering Gear	0.220	2.00	-12.00	0.44	-2.640
Fastening	0.024	1.50	-12.35	0.036	-0.296
TOTAL	0.504			0.736	-6.238
			VCG=	**1.46 m**	
			LCG=	**-12.38 m**	

RIGGING	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Mast	1.912	5.00	-4.00	9.560	-7.648
Boom	0.887	7.00	-7.00	6.209	-6.209
Stays	0.529	5.00	-4.00	2.645	-2.116
Main winch	2.000	3.50	-4.80	7.000	-9.600
Anc. winch	0.500	4.50	13.50	2.250	6.750
Fitting	0.800	5.00	-4.50	4.000	-3.600
TOTAL	**6.628**			31.664	-22.423
			VCG=	**4.78 m**	
			LCG=	**-3.38 m**	

MACHINERY	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Main Engine	3.00	1.00	-7.00	3.000	-21.000
Auux. Machinery	4.50	1.20	-7.00	5.400	-31.500
Shaft	0.20	0.65	-10.00	0.130	-2.000
Propeller	0.35	0.65	-11.50	0.228	-4.025
Hydraulic System	2.00	2.00	-7.00	4.000	-14.000
F. Water System	1.00	2.00	-7.00	2.000	-7.000
TOTAL	**11.05**			14.7575	-79.525
			VCG=	**1.34 m**	
			LCG=	**-7.20 m**	

Table 5.6 Weight and CG calculations for "PD1"

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Hull structure	53.00	2.29	121.37	-0.39	-20.67
Super structure	17.11	5.66	96.87	5.73	98.06
Hull fitting	0.50	1.46	0.74	-12.38	-6.24
Rigging	6.63	4.77	31.62	-3.38	-22.40
Machinery	11.05	1.34	14.76	-7.20	-79.53
Outfitting	18.50	6.50	120.25	2.00	37.00
Fishing gear	5.00	3.00	15.00	-7.00	-35.00
TOTAL	111.80		400.59		-28.78
	VCG=	3.58			
	LCG=	-0.26			
	LIGHTSHIP	**CONDITION**			

Table 5.7 Calculation of the displacement of "PD1" in lightship condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	111.80	3.58	400.24	-0.26	-29.07
Fuel	27.00	2.00	54.00	-7.30	-197.10
Provisions	1.50	3.00	4.50	5.00	7.50
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	10.00	2.10	21.00	-11.35	-113.50
Fish	–	–	–	–	–
Ice	51.75	0.80	41.40	3.00	155.25
TOTAL	205.05		531.64		-161.92
	VCG=	2.59			
	LCG=	-0.79			
	DEPARTURE	**CONDITION**			

Table 5.8 Calculation of the displacement of "PD1" in departure condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	111.80	3.58	400.24	-0.26	-29.07
Fuel	13.50	1.50	20.25	-7.30	-98.55
Provisions	0.75	3.00	2.25	5.00	3.75
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	5.00	1.75	8.75	-11.35	-56.75
Fish	51.75	0.80	41.40	0.00	0.00
Ice	25.88	0.80	20.70	0.00	0.00
TOTAL	211.68		504.09		-165.62

VCG= 2.38

LCG= -0.78

HALF LOAD CONDITION

Table 5.9 Calculation of the displacement of "PD1" in half loaded condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	111.80	3.58	400.24	-0.26	-29.07
Fuel	13.50	1.50	20.25	-8.15	-110.03
Provisions	0.75	3.00	2.25	5.00	3.75
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	5.00	1.75	8.75	-11.35	-56.75
Fish	103.50	1.60	165.60	0.97	100.40
Ice	25.88	1.60	41.41	0.97	25.10
TOTAL	263.43		649.00		-51.59

VCG= 2.46

LCG= -0.20

WITH 100% FISH HOLD LOADED CONDITION

Table 5.10 Calculation of the displacement of "PD1" in fully loaded condition

HULL STRUCTURE	WEIGHT (tonnes)
Plate	32.00
Frame	15.00
Keel	0.88
Brackets	0.10
Stem	0.32
Stem Post	0.12
Concrete	2.11
	50.53
Fastening (5%)	2.53
TOTAL	**53.05**

SUPER STRUCT.	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
DECK 1	6.735	4.00	5.15	26.940	34.685
DECK 2	3.839	8.50	7.80	32.632	29.944
	10.574				
Fast.(5%)	0.529				
TOTAL	**11.103**			59.572	64.629
		KG=	**5.37 m**		
		LCG=	**5.82 m**		

HULL FITTING	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Rudder Stock	0.260	1.00	-12.70	0.26	-3.302
Steering Gear	0.220	2.00	-12.00	0.44	-2.640
Fastening	0.024	1.50	-12.35	0.036	-0.296
TOTAL	0.504			0.736	-6.238
			VCG=	**1.46 m**	
			LCG=	**-12.38 m**	

RIGGING	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Mast	1.912	5.00	-4.00	9.560	-7.648
Boom	0.887	7.00	-7.00	6.209	-6.209
Stays	0.529	5.00	-4.00	2.645	-2.116
Main winch	2.000	3.50	-4.80	7.000	-9.600
Anc. winch	0.500	4.50	13.50	2.250	6.750
Fitting	0.800	5.00	-4.50	4.000	-3.600
TOTAL	**6.628**			31.664	-22.423
			VCG=	**4.78 m**	
			LCG=	**-3.38 m**	

MACHINERY	W (t)	KG (m)	LCG (m)	V. MOM.	H. MOM.
Main Engine	3.00	1.00	-7.00	3.000	-21.000
Auux. Machinery	4.50	1.20	-7.00	5.400	-31.500
Shaft	0.20	0.65	-10.00	0.130	-2.000
Propeller	0.35	0.65	-11.50	0.228	-4.025
Hydraulic System	2.00	2.00	-7.00	4.000	-14.000
F. Water System	1.00	2.00	-7.00	2.000	-7.000
TOTAL	**11.05**			14.7575	-79.525
			VCG=	**1.34 m**	
			LCG=	**-7.20 m**	

Table 5.11 Weight and CG calculations for "PD2"

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Hull structure	53.00	2.29	121.37	-0.39	-20.67
Super structure	11.10	5.37	59.61	5.82	64.60
Hull fitting	0.50	1.46	0.74	-12.38	-6.24
Rigging	6.63	4.77	31.62	-3.38	-22.40
Machinery	11.05	1.34	14.76	-7.20	-79.53
Outfitting	18.50	6.50	120.25	2.00	37.00
Fishing gear	5.00	3.00	15.00	-7.00	-35.00
TOTAL	105.78		363.34		-62.24
	VCG=	3.43			
	LCG=	-0.59			
	LIGHTSHIP	**CONDITION**			

Table 5.12 Calculation of the displacement of "PD2" for lightship condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	105.78	3.43	362.83	-0.59	-62.41
Fuel	27.00	2.00	54.00	-7.30	-197.10
Provisions	1.50	3.00	4.50	5.00	7.50
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	10.00	2.10	21.00	-11.35	-113.50
Fish	–	–	–	–	–
Ice	51.75	0.80	41.40	3.00	155.25
TOTAL	199.03		494.23		-195.26
	VCG=	2.48			
	LCG=	-0.98			
	DEPARTURE	**CONDITION**			

Table 5.13 Calculation of the displacement of "PD2" for departure condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	105.78	3.43	362.83	-0.59	-62.41
Fuel	13.50	1.50	20.25	-7.30	-98.55
Provisions	0.75	3.00	2.25	5.00	3.75
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	5.00	1.75	8.75	-11.35	-56.75
Fish	51.75	0.80	41.40	0.00	0.00
Ice	25.88	0.80	20.70	0.00	0.00
TOTAL	205.66		466.68		-198.96
	VCG=	2.27			
	LCG=	-0.97			
	HALF LOADED	**CONDITION**			

Table 5.14 Calculation of the displacement of "PD2" for half loaded condition

ITEM	WEIGHT (tonnes)	VCG (m)	VERTICAL MOMENT	LCG (m)	LONG. MOMENT
Lightship	105.78	3.43	362.83	-0.59	-62.41
Fuel	13.50	1.50	20.25	-8.15	-110.03
Provisions	0.75	3.00	2.25	5.00	3.75
Crew	3.00	3.50	10.50	5.00	15.00
Fresh water	5.00	1.75	8.75	-11.35	-56.75
Fish	103.50	1.60	165.60	0.97	100.40
Ice	25.88	1.60	41.41	0.97	25.10
TOTAL	257.41		611.58		-84.94
	VCG=	2.38			
	LCG=	-0.33			
	WITH 100 % LOADED	**FISHHOLD CONDITION**			

Table 5.15 Calculation of the displacement of "PD2" for fully loaded condition

5.5.2 Comparison between the PD1 and the PD2

As a result of the modification of the traditional design two different general arrangement plans have been proposed to the Turkish fishermen. The advantages and disadvantages of each arrangement may be summarized as follows:

(a) The PD1 has higher superstructure than the PD2 has. This may be considered as an advantage from fishermen's point of view as it enables better view to see the fish as well as the activities taking place on the deck.

(b) Having the accommodation on the second deck provides better comfort than having it under the main deck. In this respect, the PD1 might be preferable to the PD2.

(c) It may be said that the PD1 is more impressive because of higher superstructure. This is a kind of general feeling among the fishing vessel owners and might be worth considering in relation to market.

(d) The main disadvantage of the PD1 is that it has a tendency to trim by the bow when there is nothing in the fish hold and the tanks are almost empty. This undesirable trim makes the handling of the vessel more difficult and reduces the manoeuvrability.

(e) Because the superstructure area of the PD1 is higher than the PD2, the PD1 is subjected to more air resistance than the PD2, which causes an increase in fuel consumption to keep the speed at the same level as the PD2

(f) The PD2 is more economical to build than the PD1 as it allows a saving of 5.4 % in steel weight.

5.5.3 Derivation of the midship section of the proposed design with respect to Lloyd's Rules

The following symbols and definitions are applicable to this section unless otherwise stated.

L=length, in meters
B=beam, in meters
D=depth, in meters
T=draught, in meters
s=spacing of secondary stiffeners, in mm
S=spacing or mean spacing of primary members, in meters
l=overall length of stiffening member, or pillar, in meters
l_e=effective length of stiffening member, or pillar, in meters
Z=section modulus of stiffening member, in cm^3
I=inertia of stiffening member, in cm^4
A=cross-sectional area of stiffening member, in cm^2
t=thickness of plating, in mm
Z_{RD}=minimum hull midship section modulus at deck, in cm^3
Z_D=actual hull midship section modulus at deck but is not to be taken greater than $1.5Z_{RD}$
Z_{RB}=minimum hull midship section modulus at keel
Z_D=actual hull midship section modulus at keel but is not to be taken greater than $1.5Z_{RB}$
$F_D=Z_{RD}/Z_D$
$F_B=Z_{RB}/Z_B$
$F_M=F_B$ or F_D, whichever is the greater
k=higher tensile steel factor
ρ=relative density of liquid carried in a tank but it is not to be taken less than 1.025
C=stowage rate, in m^3/tonne
H_{MF}=vertical framing depth, in meters, of main frames
H_{TF}=vertical framing depth, in meters, of 'tween deck
H=H_{MF} or H_{TF} as applicable

H_1=H, but need to be taken greater than 3.5m
D_1=D, but need not be taken greater than 1.67
h_4=tank head, in meters
h_5=head, in meters, measured from the middle of H to the deck at side
h=h_4 or h_5, whichever is the greater

5.5.3.1 Deck openings

If l>2.5m and b>1.2m or 0.04B (whichever is the lesser) are always to be deducted from sectional area used in the section modulus calculations.

Where l is the length of the hatch, and b is the width of the hatch.

5.5.3.2 Bottom shell and bilge plating for transverse framing

Minimum thickness is to be the greater of the following:

(a) $t = 0.001 s_1 f_1 (0.056L + 16.7)\sqrt{F_B / k}$

(b) $t = 0.0078 s_1 \sqrt{\dfrac{Tk}{2.5 - 1.5F_B}}$

S=B/3=8.25/3=2.75m

$s_1 = 470 + L / 0.6$=470+27/0.6=515mm

$f_1 = \dfrac{1}{1 + (\dfrac{s}{1000S})^2}$=0.966

$F_B=Z_{RB}/Z_B$ and $Z_B=1.5Z_{RB}$ and k=1

(a) t=0.001×515×0.966(0.056×27+16.7)×0.816=7.39mm≈7.5mm

(b) $t = 0.0078 \times 515\sqrt{\dfrac{2 \times 1}{2.5 - 1.5 \times 1 / 1.5}} = 4.638\text{mm}$

In fishing vessels, the thickness of the bottom shell plating is to be not less than (6+0.06L) mm.

t=(6+0.06×27)=7.62mm≈**8mm**

5.5.3.3 Side shell plating for transverse framing

Minimum thickness is to be the greater of the following:

(a) Within D/4 from the gunwale:

(i) $t = 0.00085 s_1 f_1 (0.083L + 10)\sqrt{F_D / k}$

$=0.00085 \times 515 \times 0.966(0.083 \times 27+10) \times 0.816=4.22$mm

(ii) $t = 0.0049 s_1 \sqrt{T \times k} = 0.0049 \times 515\sqrt{2 \times 1} = 3.568$mm

(b) Within D/4 from mid-depth:

The greater of the following:

(i) $t = 0.001 s_1 (0.059L + 7)\sqrt{F_M / k}$

$=0.001 \times 515(0.059 \times 27+7) \times 0.816=3.61$mm

(ii) $t = 0.0059 s_1 \sqrt{T \times k} = 0.0059 \times 515\sqrt{2 \times 1} = 4.29$mm

(c) Within D/4 from base (excluding bilge plating):

The greater of the following:

(i) $t = 0.00085 s_1 f_1 (0.083L + 10)\sqrt{F_B / k}$

$=0.00085 \times 515 \times 0.966(0.083 \times 27+10) \times 0.816=4.22$mm

(ii) $t = 0.007 s_1 \sqrt{\frac{Tk}{2.5 - 1.5F_B}} = 0.007 \times 515\sqrt{\frac{2 \times 1}{2.5 - 1.5}} = 4.16$mm

(d) Sheerstrake:

The greater of the following:

(i) $t = 0.001s_1f_1(0.083L + 10)\sqrt{F_D / k}$

$=0.001\times515\times0.966(0.083\times27+10)\times0.816=4.97$mm

(ii) $t = 0.001s_1\sqrt{Lk} + 2.5 = 0.001\times515\sqrt{27\times1} + 2.5 = 5.176$mm

(iii) $t = (6.5 + 0.033L)\sqrt{ks_1 / s_b} = (6.5+0.033\times27)\times1 = 7.39$mm

In fishing vessels, the thickness of the side shell plating is to be not less than (6+0.06L) mm.

$t=(6+0.06\times27)=7.62$mm≈**8mm**

5.5.3.4 Deck plating for transverse framing

Minimum thickness is to be the greater of the following:

(a) $t = 0.001s_1f_1(0.083L + 10)\sqrt{F_D / k}$

$=0.001\times515\times0.966(0.083\times27+10)\times0.816=4.97$mm

(b) $t = 0.001s_1\sqrt{Lk} + 2.5 = 0.001\times515\sqrt{27\times1} + 2.5 = 5.18$mm

Under the trawl winch, windlass, mast, gallows:

$t=(0.04L+7.5)$ where L not less 30m

$t=(0.04\times30+7.5)=8.7$mm≈**9mm**

5.5.3.5 Shell framing (transverse)

Section modulus Z, in cm^3, is to be taken the greater of the following:

(a) $Z=skTPcf_2\times10^{-3}$

$c=D_1/D$ (D<7.5m)

$c=1.67/3=0.55$

$$P = (1.77H^2 + 0.145K_1D_1^2 + 14.5)(1 - \frac{x}{1.4D})$$

x=distances, in meters, of tank top or deck

$K_1=0.35$

$P=(1.77\times 2^2+0.145\times 0.35\times 1.67^2+14.5)(1-\frac{2}{1.4\times 3})=11.295$

$Z=515\times 1\times 2\times 11.295\times 0.55\times 1\times 10^{-3}=6.39cm^3$

(b) $Z=9.1skD_1f_2\times 10^{-3}=9.1\times 515\times 1\times 1.67\times 10^{-3}=7.826$

(c) $Z=1.24skTPC_1cf_2\times 10^{-3}$

$C_1=0.027D_2+1.22=0.027\times 2+1.22=1.382$

$Z=1.24\times 515\times 1\times 2\times 11.295\times 1.382\times 0.55\times 10^{-3}=\mathbf{10.965cm^3}$

$I=\frac{3.2}{k}HZ=\frac{3.2}{1}\times 2.5\times 10.965=\mathbf{87.72cm^4}$

Having the plate area of 40cm² (50cm×0.8cm) and choosing unequal angle section from German DIN standards, the nearest standard section will probably be **60mm×40mm×5mm** and have the following section properties:

$\mathbf{Z=16.8cm^3}$

$\mathbf{I=97.6cm^4}$

5.5.3.6 Primary structure

Section modulus Z, in cm³, is to be taken the greater of the following:

$Z=7.75kSh_5l_e^2=7.75\times 1\times 2.75\times 1\times 6^2=767.25cm^3$

$Z=11.71\rho kSh_4l_e^2=11.71\times 1.025\times 1\times 2.75\times 1\times 6^2=\mathbf{1188cm^3}$

$I=\frac{2.5}{k}l_eZ=\frac{2.5}{1}\times 6\times 1188=\mathbf{17820cm^4}$

Determining the section properties for deck girder and bottom girder is rather a trial and error process. By using I-Z Diagram we arrive to properties:

For deck girder:

I=25200cm⁴ and Z=1200cm³ (with plate) and

I=10538cm⁴ (without plate)

For bottom girder:

$I=24150cm^4$ and $Z=1200cm^3$ (with plate) and

$I=12666cm^4$ (without plate)

5.5.4 Comparison of the midship sections between the traditional design and proposed design based on the Lloyd's Rules

Referring to Fig.5.4, midship section scantlings of the vessels of the traditional design and the proposed design are presented in Table 5.16 and Table 5.17, respectively.

Calculation of the midship section modulus:

(i) Traditional design (Table 5.16):

1/2 moment of inertia referred to base line:

$$1/2I_{BL}=\sum I_0+\sum(A_i\times y_i^2)=120794.19+44271429=44392223.19cm^4$$

Neutral axis above base line:

$$y=\frac{\sum(A_i\times y_i)}{\sum A_i}=165008.6/859.6=192cm$$

1/2 moment of inertia referred to neutral axis:

$$1/2I_{NA}=1/2I_{BL}-(\sum A_i)\times y^2=44392223.19-(859.6)^2\times(192)^2=12717214cm^4$$

Therefore:

$I_{NA}=2\times 1/2I_{NA}=25434428cm^4$ and the section modulus at deck and keel:

$Z_{deck}=I_{NA}/(330-192)=184307cm^3$

$Z_{keel}=I_{NA}/192=132471cm^3$

(ii) Proposed design (Table 5.17):

If the above process is repeated for Table 5.17 it would be found:

Neutral axis above base line:y=188cm, and

I_{NA}=26299567cm^4

Z_{deck}=185208cm^3

Z_{keel}=139891cm^3

As can be seen from the above results that the actual and required moment of inertia of these vessels and the section modulus are very close to each other. The discrepancies between the results may be considered to be insignificant.

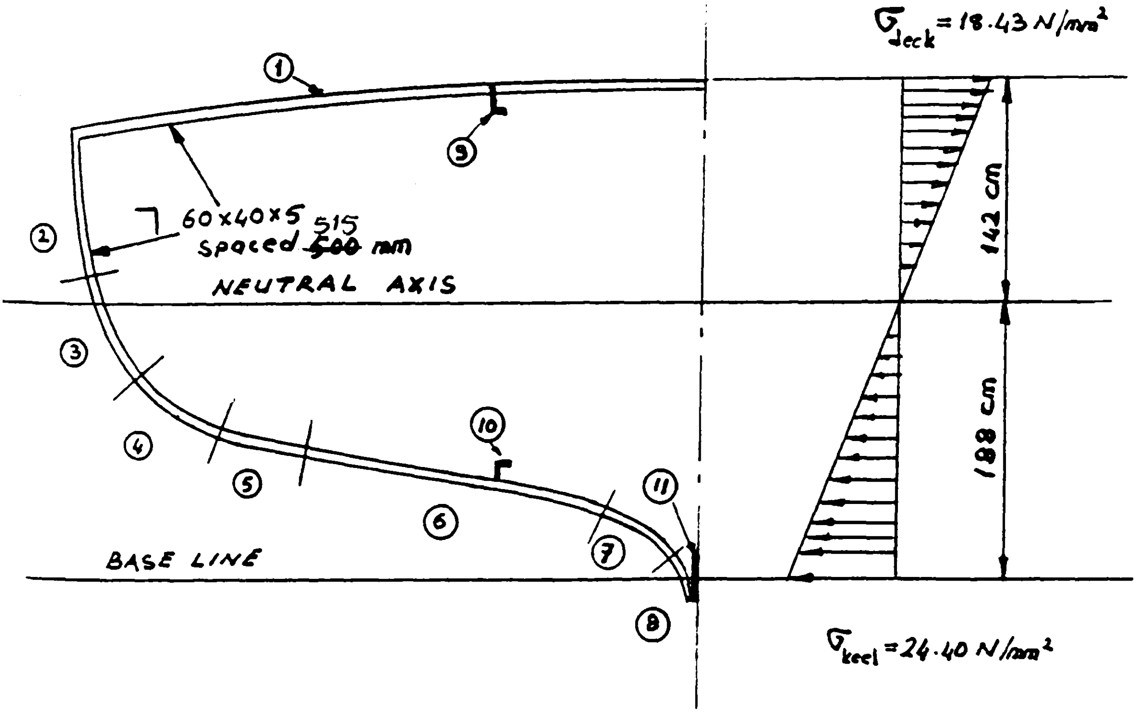


Fig.5.4 Midship section

Item No	Scantling (cmxcm)	A (cm^2)	y (cm)	Axy (cm^3)	Axy^2 (cm^4)	Io (cm^4)
1	285x0.9	256.5	325	83362.5	27092813	-
2	100x0.8	80	250	20000	5000000	66667
3	70x0.8	56	200	11200	2240000	22867
4	32x0.8	25.6	122	3123.2	381030	2185
5	58x0.8	46.4	100	4640	464000	13007
6	232x0.8	185.6	74	13734.4	1016346	-
7	42x0.8	33.6	33	1108.8	36590	-
8	34x0.8	27.2	0	0	0	2620
9	Deck girder	82.6	320	26432	8458240	10538
10	Bottom girder	104.4	70	7308	511560	12666
11	17x1.1	9.35	-4	-37.4	150	450
		907.25		170871.5	45200729	131000

Table 5.16 Calculation of the midship section modulus of vessel of proposed design

Item No	Scantling (cmxcm)	A (cm^2)	y (cm)	Axy (cm^3)	Axy^2 (cm^4)	Io (cm^4)
1	410x0.7	287	325	93275	30314375	-
2	100x0.9	90	250	22500	5625000	75000
3	70x0.8	56	200	11200	2240000	22867
4	32x0.8	25.6	122	3123.2	381030	2185
5	58x0.8	46.4	100	4640	464000	13007
6	232x0.8	185.6	74	13734.4	1016346	-
7	42x1	42	33	1386	45738	-
8	34x1	34	0	0	0	3275
9	Deck girder	39	320	12480	3993600	1548
10	Bottom girder	39	70	2730	191100	1548
11	30x1	15	-4	-60	240	1365
		859.6		165008.6	44271429	120794

Table 5.17 Calculation of the midship section modulus of vessel of traditional design

5.5.5 Longitudinal strength

The midship section of the fishing vessel of proposed design has been checked for longitudinal strength in accordance with the Lloyd's Rules.

The diagrams of the buoyancy and the weight distribution as well as the load and the still water bending moment and the shear force are presented in Fig.5.5 and Fig.5.6 The diagrams correspond to the most critical loading condition the fishing vessel is found to encounter, which may be referred to as the "departure condition" for fishing grounds. This is the loading condition in which the maximum bending moment occurs as there is minimum weight in the fish hold (almost located in the middle) and the maximum weight at the ends of the vessel. As can be seen from the bending moment diagram, the maximum bending moment occurs around amidships of the vessel and has a value of about 47 tm (461 kN m). With reference to Section 5.5.3, the maximum bending stresses for the deck and the keel and the maximum shear stress may be calculated in accordance with the Lloyd's Rules as demonstrated below:

A fishing vessel is considered as a Category 2 ship, which covers the followings:

a) General and miscellaneous cargo ship

b) Ships for the carriage of bulk dry cargoes such that the loading in each hold or compartment is less dense than that corresponds to a stowage rate of $1 m^3$/tonne

c) Ships for liquefied gases.

The following symbols are applicable to this section:

I=moment of inertia, in cm^4, of the hull midship section about the horizontal neutral axis, z=vertical distance, in meters, from the neutral axis to the moulded deck line at side or, the line of top of the keel, as appropriate,

M_s=design still water bending moment, in kN m

M_w=Rule wave bending moment amidships, in kN m

Q_s=design still water bending force, in kN

σ_s =still water bending stress, in N/mm^2

σ_w =Rule wave bending stress, in N/mm2

σ_c =Rule combined stress ($\sigma_s+\sigma_w$), in N/mm^2

τ_c =combined shear stress, in N/mm^2

The values of the moment of Inertia about the neutral axis and the area of the cross section are calculated in Table.13, and the values of the maximum bending moment and the shear force can be taken from the relevant diagrams (Fig.4).

Design still water bending moment (M_s)

Design still water bending moment, as can be seen from Fig.4 is the maximum at 2.5 aft of the amidships, corresponding to section 8 1/2. It has the value of 47 tm (461 kN m) and its value is 28 tm (275 kN m) at the amidships.

Rule wave bending moment (M_w)

$M_w=fC_1L^2B^2(C_b+0.7)\times10^{-3}$ at midships

$C_1=0.0412L+4$ (L<90 m)

C_1=0.0412x27+4=5.1124

f=78.5 (for short voyages)

M_w=78.5x5.1124x27^{2}x8.25(0.6+0.7)x10^{-3}

M_w=3138 kN m

The value of Rule wave bending moment at section 8 1/2 is calculated from the maximum Rule wave bending moment by means of an interpolation factor, thus:

M_w=0.9x3138

M_w=2824 kN m

Combined bending moment (M_c)

At section 8 1/2:

M_c=M_s+M_w=461+2824

M_c=3285 kN m

At amidships:

M_c=M_s+M_w=275+3138

M_c=3413 kN m

As can be seen from the above that combined bending moment is the maximum at the amidships.

Design still water shear force (Q_s)

From Fig.5.6, the value of the shear force can be read as:

Q_s=17 tonne=167 kN

Maximum permissible stresses

For Category 2,

$\sigma_c = 178$ N/mm^2
$\sigma_s = 99.5$ N/mm^2
$\sigma_w = 78.5$ N/mm^2

Longitudinal vertical bending stress at deck and keel

The maximum stresses due to longitudinal bending at the deck and keel are given by:

$$\sigma_{deck} = \frac{M_s + M_w}{Z_D} \times 10^{-3}$$

$$\sigma_{keel} = \frac{M_s + M_w}{Z_B} \times 10^{-3}$$

Where Z_D and Z_B are the actual section moduli of the hull, in cm^3, at the deck and keel respectively.

$$\sigma_{deck} = \frac{275 + 3138}{185208} \times 10^{3}$$

$$\sigma_{deck} = 18.43 \text{ N / mm}^2$$

$$\sigma_{keel} = \frac{275 + 3138}{139891} \times 10^{3}$$

$$\sigma_{keel} = 24.40 \text{ N / mm}^2$$

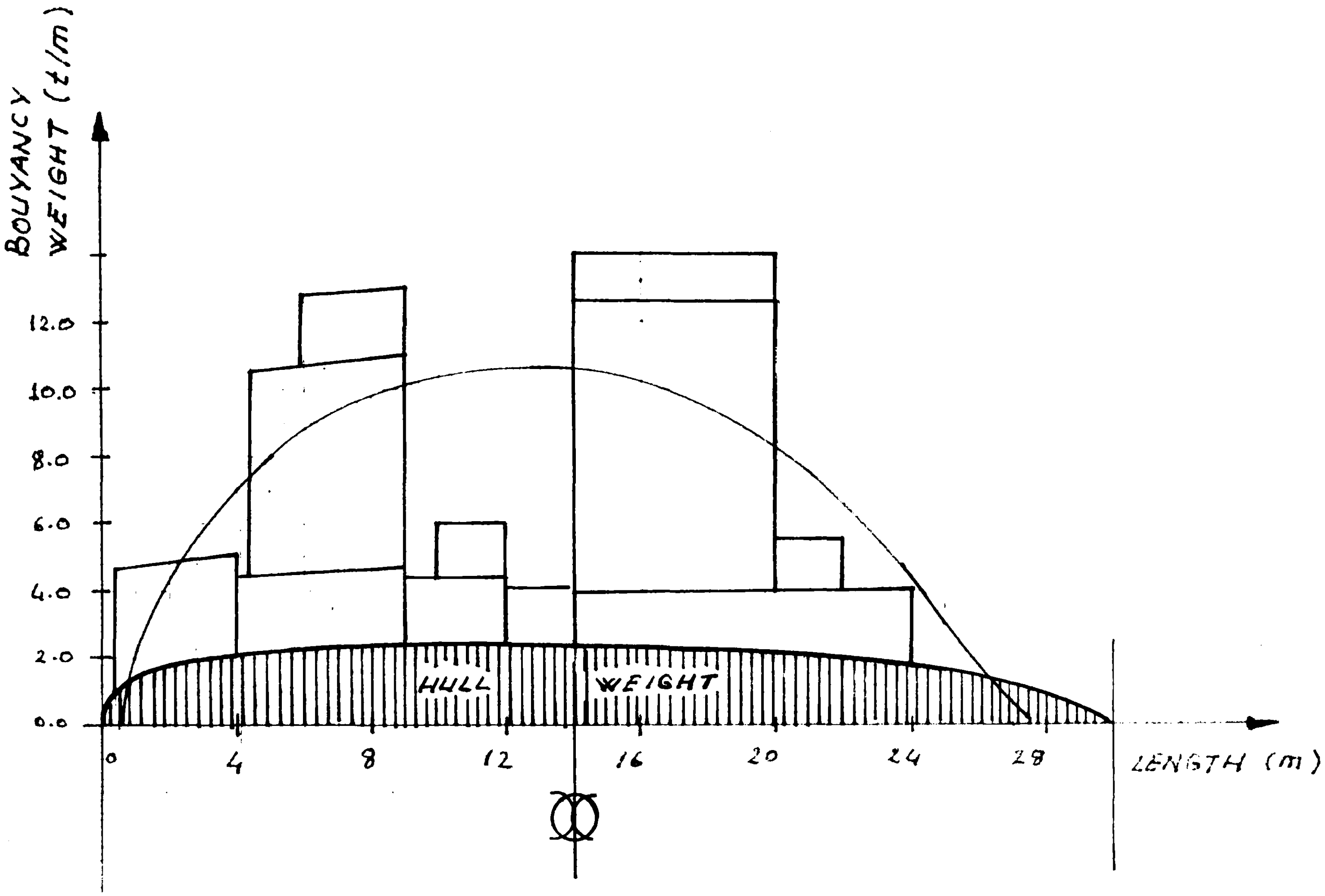


Figure 5.5 Weight distribution and buoyancy diagrams

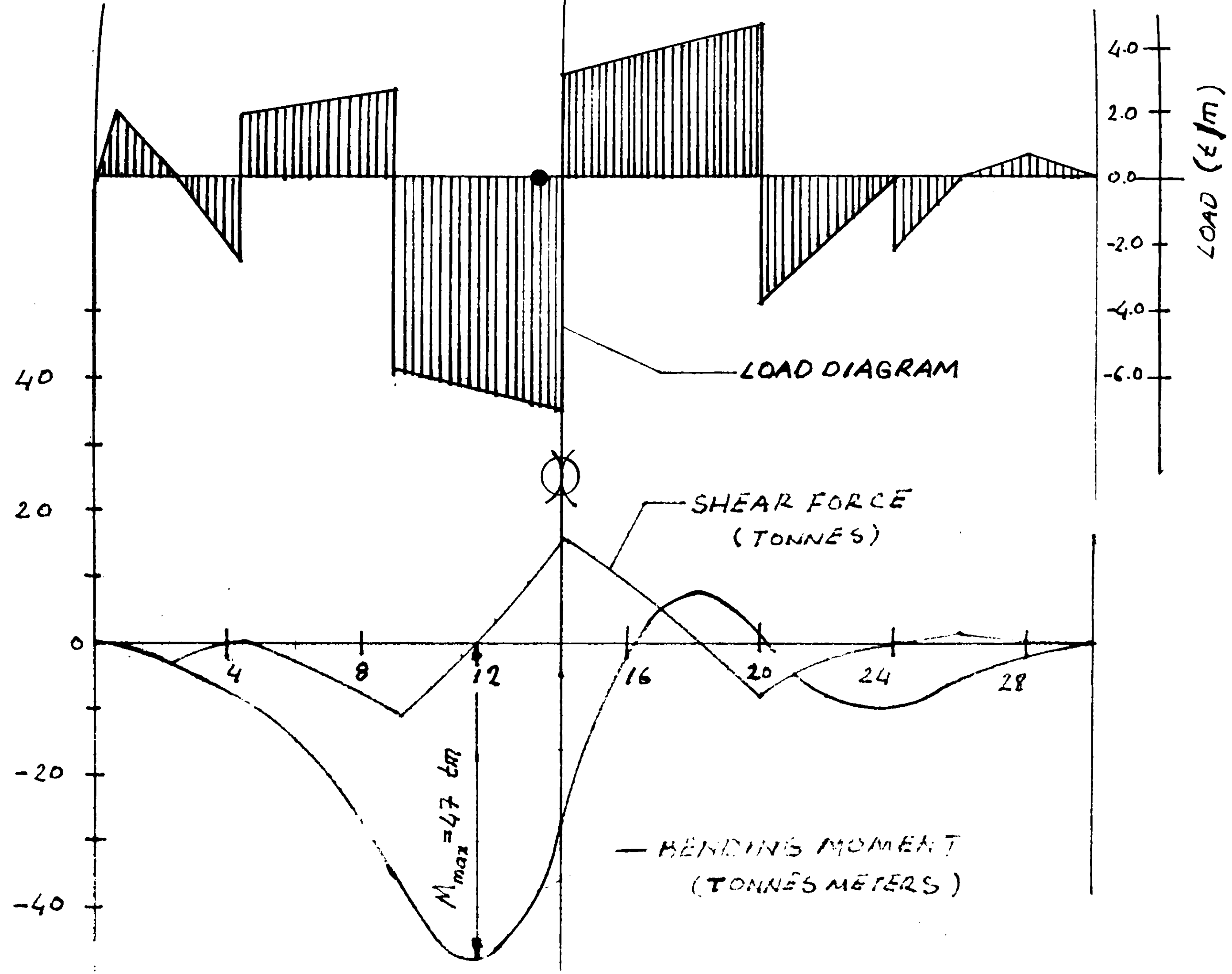


Figure 5.6 Load, bending moment and shear force diagrams

As can be seen from the above results that the stresses are very small in magnitude in relation to the permissible stresses, thus making the vessel structure safe in terms of overall strength. This is not an unusual result for small ships where local strength and minimum thickness are the deciding factors.

5.5.6 Minimum hull midship section modulus

For unrestricted sea-going service the minimum hull midship section modulus, Z_R is to be not less than the greater of the following values:

(a) $Z_R = C_1 L^2 B (C_b + 0.7)$ cm^3

$C_1 = 0.0412L + 4 = 0.0412 \times 27 + 4 = 5.1124$

C_b is to be taken not less than 0.60.

$Z_R = 5.1124 \times 27^2 \times 8.25(0.6+0.7) = \mathbf{39971 cm^3}$

(b) $Z_R = \dfrac{M_s + M_w}{\sigma_c} \times 10^3$ cm^3

$\sigma_c = 178$ N/mm^2

$Z_R = \dfrac{275 + 3118}{178} \times 10^3 = 19174 cm^3$

The actual midship section modulus (see Page 104) is about 3.5 times greater than minimum hull midship section modulus calculated above.

5.5.7 Stability

Although there are no certain stability criteria implemented by the Turkish authorities for fishing vessels, it is thought to be beneficial to introduce such stability criteria of a world wide organization as the IMO for the derivative design.

The specific requirements in relation to the statical stability curve (presented in Fig.5.7) are given below[28]:

A- Area under curve of up to 30 degrees to be not less than 0.055 metre-radian.

B- Area under curve up to x degrees to be not less than 0.09 metre-radian.

C- Area between 30 degrees and x degrees to be not less than 0.03 metre-radian.

x- 40 degrees or any lesser angle at which the lower edges of any openings in the hull, superstructure or deck houses which lead below deck and cannot be closed weathertight, would be immersed.

E- Maximum GZ to occur at an angle of not less than 25 degrees and to at least 0.20 meters at an angle equal to or greater than 30 degrees.

F- Initial GM to be not less than 0.35 meters.

Statical stability curves of the Proposed Design 1 (PD1) for four typical loading conditions are drawn in Fig.5.8. As can be seen from the statical stability curves that the proposed design is found to well satisfy the above minimum stability criteria.

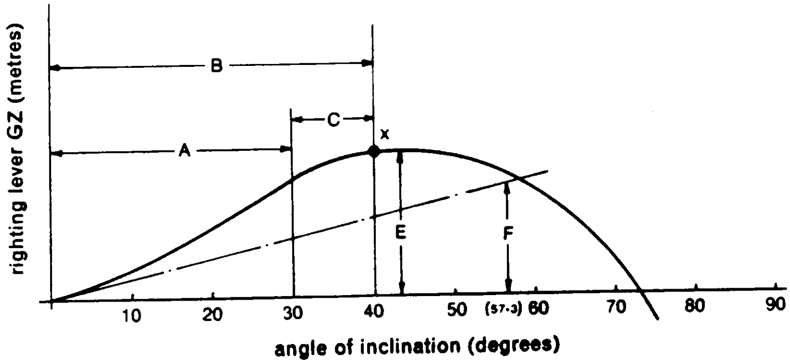


Fig.5.7 Statical Stability Curve (GZ Curve)

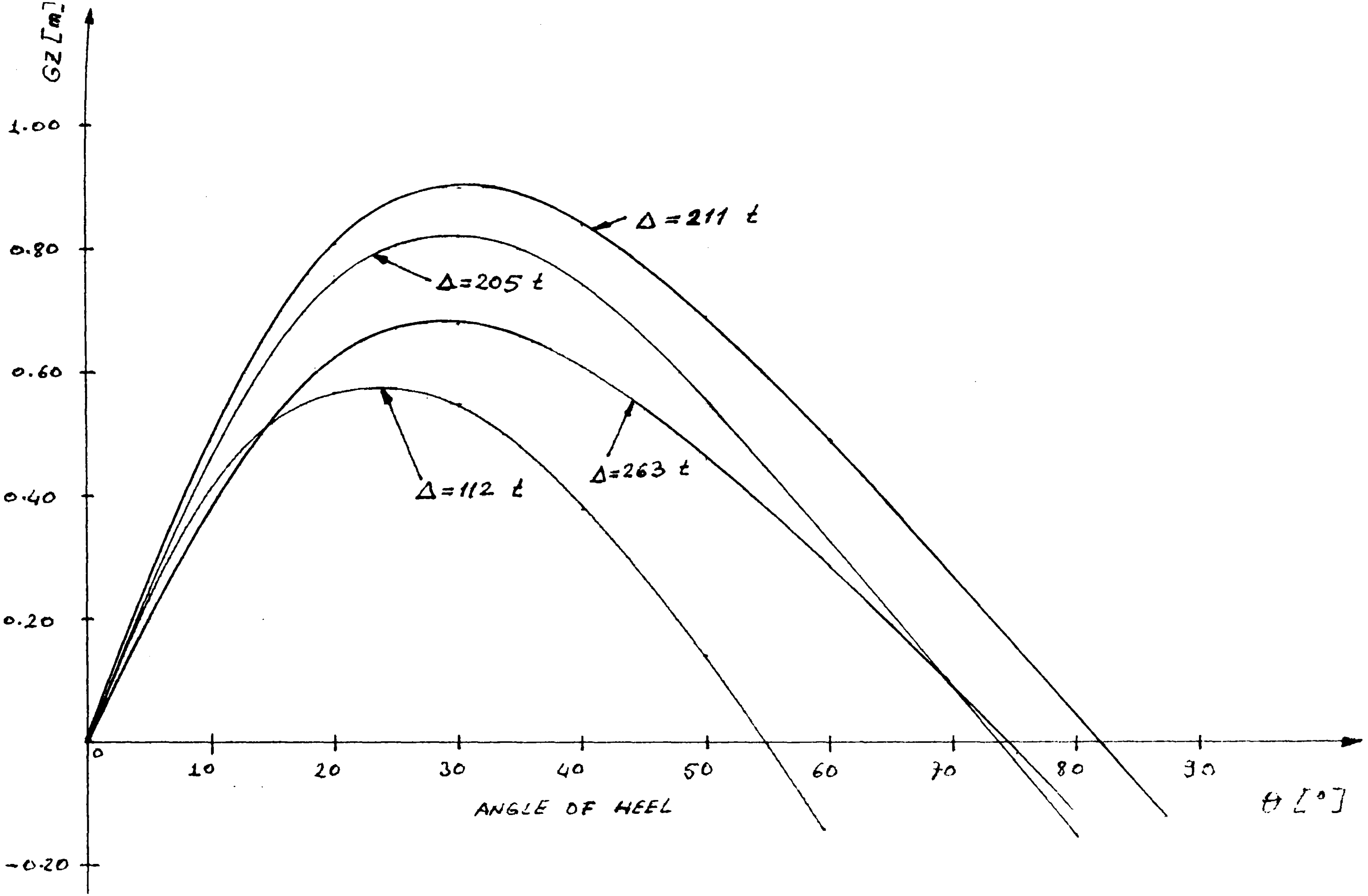
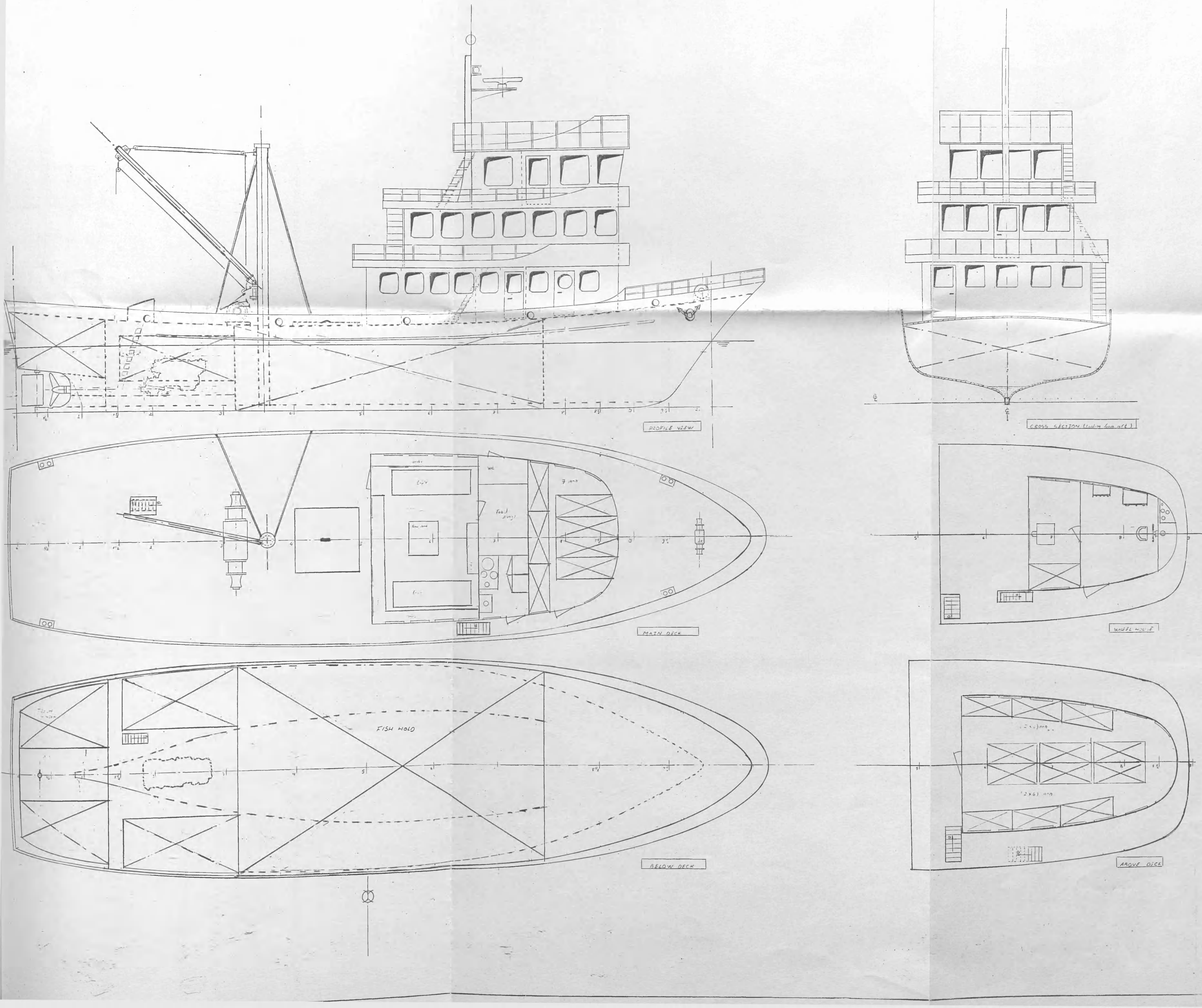


Figure 5.8 Statical stability curves of proposed design



PROPOSED DESIGN 1

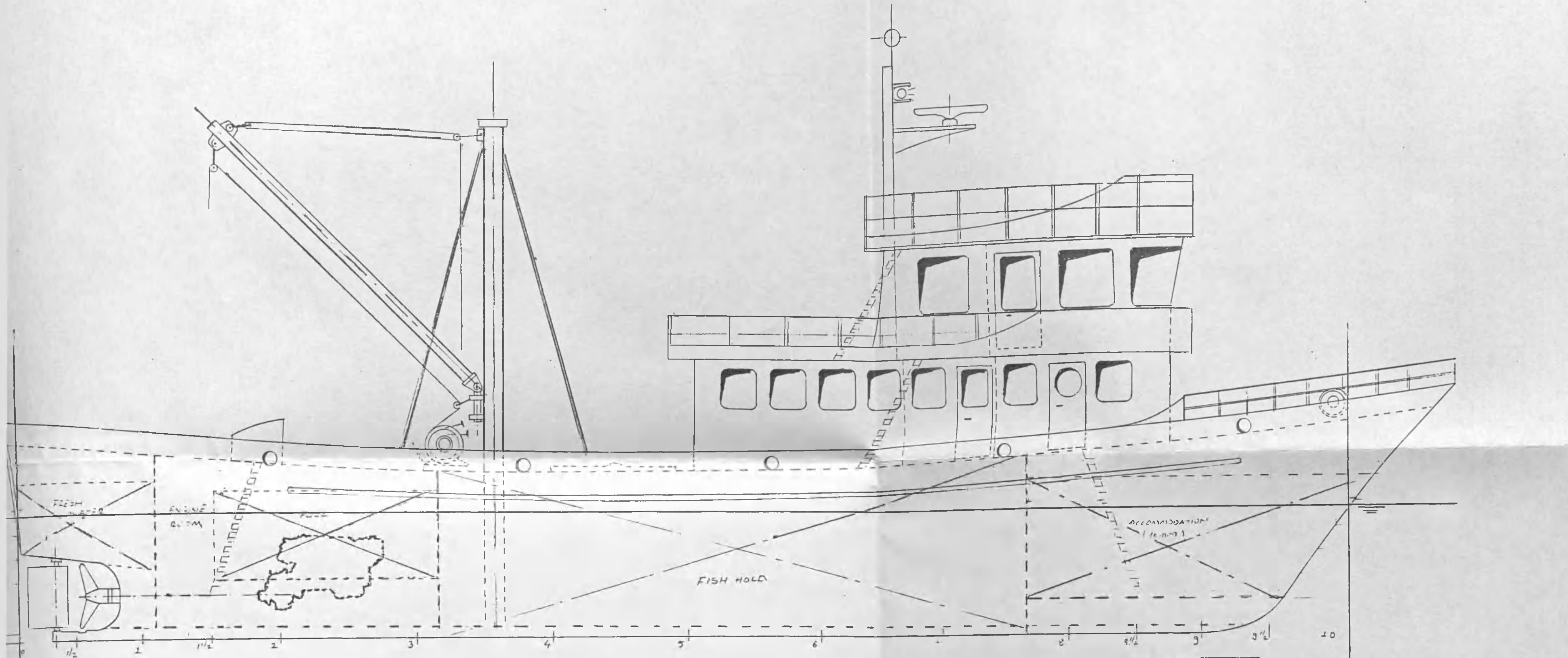
MAIN PARTICULARS

LENGTH OVERALL	30.00m
LENGTH PERPENDICULAR	27.00m
LENGTH WATERLINE	27.45m
BEAM	8.25m
DRAUGHT	~~2.46m~~ 2·36 m
DEPTH	3m
MAIN ENGINE	400HP
DISPLACEMENT	263 tonnes

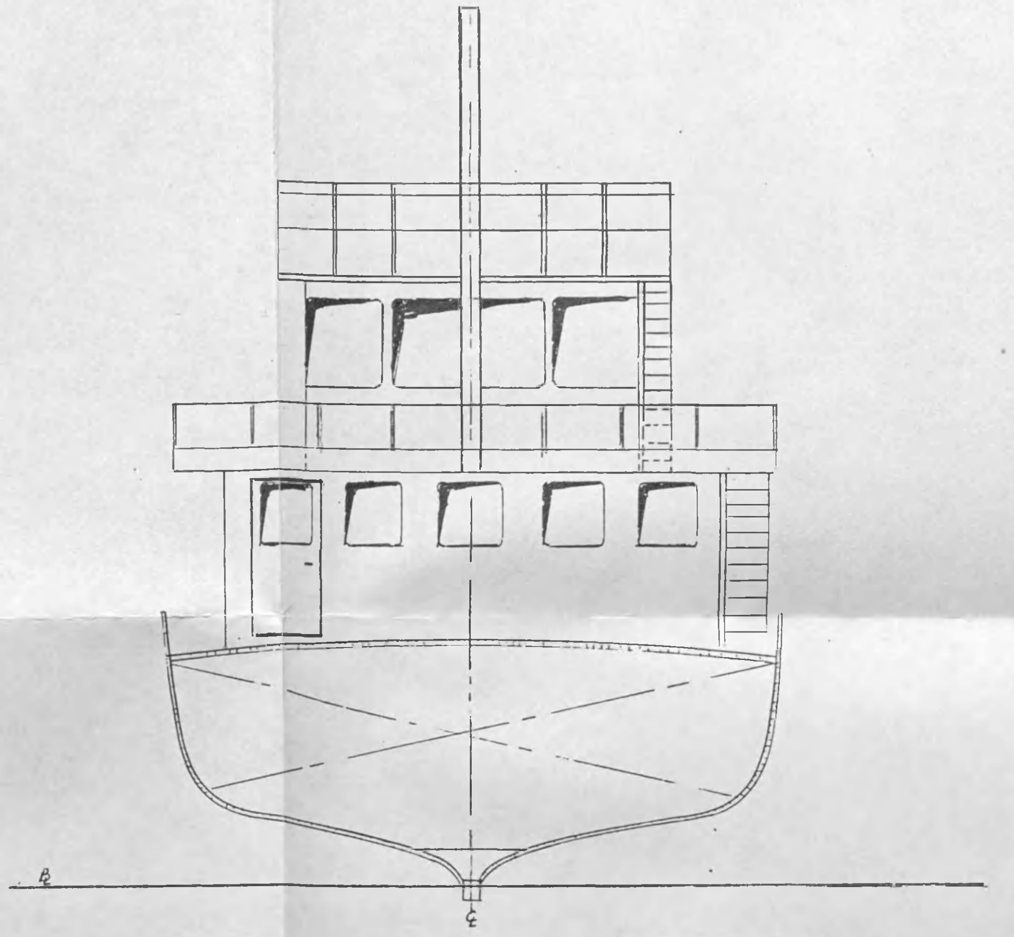
CAPACITIES

FISH HOLD	195 cubic meter
FUEL	30 cubic meter
FRESH WATER	7 cubic meter
ACCOMMODATION	30 men
DURATION	10 days
FUNCTION	Trawler/Seiner
CONSTRUCTION	Steel

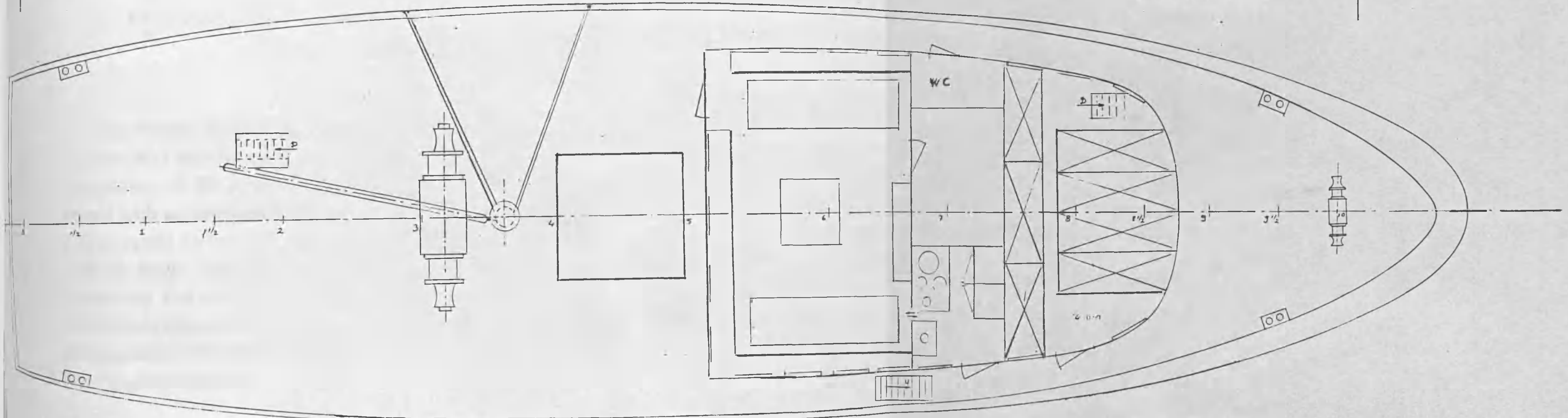
SUPERVISER	Dr.R.M.CAMERON and I.E.WINKLE
RESEARCHER	A.C.DINCER
DATE	28.01.1991 Glasgow
SCALE	1/100



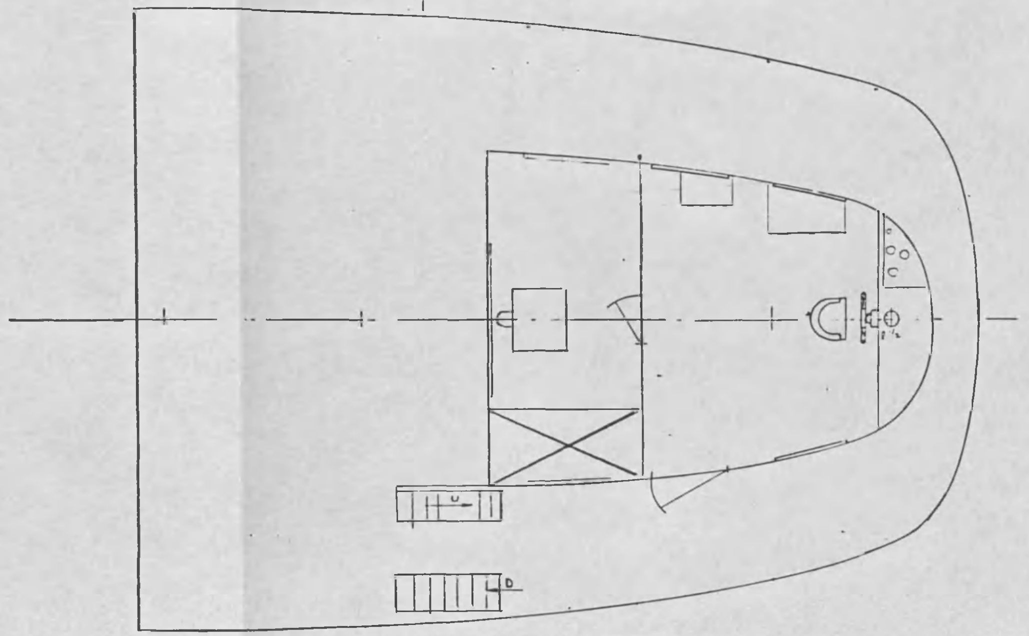
PROFILE VIEW



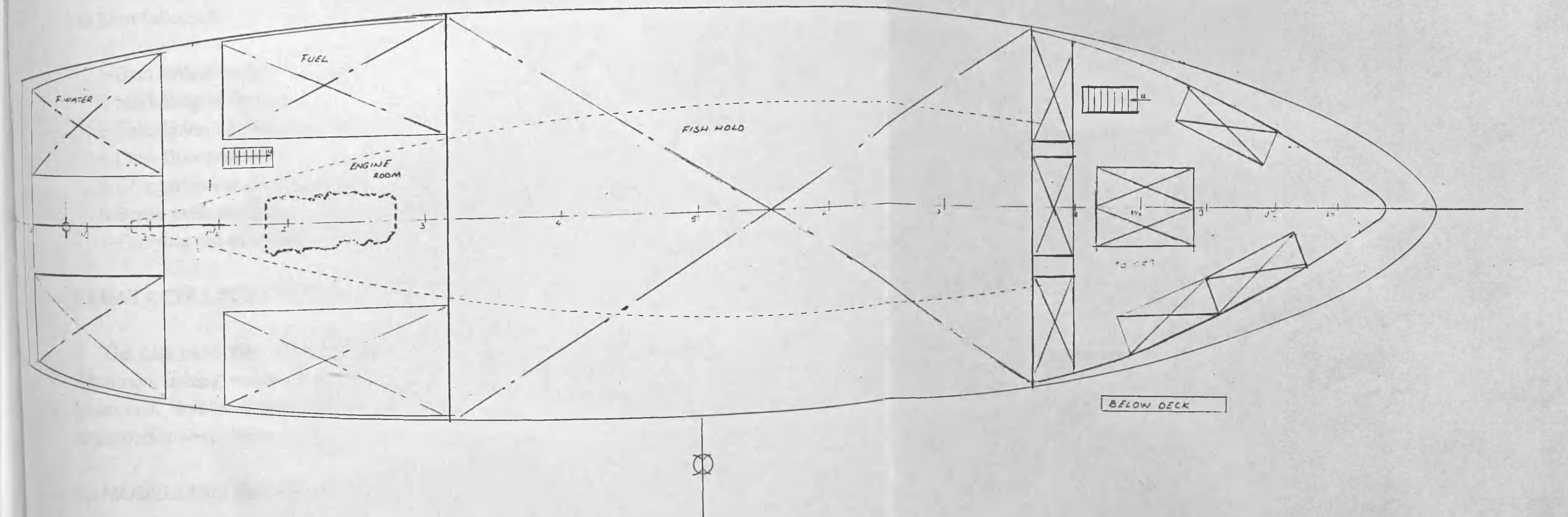
CROSS SECTION



MAIN DECK



WHEEL HOUSE



BELOW DECK

PROPOSED DESIGN 2

MAIN PARTICULARS

LENGTH OVERALL	30.00m
LENGTH PERPENDICULAR	27.00m
LENGTH WATERLINE	27.45m
BEAM	8.25m
DRAUGHT	~~2.34m~~ 2.33 m
DEPTH	3m
MAIN ENGINE	400HP
DISPLACEMENT	257 tonnes

CAPACITIES

FISH HOLD	195 cubic meter
FUEL	30 cubic meter
FRESH WATER	10 cubic meter
ACCOMMODATION	30 men
DURATION	10 days
FUNCTION	Trawler/Seiner
CONSTRUCTION	Steel

SUPERVISER	Dr.R.M.CAMERON and I.E.WINKLE
RESEARCHER	A.C.DINCER
DATE	28.01.1991 Glasgow
SCALE	1/100

CHAPTER 6

ECONOMIC EVALUATION OF PURSE SEINE FISHING VESSELS OF THE BLACK SEA

This chapter deals with techno-economic evaluation of purse seine fishing vessels of Turkey operated in the Black Sea. Then it concentrates on the comparison of the profitabilities of vessels of three different sizes: i) smaller vessel with an auxiliary boat, which largely represent the existing situation, ii) parent vessel on her own, and iii) larger vessel on her own. The smaller vessel and the larger vessels were evaluated from the parent vessel, respectively, shortening and extending the length of parent vessel by 6 meters. All other dimensions assumed to remain unchanged. Furthermore, it has been assumed that all these three vessels are to have the same machinery on board, and same size of fishing gear to operate.

In carrying out the task of techno-economic evaluation, the following strategy has been followed:

1-Data collection from existing fishery
2-Modelling of fishing pattern
3-Calculation of investment cost
4-Cash flow analysis
5-Comparison of profitabilities of vessels
6-Break-even analysis
7-Carrying out sensitivity analysis

6.1 DATA COLLECTION FROM EXISTING FISHERY

The data used throughout this chapter has been collected from a number of fishermen, fishing vessel yards and various organizations of Turkey. It should be mentioned that in some cases where the required data did not exist some assumptions were made.

6.2 MODELLING THE FISHING PATTERN

On the basis of the collected data, fishing for anchovy has been modelled. Anchovy is winter seasonal fish, available at the densest concentration in the period from November to March. It descends during the day to a depth of 70 to

90 meters, and rises during the night to the higher water layers thereby moving toward the coast into depths of 10 to 40 meters. Purse seine is the predominant gear, accounting for 95% of total anchovy catches.

Maximum fishing ground distance has been assumed to be 50 miles out from the shore. Average speed of the vessels has been taken to be 10 knots, and the actual fishing time to be 8 hours (from 8.00pm to 4.00am) per day, and annual fishing days have been assumed to be 100 days, leaving 20 days allowance for unfavourable weather conditions. Furthermore, the average catch rate has been estimated to be 17 tonnes per hour. Vessels may be employed outwith the anchovy season but their primary purpose is to catch anchovies and other off season uses are not considered.

6.3 CALCULATION OF INVESTMENT COST

Investment cost of a fishing vessel may be considered to be comprised of vessel production cost, machinery cost, fishing gear and equipment cost.

Estimating Production Cost:

There is no straightforward formula by which the cost can be immediately found and the more accurate the desired estimate the more detailed will the cost data have to be and a greater breakdown of material and labour costs will be needed. This section looks at the question of cost estimating for steel fishing vessels of the Black Sea type and indicates desirable data collected and application. Cost data will vary considerably from one country to another and within countries, therefore only local knowledge can provide the builder with the final figures to meet his own situation.

Total production cost of the vessel may be broken down into three components:

a) Steel cost
b) Labour cost
c) Overhead cost, which consists of cost of electricity and cost of welding electrodes, and shipyard facilities are general.

In calculating production costs of vessels the following data has been used.The data belongs to year of 1989 and obtained from Sürmene Shipyard, which is the largest fishing vesselyard in Turkey. All calculations have been based on the annual consumption of steel, electricity, and welding electrode.

Number of vessels built in the year	6
Total invoiced steel weight	445 tonnes
Estimated scrap allowance	3%
Net steel weight	432 tonnes
Price of steel	US$ 302/tonne
Number of welding electrodes	37500 units
Price of welding electrode	US$ 0.03/unit
Amount of electricity	130,000 kwh
Price of electricity	US$ 0.04/kwh
Number of workers	40
Number of working days a year	300
Average working hours per day	8
Average cost per manhour	US$ ~~0.04~~ 0.44
Total manhours per year	300×8×40=96,000

Calculation procedure for the consumables and labour is illustrated in Table 6.1. It has been assumed that consumables and labour are proportional to an area function of L×B. Thus the calculation procedure simply consists of evaluation of L×B for each vessel and dividing by the sum. This gives the proportion of total consumable "c" used by each vessel. Multiplication of the proportion "c" by the total amount of consumable (steel weight, electricity, electrode, as well as manhour) in the year gives the amount of consumable used for each vessel. Then the consumables can easily be converted into costs by means of price per consumable.

Since ~~the~~ all the consum~~ptions~~ables were based on L×B , then the costs can be expressed mathematically as a function of L×B. The nature of the function is a straight line. In Fig.6.1, L×B values have been plotted against steel costs, labour costs, overhead costs and the total costs. Fitting a straight line function to those points the following equations have been obtained:

$$C_{ov} = -18.829 + 12.212 \times (L \times B) \qquad (6.1)$$

$$C_{lb} = -46.417 + 31.348 \times (L \times B) \qquad (6.2)$$

$$C_{st} = -142.66 + 96.819 \times (L \times B) \qquad (6.3)$$

$$C_{tot} = -207.91 + 140.38 \times (L \times B) \qquad (6.4)$$

Where,

C_{ov} = overhead cost in US$
C_{lb} = labour cost in US$
C_{st} = Steel cost in US$
C_{tot} = total cost in US$
L=length overall in meters
B=maximum beam in meters.

LxB (mxm)	LxB (m^2)	c	Steel Weig. (tonnes)	Steel Cost (US$)	Manhour	Labour Cost (US$)	No of Electrode	Electrod. Cost (US$)	Electricity (kW/h)	Elect. Cost (US$)	Total Cost (US$)
25x7	175	0.129	55.73	16830	12384	5449	48375	1451	16770	671	24401
26x7	182	0.134	57.89	17482	12864	5660	50250	1508	17420	697	25347
27x8	216	0.159	68.69	20744	15264	6716	59625	1789	20670	827	30075
28x8	224	0.165	71.28	21527	15840	6970	61875	1856	21450	858	31210
30x9	270	0.199	85.97	25962	19104	8406	74625	2239	25870	1035	37642
32x9	288	0.213	92.02	27789	20448	8997	79875	2396	27690	1108	40290
Total	1355	1	432		96000		375000		130000		

LxB (mxm)	LxB (m^2)	Steel Cost (US$)	Labour Cost (US$)	Overh. Cost (US$)	Tot.Prod.Cost (US$)
25x7	175	16830	5449	2122	24401
26x7	182	17482	5660	2204	25346
27x8	216	20744	6716	2616	30076
28x8	224	21527	6970	2714	31211
30x9	270	25962	8406	3274	37642
32x9	288	27789	8997	3504	40290

Table 6.1 Calculation of the production cost

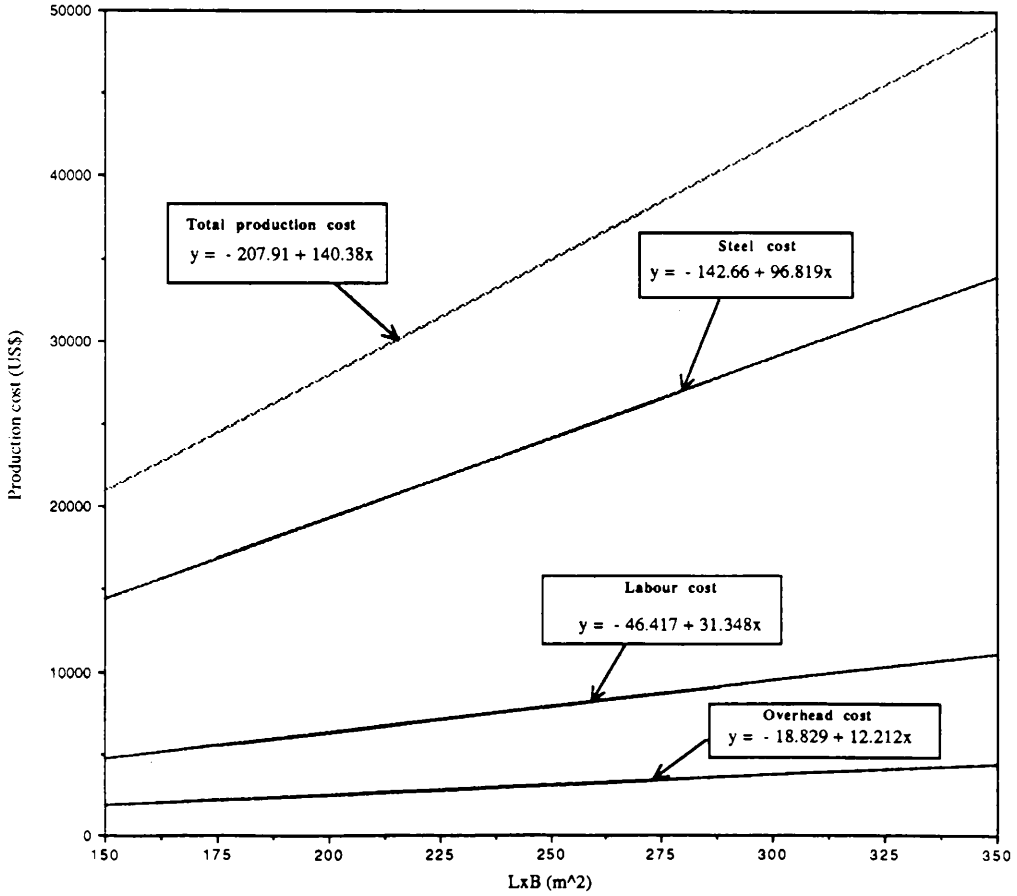


Fig.6.1 Vessel production cost

ITEM	21m *Unit*	 *Cost* (1000US$)	27m *Unit*	 *Cost* (1000US$)	33m *Unit*	 *Cost* (1000US$)
Hull construction		55		69		83
Main engine	350 HP	25	350 HP	25	350 HP	25
Auxiliary generator	50 KW	17	50 KW	17	50 KW	17
Stern gear,safting,propeller		4		4		4
Piping systems, pumps		1		2		2
Steering system		2		2		3
Electrics		1		2		2
Deck equipment		5		5		5
Navigation&fish finding equip.		15		15		15
Miscelaneous		1		1		1
Vessel cost		**126**		**142**		**157**
Net	350*600 fath	15	350*600 fath	15	350*600 fath	15
Skiff	120 HP	10		10		10
Total investment		**151**		**167**		**182**
Dimensions (LxBxD)	594		743		891	
Fish hold capacity (tonnes)	44.8		92.2		136	

Table 6.2 Calculation of the investment cost of vessels of 350HP

Total production cost may then be calculated from equation (6.4). It has been estimated that the builder sells the vessel at 100% profit to fisherman.That is the cost included in investment cost. It should however be mentioned that the above formulas are valid only for areas of 150 to 350 square meters of L×B.

Calculation of total investment cost for three vessels of different size are illustrated in Table 6.2. It should be noticed that all vessels are assumed to operate the same size of gear.

6.4 CASH FLOW ANALYSIS

Every investment is undertaken in order to produce a product or provide a service that translates to annual sales. After all annual costs and taxes have been deducted, the remainder, including depreciation, is called cash flow, and cash flow minus depreciation is called net cash flow. The procedure is illustrated in Table 6.4. It would be useful to explain briefly some of its components. Investment and operating costs of auxiliary boat are shown in Table 6.5.

6.4.1 Fish Revenues

Forecasting future revenues from fishing is more difficult than estimation of cost. Fishing is inherently uncertain and the price for fish fluctuates. In the analysis carried out it has been assumed that on average all vessels return to port with their fish hold half full and that the fish price is US$0.12/kg. Different assumptions and the inclusion of probabilities would produce different results.

In good fishing conditions at the assumed catching rate of 17 tonnes/hour the 33 m vessel could fill her hold in the 8 hours allowed on the grounds. A still larger vessel would need more time fishing while the smaller vessels would return to port within the 8 hour period. Application of probability to the amount of fish caught in 8 hours would change the relative merits of the boats studied.

6.4.2.Fuel Costs

Fuel consumption may be calculated taking the daily consumption and required number of days to be spent by the vessel at sea. Although during fishing operations the full power of the engine is not necessarily used, it is customary to make calculations taking full power and appropriate consumption rate for the whole trip into consideration. For preliminary purposes a consumption of 0.28 lt/kW/hr may be estimated for diesel installations. Average fuel price being assumed as US$ 0.50/lt, the annual fuel cost may be calculated:

$$C_{fuel}=0.28\times P_B\times N\times 0.5$$

$$C_{fuel}=0.14\times P_B\times N \qquad (6.5)$$

Where,

C_{fuel} is the annual fuel cost in US$

P_B is the brake power in kW

N is the number of annual running hours=18x100=1800 hours (18 hr/day assumed. For auxiliary boat 10 hr/day assumed)

6.4.3 Lubrication Oil Cost

It has been assumed to be 5% of fuel cost

6.4.4 Insurance

The cost of insurance has taken to be 5% of vessel cost

6.4.5 Crew Salary

Crew salary is directly proportional to catch revenue. Although there is no certain data of what the actual proportion is, in this study it has been assumed to be 25%.

6.4.6 Cost of Ice

Weight of ice can be taken 50% of fish weight. Ice price has been taken to be US$ 30 per tonne of ice.

6.4.7 Cost of Repair and Maintenance

Cost estimate of repair and maintenance has been based on the following break-down units as a percentage of cost new:

Hull	8%
Engine	7%
Deck machinery and equipment	7%
Fishing gear	50%

6.4.8 Depreciation

A capital asset such as a plant or a piece of equipment, loses its initial value over time due to physical deterioration and technological obsolescence. This gradual loss of an asset's value is called "depreciation". In accounting, depreciation is treated as an annual expense, and is charged against earnings before taxes during useful life of the asset. When an asset has been fully depreciated, its initial cost is reported as having been fully recovered. However this concept ignores the change of value due to inflation.

The simplest method of calculating the depreciation is the straight-line method, which divides the initial cost of the asset by the number of years of its estimated life. In our cash flow, the depreciation has been taken to be 10% of vessel cost new each year.

6.4.9 Average Cost of Capital

The interest rate used to discount the cash flow of a project is the key variable of a project's acceptability. That rate is the cost of capital. In general, the cost of capital is said to be comprised of the costs of the various types of financing that a company uses for its long-term capital investments.

In Turkey, fishermen are supported by the Agricultural Bank of Turkey, from where they can get a loan of 60% of their investment costs. The conditions of the loan and the pay-back procedure are illustrated in Table 6.3. As can be seen from this table, the interest rate is 43%, and in the first year there is no interest charged. The rest of the capital borrowed is to be paid back in five years time with five equal instalments based on the amount of total capital borrowed.

Average cost of capital is the average amount of interest paid during the pay-back. If Table 6.3 is systematized mathematically, average cost of capital comes out to be 10.2% of the investment cost approximately for this particular type of loan procedure.

YEAR	INVC=196 (21m vessel+ auxiliary boat) LOAN=0.60x INVC=117.6				INVC=167 (27m vessel) LOAN=0.60x INVC=100.2				INVC=182 (33m vessel) LOAN=0.60x INVC=109.2			
	Uncovered balance beginning of the year	Equal installments	Interest 43%	Uncovered balance at the end of the year	Uncovered balance beginning of the year	Equal installments	Interest 43%	Uncovered balance at the end of the year	Uncovered balance beginning of the year	Equal installments	Interest 43%	Uncovered balance at the end of the year
0	117.60	-	-	117.60	100.20	-	-	100.20	109.20	-	-	109.20
1	117.60	23.52	-	94.08	100.20	20.04	-	80.16	109.20	21.84	-	87.36
2	94.08	23.52	40.45	70.56	80.16	20.04	34.47	60.12	87.36	21.84	37.56	65.52
3	70.56	23.52	30.34	47.04	60.12	20.04	25.85	40.08	65.52	21.84	28.17	43.68
4	47.04	23.52	20.23	23.52	40.08	20.04	17.23	20.04	43.68	21.84	18.78	21.84
5	23.52	23.52	10.11	0.00	20.04	20.04	8.62	0.00	21.84	21.84	9.39	0.00
Average cost of capital			20.23				17.23				18.78	

Table 6.3 Bank loan procedure

	21m+Aux.	27m	33m
	(1000US$)	(1000US$)	(1000US$)
Cash inflow:			
Fish revenues	564.00	552.00	816.00
Cash outflow:			
Investment cost	196.00	167.00	182.00
Operating cost:			
Fuel-main	95.00	66.00	66.00
Fuel-auxiliary	15.00	15.00	15.00
Lube oil (5% of fuel cost)	5.00	3.00	3.00
Skiff operation	13.00	13.00	13.00
Provisions	4.00	4.00	4.00
Ice	47.00	46.00	72.00
Average cost of capital	20.00	17.00	19.00
Insurance (5% Of vessel cost)	8.00	7.00	8.00
Repair & maintenance	17.00	15.00	16.00
Crew salary (25% of catch)	141.00	138.00	204.00
Miscellaneous (10% of op. costs)	34.00	30.00	39.00
Total operating costs	399.00	354.00	459.00
Earnings	165.00	198.00	357.00
Depreciation (10% of vessel cost)	18.00	14.00	16.00
Earnings before taxes	147.00	184.00	341.00
Taxes (30%)	44.10	55.20	102.30
Net cash flow	102.90	128.80	238.70

Table 6.4 Cash flow estimate of 350HP vessels for base catch rate

Particulars of the auxiliary boat:

L=16m
B=5.5m
D=2.8m
T=2.3m
C_B=0.42
Fish capacity=50 tonne
Cubic Number=243

Item	Unit	Costs (1000US$)
Investment cost:		
Hull construction		25
Main engine	272 HP	14
Equipment		5
Miscellaneous		1
Investment cost:		**45**
Operating costs:		
Fuel		29
Lubrication (5 % Of fuel)		2
Ice (12.5t/day at 20 US$/t)		25
Depreciation (10 % of vessel cost)		5
Insurance (5 % Of vessel cost)		2
Repair&Maintenance		3
Miscellaneous (10 % of operating costs)		7
Total operating costs:		**73**

Table 6.5 Investment and operating cost of auxiliary boat

			21m+Aux. vessels			
Year	0	1	2	3	4	5
Earnings	-196	247.50	371.25	556.88	835.31	1252.97
Depreciation	-	18.00	18.00	18.00	18.00	18.00
EBT	-	229.50	353.25	538.88	817.31	1234.97
Taxes (25%)	-	57.38	88.31	134.72	204.33	308.74
NCF	-196	172.13	264.94	404.16	612.98	926.23
PVNCF	**-196**	**114.67**	**117.75**	**119.75**	**121.08**	**121.97**

			27m vessel			
Year	0	1	2	3	4	5
Earnings	-167	297.00	445.50	668.25	1002.38	1503.56
Depreciation	-	14.00	14.00	14.00	14.00	14.00
EBT	-	283.00	431.50	654.25	988.38	1489.56
Taxes (25%)	-	70.75	107.88	163.56	247.10	372.39
NCF	-167	212.25	323.63	490.69	741.29	1117.17
PVNCF	**-167**	**141.5**	**143.84**	**145.39**	**146.43**	**147.12**

			33m vessel			
Year	0	1	2	3	4	5
Earnings	-182	535.50	803.25	1204.88	1807.31	2710.97
Depreciation	-	16.00	16.00	16.00	16.00	16.00
EBT	-	519.50	787.25	1188.88	1791.31	2694.97
Taxes (25%)	-	129.88	196.81	297.22	447.83	673.74
NCF	-182	389.63	590.44	891.66	1343.48	2021.23
PVNCF	**-182**	**259.75**	**262.42**	**264.20**	**265.38**	**266.17**

Average rate of inflation: 50%

Table 6.6 Effect of inflation on cash flow of 350HP vessels for base catch rate

6.4.10 Impact of Inflation on Cash Flow

When discounting cash flows, the interest rate is usually stated in nominal terms. Therefore cash flow should be estimated in future current dollars, reflecting the rising trend in prices and costs embodied in the forecasted values of the sales and operating costs.

The required computation for the annual cash flow of this project is shown in Table 6.6. It was assumed that the expected rate of the annual inflation will be 50% per year, in the next five years, and the inflation rate will be the same for both sales and costs. As it was mentioned previously that depreciation does not increase with inflation, because it is based on the original cost of the investment under current tax laws.

Coming back to Table 6.6, it can be noticed that at the end of the first year the earnings will be US$ $165\times(1+0.50)^1$=US$ 247.5; in the second year US$ $165\times(1+0.50)^2$=US$ 371.25; and so on. After calculating the inflated cash flows, by inverse process they were brought back to their present values, abbreviated as PVNCF (present value of net cash flow) in the same table. It can be seen that the cash flows are larger than those in Table 6.4.

6.5.COMPARISON OF PROFITABILITIES OF VESSELS

In order to decide whether an investment should be undertaken or whether one particular investment should be preferred to another, one needs to have some kind of tool or measure for evaluation. In the literature on investment theory, there are several tools for decision making on investments.Perhaps the method most widely used by engineers and business managers in evaluating capital projects is the ***internal rate of return method***, commonly known as IRR.

6.5.1 Internal Rate of Return (IRR) Method

The internal rate of return method is based on discounted cash flow. This method calculates the interest rate at which the Net Present Value is zero. If this rate is above normal interest rates on investments then the project is satisfactory, if below the project unsatisfactory. Of course the risk must also be assessed and is generally allowed for by an increase of required interest rate of return above interest rates such as saving accounts where little risk exists.

21m+ Aux. Boat

Year	Net cash	Present Value factors		Present Value	
	Flow	50%	55%	50%	55%
0	-196.00	1.000	1.000	-196.00	-196.00
1	114.67	0.667	0.645	76.48	73.96
2	117.75	0.444	0.416	52.28	48.98
3	119.75	0.296	0.269	35.45	32.21
4	121.08	0.198	0.173	23.97	20.95
5	121.97	0.132	0.112	16.10	13.66
NPV				8.29	-6.23
IRR=	53%				

27m Boat

Year	Net cash	Present Value factors		Present Value	
	Flow	80%	85%	80%	85%
0	-167.00	1.000	1.000	-167.00	-167.00
1	141.50	0.556	0.541	78.67	76.55
2	143.84	0.309	0.292	44.45	42.00
3	145.39	0.171	0.158	24.86	22.97
4	146.43	0.095	0.085	13.91	12.45
5	147.12	0.053	0.046	7.80	6.77
NPV				2.69	-6.26
IRR=	82%				

33m Boat

Year	Net cash	Present Value factors		Present Value	
	Flow	140%	145%	140%	145%
0	-182.00	1.000	1.000	-182.00	-182.00
1	259.75	0.417	0.408	108.32	105.98
2	262.42	0.174	0.167	45.66	43.82
3	264.20	0.072	0.068	19.02	17.97
4	265.38	0.030	0.028	7.96	7.43
5	266.17	0.013	0.011	3.46	2.93
NPV				2.42	-3.87
IRR=	142%				

Table 6.7 Calculation of IRR of 350HP vessels for base catch rate

6.5.2 Calculation of Internal rate of Return

The internal rate of return is calculated from the net cash flow of the project, expenses being regarded as negative items and revenues as positive. There is some unique rate of interest at which the algebraic sum of the discounted value is zero, and this is the internal rate of return. To find the appropriate rate of return is rather a trial and error process. this calculations are easily performed with a spreadsheet on a microcomputer. If we calculate for a rate of return at which the residual sum is positive, the true rate will be higher, since the series has to be more heavily discounted, and we can calculate again for a higher rate. If the sum now is negative, the true IRR can be found by interpolation. It is necessary to say that since the relationship between the rate of return and discounted factor is not linear, but curvilinear, there is an interpolation error, but this will be negligible if the two trial rates of interest are not more than 5% apart. The illustration of such a calculation is given in Table 6.7. From this table it can be seen that the IRR is largest for the 33m vessel, thus making her more economical than the other two vessels.

6.6.BREAK-EVEN ANALYSIS

As a complementary tool or measure for fishing vessel calculations, a so-called *break-even analysis* may be applied. Instead of trying to quantify in money term the risk embodied in, for example, the fish revenue factor, the potential investor may ask the question: what is the minimum catch needed, other factors unchanged for a given fishing boat to break even? Or, if the price of fish is considered the factor most in doubt, the investor may ask what is the minimum price needed with the given catch rate, cost of capital, crew share, etc, not to incur a loss? After having calculated the various minimum values, the investor will generally be in a position to judge whether the "safety margin" (the difference between the assumed realistic catch and the minimum catch) is large enough to make the investment worthwhile.

Break-even analysis disregards the time value of effect of money and takes only account of costs and earnings for one period (typically one year) of the service life of the investment. The essential feature about the break-even calculation is that it differentiates between fixed costs (usually depreciation, interest on capital, maintenance) which are incurred by the vessel owner regardless of the size of the fishing efforts and variable costs (usually cost of fuel, lubricants, ice) which tend to vary directly in proportion to the length of fishing operations.

	21m+Aux. Boats	27m Boat	33m Boat
	(US$ 000)	(US$ 000)	(US$ 000)
Fish Revenues	564	552	816
Annual fixed costs:			
Provisions	4.00	4.00	4.00
Depreciations	18.00	14.00	16.00
Average cost of capital	20.00	17.00	19.00
Insurance	8.00	7.00	8.00
Maintenance&Repair	17.00	15.00	16.00
Total fixed costs:	**67.00**	**57.00**	**63.00**
Annual variable costs:			
Fuel-main	95.00	66.00	66.00
Fuel-auxiliary	15.00	15.00	15.00
Lube oil	5.00	3.00	3.00
Skiff operation	13.00	13.00	13.00
Ice	47.00	46.00	72.00
Crew salary	141.00	138.00	204.00
Miscellaneous	34.00	30.00	39.00
Taxes	44.10	55.20	102.30
Total variable costs	**394.1**	**366.2**	**514.3**
Total costs	**461.1**	**423.2**	**577.3**
Net profit	**102.9**	**128.8**	**238.7**

Table 6.8 Break-even analysis for 350HP vessels

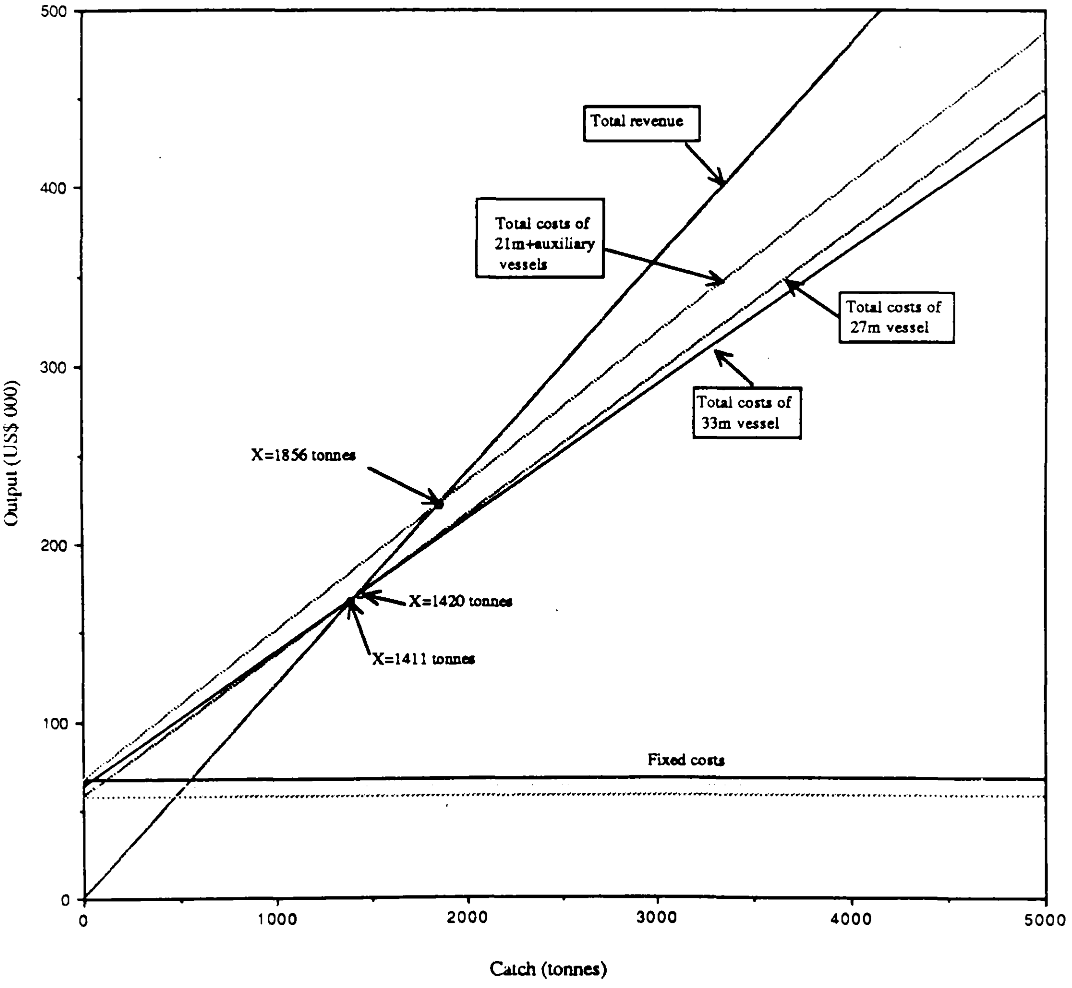


Fig.6.2 Break-even diagram for 350Hp vessels

Calculation of fixed costs, variable costs and total costs and revenues for the vessels under investigation is illustrated in Table 6.8. If total revenues and total costs are expressed as a function of common variable X, which in our case is the catch rate, break-even point may then be found mathematically by equalising the functions to each other since the break- even is the intersection point of the two functions.

Total revenues and total costs may be expressed by the following linear equations:

$TR=A.X$ (6.6

$TC=FC+V.X$ (6.7)

Where A is the fish price, FC is the total fixed cost per year, X is the value of common independent variable per year, and V is the average variable cost per unit of X. In Fig.6.2, total revenues and total costs of each vessel are shown graphically. Returning the calculation of the break-even points for each vessel it can be written:

For for 21m+auxiliary vessels;

$0.12X=67+0.0839X$

$X=1856$ tonnes

For the 27m vessel;

$0.12X=57+0.0796X$

$X=1411$ tonnes

For the 33m vessel;

$0.12X=63+0.0756X$

$X=1420$ tonnes

As can be seen from the above calculations that the break-even ~~volume~~ catch for the 21m+aux. vessels is 1856 tonnes per year. This corresponds to 39% of the assumed annual catch (4700 tonnes). For the 27 m vessel the break-even catch is 1411 tonnes and it corresponds to 31% of the assumed annual catch (4600 tonnes), and for the 33m vessel the break-even catch is 1420 tonnes and it corresponds to 21% of the assumed annual catch (6800 tonnes). The" safety margin" (the difference between the assumed realistic catch and the break-even catch) is therefore largest for the 33 vessel, thus confirming the higher profitability of this vessel.

6.7 CARRYING OUT SENSITIVITY ANALYSIS

6.7.1 Effect of Annual Catch Variation on Internal Rate of Return

For fishing vessel investments, annual catch is perhaps the single most important variable influencing relative profitability.

To apply sensitivity analysis to our vessels, the annual catch rate (base catch rate) has been increased and decreased by 20%, and all other input data unchanged. To find the IRR of these vessels, the procedure explained in the previous section has been repeated for both the 20% increased catch rate and the 20% decreased catch rate, and the process associated with those calculations involved are covered from Table 6.9 to Table 6.14.

For a comparison purpose, the IRR of these vessels for the three various annual catch rates (base case, +20%, -20%) are presented in Table 6.15. In addition, in Fig.6.3, the values of the IRR of these vessels have been plotted in a diagram as a function of vessel size (CUNO). In the same diagram the impact of changes in the annual catch rates (±20%) has also been indicated. As can be seen from this figure, 20% change in the annual catch rate has caused an average change in the IRR of these vessels by about 50% in the same direction of change, either increase or decrease.It should also be noticed from Table 6.15 that the effect of change in the annual catch rate on the IRR is the smallest for the 33m vessel, thus making this vessel less sensitive against the catch rate change than the other vessels.

	21m+Aux.	27m	33m
	(1000US$)	(1000US$)	(1000US$)
Cash inflow:			
Fish revenues	677.00	662.00	979.00
Cash outflow:			
Investment cost	196.00	167.00	182.00
Operating cost:			
Fuel-main	95.00	66.00	66.00
Fuel-auxiliary	15.00	15.00	15.00
Lube oil (5% of fuel cost)	5.00	3.00	3.00
Skiff operation	13.00	13.00	13.00
Provisions	4.00	4.00	4.00
Ice	47.00	46.00	72.00
Average cost of capital	20.00	17.00	19.00
Insurance (5% Of vessel cost)	8.00	7.00	8.00
Repair & maintenance	17.00	15.00	16.00
Crew salary (25% of catch)	169.25	165.50	244.75
Miscellaneous (10% of op. costs)	34.00	30.00	39.00
Total operating costs	427.25	381.50	499.75
Earnings	249.75	280.50	479.25
Depreciation (10% of vessel cost)	18.00	14.00	16.00
Earnings before taxes	231.75	266.50	463.25
Taxes (30%)	69.53	79.95	138.98
Net cash flow	162.23	186.55	324.28

Table 6.9 Cash flow estimate of 350HP vessels for 20% increased catch rate

			21m+Aux. vessels			
Year	0	1	2	3	4	5
Earnings	-196	374.63	561.94	842.91	1264.36	1896.54
Depreciation	-	18.00	18.00	18.00	18.00	18.00
EBT	-	356.63	543.94	824.91	1246.36	1878.54
Taxes (25%)	-	89.16	135.99	206.23	311.59	469.64
NCF	-196	267.47	407.96	618.68	934.77	1408.91
PVNCF	**-196**	**178.31**	**181.32**	**183.31**	**184.65**	**185.54**

			27m vessel			
Year	0	1	2	3	4	5
Earnings	-167	420.75	631.13	946.69	1420.03	2130.05
Depreciation	-	14.00	14.00	14.00	14.00	14.00
EBT	-	406.75	617.13	932.69	1406.03	2116.05
Taxes (25%)	-	101.69	154.28	233.17	351.51	529.01
NCF	-167	305.06	462.85	699.52	1054.52	1587.04
PVNCF	**-167**	**203.37**	**205.71**	**207.27**	**208.30**	**208.99**

			33m vessel			
Year	0	1	2	3	4	5
Earnings	-182	718.88	1078.31	1617.47	2426.20	3639.30
Depreciation	-	16.00	16.00	16.00	16.00	16.00
EBT	-	702.88	1062.31	1601.47	2410.20	3623.30
Taxes (25%)	-	175.72	265.58	400.37	602.55	905.83
NCF	-182	527.16	796.73	1201.10	1807.65	2717.48
PVNCF	**-182**	**351.44**	**354.10**	**355.88**	**357.07**	**357.86**

Average rate of inflation: 50%

Table 6.10 Effect of inflation on cash flow of 350HP vessels for 20% increased catch rate

21m+ Aux. Boat

Year	Net cash Flow	Present Value factors		Present Value	
		85%	90%	85%	90%
0	-196.00	1.000	1.000	-196.00	-196.00
1	178.31	0.541	0.526	96.47	93.79
2	181.32	0.292	0.277	52.95	50.23
3	183.31	0.158	0.146	28.96	26.76
4	184.65	0.085	0.077	15.70	14.22
5	185.54	0.046	0.040	8.53	7.42
NPV				6.60	-3.58
IRR=	88%				

27m Boat

Year	Net cash Flow	Present Value factors		Present Value	
		120%	125%	120%	125%
0	-167.00	1.000	1.000	-167.00	-167.00
1	203.37	0.455	0.444	92.53	90.30
2	205.71	0.207	0.198	42.58	40.73
3	207.27	0.094	0.088	19.48	18.24
4	208.30	0.043	0.039	8.96	8.12
5	208.99	0.019	0.017	3.97	3.55
NPV				0.53	-6.06
IRR=	120%				

33m Boat

Year	Net cash Flow	Present Value factors		Present Value	
		195%	200%	195%	200%
0	-182.00	1.000	1.000	-182.00	-182.00
1	351.44	0.345	0.333	121.25	117.03
2	354.10	0.119	0.111	42.14	39.31
3	355.88	0.041	0.037	14.59	13.17
4	357.07	0.014	0.012	5.00	4.28
5	357.86	0.005	0.004	1.79	1.43
NPV				2.76	-6.78
IRR=	196%				

Table 6.11 Calculation of IRR of 350HP vessels for 20% increased catch rate

	21m+Aux.	27m	33m
	(1000US$)	(1000US$)	(1000US$)
Cash inflow:			
Fish revenues	451.00	442.00	653.00
Cash outflow:			
Investment cost	196.00	167.00	182.00
Operating cost:			
Fuel-main	95.00	66.00	66.00
Fuel-auxiliary	15.00	15.00	15.00
Lube oil (5% of fuel cost)	5.00	3.00	3.00
Skiff operation	13.00	13.00	13.00
Provisions	4.00	4.00	4.00
Ice	47.00	46.00	72.00
Average cost of capital	20.00	17.00	19.00
Insurance (5% Of vessel cost)	8.00	7.00	8.00
Repair & maintenance	17.00	15.00	16.00
Crew salary (25% of catch)	112.75	110.50	163.25
Miscellaneous (10% of op. costs)	34.00	30.00	39.00
Total operating costs	370.75	326.50	418.25
Earnings	80.25	115.50	234.75
Depreciation (10% of vessel cost)	18.00	14.00	16.00
Earnings before taxes	62.25	101.50	218.75
Taxes (30%)	18.68	30.45	65.63
Net cash flow	43.58	71.05	153.13

Table 6.12 Cash flow estimate of 350HP vessels for 20% decreased catch rate

			21m+Aux. vessels			
Year	0	1	2	3	4	5
Earnings	-196	120.38	180.56	270.84	406.27	609.40
Depreciation	-	18.00	18.00	18.00	18.00	18.00
EBT	-	102.38	162.56	252.84	388.27	591.40
Taxes (25%)	-	25.60	40.64	63.21	97.07	147.85
NCF	-196	76.79	121.92	189.63	291.20	443.55
PVNCF	**-196**	**51.19**	**54.19**	**56.19**	**57.52**	**58.41**

			27m vessel			
Year	0	1	2	3	4	5
Earnings	-167	173.25	259.88	389.81	584.72	877.08
Depreciation	-	14.00	14.00	14.00	14.00	14.00
EBT	-	159.25	245.88	375.81	570.72	863.08
Taxes (25%)	-	39.81	61.47	93.95	142.68	215.77
NCF	-167	119.44	184.41	281.86	428.04	647.31
PVNCF	**-167**	**79.63**	**81.96**	**83.51**	**84.55**	**85.24**

			33m vessel			
Year	0	1	2	3	4	5
Earnings	-182	352.13	528.19	792.28	1188.42	1782.63
Depreciation	-	16.00	16.00	16.00	16.00	16.00
EBT	-	336.13	512.19	776.28	1172.42	1766.63
Taxes (25%)	-	84.03	128.05	194.07	293.11	441.66
NCF	-182	252.10	384.14	582.21	879.32	1324.97
PVNCF	**-182**	**168.07**	**170.73**	**172.51**	**173.69**	**174.48**

Average rate of inflation: 50%

Table 6.13 Effect of inflation on cash flow of 350HP vessels for 20% decreased catch rate

21m+ Aux. Boat

Year	Net cash Flow	Present Value factors		Present Value	
		10%	15%	10%	15%
0	-196.00	1.000	1.000	-196.00	-196.00
1	51.19	0.909	0.870	46.53	44.54
2	54.19	0.826	0.756	44.76	40.97
3	56.19	0.751	0.658	42.20	36.97
4	57.52	0.683	0.572	39.29	32.90
5	58.41	0.621	0.497	36.27	29.03
NPV				13.05	-11.59
IRR=	13%				

27m Boat

Year	Net cash Flow	Present Value factors		Present Value	
		35%	40%	35%	40%
0	-167.00	1.000	1.000	-167.00	-167.00
1	79.63	0.741	0.714	59.01	56.86
2	81.96	0.549	0.510	45.00	41.80
3	83.51	0.406	0.364	33.91	30.40
4	84.55	0.301	0.260	25.45	21.98
5	85.24	0.223	0.186	19.01	15.85
NPV				15.37	-0.11
IRR=	40%				

33m Boat

Year	Net cash Flow	Present Value factors		Present Value	
		85%	90%	85%	90%
0	-182.00	1.000	1.000	-182.00	-182.00
1	168.07	0.541	0.526	90.93	88.40
2	170.73	0.292	0.277	49.85	47.29
3	172.51	0.158	0.146	27.26	25.19
4	173.69	0.085	0.077	14.76	13.37
5	174.48	0.046	0.040	8.03	6.98
NPV				8.83	-0.76
IRR=	90%				

Table 6.14 Calculation of IRR of 350HP vessels for 20% decreased catch rate

Vessel size	CUNO (m^3)	Internal rate of return (%)		
		-20%	Base case	20%
27m	743	40	82	120
21m+aux.	837	13	53	88
33m	891	90	142	196

Table 6.15 Comparison of the IRR of 350HP vessels for ∓20% catch rate

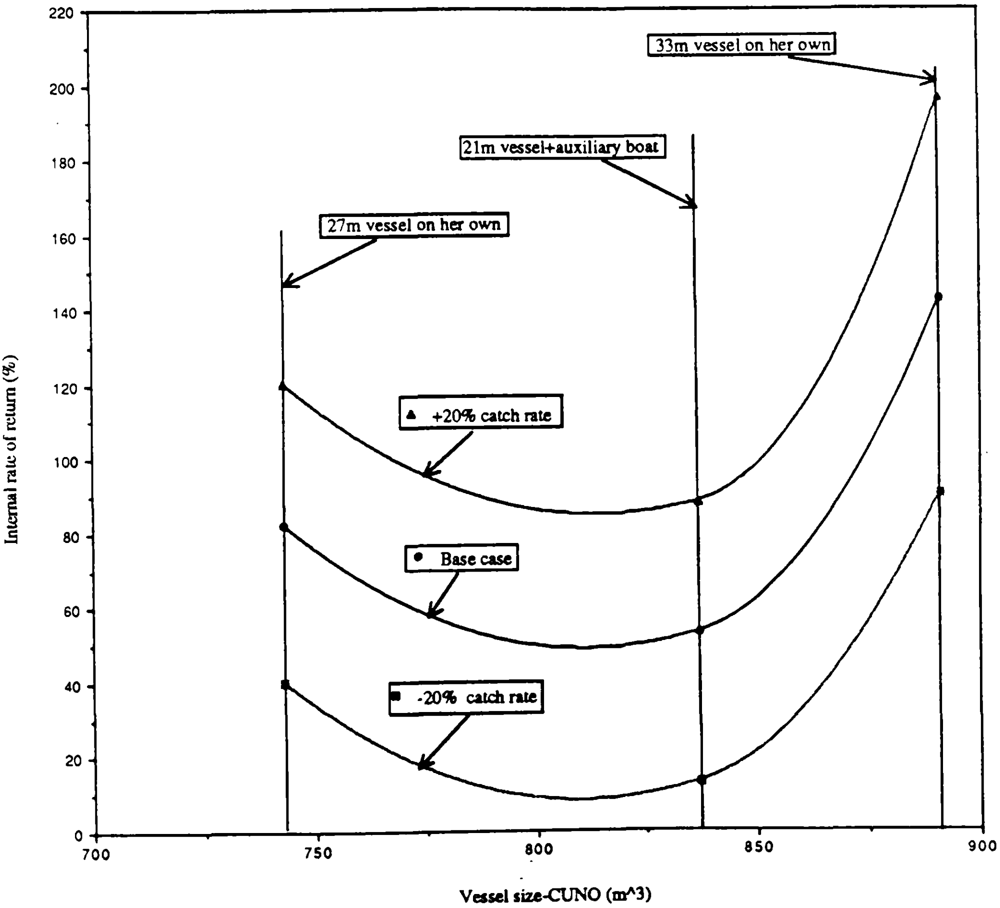


Fig.6.3 Sensitivity analysis of 350HP vessels for ∓20% catch rate

6.7.2 Effect of Doubling Engine Power on Internal Rate of Return

As it may be noticed from Table 6.2 that machinery cost is a large proportion of the total investment cost. It therefore might also be interesting to examine the impact of doubling the main engine on The IRR of these vessels, assuming again all the other input data unchanged including the engine size of the auxiliary boat. So we now have 700 HP engine on all three vessels instead of 350 HP. It also should be mentioned that the comparison was made only at one catch rate which has previously been referred to as "base case".

The IRR of these vessels of 700 HP has been calculated in the same manner as it was done for 350 HP case. The details of the calculations are presented from Table 6.16 to Table 6.19.

Comparison of the IRR of the 350 HP case and the 700 HP case is given in Table 6.20. From this table it can be seen that doubling the power of the vessels has caused a significant decrease in the IRR. Another feature of this table is the fact that the 21m+aux. vessels and the 27m vessels have been put at a disadvantage in comparison with the 33m vessel, since the decrease in the IRR is again smallest (30%) for this vessel. Nevertheless the 33m+aux. vessels appears to be the worst among those with 70% decrease in the IRR. The effect of such power change on the IRR has also been shown graphically in Fig.6.4.

The amount of power installed in some existing Black Sea fishing boats is close to 700HP and this section was included to cover these existing boats. Not unexpectedly the IRR is reduced and there seem little advantage in time on voyage as the distance to be travelled is small. No doubt an explanation of such choice has to be related to prestige and to the ability to import machinery without custom duty, it is not an advantage in any simple economic comparison. Naturally reaching port first may offer a slightly better price for the catch but it could hardly compensate for the additional capital cost.

It could be interesting to study the internal rate of return when two fishing vessels of 21m share an auxiliary vessel. Of course this can be impractical as it means that the fishing vessels must share the fishing ground when the masters of the boats prefer to discover their own fishing grounds.

	21m		27m		33m	
ITEM	***Unit***	***Cost* (1000US$)**	***Unit***	***Cost* (1000US$)**	***Unit***	***Cost* (1000US$)**
Hull construction		55		69		83
Main engine	700 HP	50	700 HP	50	700 HP	50
Auxiliary generator	50 KW	17	50 KW	17	50 KW	17
Stern gear,safting,propeller		4		4		4
Piping systems, pumps		1		2		2
Steering system		2		2		3
Electrics		1		2		2
Deck equipment		5		5		5
Navigation&fish finding equip.		15		15		15
Miscelaneous		1		1		1
Vessel cost		**151**		**167**		**182**
Net	350x600 fath	15	350x600 fath	15	350x600 fath	15
Skiff	120 HP	10		10		10
Total investment		**176**		**192**		**207**
Dimensions (LxBxD)	594		743		891	
Fish hold capacity (tonnes)	44.8		92.2		136	

Table 6.16 Calculation of investment cost of vessels of 700HP

	21m+Aux.	**27m**	**33m**
	(1000US$)	(1000US$)	(1000US$)
Cash inflow:			
Fish revenues	564.00	552.00	816.00
Cash outflow:			
Investment cost	221.00	192.00	207.00
Operating cost:			
Fuel-main	147.00	118.00	118.00
Fuel-auxiliary	15.00	15.00	15.00
Lube oil (5% of fuel cost)	8.00	6.00	6.00
Skiff operation	13.00	13.00	13.00
Provisions	4.00	4.00	4.00
Ice	47.00	46.00	72.00
Average cost of capital (0.102*IC)	23.00	20.00	21.00
Insurance (5% Of vessel cost)	10.00	8.00	9.00
Repair & maintenance	18.00	16.00	17.00
Crew salary (25% of catch)	141.00	138.00	204.00
Miscellaneous (10% of op. costs)	40.00	36.00	45.00
Total operating costs	466.00	420.00	524.00
Earnings	98.00	132.00	292.00
Depreciation (10% of vessel cost)	20.00	17.00	18.00
Earnings before taxes	78.00	115.00	274.00
Taxes (30%)	23.40	34.50	82.20
Net cash flow	54.60	80.50	191.80

Table 6.17 Cash flow estimate of vessels of 700HP

			21m+Aux. vessels			
Year	0	1	2	3	4	5
Earnings	-221	147.00	220.50	330.75	496.13	744.19
Depreciation	-	20.00	20.00	20.00	20.00	20.00
EBT	-	127.00	200.50	310.75	476.13	724.19
Taxes (25%)	-	31.75	50.13	77.69	119.03	181.05
NCF	-221	95.25	150.38	233.06	357.10	543.14
PVNCF	**-221**	**63.50**	**66.84**	**69.05**	**70.54**	**71.52**

			27m vessel			
Year	0	1.00	2.00	3.00	4.00	5.00
Earnings	-192	198.00	297.00	445.50	668.25	1002.38
Depreciation	-	17.00	17.00	17.00	17.00	17.00
EBT	-	181.00	280.00	428.50	651.25	985.38
Taxes (25%)	-	45.25	70.00	107.13	162.81	246.35
NCF	-192	135.75	210.00	321.38	488.44	739.04
PVNCF	**-192**	**90.50**	**93.33**	**95.22**	**96.48**	**97.32**

			33m vessel			
Year	0	1.00	2.00	3.00	4.00	5.00
Earnings	-207	438.00	657.00	985.50	1478.25	2217.38
Depreciation	-	18.00	18.00	18.00	18.00	18.00
EBT	-	420.00	639.00	967.50	1460.25	2199.38
Taxes (25%)	-	105.00	159.75	241.88	365.06	549.85
NCF	-207	315.00	479.25	725.63	1095.19	1649.54
PVNCF	**-207**	**210.00**	**213.00**	**215.00**	**216.33**	**217.22**

Average rate of inflation: 50%

Table 6.18 Effect of inflation on cash flow of 700HP vessels for base catch rate

21m+ Aux. Boat					
Year	Net cash Flow	Present Value factors		Present Value	
		15%	20%	15%	20%
0	-221.00	1.000	1.000	-221.00	-221.00
1	63.50	0.870	0.883	55.25	56.07
2	66.84	0.756	0.694	50.53	46.39
3	69.05	0.658	0.579	45.43	39.98
4	70.54	0.572	0.482	40.35	34.00
5	71.52	0.497	0.402	35.55	28.75
NPV				6.11	-15.81
IRR=	16%				

27m Boat					
Year	Net cash Flow	Present Value factors		Present Value	
		35%	40%	35%	40%
0	-192.00	1.000	1.000	-192.00	-192.00
1	90.50	0.741	0.714	67.06	64.62
2	93.33	0.549	0.510	51.24	47.60
3	95.22	0.406	0.364	38.66	34.66
4	96.48	0.301	0.260	29.04	25.08
5	97.32	0.223	0.186	21.70	18.10
NPV				15.70	-1.94
IRR=	39%				

33m Boat					
Year	Net cash Flow	Present Value factors		Present Value	
		95%	100%	95%	100%
0	-207.00	1.000	1.000	-207.00	-207.00
1	210.00	0.513	0.500	107.73	105.00
2	213.00	0.263	0.250	56.02	53.25
3	215.00	0.135	0.125	29.03	26.88
4	216.33	0.069	0.063	14.93	13.63
5	217.22	0.035	0.031	7.60	6.73
NPV				8.30	-1.51
IRR=	99%				

Table 6.19 Calculation of IRR of vessels of 700HP for base catch rate

VESSEL	CUNO (m^3)	Internal rate of return (%)		Decrease (%)
		350HP	700HP	
27m	743	82	39	65
21m+aux.	837	53	16	70
33m	891	142	99	30

Fig. 6.20 Comparison of IRR between vessels of 350HP and 700HP for base catch rate

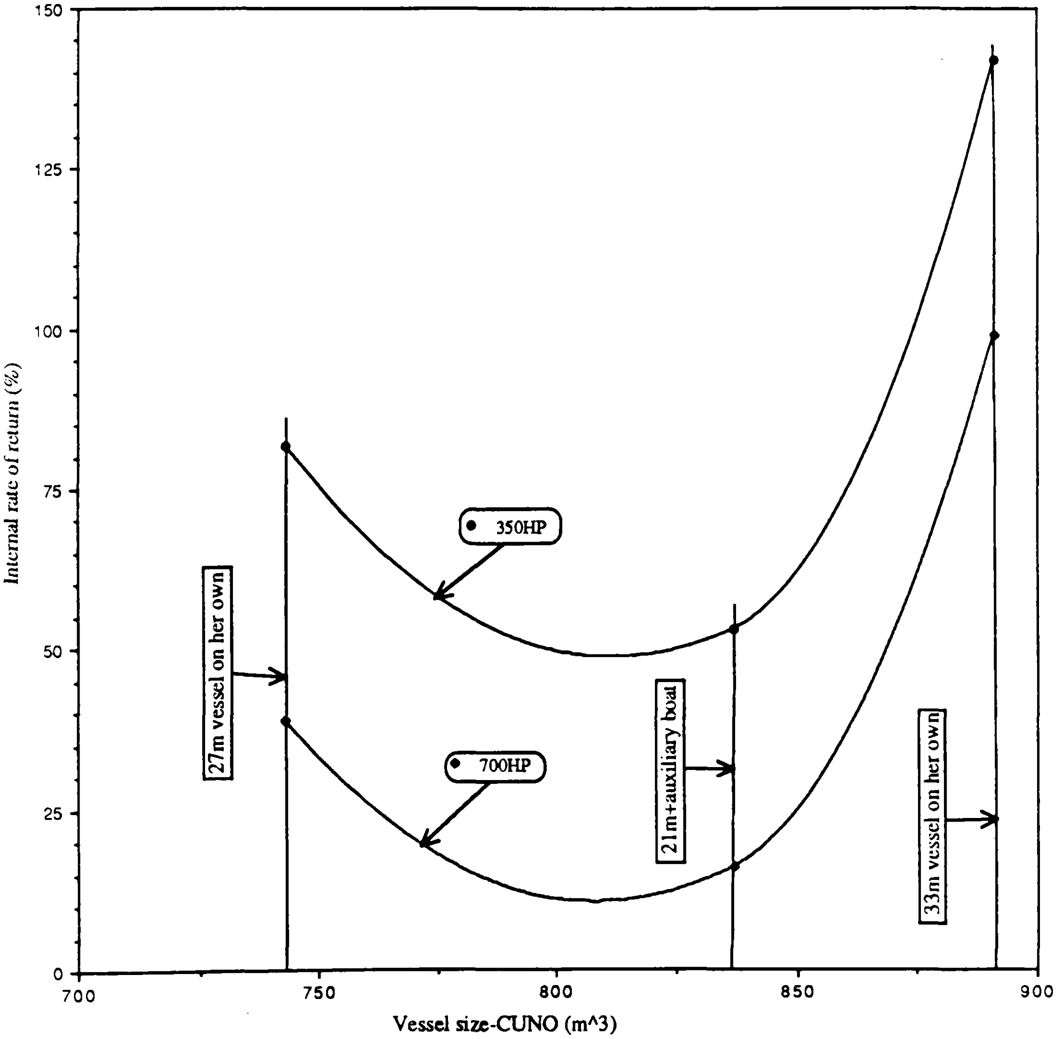


Fig. 6.4 Comparison of IRR between vessels of 350HP and 700HP for base catch rate

CHAPTER 7

CONCLUSIONS

7.1 Conclusions

The general conclusion that can be drawn from this study is that the original aims and objectives, as described in Chapter 1, have been achieved. That is to say, that this study proposes a more efficient design than one which is already in existence.

It can be seen from Table 2.4 that the number of fishing vessels in Turkey are increasing rapidly year by year along with the increment of size (length) and machinery power. One of the reasons ~~of~~ for this is that the Turkish government has introduced a law in 1972 which allows fishermen to import machinery and equipment required for their vessels exempt from custom duty. The Agricultural Bank of Turkey is also responsible for the increase of number of fishing vessels because of providing credit to fishermen since 1953.

Looking at the distribution of the fishing vessels (Table 2.5), it may be observed that the highest number of fishing vessels exists in the region of Black Sea. This should be attributed to the abundancy of fish stocks available, and the highest concentration of large size fishing vessels again appears in the same region due to anchovy stocks. To emphasise the prime importance of the Black Sea it is worth remembering that the Black Sea provides the highest catch rate among the Turkish outland waters with an average percentage of 85.7. A major proportion of the total Black Sea catch is composed of anchovy.

While fish production in Turkey has shown significant fluctuation over recent years, the trend has been a rising one and the authorities have confirmed that fish resources in the waters around the Turkish coasts, particularly in the Black Sea, can sustain considerably higher catches. However, it should be mentioned that over past three years (1989 to 1991), quite unexpectedly, there was a dramatic decrease in anchovy stocks in the Black Sea and the exact reason for the disappearance of the anchovy has not been explained. As the results in this Thesis are based on ample availability of anchovy they would need revision were this is not the case.

As fishing is an important source of employment in certain coastal regions and fish is a cheap but highly nutritious food, official policy in the 1950s has been aimed at promoting a considerable expansion of fish production. A government agency, the Meat and Fish Office, has been established to implement this policy.

The Turkish authorities have made some loan assistance available to modernise the equipment and gear of the fishermen, which, it is expected, will be increased in coming years. In addition to this, the Meat and Fish Office is itself directly engaged in all phases of production, processing and distribution of fish. Fish imports are subject comparatively to very high customs duties and are, as yet, not liberalised. On the other hand, domestic fish production is hampered by the very limited marketing possibilities for fish and fish products on the home markets, due mainly to a distribution system which seems to be wholly inadequate in important parts of the country. This has tended to limit the volume of output which has not risen in step with growth in fishing efforts. In this situation, Turkey has had to rely on export markets for significant quantities of her fish production in many recent years.

It would seem that, if Turkey is basically in a competitive position as a fish producer, any expansion of production aided by public funds should take place under conditions of freer competition than there are at present. A fully competitive fishing industry would, however, have great scope for expansion in foreign as well as domestic markets. As fish consumption in Turkey is comparatively very low, it seems likely that considerable possibilities exist for increased consumption of fish. Special attention should, therefore, be given to the improvement and rationalisation of fish distribution throughout the country. Efforts should also be made to initiate and develop consumer education and information.

Many excellent papers on preliminary design have appeared on the past few years and some of these are given in the References. However, the preliminary design methods for fishing vessels presented in Chapter 3 are perhaps the most practical and straightforward tools to use in the first approximation. In estimating the main particular (L,B,D,T,V,Δ) and the coefficients of form (C_b, C_p, C_w) the equations 3.1 to 3.8 can be used. In addition, to estimate the main dimensions without requiring any calculations, Fig.3.1 can be used.

To estimate the main dimensions by means of Method 2 (Equation 3.9), it is required to establish the following numerical values from the list of similar vessels: L/B, B/T, B/D,C_b . In this case it is sensible to know some effects of a these proportional ratios of main dimensions on the design:

L/B ratio influences the resistance and stability of the vessel.

B/T ratio is also a factor in resistance considerations, but also has influence on stability.

B/D ratio can be taken as a stability influencing factor.

C_b is a very characteristic value and is used to compare the fineness of hull forms.

Group weights can be calculated from the empirical equations numbered 3.10 to 3.21.

The required engine power (P_B) can be calculated from Equation 3.15 based on Admiralty Coefficient, which is considered as a constant figure for vessels of similar type.

In Chapter 4, steel weight estimation is presented by two methods both of which are based on numerals L×B.

i) Builder's method: W_1=0.319(L×B) and
ii) Rough method: W_2=0.323(L×B)

As can be seen from the above formulae that these two methods are very close to each other, the formula that is based on the builder's method gives 1 % higher estimate in steel weight than one based on a statistical method. It might be more convenient to set up an average formula from these above equations for the estimate of steel weight for the Black Sea fishing vessels.

$$W_{st}=0.319(L\times B)$$

Where, L, B are in meters and W_{st} is in tonnes.

Although the applicability of the above formula is limited between the values of 175 to 288m^2 of $L\times B$, it is very practical one to estimate the steel weight for this particular type of fishing vessels.

The conclusion that can be derived from the comparison of P_E curves between Model 149A and the parent vessel (Fig.4.3) is that the traditional hull from of the Black Sea fishing vessel is reasonable ~~well designed~~ from a resistance point of view. However, installed P_B values of the Black Sea fishing vessels have been found to be much higher than the similar fishing vessels of the world (Fig.4.7). This may be attributed to the fact that selection of machinery required for the propulsion of the vessels is entirely up to the owner, who has got a limited understanding of economical fishing. In other words the choice of machinery is based on fishermen's experience, no scientific criteria is involved in this very important matter. However, the prestige of larger power and the ability to over-drive the vessel to reach port first are hard to quantify especially if the overall economic penalty of oversized machinery is not excessive.

With regard to propulsion it should be mentioned that most of the fishing vessels of the Black sea are propelled by fixed blade propellers. A vast majority of vessels are equipped with single screw and a very small number of them with twin screw propellers. There is no controllable pitch propeller used on fishing vessels, although it is the most convenient type of propeller to use on fishing vessels. The advantages in using controllable pitch propeller on fishing vessels may be summarized as follows:

a) Undirectional running of the engine
b) Ability to absorb the full engine power at any ship speed
c) Constant revolutions per minute in any condition of loading
d) Rapid manoeuvrability and control from the bridge.

The controllable pitch propeller is, however, more costly than a fixed pitch propeller and requires careful maintenance as the mechanism is of relatively high precision and also of complicated design. Overhaul and repairs can be done only by skilled personnel.

Fish hold capacity is one of the most important parameter influencing the design of a fishing vessel. Its size is desired to be as large as possible. It has been found that the Black Sea fishing vessels have their fish hold capacities some 40 % lower than permitted by the enclosed volume. This is because the mother (hunter) vessel is generally accompanied by an auxiliary boat whose presence is to carry the catch from fishing ground to the port. The design proposed in this study increases the fish hold to the fullest possible extent and eliminates such an auxiliary boat without putting at risk the freshness of the catch.

A general conclusion that can be drawn from the economic evaluation of the Black Sea fishing vessels is that a fishing vessel running on her own appears to be more economical than one accompanied by an auxiliary boat. The other conclusion that can be made is that with the assumption of abundant anchovy stocks, the profit margin from the fishing tends to increase as the size of the vessel increases.

From the point of view of production cost of the Black Sea fishing vessels, it can be said that steel and machinery are the predominant variables affecting the total production cost. From the cost analysis it has been found that the main engine accounts for some 38 % of the total production cost and material accounts for some 20 % of the total production cost. In contrast to European countries labour is very cheap in Turkey.

From the comparison of the midship sections it has been seen that the traditional design is very close to standard design based on Lloyd's Rules. With regards to longitudinal strength, both design appear to be very safe as they are subjected to comparatively very low stresses. It therefore may be concluded that for small fishing vessels, longitudinal strength is not very important, the requirements of local strength give ample longitudinal strength.

From the statical stability curve (Fig. 5.7), The Turkish Black Sea fishing vessels have found to have very high metacentre height (GM) and thus very large initial stability in comparison with the similar fishing vessels of the world. This may be attributed to relatively low value of L/B ratio. Because the righting moment lever (GZ) is very high these vessels behave rather sharply in the sea way, and therefore deserve to be called stiff.

Finally, it must be remembered that the feasibility for design of a fishing vessel of any kind is entirely dependant upon the particular fish stocks available to be exploited. If something goes unexpectedly wrong concerning fish stocks then the rest of the investment will be in jeopardy.

7.2 Areas of Future Development

A more extensive and reliable system of data collection concerning the fishery of Turkey should come into effect. When one attempts to carry out any study on the fishery side of Turkey one will suffer from lack of data and recent statistics. This even becomes more apparent when dealing with the fishing boats of Turkey. Although fishing plays a very important role in Turkey, particularly the coastal region, so far very little attention has been given to fishing vessels by the Turkish authorities. As their sizes and values increases, it would be recommended that fishing vessels should be designed to the standards of one of the classification societies such as Lloyds.

Fishermen are having to become more and more cost conscious as the profit margins from fishing are narrowed. No longer should fishing vessels be designed regardless of cost. Generally speaking, in the fishing practised in Turkish waters, the actual fishing time is less than the running time (including searching time). Therefore very large proportion of operating cost is due to relatively high running time. It is believed that exploring the possibilities of saving fuel would be of a great interest for further study.

The trend of fish hunting with its improving efficiency and technology is to put fish stocks at risk. The alternative of fish farming is already in existence commercially and may need to be given preference for investment. As with fish hunting there is much of technology in today's fish farming with the need to moor large fish cages well out to sea to limit disease and to have them at variable buoyancy, below the surface in general but taken above the surface for resupply of food and removal of stocks.

The total labour required for fish farming is probably less than for fish hunting but requires the building and operation of substantial units that must work effectively at sea and may need considerable development effort.

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ADDENDUM

MAPS OF DISTRIBUTION AND MIGRATION OF BLACK SEA FISH[37]

To keep descriptive terms on the maps to the minimum, a system of coding is used to designate the main distributional features of each species. Despite the differing taxonomic groups represented, three basic codes suffice for 14 species, namely:

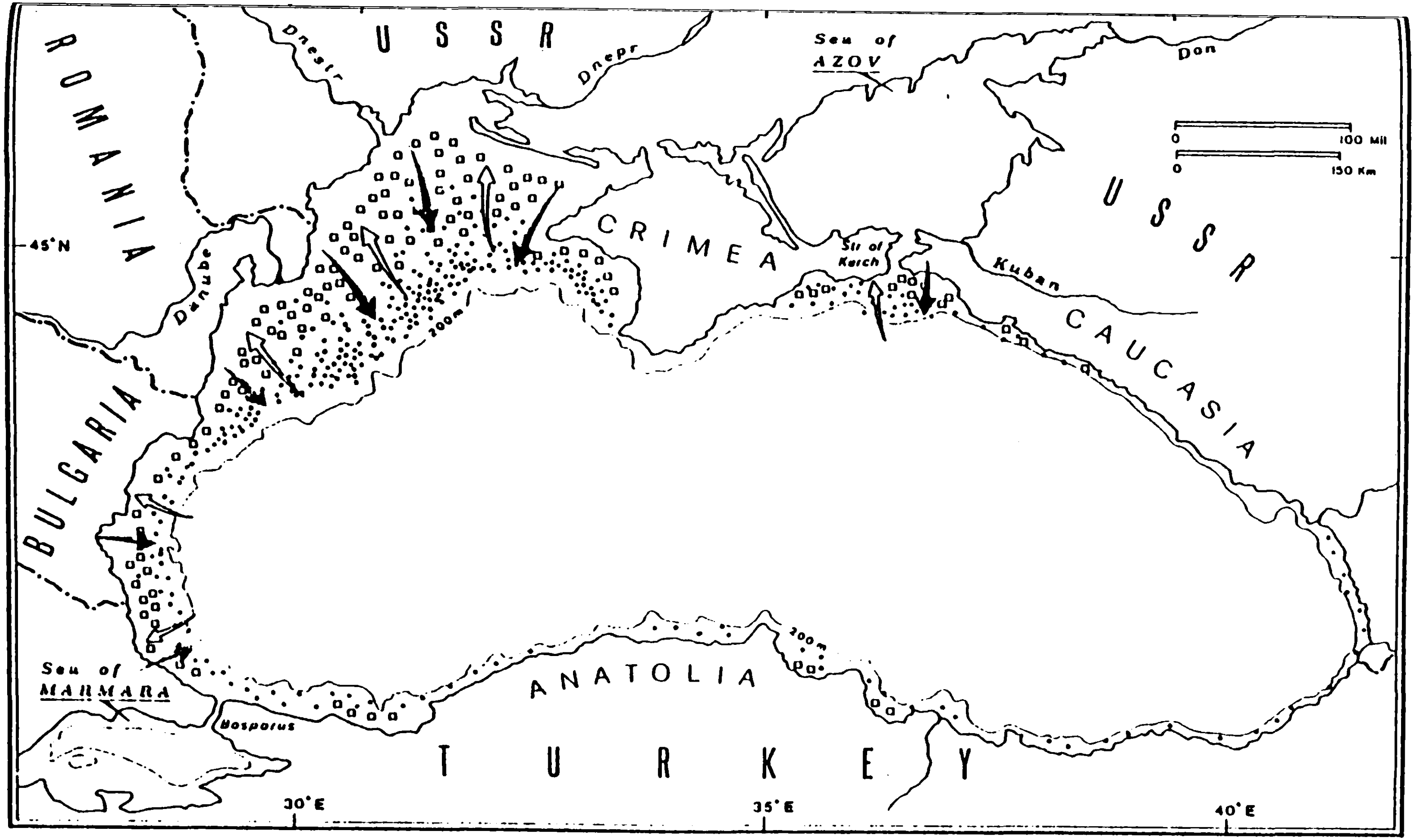
(a) general distribution

(b) feeding areas, and migration to them ░ ←

(c) spawning areas, and migration to them ▨ ⇐

(d) wintering areas, and migration to them ■ ←

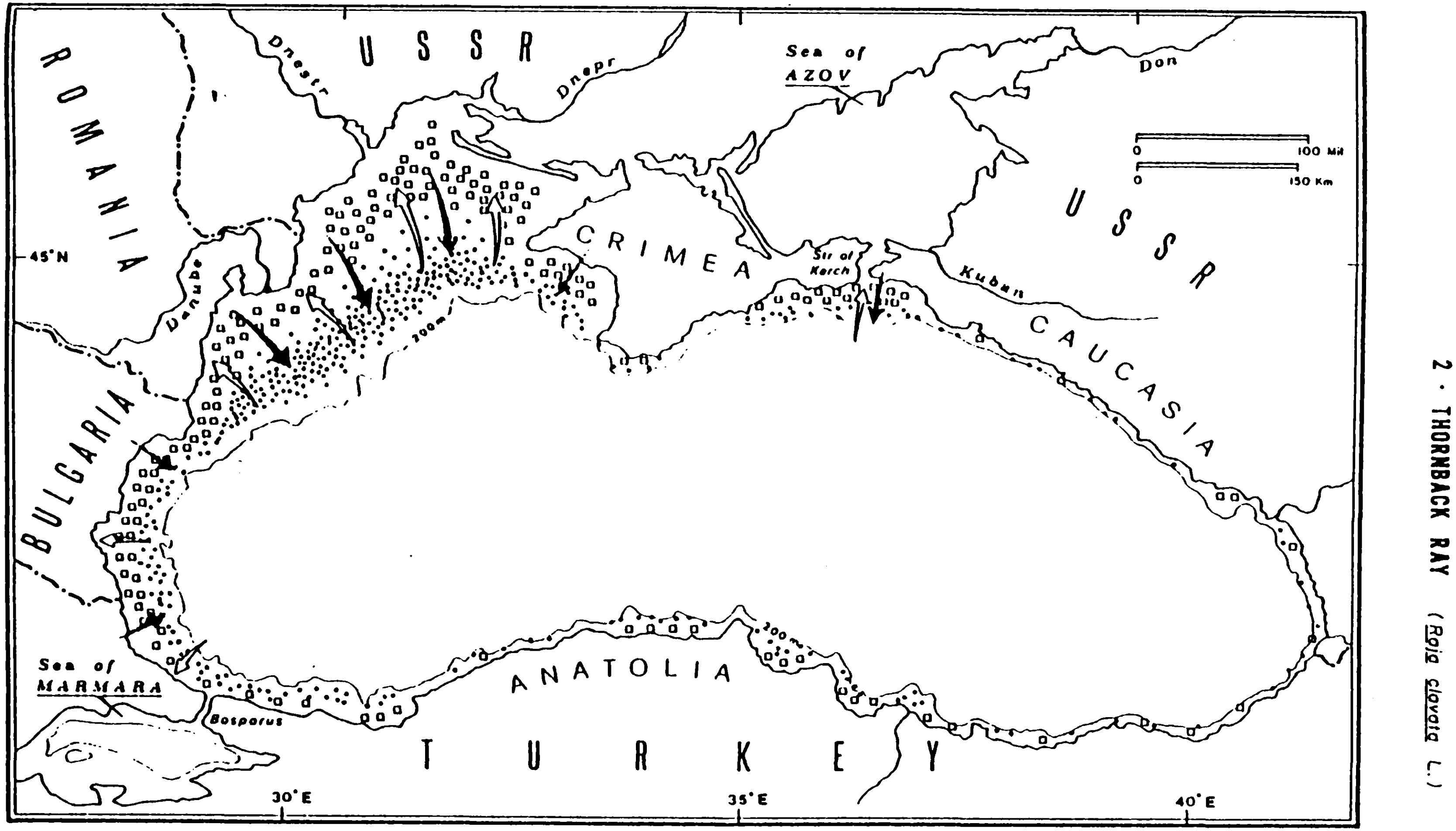
1 · PICKED DOGFISH (*Squalus acanthias* L.)



Map 1

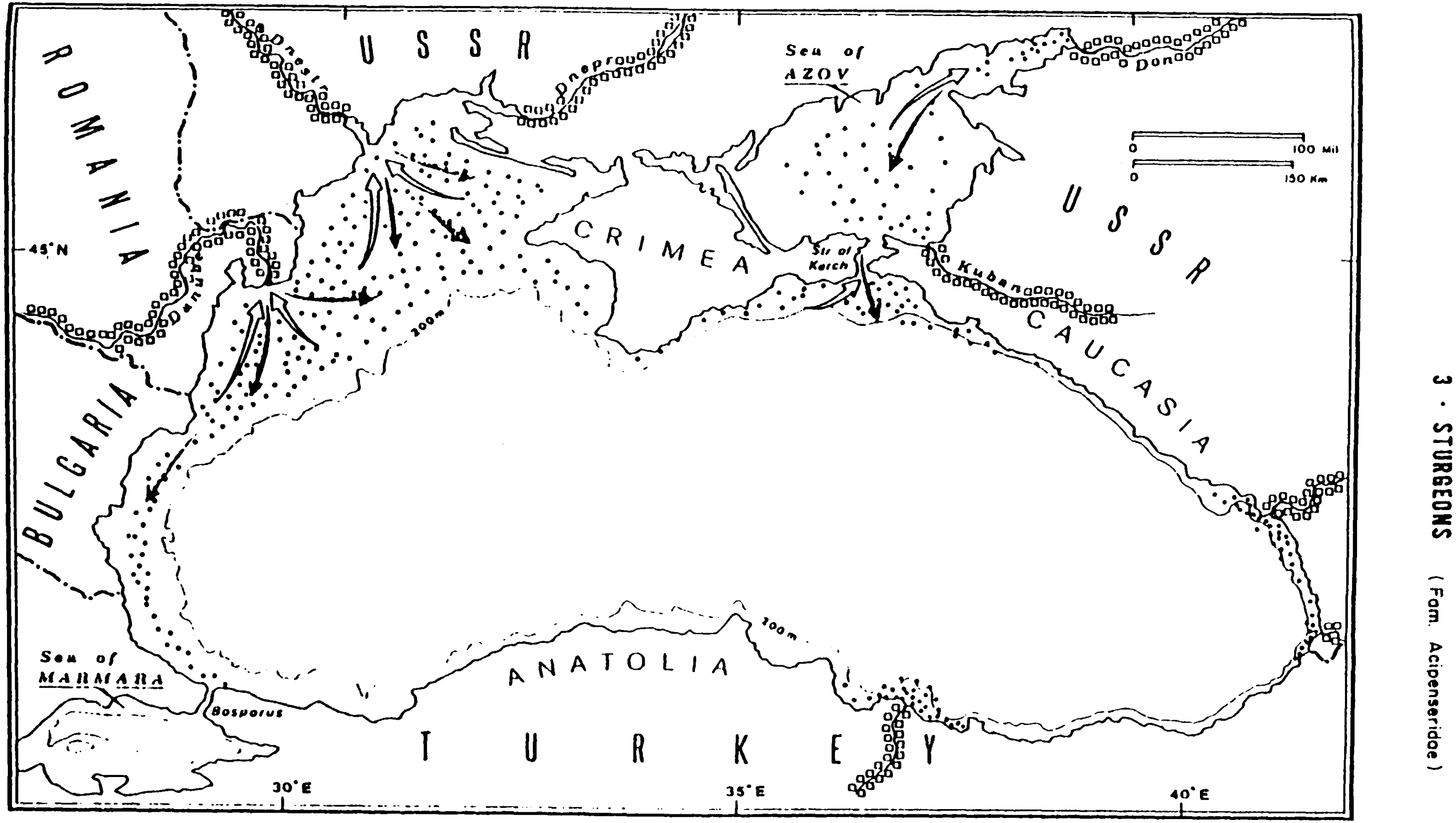
PICKED DOGFISH (Squalus acanthias L.)

Picked dogfish is a cold water species in the Black Sea. The adults are found all around the shelf region in depths from 15m to 120m. Juveniles occur in upper layers, down to 120m from the surface, over grater depths. Adults migrate towards the coast in spring (April-May) when mating takes place, and again in late autumn (October-November) to give birth to the young. Outside these periods, i.e., in summer and winter, the adults occur typically at depths of 30-90m, below the thermocline, feeding on small fish such as sprat and young whiting. Dogfish are caught mainly by trawl and fixed nets in the northwestern region, and by bottom longlines and fixed nets along the Crrimean and Caucasian coasts and in front of the Strait of Krech. Large quantities are occasionally taken as a by-catch in trawl fisheries for sprat off the Bulgarian and Romanian coasts.



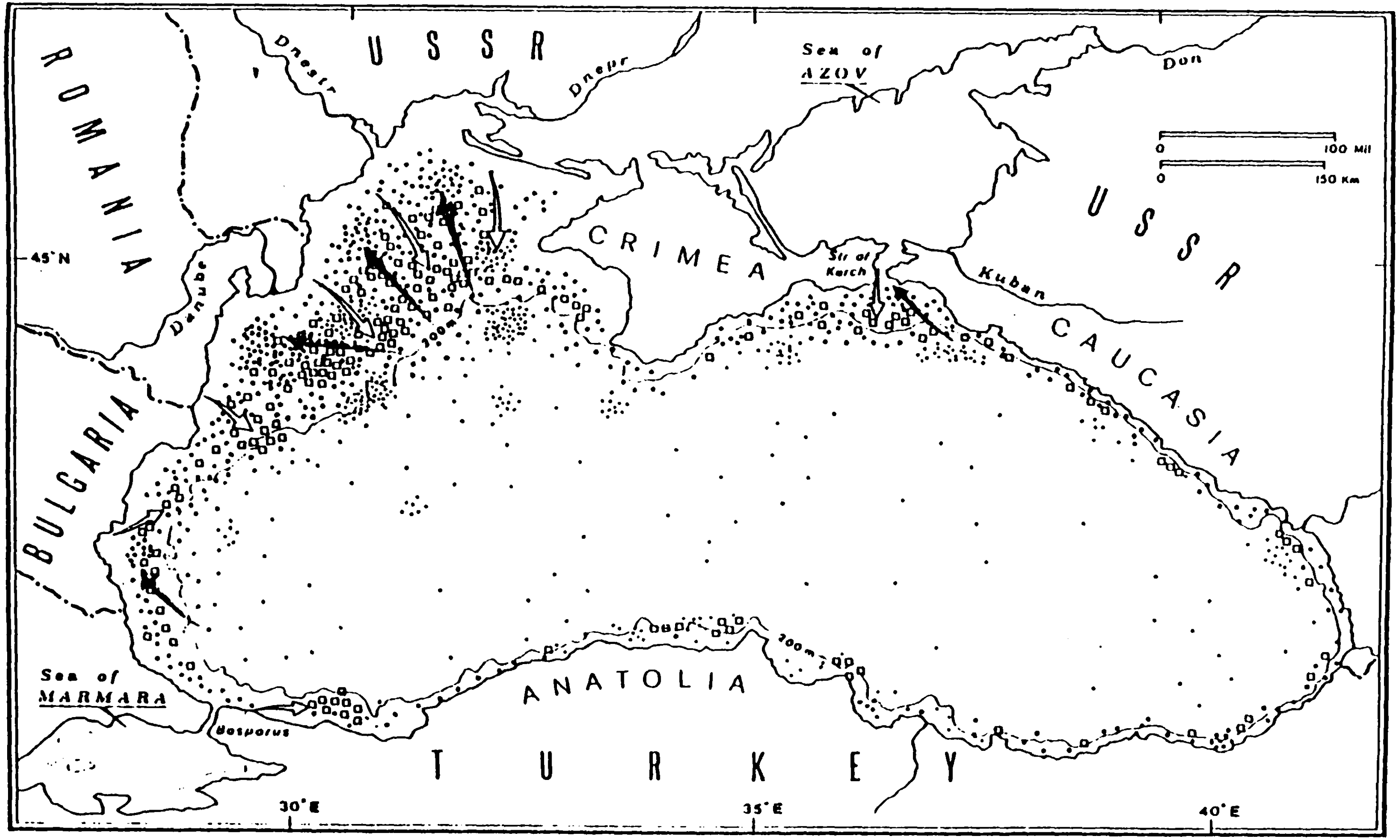
Map 2
TRORNBACK RAY (Raja clavata L.)

Like the picked dogfish, the tronback ray is a cold water fish. It occurs throughout the shelf region of the Black Sea, in depths from 10m to 100m, even where the shelf is narrowest. The adults migrate inshore (10-50m) in late spring (May-June) to lay their eggs; they then disperse to deeper water to feed. There are specialized fisheries for tronback ray by the USSR in the northwestern shelf region and by Turkey in the south. The main gear used is baited longline. Thornback ray are also caught together with picked dogfish in bottom gillnets.



Map 3
STURGEONS (Fam. Acipenseridae)

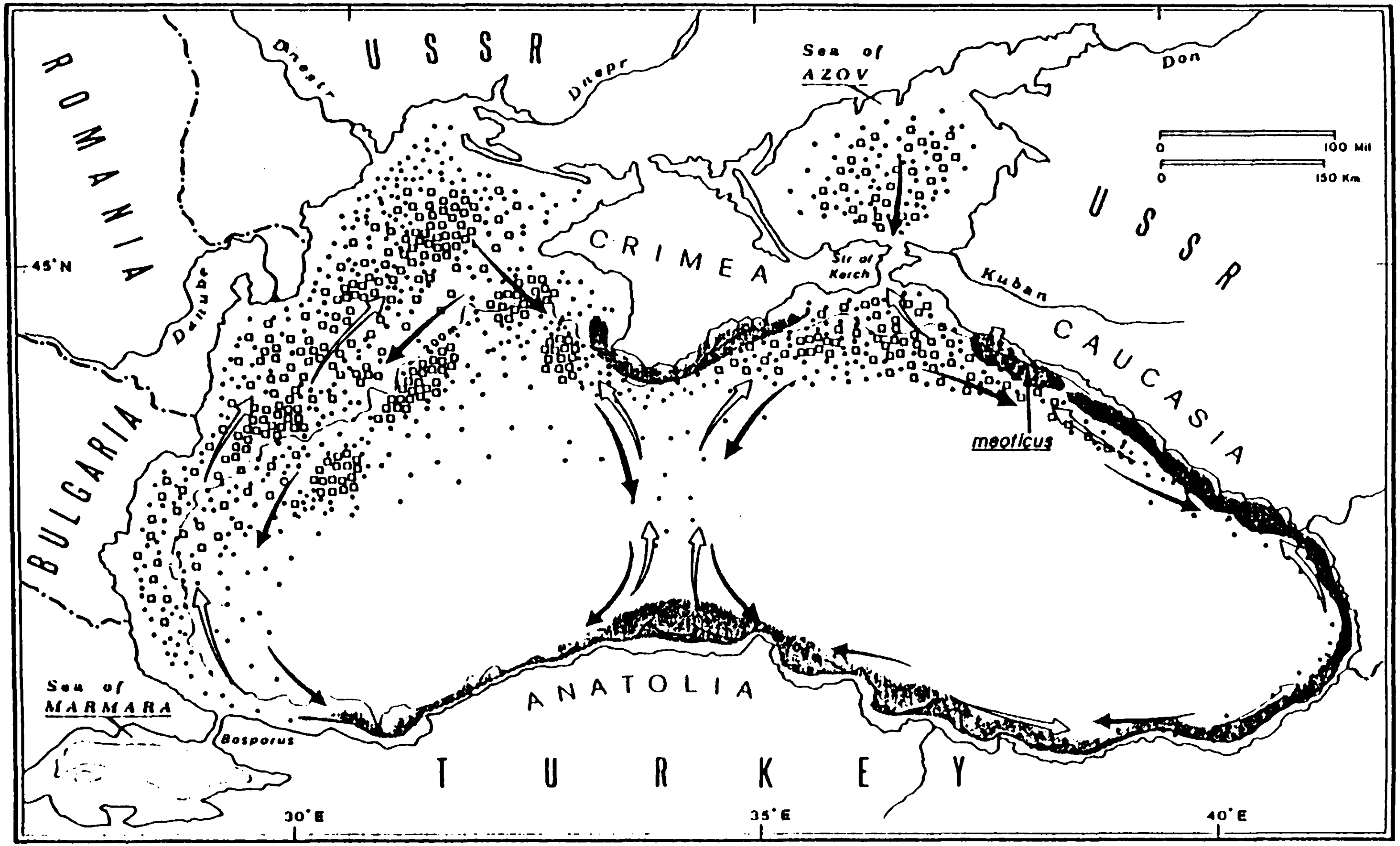
Adults begin their migration into the rivers in autumn, eventually spawning in spring (April-June). Fish which spawn in the Danube, Dniepr and Dniestr spend the rest of the life-cycle mainly in the northwestern sector of the shelf from South Crimea to north of Bosphorus. Some of the sturgeon which spawn in the more easterly Don and Kuban Rivers return to feed and grow in the shelf region to the east of Crimea. As demersal living fish, sturgeon are caught by bottom-set gear as trammel nets and baited and unbaited longlines. Like picked dogfish, sturgeons are also caught as a by-catch in the bottom-trawl fishery for sprat.



Map 4
SPRAT (Sprattus sprattus phalericus Risso)

Spawning takes place during most of the year, with a maximum between November and March. There is a tendency for the shoals to move towards the coast and northward in spring and offshore in autumn, but there are no pronounced spawning or feeding migrations. The young of the year are found widely distributed in the warm upper layers over the whole of the Black Sea. Prior to 1970, the commercial fishery for sprat used only traps and beach-nets. Bulgarian fishermen were first to introduce bathypelagic trawls, followed later by the USSR and Romania. Pelagic and bathypelagic trawls now account for 95% of commercial catches of sprat.

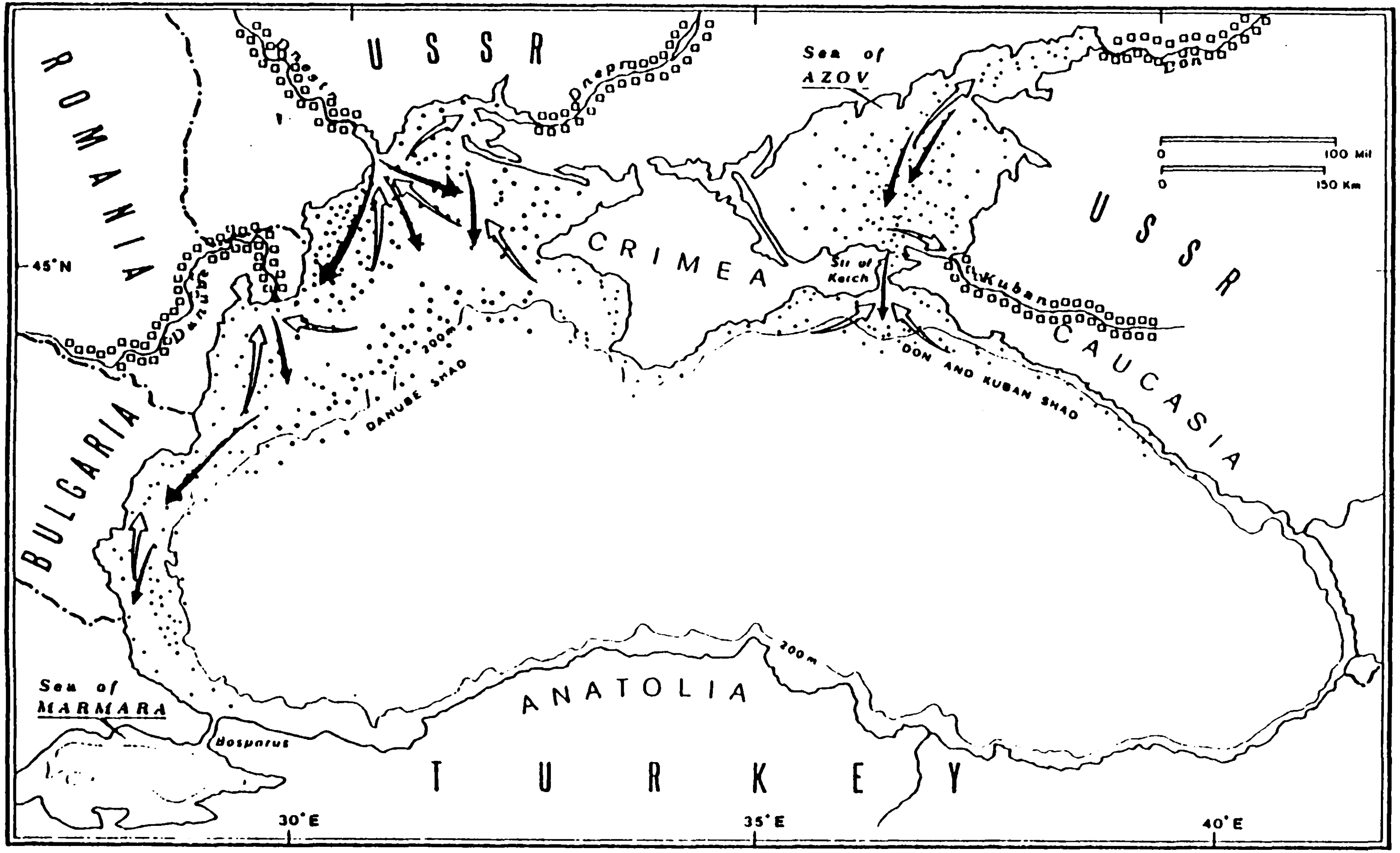
5 · **ANCHOVY** (*Engraulis encrasicholus ponticus* , Al.



Map 5
ANCHOVY (Engraulis encrasicolus ponticus Al.)

There are two sub-species of anchovy in the Black Sea, maeoticus and ponticus. The former reproduces and feeds in the Sea of Azov and hibernates along the Crimean and Caucasian coasts; it is, therefore, fished only by vessels of the USSR. The sub-species ponticus is the major component of the anchovy stocks of the Black Sea. Purse seine is the predominant gear used for anchovy, accounting for over 95% of the total Black sea catch. The remainder is caught by trap nets (Romania) and mid-water trawl (Turkey).

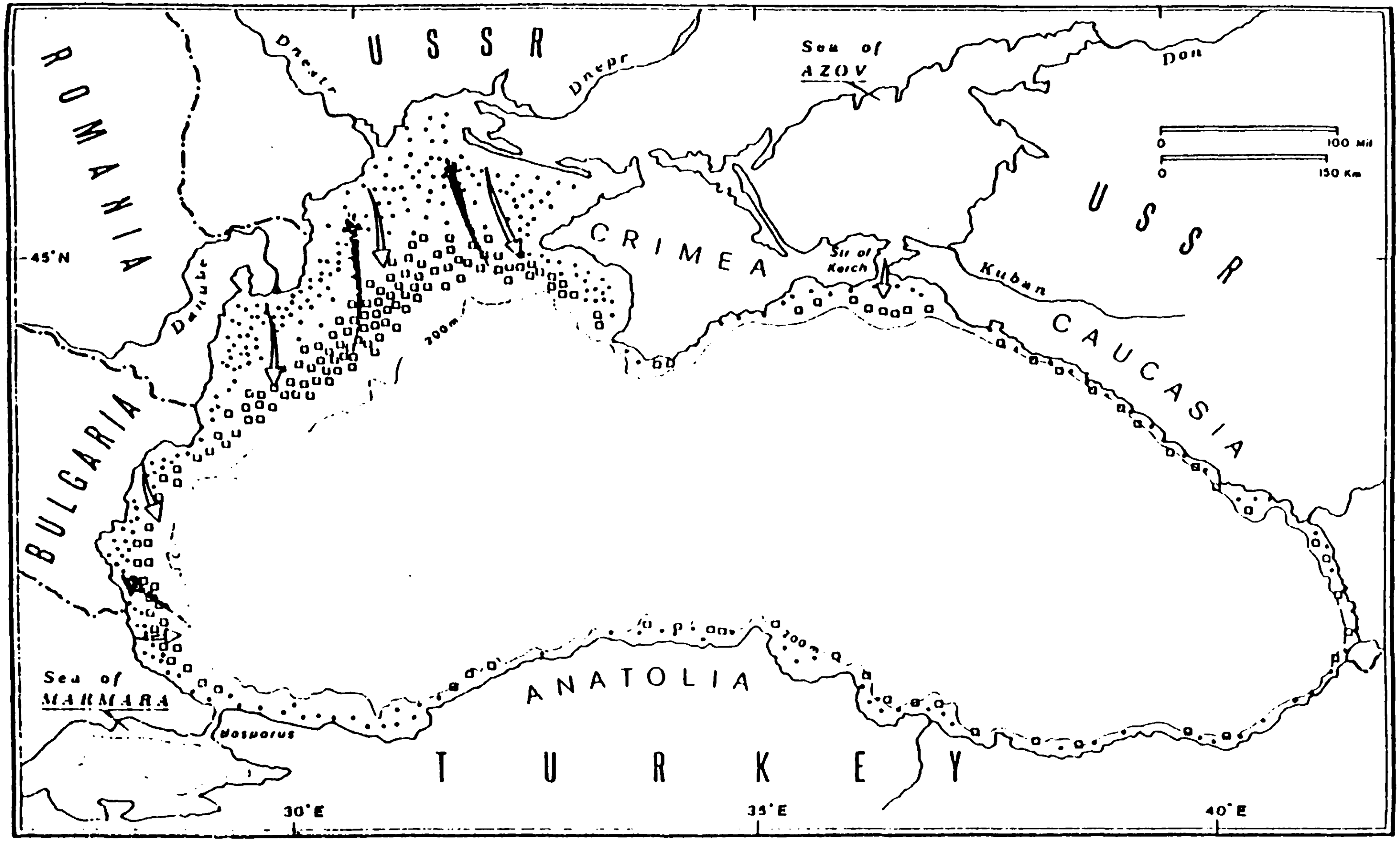
6 · SHAD (*Alosa kessleri pontica*, Risso)



Map 6
SHAD (Alosa kessleri pontica Eichiv)

The Black Sea shad is believed to comprise two races: the larger form spawns in the river Don and winters in the eastern regions of the Black Sea; the smaller form (Danube shad), which is more abundant and makes up the bulk of the commercial catches, spawns in the northwestern rivers. The fishery for shad is carried out mainly during the spawning migration, using traps in the sea and fixed nets and shore seines in the estuaries and rivers.

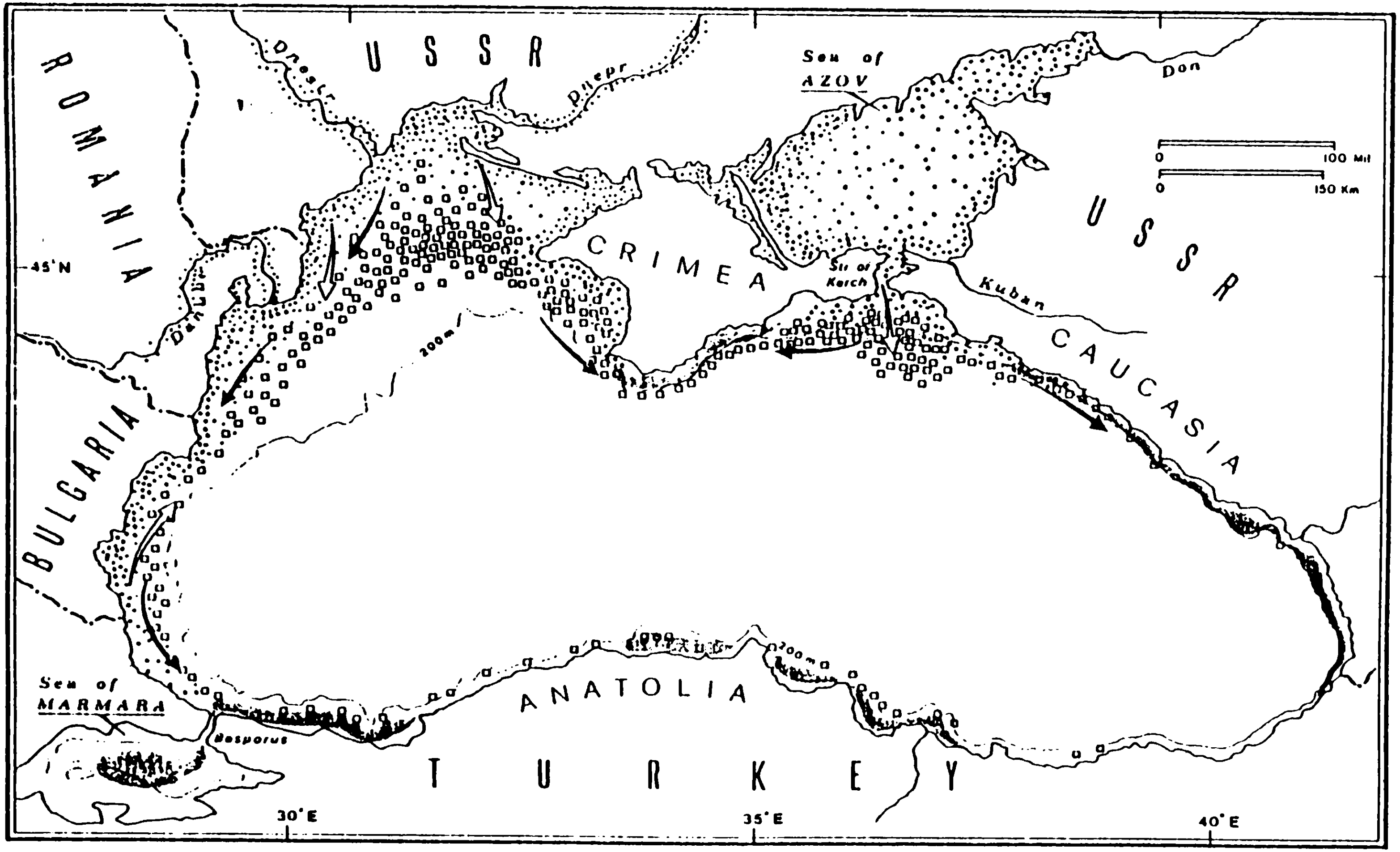
7 · WHITING (*Odontogadus merlangus euxinus*, Nordus)



Map 7
WHITING (Odontogadus merlangus euxinus Nordus)

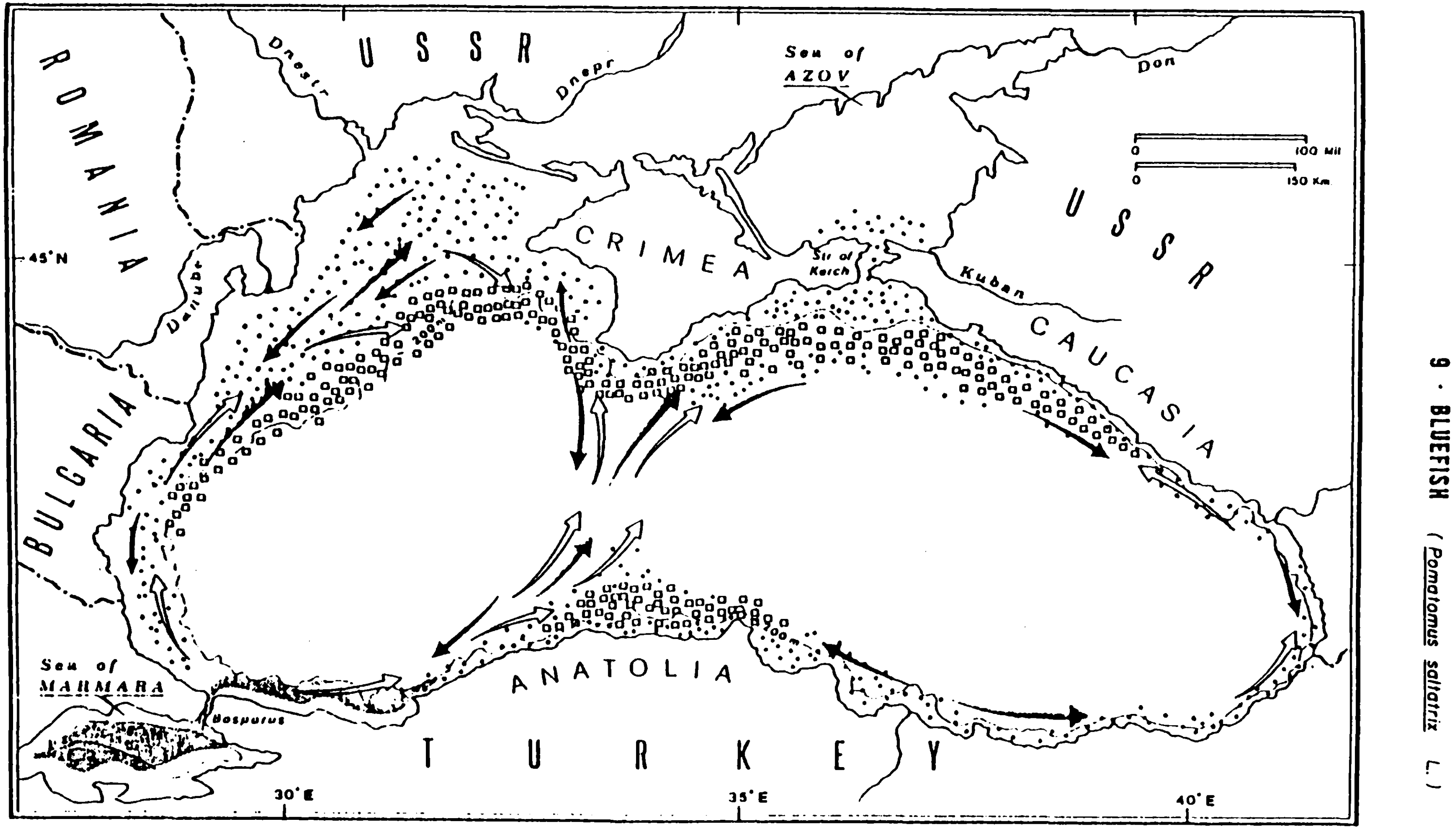
The whiting in the Black Sea is a cold-water demersal species, widely distributed throughout the continental shelf regions in depths from 10m to 130m. The young of the year also occur in the upper water layers off the shelf. Mature fish move into the deeper part of the range for spawning, returning to shallower water in spring for feeding. Whiting has also been the object of a specialized commercial fishery since 1978, except perhaps in Turkey. It is caught with traps and various kinds of demersal and bathypelagic trawls.

8 · MULLET (Fam. Mugilidae)



Map 8
MULLETS (Fam. Mugilidae)

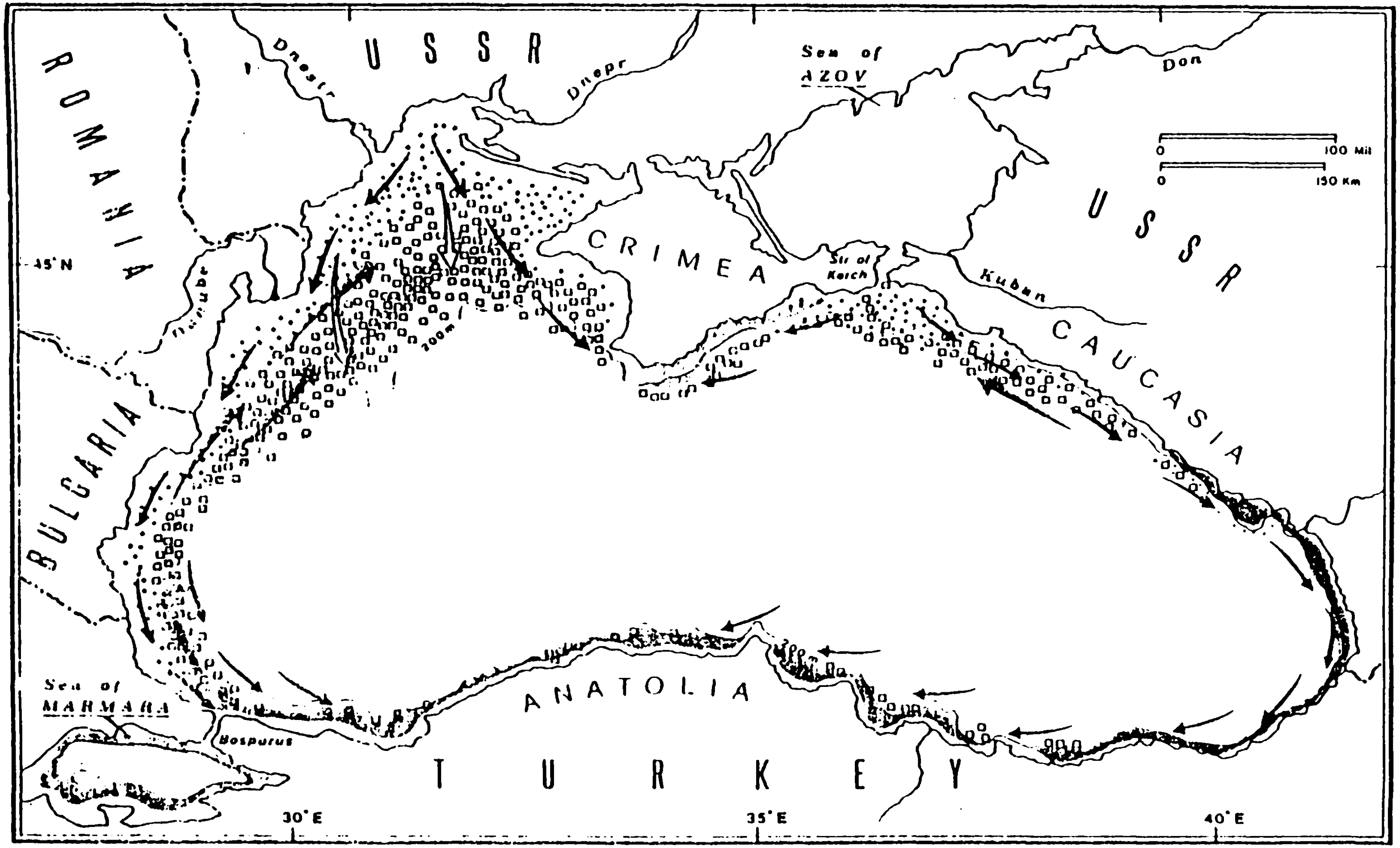
The mullet family Mugilidae is represented in the Black Sea by three common species (M. cephhalus L., M. auratus Risso and M. saliens Risso), and two rare species (M. ramada Risso and M. labrosus Risso). These species are warm-water fish and are widely distributed around the coasts and estuaries of the Black Sea. There is no substantial fishery for mullet, fish being caught in small numbers in many coastal regions.



Map 9
BLUEFISH (Pomatomus saltatrix L.)

The main part of the Black Sea stock of bluefish winters in the sea of Marmora; small numbers over-winter in the Anatolian coastal waters. After reaching maturity, at two years of age, in spring the fish enter the Black Sea through the Bosphorus and migrate to the northern and northwestern shelf regions for feeding and spawning. Most of this migration is in coastal waters, but some shoals cross the open sea from the Turkish to the Crimean coasts. The fishery for bluefish is carried out by beach nets and traps. when the stocks are abundant the dense shoals can be caught efficiently by purse-seine.

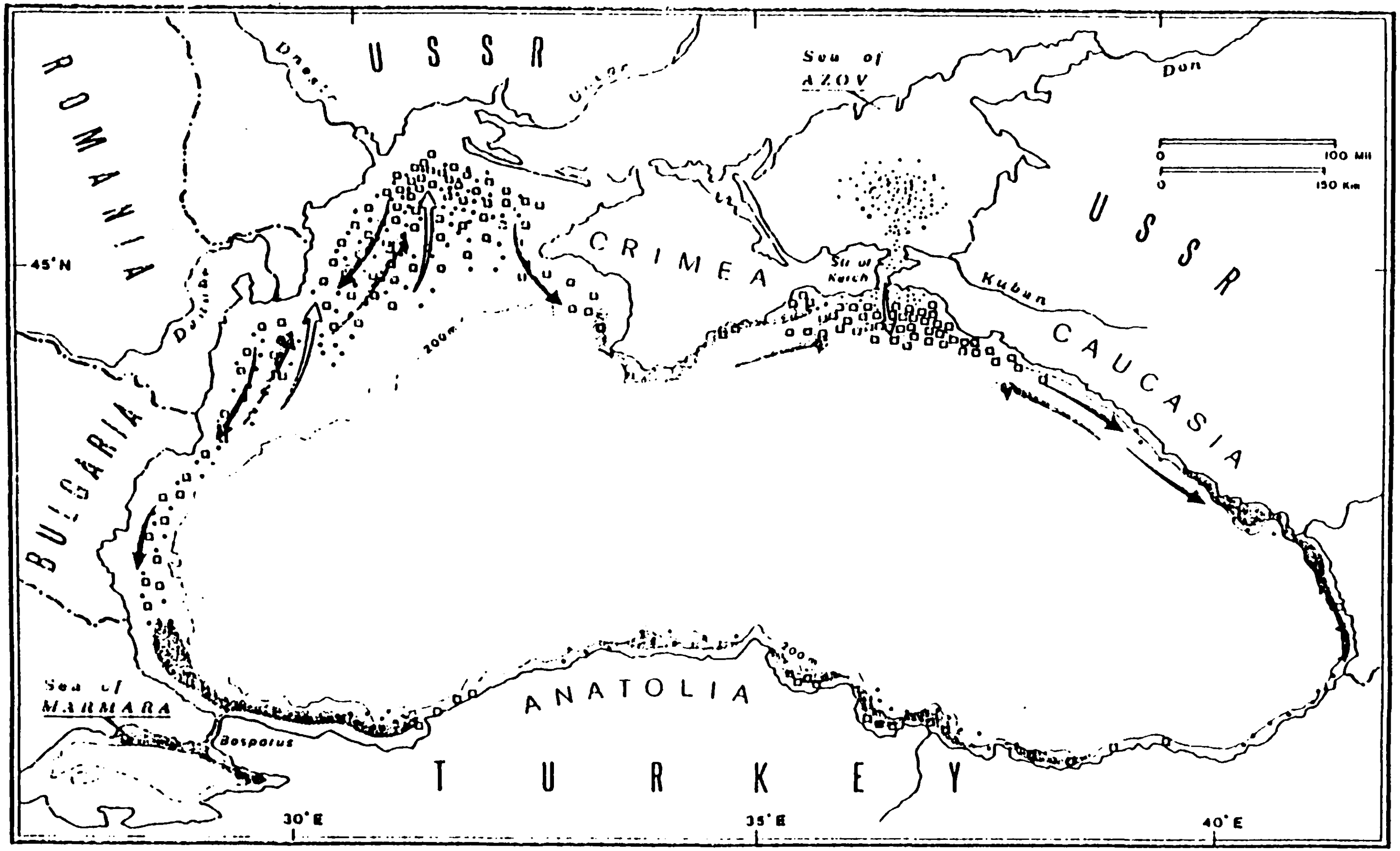
10 · MEDITERRANEAN HORSE MACKEREL
(*Trachurus mediterraneus ponticus*, Aleav.)



Map 10
MEDITERRANEAN HORSE MACKEREL (Trachurus mediterraneus ponticus Aleav.)

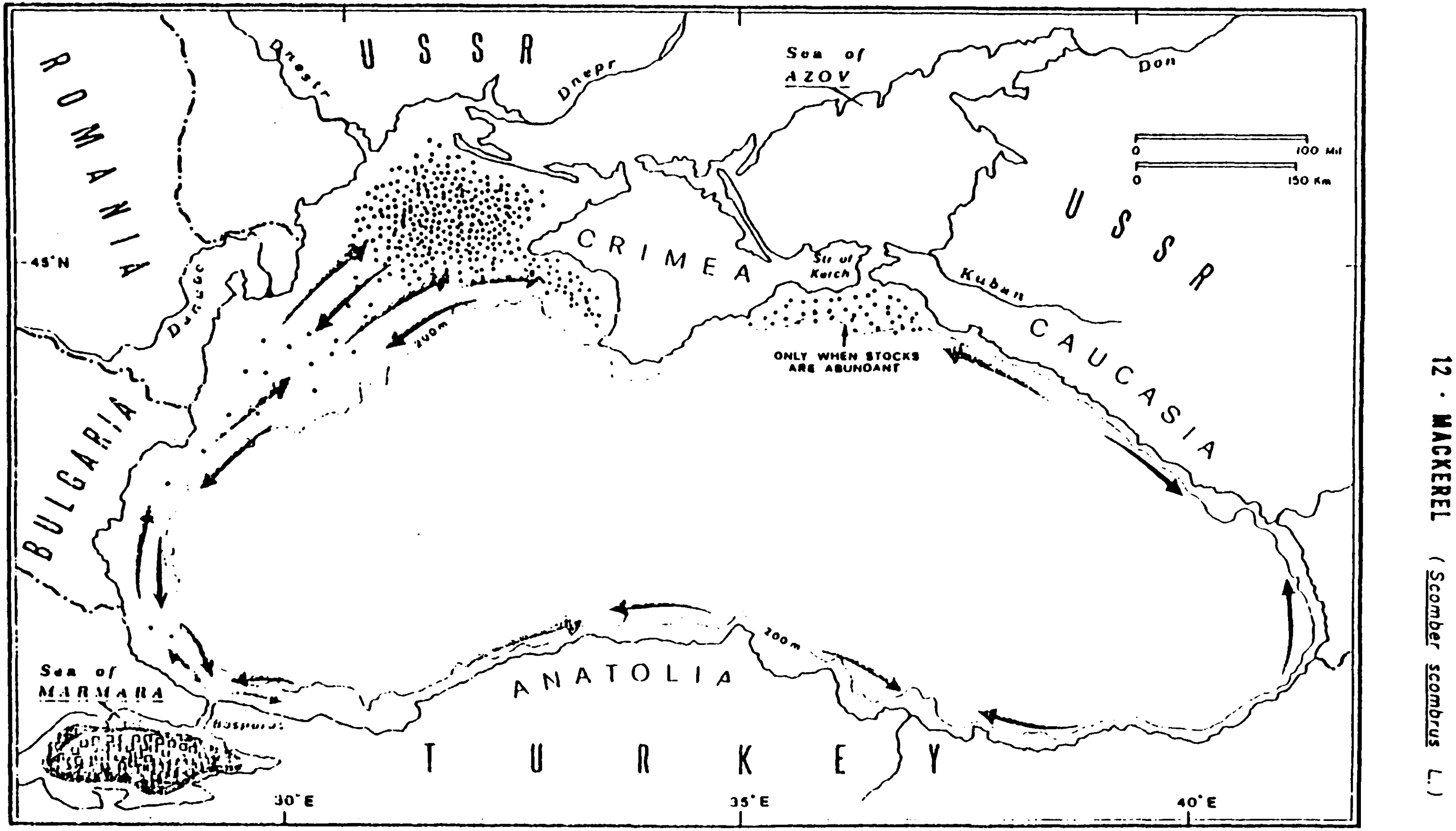
The horse mackerel over-winters along most of the coastal regions of the Black Sea and sea of Marmora, except in the coldest parts to the west and northwest. It migrates to these latter regions and off the Strait of Kerch in spring for feeding and spawning. Horse mackerel is caught with a variety of set-nets, mid-water trawls and purse-seines by all countries bordering the Black Sea.

11 · RED MULLET (*Mullus barbatus L.*)



Map 11
RED MULLET (Mullus barbatus L.)

Red mullet in the Black Sea over-winter along most of the northern (Crimean), eastern (Caucasian), and southern (Anatolian) coasts. Some fish migrate in spring to the northwestern region for spawning, but others remain in their wintering areas simply move nearer to the coast for spawning. Red mullet are caught by a variety of traps, sea nets and beach nets.

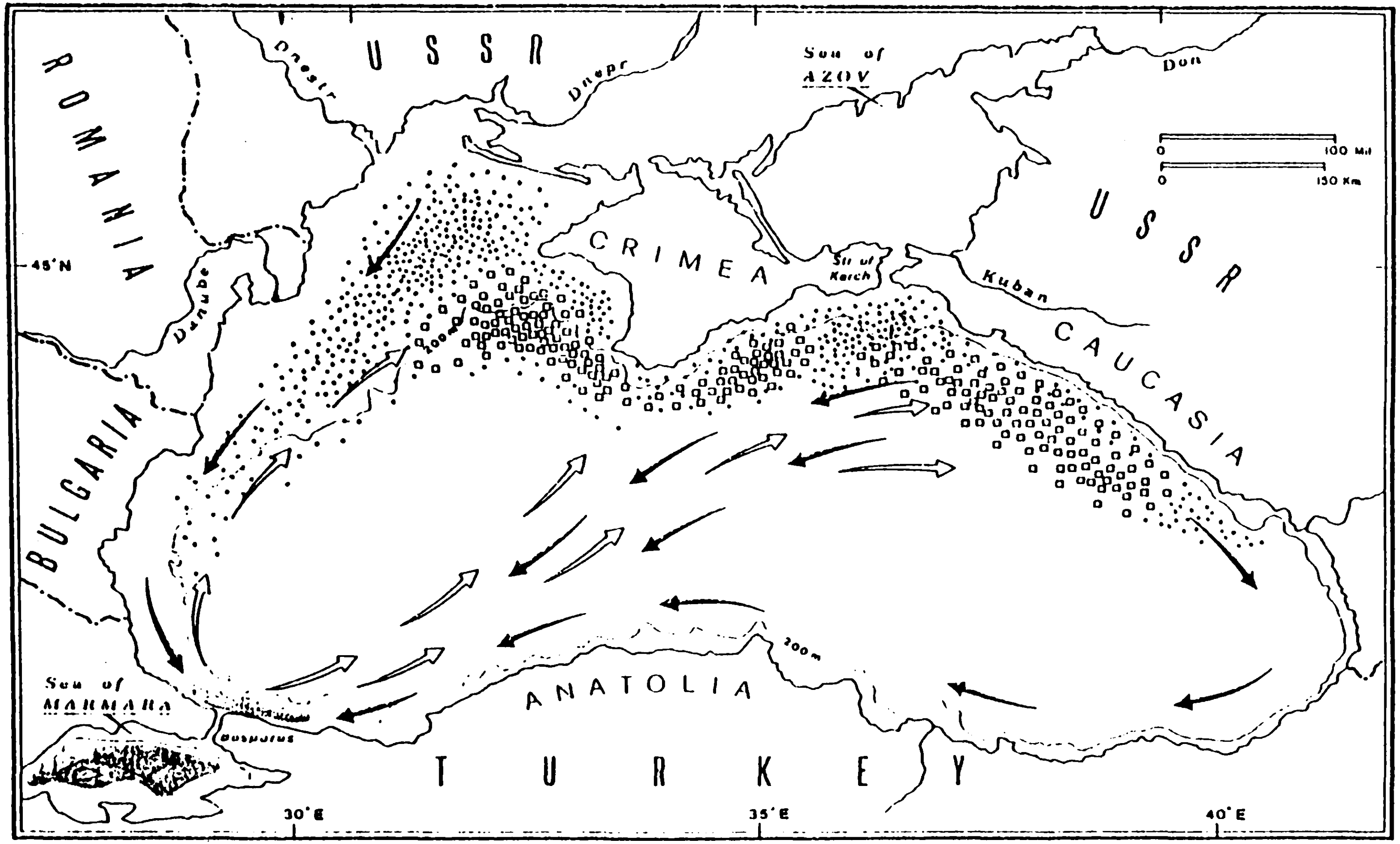


Map 12

MACKEREL (Scomber scombrus L.)

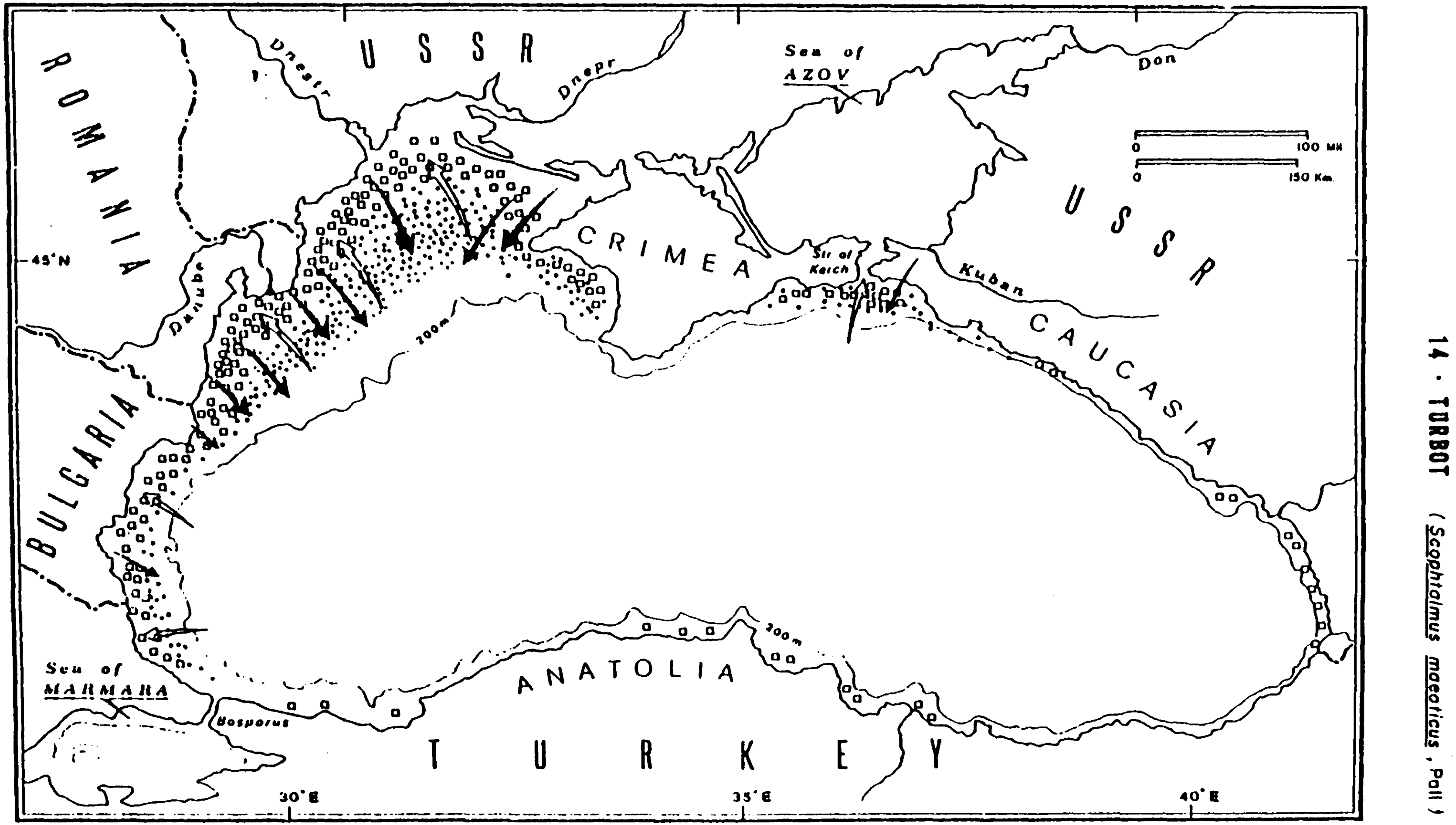
The Black Sea mackerel over-winters in the sea of Marmora and spawns there from February to May. The young reach maturity at the end of their first year of life and then join the adult stock which, after spawning, migrates through the Bosphorus into the Black Sea. Fishing for mackerel is carried out with a variety of gears, mainly traps, sea nets and purse-seine.

13 · ATLANTIC BONITO (*Sarda sarda*, Bloch)



Map 13
ATLANTIC BONITO (Sarda sarda Bloch)

The bonito is an active migrant, whose distribution varies considerably with the contemporary stock size. It over-winters in the Aegean Sea and Sea of Marmora, entering the Black Sea in late spring and early summer. Fishing for bonito is carried out mainly by purse-seine, with trap-nets and drift-nets used to lesser extent.



Map 14
TURBOT (Scophthalmus maeoticus Pall)

The turbot is a demersal fish, found on all continental shelf regions of the Black Sea down to a depth (in winter) of 140m. The turbot does not undergo extensive lateral migrations. It moves towards the coast in spring for spawning and feeds there during summer on smaller migratory species. It moves back into deeper water for winter. Turbot are caught by conventional demersal trawls and other gear.