Subsea Strathspey Project Analysis of Risks from Fisheries Activities

Consultancy Services Report No. 26

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Sea Fish Industry Authority
Technology Division

CONFIDENTIAL

SUBSEA STRATHSPEY PROJECT

ANALYSIS OF RISKS FROM FISHERIES ACTIVITIES

Client: Texaco North Sea UK Company

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INDEX

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1. INTRODUCTION AND SUMMARY

This report contains the findings of a study carried out by Seafish to assess the risks to a proposed underwater wellhead/manifold assembly to be established by the client at a defined location. A feature of the assembly is the relatively short expected operating life and the proposed absence of surface installations for much of the operating period of the installation. The study addresses itself to identifying current and future levels of fishing activity in the area, the loads to be carried by the underwater assembly should fishing gears come into contact with it, and possible means of preventing such contact. As part of the study Seafish have produced a chartlet which it is proposed could be circulated widely to fishing vessel skippers likely to operate in the area.

The area of interest to this study (the "study area") is judged to have lower than average fishing activity when compared with the Northern North Sea activity as a whole. This reflects its relative remoteness and the absence of geographical features which might cause fish stocks to have greater abundance than other regions. The target species in the area are haddock, cod, whiting and saithe (in that order) and the prominent fishing methods used are Scottish seining and pair and single boat demersal trawling. Use of beam trawl by high power vessels is considered as unlikely, given the low catches of flatfish stocks in the area. The overall effect is that both risk of collision and consequent effects of such collisions is considered to be low.

Future developments in fishing activity are expected to lead to a reduction in vessel numbers and effort, though very small numbers of large trawler vessels might enter the fishery, which is currently dominated by medium sized vessels of about 24m length and 750 max. installed horsepower.

Information is provided by which the necessary nature and strength of underwater assemblies can be judged and proposals for a permanent surveylance system are described. However, it must be borne in mind that a number of similar subsea installations have already been established in the area and that the need for a continuous surveylance system can be confirmed, or otherwise, when the installation takes place and by reference to damage experienced with the existing installations.

Following discussions with technical staff of the Client, a number of minor revisions have been made to the text of the report. An additional Appendix has been added; this was originally transmitted to the Client on 8th March 1991 to provide further descriptions of the sequence of events/loads at the time of impact between fishing gears and subsea installations and has subsequently been incorporated into this report.

2. ESTIMATION OF RISK OF GEAR/SUBSEA MANIFOLD COLLISION

2.1 Introduction

The degree of risk of contact between an unmarked underwater obstruction and a fishing vessel's gear, and also of the likelihood of damage from such contact, will be related to the intensity of fishing effort in the area and to the fishing activity carried out. An estimate of the likely risks is made from a combination of official statistics, a knowledge of the seabed conditions and by contact with individuals and organisations which may be willing to offer private information for the purposes of a study such as this.

2.2 Current Level of Fishing Activities

The area under consideration is on the UK side of the UK-Norway Median Line. The manifold position is some 5nm West of the Median Line. It is within EEC jurisdiction and is thus open to all Member State vessels (with some specific exceptions) and also to vessels from Norway under severely restricted circumstances. It lies within the statistical rectangle No.26 of the International Commission for Exploration of the Sea (ICES) Area IVA and their records are the first source of information. Each of the rectangles comprises the sea area with a 1 degree range of latitude and a half degree range of longitude - about 900 square nautical miles at a latitude of 60^{o} North. Rectangle IVA26 covers the area $59^{o}30'$N to 60^{o}N and from 1^{o}E to 2^{o}E.

Though figures of effort are not readily available, it is possible to make sensible deductions from information on catch levels and catch mixtures within the area. Table 1 shows the relative catches of the three main fish classes during 1988 and 1989 for the defined rectangle and for the adjacent rectangles on all sides. It can be seen that catch levels for demersal species (i.e. vessels using trawls in contact with the seabed) are higher in the regions to the South and West of the Rectangle IVA26. As the area of interest to this study is in the North East quarter of the rectangle, catches (and effort) are probably less than the average for the Rectangle as a whole. Pelagic and shellfish catches (typically trawling for scallops using dredge systems) are of negligible importance in the review area. The values for the pelagic fishery do show major variances between the two years, as an indication of the variations in movement of pelagic stocks. It can be expected that pelagic stocks might be taken in the sector from time to time, particularly to the Southern extremity. Vessels fishing the area are predominantly of UK origin. Norway has well established fisheries some 60nm North of the study area and also to the immediate East of the Median Line, and Danish fishing vessels also concentrate their efforts well North and South of the study area.

Examination of a further set of data provides some information on catches by species and by fishing method. The dominant demersal stocks of the area are haddock, cod, whiting and saithe, in order of commercial importance. Information for recent years (and again for Rectangle IVA26 and the eight adjacent rectangles) shows that Scottish seining, demersal pair trawling and otterboard demersal trawling methods dominate the catches. There is no evidence suggesting that the area is utilised by beam trawlers. The low catches of flatfish species in the area make it unlikely that such vessels would be able to take adequate catches to justify their high operating costs. The loads associated with the expected fishing methods are discussed in a later section of this report.

The fishery is predominantly a winter one with some 50% of catches taken in February and March and about 75% of catches taken in the period November to March inclusive.

The seabed within the whole rectangle is generally suitable for all three of the fishing methods prevalent in the area, with the exception of an area of shingle in the SE sector of the rectangle and an area of mud in the NW sector of the rectangle, and on which neither Scottish seining nor pair trawling activities would be expected. This "foul ground" occupies some 3% of the entire rectangle.

2.3 Future Levels of Fishing Activity

In predicting future fishing activities in the area, one is bound to take note of plans within the European Community to reduce the overall size of the fishing fleets, particularly in Northern Community waters, in the medium term. There are a number of scenaria which, for demersal fisheries, range from levels of fishing equivalent to current efforts to about 20% reduction or even less. This reflects low catch per unit effort values for the existing North Sea fishery and for which plans are in hand to reduce effort, either by enforced extension of port turnround times or by reduction of the number of vessels in the fleet. Plans for reduction of fleet activities are being directed at those sectors of the fleet which take the stocks of haddock, whiting and cod (all of which are judged to be under particular pressure at the present time). Thus the fisheries of the study area would be affected by application of the plan eventually selected. A feature of any of the different plans would be that effort, once reduced by one means or another, would thereafter be closely controlled to prevent a reversion to overfishing of the stocks.

One possible option for fisheries expansion would be a development of the shrimp fishery, currently prosecuted some 90nm to the South and West of the study area. Current shrimp fisheres are limited by the lack of adequate onboard and onshore processing facilities and the fleet naturally does not move further from its home ports than is needed to take the quantities that industry can currently process and sell. If better processing machinery becomes available, then it is possible that the catching area will be extended to take in new stocks. However, the expansion would need to be of the order of 3 or 4 fold before the study area became a part of the fishery. It is certain, too, that strict regulations would be enforced to limit the use of small mesh nets (which are required by the shrimp fishery) in order to conserve stocks of demersal fish in the area. Thus the possibility of an effort from this fishing fleet is discounted from the projections on future effort.

Calculations from available data suggest that the maximum current effort would be of the order of 75 vessels fishing within the rectangle throughout the busiest months of February and March. This value would fall to (say) 60 vessels after application of the new control measures. Within a 5 nautical mile radius of the proposed installation (which, as noted earlier, is in the quadrant of the rectangle judged to have the lowest fishing activity), expected fishing activity would be of the order of not more than 2 vessels on average during the busiest months of the year.

Another option to be considered would be a restructuring of the fleet in which two or more small vessels were replaced by a single larger one. Current legislation allows for aggregation of fishing rights of two or more vessels into a new larger one (with size increase and catch quota penalties) and it is possible that some of the present fleet of vessels of up to about 750hp might be replaced by a smaller number of vessels with installed towing powers of up to about 1500hp. Risk of individual collisions would fall, but the consequences of any collision would increase. The larger vessels would invariably practise single or twin demersal trawing. At the present time the regulations provide an obstacle to aggregation, but it might be expected that some easement would take place and that larger vessels (say 30m) may appear on grounds currently utilised by 24m vessels. However, the numbers of such vessels to be brought into service in the next 10 years might be very small, with perhaps 1 vessel out of 60 in the sector of the larger class size.

The manifold and distribution pipelines may cause a fish aggregation effect and fishermen would seek to take advantage of this by fishing on or near the pipelines. The risk to oil industry installations from these practices is low, since a fisherman would confirm the position of the manifold itself before starting his fishing operation in the area. However, it does highlight the need to clearly identify the shape and position of all "outlying" units, such as the shut down valves and housings, and to take care to bury or protect umbilical or other small diameter cables or pipes in the area. The overall effect of creating an aggregation device can never be predicted accurately; one possible effect is that there would be a slight increase in fishing effort during the "slack" period (April to October) as fishermen "tested" the waters for any aggregation effect. The increased level of effort would be quickly suspended if fishing results showed no benefits. In the heavier fishing period, the effect would depend on whether the fish stocks made use of the new habitat; one prospect is that fishing effort might be expanded in the study area as the fish in the area themselves became concentrated in the region of the pipeline. However, the study area is obviously in a fringe location for the stocks so the effect will not probably be great.

3. COLLISION AVOIDANCE TECHNIQUES

3.1 Dissemination of Information Regarding the Obstruction

The primary means of avoiding damage to either the assembly itself or to fishing gear is to disseminate information as widely as possible to fishermen expected to operate in the area. Current means include:

(i) Inclusion of the position of the assembly in the "Yellow Card" booklet produced by Seafish. This booklet is updated periodically by Seafish and circulated widely in both UK and continental fisheries. Many fishermen receive the booklet directly by post, while many other copies are sent to Vessel Agencies, Port Authorities and Fisheries Officers. Typically information on the position of new "obstructions" is obtained from the oil industry via the medium of the UKOOA. Seafish re-calculates the co-ordinates into the various navigational system codes before issue of the booklet. A monthly update list is provided to the fisheries press. Some 27 oil industry installations are already included in the booklet within the ICES Rectangle IVA26. The lists provide information on the type of obstruction; it can be noted that ICES IVA26 already contains 7 subsea operational wells which are not within established safety zones and are not marked by buoys.

(ii) Positions of oil industry and other obstructions are included in the "Kingfisher Charts" series produced by Seafish. These are a series of large scale charts produced specifically for fishermen and give information intended to allow them to avoid underwater obstructions which could damage fishing gear and disrupt fishing. The charts are available in printed form only at the present time, but would be expected to become available in digital database form for display on the "video navigator" systems now in regular use on many modern fishing vessels.

Once again the service includes notification of additions to the database of information, as and when new obstructions are identified.

(iii) In the future the company may wish to circulate "chartlets" which give details of the manifold assembly, connecting pipelines, etc., together with contact telephone/fax numbers for further information as required. A typical chartlet is enclosed with this report. It can be predicted that most vessels will be directly connected into a telephone network during the next ten years so that ready access to an enquiry bureau or to a pre-recorded voice or fax message service will be more convenient than now.

3.2 On-Site Warning of Underwater Obstructions

In general the risk of collisions between the assembly and the fishing gear is small as has already been discussed in an earlier section of the report. Currently the action of giving due notification of positioning of an underwater obstruction through the "Yellow Card" system is accepted as a counter to claims for damage to fishing gears which fishermen might make to the United Kingdom Offshore Operators Compensation Fund. As a consequence, fishermen generally ensure that they study the content of the Yellow Card carefully since they know the financial consequences of damage to their gear will fall on them if they make a mistake. However, it might also be considered prudent to provide direct on-site warning of the obstruction. Options include:-

(i) A marker buoy may be rigged to mark the position of the manifold. For preference the device should carry an identifying radar transponder and light.

(ii) A variant on the marker buoy theme would be a remote sensor buoy station. This could be connected to transponders on the manifold to provide information on operation of the manifold as polled on demand from the relevant production platform in the area, using either satellite communications or direct radio links. An advantage foreseen is that the device could be applied or withdrawn at short notice.

(iii) Watch could be maintained using radar mounted on the nearest permanent production platform. Vessels approaching within one nautical mile of the manifold could be advised by radio of the position of the manifold. It should be noted that vessels using the Scottish seine method "shoot" the fishing gear at a speed of about 6 knots, enclosing a triangular area with each leg about 1200m long. Entanglement of their nets would be bound to occur if the "shoot" surrounded the manifold, but would not occur otherwise since the vessel remains effectively motionless when hauling the gear. For the trawling methods, the clear signs of potential collision would be noted from the track either of one vessel, or of two vessels on parallel courses, steaming on a collision course with the manifold at a speed of about 3 to 4 knots. Special watch should be kept for pair trawler operations since it would not be necessary for either vessel to pass directly over the manifold (which would then be detected on the vessel's echo sounder) for a collison to occur. A single vessel towing a fishing gear would generally be expected to pass over any obstruction to its nets in the course of the tow, though there are a number of circumstances in which this might not be the case. It is also possible that a trawler may not be able to take the necessary evasive action given the extent of the manifold and outlying valve assemblies. Thus any warning to fishing vessels regarding the position of the manifold should be given at a one mile radius from the manifold if a change of course is to be effective.

4. POSSIBLE COLLISION FORCES DUE TO FISHING ACTIVITIES

From the fishing activity analysis it has been found that the most prevalent types of fishing likely to be undertaken in the study area are:

(a) Scottish Seining
(b) Pair Trawling - Demersal (2 x 750hp vessels)
(c) Single Boat Demersal Trawling (1 x 750hp vessels)

in the given order of importance.

Less likely but a possibility for future operations would be a higher powered version of option (c), i.e.

(d) Single Boat Demersal Trawling (1 x 1500hp vessels)

Brief descriptions of the different methods are given in the Appendices, as an aid to understanding of the possible collision options. The scale of the forces involved is summarised in the brief statements below.

4.1 Scottish Seining

Vessels which undertake this fishing method are generally up to 24m in length with displacement typically of about 360 to 400 tonnes. The horsepower necessary for this fishing method needs only to comprise of a power to drive the hydraulic pumps used in the net hauling operation, together with a power to propel the ship at about 2 knots - in total, a horsepower of about 400.

Frequently, however, the vessels are also capable of trawling and have an installed horsepower to suit that method which is substantially higher - about 750 as a maximum.

Allowing for an added mass coefficient of 10% and ignoring the mass of the seabed fishing gear:

MOMENTUM OF FISHING SYSTEM BEFORE IMPACT

= Mass of Vessel x 1.1 x Net Speed

MOMENTUM OF TRAWL BEFORE IMPACT

= 400 x 1.1 x (2 x 1.689)/32.2

= <u>46 tons ft/sec</u>

KINETIC ENERGY BEFORE IMPACT

= $0.5mv^2$

= $0.5 \times 400 \times 1.1 \times (2 \times 1.689)^2/32.2$

= <u>78 ft. ton</u>

However, in the event of the trawl gear becoming fast, the attempt to free it could create forces in excess of these and if a dual purpose vessel of up to 750hp is being used, the forces could be as high as:

$$\frac{750}{100} \times 1.5 \times 2 \quad = \underline{22.5 \text{ tons}}$$

allowing for a surge factor of 2. However, the ropes used would not withstand a strain greater than about 5 tonnes.

4.2 Demersal Pair Trawling (2 x 750hp)

Vessels which undertake this fishing method are generally up to 24m in length. The trawl is towed between two vessels up to speeds of 3½ knots and would have, just before impact, a typical:

MOMENTUM = $(2 \times 400 \times 1.1) \times (3.5 \times 1.689)/32.2$
= 162 tons ft/sec

KINETIC ENERGY = $0.5mv^2$ ft
= 478 ft. ton

An allowance of 10% is made for the added mass coefficient effect in the calculation above and applying the factor of 2 covering for increased forces to absorb surge of the vessels or attempts to free the trawl gear from a fastener (using one vessel), the maximum forces could be:

$$2 \times \frac{750}{100} \times 1.5 = 22.5 \text{ tons}$$

4.3 Single Boat Demersal Trawling (1 x 750hp)

Again vessels which undertake this type of fishery are generally up to 24m in length and fish similarly to the pair seine vessels but use trawl doors to keep the mouth of the trawl net open. Typically the forces which are applied just before impact are (at 3.5 knots towing speed):

MOMENTUM = 81 tons ft/sec
KINETIC ENERGY = 196 tons ft

and applying the factor of 2 for increased forces due to vessel surge or attempts to free the trawl from a fastener:

$$\text{MAX FORCE on one warp line} = 2 \times \frac{750}{100} \times 1.5 = 22.5 \text{ tons}$$

4.4 Single Boat Demersal Trawling (1 x 1500hp)

Vessels undertaking this type of fishery with very large nets are approaching 33m in length and with a displacement of up to 500 tonnes. The fishing method is the same as for the smaller middle water vessel, but the complete trawl gear is much larger and heavier. Trawling speeds of up to 3½ knots can be achieved and thus the typical forces which may be applied to a seabed obstruction just before impact are:

$$\text{MOMENTUM} = 500 \times 1.1 \times (3.5 \times 1.689) = \underline{101 \text{ tons ft/sec}}$$

$$\text{KINETIC ENERGY} = 0.5 \times 500 \times 1.1 \times (3.5 \times 1.689)^2/32.2 = \underline{298 \text{ ft tons}}$$

$$\text{MAX FORCE on one warp} = \frac{1500}{100} \times 1.5 = \underline{22.5 \text{ tons}}$$

Applying the factor of 2 for increased forces due to vessel surge or attempts to free the trawl from a fastener:

MAX FORCE in one trawl warp = 45 tons

Warp failure would be expected in these circumstances.

4.5 Summarising

It can be seen from the above that the design of the oil wellhead obstruction being considered should cater for impact parameters of at least:

45 tonnes for warp line tension
162 ton ft/sec for Total Momentum in System
478 tons ft for Total Kinetic Energy in System

Further calculations to determine maximum design forces are given in Appendices I and III.

Note that the Surge Loads defined above would represent the effects of a vessel skipper making an effort to free/destroy his fishing gear in order to retrieve the greater part of it (say warps and otterboards, but not necessarily the net). A number of other manouvres would already have taken place in advance of this drastic action, generally attempting to reverse the direction of tow or even to achieve a direct lift on the trawl components. The forces involved in a direct lift operation would be limited by the performance of the winch installed on board, and to some extent by the capability of the vessel to withstand the capsizing forces involved. Given that the vessel would be laid directly over the obstruction, with warp barrels full except for the short length of warp between the surface and the obstruction, then the total lift force which could be applied would be limited to about 20 tons for the largest vessel considered in this study. The lift would be applied slowly and would create forces much less than achieved by the surge load approach. The horizontally applied surge load thus remains the critical load option.

TABLE 1: Fish Catches in Northern North Sea - Tonnes - 1988(1989)1

Species	ICES Area Codes		
	IVA15	**IVA16**	**IVA17**
Demersal	2563 (1854)	984 (979)	185 (103)
Pelagic	(2184)	(1)	
Shellfish	1 (5)	(1)	(1)
	IVA25	**IVA26**	**IVA27**
Demersal	2562 (1908)	1523 (1782)	1445 (1887)
Pelagic	191 (5947)	(1)	(1)
Shellfish	(4)	(1)	
	IVA35	**IVA36**	**IVA37**
Demersal	4277 (4034)	2399 (3032)	1763 (2592)
Pelagic	(2434)	(426)	
Shellfish	1	1	

The area covered by the above table ranges from 59°N to 60°30'N and from 0°E to 3°E.

APPENDICES

APPENDIX I

This report gives a general assessment of the likely forces which may give rise to Damage Potential to Oil Wellhead Obstructions in the North Sea by fishing gear worked by fishing vessels.

It contains descriptions of fishing vessels, their groupings, descriptions of the fishing gear and methods used.

The maximum impact and pulling forces which may be applied are assessed and the effects of attempts to release snagged fishing gear are examined.

APP.I

TRAWLERS

These vessels use a net known as a trawl and have sufficient power to tow the net at the required trawling speed.

Trawlers may be divided into classes or types determined by type of trawl used, layout, vessel size and areas of operation. These classifications often combine and overlap.

Three basic types of trawl are used viz:-

(1) **Demersal** — a towed net having contact with the seabed and having the mouth held open by trawl doors or otter boards.

(2) **Pelagic** — a towed net never having contact with the seabed.

(3) **Beam** — a towed net having contact with the seabed and having the mouth held open by a horizontal beam.

Vessels which handle the trawl net over the side are known as side trawlers - the net usually being a demersal trawl. Vessels which handle the trawl net over the stern are known as stern trawlers - the net being either demersal or pelagic. Vessels towing a beam trawl are known as beam trawlers.

Inshore Trawlers are vessels up to about 18 metres in length.

Middle Water Trawlers are vessels up to about 24 metres in length.

Distant Water Trawlers are vessels up to about 33 metres in length, operate in any sea area making about 24 day trips.

Freezer and Factory Trawlers are invariably vessels over 33 metres in length operate in any sea area and able to stay at sea for many weeks.

SIDE TRAWLERS (Figure No.1)

On side trawlers the trawl is set over the side and the warps pass through blocks hanging from two gallows, one forward and one aft.

Usually the superstructure and the wheelhouse are placed aft, the fish hold is situated amidships and the trawl winch transversly at the front of the superstructure.

Although the stern trawler is now accepted as the logical development from the side trawler, this type will be with us for some time.

> Side trawlers up to 18 metres in length are generally classed as Inshore Trawlers.
>
> Side trawlers up to 24 metres in length are generally classed as Mid Water Trawlers.
>
> Side trawlers up to 33 metres in length are generally classed as Distant Water Trawlers.

Many side trawlers go pair fishing, wherein each boat takes one of a pair of warps, and the use of otter boards is avoided.

The low freeboard inherent in the side trawler which makes possible the side handling of the gear, also allows a lot of 'green' water aboard in bad weather.

The amount of warp used depends mainly on the depth of water being fished, and is roughly three times that depth. This is varied to some extent by the nature of the bottom and the weather. Too much warp on a muddy bottom makes the gear dig in, and in heavy seas the gear tends to snatch and lift with the trawler's motion, unless extra warp is used.

STERN TRAWLERS (Figure No. 2)

On these vessels the warps are led from the trawl winch to a gantry arranged at the stern and thence over the stern. On stern trawlers the wheelhouse and accommodation is usually arranged from midships forward with the trawl winch immediately aft of the wheelhouse. On inshore and middle water vessels the net may in part be handled over the side of the vessel. On the distant water vessels and freezer vessels the net is handled over the stern using the ramp.

WET-FISH TRAWLERS

This term is used for trawlers, on which the fish is kept in the hold in the fresh/"wet"/condition. Wet-fish trawlers therefore operate usually in areas not too far distant from the landing place.

The majority of small trawlers and some medium sized trawlers are not equipped with refrigerating plants but many of them have insulated fish holds and carry ice to preserve fish.

FREEZER AND FACTORY TRAWLERS (Figure No. 3)

Freezer Trawlers

These are trawlers on which the fish is preserved by freezing. The majority of trawlers operating on distant waters are freezer trawlers.

Freezer trawlers are outfitted with refrigerating plant and freezing equipment. The holds are insulated and refrigerated, an example of a freezer trawler is shown in Figure No. 3.

Factory Trawlers

These are generally large stern trawlers equipped with processing plant including mechanical gutting and filleting equipment with accompanying freezing installation, fish oil, fish meal and sometimes canning plants.

Separate holds for each of the products are provided.

Factory trawlers have a large crew, the greatest portion of which consists of fish factory crew.

Extensive superstructures combined with stern trawling arrangements are typical features of factory trawlers.

Beam Trawlers (Figure No. 4)

These trawlers use strong outrigger booms to tow their fishing gear. These outriggers are usually fastened to the mast and extend out from the sides of the vessel each towing a beam trawl by means of warps passing through blocks at the ends of the outriggers.

THE TRAWL AND HOW IT WORKS

Basically, a trawl is a conical scoop of netting designed to herd fish into it. Once inside the main net, the fish find their way into the of the scoop - known as the 'cod end', from which the only escape is for undersized fish - through the meshes of the net.

Studying Figures 5 and 6 it can be seen that the 'herding' parts of the trawl are the wings, the main part, made up by the bellies, battings, and on a bottom trawl, the square, which is to prevent upward escape of the fish when disturbed by the footrope. This runs from one lower wing to the other, to keep the trawl on the bottom and disturb the fish.

Demersal Trawls (Figure No. 7)

On demersal trawls (bottom) heavy iron or hard rubber bobbins are attached to the footrope to hold it close to the sea bed and resist the tendancy for the trawler to tow the gear to the surface. They also serve as 'wheels' which roll over small obstructions and irregularities. The bobbins, with intermediate spacers also of iron or rubber, are found at the centre of the footrope's span and are flanked by numerous rubber discs. The footrope is often the first part of the trawl to find a 'fastener' on the sea bed and thus has to be very strong, yet flexible.

The trawl is kept open vertically by floats along the headrope and horizontally by otter boards, also known as doors, exacting a sideways pull.

Although the trawl and its gear are heavy when out of the water, much of its weight is lost once it is submerged, for everything weighs less in water.

Pelagic Trawls (Figure No. 8)

Pelagic trawls do not have this bottom contact gear but have weights hanging from the bottom warps close to the net to assist in keeping the mouth of the trawl open.

Otter Boards (Figure No. 10)

Otter boards, also known as trawl boards or doors, are used to open the mouth of the trawl laterally.

The conventional otter board is simply a number of flat boards bolted together, with a heavy 'shoe' as ballast and for protection against damage. The lower corners are rounded to prevent digging in, enable them to override bottom irregularities and to avoid snagging submarine cables.

Their length is approximately twice their height and the surface area and weight are suited to the horsepower of the fishing vessel. Planks of wood, usually oak, are fitted lengthways into a frame made from steel channel and braced back and front with steel bars or steel channel. A heavy steel keel is welded to the bottom edge and the lower sides are protected from damage by steel side plates.

Some oval doors are made of wood and steel, others, such as the Morgere Polyvalent type are all steel, and many have heavy ballast weights in the bottom edge. Polyvalent doors are stable when not in contact with the bottom, and can be used with semi-pelagic trawls fishing just above the bottom.

Pair Trawling (Figure No. 9)

Pair trawling is a method of using two vessels to tow a single large trawl between them and which may be either demersal or pelagic.

In this method there is no requirement for trawl doors as the spread of the mouth of the net is achieved by the vessels each pulling a warp and steering a parallel course to each other at a fixed distance apart.

This method has a greater fish catching potential then when each vessel tows its own smaller net.

Beam Trawling (Figure No. 11)

Basically the beam trawl is a demersal or bottom trawl held open horizontally by a steel tube (the beam) and vertically by heavy 'beam heads', hoop-like skids of steel fitted with a heavy shoe. By virtue of their limited height, the beam heads restrict catching depth to a few feet from the seabed, so that the beam trawl is favoured for plaice and sole. In recent years, beam trawling vessel's skippers have utilised more and more heavy tickler chain to 'dig' the fish from the seabed, and some vessels tow as much as 3 tones of chain hung between the beamheads.

The chains increased catching power considerably, which led to some overfishing, which led to more chain, more horsepower to tow it and bigger boats to accommodate the necessary engine and winch required.

It is not difficult to imagine the effect of one of the trawls coming fast on the seabed, with the weight of the boat, a 1000 hp engine and possibly a following tide all combining to throw weight on to the 'anchored' trawl. This can cause the boat to broach-to and founder unless the load is quickly taken off the overloaded trawl warp.

In an effort to overcome this danger, a quick-release slip-hook was devised which, when tripped, transferred the towing strain to a point on the bow, so that the vessel would swing safely head-on to the gear.

Electric Trawls

The heavy tickler chains described on an earlier page and the need to tow the gear at speeds at high as 7 knots are responsible for very high fuel costs for beam trawlers. It has been found that a lighter, cheaper, more easily handled rig consisting of a pair of 9 metre beam trawls with light chain footropes is very effective on shrimp, soles, plaice and eels, when fitted with beam-mounted trailing chains into which wire electrodes are woven.

Seine Net Vessels (Figure Nos. 12 and 13)

Vessels which conduct this method of fishing are generally 18-24m long overall and similar to a side trawler in layout. Some of this class of vessel are dual purpose, undertaking both bottom trawling and seining.

For this fishing method, fishing area is surrounded by a net attached to very long ropes. Next the net is towed or dragged over the bottom. It is not to be confused with purse seining which is an encircling net used for catching schooling fish.

The nets used in this type of fishery are similar to light high opening bottom trawls but they use long lengths of seine rope spread out on the seabed on each side of the net as shown in Figure No. 10.

Seine netting can be either anchor seining, where the boat works from an anchored buoy, sets the net, then returns to the mooring and hauls the gear toward itself by the ropes, or as 'flydragging'. Flydraggers start from a free-floating dhan buoy, set the gear as before, return to and pick-up the buoy, then move slowly ahead as the seine ropes come in over one quarter.

Pair Seining

A third variation is pair seining, where each boat carries one rope warp, first shooting the net and then laying out the rope in the normal pattern. By steaming on a converging course, the boats perform the same function as the winch on a single boat, but towing the net for some distance as a trawl. When the boats finally came alongside, the ropes are hauled in until the net is recovered.

Purse Seining (Figure Nos. 14 and 15)

This type of purse seiner has the bridge and accommodation located aft. The fish hold is situated amidships.

The net is mostly carried on the upper deck and the power block is fitted to the side of the bridge with separate transport blocks or roller to stow the net on the aft deck (See Figure No. 14).

The pursing winch is normally situated forward with the drums facing the pursing davit.

Purse seining is the method of capturing a shoal of fish by surrounding it with a deep curtain of netting - the purse seine net. The bottom edge of net is then closed under the shoal and the net hauled in until the 'purse' is closed and is as small as the entrained shoal permits. The fish are then lifted out by brail or by pump.

A typical purse net for herring may be about 150 metres long by 25 metres deep.

Vessels which handle this type of fishing net are generally over 33 metres in length.

Longliners (Figure No. 16)

These vessels use lines and hooks with bait or lure.

Longlines can be operated from vessels of any size adapted for the length of longline to be set. Bottom longlines are placed on or near the bottom and drifting longlines are maintained at the surface or at a certain depth by means of floats.

In typical arrangements the gear is hauled from the bow or from the side with a mechanical or hydraulic line hauler and the lines are set over the stern.

The wheelhouse can be situated aft or forward, but on larger vessels the bridge is generally placed aft. Several automatic or semi-automatic systems are used on bigger boats to bait the hooks and to shoot and haul the lines.

Fishery Research Vessels (Figure No. 17)

These vessels are mainly engaged in fish stock assessment, experimental fishing using various gear and in fish handling/store experiments. The size of fishery research vesels depends on the area operation and on research programmes.

The vessels are usually fitted for the operation of two or more types of fishing gear. Special winches for taking samples and apparatus measurements of environmental characteristics are provided.

EFFECTS OF COLLISION BETWEEN TRAWL GEAR AND SEABED OBSTRUCTIONS

Dynamic Load Applied to Seabed Obstruction

The maximum dynamic load which may be applied to an obstruction will be applied by a demersal type trawl being towed by either two vessels - pair trawling or by a beam trawler towing two trawls simultaneously.

The maximum static pull or a vessel is dependant on the horse power available to the propeller and the design criteria of the propeller. The propeller will demand of the engine a horsepower, up to the design h.p. of the propeller dependant on the load put on it. Thus the propeller is designed on a horsepower not exceeding that of the engine.

The maximum thrust of a propeller will in general terms not exceed 1.5 tonnes per 100 h.p. delivered to it. It can be seen, therefore, that the maximum static pull will not exceed 1.5 tonnes per 100 h.p.

For a propeller designed to give maximum pull at trawling speed the pull is nominally the same as the static pull - 1.5t/100 b.h.p. up to trawling speeds of 4 knots.

This factor should be used to determine the load on over-trawlable subsea structures.

To determine design loads a structure which may foul the fishing gear, the force needed to decelerate the vessel should also be considered.

A typical calculation is presented in Appendix III.

EFFECTS OF FREEING FASTENER

Attempts to free trawl gear from an obstruction on the seabed has many scenerios. The force applied to the obstruction must, however, lie within the limits of the static pull of the vessel and the maximum breakout speed which could be achieved.

Thus it may be said that the calculated warp line tension values when multiplied by the surge factor of two would cover any additional forces applied in freeing a fastener.

Generally when fishing gear becomes fast on a seabed obstruction the skipper will try and manoeuvre the vessel such that the gear will be pulled away in the opposite direction to the direction of the initial tow.

If this fails the next course of action would be to release the warp attached to one side of the vessel, buoy it off, and then alter course to tow the gear round the back of the obstruction whilst hauling in.

Only in extreme cases and with due consideration to the safety of the vessel and its crew would an attempt to 'break out' at speed be attempted.

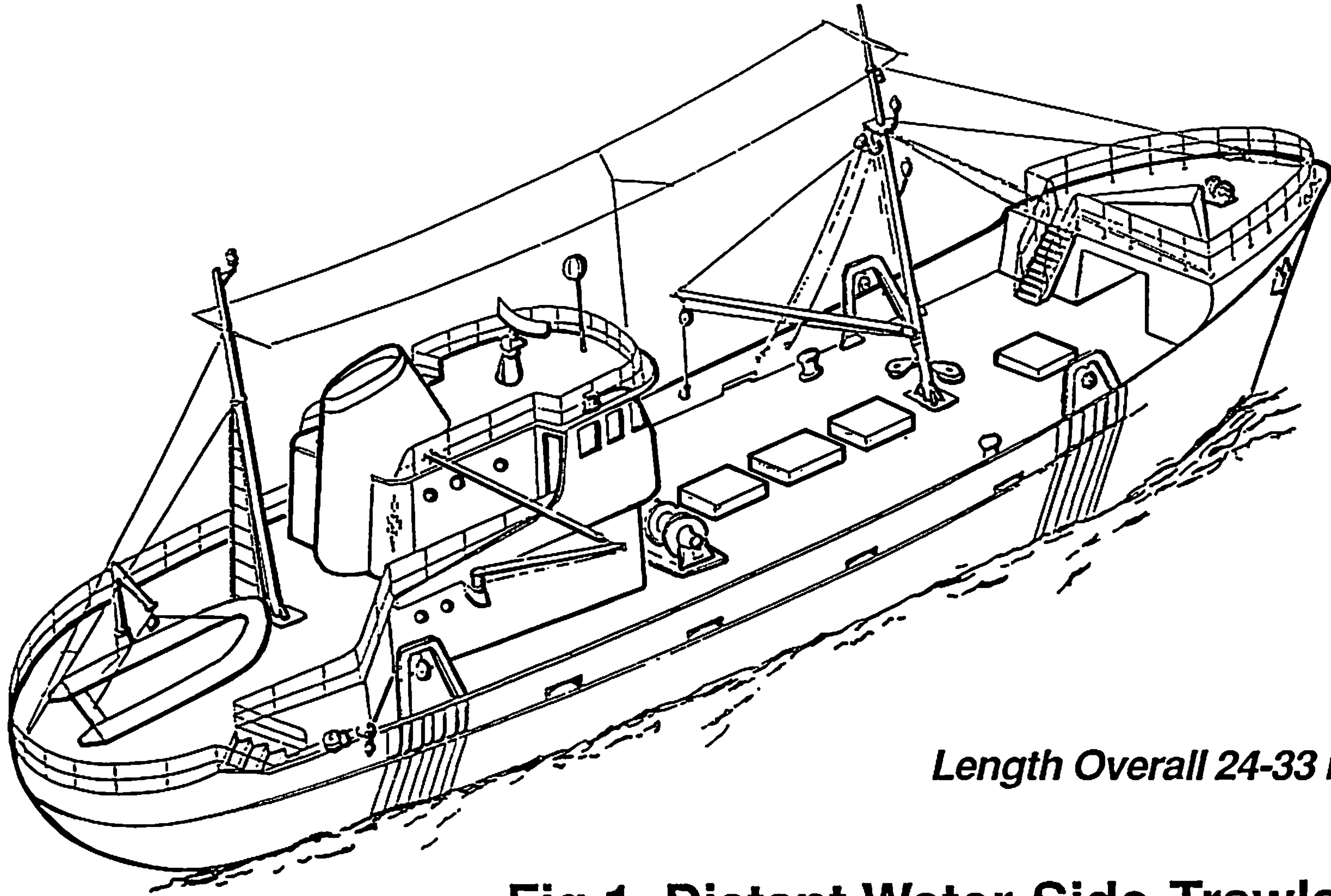
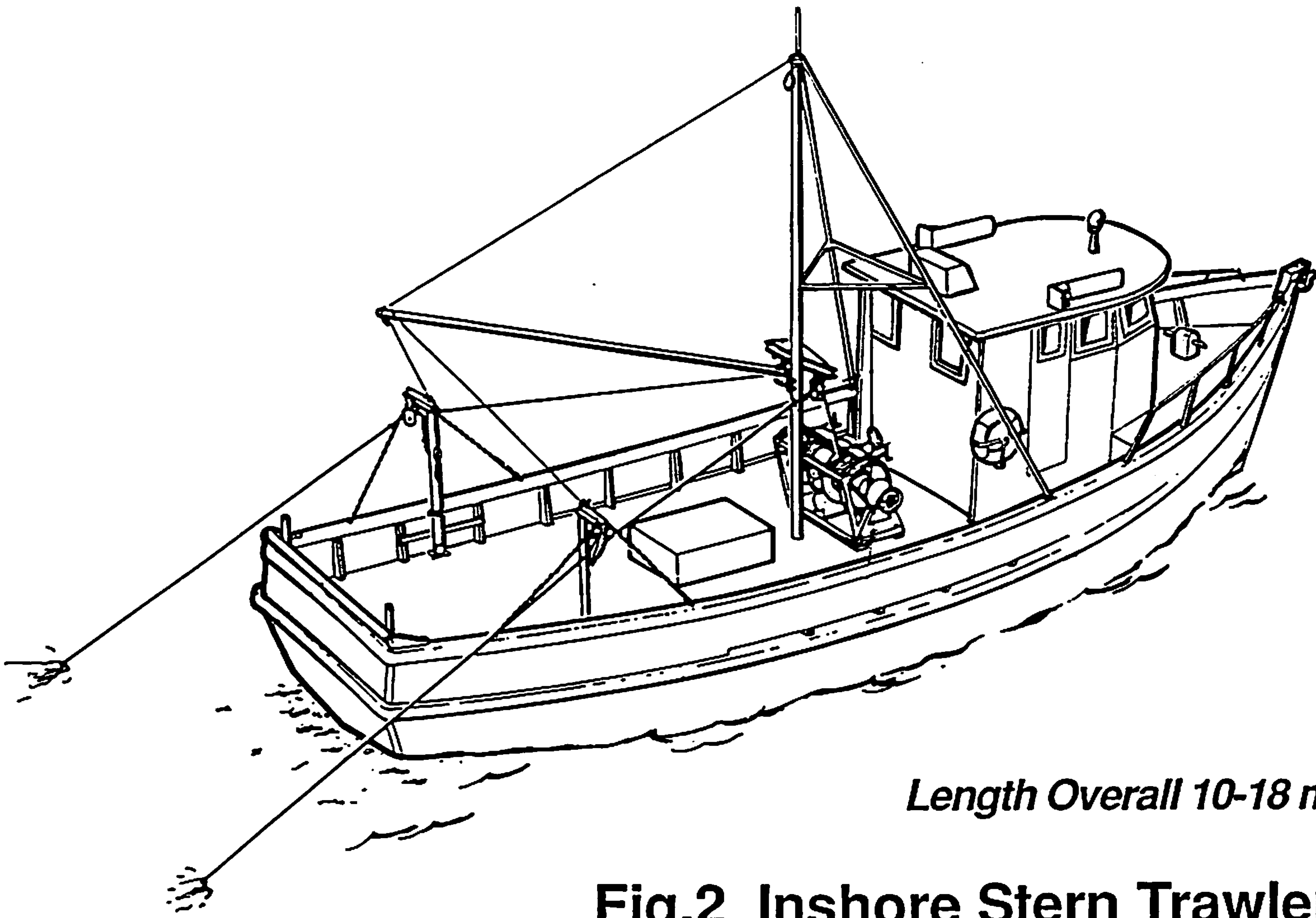
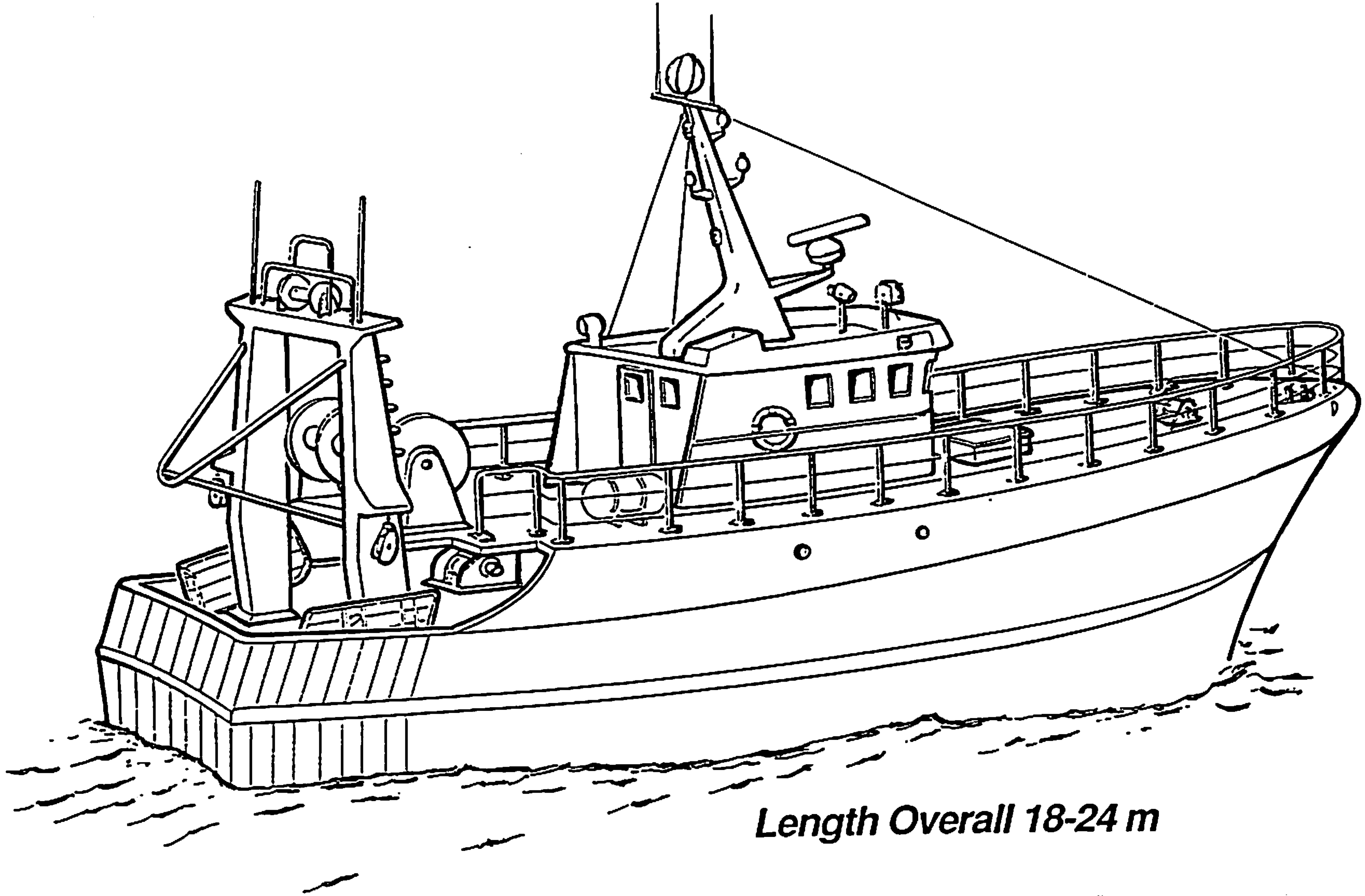


Fig.1 Distant Water Side Trawler



Length Overall 10-18 m

Fig.2 Inshore Stern Trawler



Length Overall 18-24 m

Fig.2a Middle Water Trawler

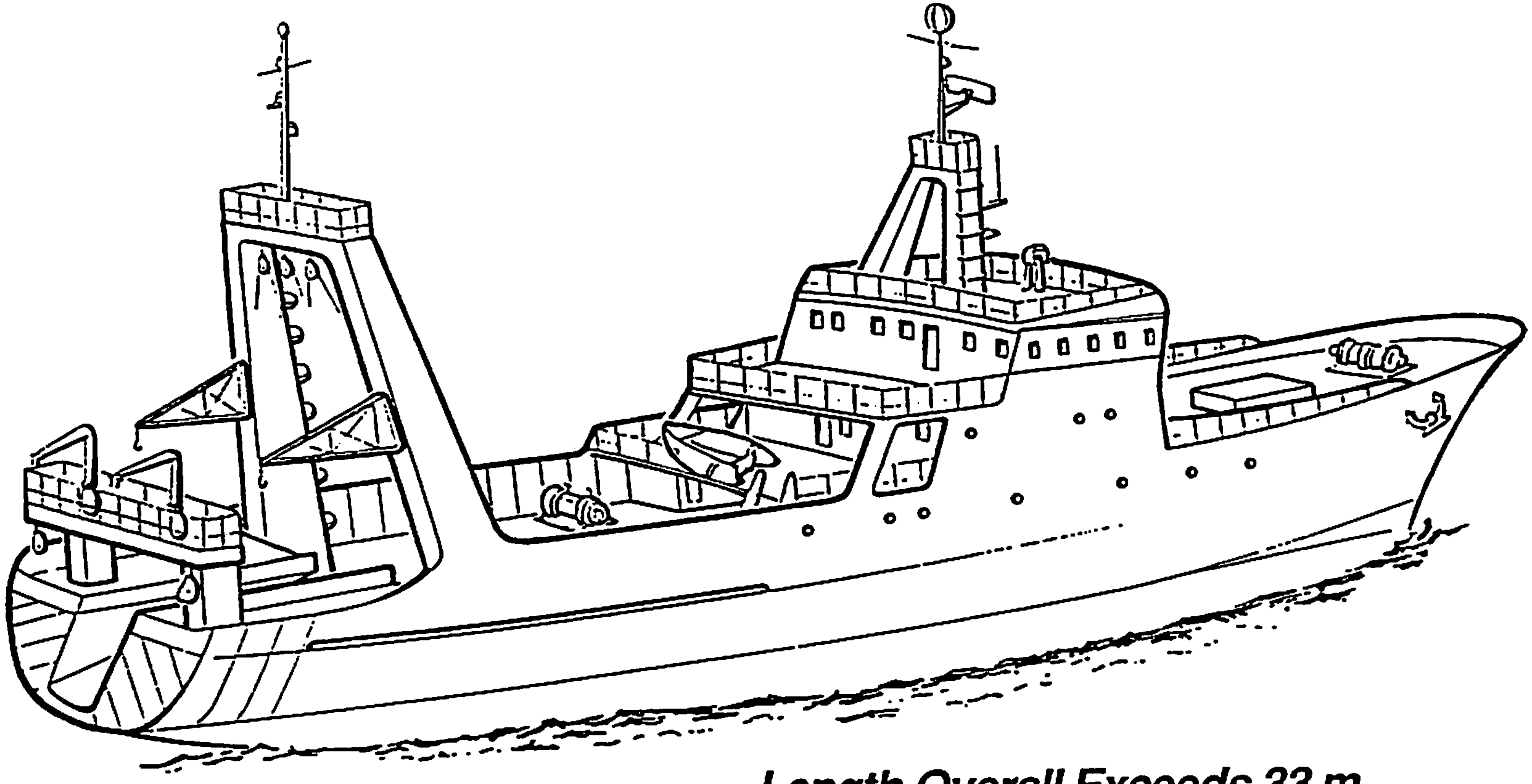


Fig.3 Freezer and Factory Trawler

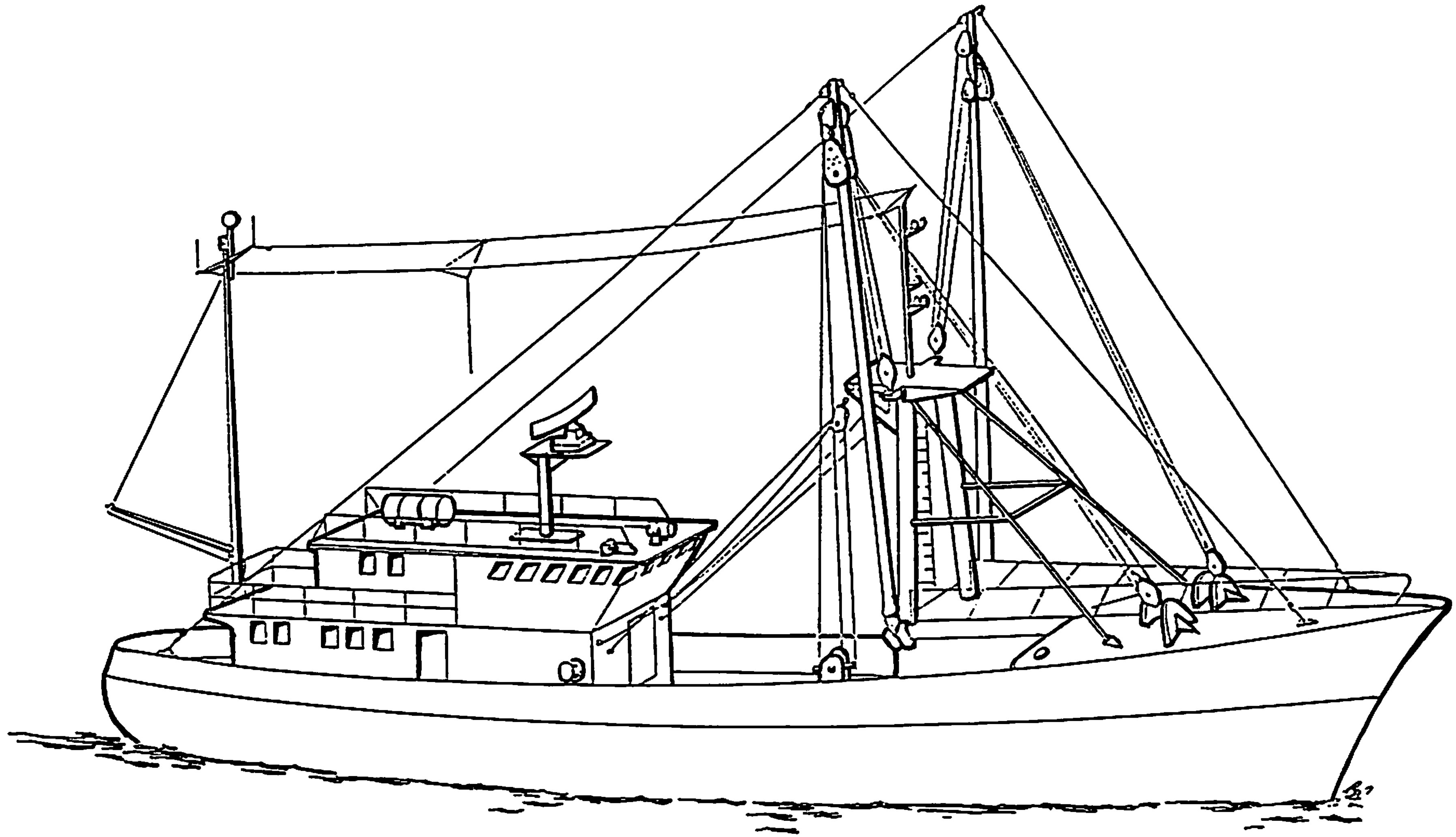


Fig.4 Beam Trawler *Length Overall Exceeds 24 m*

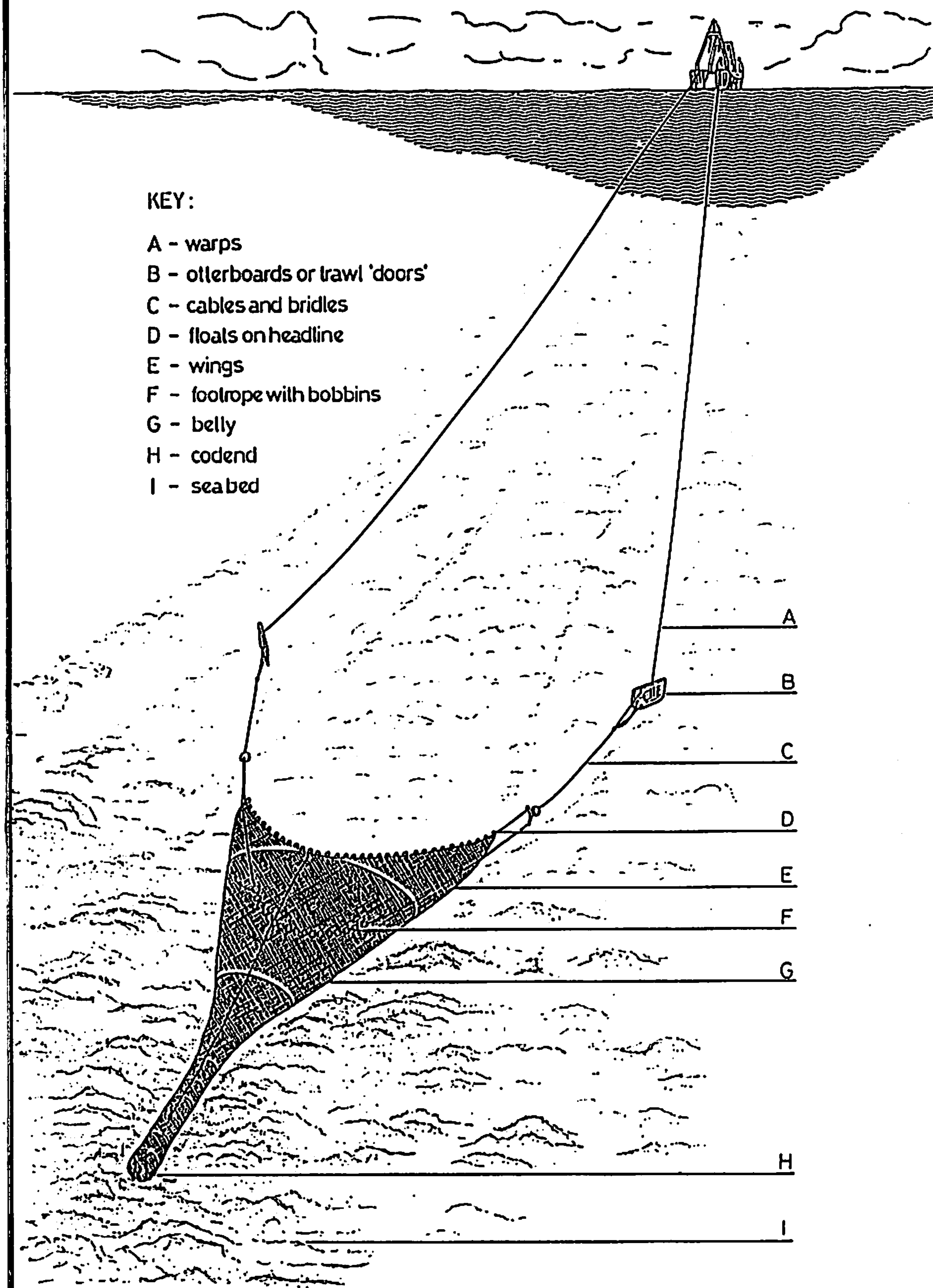
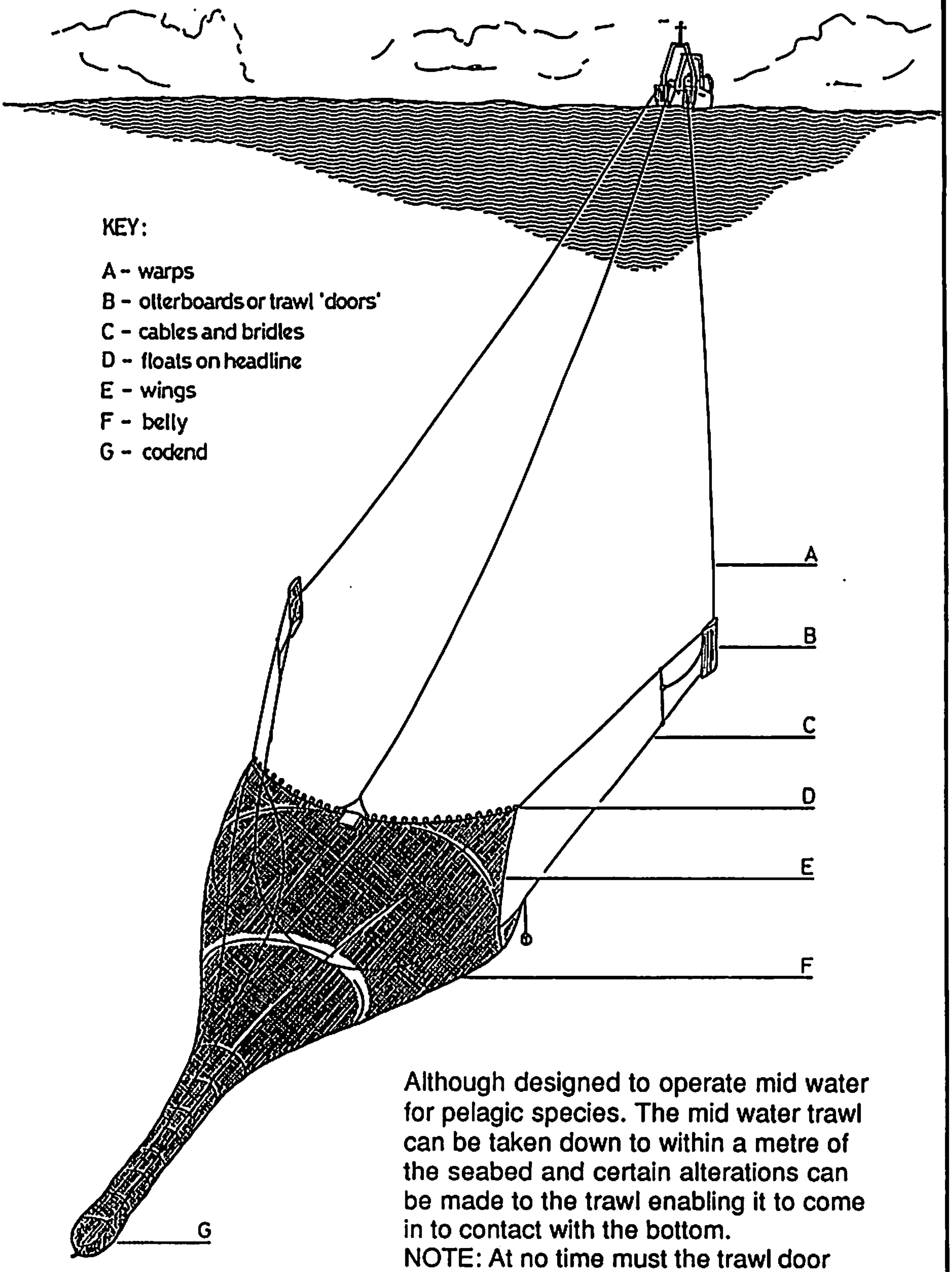


Fig.5 Demersal Trawling *(Bottom)*



Although designed to operate mid water for pelagic species. The mid water trawl can be taken down to within a metre of the seabed and certain alterations can be made to the trawl enabling it to come in to contact with the bottom.
NOTE: At no time must the trawl door touch the bottom.

Fig.6 Pelagic Trawling *(Mid Water)*

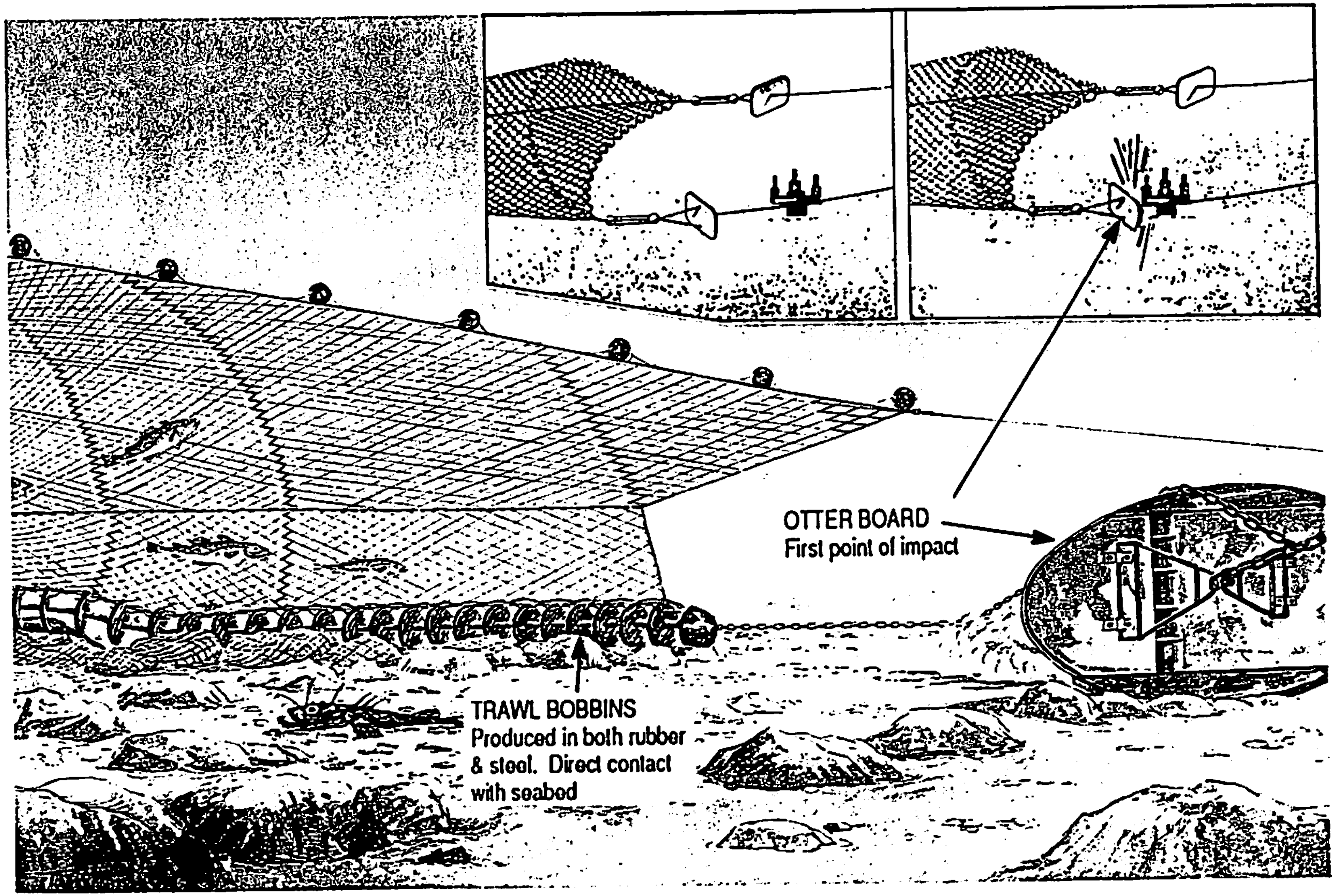


Fig.7 Demersal Trawl

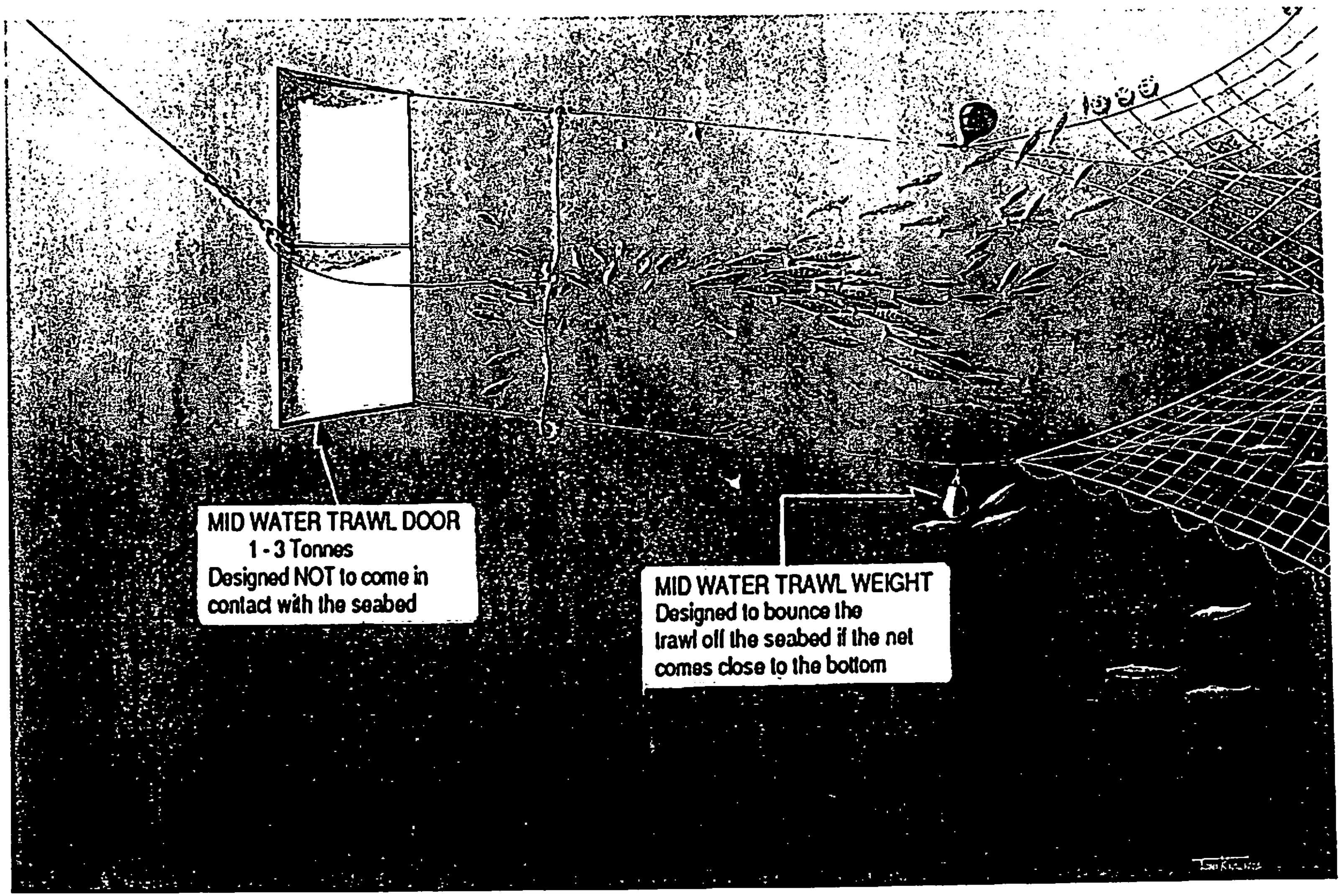
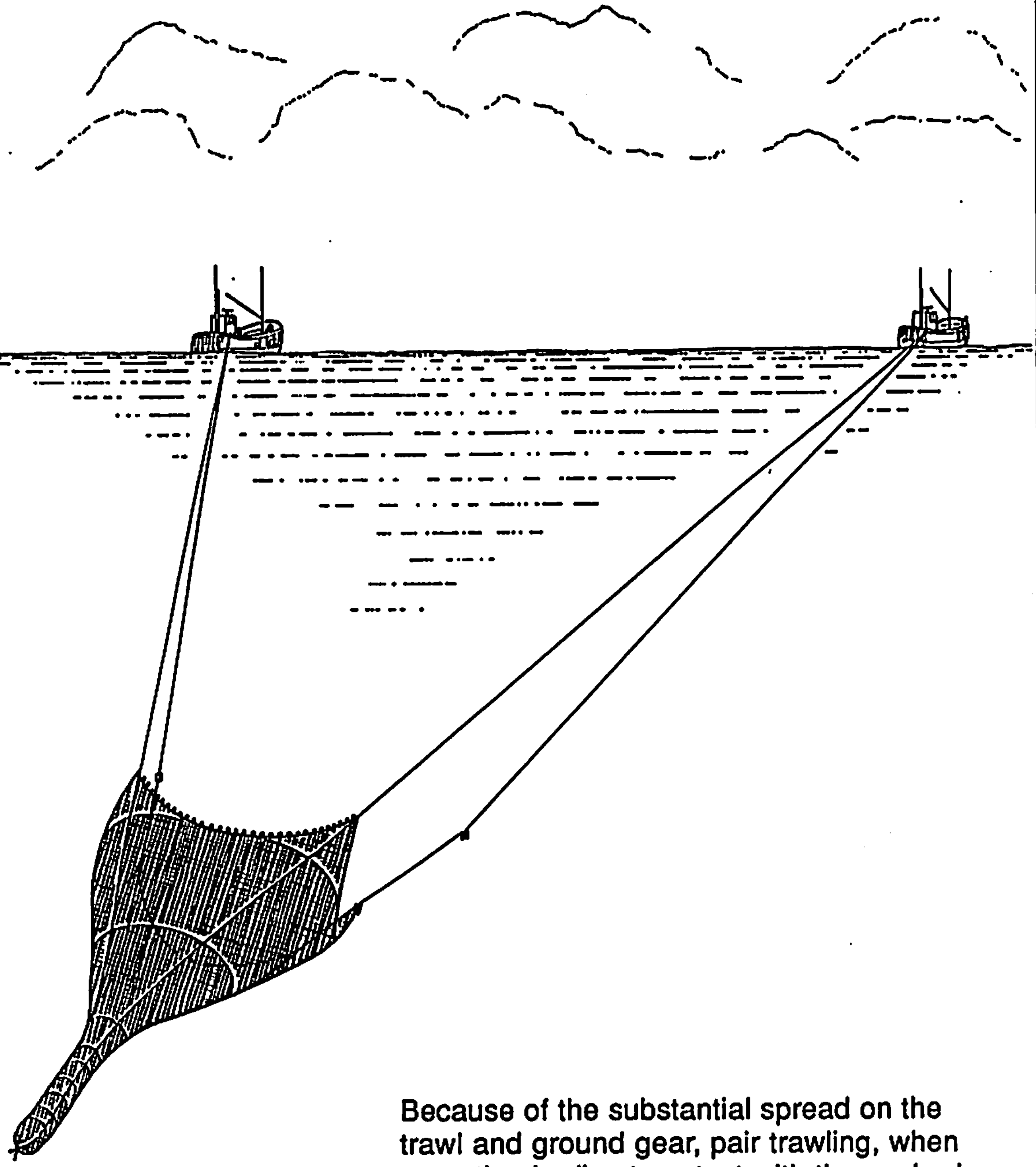
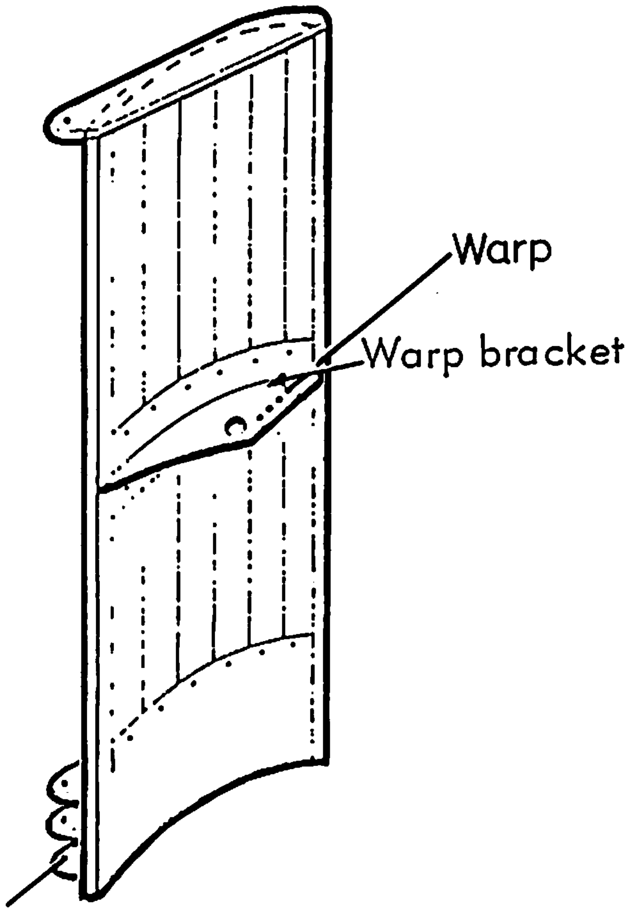


Fig.8 Pelagic Trawl



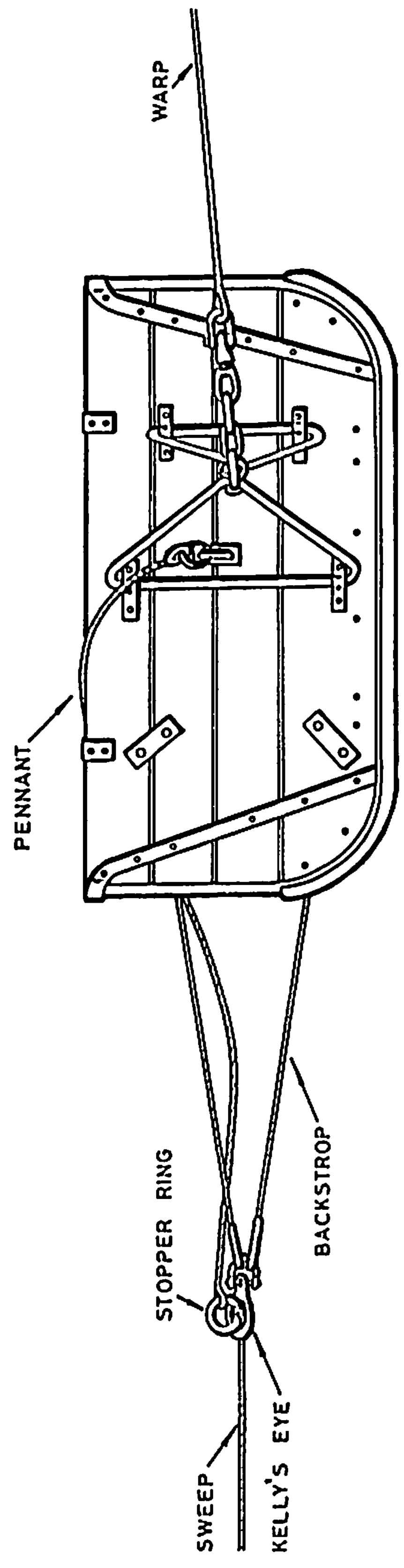
Because of the substantial spread on the trawl and ground gear, pair trawling, when operating in direct contact with the seabed will have far more chance of making contact with cables and installations.
NOTE: Pair trawlers working their trawl on the seabed may have up to 50 metres of chain between the trawl and towing warps, this chain will be in touch with the bottom.

Fig.9 Pair Trawling *(Mid Water)*



Pelagic Trawl Board

Fig.10



Flat Otter Board

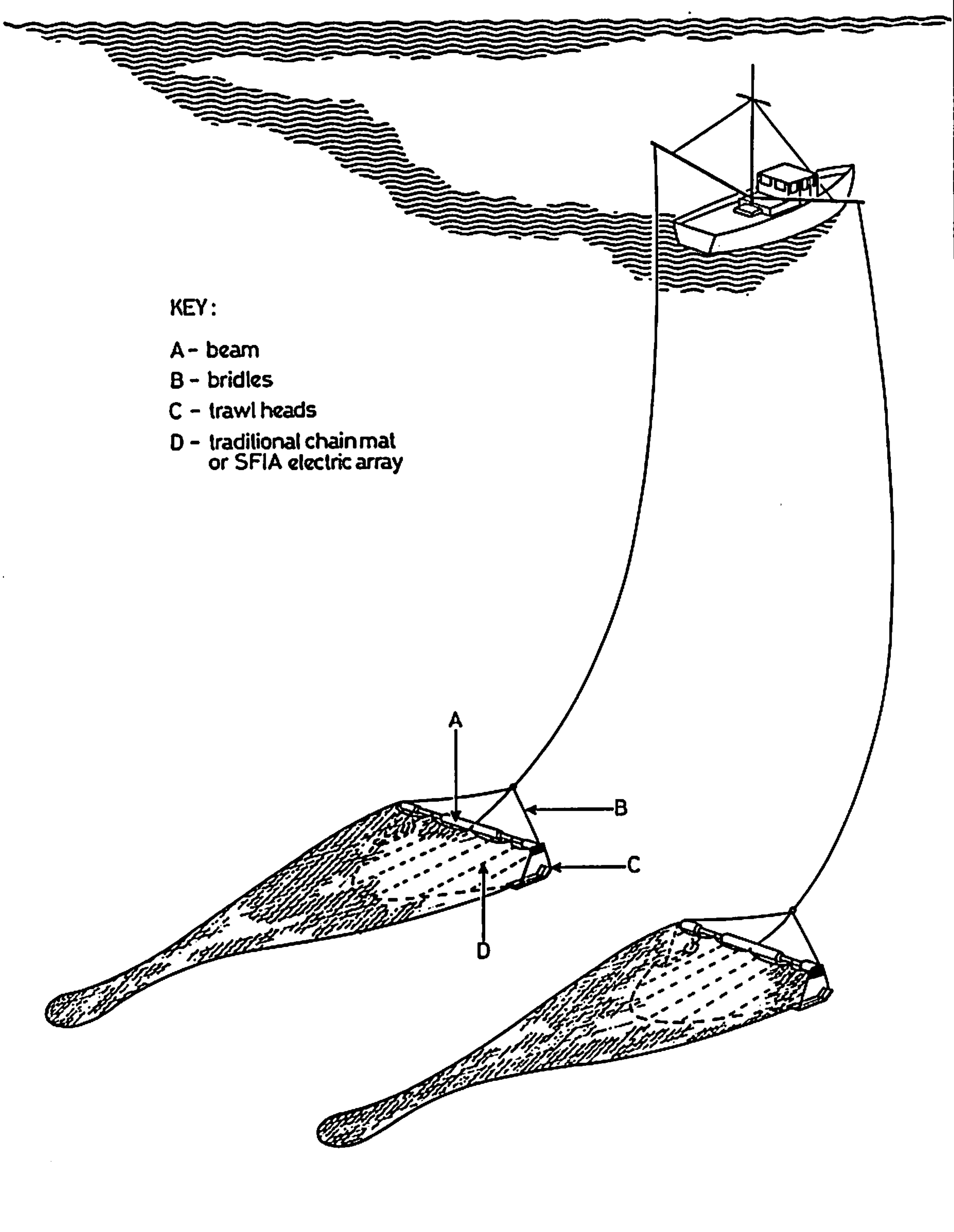


Fig 11. Beam Trawling *(Bottom)*

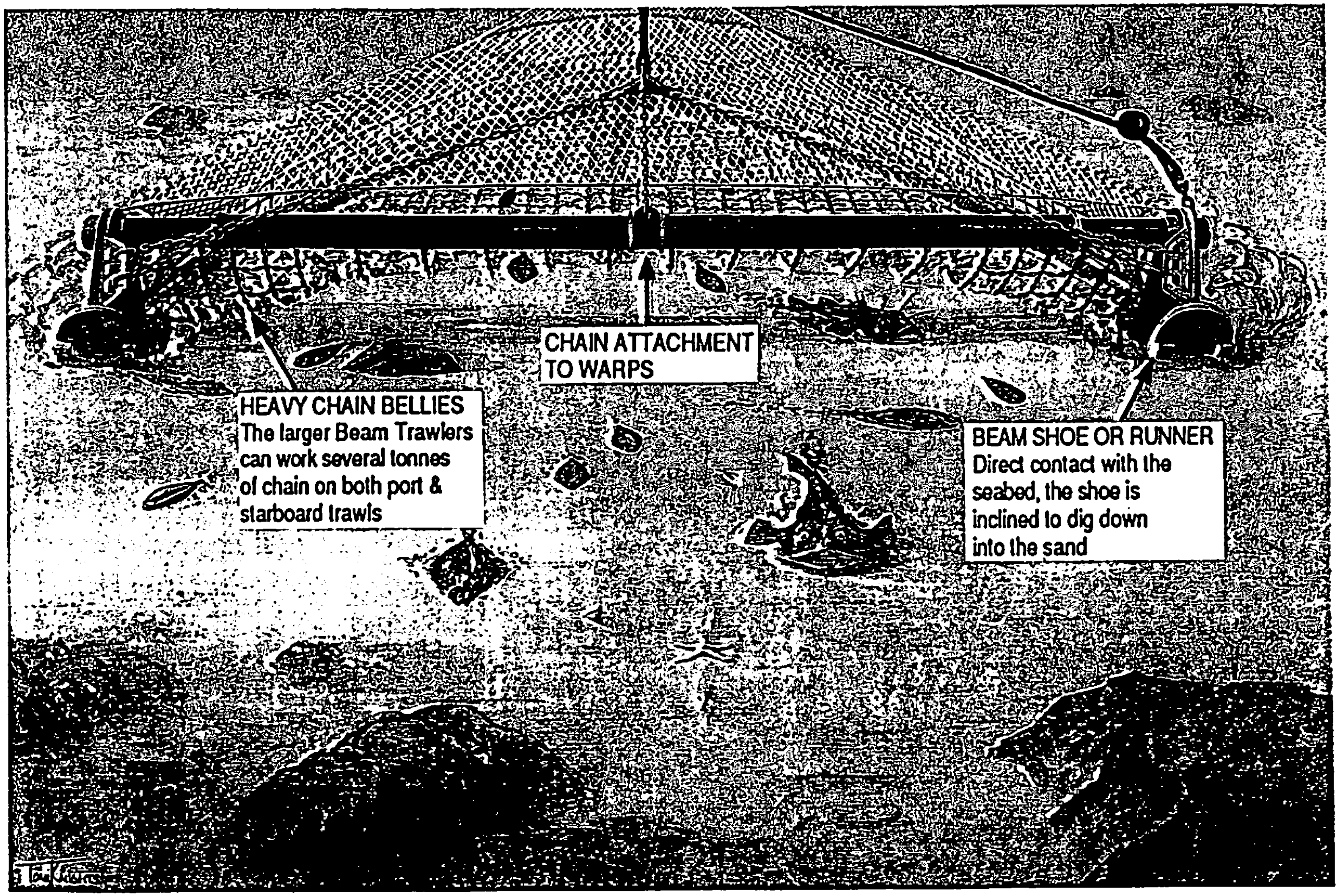
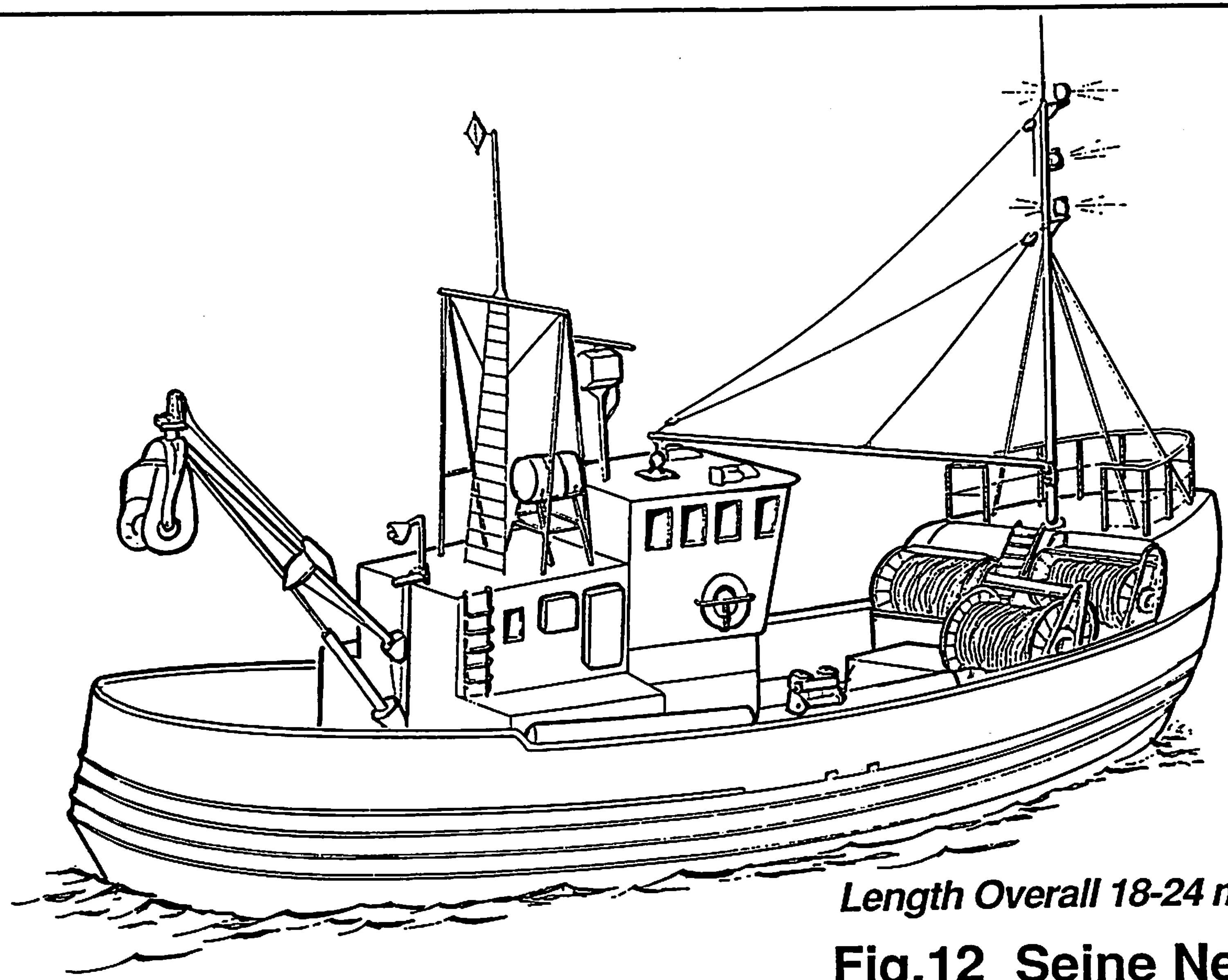


Fig.11a Beam Trawling *(Bottom)*



Length Overall 18-24 m

Fig.12 Seine Netter

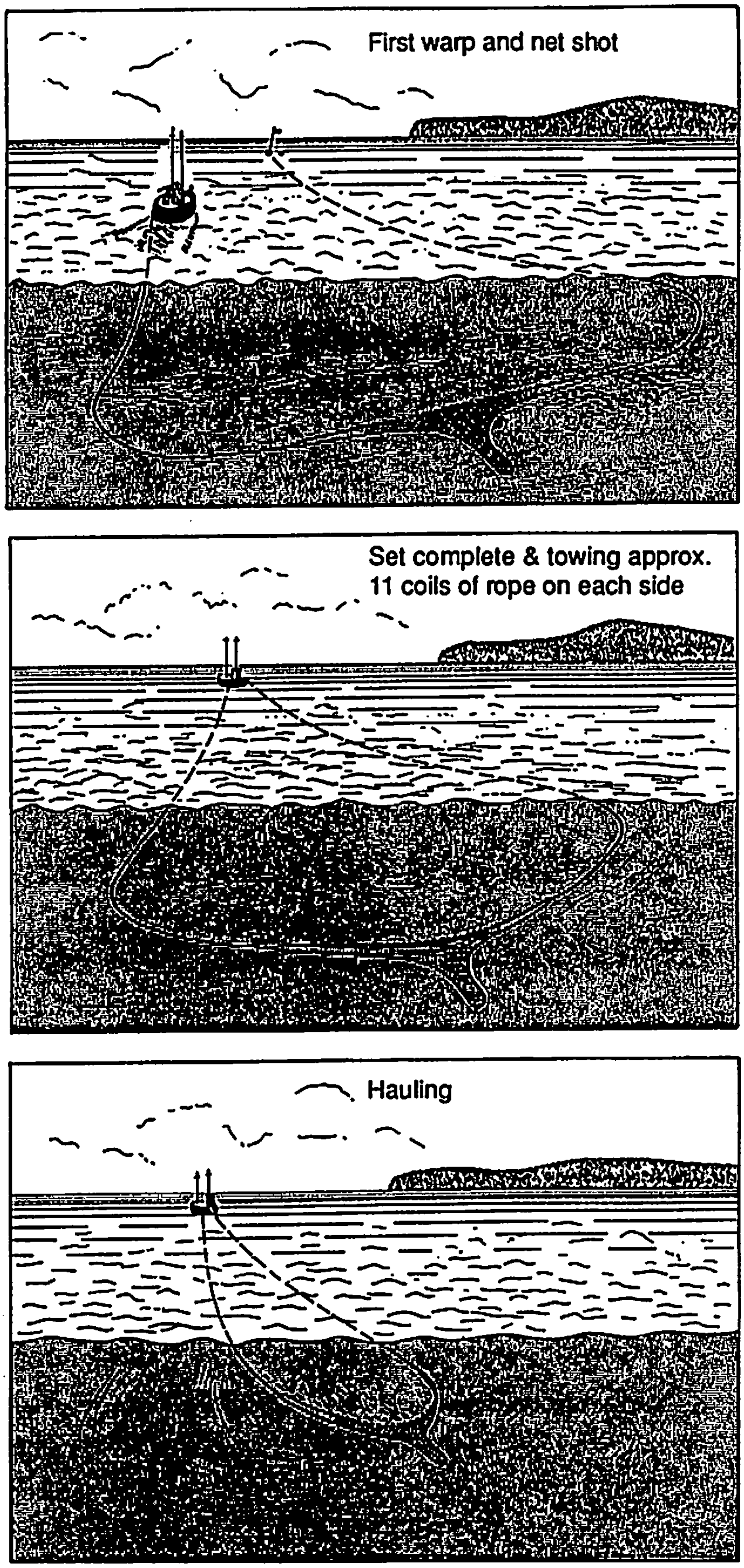
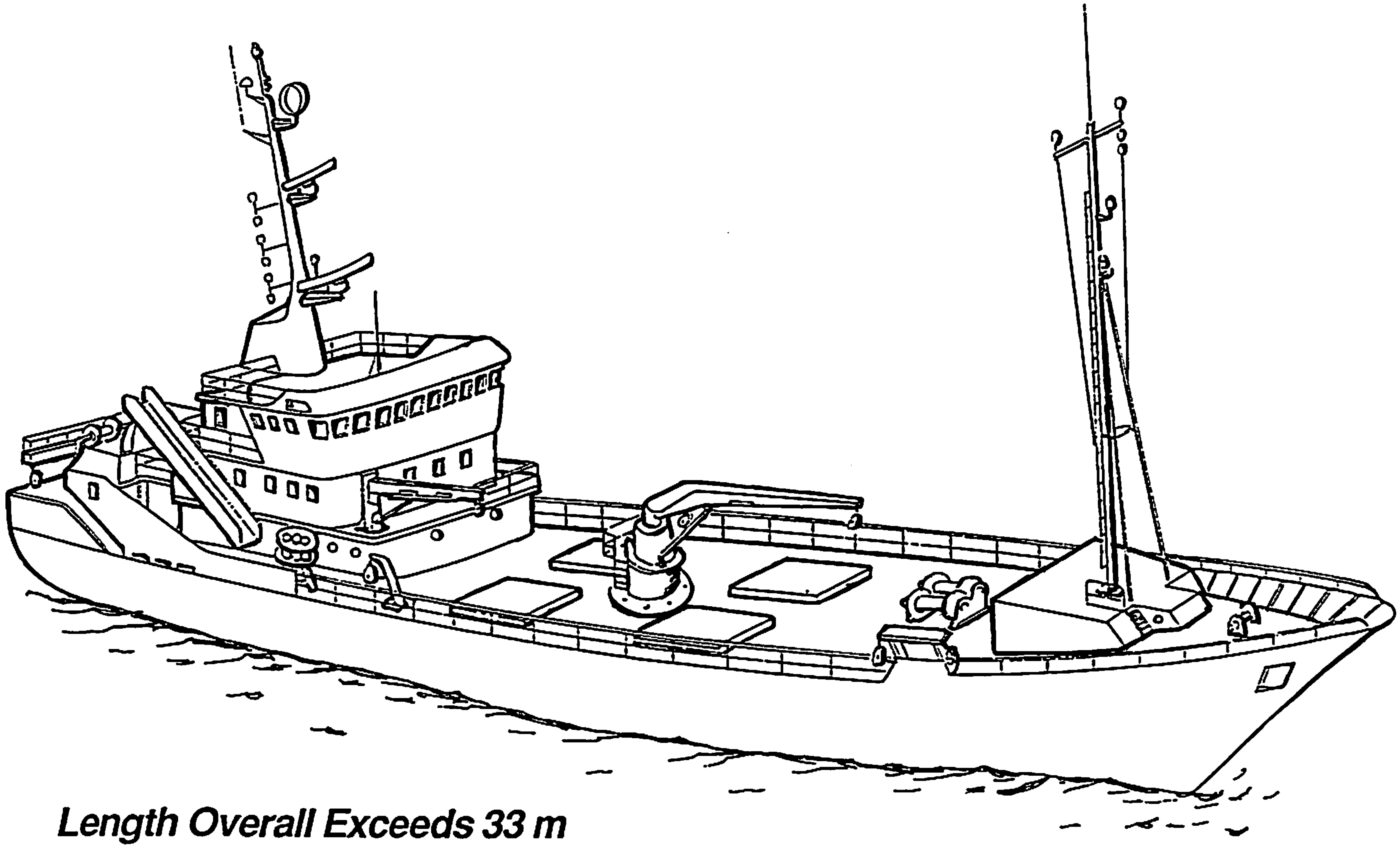
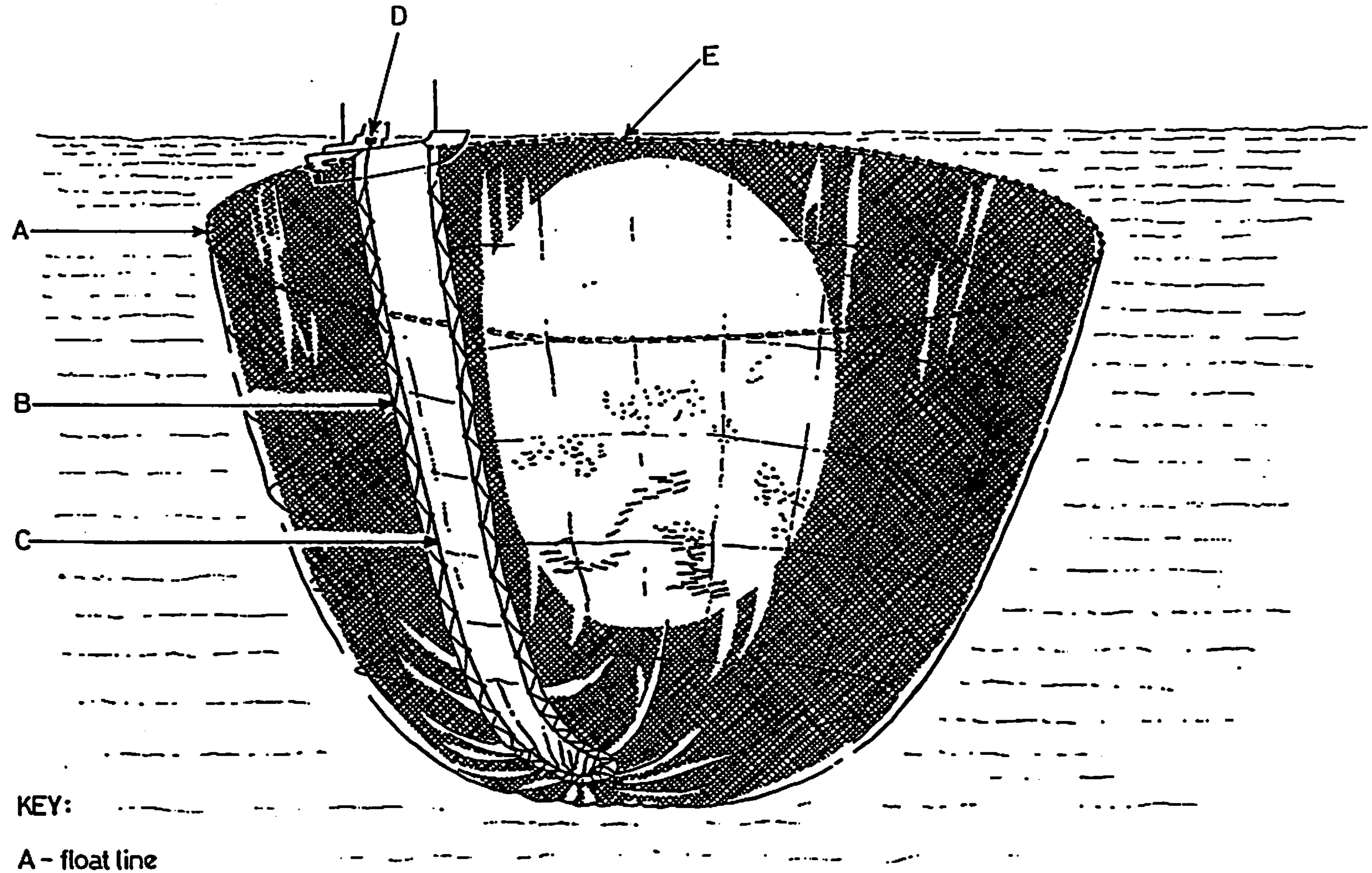


Fig.13 Fly & Seine Trawling *(Bottom)*



Length Overall Exceeds 33 m

Fig.14 European Type Purse Seiner



KEY:

A - float line
B - weighted sinker line
C - purse wire
D - net hauler
E - floats

Fig.15 Purse Seine Fishing *(Mid Water)*

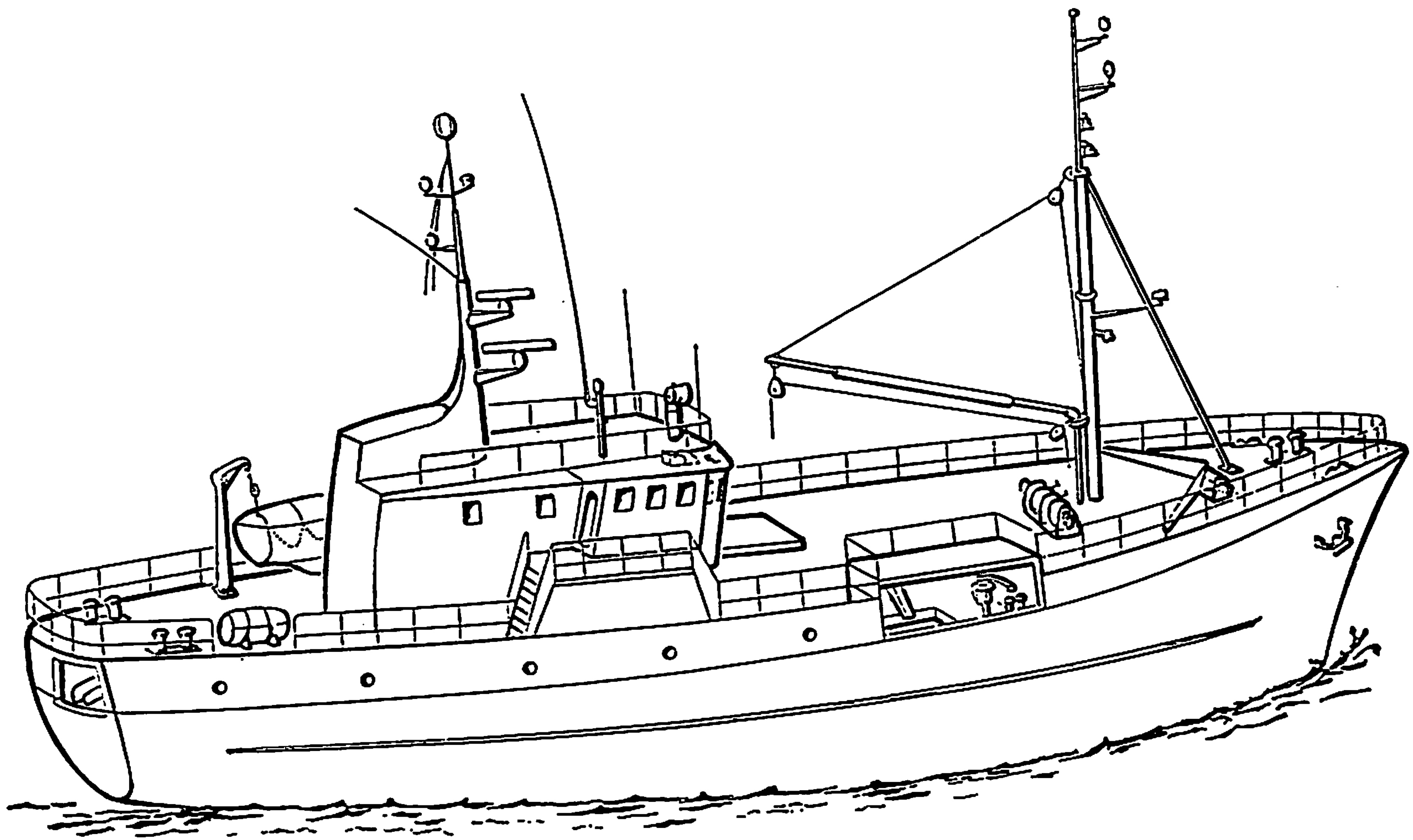


Fig.16 Large Longliner *Length Overall 18-33 m*

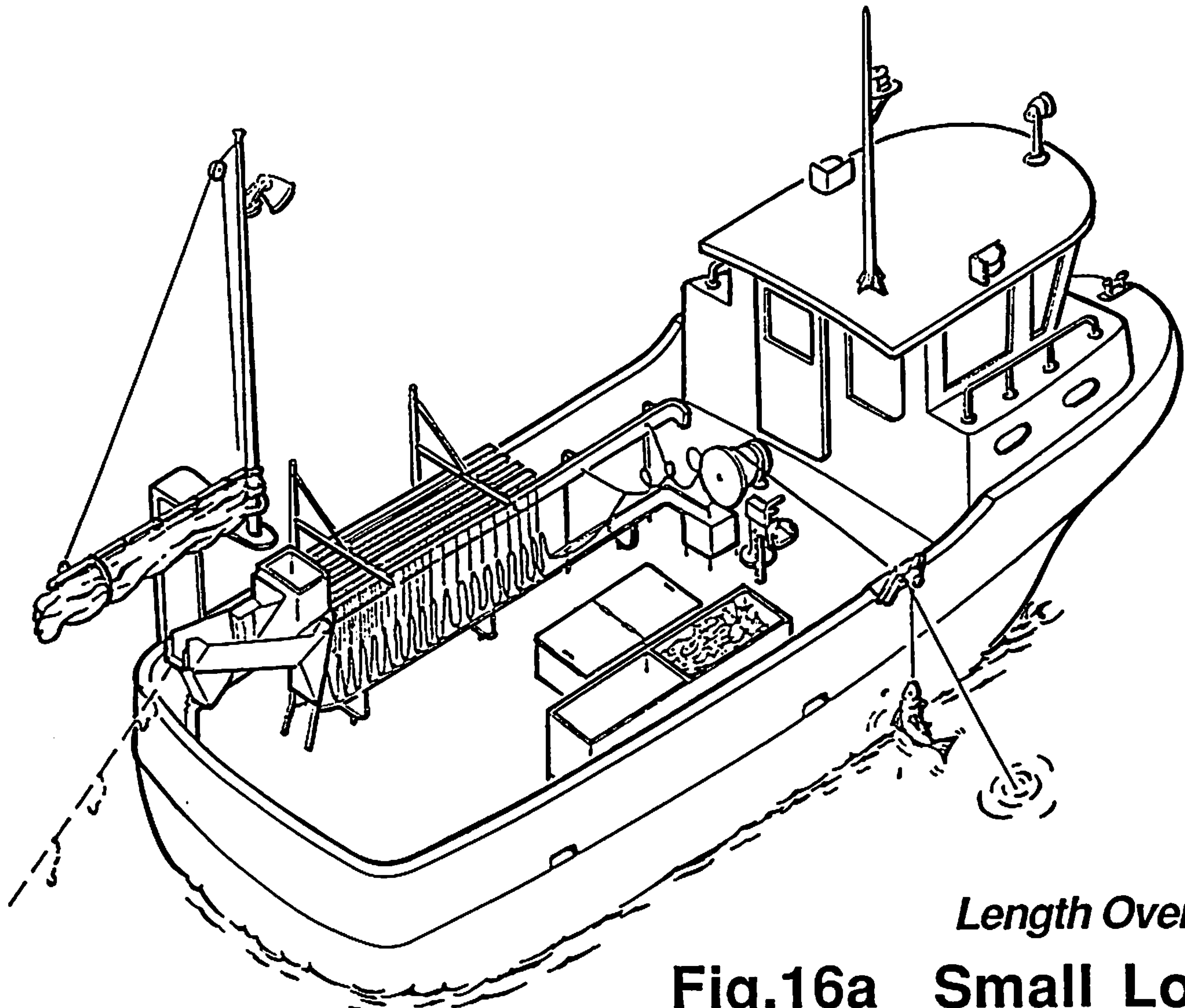
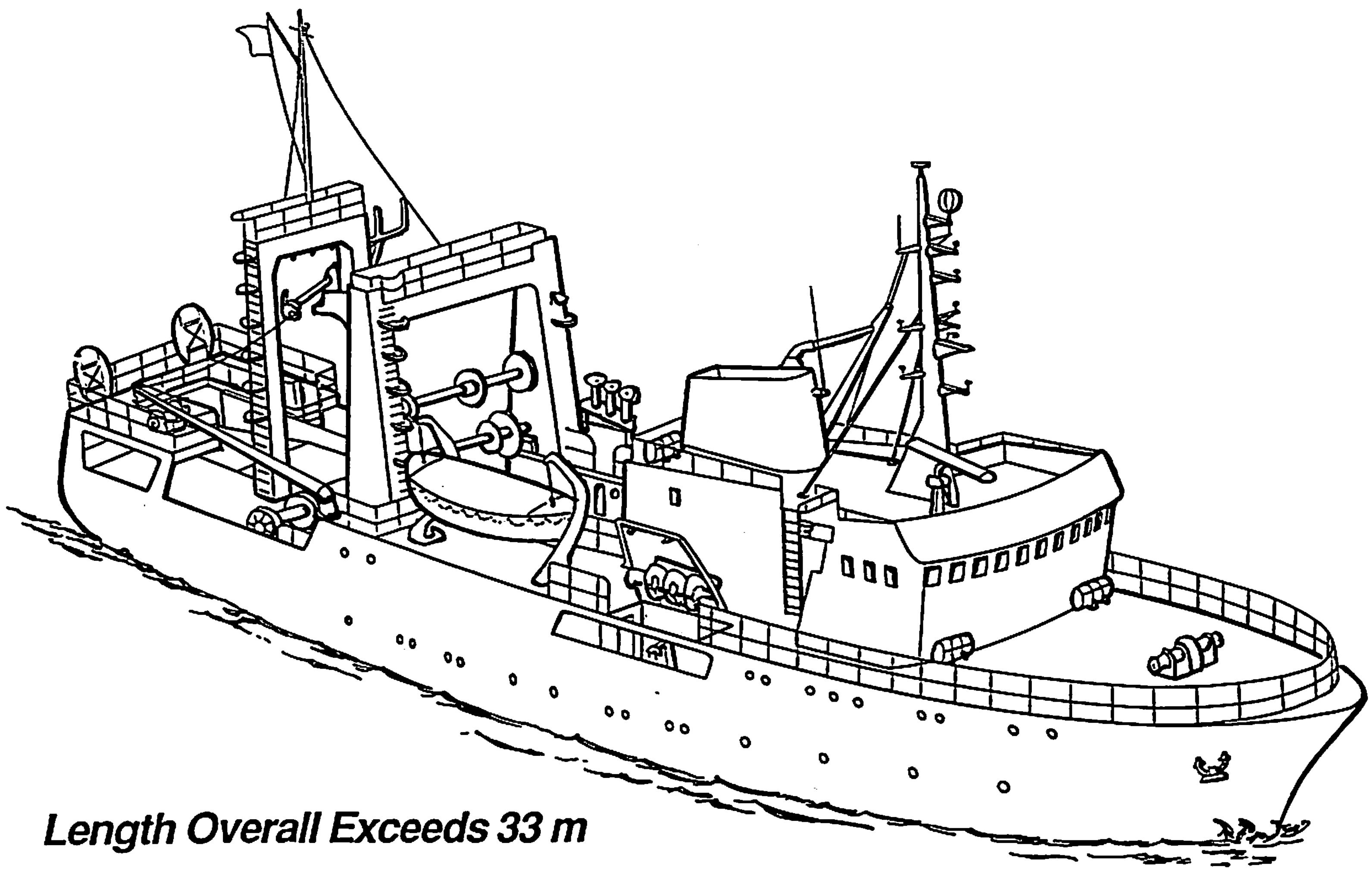


Fig.16a Small Longliner



Length Overall Exceeds 33 m

Fig.17 Fishery Research Vessel

APPENDIX II

Technical Options for Providing Warnings of Hazard to Fishermen

The study team producing this report have concluded that no special "hazard warning" arrangements need be made for the protection of the client's proposed manifold system, given that a number of such installations already in the area are apparently suffering no damage.

However, changes in the situation during the period of construction of the manifold may provide evidence of increased risks, possibly by increases in the numbers of oil installations to the extent that they limit the fishing option open to fishermen.

In the circumstances, the information provided in this appendix is offered as an aid to decision making in an increased risk situation.

1. SURFACE HAZARD WARNING SYSTEMS

1.1 Buoys

The buoy is possibly the most widely used aid for marking the position of subsea hazards. In UK and Irish waters they are normally provided and maintained by the General Lighthouse Authorities. The cost for provision and maintenance of buoys and other aids, such as lights and beacons, is provided for by Light Dues paid by ship owners and more recently fishing vessels. Even if safety zones are granted for a subsea installation, the provision of buoys is recommended.

As a surface hazard warning device, the buoy alone is not considered sufficient for this application to warn vessels, in all weather conditions, that they are approaching a hazardous area. For this reason if a buoy is deployed over the subsea installation, it should be enhanced by a radar beacon (Raycon) or a combination of radar reflectors, light source and bell.

1.2 Raycon

The Raycon device, when interrogated by a ship's radar, instantly transmits a pulse which is received by the ship's radar receiver and observed as a clearly defined line on the radar display and provides an instant range and bearing of the hazard marker buoy.

Most radar beacons in use today have a dual frequency capability, able to respond to both X and S band radar transmissions, common to all vessels, at a range of up to 20 miles. Furthermore, the response from the beacon can be coded by pulse or modulation coding techniques and thus provide a signature unique to the subsea installation. The power requirement is low and easily maintained by use of solar powered cells.

For a beacon to operate efficiently, the antennae must be of sufficient height above sea level to enable reception in all weather conditions and for this reason high elevation buoys should be deployed.

1.3 Lights

To cover all situations, such as occasions when the radar is switched off or is not operating as a result of malfunction, it would be advisable to further enhance the marker system by the use of a solar powered high intensity light. As with the radar beacon, the flash rate could be similarly coded and unique to the installation.

1.4 Radar Watch Alarms

Radar watch alarms are now a common feature on most radars, operation of the system is simple. The operator, by use of the range marker, selects the range limits such that any vessel crossing the limit lines activates an audio/visual alarm. The operator is then able to identify the range and bearing of the intruder from the echo on the display, and thus alert the vessel on the emergency radio channel that the vessel is entering an area of a subsea installation which should be avoided by fishing vessels.

Limitations of the system are such that it relys on the approaching vessel receiving the warning. However, most fishing vessels are equipped with VHF scanning receivers which automatically lock on to voice transmissions and significantly reduce the risk of the message not being received.

A system such as this, operating from the main platform, would be very cost effective.

2. SUBSEA HAZARD WARNING SYSTEMS

2.1 Sonar Devices

The use of sonar to identify subsea obstructions to surface vessels is both reliable and well proven. An array of "pingers" around the perimeter of the installation, powered from the main platform via an ambilical link, and identifiable on the sonar receivers of approaching fishing vessels, is at face value an attractive option.

However, there are severe limitations on the use of such a system for warning fishing vessels. Pingers are normally narrow bandwidth devices operating on a fixed frequency, usually in the range 8 to 100KHZ. In a recent survey by Seafish of the types and operating frequencies of fish finding sonar equipment in use in the industry at this time, it was identified that there were twenty eight different operating frequencies in the range 12 to 200KHZ used in current commercial sonar equipment.

The cost of providing an acoustic array with such a diverse range of frequencies for the Strathspey installation would be prohibitive and as such is not considered as a viable option.

2.2 "Inert" Marker Devices

A cheaper variant of a subsea warning system would involve provision of an "inert" array, intended to provide warning signals when detected on a fishing vessel echo sounder. A single unit in the array would comprise a float device about 2m long by 300mm diameter held down by an appropriate weight (say 200kg) by a tether line 2m long. By allowing the device to float free of the seabed, it can be assured that the echo sounder will present an identifiably separate echo from the device. The devices could be sited at 20m intervals on a "warning circle" of appropriate diameter. A fishing vessel passing above would typically "see" two such devices with its echo sounder beam. Each device would be independantly set and, given that the base weight was of a conical form, could be trawled over without significant damage either to the device or to the trawl gear. The presence of the array could be checked periodically by use of an echo sounder on a company service vessel.

An "inner circle" warning system of about 200m diameter (requiring 32 independent float devices) would "mark" the manifold position but would not necessarily provide a warning either for pair trawlers or Scottish Seine vessels fishing the area. To provide warnings to such vessels, it would be necessary to mark out a circle of about 1km diameter requiring placement of at least 160 float devices. Presumably permission would need to be sought from the appropriate authorities to establish such an array, which would effectively be creating an exclusion zone.

APPENDIX III

DESCRIPTION OF POTENTIAL COLLISION OPTIONS

Subsequent to the presentation of the Draft Report, an exchange of correspondence took place between Seafish and the Client in which the description of the different options in collisions was expanded. A summary of the correspondance is given in the following Appendix.

APP.III

Analysis of Risks from Fisheries Activities

Our calculations for estimating kinetic energy and static loads associated with contact between gears and seabed installations have been based on a simplistic approach but we would justify this on the basis that our sea trials programmes, in which we measure warp loads at the vessel, provide us with information on the total combinations of forces involved in underwater contact situations.

Breaking Strength of Wires

Warps would typically be 26 or 28mm dia of 36 to 42 tonnes breaking strain. Cables and bridles will be either the same or less (but remember that bridles will be duplicated or even triplicated depending on the shape of the net). In general the warp and cable size is chosen to provide reasonable life in an abrasive environment and invariably has a "new delivered" breaking performance well above the capacity of the towing vessel on which it is used. However, the conditions on which it runs over the blocks and is stored on undersized warp drums invariably degrades its potential performance almost from new. Weights of warps are given in a later section.

Displacement of Vessel

The displacement of a typical modern stern trawler 30m long would be about 460 to 500 tonnes.

Given that vessel speeds are low and that the quantities of water being transferred by the propeller are greatly in excess of that which would be required to move the vessel alone at the requisite speed, we would judge the value of added mass to be not more than 10%. This value has been used in the calculations.

Weight of the Trawl

The weight of individual components is probably more relevant to an understanding of the situation than the total weight since the form of contact can vary and different loadings would apply to the different cases. Some typical weights are:

Warp	2.8 kg/m in air
	2.1 kg/m in water (say 840 kg per warp)
Otterboards	800-1200 kgs each in air
	680 - 1020 kgs each in water
Cable/Bridle Assemblies	200 kg per side in air
	160 kg per side in water
Ground Rope Assembly	2200 kg in air
	1000 kg in water

for rigs using traditional spherical bobbins; and

	1400 kg in air
	1000 kg in water

for a modern "rockhopper" gear which does not contain flotation elements.

Float Assembly (say 30 floats)	110 kg in air
vertical lift	95 kg in water

In the future we are likely to see increasing use of kite assemblies as partial replacement for floats. These provide a lift force dependent on forward speed and have little or no floatation component of force.

Net and Codends	2300 kg in air
	900 kg in water

Considering the different options of fishing gear/manifold contact:

If initial contact (and complete 'lockup') is made on one otterboard (at A) the "slack" associated with the catenary effect is taken up within 2 seconds and the vessel will stop. As forward motion ceases, the load on the alternate warp falls and all towing forces are transferred through the single warp. The vessel will slew in reaction to this transfer of load. Reaction on the vessel bridge would be swift (the propeller pitch and speed settings are controlled directly from the wheelhouse console). If crew reaction is slow, some relief from the loadings will be provided by the action of the autopilot which will alter the rudder angle to attempt to revert to the original vessel course, and reduce the propeller thrust effect by doing so.

It might be noted that the design of c.p. propellers for fishing vessels is such that propeller thrust is optimised within the towing speed range. The effect is such that the delivered thrust will not increase and will probably reduce slightly as the vessel is brought to a standstill, i.e. the static bollard pull is not the highest possible pull value. The situation would be different for a fixed propeller installation but these would not be encountered on stern trawlers of the size we are considering.

The elements to be considered in calculating momentum and kinetic energy to be absorbed would be the vessel, warp and a single otterboard. I would judge the loading on a seabed installation to vary as follows:

At impact	7 tonnes
Immediate increase to reflecting the absorbtion of kinetic energy.	14 tonnes
Followed by static pull sequence at reflecting total transfer of propeller thrust to one warp.	14 tonnes

If initial impact takes place at the forward end of the bridles (point B), the sequence will start from a position of lower loading (say 3.5 tonnes at impact). As the bridle remains under restraint, the otterboard will be dragged out of position, face down to the seabed and absorbing some of the pulling force exerted from the vessel. The forward momentum of the otterboard is absorbed at first impact by a combination of load transfer to the seabed installation and change of direction of travel of the board. Within 2 seconds the warp/otterboard/ cable assembly will take up a straight line with instant increase to 7 tonnes pull and then up 14 tonnes as described above, The momentum would be absorbed in two stages, i.e.:

Stage 1 Bridle link, cable and otterboard
Stage 2 Vessel and warp.

The sequence of events could be identified as follows:

At impact	3.5 tonnes
Immediate increase to 7 tonnes but some decay	
Increase pull to	7 tonnes
Impact effect is to increase load to	10.5 tonnes
Transfer of load to single warp pull increases to	14 tonnes

The two stage loading sequence reduces the effect of individual load increases.

The situation is similar for impacts at points within the groundline section of the net. Initial contact loading would be followed by a series of load increases as the shape of the net assembly changed. As the point of contact moves nearer to the centreline of the net, the second warp takes a part in the load transfer mechanism without increasing the total loading to be absorbed by the structure.

Some time is taken up in distorting the net (perhaps as long as 10 seconds) and forward momentum of most of the gear elements is lost during this period. However, forward motion of the vessel is unaffected and the major effect is that of absorbing the kinetic energy of the vessel during a period of not more than 2 seconds at the end of the sequence, and as described above.

For a high subsea installation such as the manifold assembly, the initial point of contact could be the headline of the net rather than any of the positions C, D, E or F on the groundline. This contact would be made at any height up to about 8 metres dependent on the part of the net involved (our video film might provide a better understanding of net shape). The sequence of net distortion would take place as described earlier, but it is almost certain that the headline would part when a load of not more than about 4 tonnes was being applied. The lower bridle and groundrope assembly would be slack at this time, but would be pulled forward again as the headline parted only to be halted after a few metres of forward travel. Since the groundrope would now be laid nominally in line with the direction of vessel travel, the subsequent take up of load would occur in the same manner as if the otterboard had been the contact point. At this point, momentum of vessel warp, otter-board cable and ground gear would all be relevant to the calculations of load.

In the following calculations, the assumptions used are:

(i) The masses of the underwater components are generally of little significance in comparison with that of the vessel itself. The vessel parameters can thus be used for most calculations without significant error.

(ii) The energy is absorbed in less than 2 seconds (we calculate that takeup of the slack wire of the catenary of warp will take some 0.4 seconds and that extension of the length of warp due to increase of load from 7 to 14 tonnes adds another 1.6 seconds, which includes an allowance for slewing action caused by uneven load between warps).

Thus for a 30m, 1500hp vessel with a displacement of 500 tonnes travelling at 3.5 knots (1.8m/sec) and with an added mass coefficient of 10%.

Kinetic Energy in the system:

amc = 10% $= 0.5\ mv^2$

$= 0.5 \times (500 \times 1.1) \times 1.8 \times 1.8/9.81$

= <u>91 tonnes m</u>

At snagging condition, this energy is tranformed into strain energy in the warp line, the vessel and the subsea structure and into frictional losses.

Force to be absorbed $= F = m\ a$

where a $= (1.8-0)/2$

$= 0.9 m/sec^2$

$\therefore F$ $= 500 \times 1.1 \times 0.9/9.81$

= <u>50 tonnes</u>

This force represents the upper bound for loads applied by otterboard trawlers. Masses of underwater components are ignored.

At a localised level the impact of an otterboard on the seabed installation represents the most severe damage option. However, the external forces directed through warps and cables will also centre out to the impact loadings. The situation is that the otterboard is subject to a forward pull from the warp and, in turn, imparts a force through the cables. The effective force may be taken to be half of the total warp pull, i.e. 3.5 tonnes. In fact this force might be considered as dominating the local loading. If it si assaumed that the equivalent impact energy is proportion to vessel speed, then:

Local Impact Energy = Kinetic Energy of Board + energy transmitted by warp line

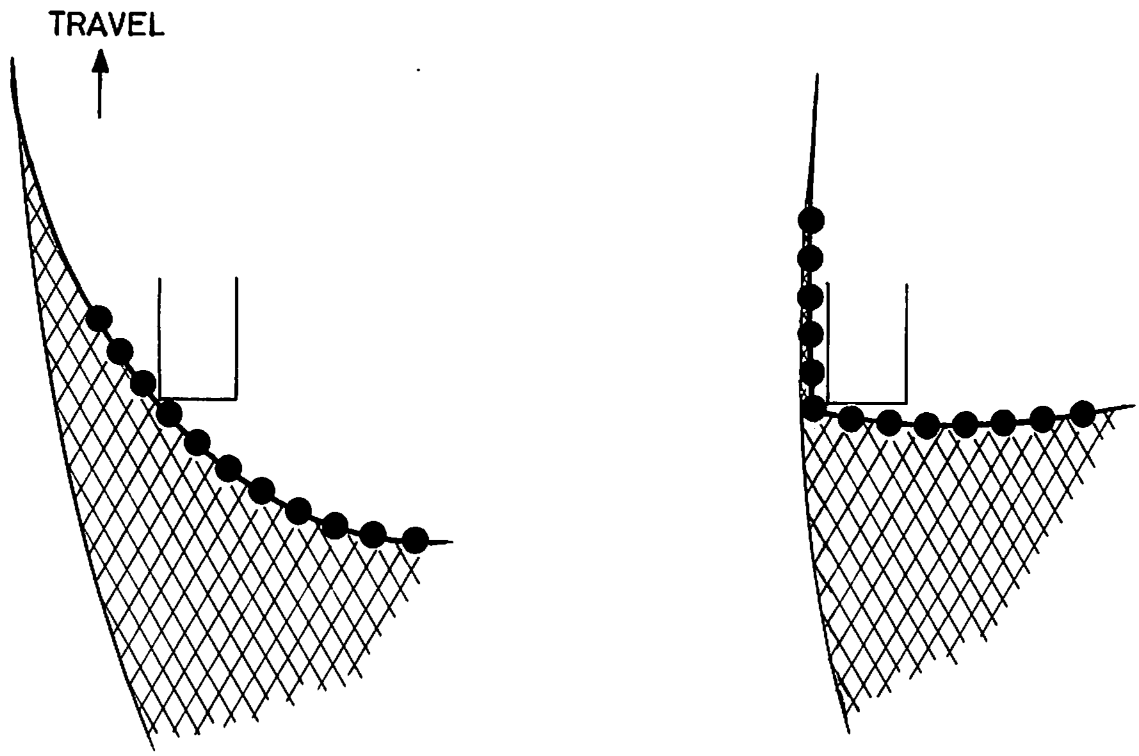
$= 0.5\ mv^2 + fv$

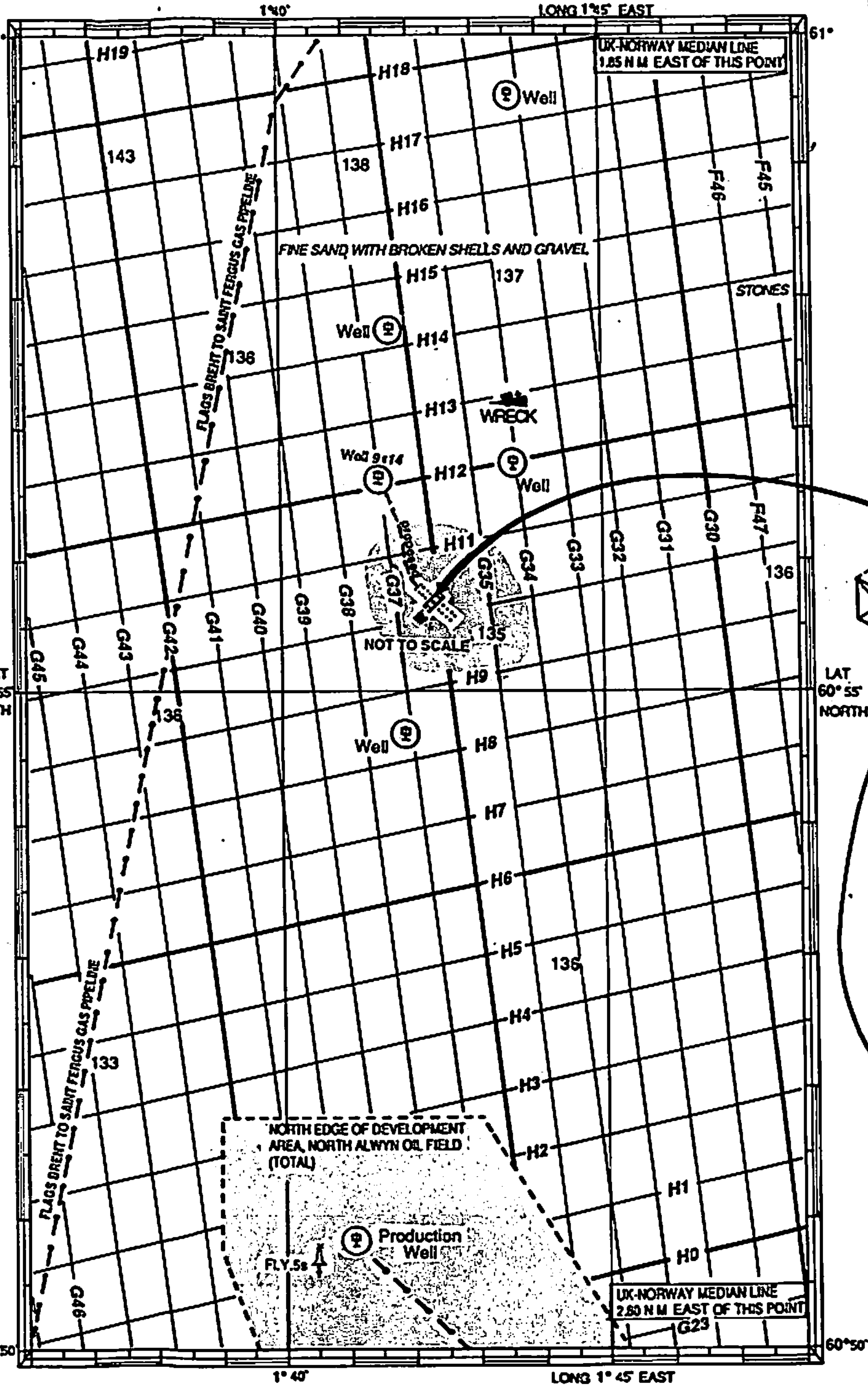
$= 0.5 \times 1 \times 1.8 \times 1.8 + 3.5 \times 1.8$

$= 1.62 + 6.30$

= <u>8 tonnes m</u>

The sketch shows the contact with groundrope.





TEXACO

KINGFISHER CHARTS

SPECIAL CHARTS SERVICES

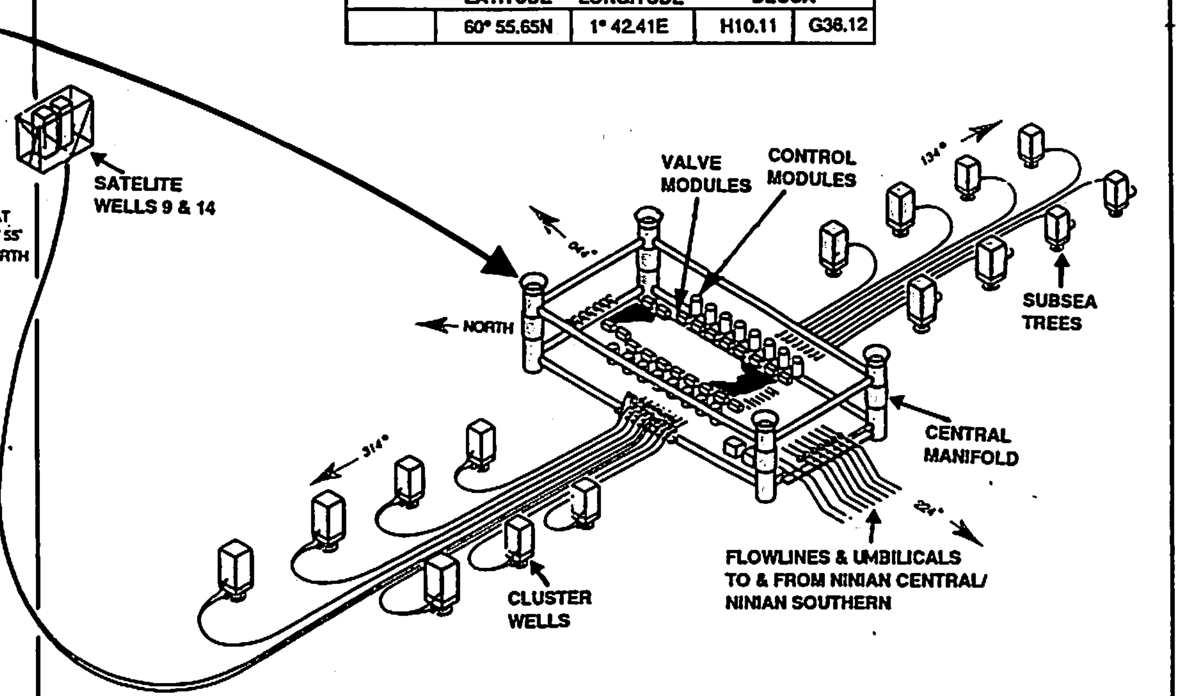
KINGFISHER

STRATHSPEY FIELD DEVELOPMENT

WELL	LATITUDE	LONGITUDE	DECCA	
3/4a-10	60° 56.73N	1° 43.61E	H11.97	G34.09
3/4a-11	60° 59.51N	1° 43.51E	H17.37	G33.32
3/4a-12	60° 54.68N	1° 41.75E	H08.40	G37.38
3/4a-13	60° 57.75N	1° 41.66E	H14.27	G36.45
3/4-14	60° 56.53N	1° 41.50E	H11.97	G37.09
3/4-16	60° 54.68N	1° 41.75E	H08.39	G37.38
3/4a-15	60° 50.81N	1° 41.00E	A03.31	I36.73
3/4a-9	60° 58.53N	1° 41.50E	H11.97	G37.09

SUBSEA MANIFOLD POSITION

	LATITUDE	LONGITUDE	DECCA	
	60° 55.65N	1° 42.41E	H10.11	G38.12



DECCA COORDINATES - 0E VESTLANDET CHAIN
OBSERVED READINGS - NO FIXED ERRORS

Produced by the Kingfisher Charts "SPECIAL CHARTS SERVICES" of the Sea Fish Industry Authority
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