DEEPWATER FISHING ALONG THE CONTINENTAL SLOPE

Seafish Seminar
held at Banff
15th November 1991

Seafish Report No. 403

January 1992

Sea Fish Industry Authority
Technology Division

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SUMMARY

Demersal fishing on the Continental Shelf rarely takes place in depths greater than 200m. Beyond this, along the Hebridean Shelf, the Continental Slope descends at a relatively steep gradient to the floor of the Rockall Trough at about 2500m. For the most part, this represents the maximum depth of ocean floor in the N.E. Atlantic, although there is deeper water to the south and west of the British Isles in the Porcupine Abyssal Plain.

The opportunities for deepwater fishing lie on the Continental Slope rather than at the bottom of the Trough. It is, therefore, more appropriate to refer to the fishery as the deepwater slope fishery with a probably maximum depth of about 1500m.

There are in excess of 80 species on the slope, most of which are unknown in marketing terms. The marketable species are:

Grenadier
Orange Roughy
Black Scabbard Fish

These are slow growing fish and very little is known about the biology or reproduction (fecundity). There is concern that over exploitation could rapidly wipe out the resources as has happened with the New Zealand roughy fishery. Recovery times can be expected to be far longer than the traditional cod and haddock stocks.

The engineering of slope fishing needs to be developed. It is likely that the species migrate up and down the slope. Fish detection at the depths encountered will only be possible with echo sounders operating at less than 50KHz; fortunately most vessels able to fish the deep water will be equipped with such systems.

Winch design is critical and there is a need to do more work on this in order that there is adequate power available with a full length of warp out to recover the gear. Traditional winch design for shallow water operations necessitates a different engineering approach. The skill will be in meeting both requirements in a single installation.

Gear design is not, at this stage, perceived as a problem until more information is available about behaviour, discards and distribution of the species (on bottom, off bottom or semi pelagic). Suggestions have been made that pair trawling might be more efficient since the available power on each vessel could be directed onto one warp only at the critical time of starting to haul the gear. Warp sizing accompanied by good spooling on the winch can be a benefit.

Very little is known about post harvest care of these species, although an information file is now being built up, much of it based on the New Zealand orange roughy fishery. The fish are delicate and easily bruised. They are also difficult to handle although the flesh quality and taste can be excellent.

The slope fishery is an opportunity but it needs to be tackled with care and attention to detail. It is also important for the British industry to secure a stake in the fishery before too long.

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1. INTRODUCTION

These notes are based on a Seafish seminar held at Banff in Scotland on 15th November 1991 which was attended by a wide cross section of representatives from the fishing industry, fish trade and ancillary sectors such as electronics and Government research.

The purpose of the seminar was to review the current state of knowledge about fishing in deepwater along the Continental Slope to the north and west of the British Isles and assess the opportunities for British vessels in the area.

2. DEFINITIONS

Demersal fishing on the Continental Shelf rarely takes place in depths greater than 200m. Beyond this, along the Hebridean Shelf, the Continental Slope descends at a relatively steep gradient to the floor of the Rockall Trough at about 2500m. For the most part, this represents the maximum depth of ocean floor in the N.E. Atlantic, although there is deeper water to the south and west of the British Isles in the Porcupine Abyssal Plain.

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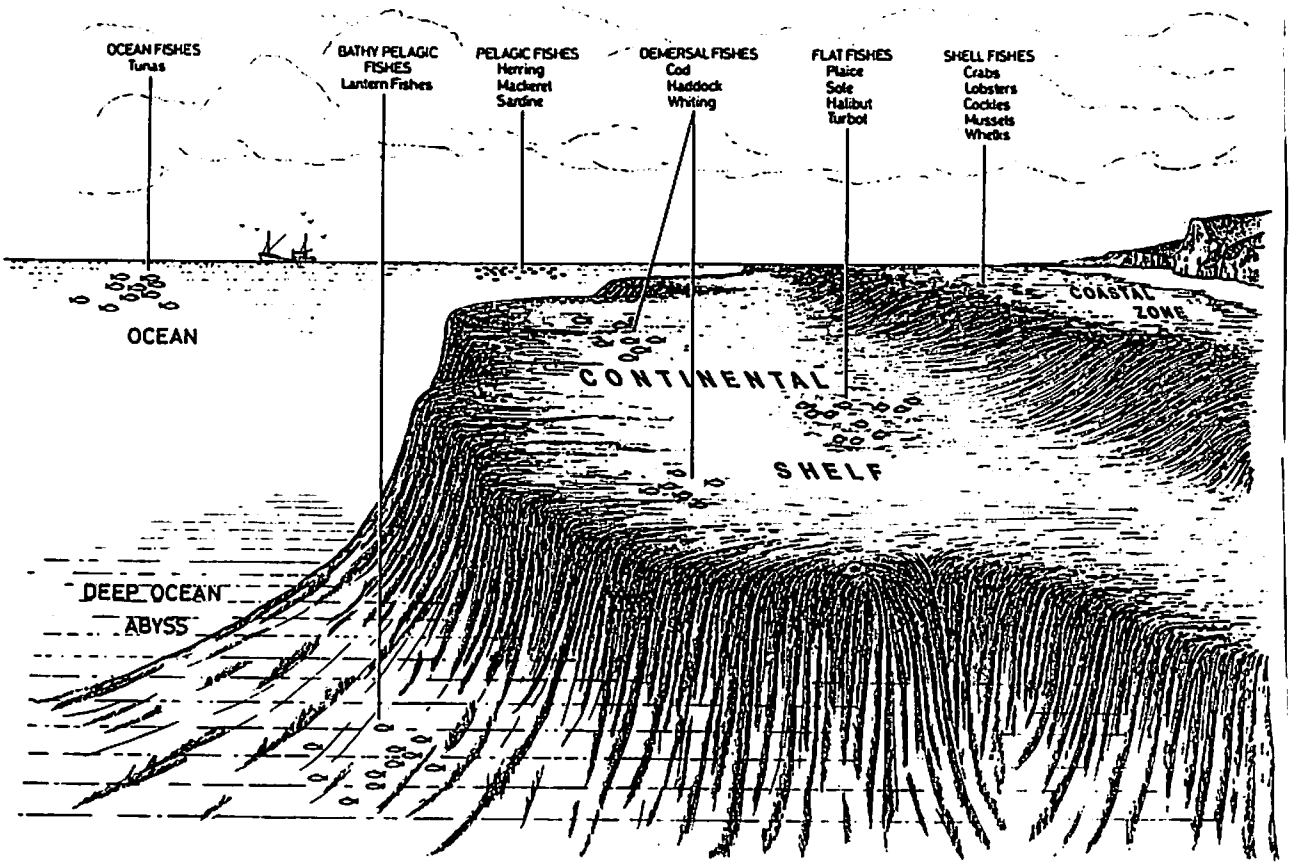
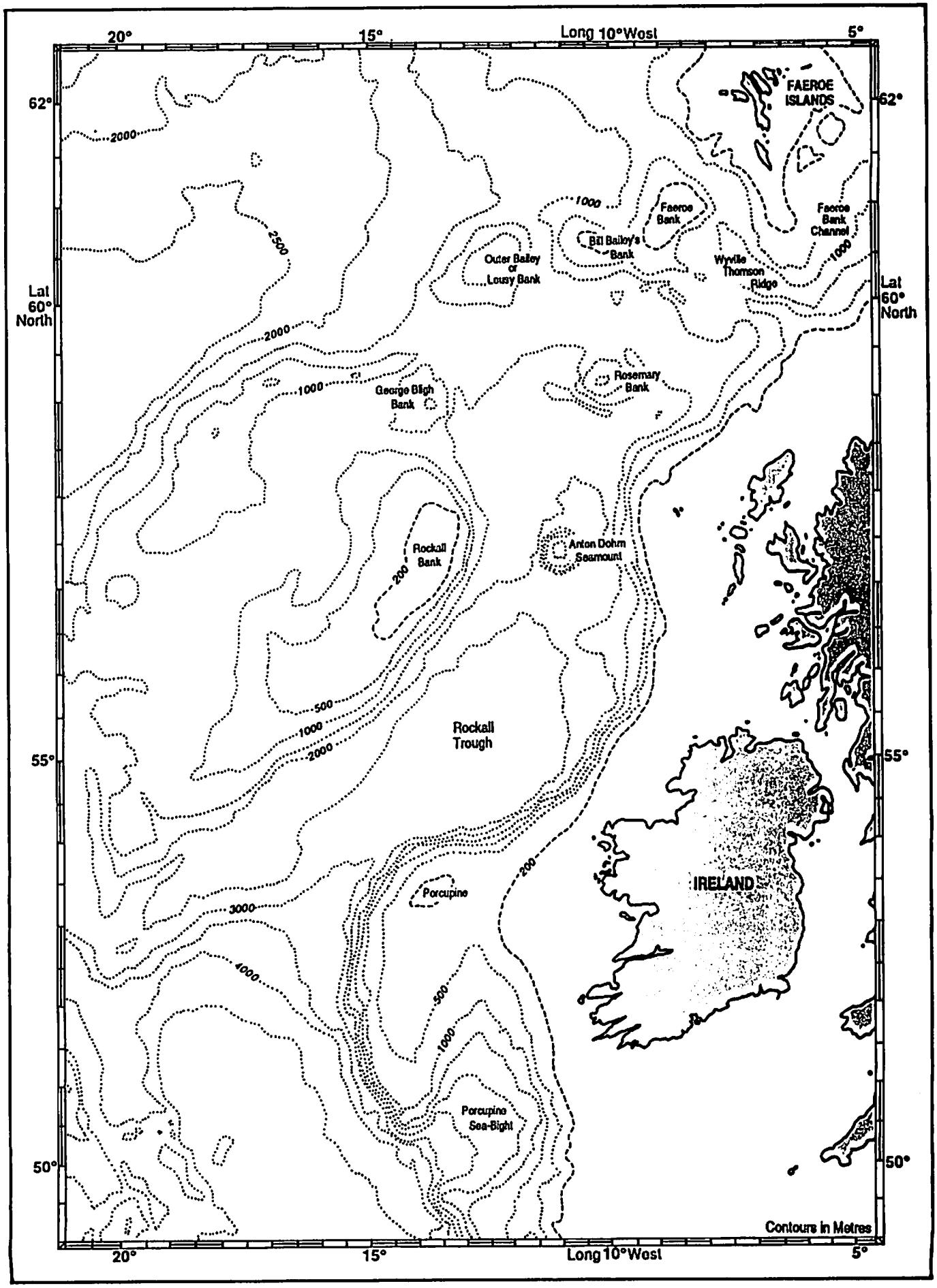


Fig. 1: Continental Shelf

3. FISH SPECIES

Compared with other areas of the eastern North Atlantic, such as off West Africa and Madeira northwards to the Porcupine Seabight, comparatively little is known of the deepwater species on the slope and in the Rockall Trough. The abundance of commercial species, such as cod, haddock and whiting, on the Continental Shelf of the British Isles, Iceland and Norway, has not resulted in any urgent need to study deepwater fish. The area, however, is not entirely unknown to British fishermen who have fished on the slope for halibut, angler fish and more recently argentines.

The most comprehensive information is held by the Scottish Marine Biological Association (SMBA) at Oban, Scotland, who have identified at least 85 species belonging to 34 families in depths ranging from 500m to 2000m. It is important to note that species distribution depends as much on depth as horizontal location with some species simply not being apparent at certain depth zones.



Eastern Atlantic Slope

Fig.2

The nature of the surveys carried out by the SMBA does not lead to any concrete data on abundance except to note that the greatest biomass occurred at mid slope depths of 750 to 1000m.

Fig. 3 shows the distribution of the main species by water depth.

Deepwater Fish

Latin Name	English Name
Micromesistius poutassou	Blue Whiting
Chimaera monstrosa	Rabbit Fish
Agentina silus	Atlantic Argentine Smelt
Coryphaenoides rupestris	Grenadier
Lepidon eques	Orange Perch Family
Nezumia aequalis	Another form of Grenadier
Alepocephalus bairdii	Smoothhead
Hoplostethus atlanticus	Orange Roughy, often mistaken for Beryx spp
Epigonus telescopus	Bulls Eye
Trachyrincus murrayi	Another form of Grenadier
Molva dypterygia dypterygia	Blue Ling
Squalidae	Small Sharks and Dog Fish
Rajidae	Rays
Conger conger	Conger Eel
Aphanopus carbo	Black Scabbard Fish

Most of the above species are considered to be demersal species but blue whiting and black scabbard are more representative of pelagic fauna, although they have been caught near the bottom.

Much more needs to be known about the distribution (vertical and horizontal), daily migration, seasonal migration and shoaling habits before these species can be properly exploited. Information about age, sexual maturity and reproduction is also limited and there are risks that stocks could be quickly overfished to beyond the sustainable yield level by indiscriminate fishing.

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Rockall Trough. Sample Area 56°45 N 10°20 W.

Eastern Side of Continental Shelf Slope. Distribution of Main Species.

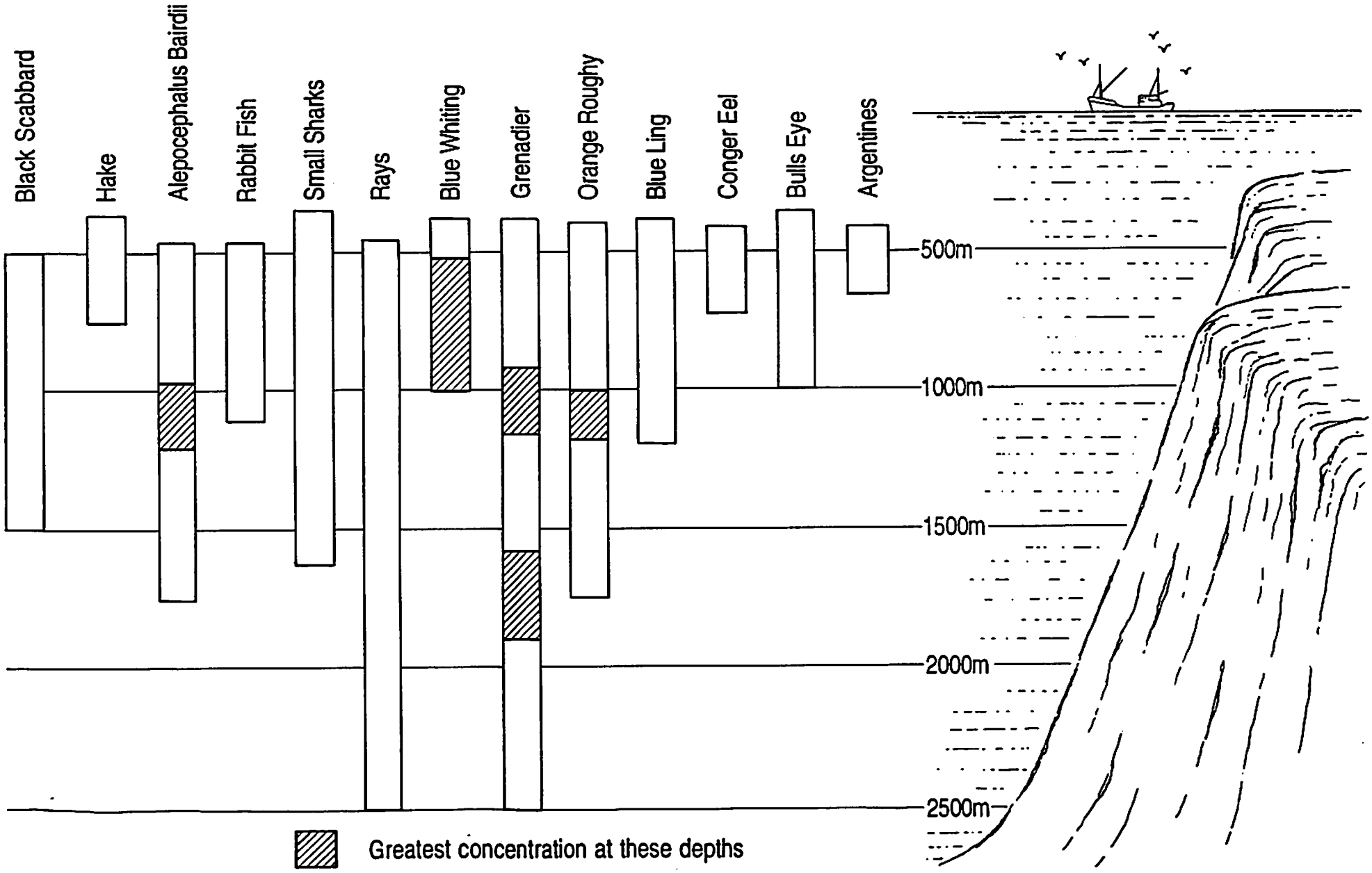


Fig.3

4. MARKETS

Crucial to the success of deepwater fishing on the Slope will be proper development of market opportunities. To date there are limited markets for:

Micromesistius poutassou	Blue Whiting
Agentina silus	Atlantic Argentine Smelt
Coryphaenoides rupestris	Grenadier (note certain other grenadiers have a poor textured flesh and should not be confused with rupestris
Hoplostethus atlanticus	Orange Roughy
Aphanopus carbo	Black Scabbard Fish

The Japanese and French markets are likely to give satisfactory returns to exporters, but the seminar stressed the following important points.

- Sales will be based on kg weight of fish and not box weight.
- Overfilling of boxes almost certainly leads to crush damage and loss of value.
- For the most part, the flesh is soft and will be easily damaged by jagged ice. Plenty of crushed (flake or plate) ice should be used.
- Grenadiers for France should be gutted and tailed but not headed.
- Fish to be well washed after gutting.

Prices are very variable depending on quality and quantity available. Prices in Boulogne on 15th November 1991 for whole Scabbard fish ranged from £1.50 to £2.20/kg. More general information from Le Marin for May 1991 was:

Orange Roughy	£0.6 to £1.8/kg whole fish £6.0/kg for fillets
Scabbard fish	£1.30/kg whole fish
Grenadier	comparable to cod, e.g. £1.1/kg

5. FISHING VESSELS AND EQUIPMENT

The typical large Scottish seiner trawler of 24m overall length and 500-700hp will be limited to trawling in a depth of about 700m. The limitations are towing power and winch design. Some larger units in the UK fleet, such as the SOUTHELLA, will be able to prosecute Slope fishing down to 1000m without difficulty

5.1 Winch Requirements

A critical design feature for the vessels is winch design. Conventional winch design with irregular spooling and fixed torque will lead to special difficulties in deepwater. The warp load at maximum diameter of the winch barrel could create loads on the motor and pump far in excess of their capabilities.

Ideally the winch system should be re-designed for the deepwater situation which makes a complete break with traditional design and practice. However, most UK vessels used in deep water fisheries in the short term would utilise as mauch of their existing equipment as was possible. Radical re-design of winch systems might have to wait for the next generation of vessels.

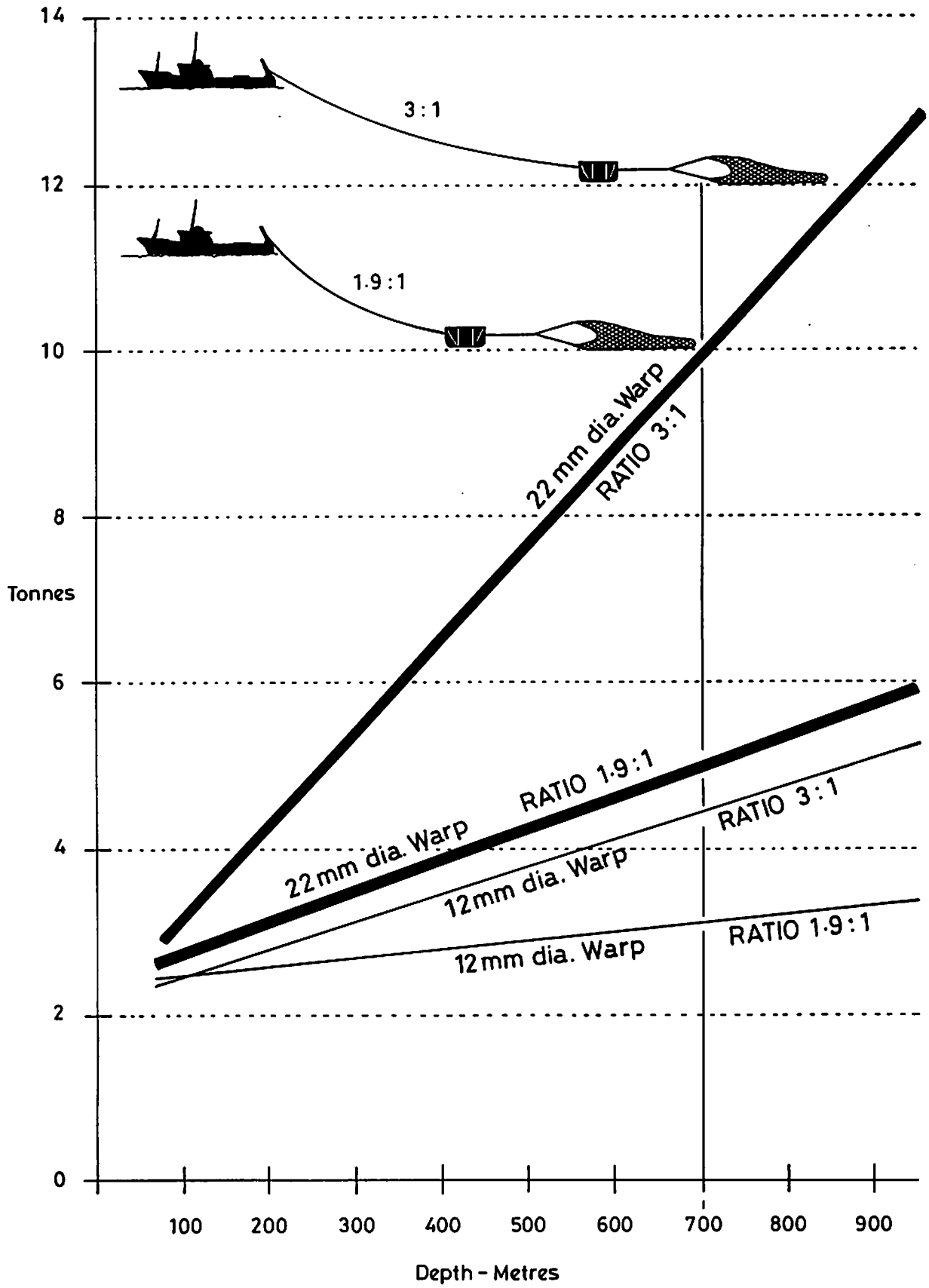
As vessels fish ever deeper waters, the weight of warp run between the vessel and its gear assumes greater significance. To reduce this effect, it is possible to reduce the warp length to water depth ratio from the traditional value of 3 or more down to as low as about 1.9 to 1, thus reducing the length of warp which needs be carried to work in a specified water depth. Another option worthy of consideration is to reduce the diameter of warp carried, though in this case it becomes essential to attend to manufacturers recommendations on proper spooling arrangements and on minimum acceptable drum and sheave diameters. Figures 4 and 5 show the effects that can be achieved by changes in warp length/depth ratios and warp diameters. In Figure 4 the effect on warp

load of towing either 12mm or 22mm warp at a range of warp length/depth ratios is shown. The benefits of changing length/depth ratio is particularly noticable for the larger diameter warp. It should be noted that the differences arise from the different weights and lengths of the two warps considered in the examples. The towing pull at the otter-boards is consistent for all four situations.

In figure 5 the effect on winch storage requirements is plotted for the same warp size and length/depth combinations. The advantages in saving of winch space when using either a smaller warp size or a reduced length/depth ratio are clearly seen. It should be noted that if warp of a reduced diameter were to be used, then a portion of heavy warp would be used immediately forward of the otterboards in order to withstand the abrasion loads.

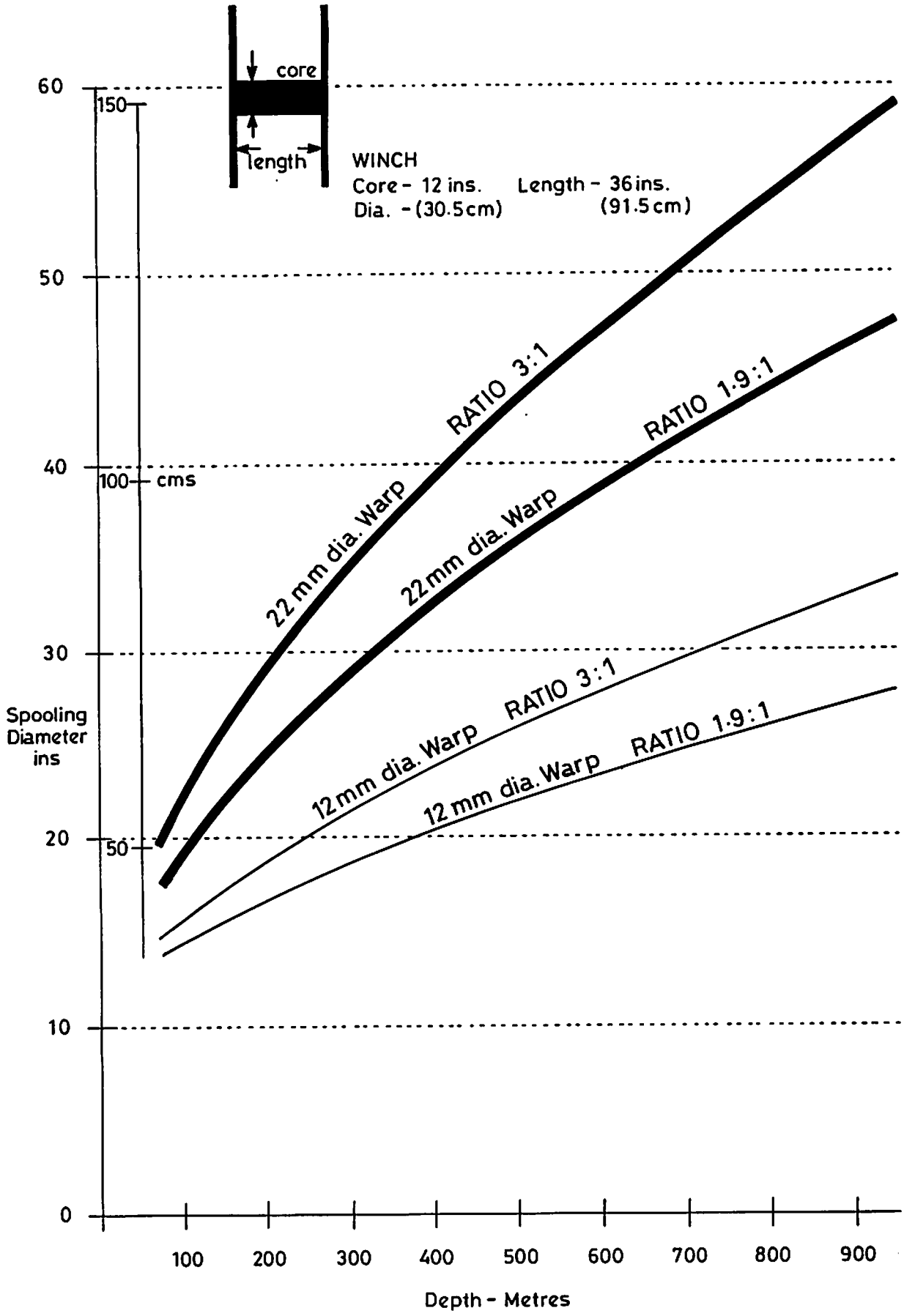
The problem of installing appropriate winch power was also discussed at the seminar. In many instances it would be necessary to install additional pumps and motors to provide adequate pull and speed characteristics for the trawl winch. Careful selection of equipment is essential if all needs are to be met without use of excessive power or without delays due to slow hauling. In this respect it is worth remembering that hauling times of 30 minutes or more would be expected and that errors in winch specification can add significantly to this. An optimum winch characteristic would be a "constant power" curve, but many installations will be of the viable delivery (either stepped or infinitely variable) and which provide only for a pre-selected combinations of pull and speed options.

An example of good and poor choice of available options is shown in Figure 6. In both graphs on the figure, the available pull and speed are plotted against the winding on diameter of the barrel of the winch. The starting situation is, of course, the same for both winch options.



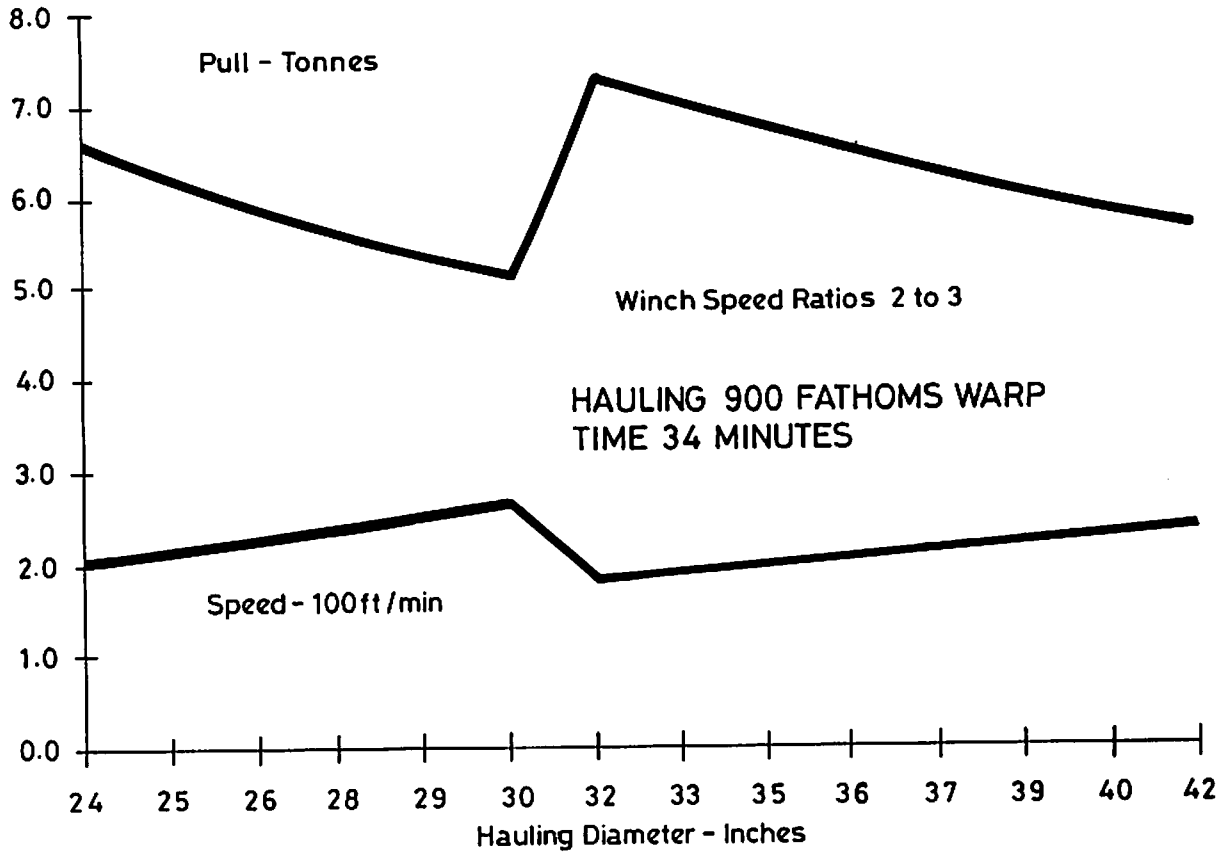
Relationship between warp load - depth of water - warp length to depth ratio and wire diameter

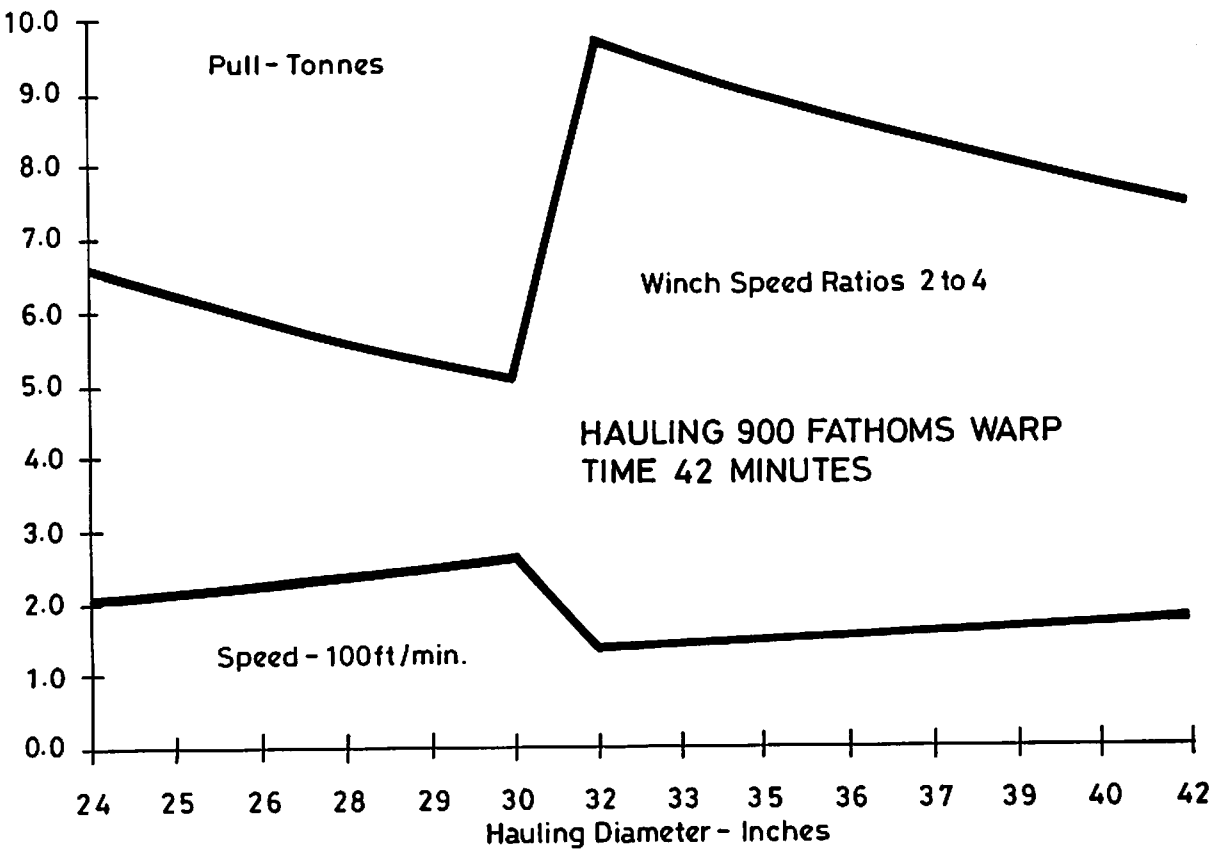
Fig.4



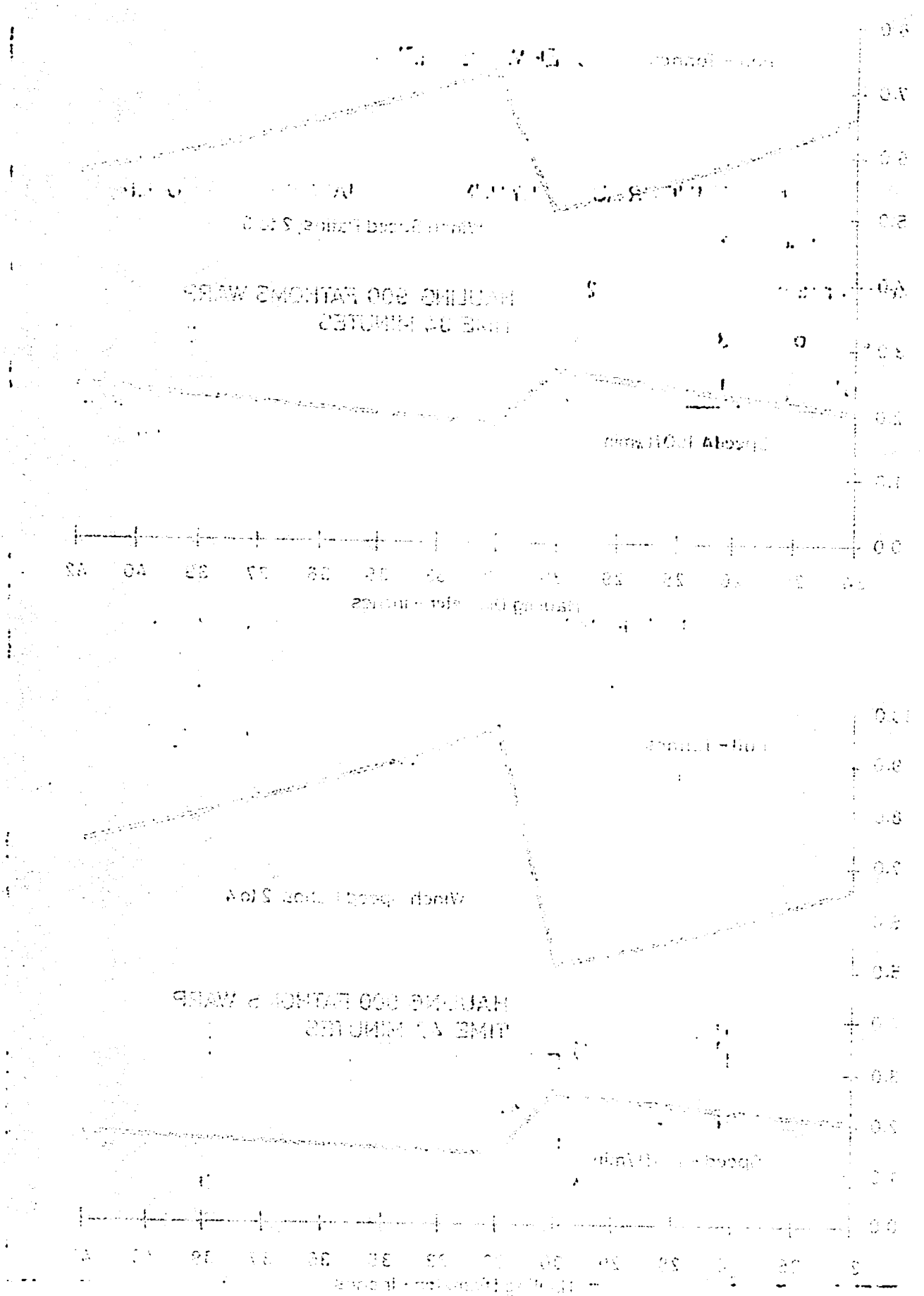
Relationship between spooling diameter of winch - warp diameter warp to depth ratio and water depth.

Fig.5



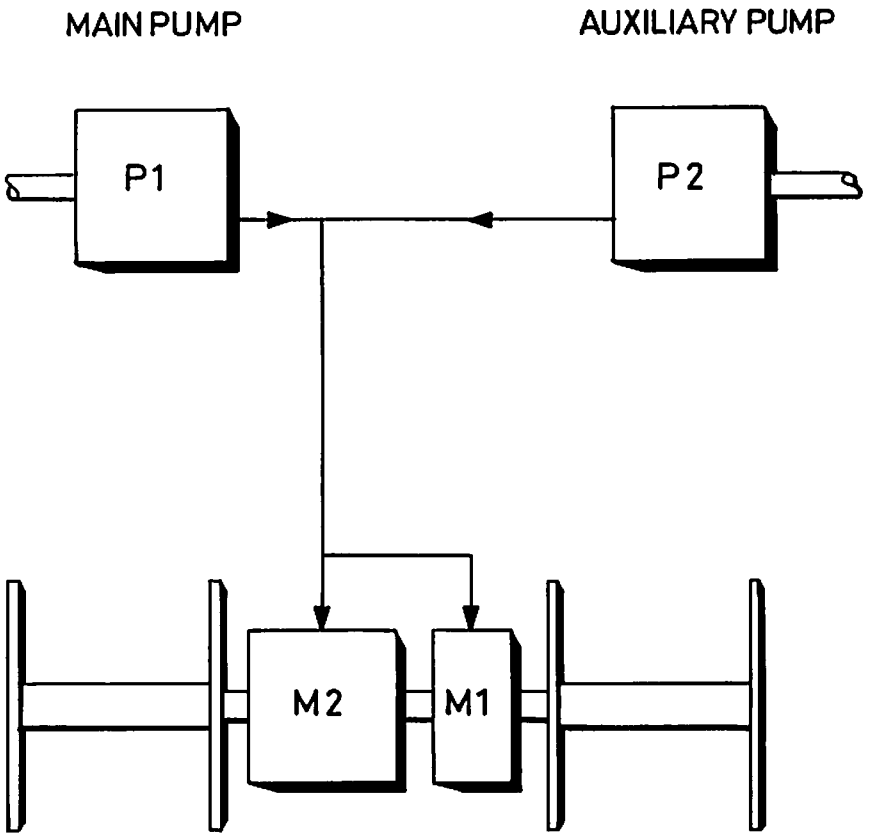


Effect of different winch speed ratios :- 2 to 3 compared with 2 to 4 Fig.6



DEEP WATER FISHING

	MAIN PUMP OR AUXILIARY PUMP			MAIN PUMP + AUXILIARY PUMP		
Pumps in use	1	1	1	1 + 2	1+2	1+2
Motors in use	1	2	1+2	1	2	1+2
Speed ratio	3	1·5	1	6	3	2
Pull ratio	1	2	3	1	2	3
	SHALLOW WATER				DEEP WATER	



Twin pump / twin motor system for shallow and deep water fishing. Fig.7

At a constant running speed on the winch, the hauling speed increases with winding-on diameter while available pull decreases. Hauling commences in the "high speed" mode but it eventually becomes necessary to "change down" to the low speed mode when the available pull falls to the actual warp load. If the winch change option is 3 to 2 (achieved by using motors of different capacities which can be run singly or in parallel), then the low speed option provides adequate pull and a reasonable hauling speed. If the ratio option is 2 to 1 (such as when two motors of the same size are used), then much higher pulls become available (in fact more than is required for the task), but there is a penalty in running speed of the winch and hauling times are extended as a consequence. For the given example, hauling time is extended from 34 minutes to 42 minutes although maximum power demands on the winch system are the same.

It is important to take traditional fishing demands into account when developing the winch system so that shallow water operations can be carried out without undue power demands or efficiency loss. A possible option for a hydraulic winch system would be to provide hydraulic pumps on both the main and auxiliary engines and a three speed motor combination at the winch. The winch motors would be different sizes and could be used as singles (either of the two motors) or in parallel combination. This arrangement would provide as many as 6 drive options with the winch being driven from one engine for shallow water fishing and from both engines when deepwater fishing.

Figure 7 shows the arrangement and identifies the different pull and speed options.

After some discussion the following points were noted as being important when considering fishing in deeper waters with an existing trawler:

i. Effective warp spooling is most desirable, firstly to produce an even progression of loads on the motor and pump and secondly to minimise crippling of the warp so that a smaller warp diameter may be possible. All aspects of the warp runs on the vessel should meet warp manufacturers recommendations. Warps of traditional sizes would be used for the lowest sections which are likely to contact the seabed.

ii. Winch must be variable torque option - constant horsepower control or two, three or four speed option might be used.

iii. Power options should be suitable for deep and shallow water operations - twin pumps will often serve purpose best.

iv. A single trawl warp option (i.e. shoot the full warp from one barrel then attach aa further warp from the second barrel and shoot again) may be used to increase fishing depth capacity of an existing vessel. However, the winch system must be such that all the available winch power can be applied through either of the barrels alone when hauling again.

v. Power requirements can be reduced if warp of lower diameter is used. It becomes more important to attend to minimum winch core and sheave sizes, effective spooling on winch and warp lead angles.

vi. Warp load meters may not provide much information in normal fishing operations, but are important when controlling winch during hauling or when fasteners are encountered.

5.2 Fishing Gear

The seminar discussed gear options, but it was generally felt that conventional bottom trawls fitted with deepwater floats and heavier ground gear and boards would be appropriate in the early stages until more was known about the stocks and their distribution.

Experience, however, from the SMBA suggests that some species may be semi pelagic and possibly a high headline narrow opening trawl may at some stage be worth experimenting with.

Reduction in warp diameter was discussed and it is known that this is possible provided there is good spooling. A further suggestion was that it may be possible to tow from a single warp onto two long bridles. This would permit all the available power to be made available to a single winch drum. It was also suggested that pair trawling using two Scottish seiners of 24m and around 500hp would permit a deeper water capability than a single boat. The use of otterboards by the pair trawlers would close the separation distance between the two vessels to within realistic limits.

Longlining and handling for species such as scabbard, roughy and grenadier should not be ruled out.

At the present time there are many diverse views on gear options, but little concrete evidence exists to form conclusions

5.3 Echo Sounders

The seminar agreed that the majority of fishing vessels able to fish the deepwater grounds will be equipped with an echo sounder in the frequency range 28 to 50KHz - at frequencies above 50KHz signal attenuation becomes a problem - with a power and range capability sufficient to distinguish the physical features of the seabed down to a 1000 metres and detection of fish shoals off the seabed to 500 metres.

Such equuipment, however, would not be appropriate for the detection of individual fish targets on or close to the seabed. This would require an echo sounder with a much higher level of technical sophistication,

employing narrow and spilt beam technology, variable pulse lengths and a high acoustic source level and receiver gain, which would not only substantially increase the individual fish detection range but also provide more detailed seabed information. Depth detection in excess of 2000 metres would not be impossible.

Similarly when fishing steeply sloping ground, the use of narrow beam transducers and short pulse lengths are more effective in reducing the shadow zone, which occurs when the return echo from the outer edge of the beam masks fish targets further down the slope; the wider the beam angle the greater the shadow zone.

Nevertheless, despite the obvious advantages of the above systems in fish detection on both rough and sloping grounds and the extended range capability, they are expensive and normally only carried by research vessels and fishing vessels such as the ARTIC CHALLENGE and the SOUTHELLA. Other limitations for installation on vessels under 30 metres is the size of the hull mounted transducer which, to achieve a narrow beam angle, by necessity is signficiantly larger than the conventional alternative.

The seminar recognised the superior qualities of the echo sounder described, but in general agreed that the performance of echo sounders currently carried by most vessels would be sufficient for the initial exploratory stages.

6. CARE OF THE CATCH AND END USE

Very little is known about the post harvest care problems of deepwater fish. Previous work by Torry Research Station has shown that these species are less easy to gut than cod and the viscera do not come away cleanly. Bleeding, too, has been noticed to be less easy and this may well lead to some discolouration. It is known that skin colour and general appearance deteriorate more rapidly than the more traditional species and that the soft flesh is easily bruised with ice. Well iced, all species keep in good condition comparable to cod in shelf life.

The grenadier and scabbard fish pose special problems in handling. The grenadier has a rough skin which necessitates the use of gloves during gutting and filleting and the skin prevents the fish from easily sliding on chutes and conveyors. The scabbard fish has sharp spines. The fillet yields from gutted fish obtained on previous trials at Torry Research Station in 1974 were for skin-off fillets.

Orange roughy	35.8%
Grenadier	33.8%
Scabbard fish	19.0%

No detailed information is available on extended freezing trials, but there is no reason to anticipate there would be any major differences with other demersal species. During the 1974 Torry trials, batches of deepwater fish were frozen for short periods of time.

The end use is likely, in the first instance, to be a substitute for the more familiar demersal species such as cod and haddock. It is possible that overseas markets could be developed in Japan and the US for the grenadier, scabbard fish and orange roughy, but the supplies are likely to be limited and irregular which will hinder any marketing campaign. The current French initiatives to develop a deepwater slope fishery are likely to set patterns of end use in the medium term.

Three species, grenadier, scabbard and orange roughy, were cooked at the seminar and sampled by attendees. The samples had previously been frozen and purchased on the Boulogne market. All three species were cooked by baking, poaching and grilling and gave acceptable results and could be easily substituted for any traditional white fish. The best, in terms of texture and flavour, was orange roughy.

7. CONCLUSIONS

i. The slope of the Continental Shelf to the west of the Hebrides will probably yield commercial quantities of marketable fish. Of these the most promising are the grenadiers, orange roughy and scabbard fish.

ii. Very little is known about these species and it would be bad judgement to over exploit the stocks until knowledge can be improved. This will necessitate collaboration between fishermen and scientists. Such research should be carried out at European Community level because of the importance of these stocks to the Community as a whole.

iii. Initially, exploitation of these stocks will be a progression from the Shelf to the Slope and the species will be seen as substitutes for the more familiar demersal fish. This should prevent the over exploitation taking place.

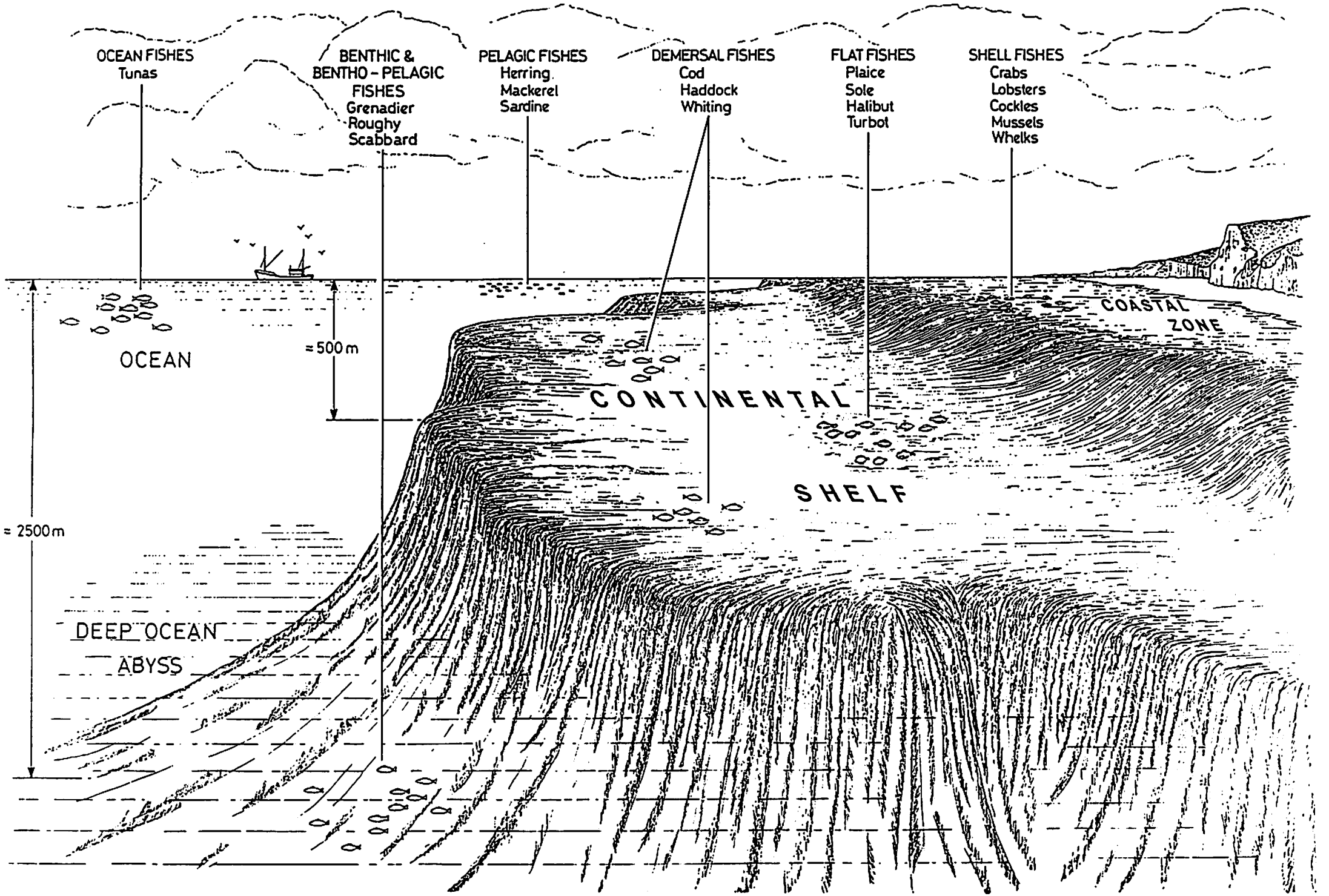
iv. The engineering aspects of vessel and winch design will require a specialised study. It is already clear from experience to date that almost all UK vessels will be limited to operations at depths less than 1000m and many to less than 700m. Research into winch design, spooling, warp sizing, etc., can be carried out relatively quickly following in-service measurements of loads when working at depths in excess of 200m.

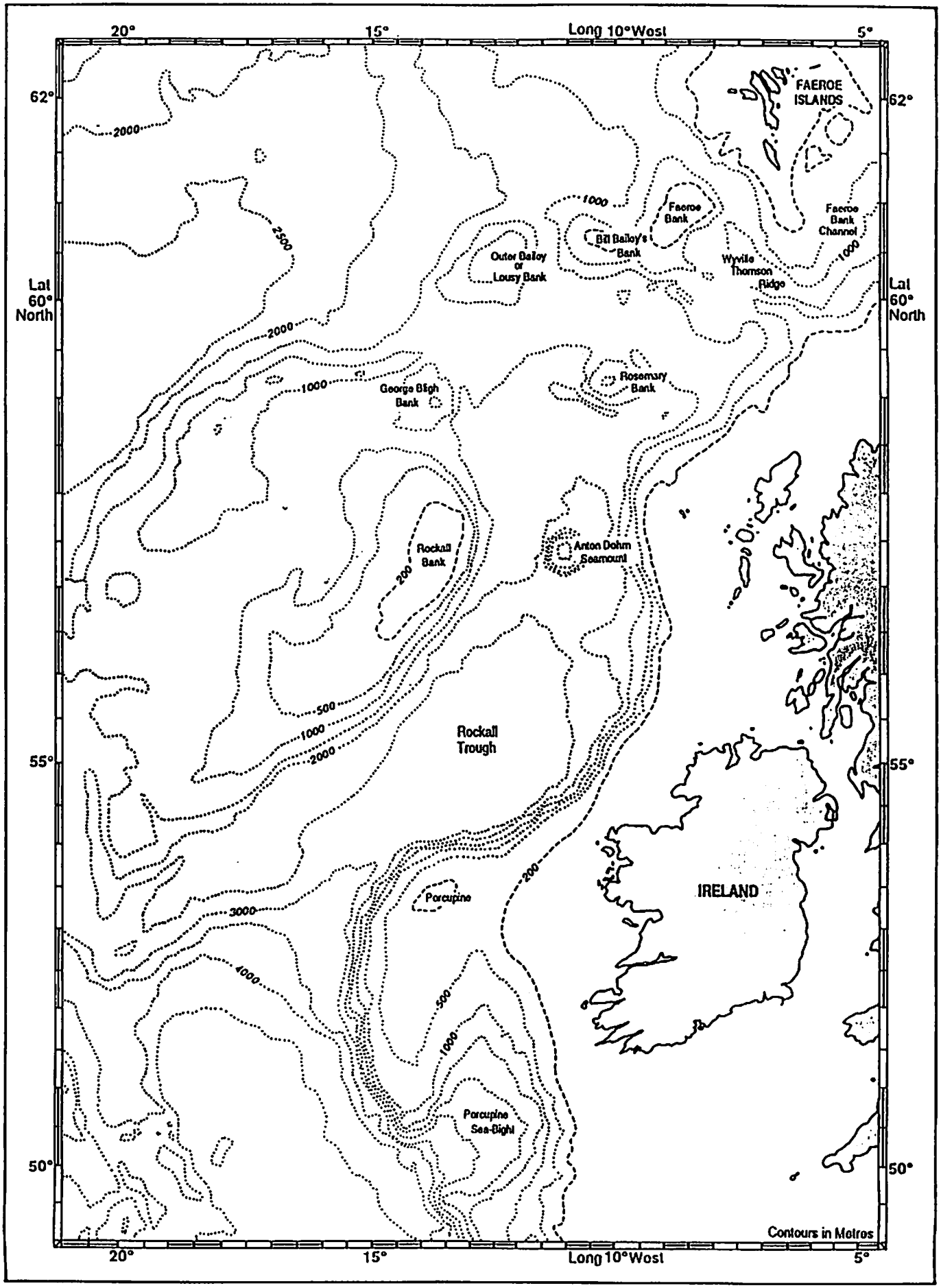
v. Post harvest care will need a special study, both to reduce the risk of spoilage or damage and to ensure the work content is not excessive.

vi. Crucial to the success of deepwater slope fishing, is adequate support by processors and buyers. At present the French markets are developing well and it may be possible to secure a share in these. In the long term, however, it would be hoped that UK processors would take these species and experiment with new products to replace diminishing supplies of cod and haddock.

vii. Whilst it is recognised that echo sounders are available to meet the criteria for fish detection and provision of seabed information at depths in excess of 2000 metres, the take up of such systems will be low, with vessel owners preferring to use their existing systems until such time as the viability of the fishery and markets are established.

viii. There is very little information at present on gear options. The use of modified conventional trawl gear is preferred by most skippers interested in deepwater slope fishing. There are, however, a number of other options which should be given further consideration.


OCEAN FISHES
Tunas
BENTHIC &
BENTHO – PELAGIC
FISHES
Grenadier
Roughy
Scabbard
PELAGIC FISHES
Herring
Mackerel
Sardine
DEMERSAL FISHES
Cod
Haddock
Whiting
FLAT FISHES
Plaice
Sole
Halibut
Turbot
SHELL FISHES
Crabs
Lobsters
Cockles
Mussels
Whelks
OCEAN
≈500 m
COASTAL
ZONE
CONTINENTAL
SHELF
≈2500 m
DEEP OCEAN
ABYSS



Eastern Atlantic Slope

Fig.2

Rockall Trough. Sample Area 56°45 N 10°20 W.

Eastern Side of Continental Shelf Slope. Distribution of Main Species.

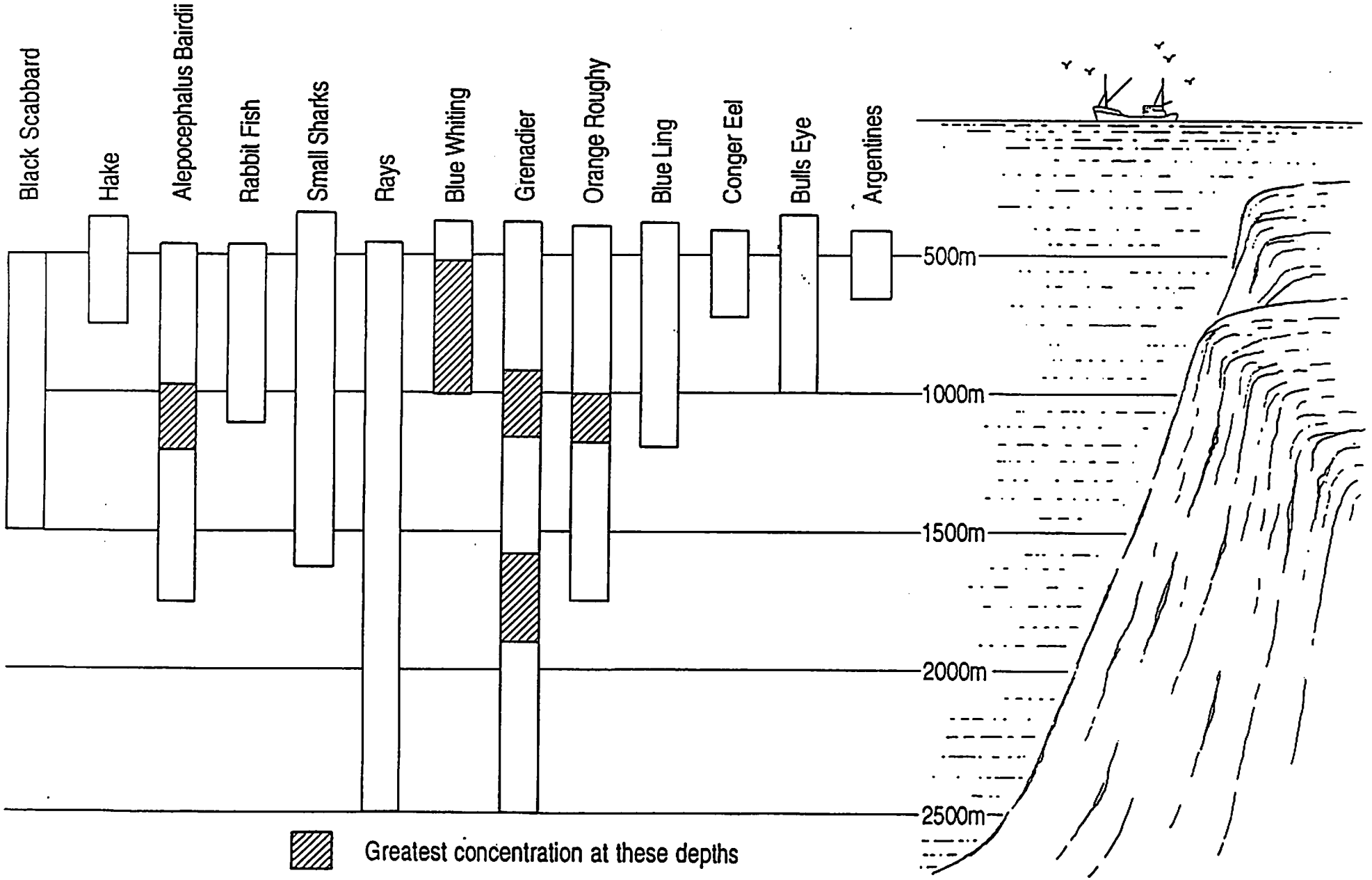
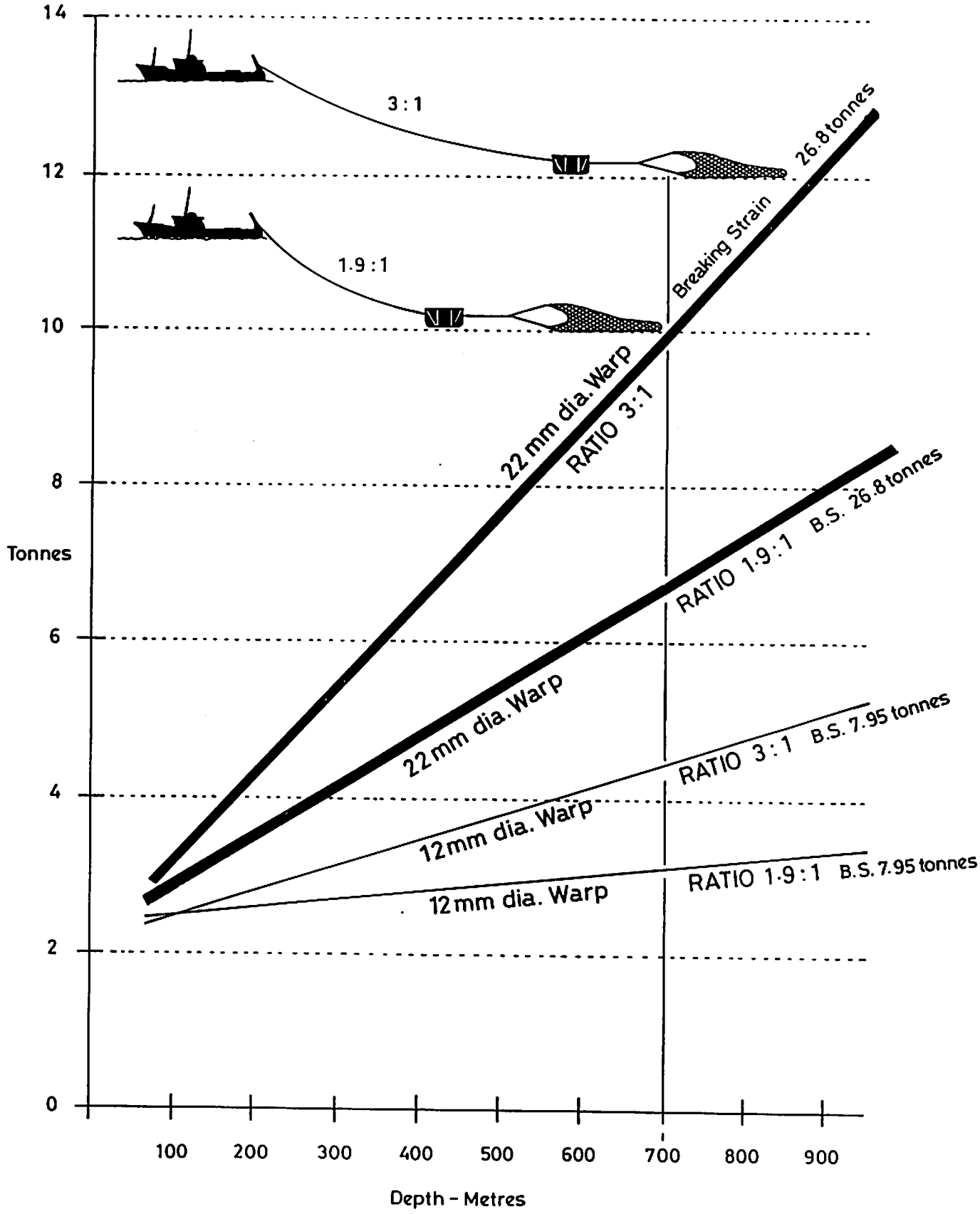


Fig. 3



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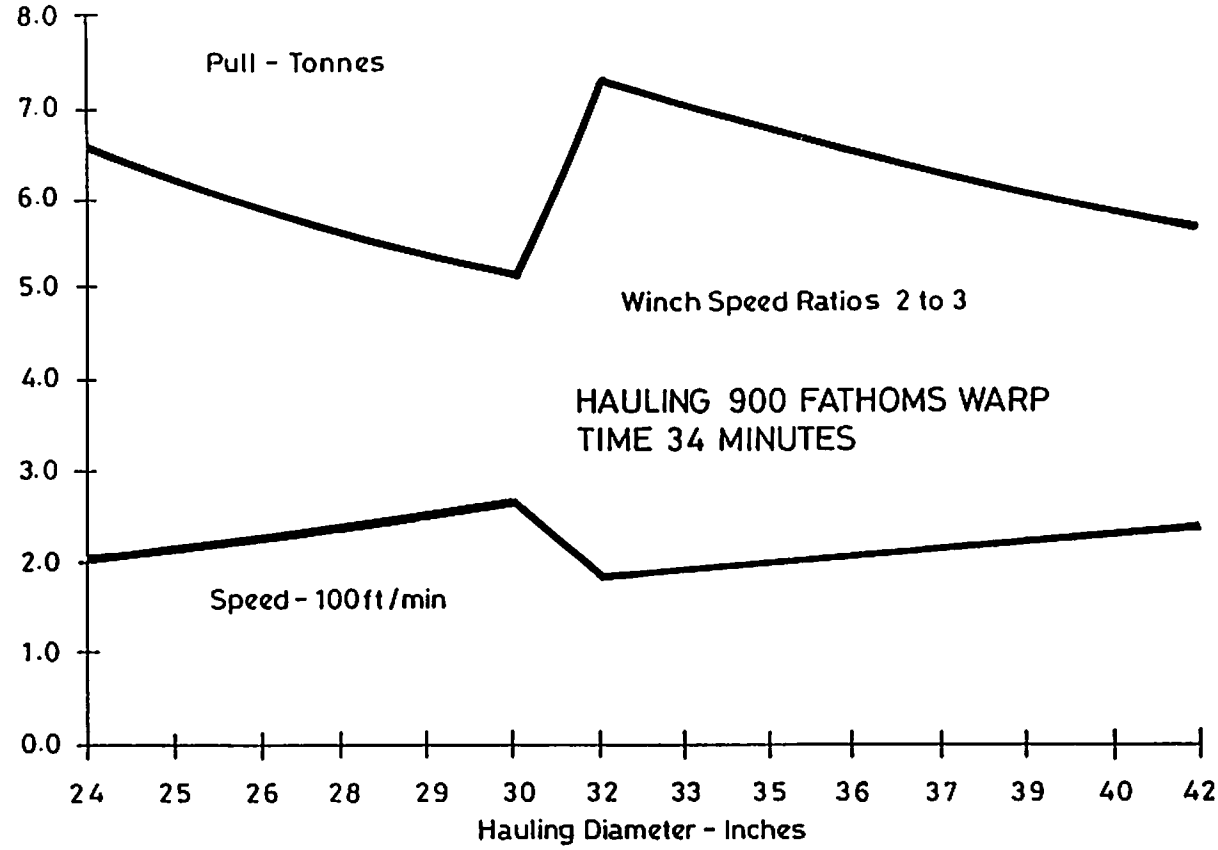
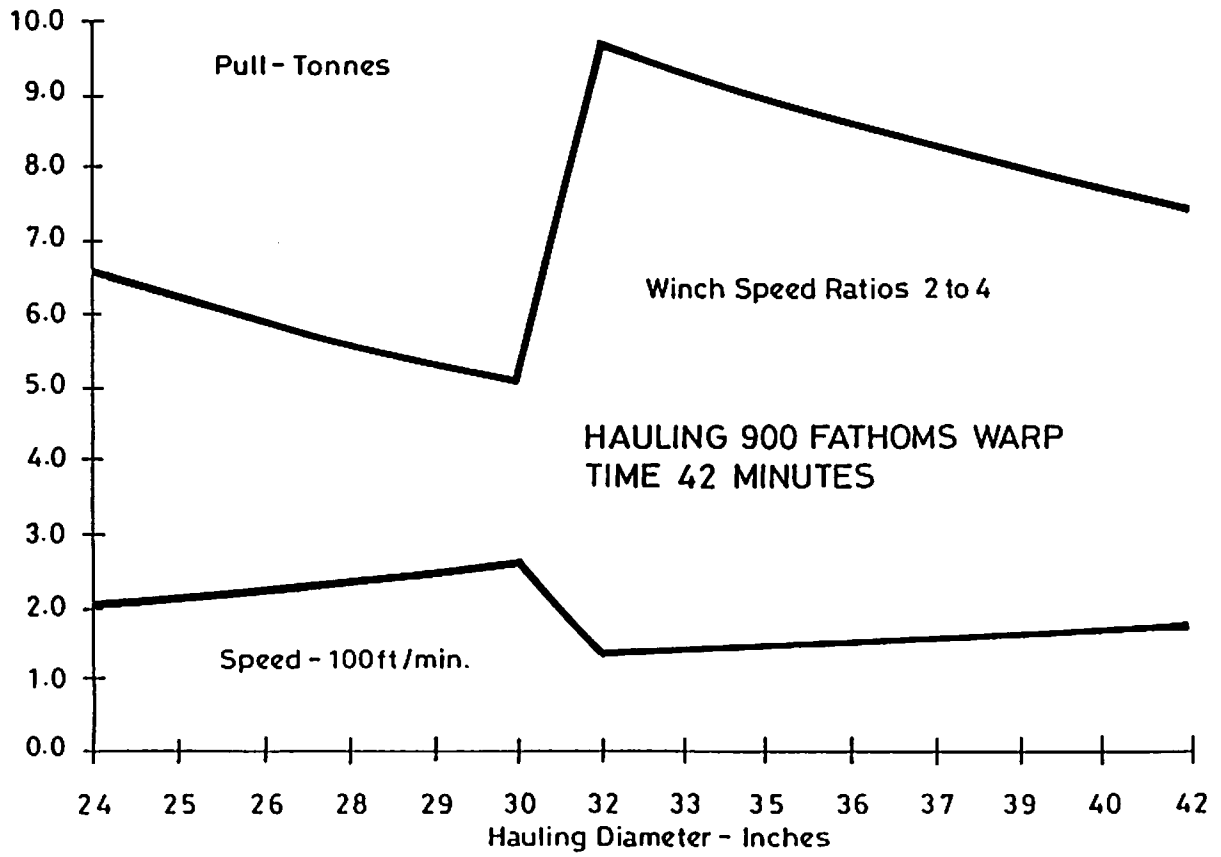
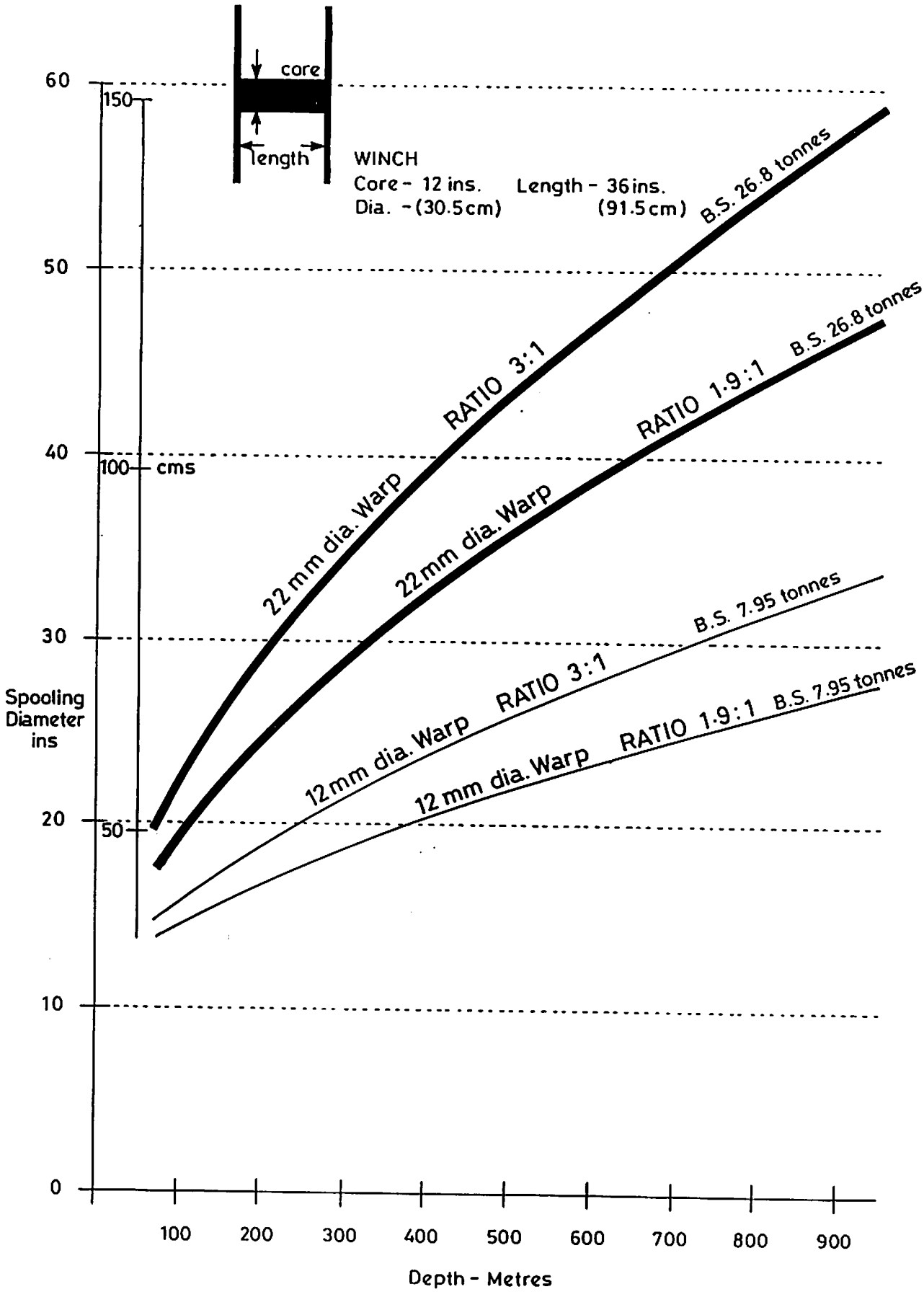


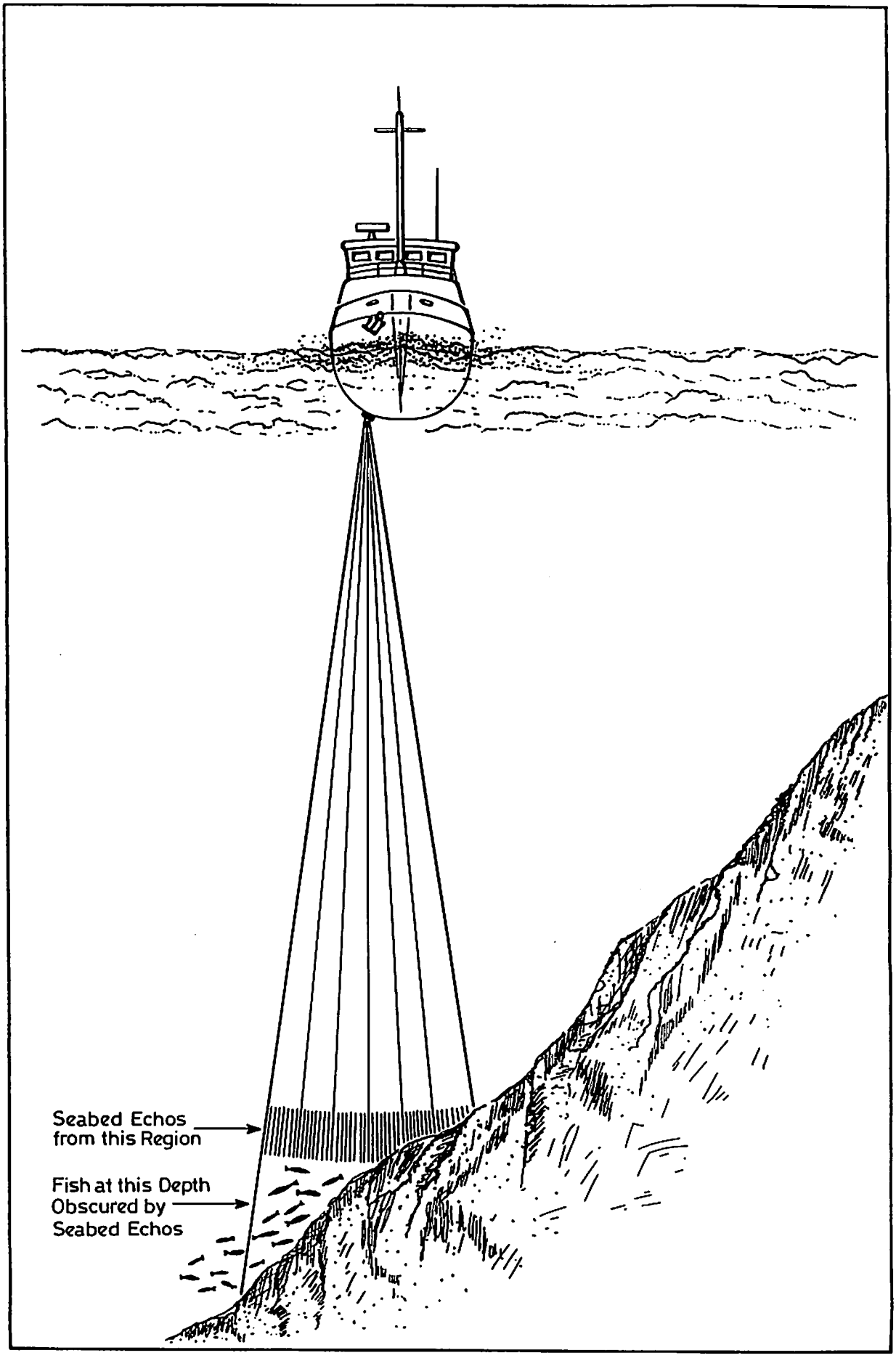


Effect of different winch speed ratios :- 2 to 3 compared with 2 to 4 Fig.6



Relationship between spooling diameter of winch - warp diameter warp to depth ratio and water depth.

Fig.5



Steeply Sloping Seabed Masks Fish Echoes Fig.7