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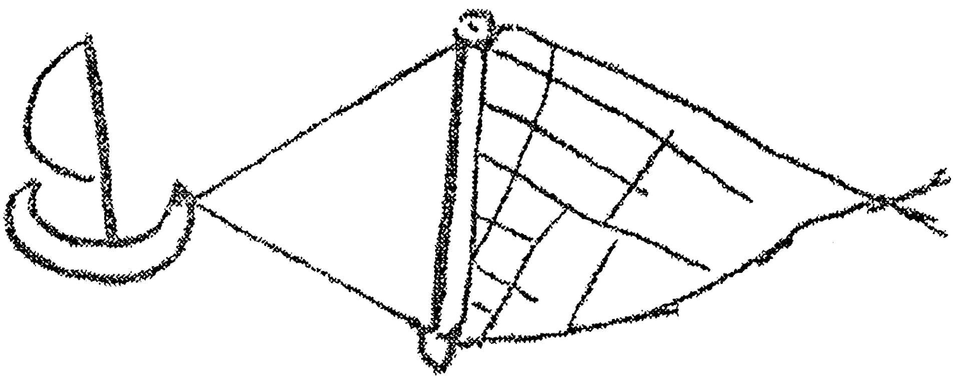
REPORT FROM FTFB SUBGROUP:

EVALUATION OF SOURCES OF VARIABILITY IN THE FISHING POWER OF THE GOV TRAWL



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1. INTRODUCTION

1.1. Background

The International Bottom Trawl Survey, (IBTS), began in 1991, and is carried out quarterly in the North Sea, Skagerrak and Kattegat. The IBTS replaced or incorporated the following "otterboard" surveys previously conducted in these areas:

The International Young Fish Survey (IYFS)
The English Groundfish Survey
The Scottish Groundfish Survey
The Groundfish Survey by Federal Republic of Germany
The Dutch Groundfish Survey
The Swedish Nephrops Survey

A brief description of these surveys and a Norwegian shrimp survey, with references to a more detailed literature, are given in the Report of the International North Sea, Skagerrak and Kattegat Bottom Trawl Survey Working Group (Anon., 1990). The IYFS has the longest history, going back to 1960-61 when the first large international surveys were carried out under ICES auspices.

During the first years of the IYFS a 78 ft Dutch herring bottom trawl was recommended as a standard gear. However, for various reasons most participants used other gears and the fishing method was not fully standardised. This situation was unsatisfactory, and in 1976 after a series of comparative fishing experiments a new standard gear was proposed: the French 36/47 GOV (Grand Overture Verticale) bottom trawl. An initiative to standardise the sampling gear in use was undertaken by A. Corten of RIVO (Netherlands). A series of model tests was conducted in the flume tank of the former DFTF at Hirtshals, during which the effect of various components of the rigging on the trawl geometry was analysed. Skippers and crew of several research vessels participated to create more awareness among the users of the GOV about effects on trawl performance. Results of the study were presented by Wileman (1984.)

The first manual for the IYFS was prepared by the IJmuiden laboratory in 1978. This manual was revised in 1981 and 1986 by the ICES's Young Herring Survey and Gadoid Survey Working Groups. (Anon., 1981 and 1986). In 1990 the IBTS Working Group decided that the standard gear and fishing method presently used in IYFS would be applied in the new survey. It was also agreed that the manual needed a further revision and a first draft was circulated to the members of the IBTS Working Group.

In 1982 it was decided to set up an IYFS data base at ICES headquarters in Copenhagen (Anon., 1982). Technical data on the construction of the data base, exchange tape specifications and standard output can be obtained from ICES or in Hansen et al (1983), Anon., (1986) and Pedersen(1988). The data base contains biological data and gear parameters. Environmental data sampled during the IYFS, primarily salinity and temperature at surface and bottom, are also available at ICES.

The first attempt to estimate sources of variation in the IYFS indices of abundance was published by Daan and Buijse (1986) using IYFS data from years 1983 to 1985. The authors calculated recruitment indices for various subsets of catch data: a. excluding single countries; b. splitting in even and uneven haul numbers; c. sorting stations by depth, temperature and salinity contours. In a second approach the authors tested inter-ship variation based on catches in rectangles fished by pairs of vessels. The results, regarded as preliminary by the authors, indicated small differences in catching power for most of vessels, with the exception of two vessels, which showed consistently lower efficiencies for some species. The authors concluded that the standardisation introduced so far in the survey had improved the estimate and that corrections introduced would only marginally affect the final index. They also concluded that the survey is well buffered against possible inter-ship variation. The catch rates were found to be more seriously affected by depth, temperature and salinity than inter-ship variation. They also recommended further studies of the effect of these environmental factors and suggested an introduction of a fixed station design in the survey.

Further analysis of IYFS data is reported by Sparholt (1990) who used the general linear model (GLM) to explain the variation in catch rates of 1-,2- and 3+ ringer herring. The analysis included differences between years, vessels, time of day, depth, area and area* year interactions. All effects were found to be significant at 5% level and explained about half of the variation in catch rate. The vessel effect was particulary pronounced for 1-ringed herring indicating, despite standardisation, some vessels were very in-effective in catching these herring.

At the meeting of the IBTS Working Group in 1990 (Anon., 1990) a GLM analysis of the IYFS data was used to investigate between-ship variation in 1-group catches of cod, haddock, whiting, Norway pout, herring and sprat. The variables year, ship (including ship and gear), sampling rectangle and day/night were included as class variables with depth as a continuous variable. Results showed substantial differences between vessels in fishing power by species (Figure 1.1). The analysis also indicated trends in fishing power over time (Figure 1.2). The group commented that the GLM analysis used is rather crude and does not take into account possible effects of annual changes in species distribution. The area allocation between the participating vessels has not changed substantially over the years analysed, so changes in species distribution between years could affect the outcome of the analyses.

The effect of changing sweep length with depth according to the manual was also analysed. The manual recommends that a sweep length of 50 m should be used at depths less than 70 m and 100 m sweeps in deeper waters. The increase in catch rate of 1-ringed herring was estimated to be about 65% when the sweep length was increased by 50 m.

1.2. Terms of reference and participation.

The reported differences in fishing power between vessels and over time have caused great concern within ICES committees involved in assessment work and at the 78 th Statutory Meeting it was decided to include this issue in the terms of reference for the Fishing Technology and Fish Behaviour (FTFB) Working Group, as follows:

a) evaluate the source of inconsistent performance in existing survey trawls, in particular the GOV net, and improve performance monitoring for survey trawls;
(ICES Com. Res. 1990/2:8).

The FTFB Group agreed at the 1991 meeting in Ancona (Anon., 1991) that recent findings about trawl performance and selectivity should be used to review existing manuals and suggest improvements. A small sub-group consisting of:

A. Engås	Norway	
O. Hagström	Sweden	(convener)
P. Koeller	Canada	

K. Lange	Germany
B. van Marlen	Netherlands
P. Stewart	Scotland

was appointed to discuss these matters and to agree upon further action.

The Sub-group defined their Terms of Reference as:

a) review of factors that could be the source of bias and variation in trawl performance.

b) review of the present Manual for ICES IYFS/IBTS

2. RESULTS OF THE QUESTIONNAIRE.

2.1. General comments

To investigate the present status of gear handling, rigging and fishing practise in relation to the recommendation given in the manual a questionnaire was distributed to all contact persons in IYFS. The questionnaire is given as Appendix 1.
The results are summarised in Table 2.1 which gives a very simplified overview of the present situation. Answers have been categorised as much as possible as "yes" or "no" leaving little room for elaborations. Some of the answers in the table could therefore be disputed, but the procedure is useful for detecting major deviations from the recommendations given in the manual.

2.2. Gear

The GOV used by the participating countries are made by national manufacturers and, with the exceptions of Scotland, Denmark and Sweden claimed to be made strictly according to original specifications. In the case of Sweden and Denmark the deviation is in the extension part which has the same mesh size as the cod-end. The Scottish alteration is in the netting material where panels with meshes >50 mm are made of polyethylene twine rather than polyamide.
Checking the GOV when delivered from the manufacturer is however, not a common practice in all countries and pre-survey checks are not standard procedure. Only two countries have developed a more detailed protocol than given in the manual. All countries report that assessment of net damage is used in a validity check to decide whether a haul is valid or not but the rules vary. Variation in manufacturing and maintenance of the trawl are regarded as a problem in the standardisation of the method by most countries.

2.3. Rigging of the GOV.

The standard rigging is reported to be used by all countries with Netherlands as the only exception. Tridens uses a semi-pelagic rigging (see Wileman 1984) when trawling in areas with sand dunes.
Most of the countries use the standard ground gear with the recommended extra weights but Germany and Scotland use bobbins in the northern areas.
Some countries do not use the standard kite or even use the kite at all, which could change the vertical opening and the fishing power of the GOV.
Variation in the buoyancy from 122 kg to the recommended 175 kg is also reported. The large variation in the length of the backstrops used from about

5 m to 13 m calls for better standardisation of the total length of sweep and backstrop.

2.4. Fishing Method

The recommended speed of 4 knots is not clearly defined in the manual. The IYFS working group therefore decided in 1989 that the fishing speed of 4 knots should be measured as ground speed (Anon., 1989b). This recommendation has not been implemented by all countries. England and France still use vessel speed through the water. Changes of sweep length from short (50 m) to long (100 m) when bottom depth exceeds 70 m are applied by most participants except Scotland, which uses 50 m sweeps in all depths. The degree of bottom contact is judged by visual inspection of the gear/catch and in addition acoustic equipment is used by some countries. Door spread is monitored by four countries and vertical opening by all. Monitoring of both door spread, wing-end spread and vertical opening is carried out by Scotland only. Scanmar equipment is used by all countries monitoring spread.
Adjustment of trawl direction to current or wind/waves iscarried out as a routine by Norway and Sweden only. Some countries report that towing before the wind is used only in bad weather.
The recommended warp/length ratio is used by all countries. The warp diameter varies from 18 mm to 32 mm.

2.5. Conclusions.

The survey shows in many aspects a high degree of standardisation between the countries, but deviations from the manual are reported that could cause serious changes in catch per unit effort. The responses also indicate that improvements are needed in the manual, in implementing recommendations and measuring the trawl both when delivered from manufacturers and prior to surveys.

3. SOURCES OF VARIABILITY.

3.1. Fundamental aspects of survey trawl performance.

The standardisation of survey trawls should include all details of the rigging. Variations in rigging between vessels can result in different shapes and sizes of the net opening, making comparison of catches difficult. It is also necessary to use a fixed towing speed for all hauls because speed influences the shape of the net opening. The following effects of alterations in rigging and fishing method on the performance of the trawl should be considered.

3.1.1. Through water speed of the net

When towing, the shape of the trawl, especially the net opening, is determined by the balance of two types of forces.

(a) *Hydrostatic forces*
Lift of the headline floats, weight and buoyancy of the net material. These forces are constant at all towing speeds.

(b) *Hydrodynamic forces*
Drag of all parts of the trawl, spreading force (lift) of the trawl doors and the kite, lift of those parts of the trawl towed with an angle of attack to the flow direction different from zero. These forces are proportional to the square of the towing speed.

The balance of these forces will be disturbed when towing speed is altered and consequently the shape of the trawl will change. The towing speed of a survey trawl should therefore be kept as constant as possible.

3.1.2. Trawl doors

The spreading force of the trawl doors opens the trawl mouth horizontally. This spreading force or lift can be expressed as :

$$L = 0.5\ \rho\ V^2\ A\ C_L(\alpha)$$

L	=	lift or spreading force
$C_L(\alpha)$	=	lift coefficient
ρ	=	density of the water
V	=	speed through water
A	=	trawl door area
α	=	angle of attack

With ρ being constant and a constant towing speed as recommended above, the two factors that influence the spreading force are $C_L(\alpha)$ and A. For the GOV trawl a Polyvalent door (oval, cambered, one slot) of $A = 4{,}5\ m^2$ is recommended. There is a maximum value of $C_L(\alpha) = 1{,}2$ with this type of door at an angle of attack of 28° - 34° (Lange 1976). If a different type of door is used its size should be adapted so that the product $A \times C_L(\alpha)$ is equal to the corresponding value of the recommended 4,5 m^2 Polyvalent door. Wind tunnel testing (Lange op.cit.) suggests that the spreading power of Polyvalent doors drops drastically when the angle of attack is increased to about 35° to 40°. This indicates that the rigging of the doors may be as important as their size and type (Wileman 1984).

3.1.3. Length of warps and bridles +sweeps

Looking at the trawl door/warp/bridle-arrangement in a plan view, (Figure 3.1) it is apparent that the force on the otterboard F_O can be divided into drag F_{Ox} and spreading force F_{Oy}, the latter balanced by the y-components of the warp and sweep tension F_{Wy} and F_{By} respectively, (y being the direction parallel to the spreading force F_{Oy}). With increasing warp length the angle *a* between the warp and the towing direction gets smaller with a (theoretical) ultimate value of zero with infinitely long warps. In this case the y-component of the warp tension F_{Wy} will necessarily be zero and all the spreading force F_{Oy} of the otterboard has to be balanced by the y-component of the sweep tension F_{By} alone, which will give increased door spread and wing spread. This effect was measured in full scale as well as in model tests (Hagström 1987, Galbraith 1986, Engås and Godö 1989, Wileman 1984).

Usually increased wing-spread is combined with a decrease in headline height, causing the net mouth opening to deviate from the standard value. When the fishing depth changes, the warp length must also be changed to keep the door spread approximately constant. The warp/depth relationship recommended in the GOV manual does not achieve constant door spread, wing spread and headline height. To obtain a high degree of constancy in door spread as warp length changes, the ratio of warp to sweep length (including backstrops and bridles) should be held constant. It is not practical however to vary sweep length for each haul during a survey and hence a certain amount of variation in spread between hauls must be accepted. It is known that this will introduce size dependent selectivity in the catches and is undesirable. An alternative solution to the problem - the use of a constraining rope - is discussed in section 4.2.6.

3.1.4. Headline floatation

Headline height is mainly influenced by the headline lift of floats (hydrostatic), kites (hydrodynamic) and towing speed. By changing the number or type of floats or kite design the headline height of a GOV can vary between 3,3 m and 7,8 m (Wileman 1984). The rigging of the kite could also influence the headline height.

3.1.5. Groundgear

The groundgear has some influence on the dimensions of the net opening (Galbraith 1986). However, the escapement of fish between the rubber discs of a groundrope can affect the catchability of a standard survey trawl (Engås and Godö 1989).

3.2. Problems encountered in the construction and use of survey trawls.

At a recent international workshop in St. John's New-foundland, gear experts and trawl survey biologists listed the factors influencing survey trawl performance and fish capture efficiency, determined which of these factors could be measured and controlled and attempted to provide an indication of their relative importance. This is a difficult and complex problem because of the relatively large number of factors which have been demonstrated to influence trawl performance, but whose influence on capture efficiency is unknown and can only be surmised. Even with a stable trawl performance, capture efficiency can vary with biological factors such as size or life history group, or with environmental factors such as ambient light, temperature, etc.

The factors listed at the St. John´s workshop are reproduced in Table 3.1, and are categorized according to their controllability by survey program or vessel personnel. The factors which are directly controllable fall mainly under the gear, vessel, and human categories. Notwithstanding the many direct relationships between them, the large number of factors contributing to inconsistent trawl behaviour is daunting- the question becomes: which factors are practically measurable, and which are important enough in terms of their effect on capture efficiency to warrant the considerable expenditure involved in measurement and, if that is the objective, control.
The following factors were judged to be among the most important.

3.2.1.Trawl construction and rigging.

Trawl rigging components, when altered, affect trawl behaviour and capture efficiency. In addition to these construction factors mentioned above (flotation, foot rope construction and weight) a number of other GOV trawl components are known to have a significant effect on trawl geometry if changed from specifications. These include:

(a) *Bridles*. A number of variations on the specified bridle system are used by the various vessels conducting the IYFS/IBTS. Changes from specification will result in changes to the shape and mesh opening in the bellies, which could lead to changes in size selectivity for some or all species captured.

(b) *Sweeps*. Sweep lengths are varied according to the manual except for Scotland. Section 2.2. These changes significantly influence gear spread and sweep angles (see Section 3.1.3) and hence the swept area/volume and herding characteristics of the trawl. Substantial changes in capture efficiencies can result.

(c) *Doors*. Not all IYFS/IBTS vessels are able or have chosen not to fish the specified doors. Use of non-standard doors or different rigging can introduce a significant variation or bias into survey estimates by varying swept area/volume, formation of sand clouds and herding characteristics in an unpredictable way.

(d) *Net materials* It is often difficult to adhere to specifications because of problems in obtaining certain materials, twine and mesh sizes, etc. in some countries participating in the IYFS/IBTS. While some changes of this kind have substantial impact on net geometry and capture efficiency (e.g. codend mesh size or length, twine diameters), others have surprisingly little effect (e.g.change from polyethylene to nylon with equal drag coefficients (Galbraith 1982). It is often impossible to predict the effect of these changes. For this reason the original French net specifications should not be changed unless extensive model tests or full scale instrumented trials have shown them to have little or no effect on net geometry and capture efficiency.

3.2.2. Swept area/volume

Changes in swept area and swept volume between areas or depths have been shown to bias significantly abundance estimates in three separate survey series. (Godö and Engås, 1989; Rose and Walters, 1990; Koeller ,1991) These quantities can be measured, and controlled directly by controlling gear spread, vertical opening, ship's speed and tow duration (active control), or indirectly by adjusting catches according to the measurements taken (passive control).

(a) *Speed* is important because it influences the magnitude and variability of swept area/volume, i.e. the length of the swept path and vertical opening. There is controversy on the kind of speed measurements to take i.e. speed through the water or over the ground. Speed over ground appears to be the most common standard in use, although there is disagreement on whether the desirable standard should be this or trawl speed through the water, which can now be measured. The key to this problem is knowledge of fish behaviour and orientation i.e. if it is relative to the current or the sea bed. If fish maintain position on the ground by visual cues then ground speed and constant distance covered is wanted. If they behave passively e.g. like plankton or swim with the net (optomotor reflex response, for which there is much evidense) then speed through the water and a constant amount of water filtered may be warranted. In any case there can be a substantial difference between the two types of measurement. It is important that a standard method is used in surveys where many different vessels take part. On the other hand, speed appears to have relatively little effect on the geometry of the GOV trawl within a range of +/- one knot around the target speed of four knots for the IYFS/IBTS.

(b) *Trawl spread* is important because it also influences the magnitude and variability of swept area. Many survey programs traditionally have used a constant wing spread as width of the swept path for all tows, usually an average spread derived from a limited number of experimental tows. Unfortunately, trawl spreads vary widely from tow to tow with depth, scope, bottom type, warp size, warp attachment positions, speed, bridle lengths etc., and these variations in spread have been shown to bias abundance estimates. The issues here are whether the spread measured should be wing spread or door spread (i.e. what is the effective spread relative to fish capture?), if spread should be measured for all sets and used to determine swept area (passive control), or whether spread should be kept constant by manipulating the amount of warp out, using restraining ropes between doors, etc. (active control).

(c). *Trawl height*, which affects swept volume, selectivity and capture efficiency if fish move above the trawl headline. This problem can be addressed by supplementing trawl catch information with acoustic data, to determine the proportion of the population above the headline, or using a trawl with a larger vertical opening. The existing GOV net's vertical opening can vary depending on the type and number of floats used, and with kite design and construction. Variation from the specifications should be avoided to prevent changes in capture efficiency from vessel to vessel, or survey to survey. If the specified floats cannot be obtained, then an equivalent buoyancy should be used (see also Section 3.1.4).

3.2.3. Bottom contact.

Bottom contact influences selectivity and capture efficiency (escape under the footrope), often of the smaller size groups. The time the net is actually fishing on the bottom, which may be substantially different from the time it is perceived to be fishing is another factor. Changes in footrope design can often improve selectivity problems of this kind, and some information on bottom contact can be obtained acoustically. The GOV specifications call for extra weight on the relatively light rubber disc footrope to ensure good bottom contact, and hence capture efficiency. Although heavier footrope gear could make better contact than the GOV's rubber discs, some types (e.g. large rubber bobbins) will allow more fish to escape beneath them(Ehrich 1987; Engås and Godø,1989a).

3.2.4. Current direction relative to tow direction.

The common practice of randomising direction of the tow where possible (except for some station locations such as along a slope) by towing toward the next station does not account for tides or cross currents which distort net geometry and affect capture efficiency. For example, random direction standard survey sets have higher variability in the trawl spread vs. height relationship than experimental sets where tow direction is fixed relative to current direction (Koeller 1991). Decreasing the variability of the current direction relative to tow direction should also decrease the variability of fish behaviour during the catching process.

3.2.5. Human factors.

A wide variety of human factors influence gear deployment, trawl construction and many other quality control aspects. These factors can be controlled through development and implementation of various protocols, ranging from purchase and acceptance procedures for new trawls and trawl parts, to gear damage assessment and tolerances, to training of survey personnel and crew in basics of gear technology and standard fishing procedures (Paschen 1991).

4. HOW TO REDUCE VARIABILITY.

4.1. Gear specification

4.1.1. General remarks.

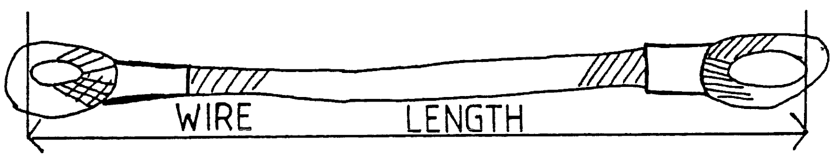
This section will deal with suggestions on how to improve the net drawing and description of rigging of the GOV trawl. Examples are given that could be used to work out a new, more detailed description of the standard GOV-trawl. The original description of the GOV trawl and the rigging as given in the Manual (Anon., 1986.) are shown in Figures 4.1 and 4.2.

4.1.2. Net drawing.

The original net drawing is not detailed enough and some important information about the material, joints, mesh definition, fishing line etc. is omitted. The Group therefore suggests that a new net drawing of the GOV trawl is applied. The new drawing as given in Figure 4.3 conforms with the recommendation given by the Net Drawing Study Group Report (Anon., 1989a). It is therefore recommended that this drawing is used in the manual.

4.1.3. Rigging.

The drawing in the existing manual supplies a fair amount of detail on the drawing of the rigging (Figure 4.2). It is recommended to measure wire length as given in the text figure below. The values given in Figure 4.2 are based on this method.



4.1.4. Standard ground gear.

The groundrope is well specified, but the fishing line is not (Figure 4.2). The material used should be specified. Some more dimensions can be included for example, the connecting chains between fishing line and groundrope should be 30 cm long with a diameter of 14 mm, and spaced 100 cm apart.

4.1.5. The otterboard.

The manual specifies 3,1 x 1,8 m or 4,5 m^2 Polyvalent doors without giving specification of weight and rigging. The original French drawing gives a weigth of 1000/ 1100 kg. The current practice in the survey is to use the recommended Polyvalent doors of 4,5 m^2 but the weights vary from 1100 to 1400 kg according to the reports. Only one country (Sweden) operate a different trawl door: Dan-Gren 3.00 x 1,95 m or 5,85 m^2. (See Table 2.1).
It is recommended that the weight of the trawl doors should be 1200 kg which seems to be used by most countries. The rigging should be with medium shearing efficiency which means that backstrops are shackled in the middle holes. The recommended otterboard are shown in Figure 4.4.

4.1.6. Check list of important dimensions.

It is important to check the trawl components regularly. A checklist of the GOV trawl and the rigging, mounting of the kite, has been produced by Marine Laboratory in Aberdeen. The Group recommends that the new checklist for the GOV trawl is used in IBTS. The checklist is given in Figures 4.5 to 4.9. A full check should be carried out at least when the trawl is delivered. Following major gear damage and subsequent repair, the affected sections of the trawl should be checked.

4.2. COMMENTS TO THE FISHING METHOD.

4.2.1. General comments.

When gear performance data are available during a haul, it is possible to adjust warp length and towing speed continuously to modify gear shape to achieve target values. This is an active approach to controlling survey trawl performance. This approach is not recommended. It is thought more important to achieve a uniform speed and that the approach for the GOV trawl should be passive, accepting and noting the gear geometry produced by the speed and warp length set for the haul.

4.2.2. Warp-to-depth ratio

A depth dependent warp-to-depth ratio, based on a warp diameter of 22 mm, is recommended for the 37/47 m GOV trawl (Anon., 1986). To make the doors stay upright and maintain the same ground contact under varying conditions, the warp length must be correctly adjusted to depth. Therefore it is strongly recommended that when using the present fishing method the recommended warp to depth ratio should be followed. It is however noted that the warp diameters in use vary widely from 18 - 32 mm are. It is likely that this will affect the warp to depth ratio and it is therefore recommended that this effect is investigated.

4.2.3. Sweep length

Sweep lengths of 50 m and 100 m have been used during the surveys depending on the bottom depth (Anon., 1986).
It is strongly recommended that only 60 m sweeps including the length of backstrops are used. The choice short sweeps is based on experiments showing less biased estimates for small fish than obtained with longer sweeps (Engås and Godö 1989).

4.2.4. Start and stop time of the haul.

Each haul in IYFS lasts 30 minutes. The starting time being defined as the moment the doors and the footrope have settled on the sea bed. These events are generally documented with netsonde or acoustic sensors.
The present means of assessing bottom contact of the footrope by netsonde or height sensors or polishing of chains etc. are however not good enough and the information could be misleading.
It is therefore recommended that research is carried out to develop instruments giving a more accurate measurements of the distance between the ground gear and the bottom than is obtained with existing equipment.

Stop time is the time at start of hauling.

4.2.5. Shooting and hauling procedure.

As the winch systems on board the vessels participating in the surveys are different, it is difficult to recommend a shooting and hauling procedure. Hauling should be carried out as fast as possible to prevent extra fishing time on the bottom after the recorded end of the haul.

4.2.6. Towing speed.

Standard towing speed has been four knots measured as trawl speed over the ground. It is now recommended that the standard speed should be speed of the trawl through the water and measurements of both this speed with mounted sensors and trawl speed over the ground with GPS (Global Position System), or an equally accurate navigation system, should be carried out. Actual speed over the ground during each haul should be calculated from the measured distance travelled whilst the gear is in contact with the bottom.

4.2.7. Constraint of door spread

Measurements of door spread carried out on the 36/47 m GOV trawl show increasing swept area/volume with depth and considerable differences in spread between the 50 m and 100 m sweep lengths recommended for shallow and deep water respectively (Hagström 1987, Galbraith 1986). Ideally, a survey trawl should have constant swept area/volume. Several proposals to achieve this have been put forward and tested. In commercial fisheries it is common to use constraint in pairtrawling and in single boat trawling i.e Nephrop fishery. Automatic trawl systems, which actively control the spread by adjusting warp length, have been considered. However active control of the trawl is not recommended by this group because of the complex fishing method or expensive equipment required. A method using a constraint seems to be a more promising approach.

Recent measurements of door spread when constrained by a rope between the the warps (Engås and Ona 1991) show a large reduction in the variation of spread. The method is technically very simple and does not require changes of the deck layout or winch system on board traditional research vessels (Figure 4.10).
The rope (PA 12 mm) is mounted on the warps 150 m in front of the doors, which is the minimum warp length to be used. Slip hooks allow the warps to rotate. Stoppers made of rope and mounted on each side where the slip hooks are connected to the warp prevent the rope from sliding up or down the warps (Figure 4.10). The constraint rope should be at least 20 cm longer than the maximum distance between the towing blocks of the vessels participating in the survey.

The present recommendation of warp/depth ratio will have to be changed when a constrain technique is applied. The objective should be to adjust the warp length so that 2/3 of the trawl door weight in water is upwards foce at the warp end nearest the door. This force depends on the warp tension and the elevation angle of the warp. (Figure 4.10.)

If the constraint method is applied it is recommended that a depth sensor is mounted on the constraint rope between the warps. By using the echo-sounder to measure bottom depth and the depth sensor it is possible to keep the rope distance off the bottom fixed and thereby the ground contact of the doors constant under varying conditions (Engås and Ona 1991).

Research should be carried out to measure the warp tension at the end nearest to the doors. This would determine the angle to be used to get an upwards force at the door of 2/3 of the weight of the door in water.
The constraint technique necessitates that the trawl doors used have enough spreading force in shallow water to obtain a door spread of about 70 m with 60 m sweeps and backstrop. Although the constraint rope seems very promising the method needs more testing with a GOV trawl and the Group recommends that further research be carried out before the method is applied as standard.

4.3. MONITORING SURVEY TRAWL PERFORMANCE.

The primary objective in monitoring trawl performance is to confirm that the gear is operating in the prescribed manner with a relatively constant capture efficiency. By recording a wider range of gear and environmental parameters however, it should be possible to investigate how the catch of each species/size group relates to gear performance and environmental conditions.

The behaviour of fish in towed fishing gears has been studied extensively during the last 20 years, by direct observation underwater using divers or underwater vehicles with television equipment. This has revealed the complexity of the capture process and identified gear and environmental factors which determine catch efficiency and selectivity. A trawl is not simply a sieve but a herding device whose operation depends crucially on fish response. When fish encounter a trawl, they are normally shepherded by the otter boards and bridles to the mouth of the net, where they turn and swim with the gear until exhausted. Thus the visibility of gear to the fish and their swimming abilities are key factors in the capture process. When visibility is low, the fish can see only a small part of the gear and tend to be herded readily into the body of the net. With good visibility, fish can detect the gear at greater ranges and can avoid it more easily. The visibility of gear components depends on light intensity, water turbidity and sometimes on bioluminescence. Swimming speed and endurance, which are dependent on water temperature, determine whether a fish will be caught. It is the speed of the net relative to the fish, the speed through the water, which is critical in fish capture.

The mechanical performance of towed gears has also been studied and instrumentation is available to measure comprehensively and routinely the forces in and the geometry of trawls and other towed gears. To maintain the catching capacity of a trawl, door spread, mouth opening, bottom contact and speed must be consistent between hauls. The minimal requirements are to measure door spread, headline height and towing speed. This ensures that the net has the normal geometry and that it is on the bottom. Wingend spread should also be recorded as an additional check on gear geometry. Acoustic spreadmeters for this purpose are commercially available. It is thought that pulsing of the gear during bad weather may affect catching efficiency. This can be monitored by noting the variance in the door spread.

In addition to measurements of the trawl geometry observations by means of an underwater-TV-camera are useful to investigate the influence of rig alterations on the performance of a standard trawl. By a combination of measurements and TV-observations it should be possible to make the performance of standard trawls, more consistent.

Forces on the groundgear vary with bottom type and this can affect net shape. On harder ground less sediment is thrown up by the doors to form clouds along the sweep wires which can affect herding efficiency. The type of sea bottom encountered during a haul should be noted. Echo-sounding equipment which classifies sea bed types is commercially available.

In summary it is recommended that door spread, wingend spread, headline height and speed over the ground and speed through the water be recorded during each haul. If possible, the measurements should be recorded at 30 sec. intervals or less and a variance estimate should also be made.

Methods of instrument mounting are well described by manufacturers. The trawl is relatively small and problems concerning the transmission of signals through the water are not likely to occur except in very shallow water where the receiving signal could be blocked by the propeller wake. The spread sensors on the doors have to be set at a particular angle of attack, pitch and heel to pick up the echo from the opposite trawl door. It is also recommended to measure the towing speed at the mouth of the trawl. The mounting of the speed sensor is known to be critical for the quality of the received data.

5. SUMMARY OF RECOMMENDATIONS FOR THE MANUAL.

1. It is recommended that the detailed net drawing, Figure 4.3 is used.

2. It is recommended that in the drawing of the rigging the lengths of wires are as defined in this report.

3. It is recommended that the connecting chains between fishing line and groundrope are 30 cm long with a diameter of 14 mm and spaced 1 m apart.

4. It is recommended that the checklist in Figures 4.5-4.9 is used in measuring of the GOV.

5. It is recommended that a fixed total length of backstrop and sweep of 60 m is used in all depths.

6. It is recommended that the weight of the Polyvalent 4,5 m^2 door is 1200 kg and the backstrops should be attached to the middle towing point.

7. It is recommended that start time should be defined as the time when the net reaches the sea bed. Stop time should be defined as the time at start of pull back.

8. It is strongly recommended that when using the present fishing method the specified warp/depth ratio should be used.

9. It is recommended that the effect on the door spread and gear geometry of using different warp diameters is studied.

10. Standard towing speed should be target at 4 knots, defined as speed of the trawl through water. Ground speed should also be measured .

11. It is recommended that the following gear parameters should be recorded throughout each haul:

    speed through water of the net
    ground speed
    door spread
    vertical opening
    wing-end spread

12. The Group recommends that underwater observations of the GOV trawl in a survey situation are carried out on all research vessels as an integral part of the national training program.

13. Active control of the trawl is not recommended and the most promising method to reduce variability appears to be the constraint rope method. The Group therefore recommends that this method is subjected to field test with the GOV and applied in the IBTS, if proven useful and found not to influence capture efficiency

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Table 2.1. Summary of present practice in the IYFS on gear handling, rigging & fishing method.

	Country Denmark	England	France	Germany	Netherland Tridens	Netherland Isis	Norway	Scotland	Sweden
Gear									
1. Manufacturer	Nat.(Cosmos)	France(Gloriant)	Nat.(Concarneau)	Nat.(Engel)	Nat.(IJ.St.)	Nat.(IJ.St.)	National	National	National
2. Is the GOV made strictly according the original specification?	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
3. Is the GOV measured up, when delivered, to see if it is made according to the specification ?	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes
4. Do you have a separate protocol of the GOV ?	No	Yes	No	No	No	No	No	Yes	No
5. Routine measurements prior to survey	No	Bridles /sweeps	2-3 times a yr.	Bridles	No	No	No	Bridles/sweeps	Bridles/sweeps
6. Net damage evaluation: part of haul validity checl	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Do you regard variation in manufacturing of the GOV or the maintainance of the trawl an importar part in the standardization ?	Yes	Yes	Yes	Yes	No	No	Yes maintenace	Yes	Yes
Rigging of the GOV									
1. Standard rigging	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Standard ground gear	Yes	Yes	Yes	No	Yes	Yes	Yes	No (IVa type B)	Yes
3. Total weights(kg in air)on ground rope	210	210	210	210	210	210	210	210	150-210
4. Kite (standard=Ex 0,72 m2, 5 floats.)	0,96 m2 3 floats	standard	stand. or netsond	standard	standard	standard	No kite	standard	standard
5. Doors(standard=Polyvalent 4,5 m2)	stand./1200 kg	stand./1400 kg	stand./1300 kg	stand./1200 kg	stand./1200 kg	3,82m2/800 kg	stand./1100 kg	stand./1100 kg	5,85 m2/1050kg
6. Buoyancy of floats.	172 kg	175 kg	N/A	175 kg	125 kg	125 kg	172 kg	172 kg	130
7. Length of backstrops	N/A	11.6 m	N/A	9 m	5 m	3,5 m	N/A	13.1 m	12.6 m
Fishing Methods									
1. Towing speed measured as:									
vessel speed through water	Yes	Yes	No	Yes	No	No	No	No	Yes
vessel speed over ground	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
target speed in knots	N/A	4	4	4	4	4	4	4	4
2. Changes of sweeps according to manual	Yes	Yes	Yes	Yes	Yes	Yes	No	only 50 m sweep	Yes
3. Acoustic measurements of bottomcontact	Yes				Yes	Yes	N/A	Yes	Yes
Visual inspection of gear/catch		Yes	Yes	Yes	Yes	Yes	N/A		Yes
4. Gear parameters monitored during trawling									
door spread	Yes	Yes	No	No	Not always	Not always	No	Yes	Yes
verical opening	Yes	Yes	Not always	Yes	Yes	Yes	Yes	Yes	Yes
wing-end spread	No	No	No	No	No	No	No	Yes	No
5.Trawl mensuration equipment used									
door spread	Scanmar	Scanmar			Scanmar	Scanmar		Scanmar	Scanmar
verical opening	Scanmar	Scanmar	Net-sonde	Net-sonde	Net-sonde	Net-sonde	Scanmar	Scanmar	Scanmar
wing-end spread								Scanmar	
6. Adjustment of trawl direction to current/wind	Yes	Sometimes	Sometimes	No	Sometimes	Sometimes	Sometimes	Sometimes	
7. Recommended warp length/depth used.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Warp diameter in mm	20	26	22	32	28	20	23	26	18

TABLE 3.1. Factors known or assumed to affect survey gear performance and fish capture efficiency, from Survey Trawl Workshop, St. John's, Newfoundland, Mars 18-19, 1991. Numbers under "How controlled" column refer to: 1- directly controllable; 2-indirectly controllable through survey design; 3- indirectly controllable through gear or vessel design.

	How measured or observed	How Controlled
PHYSICAL (Gear/Vessel)		
gear		
height		
door spread	SCANMAR	1, 3, change floats, spread
wing spread	SCANMAR	1, 3, change warp out
wing spread	SCANMAR	1, 3, change warp out
warp out (choice of)	gear trials	1, protocol
warp angle	?	1, course rel. to currents
warp size	calipers	1, protocol
net speed (water)	SCANMAR	1, pitch, power
door stability	SCANMAR, UWTV	1, 3, protocol
sweep length	measuring tape	1, 3, protocol
sweep angle	calculated	1, 3, protocol
door construction	measure door	1, 3, protocol
sand cloud charac.	UWTV	1, 3, stabilize doors
gear visibility (to fish)	?	1, 3, protocol
net construction	measure up trawl	1, 3, protocol
net design	measure up trawl	1, 3, protocol
bot. contact (footgear)	selectivity exp., UWTV door, chain polish	1, 3, change footgear
bot. contact (duration)	SCANMAR	1, tow timing
net damage	deck observation	1, protocol
floatation	bouyancy guage	1, protocol
net shrinking/stretch	measure net	1, protocol
net load (clogging)	SCANMAR, weight	1, 3, tow duration
mesh size/shape	mesh guage	1, 3, protocol
vessel		
winch power	winch guages	1, 3, winch controls
winch speed	winch guages	1, 3, winch controls
warp tension	SCANMAR, etc.	1, speed, load, etc
warp measures	marks, guages	1, calibration
navigation	Loran, GPS	1, calibration
tow length	time	1, protocol
ship speed (ground)	doppler, loran, etc	1, pitch, power
ship speed (water)	Sal log	1, pitch, power
hauling speed	log, winch controls	1, ships & winch speed
shooting speed	log, winch controls	1, ships & winch speed
vessel:gear comb.	design	3, design
propellor type	design	3, design
hull design	design	3, design
noise/sound profile	accustics	3, design
heading	compass	1, tiller

ENVIRONMENTAL

Physical

current direction	SCANMAR, ADCP	1, course rel. to current
current velocity	SCANMAR, ADCP	1, speed rel. to current
depth	sounder	1, change warp out
bottom slope	sounder	1, change warp out
fish./unfishability	sounder, experience	1, 2, avoid areas
ice	ice forecasts	1, 2, avoid areas
bottom type	sounder, maps	1, warp out, sweeps, etc.
sea state/wind/swell	deck observation	1, maximum for work
light/turbidity	light meter, observe	2, survey design
bioluminescence	light meter	2, survey design
temperature	thermometer	2, survey design
oxygen	Oxygen determinations	2, survey design

Biological

avoidance	UWTV, selectivity exp.	3, net design
swimming speed	UWTV, selectivity exp.	3, net design, use
species	UWTV, selectivity exp.	2, 3, survey/net design
size	UWTV, selectivity exp.	3, net design
vertical distribution	UWTV, selectivity exp.	2, 3, survey/net design/acoustics
species composition	UWTV, selectivity exp.	2, 3, survey/net design
geographical distrib.	survey data analyses	2, survey design
migration	survey data analyses	2, survey design
density (at station)	UWTV, selectivity exp.	1, tow length
food availability	stomach observations	2, survey design
spawning	survey data analyses	2, survey design
other seasonal	survey data analyses	2, survey design

HUMAN

chief scientist	appraisals	1, assignment practices
protocol availability	inventoru	1, protocol development
attitude/diligence	observation	1, man'mnt/hiring practices
knowledge	observation	1, training
training	course evaluation	1, curriculum choices
net construction	measure up nets	1, protocols
net purchase	observations	1, protocols
communications	evaluation	1, protocols
watches (differences)	observations	1, protocols
haul observ. (e.g. polish)	observations	1, protocols
gear deployment	observations	1, protocols
damage assessment	deck observations	1, protocols
subsampling	observations	1, protocols
maintenance/repair	observations	1, protocols
hiring practices	observations	1, protocols

FIGURE 1.1 Relative fishing power for IYFS vessels by species in the period 1982-1989. Data from Anon., 1990.

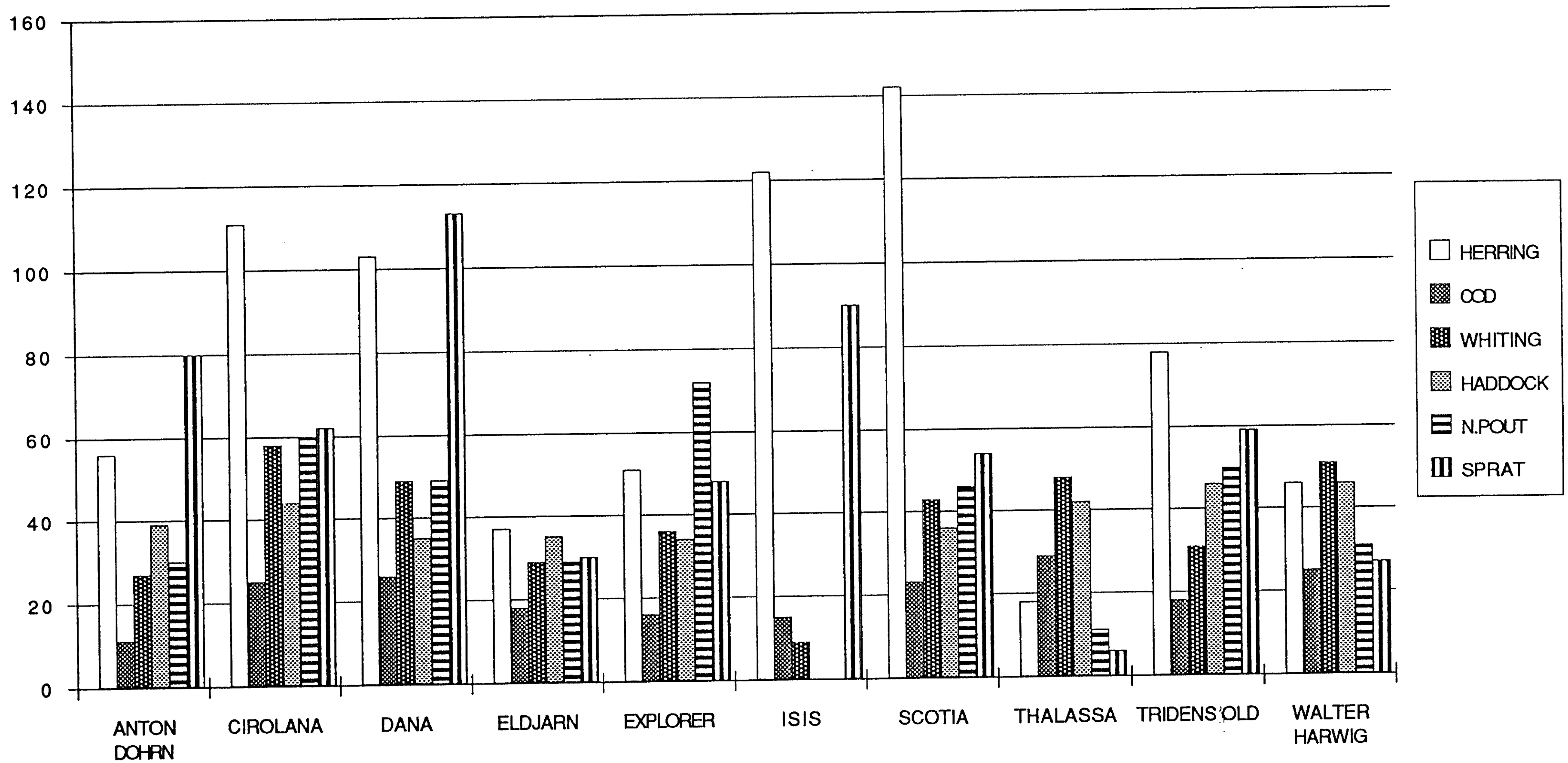
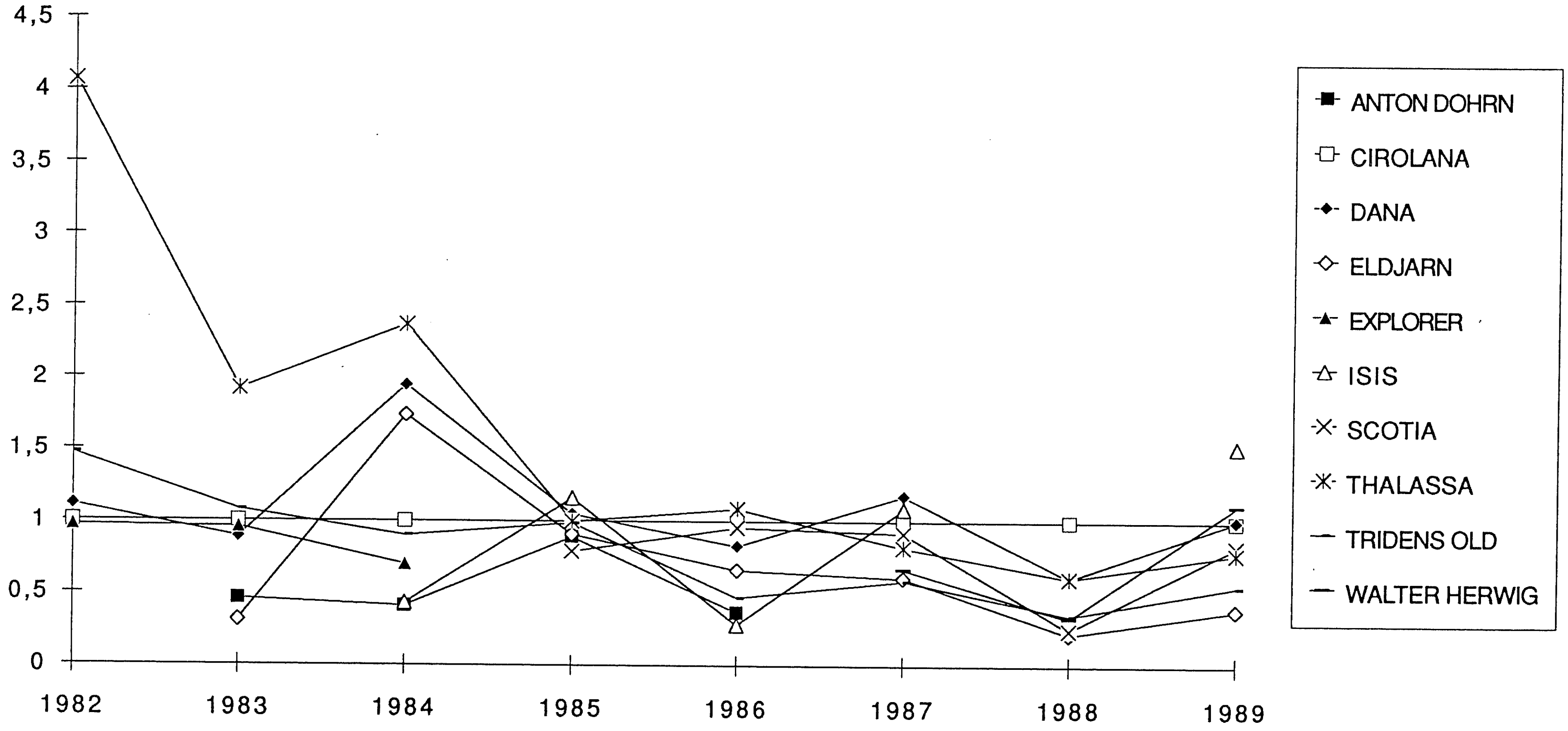


Figure 1.2. Changes in fishing power by year in 1982-1989. Fishing power of R/V Cirolana is taken as standard.



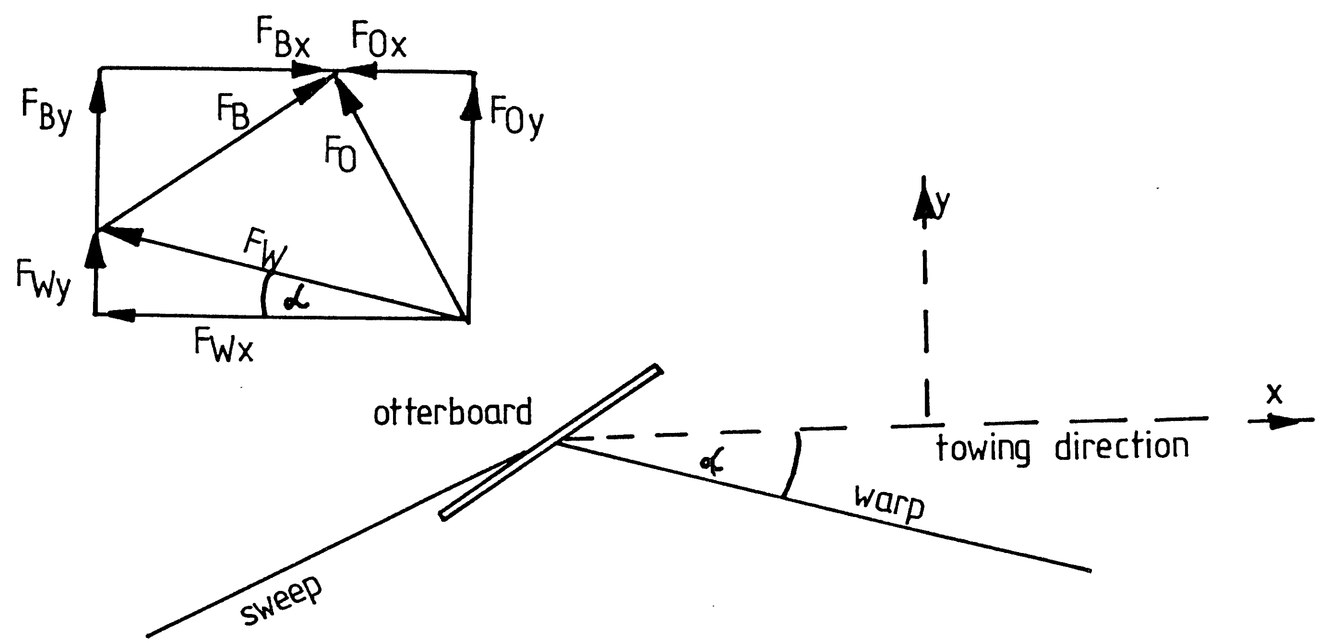
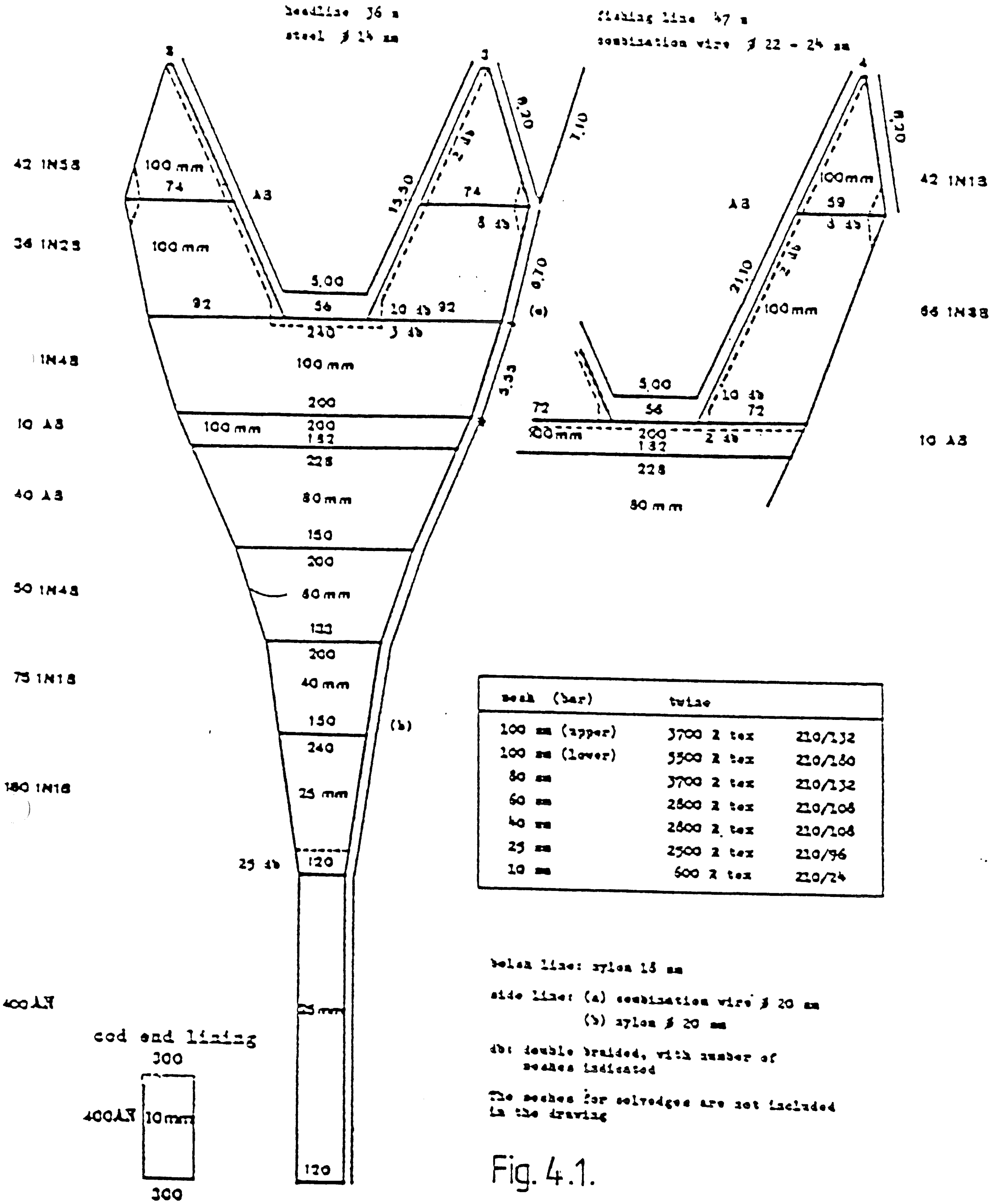


Fig. 3.1. Warp-sweep-otterboard arrangement. Balance of forces.



mesh (bar)	twine	
100 mm (upper)	3700 R tex	210/132
100 mm (lower)	5500 R tex	210/160
80 mm	3700 R tex	210/132
60 mm	2600 R tex	210/108
40 mm	2600 R tex	210/108
25 mm	2500 R tex	210/96
10 mm	600 R tex	210/24

bolch line: nylon 18 mm

side line: (a) combination wire ø 20 mm
(b) nylon ø 20 mm

db: double braided, with number of meshes indicated

The meshes for selvedges are not included in the drawing

Fig. 4.1.

CONSTRUCTION OF THE 36/47 GOV TRAWL

(fond à grande ouverture verticale)

Adapted from drawings of the Institut des Pêches Maritimes, Boulogne/Mer

scale 1/300

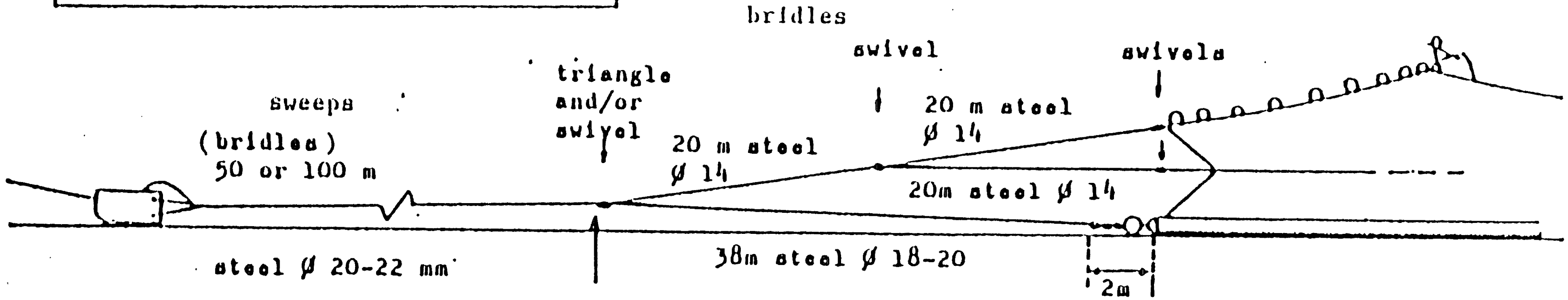
1 boat of 800-1000 HP

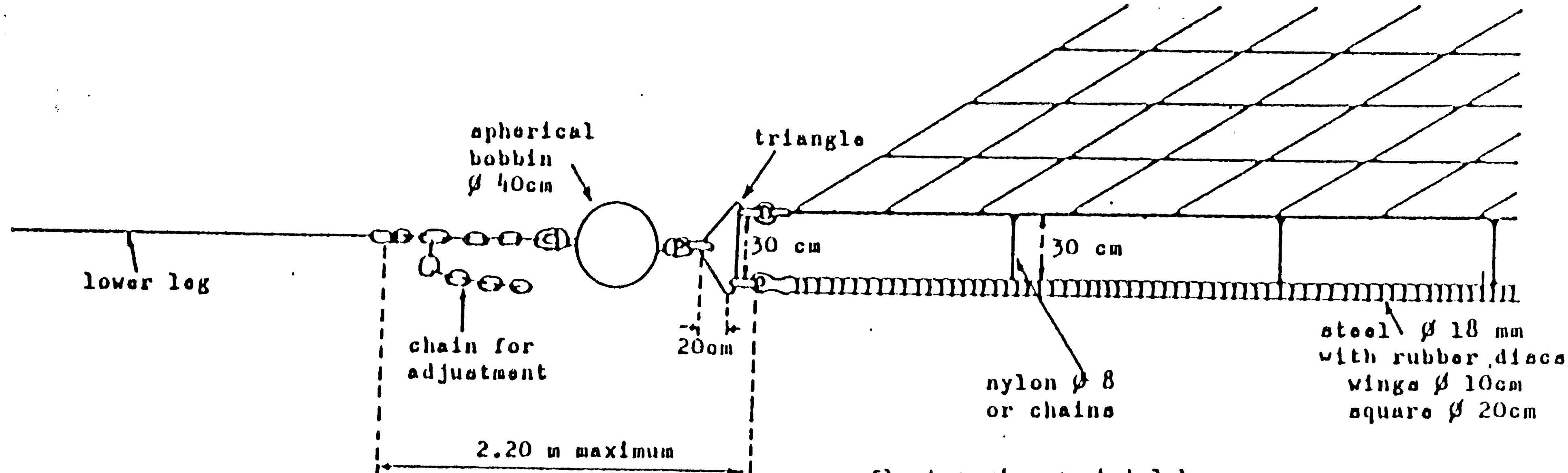
trawl doors 4.5 m^2

Fig. 4. 2.

RIGGING OF THE 36/47 GOV TRAWL

Specifications by the Institut des Pêches Maritimes, Boulogne/Mer





trawl doors: 4.5 m² Polyvalent

difference between upper and lower leg:
normally: 0 (upper 40, lower 38+2)
rough grounds: -0.30 (upper 40, lower 38+1.7)
if net fishes too light: +0.20 (upper 40, lower 38+2.2)

floats: wings: total buoyancy...........
square: total buoyancy ....

kite : type "Exocet" with 5 floats

weights: square: 70 kg approx.
each wing 35 kg "
wing ends 35 kg "

This specification has been drawn up in accordance with the recommendations of the Study Group on Net Drawing, ICES C.M. 1989/B:44

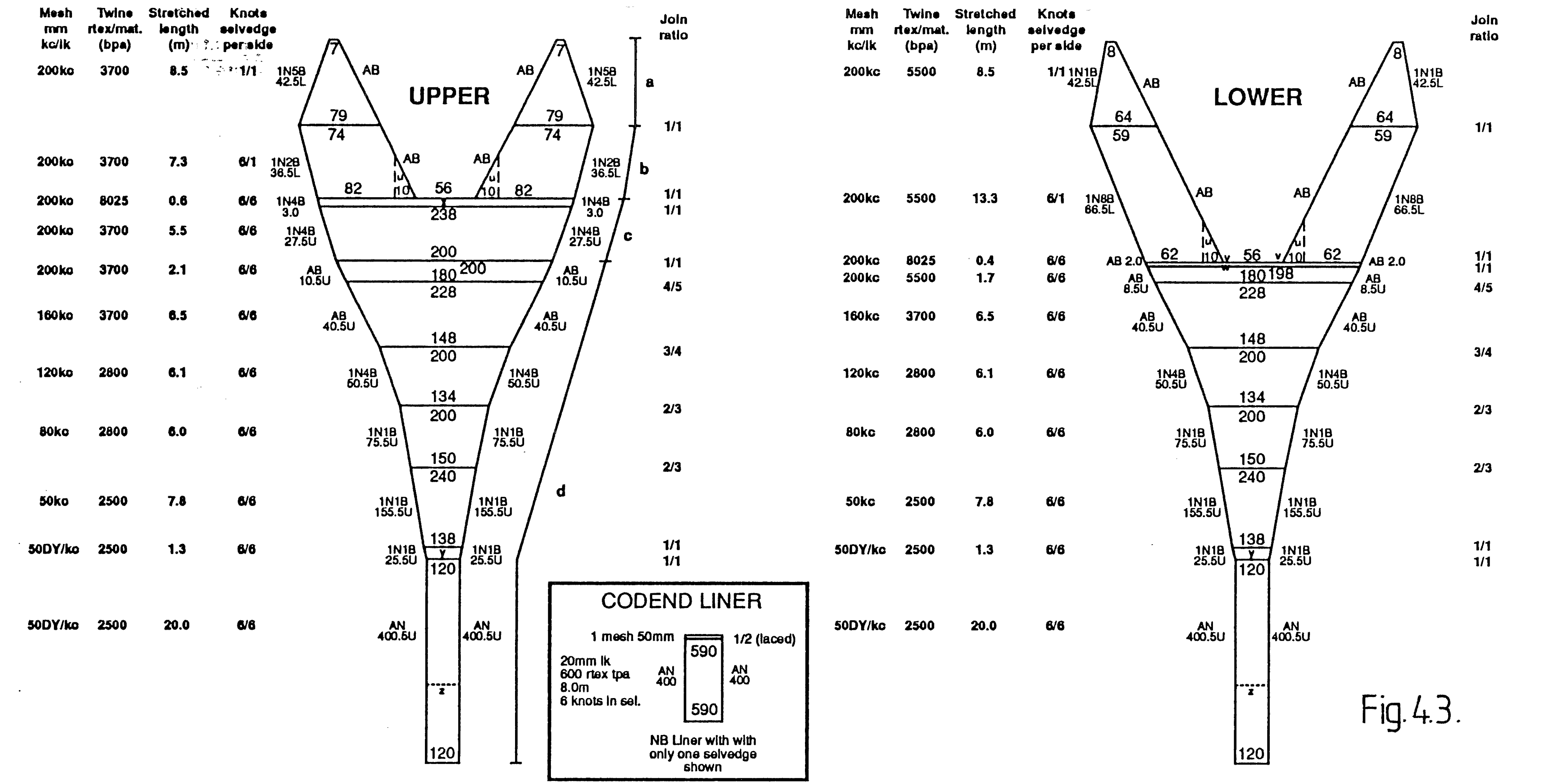


Fig. 4.3.

Headline : 36m (15.50 + 5.00 + 15.50) x 14mm ϕ wire (f/c) served (6/19 - 12/6/1 65.8kg/100m).
Fishingline : 47.20m (21.10 + 5.00 + 21.10) x 22mm ϕ combination wire 6 strand/steel core 54.6kg/100m).
Winglines : Upper 8.2m, Lower 8.2m x 22mm ϕ combination wire (6 strand/steel core 54.6kg /100m)

a - 7.1m x 14mm ϕ wire (6/19 - 12/6/1 - 65.8kg/100m)
b - 6.7m x 20mm ϕ combination wire (6 strand/steel core - 54.4kg/100m)
c - 5.55m x 20mm ϕ combination wire (6 strand/steel core - 54.4kg/100m)
d - length for length x 20mm ϕ nylon (3 strand - 26kg/100m)

u - Gussets 8025rtex
v - 4 meshes gathered at quarters

w - 200 198
x - 240 238
y - 138 120

z - Joining position for Liner

kc = knot centre to knot centre
lk = inside knot measurement
tpa = polyamide twine/twisted
bpa = polyamide twine/braided

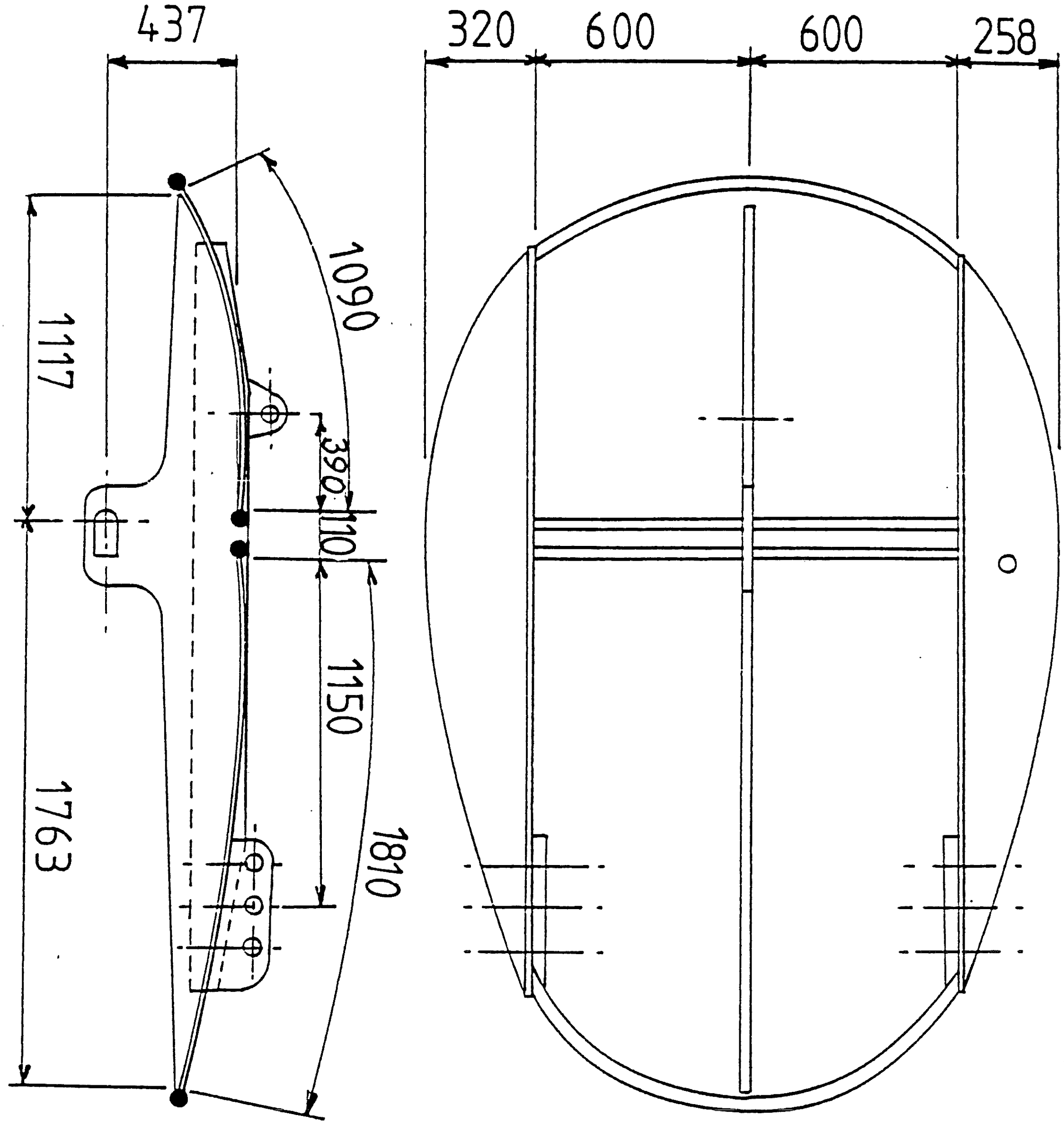
Method of join used, sewing.
Type of knot, weavers knot.

NOTE TO NETMAKERS

The numbers of meshes shown for netting panel widths do NOT include selvedge meshes. Five meshes (six knots) per selvedge must be added where indicated. Conversely to obtain panel depths one row (1/2 mesh) must be subtracted from each panel as the joining row is included in the number of meshes deep. The total numbers of meshes (width and depth) for each individual panel are set out in GOV 36/47 Groundfish Survey Trawl Checklist (Page 2 of 5)

AA Ø9

Fig. 4.4.



Cotes sans semelles

Panneau Polyvalent Normal	AA 3,10 x 1,80
MORGERE S.A	20.12.1991
	Ech : Croquis

GOV 36/47 GROUND FISH SURVEY TRAWL CHECKLIST

Vessel	
Cruise	
Date	
Checked by	
Checked by	
Measured to nearest cm below	

Ribline longer than netting (length for length)	YES						
	NO						

Floats	Buoyancy
60 x 200mmAL	172 Kg

Upper Bridle

ø14mm x 20m	

Port / Stbd

U/m Bridle Extn.

ø14mm x 20m	

Port / Stbd

Otterboard

Oval Poly	
4.5m SQM	

Port / Stbd

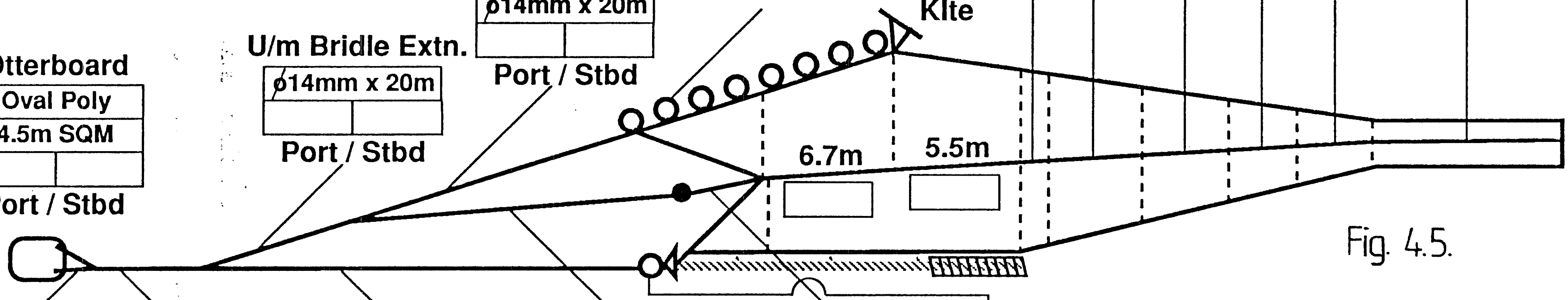


Fig. 4.5.

Sweep

ø22mm	

Port / Stbd

Lower Bridle

ø20mm x 38m	

Port / Stbd

Middle Bridle

ø14mm x 20m	

Port / Stbd

M. Bridle Extn.

ø14mm x 7.1m	

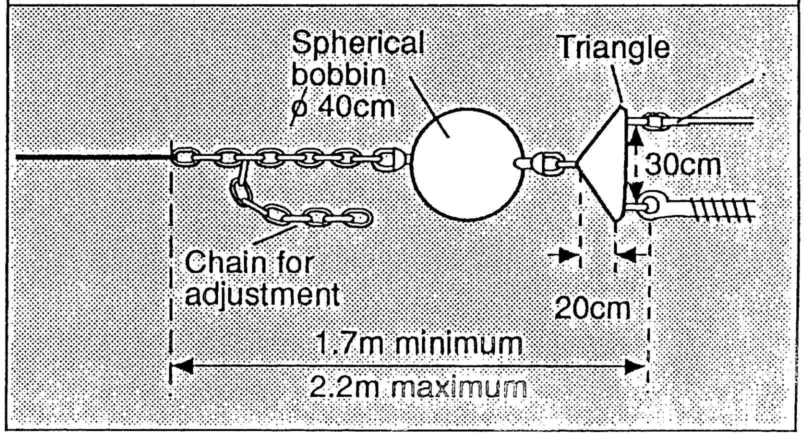
Port / Stbd

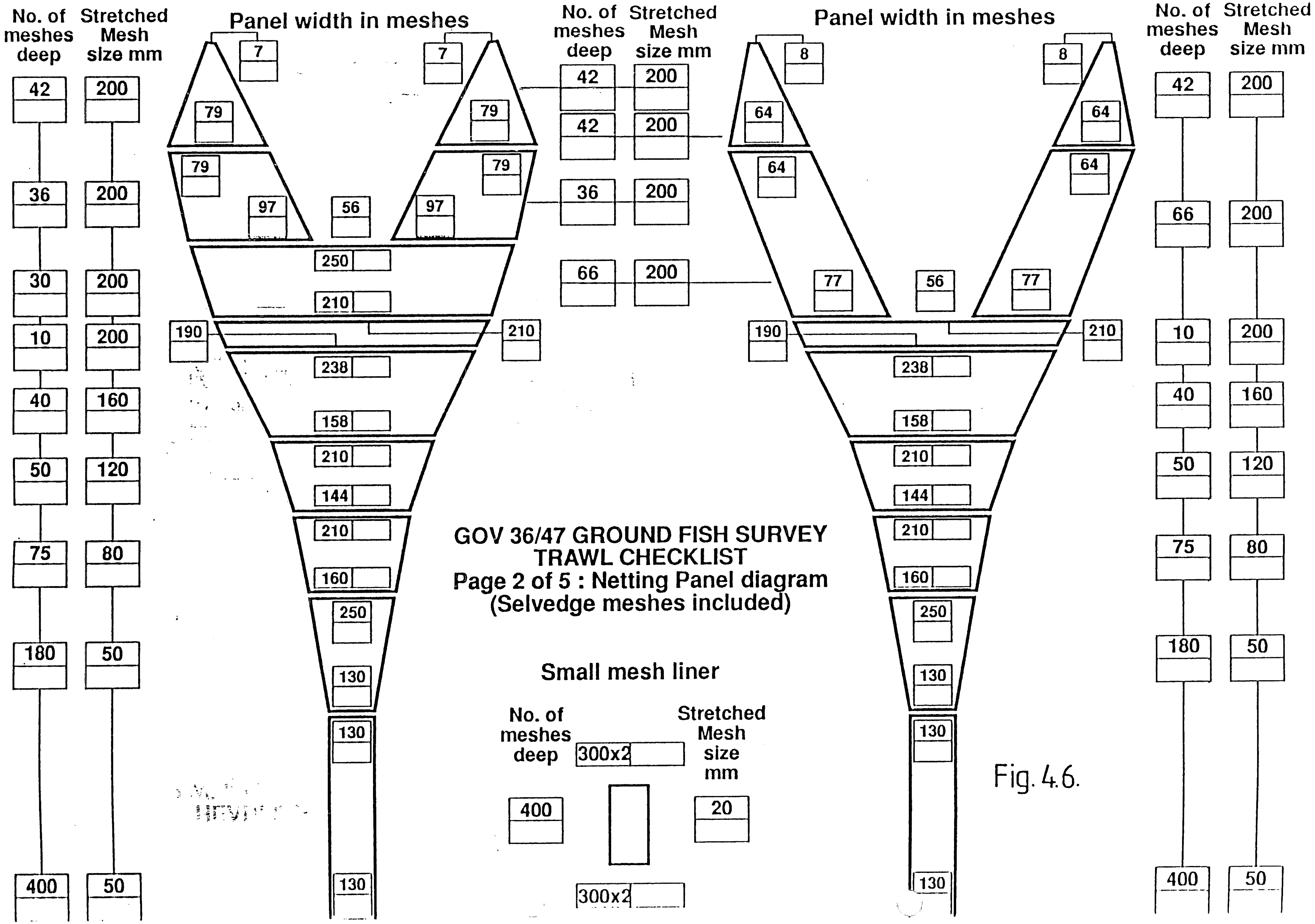
	Upper / Lower	
Backstrop		
Port		
Stbd		

Backstrop Extn.	
Port	
Stbd	

Sweep length + Backstrop length + Backstrop extension length (if used) should total 60m overall.

Details of rigging adjustments



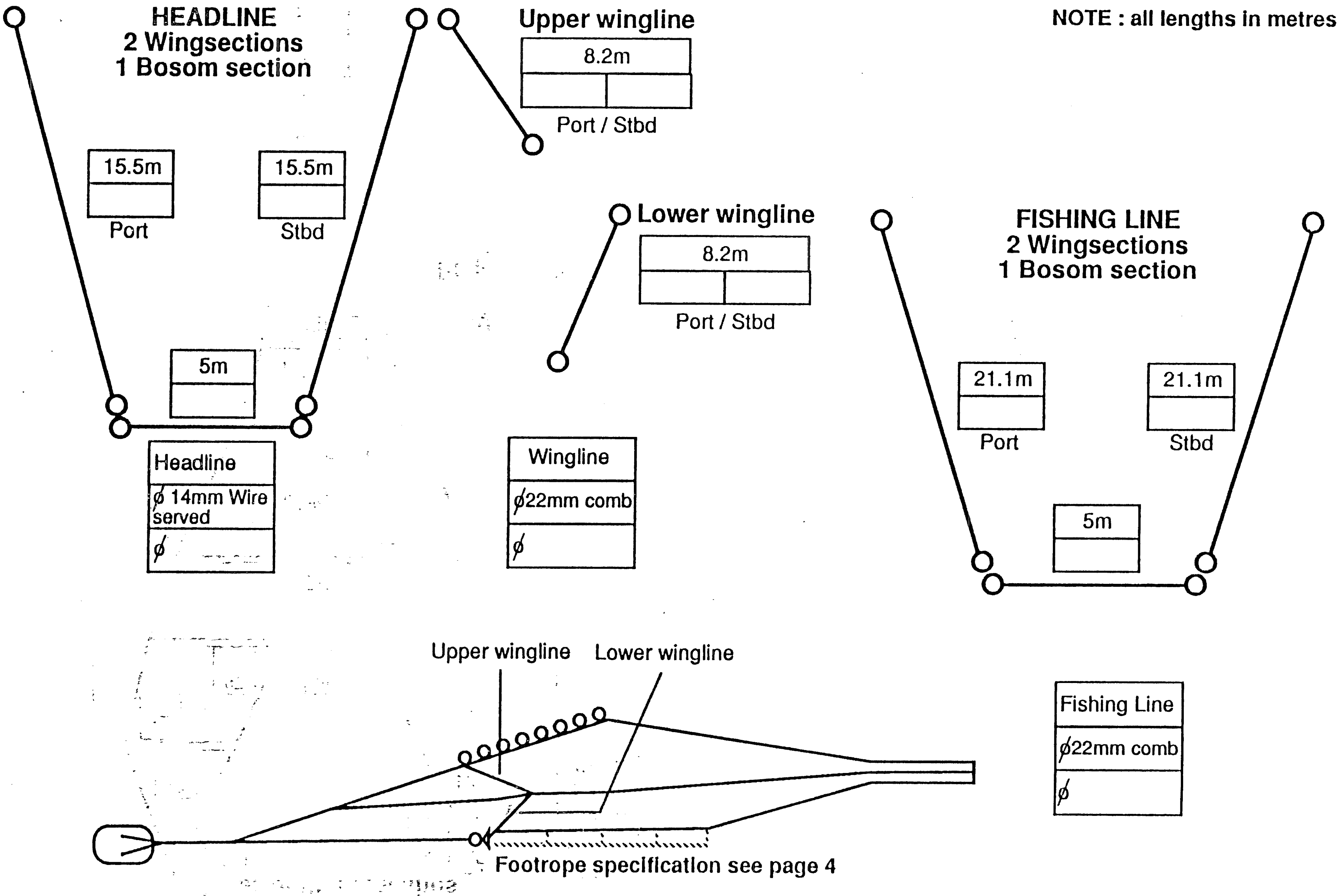


GOV 36/47 GROUND FISH SURVEY TRAWL CHECKLIST
Page 2 of 5 : Netting Panel diagram
(Selvedge meshes included)

Fig. 4.6.

GOV 36/47 ROUND FISH SURVEY TRAWL CHECKLIST
Page 3 of 5 : Frame ropes diagram

Fig. 4.7



GOV 36/47 GROUND FISH SURVEY TRAWL CHECKLIST
Page 4 of 5 : Ground gear rigging
(Maximum length of link between sections is 10cm)

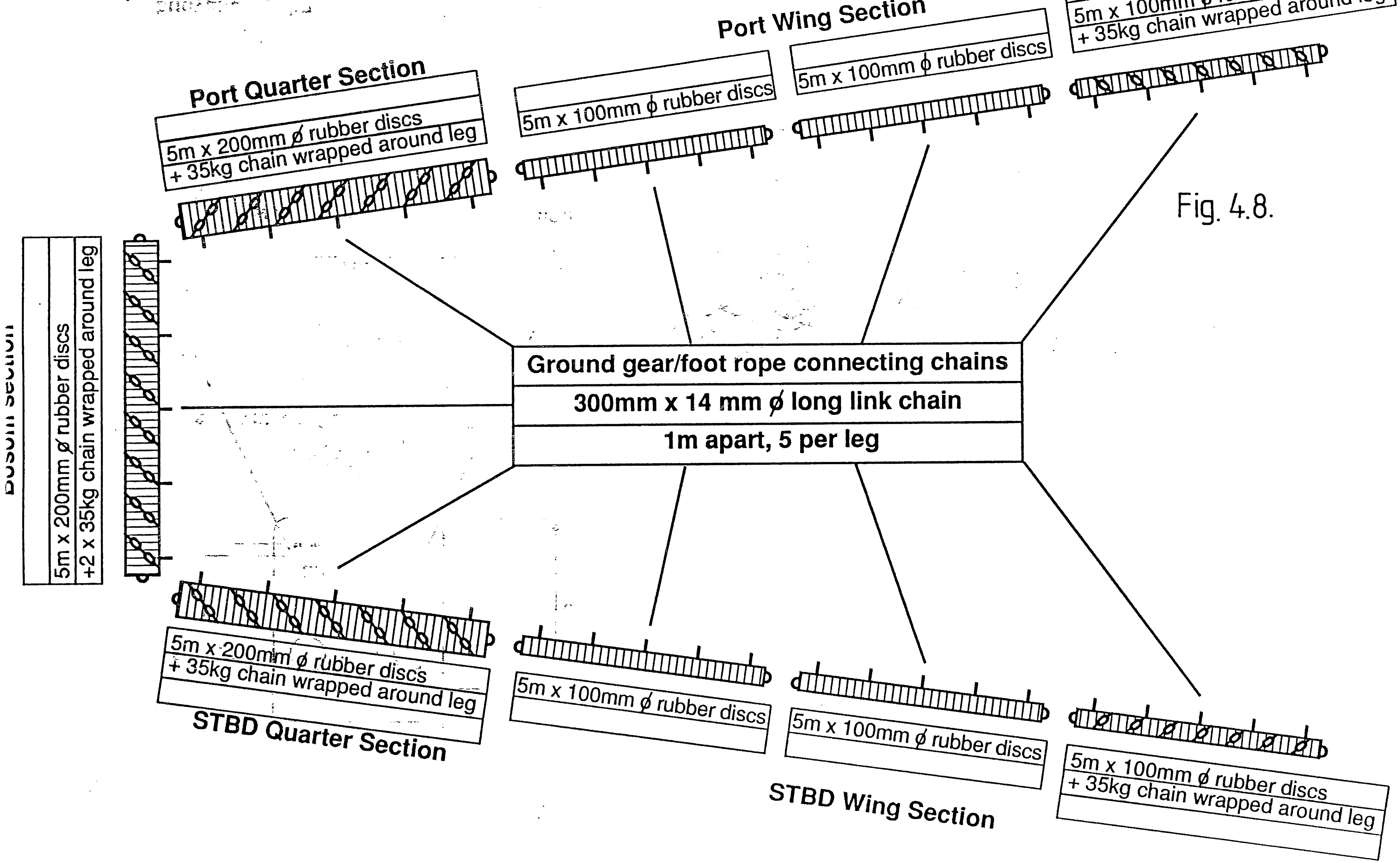
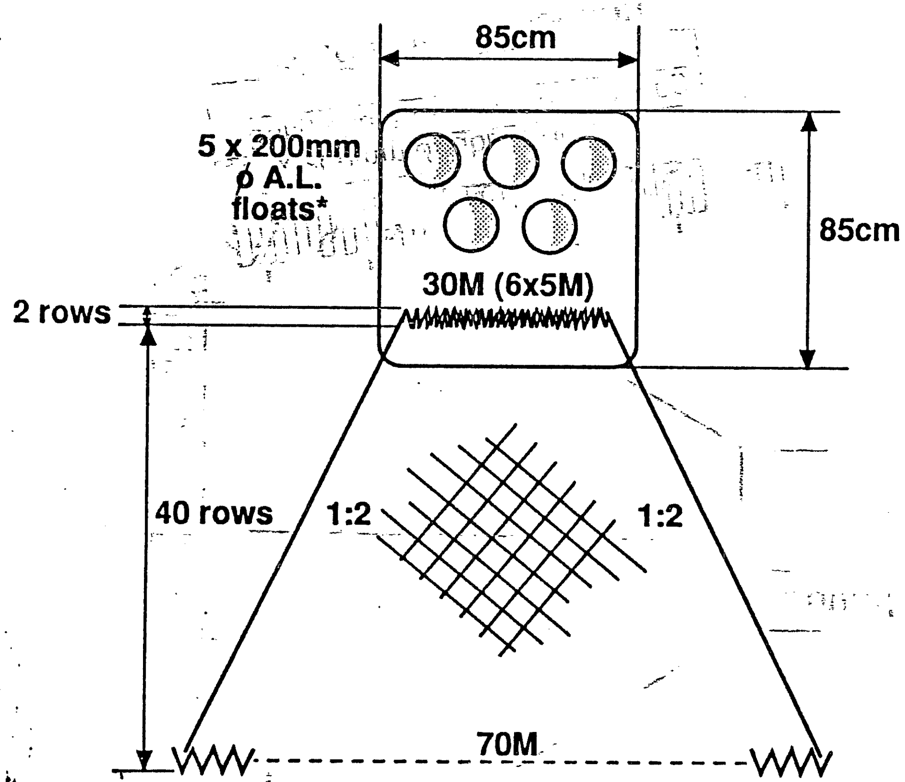


Fig. 4.8.

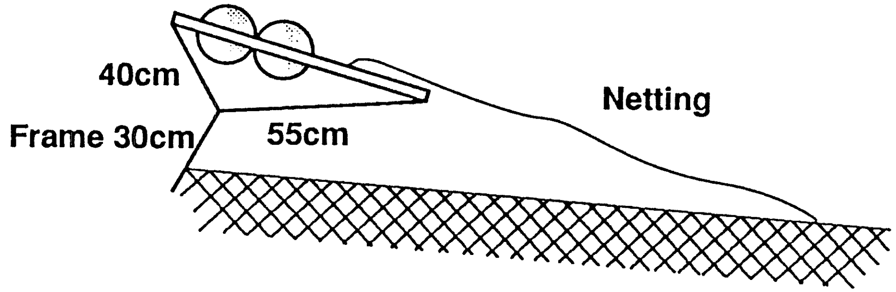
GOV 36/47 GROUND ...SH SURVEY TRAWL CHECKLIST

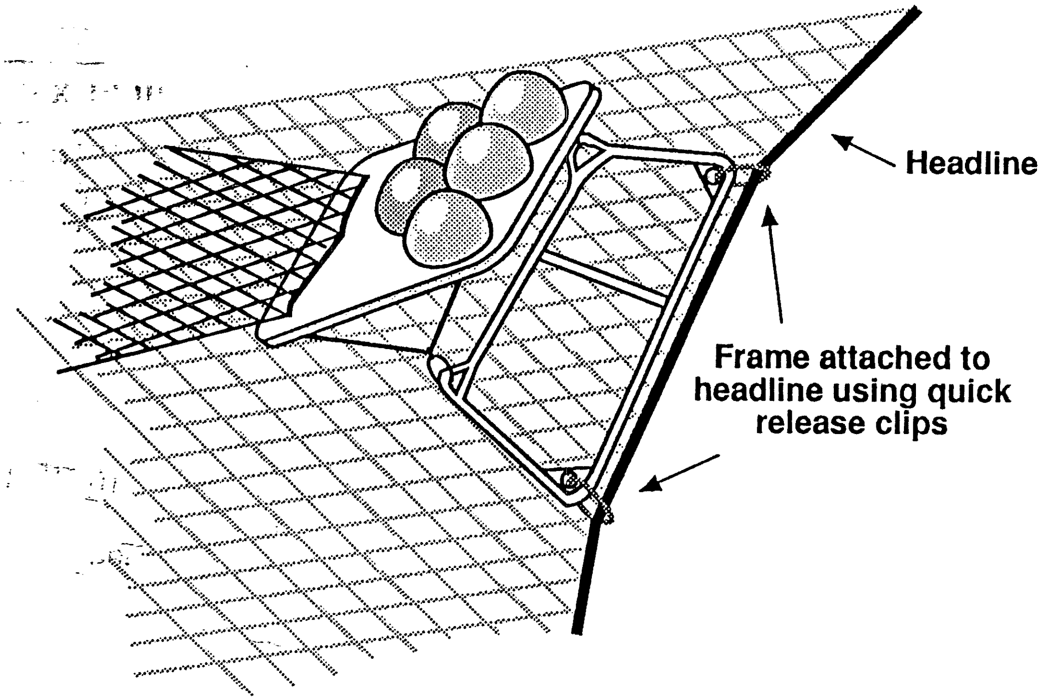
 "Exocet" kite rigging

Fig. 4.9.



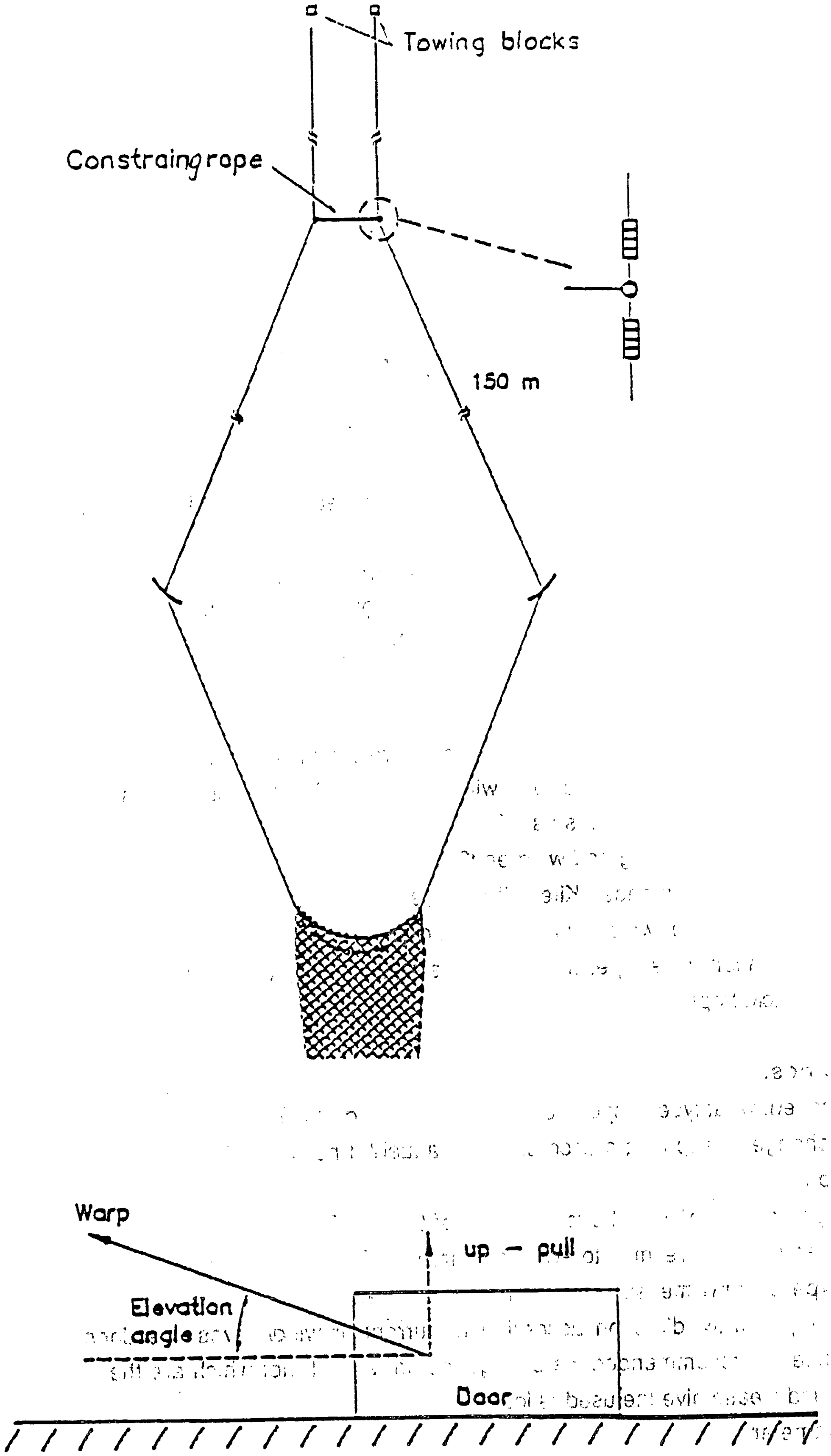
attached 52 rows down the square with a joining rate of 3M of kite netting to 2M of square netting





* total buoyancy 14 kg.

Fig. 4.10.


Towing blocks
Constraingrope
150 m
Warp
up — pull
Elevation angle
Door

APPENDIX 1.
Questionnaire about the use of ICES standard GOV trawl.

Gear

1. Is the GOV made by a national manufacturer?
2. Is the GOV made strictly according the original specification,net material, mesh size, twine diameter etc.? If not please give a description of changes.
3. Is the GOV measured up, when delivered, to see if it is made according to the specifications and who is responsible for the check?
4. Do you have a protocol of the GOV ?
5. Is the net,bridles/selvedge ropes and sweeps measured according to a protocol/specification prior to surveys?
6. Is net damage evaluation a part of the procedure to decide if a haul is valid or not?
7. If you have a damage evaluation what are your practice/roles?
8. Do you regard variation in manufacturing of the GOV or the maintenance of the trawl an important part in the standardization?

Rigging of the GOV.

1. Do you use the standard rigging? If not which are the alterations?
2. Do you use the standard ground rope with 10 cm and 20 cm rubber discs? If not which type of ground rope is used?
3. Weights: square, each wing and wing end?
4. Do you use the recommended Kite? If not describe alterations.
5. Trawl doors: give type, weight and surface area.
6. Headline floatation: give type, number,diameter and total buoyancy.
7. Length of backstrops.

Fishing methods.

1. Towing speed: what type of speed do you measure and how ?
2. Do you change sweep length according to manual? If not which is your alteration?
3. How do you measure/judge bottom contact of the gear?
4. Which parameters are monitored during trawling?
5. Which type of trawl mensuration equipment is used?
6. Do you adjust trawl direction according to current or wind/waves directions?
7. Do you use the recommended warp length/depth ratio? If not which are the reasons and please give the used ratio.
8. Warp diameter