Evaluation of by-catch reduction devices in UK *Nephrops* fisheries

The use of separator trawls in the Irish Sea

Seafish Report No. SR522

March 1999

The Sea Fish Industry Authority

Seafish Technology

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Summary

This report describes a series of fishing trials using separator trawls to reduce finfish discards in Nephrops trawling. The trials took place in the Irish Sea out of the ports of Ardglass, Kilkeel and Portavogie and covered the main periods when discards were normally reported. Three classes of vessels were chartered, reflecting the make up of the sector, and the trials were carried out under normal fishing conditions as far as possible.

The work was part of a wider exercise that sought to gain commercial acceptance of novel conservation technology. The *Nephrops* trawl fisheries were chosen because of the extreme differences between the target and discard species. This usually makes the process of species separation considerably easier than would otherwise be the case.

The exercise started with a survey of fishermen's attitudes toward technical conservation measures. That work established which devices would be most acceptable to the majority of fishermen in given areas. During the fishing trials the economic aspects of the work were monitored – mainly in terms of gear conversion costs and changes in catch quality and/or earnings.

The target species for discard reduction were whiting and haddock. It was found that the success in discard reduction was strongly related to the size of the fish. Where fish were small, typically less than 20 cm, the separation to the upper codend was very poor. Above this size, separation was good, comparing well to the levels found in other fishing trials. In these circumstances discard levels were reduced and the quality of the retained fish was very markedly better than that from a conventional net. As a result these fish made a higher price on the market. This advantage was sufficiently strong for two of the three skippers involved to buy the experimental nets. One has been used on a regular basis.

It is concluded that, as with many technical conservation measures, the separator trawl is very effective in some circumstances. Where very small fish are a problem then it is not worth considering. Where larger fish are involved, where by-catch or quota restrictions apply, or where quality is an important consideration then the use of this technology is strongly indicated.

ACKNOWLEDGEMENTS

Sea Fish Industry Authority gratefully acknowledge the Department of Agriculture for Northern Ireland (DANI), the Northern Ireland Fish Producers' Organisation (NIFPO), and the Anglo North Irish Fish Producers' Organisation (ANIFPO) for their assistance in setting up and conducting these trials.

Special thanks are extended to the skippers and crews of the MFVs *Village Queen, Dee Star* and *Girl Anne III* for providing their expert services and assistance throughout the work.

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1 INTRODUCTION

The work described in this report is part of an ongoing programme aimed at optimising whitefish selectivity through the more effective use of technical conservation measures, by-catch reduction devices (BRDs). Particular emphasis has been placed on *Nephrops* trawl fisheries, a number of which are recognised as having discard problems.

Separator trawls have been identified as having considerable potential as a tool for improving selectivity in a number of demersal fisheries.

The technique works by segregating the different components of mixed species catches, so that the most appropriate selection devices can be applied to the separated elements. It is most effective in fisheries where the species to be separated are markedly different. The job of separation is much easier where morphological and behavioural differences are strongly pronounced,

In this respect, *Nephrops* fisheries with substantial roundfish by-catches are natural candidates for evaluating this type of technology.

The Irish Sea *Nephrops* fishery is centred on the three Northern Ireland ports of Kilkeel, Portavogie and Ardglass. This fishery was chosen as a starting point to examine the potential of the separator trawl as a commercially acceptable technical conservation measure.

This report covers a series of fishing gear engineering trials conducted on a twin rig trawler and three commercial fishing exercises on vessels from three power categories. The trials were conducted at various times between the months of January and August to take account of variations in the catch profiles throughout the *Nephrops* season.

The fishing gear engineering trials were carried out on a twin-rig trawler from the largest of the three power categories. They involved full instrumentation, measuring all the principal gear parameters including warp tensions, door spreads, wing end spreads, headline height and trawl speeds. Using the twin-trawl arrangement enabled direct comparison between a standard trawl and a modified net incorporating the separator panel.

The commercial fishing trials carried out on all three of the vessel classes included monitoring of all relevant catch information. This included marketable target species and by-catch, and discarded target species and by-catch. Evaluations included a full appraisal of gear handling and any implications that this particular by-catch reduction device (BRD) may have had on operational procedures.

2 BACKGROUND

The idea of using separator trawls as a by-catch reduction device (BRD) has been relatively well researched in Europe and elsewhere.

Effective separation of finfish from shellfish has been particularly well demonstrated in a number of fisheries. See, for example, Main and Sangster, 1982; Ashcroft, 1983; Charuau, 1985; Larsen, 1986; Anon, 1988; Hillis, 1989; Galbraith and Main, 1989; Anon, 1991.

Previous trials in UK *Nephrops* fisheries (Ashcroft B (1984), Arkley K (1986), Arkley K (1988)) demonstrated levels of separation of whiting from *Nephrops* of up to 90%. Commercial uptake however was slow to develop and soon lost its impetus. Despite demonstrations of the benefits of this concept in the past, there has been considerable reluctance to accept the technology. The main arguments have been based on the additional costs involved and the perception that the gear is over-complicated.

A recent Seafish survey (Arkley *et al,* 1997) canvassed the views of representative members of the UK *Nephrops* catching sector on current, and possible alternative, BRDs. It aimed to tease out the ways that fishermen view novel BRDs. It did so by looking for regional and sectoral differences in their views. The results of this industry survey were presented on a regional basis incorporating the main landing centres for *Nephrops* in England, Scotland and Northern Ireland.

The report highlighted a general dissatisfaction with current legislation surrounding BRDs. There was a willingness to support work aimed at further reductions in discards but with a number of reservations concerning some of the suggested options, which included separator trawls.

The survey work also identified the need to devise and introduce conservation measures on a regional or sectoral basis. In other words, identifying the 'right tool for the job' in each area rather than looking for a universal technical solution. This approach required taking into account factors such as vessel power, modes of operation, gear types and discard profiles.

On the basis of the survey and in consideration of the research and development work that had preceded it, it was decided to carry out further investigations into the technical options that showed most promise. The separator trawl was one such option. The main aim was to demonstrate the potential benefits of the technology by evaluations conducted under commercial fishing conditions.

The review of BRDs identified which device would be most acceptable in each of the surveyed areas. These would be applied comprehensively, accommodating all the regional variations in gear type, vessel size, ground, by-catch/discard profile and seasonal variations. The Irish Sea was selected as a starting point for the evaluation of the separator trawl concept.

3 AIMS AND OBJECTIVES

The main objective of this project was to establish whether the use of separator trawls could reduce the discarding of roundfish by-catch in Irish Sea *Nephrops* fisheries. The work also sought to demonstrate that this could be achieved in a commercially acceptable way.

As a means of achieving this overall objective, a number of aims were set as criteria for judging the outcome:

- To demonstrate that the principle of the separator trawl could be easily applied to commercially available trawl designs.
- To show that this could be achieved at relatively low cost.
- To compare the catching and handling performance of a separator trawl to that of an unmodified net of similar dimensions.
- To compare the dynamic characteristics and geometry of a standard net with that of a separator trawl over a range of commercial fishing conditions.
- To quantify the separation of round, finfish from the target species as an indicator of the potential for discard reduction.
- To identify and quantify any commercial benefits of this technology, the most likely being a reduction in catch sorting time and an improvement in target and by-catch quality and value. It was also hoped that a view could be formed on the potential for use of square mesh panels and other selection devices in the upper sections of the net to optimise by-catch size selectivity.

If the results demonstrated effective separation, combined with improved selection characteristics then an overall improvement in the reduction of by-catch discarding should be achievable. The aim was to attain these goals with minimum short-term losses to fishermen. If satisfactory results could be achieved, then, where fishermen perceive discarding as a problem, the use of this technology could be encouraged. Hopefully, then, commercial acceptance and uptake would result.

4 MATERIALS AND METHODS

4.1 Approach

The Irish Sea fishery/region was selected for testing the separator trawl on the basis of a number of criteria. The considerations included:

- fishermen's responses to the previous survey regarding the question of further work with separator trawls;
- availability of a number of experienced skippers with the interest and willingness to test the suitability of the separator technology;
- previous trials conducted in this fishery with similar separator trawl designs;
- catch composition; considering non-target catch and whether all or part of it needed to be retained. This fishery has traditionally relied heavily on the market for the whiting by-catch;
- vessel class; considering size, power, and handling arrangements. This also included single vs twin trawl operations. Suitable, representative vessels from all the required power categories were available;
- fishing grounds and associated seabed characteristics;
- gear size and design; account must be taken of variations in gear size and design and the compatibility of the proposed BRD;
- *Nephrops* seasons and any associated variations in the catch profiles with particular reference to unwanted by-catch.

In order to ensure a comprehensive evaluation was undertaken and valid results were obtained, all field trials were conducted under normal, commercial fishing conditions, as far as the nature of the work would allow.

There were two main elements to the project. The first involved establishing the gear engineering parameters of the separator trawl alongside those of a standard prawn trawl. The second was a full evaluation of each gear's performance under normal, commercial fishing conditions.

To ensure a comprehensive evaluation it was considered necessary to work with vessels that were representative of the main power categories in the fleet from across the range of vessels working in the fishery. Vessels were selected from three power categories, these were determined to be

- Up to 200hp (<200hp)
- 200 –400hp
- greater than 400hp (>400hp)

A twin-trawl operator was selected from the highest hp category to perform the instrumented gear engineering trials. This allowed for direct comparison of the separator

Gear: 500-mesh×70mm dual-purpose prawn/fish trawl manufactured by J&W Stuart, Mussleburgh, Scotland. Size 3 Bison doors were used.

4.4 Separator trawl arrangements

The main part of this work was to evaluate the performance of the separator panel in segregating finfish by-catch from the target species of prawns. New nets were supplied to all participating vessels to enable a fairer assessment of the separator panel. These were constructed and supplied by the skippers' regular net makers. Doing this enabled the vessels' skippers to evaluate the catch capabilities compared to their normally used trawl.

Considering that one of the main aims of this work was to try and gain commercial acceptance of the separator trawl technology, it was necessary to ensure that the design of the separator trawl was kept as simple and as practicable as possible. To this end the approach taken was to examine ways of simplifying the retro-fitting of a horizontal separator panel into standard, commercially available prawn trawl designs. This was achieved by testing models of preliminary designs in the Flume Tank before moving on to full scale work.

The separator panel splits the trawl horizontally. The split starts at the mouth of the net with the leading edge of the panel positioned above and slightly set back from the ground gear (Figure 2). This arrangement enables a certain amount of adjustment to be made to the height of the leading edge of the panel by means of rope strops tied between the panel and the fishing line. This can be used to control the level of separation. If too many prawns are entering the upper section of the net, then the panel height can be raised to try to ensure that they enter the net below the panel. Conversely, if too many roundfish are entering the lower section, the opposite applies.

The design of each separator panel was based on the existing net shape and mesh configurations In other words, the cutting rates of the panel matched those of the corresponding upper and lower sections of the net. The main differences were the relative widths of the corresponding net panels and the shaping at the leading edge. Figures 3, 4 and 5 show the general arrangement of the panel designs for the nets used in this project.

The cross-sectional shape of the trawl is such that the width of the separator panel has to be reduced relative to the belly and baitings sections in order to avoid slack netting. However, the degree of slackness in these areas is not as critical as at the leading edge of the separator panel. In order for the panel to perform effectively, it has to be rigged tightly. This is achieved by spreading the tension out along two small wing pieces attached onto the leading edge.

If functioning correctly, the majority of the round, finfish by-catch should be segregated into the upper of the two codends. The prawn catch is retained in the lower codend. It is this double codend arrangement that allows different selection devices and/or systems to be applied to the separated components of the catch.

During the first week of the trials, operations were conducted on a daily basis. The second half of the trials followed the vessel's normal practice of a five-day trip fishing on grounds further afield.

The equipment used during these exercises was Scanmar, gear mounted, acoustic distance sensors. The parameters measured included:

- Headline height on both nets
- Wing-end spread on both nets
- Trawl door spread and hence distance between door and centre weight
- Net speed through water

In addition, Scanmar underwater load cells were used to measure tensions behind the otter boards and centre weight. These measurements were used to establish whether both nets were in alignment within the twin-rig set up.

All Scanmar sensor data were recorded via the RX 400 interface and downloaded into a Microsoft Excel Version 5 spreadsheet for analysis. The vessel-mounted instrumentation included load cells to record tensions in all three warps. This information, along with vessel speed, both through the water and over the ground (Garmin 75 Global Positioning System GPS), was recorded via a Delta data logger.

4.6.2 Commercial fishing trials

The height of the separator panel was adjusted for maximum effectiveness over a three-day period for each trawl. This height variation was based on catch characteristics in the upper and lower codends.

Twin trawl vessel >400hp

The fishing trials on mfv *Village Queen* were conducted on a trip basis lasting 10 days in June 1998. The catches from each codend were kept separate in pounds. The crew followed normal catch handling procedures. Total bulk, the weight of whole prawns, prawn tails and fish in each codend were all recorded. Additionally, length measurements of samples of both marketable and by-catch fish were taken and recorded.

Single trawl vessel 200 - 400hp

The trials on mfv *Dee Star* took place over a 5 day period in February 1998 and a 7 day period in August 1998 from the port of Ardglass with the vessel leaving daily to fish local grounds.

Single trawl vessel <200hp

These trials took place over a five day period in March 1998 and a 6 day period in July 1998 onboard mfv *Girl Ann III* from the port of Portavogie with the vessel leaving daily to fish on local grounds.

For both the single trawl vessels, the fish from each codend were kept in separate pounds with length and quantity data taken of the main species (cod, haddock and whiting). The entire contents of the upper codend were measured unless the quantity was greater than one or two baskets in which case a sub-sample was measured and a raising factor applied.

5 RESULTS

5.1 Instrumentation trials - mfv *Village Queen*

The results from the first week of trials were extremely poor. This was due to equipment failure. Two net-mounted sensors, one measuring headline height and the other a distance sensor failed early on in the trials. Problems also arose with inconsistent readings from the towed microphone receiver, which also subsequently failed during the first day of trials. However, by swapping some of the units around between the two trawls, some results were obtained. A summary of the gear parameters can be seen in Table 1.

In order to be satisfied that valid comparisons were being made between the standard and separator trawls, the general symmetry of the twin-rig set-up had to be verified.

Indications of tensions measured behind the otter-boards and the centre weight showed that, at the normal towing position, i.e. with the middle warp 9 feet (2.7m) shorter than the outer, the gear was somewhat skew. This was reflected in the lack of headline signals transmitted back to the towed receiver. This was due to the extremely poor alignment of the transmission paths not intercepting the receiver.

Unfortunately, due to the problems with the instrumentation, it was extremely difficult to establish the settings to verify net symmetry. It was therefore decided that further trials would be based on the gear settings previously established by the skipper as a result of his experience with this system.

Only limited amounts of data were gathered with the separator trawl (Table 1). The most consistent data were achieved in the deeper water during the commercial trials when the centre warp was set 20 feet (6.1m) shorter. Here the trawls assumed symmetry producing reasonably equal wing end spreads at 22 metres on the standard net (portside) and 21 metres on the separator net (starboard). Headline heights were 2.1 metres and 2.2 metres respectively. Unfortunately the positions of the centre wire which produced symmetry created instability of the centre weight causing it to lift off the seabed intermittently.

For the majority of the trials, the twin-rig arrangements and adjustments were left to the skipper's discretion.

5.2 Commercial fishing trials - mfv *Village Queen*

At the skipper's request a comparison was made between the prawn catching capabilities of codends of similar mesh size but different twine diameters. A short exercise was conducted at the start of the trials in which the performance of 70mm mesh codends made from double 4.00mm PE twine were compared against 70mm codends made from single 8.00mm PE twine.

The heavy twine codend was fitted to the separator trawl. This trawl caught a greater amount of prawns and bulk than the standard trawl on a haul by haul basis. Twenty-five hauls produced 190 stones (1209 kilos) of whole prawns and 189 stones (1203 kilos) of prawn tails compared to 180 stones (1145 kilos) of whole prawns and 181 stones (1152

5.3 Commercial fishing trials - mfv *Dee Star*

5.3.1 February 1998

Cod separation was generally very good with 82% going into the lower codend from a relatively small catch. Very few prawns (<10 per haul on average) were found in the top.

The haddock separation figures of 74% into the top and 26% into the lower codend were within expected levels. The largest part of the separation occurred in the 23cm-34cm size classes (Figure 8a) which could explain the higher discard rate of 65% in the top codend compared to 58% in the lower.

The most disappointing separation figures were those for the whiting with only 30% going into the top codend. The most abundant fish were in the 12cm - 20cm size classes (Figure 9a) with separation figures of 23% and 77% to the upper and lower codends respectively. For whiting sizes greater than 20 cm, the figures were 49% to the top and 51% to the lower codends. Unfortunately, the numbers of whiting encountered above the minimum landing size of 27cm were extremely low. If more, larger whiting had been caught, then the separation levels may have been better, bearing in mind the trend that was observed in the Kilkeel trials.

The discard figures for whiting were disappointingly high in both upper and lower codends at 92% and 94% respectively. This was despite having a larger mesh size in the upper codend. There was some indication here that perhaps the square-mesh panel in the extension of the lower codend was not working as effectively as it should have been. One possible explanation was that some masking of the lower codend and extension was taking place. It was also observed that there did appear to be an increase in whiting numbers in the afternoon hauls both in the upper and lower codends.

5.3.2 August 1998

The results from this trip showed an improved separation over the previous trip with 44% of whiting going into the top codend. This figure was probably reduced by the entry into the fishery of the new year class of whiting in the size range 10-15cms. This is clearly seen in the bimodal distribution shown in the length/numbers plot in Figure 9b. Very few of these fish were retained in the upper codend. Once again there appeared to be a trend developing in which the level of separation improved with the increase in the size of the whiting. However, it must be borne in mind that the actual numbers of fish caught were still relatively small.

Compared to the previous trip, the separation figures for haddock were disappointingly low. Only 29% entered the top codend.

Figure 8b shows the length/numbers plot for the haddock caught on this trip. As with the whiting, a new year class, with a size peaking at 13cm, caused this separation figure to be lower then expected. These very small haddocks did not separate into the upper half of the net. It appears that the behaviour of the very small, juvenile haddock and whiting is markedly different to that of the larger size classes of these species under the same

6 DISCUSSION

6.1 Catch separation and discard reduction

One of the main reasons for selecting the Irish Sea *Nephrops* fishery for this work was the relatively high level of roundfish by-catch and discards at certain times of the year. Separator trawls have been used to good effect in similar situations elsewhere (See refs.).

Traditionally, the roundfish component of the overall catch has been of considerable commercial value. In recent years however, it appears that the quantities of marketable by-catch species such as whiting and haddock have declined. This downward trend in numbers was clearly evident from the lack of fish encountered during these trials.

The low, and at times insignificant, numbers of fish caught make it extremely difficult to make valid judgements on some of the aspects of these trials.

The main question to be answered from this project was, "Is the separator trawl appropriate for this fishery?" The answer to this question is, 'in general, no', but this requires some qualification. First, there needs to be further consideration of the non-target catch. In this fishery the finfish catch can be split into a marketable element which can be retained, and an unmarketable component which is discarded.

The amount of marketable fish retained is dependent on by-catch allowances, available quotas and market conditions. All fish below the minimum landing size must be discarded.

The indications from this work are that, in considering the marketable by-catch, there could be a case for the application of this technology. Where the quantities of marketable whiting and haddock being caught exceed by-catch allowances or quota allocations, these could be separated and released rather than being brought onboard and subsequently discarded dead.

With regard to the unmarketable catch determined by MLS, the results suggest that the separator trawl falls short of the desired effect. There are clear indications that separation levels are size related and this has resulted in very poor and inconsistent separation of fish below the MLS.

In trying to answer the principal question, a number of other factors were also considered, most of which resulted in positive responses towards separator technology in general.

6.2 Gear design, performance and handling

The separator panel design was kept relatively simple. As a result there were no significant problems experienced by the net manufacturers in accepting the designs, or in the actual construction of the nets. For the purposes of the trials, specific requests concerning the rigging of the separator panel netting onto framing ropes did involve more time and effort. Additionally, again for trial purposes, the panel was selvedged into the net separately from the top and bottom sections. This was to facilitate easy removal for

6.3 Skipper/crew reactions

All vessel crews involved readily accepted the separator trawl as being a workable and practical option. Commercial acceptance of the trawl was a primary aim of the project. In this respect, the trials achieved moderate success with the vessels in the two higher horsepower classes. For the other vessel, the most important factor seemed to be the less effective catching performance of the separator trawl compared to the vessel's standard net. Unfortunately, time constraints limited further investigations that may have identified the reasons for the inconsistent performance.

The fishermen that conducted this work initially had some reservations concerning the operation and handling of this type of gear. After only a short period of familiarisation, the fitting of a separator panel and subsequent handling of a separator trawl presented few problems.

Further, more commercially orientated reactions are described in Sections 6.4 and 6.5.

6.4 Catch handling and quality

Poor separation of the smaller year classes was a big disappointment during the trials and little could be done to improve these figures. Crews, as a result of this, did not perceive any real sorting-related benefits. Although the larger roundfish separated well and were easily sorted, the bulk still contained high numbers of small (<20cms) roundfish. It was speculated that the upper codend could have been masking the lower codend, resulting in an increase of small fish on the sorting table.

What was noticeable was the improvement in quality of the fish that were retained in the upper codend. These fish did not require any sorting from the rest of the catch and so could be gutted, washed and iced much more quickly. This, combined with the better overall condition of the fish, as a result of being kept apart from the damaging conditions within the lower codend, resulted in a much improved quality.

Where the catch mix consists mainly of larger fish and prawns, there is considerable potential for reducing overall catch sorting times. This can have quality benefits, not just for the fish but also for the prawn catch. Less time spent sorting means that all the catch can be stowed in ice more quickly.

The separator trawl did not achieve an effective separation of the roundfish by-catch. However, as a BRD, it should not be discounted entirely. When the catch profile contains by-catch species in the larger size classes (at or around MLS) it works very well and does in fact enhance the quality of the separated species. As with all BRDs, separator trawls are appropriate for some applications but are not a panacea to discarding in *Nephrops* fisheries.

6.5 Cost implications

These trials did not identify any significant increases in cost to the skippers or crews in terms of the time or effort required to work separator trawls. No fishing time was lost compared to the use of standard gear.

7 CONCLUSIONS

Despite some of the disappointing results, a number of positive conclusions can still be drawn from this work:

- The principle of the separator trawl can easily be applied to commercially available trawl designs such as those used in the Irish Sea *Nephrops* fishery.
- The catching and handling performance of the separator trawl compares favourably with that of an unmodified net of similar size.
- The separator trawl can be operated by vessels from a range of hp categories. It is also suitable for twin trawl operations.
- The separator trawl is an effective tool for separating the larger size classes (above MLS) of round, finfish species such as whiting and haddock from *Nephrops* in the Irish Sea.
- This configuration of separator trawl was unsuccessful as a means of reducing the discarding of juvenile whiting and haddock in the Irish Sea *Nephrops* fishery.
- Improved by-catch quality is achievable by the use of the separator trawl technology.

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FIGURES AND TABLES

Table 1: Instrumented gear trials - MFV *Village Queen*

STANDARD FISHING GEAR													
Centre wire position (fathoms)	Depth (fms)	Warp length (fms)	Otter-board Spread (m).	NET PARAMETER-port side		NET PARAMETERS-starboard-side		WARP TENSIONS-Surface (tonnes)			TENSIONS-Underwater-(tonnes)		SPEED-(knots)	
				Headline height(m).	Wing-end spread(m)	Headline height(m).	Wing-end spread(m).	PORT	CENTRE	STARBOARD	Behind door	Behind skid	Over ground	thro' water
9 feet short	25	100	103	no readings	no readings	no readings	18	1.2	1.6	1.3	0.4	0.15	2.4	
20 feet short	25	100	125	1.50	17.00	1.30	17.50	1.10	1.40	1.09	0.59	0.50	2.40	
24 feet short	25	100	134	1.60	none	1.20	20.00	1.10	1.53	1.10	0.60	0.50	2.40	
SEPARATOR TRAWL FISHING GEAR - Panel in Starboard net, Port standard														
Centre wire position (fathoms)	Depth (fms)	Warp length (fms)	Otter-board Spread (m).	NET PARAMETER - port side		NET PARAMETERS - starboard-side		WARP TENSIONS - Surface (tonnes)			TENSIONS - Underwater (tonnes)		SPEED (knots)	
				Headline height(m)	Wing-end spread(m)	Headline height(m).	Wing-end spread(m).	PORT	CENTRE	STARBOARD	Behind door	Behind skid	Over ground	thro' water
12 feet short	25	100	90	1.80	16.00	none	18.50	1.20	1.60	1.30	0.70	0.23	2.40	
16 feet short	25	100	98	none	none	2.00	21.00	1.10	1.50	1.20	0.65	0.36	2.40	
9 feet short	65	175	81	none	none	none	none	1.40	1.80	1.30	none	none	2.40	
20 feet short	65	175	125	2.10	21.00	2.20	22.00	1.50	2.10	1.60	0.55	0.50	2.40	

*Distance-Otterboard to skid(m) = 55m

Separation of finfish by-catch

Table 2: Summary of results

VESSEL	MONTH	SPECIES	% SEPARATION TO TOP CODEND	EXPECTED SEPARATION	% SEPARATION OVER MLS
Girl Ann III (<200 hp)	MARCH	WHITING	64	75	83
		HADDOCK	76	75	78
		COD	35	20	N/A
	JULY	WHITING	39	75	72
		HADDOCK	54	75	100
		COD	35	20	N/A
Dee Star (200-400 hp)	FEBRUARY	WHITING	30	75	40
		HADDOCK	74	75	70
		COD	17	20	N/A
	AUGUST	WHITING	44	75	87
		HADDOCK	29	75	54
		COD	18	20	N/A
Village Queen (>400 hp)	JUNE	WHITING	31	75	89
		HADDOCK	61	75	81
		COD	19	20	N/A

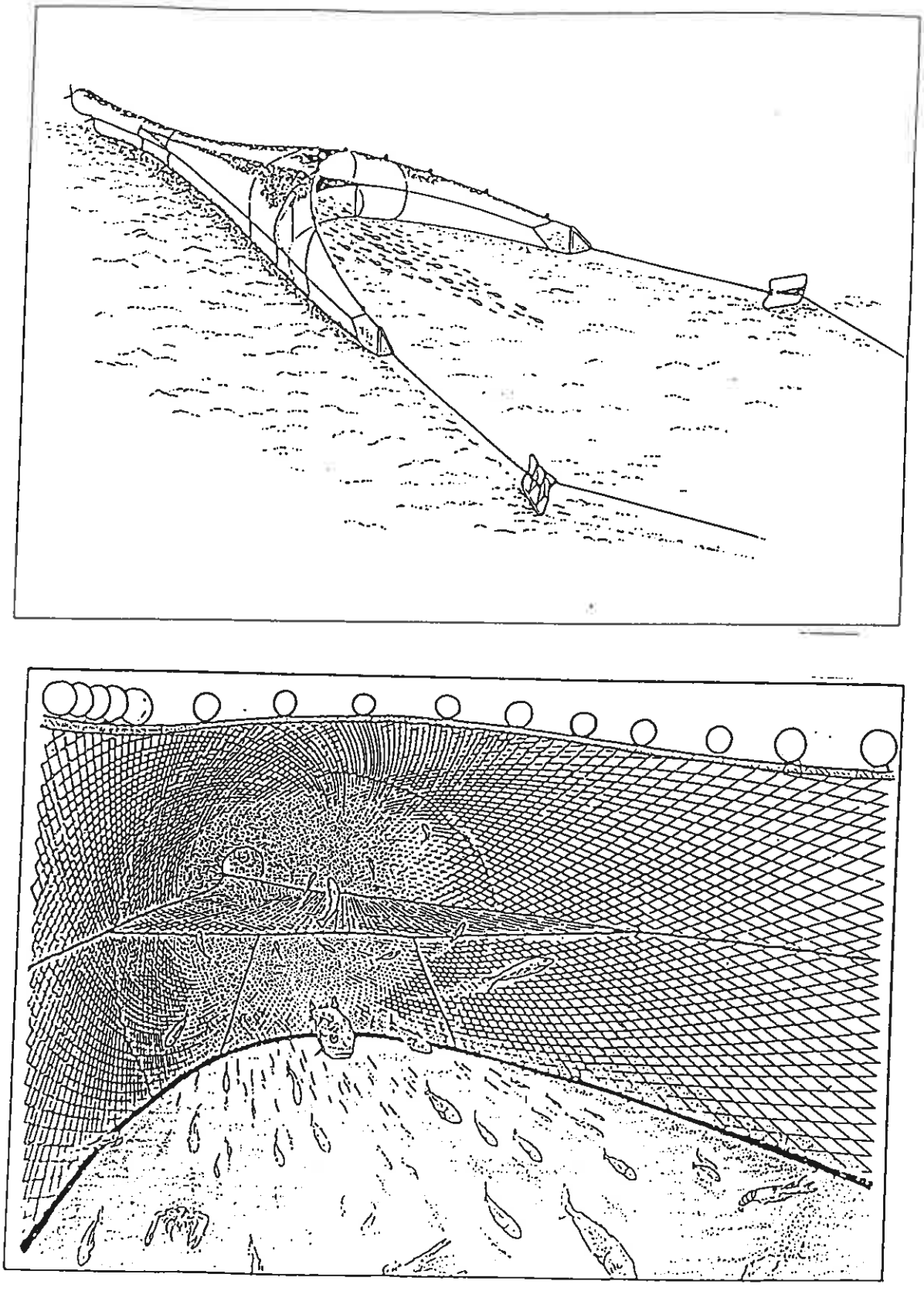


Figure 1: Sketch showing panel position and ropes controlling the panel height inside the mouth of the trawl.

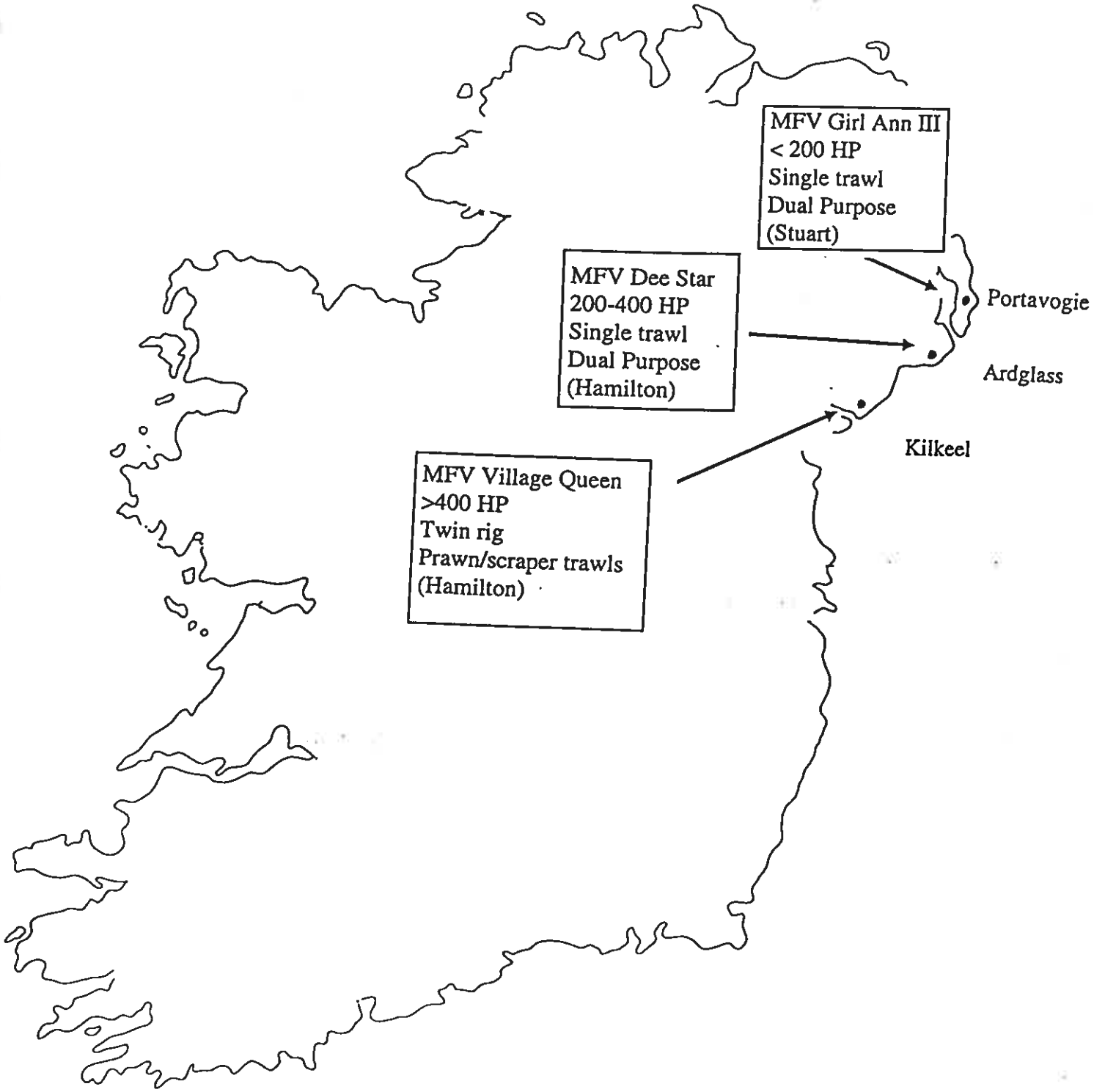


Figure 2: Ports of operation for separator trawl trials

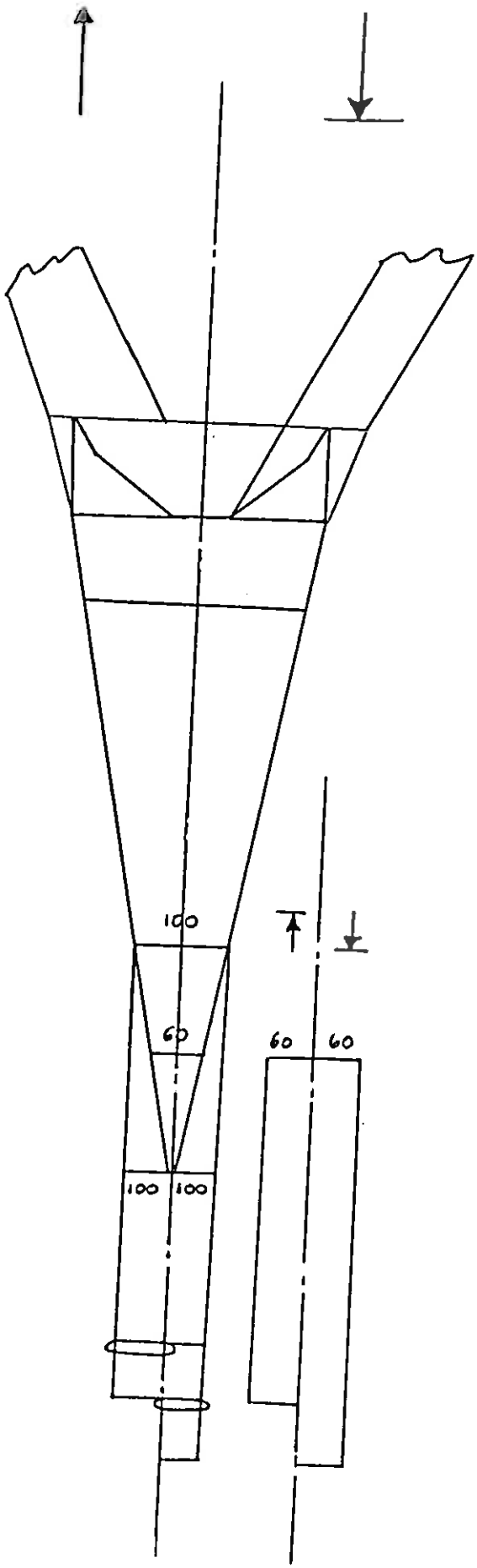


Figure 3: mfv *Village Queen*
Shape and position of separator panel relative to main body of net.
Two alternative codend attachments shown.

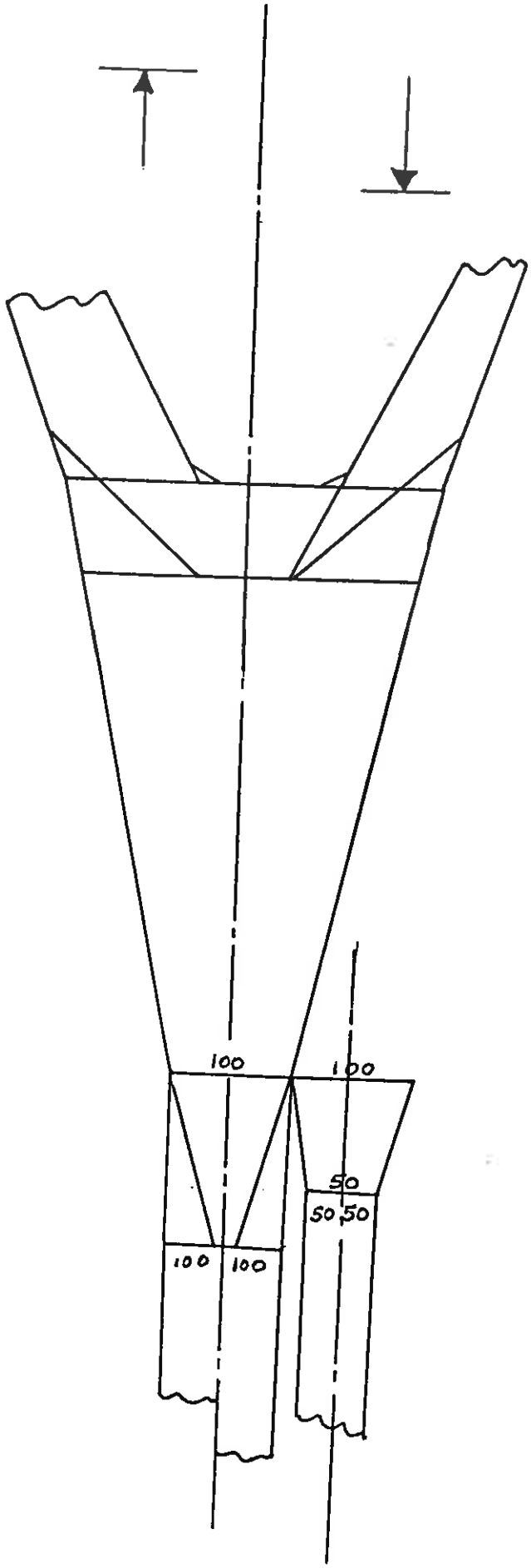


Figure 4: mfv *Dee Star*
Shape and position of separator panel relative to main body of net.
Two alternative codend attachments shown.

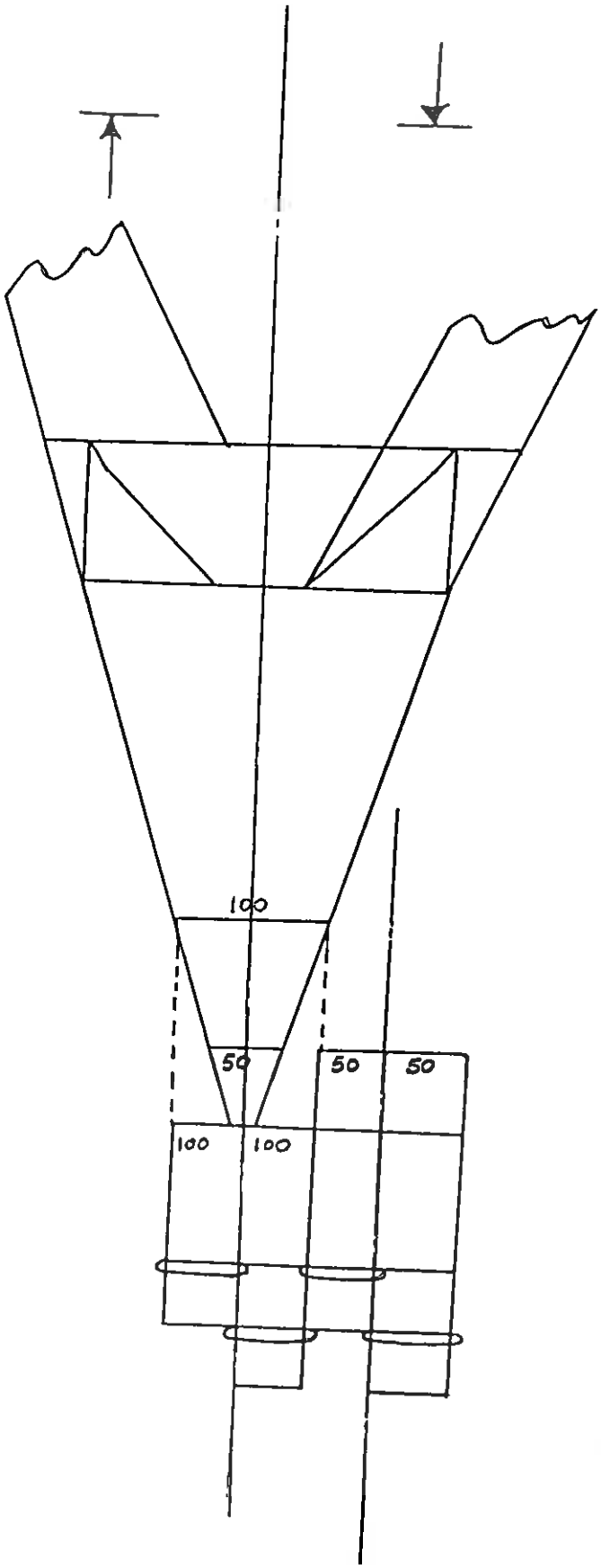


Figure 5: mfv *Girl Ann III*
Shape and position of separator panel relative to main body of net. Two alternative codend attachments shown.

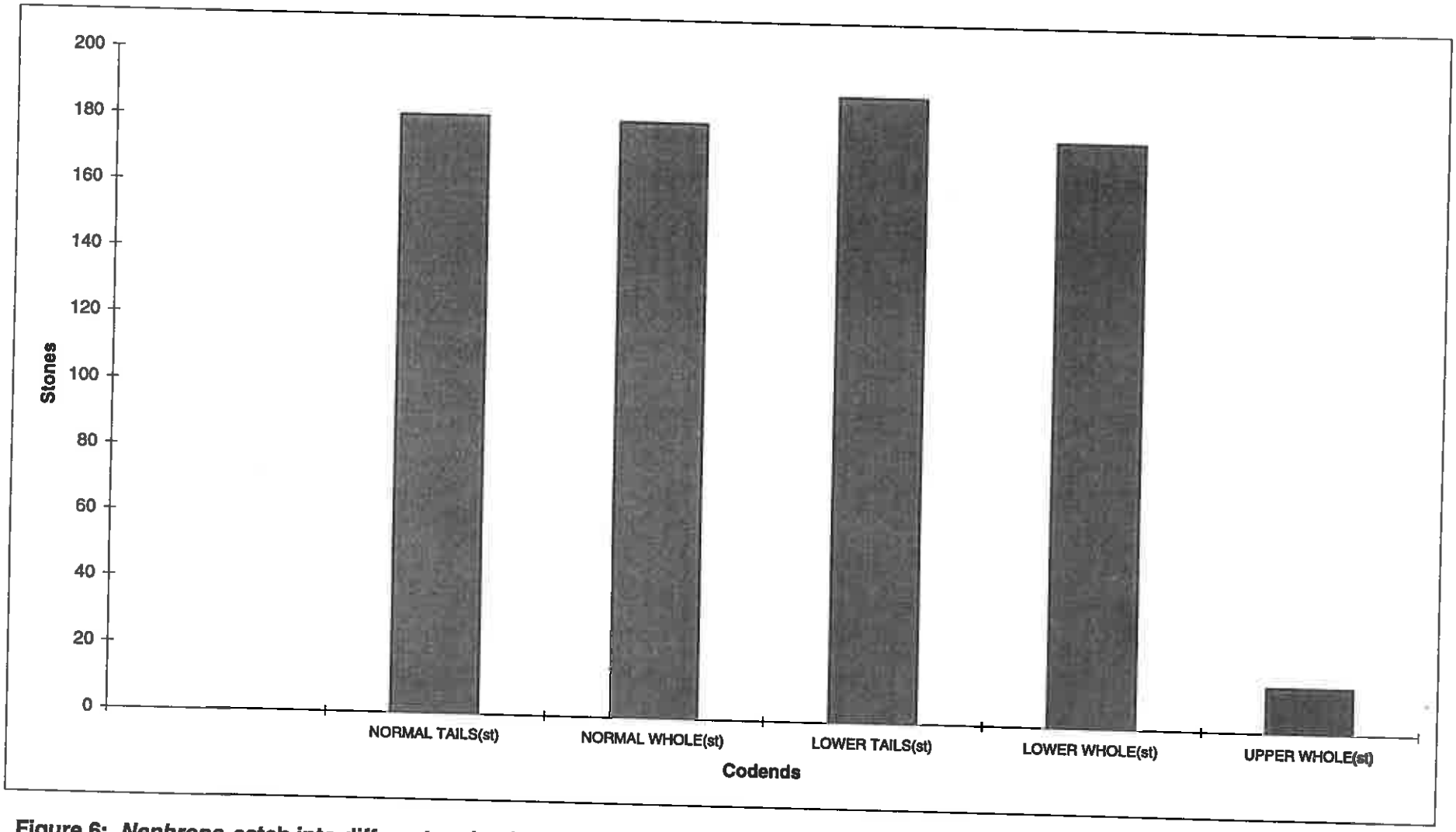


Figure 6: ***Nephrops*** **catch into different codends >400hp Twin Rig**

MFV *VILLAGE QUEEN* (>400hp) Kilkeel
Length/numbers plot for whiting

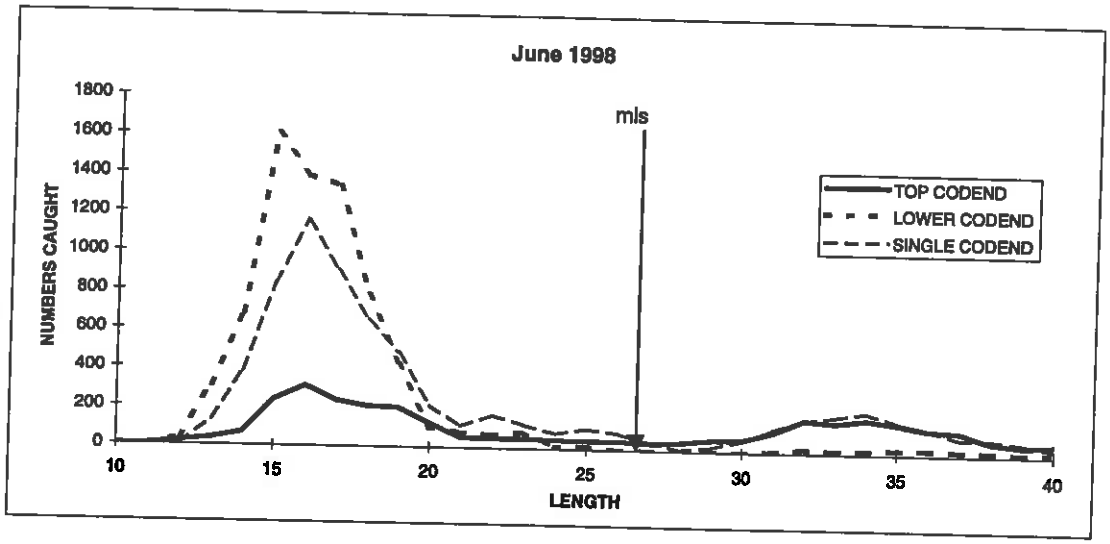
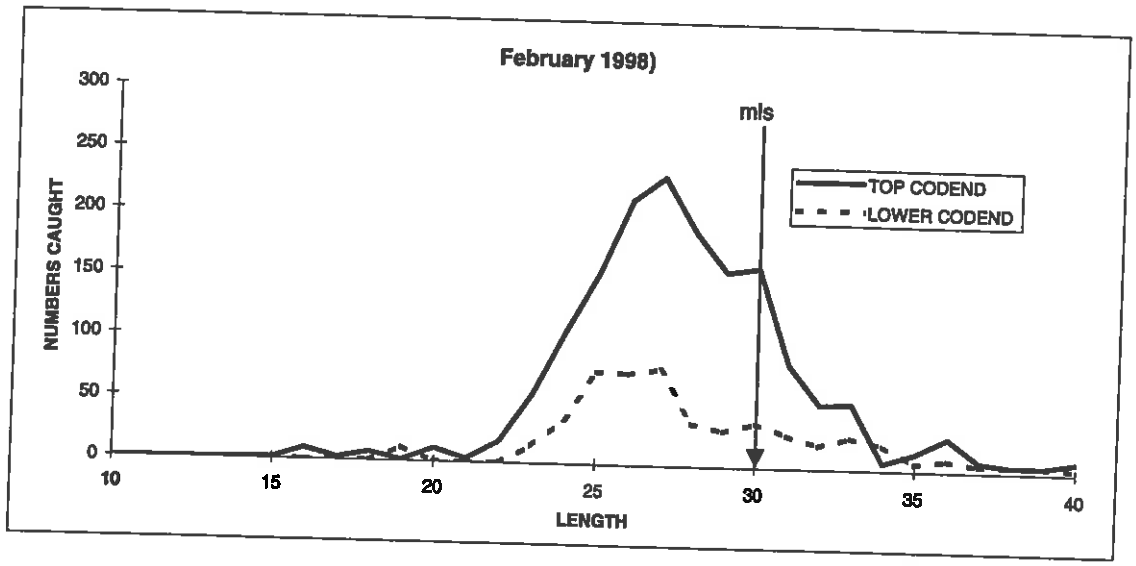


Figure 7: Whiting catch into different codends >400hp, June 1998

MFV *DEE STAR* (200-400hp) Ardglass
Length/numbers plot for haddock

a)



b)

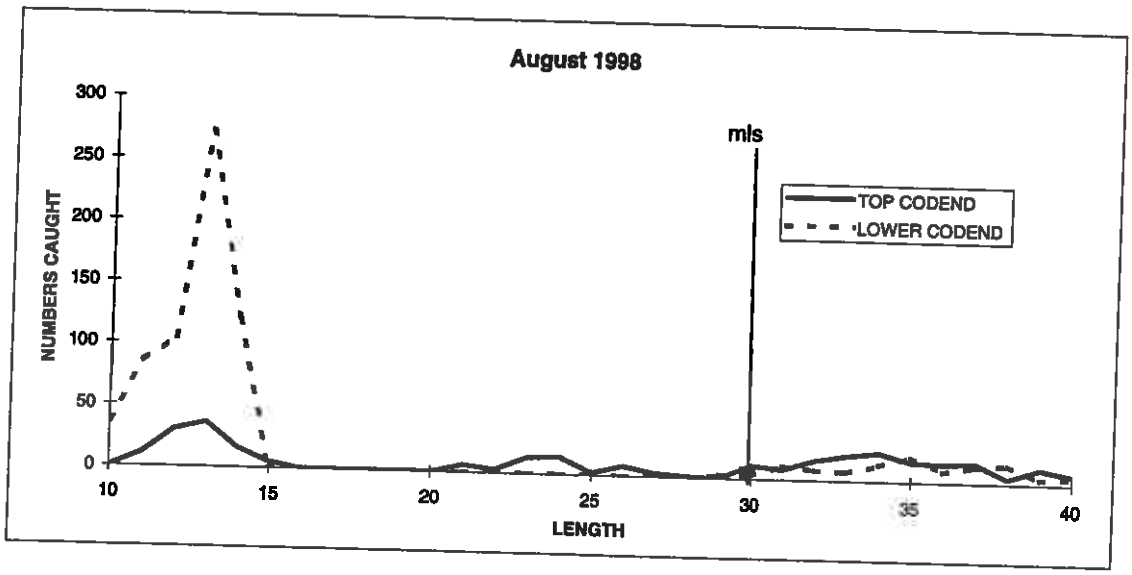


Figure 8: Haddock catch into different codends 200-400hp, February and August 1998

MFV *DEE STAR* (200-400hp) Ardglass
Length/numbers plot for whiting

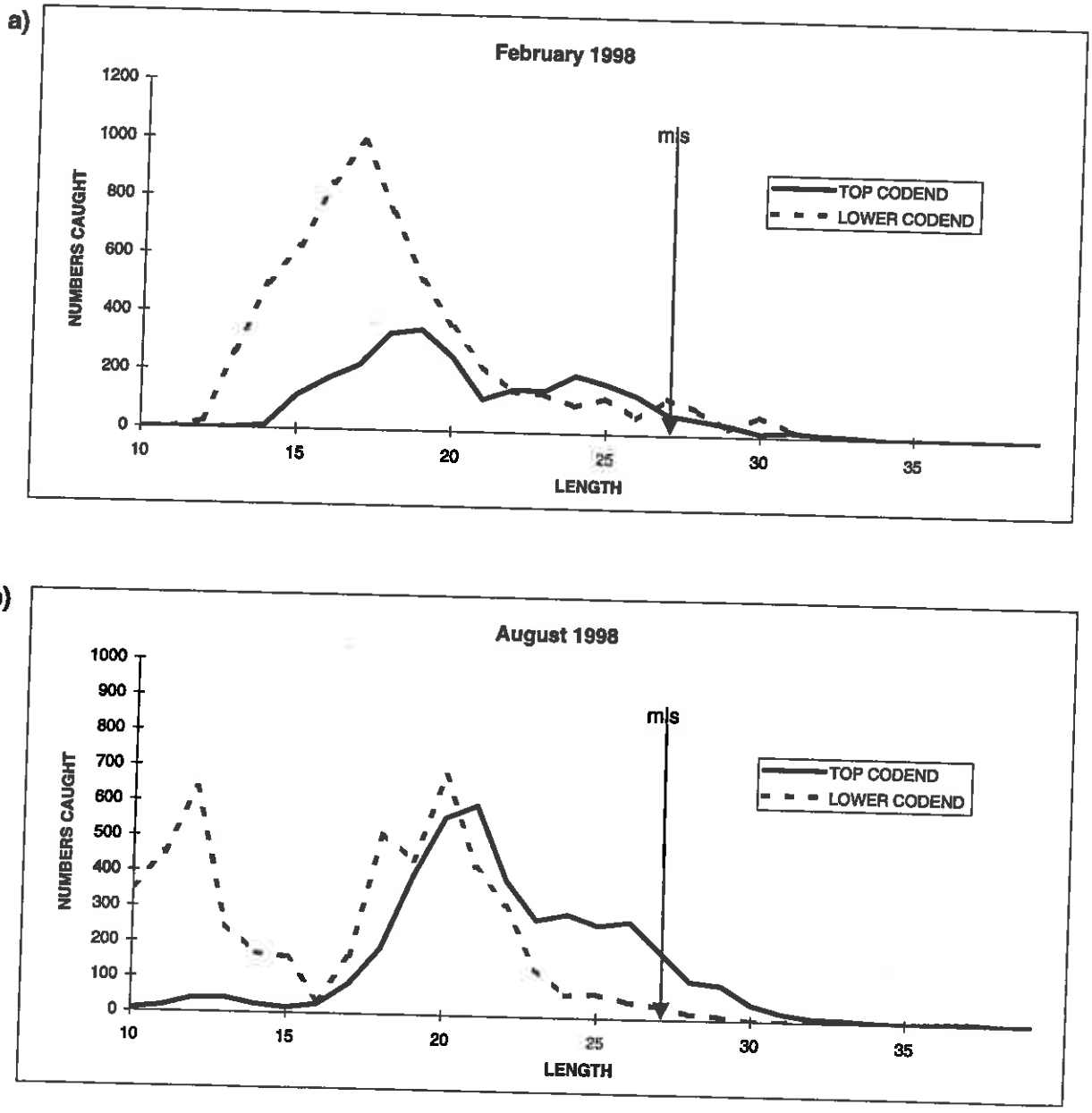


Figure 9: Whiting catch into different codends 200-400hp, February and August 1998

MFV *GIRL ANN III* (<200hp) Portavogie
Length/numbers plot for whiting

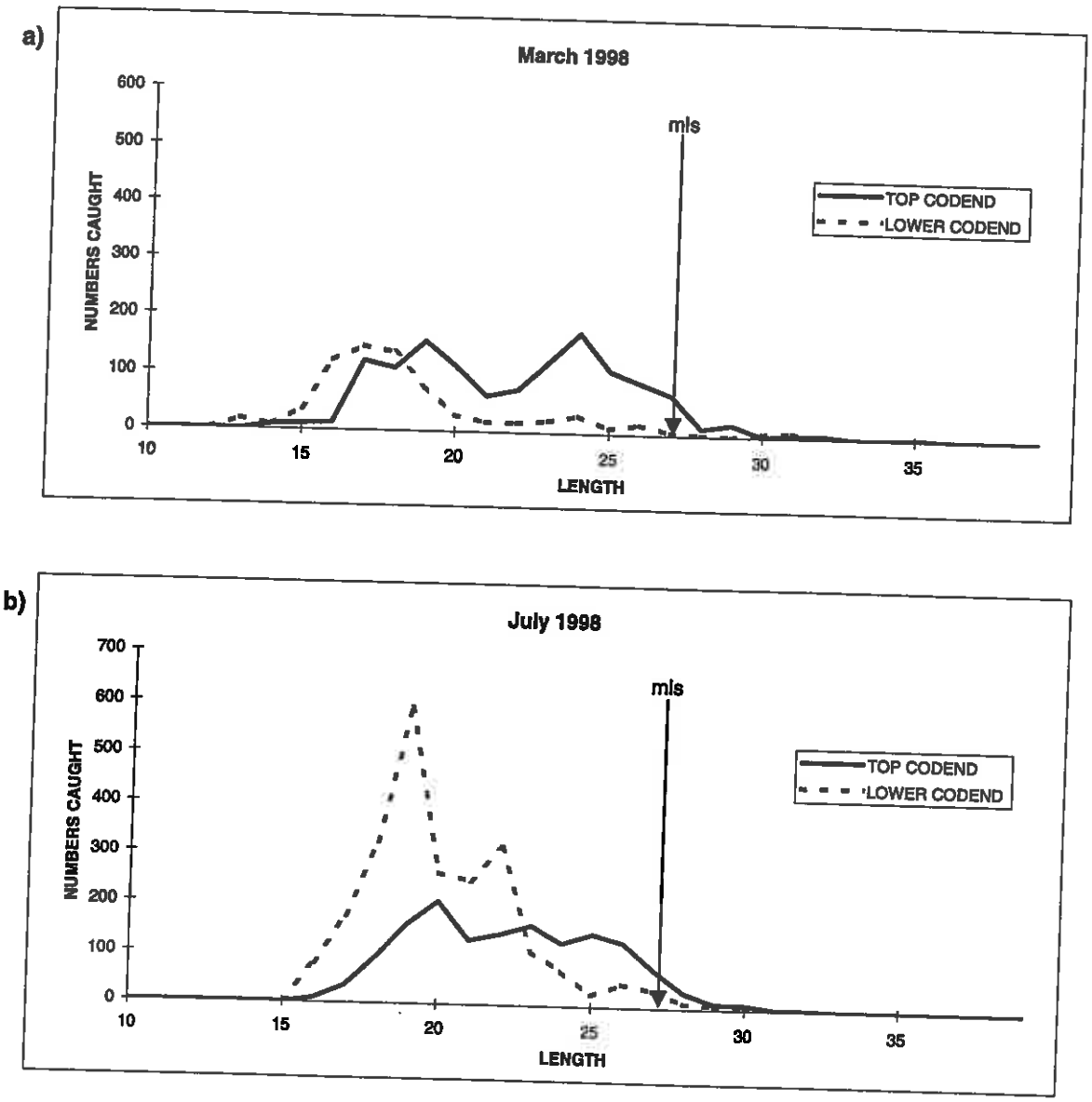


Figure 10: Whiting catch into different codends <200hp, March and July 1998

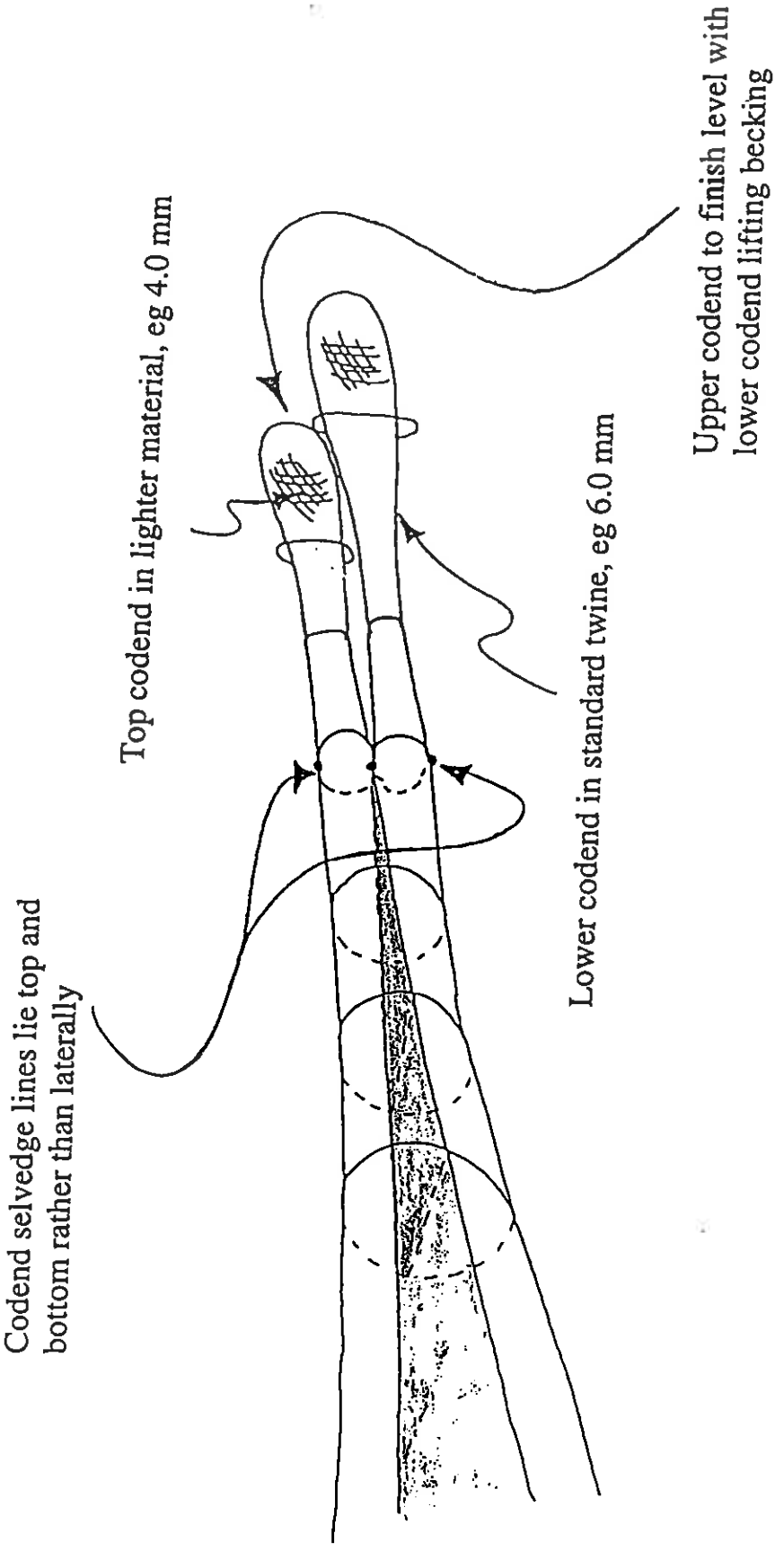


Figure 11: Diagrammatic representation of separator panel and double codend arrangement.