# Further Investigations into Selectivity in Separator Trawls

**MAFF R&D Commission 1994/95**

---

**Seafish Report No. 460**

---

December 1995

**Sea Fish Industry Authority**

**Technology Division**

# Further Investigations into Selectivity in Separator Trawls

Seafish Report No. 460
MAFF R&D Commission 1994/95
Project Code MF0612

November 1995
Authors: J. Swarbrick, W. Lart, K. Arkley

# Contents

# Sea Fish Industry Authority

## Technology Division

## Further Investigations into Selectivity in Separator Trawls

Seafish Report No. 460
MAFF R&D Commission 1994/95
Project Code MF0612

November 1995
Authors: J. Swarbrick, W. Lart, K. Arkley

## Summary

This report describes a set of MAFF funded experiments investigating selectivity in separator trawls. Previous work in this series has been described by Arkley et al., 1995. This paper sets out the gear technology aspects of the trials and how they interact with the statistical aspects. A full account of the statistical aspects is given by Cotter et al., 1995.

The same separator trawls used for the previous exercise off Whitby were deployed in the Scottish waters of the Moray Firth by the same twin rig trawler, *MFV HEATHER SPRIG BCK181*. A range of four mesh sizes were deployed between the four codends. As previously, great care was taken to ensure that the gear was working properly on the seabed by initially monitoring the gear with underwater video cameras. Combinations of mesh sizes were chosen randomly within blocks of four pre-determined combinations.

The trial confirmed the vertical separation levels and selectivity parameters established in the previous exercise off Whitby. Evidence was found that suggested the upper and lower codends of a separator trawl have different selectivity properties, purely due to their position. The trial also confirmed that a twin-rigged separator trawl with four codends was an excellent tool for obtaining selectivity data, but was unlikely to find a niche in commercial fishing due to its complexity. The potential of the separator trawl as a conservation tool was emphasised through the consistency of the vertical separation levels found when comparing the first trial with this second trial.

## Keywords
Separator trawl, vertical separation, separator panel, codend selectivity, cod, haddock, plaice, whiting, technical conservation measures.

## Abstract

This report describes the most recent in a series of trials investigating the selectivity performance of separator trawls. The two nets were deployed simultaneously on a twin rig trawler in the Moray Firth over a two week period. Four different codend mesh sizes were used in a number of combinations. The catch from each of the four codends was identified and measured. The catch data were analysed to determine the extent of vertical separation for each species and the size selectivity of each codend. Good separation was found and some useful observations made as to the influence of fish size on separation and codend position on selectivity.

# 1. Introduction

The work described in this report was carried out under MAFF Commission MF0612 and followed on from work carried out by Arkley et al. (1995) and Cotter et al. (1995), which examined codend selectivity using twin rigged separator trawls. The report describes the second of a set of two sea trials which was set up in order to obtain data for species unobtainable on the first sea trial. Both exercises were conducted on board the commercial fishing vessel *MFV HEATHER SPRIG (BCK181).*

The first of the two trials (March 1994) was conducted in English waters off Whitby. Principal species caught were cod, whiting and mixed species of flatfish. The objective of the second trial (November 1994) was to obtain data for species not encountered in sufficient numbers in the March trial and to examine the use of the twin-rig separator trawl under different fishery conditions. The second trial was conducted in the Scottish waters of the Moray Firth.

In order to replicate the selectivity experiment, both exercises were conducted in an identical manner, using the same vessel and the same nets with allowances made for differences in operational conditions between the two very different fishing grounds.

This work was carried out in conjunction with scientists from the Ministry of Agriculture, Fisheries and Food (MAFF) Directorate of Fisheries Research (DFR) in Lowestoft. Reporting was divided into two main areas: DFR (Lowestoft) concentrated on the statistical aspects, while Seafish (Hull) described the gear/fish interactions in terms of separation levels and selectivity occurring in different parts of the trawl.

The UK industry is in favour of the increased adoption of technical conservation measures as a means of reducing discards. This study of separator trawls aimed to examine the potential of technical conservation measures to substitute for other means of limiting fishing mortality.

## 1.1 Purpose of the Study

Cotter et al. (1995) have analysed the data from this and the previous trial using a method based upon Millar and Walsh (1992) in which the L50 and vertical separation levels between the upper and lower codends are estimated simultaneously on a haul by haul basis by an iterative process. They have therefore been able to provide a suite of estimates of selectivity and separation for the following species in the following mesh sizes:

| Species | Trial 1, March 1994, Whitby | Trial 2, Nov 1994, Moray Firth |
|---|---|---|
| Cod<br>*(Gadus morhua)* L. | 100mm, 140mm | - |
| Whiting<br>*(Merlangius merlangus)* L. | 100mm, 140mm | - |
| Haddock<br>*(Melanogrammus aeglefinus)* L. | - | 100mm, 120mm |
| Plaice<br>*(Pleuronectes platessa)* L. | 100mm, 140mm | 100mm, 120mm, 140mm |

### 1.2 Purpose of this Document

i. To report on the technical details of the second trial, including gear specification and ease of deployment.

ii. To describe the environment of the trials in terms of predominant species, catch per unit effort (CPUE) and nature of the fishery.

iii. To examine gear/fish interactions in terms of separation levels and selectivity in different parts of the trawl.

iv. To discuss any commercial implications of the adoption of separator trawls.

Reporting completed as part of this commission:

Arkley, K., W. Lart and J. Swarbrick, 1995, 'Sea Trials to Evaluate Selectivity of Separator Trawls used to Catch Mixed White Fish Species', Report No. SR441, Sea Fish Industry Authority, Hull.

Cotter, A. J. R., T. W. Boon and C. G. Brown, 1995, 'Statistical Aspects of Trials of a Separator Trawl using a Twin Rig Trawler', MAFF Dir. Fis. Res., Lowestoft. (Unpub).

# 2. Materials and Methods

## 2.1 Vessel

MFV Heather Sprig (BCK181) based in the Scottish port of Buckie

| | |
|---|---|
| LOA | 18.6m |
| Gross Tonnage | 49.46 |
| Engine Power | 554hp |

## 2.2 Fishing Gear

The trawls used in the twin trawl (twin rig) arrangement are the same 20m (66ft) headline nets as those used in the March 1994 trials and are described by Arkley et al. (1994), Seafish Report 441, section 4.1. However, the ground gears (Appendix III) and the choice of codend mesh sizes (Appendix II) were different.

### 2.2.1 Ground gears

The ground gears in the March trial were rigged as 'rockhoppers' for the rough grounds encountered off northeast England. Rockhopper ground gears use many large rubber discs spaced along the length of the ground gear which enables the trawl to traverse hard and rocky seabed. The grounds encountered in northeast Scotland are much finer and muddier; this means that rockhoppers are less suited both from a fishing viewpoint and from a deployment viewpoint. It was found during the March 1994 trial that the rubber rockhopper discs made the process of getting the trawls overboard and recovering them again very arduous. For the November trials, less rubber discs needed to be used on the ground gears, but the overall weight in sea water of the ground gears was maintained the same as in the March 1994 trials at approximately 195kg (see Appendix III).

### 2.2.2 Codends: all 6.1m length

**40mm upper codend with 40mm lower codend** used as reference codends.
In order to ensure a representative sample of an entire fish population could be taken, small meshed polyethylene (PE) codends of 40mm mesh size, 1.6mm diameter double twisted twine and 500 meshes circumference were used as reference codends in place of the 60mm small meshed codends used in the previous trial (Arkley et al. 1994). These 40mm codends had 4 meshes in each of two selvedges and were fitted with PE lifting bags of 100mm mesh size, 3.5mm diameter braided twine and 100 mesh circumference. Lifting bags were fitted to reinforce the 40mm mesh and to allow the codends to be emptied. The 40mm codends were deployed four times in every block (see section 2.3, 'Experimental Design'); twice on the port net and twice on the starboard net.

**100mm upper codend with 100mm lower codend**
These codends are constructed of double 3.5mm diameter braided PE twine, 100 meshes in circumference. This configuration was always deployed as a pair twice in every block; once on the port net and once on the starboard net.

**100mm upper codend with a 120mm lower codend; 100mm upper codend with a 140mm lower codend**

Both the 120mm and 140mm codends were constructed in the same manner as the 100mm codends. The 140mm codends were deployed only in blocks 1 and 2; once on the port net and once on the starboard net within each block. The 120mm codends were deployed in blocks 3 to 7 (see section 2.3, 'Experimental Design') once on the port net and once on the starboard net within each block. Due to the lack of suitable 100mm codends, each time one of the above configurations became due for deployment, a 100mm codend was detached from the 100mm/100mm pair and 'borrowed' to form the upper codend with either the 120mm or 140mm codend, as appropriate. Attachment was made by a simple arrangement using a piece of twine to interlace the chosen codend onto the upper extension.

### 2.2.3 Sweep and bridle details

The sweeps and bridle arrangements were the same as used in the previous trial (Seafish Report No. 441 [1994], section 4.1, figures. 2 & 3). The notable exception to this is the type of door used (see this report, section 3.1).

## 2.3 Experimental Design

The experimental design used in these trials was based directly on that used in the previous March trials (Seafish Report No. 441 [1994], section 4.3). There were 7 blocks of 4 hauls in each; each block contained 4 randomised codend configurations (refer to Table 1). The experimental design can be seen to fall into two halves. The two trawls in the twin rig arrangement were designated Port = 'A' and Starboard = 'B' at the start of the trial. About halfway through the trial the nets were alternated in position so that Port = 'B' and Starboard = 'A'. The intention of this was to attempt to confound any inherent differences between the two nets - excluding the codends. It would have been desirable to randomise the net/side element within each block, but this was found impractical as it would have resulted in an excessive loss of fishing time.

## 2.4 Analysis Techniques

It has been suggested (Arkley et al, 1994) that selectivity in separator trawls occurs at two points in the gear and by two different mechanisms:

i. Selectivity occurs at the codends (and to some undefined extent, along the length of the separator panel itself) and is due to the 'sieving' action of the mesh size involved as a result of the size range of fish encountering the mesh.

ii. Selectivity occurs at the mouth region of the gears and is due to vertical separation as a result of fish behaviour.

The analysis therefore investigates these two selectivity mechanisms.

### 2.4.1 Selectivity occurring in the codends

The aggregate length-frequency distribution for the 40mm reference codends was assumed to be representative of the population of fish encountered by the trawl. This length-frequency distribution was compared with that obtained in a test codend. The upper reference codend was compared with an upper test codend. The lower codends were compared in the same way.

For each mesh size and codend position (upper or lower), selectivity was assessed by comparing the numbers in each cm length group from a test codend with those from a reference codend and fitting a logistic curve (see sections 4.3 and 4.5).

### 2.4.2 Selectivity due to vertical separation

For each of the reference codends (40mm upper & lower; 100mm upper & lower), the ratio of the upper and lower size distributions was plotted. A regression using a binomial fit was performed on these data sets.

# 3. The Fishing Environment

Weather conditions ranged from calm to W5 and so did not present many problems during the trials. The ground fished ranged from soft to firm, but the type of hard rocky grounds encountered during the previous Whitby trial were not found and very little net damage was sustained.

## 3.1 Gear Geometry

Gear geometry was checked before the start of fishing trials by inspection of the gear underwater using a Remotely Operated Vehicle (ROV) supplied by the SOAFD Marine Laboratory, Aberdeen. This was done in the same manner as for the previous Whitby trial on the same Moray Firth grounds. The only alteration found necessary was to extend the lower bridles by about 15cm. During the course of the fishing trials the nets were monitored with a Scanmar acoustic telemetry system for wing-end spread, headline height above the seabed, and door (otter board) spread. These dimensions were found comparable with those obtained during the previous trial off Whitby, and so the gear could be said to be behaving consistently.

It was found that the skipper of the *HEATHER SPRIG* had adopted the use of different doors compared with the previous trial. The Whitby trial used 2.1m (7ft) high Norwegian 'Dan-Green' flat steel vee doors. This trial used ~1.5m (~5ft) 410kg Perfect 'Lindholm' spherical steel doors - a Swedish design manufactured in Denmark. At their respective optimum angles of attack, the spherical steel doors can be expected to give greater spread per unit surface area than flat steel vee doors operating under identical conditions. The use of these spherical steel doors did not adversely affect the performance of the twin-rigged trawls as monitored by Scanmar and ROV.

The height of the leading edge of the separator panel was set constant at 1m above the footrope. Underwater observations established that there were no excessive stresses on any part of the separator panel.

The 120mm mesh codend was found to be not up to specification when a selection of meshes were measured on board *HEATHER SPRIG*. This codend was not used; a 140mm mesh codend was used during the first two blocks. A new 120mm mesh codend (supplied by the SOAFD Marine Laboratory, Aberdeen) was made available for the start of block 3 and was then used for the remainder of the trial (blocks 3-7; see section 2.3).

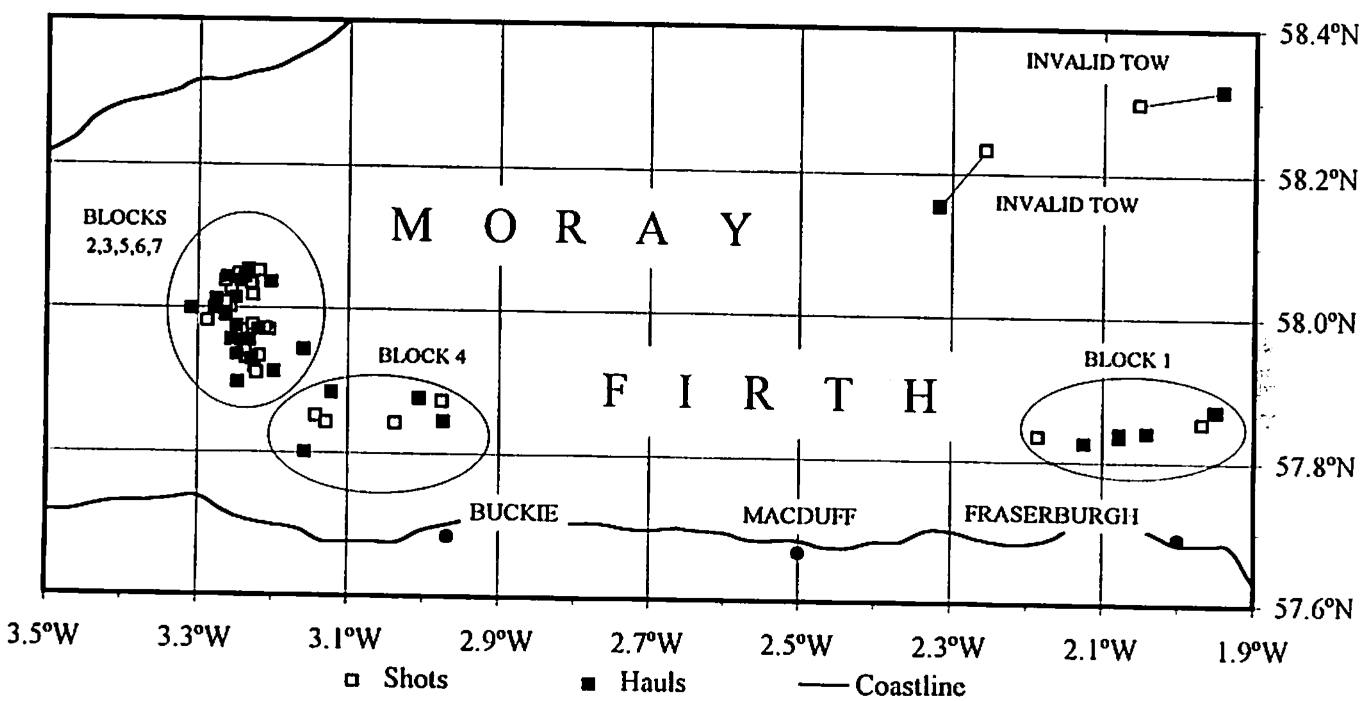
The gear was handled and the codends emptied in the same manner as described in Seafish Report No. 441 (1994), section 4.3.1. It was noted that many of the haddock caught in this study were in poor condition with evidence of ectoparasitic infections.

**Table 1** (left)
**Experimental Design**

| Haul | Block | Date | Port Net | Port Codend (U/L) | Starboard Net | Starboard Codend (U/L) |
|---|---|---|---|---|---|---|
| 1 | 1 | 19-Nov-94 | A | 40/40 | B | 100/100 |
| 2 | | 19-Nov-94 | | 100/140 | | 40/40 |
| 3 | | 20-Nov-94 | | 40/40 | | 100/140 |
| 4 | | 20-Nov-94 | | 100/100 | | 40/40 |
| 5 | 2 | 21-Nov-94 | A | 100/100 | B | 40/40 |
| 6 | | 21-Nov-94 | | 40/40 | | 100/100 |
| 7 | | 21-Nov-94 | | 40/40 | | 100/140 |
| 8 | | 21-Nov-94 | | 100/140 | | 40/40 |
| 9 | 3 | 22-Nov-94 | A | 100/120 | B | 40/40 |
| 10 | | 22-Nov-94 | | 40/40 | | 100/120 |
| 11 | | 22-Nov-94 | | 40/40 | | 100/100 |
| 12 | | 23-Nov-94 | | 100/100 | | 40/40 |
| 13 | 4 | 24-Nov-94 | A | 40/40 | B | 100/120 |
| 14 | | 24-Nov-94 | | 40/40 | | 100/100 |
| 15 | | 24-Nov-94 | | 100/120 | | 40/40 |
| 16 | | 24-Nov-94 | | 100/100 | | 40/40 |
| Invalid | n/a | 25-Nov-94 | A | 100/120 | B | 40/40 |
| Invalid | n/a | 25-Nov-94 | | 100/120 | | 40/40 |
| 17 | 5 | 25-Nov-94 | B | 100/120 | A | 40/40 |
| 18 | | 25-Nov-94 | | 40/40 | | 100/120 |
| 19 | | 25-Nov-94 | | 40/40 | | 100/100 |
| 20 | | 26-Nov-94 | | 100/100 | | 40/40 |
| 21 | 6 | 28-Nov-94 | B | 100/120 | A | 40/40 |
| 22 | | 28-Nov-94 | | 40/40 | | 100/100 |
| 23 | | 28-Nov-94 | | 40/40 | | 100/120 |
| 24 | | 29-Nov-94 | | 100/100 | | 40/40 |
| 25 | 7 | 29-Nov-94 | B | 40/40 | A | 100/100 |
| 26 | | 29-Nov-94 | | 100/100 | | 40/40 |
| 27 | | 29-Nov-94 | | 40/40 | | 100/120 |
| 28 | | 30-Nov-94 | | 100/120 | | 40/40 |

*Codend (U/L) means: Upper codend mesh (mm) / Lower codend mesh (mm)*

**Fig. 1** (below)
Location of shots and hauls



# 4. Results and Discussion

## 4.1 Catch per Unit Effort (CPUE)

The following (figures 2-10) show the catch per unit effort in terms of catch per hour, for haddock, whiting and plaice caught with different mesh sizes and with different codend positions (upper, lower). The following graphs have 'y' axis scales appropriate to the magnitude of values in the relevant data set(s).

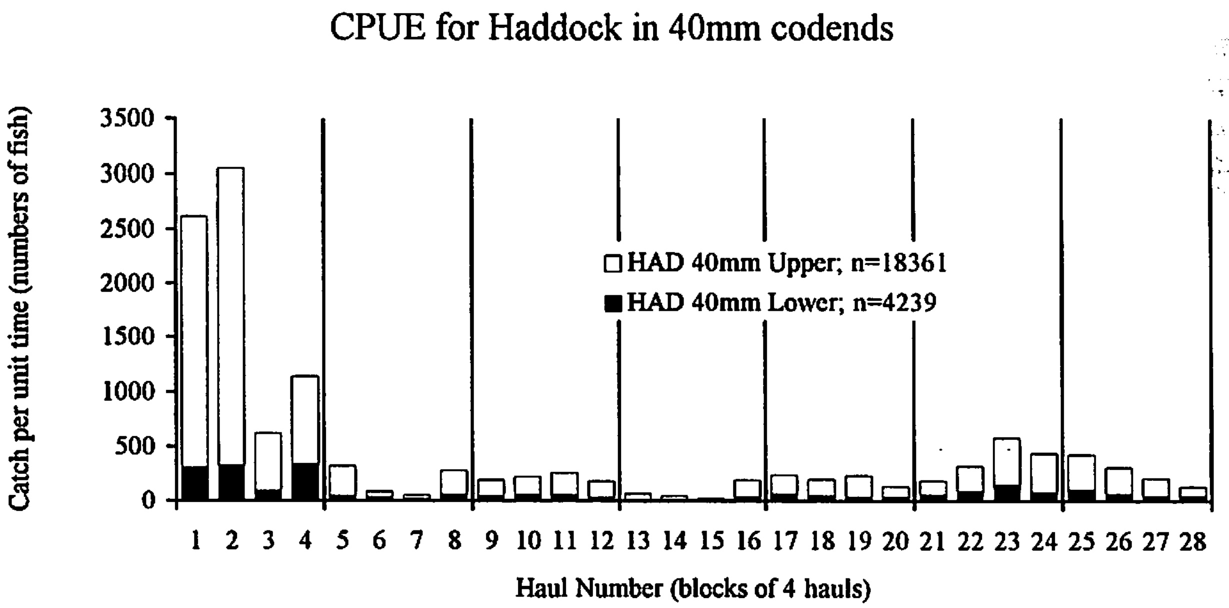



**Fig. 2 - Catch per unit effort (catch per hour) for haddock in 40mm codends**

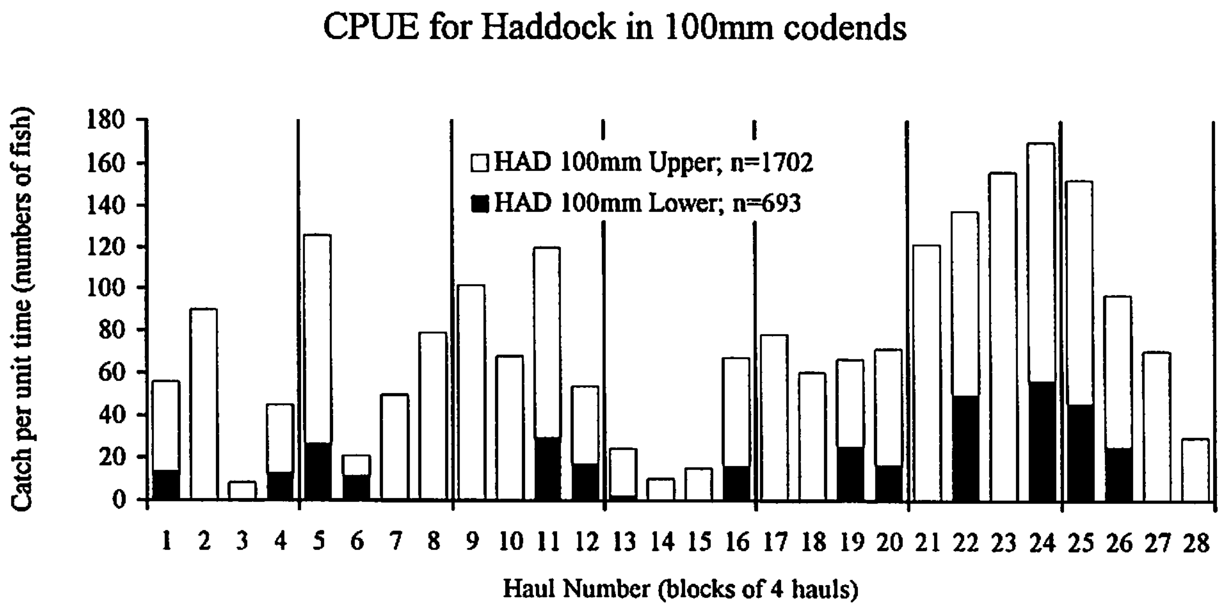



**Fig. 3 - Catch per unit effort (catch per hour) for haddock in 100mm codends**

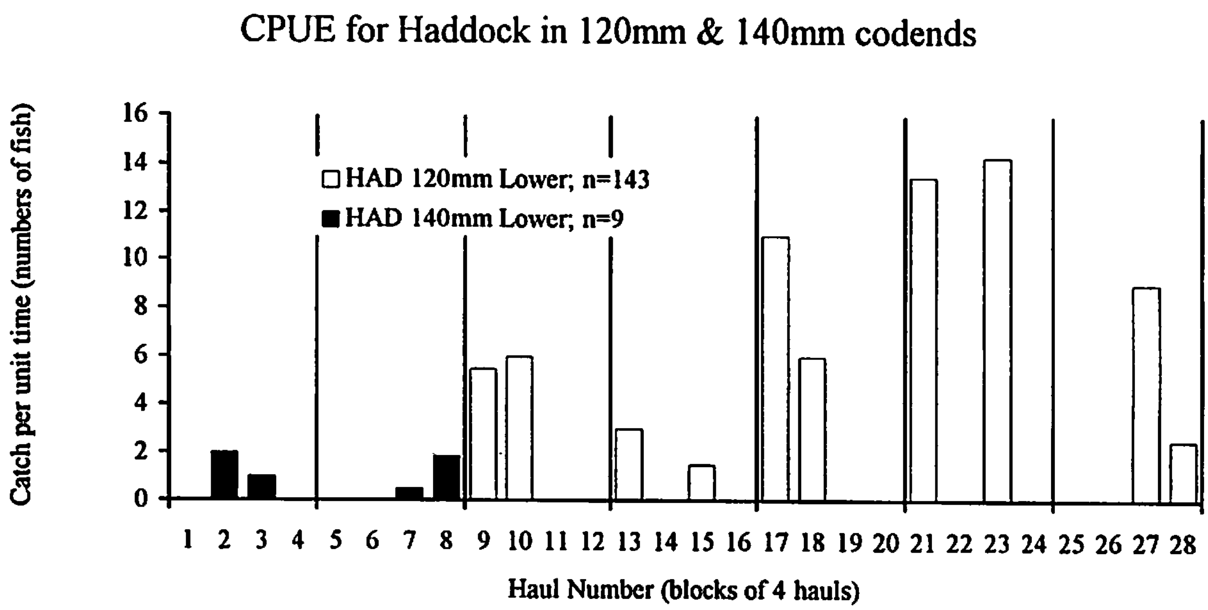



**Fig. 4 - Catch per unit effort (catch per hour) for haddock in 120mm & 140mm codends**

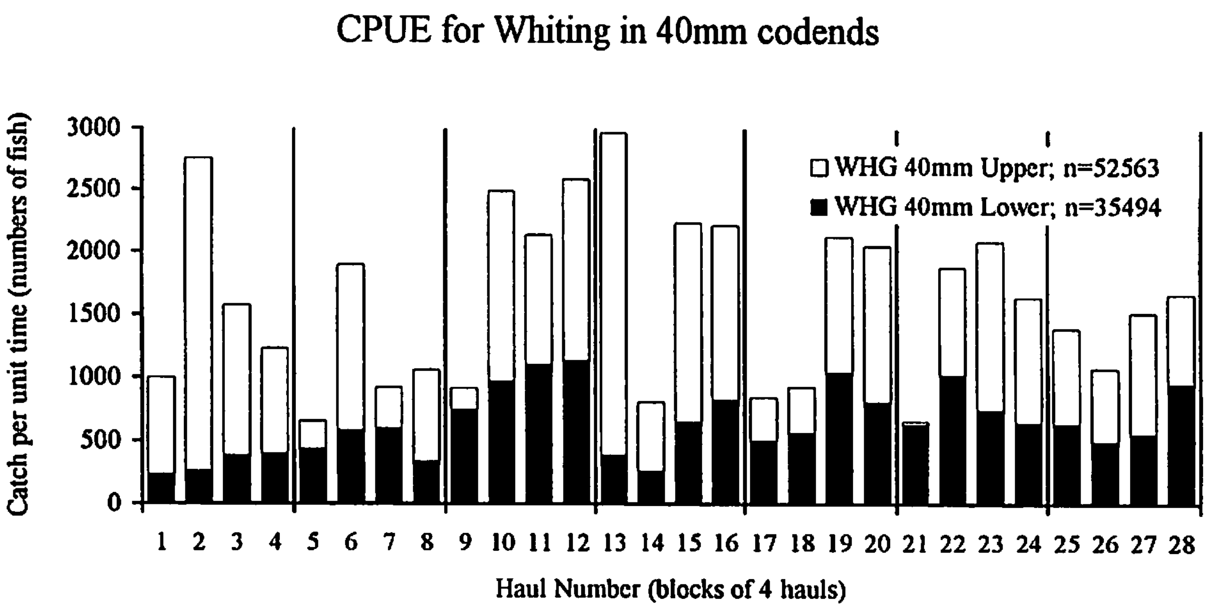



**Fig. 5 - Catch per unit effort (catch per hour) for whiting in 40mm codends**

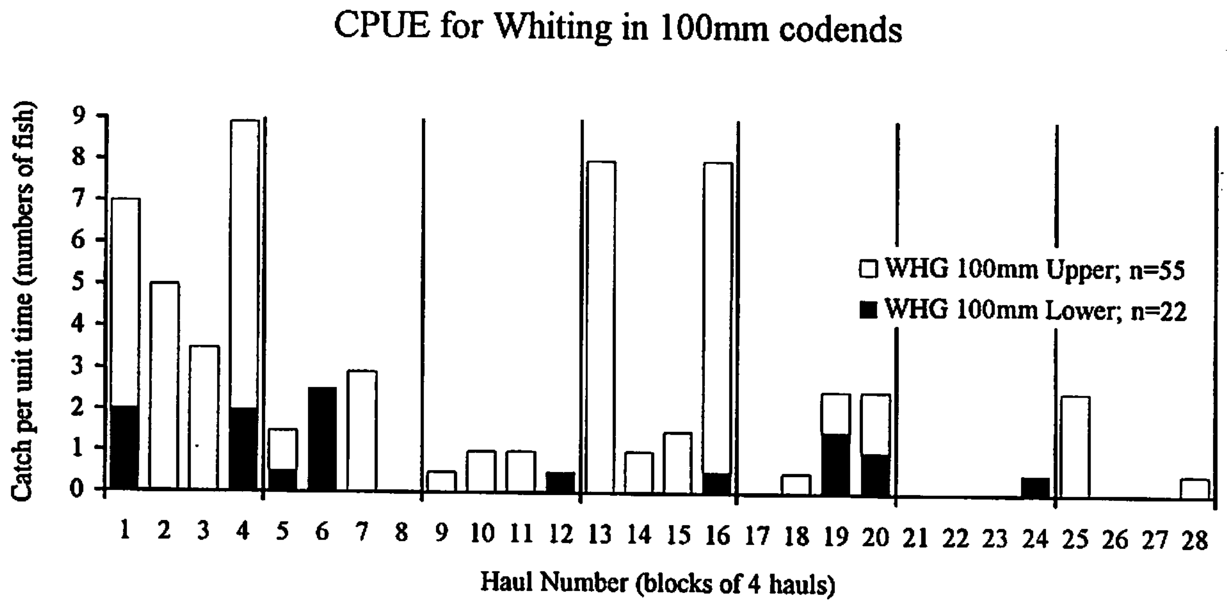



**Fig. 6 - Catch per unit effort (catch per hour) for whiting in 100mm codends**

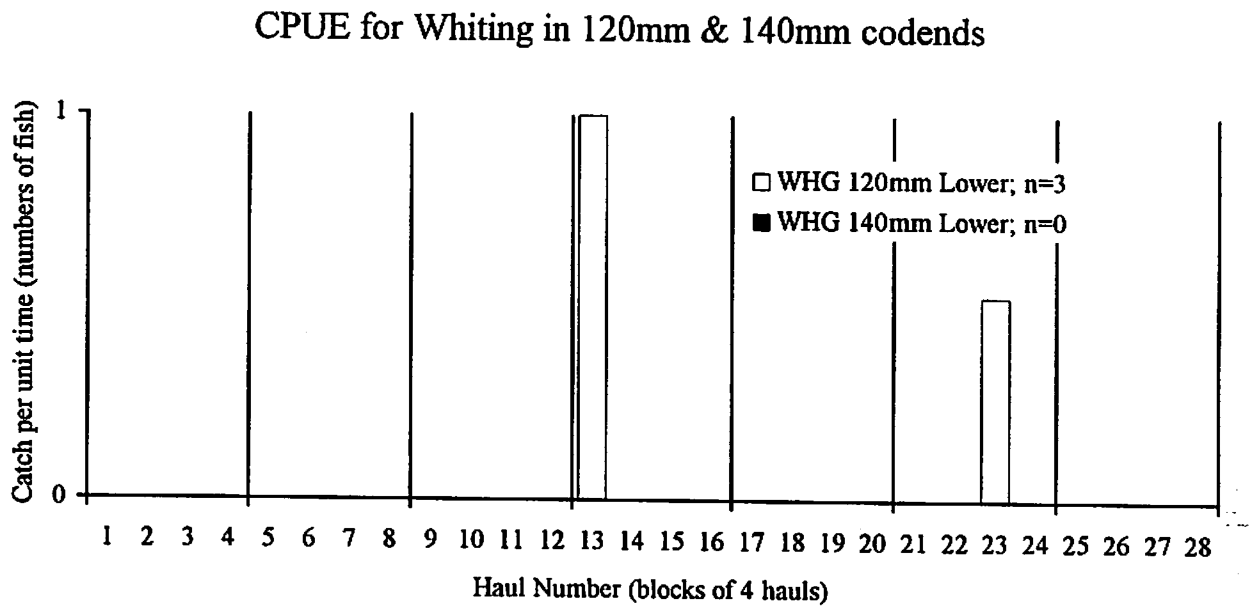



**Fig. 7 - Catch per unit effort (catch per hour) for whiting in 120mm & 140mm codends**

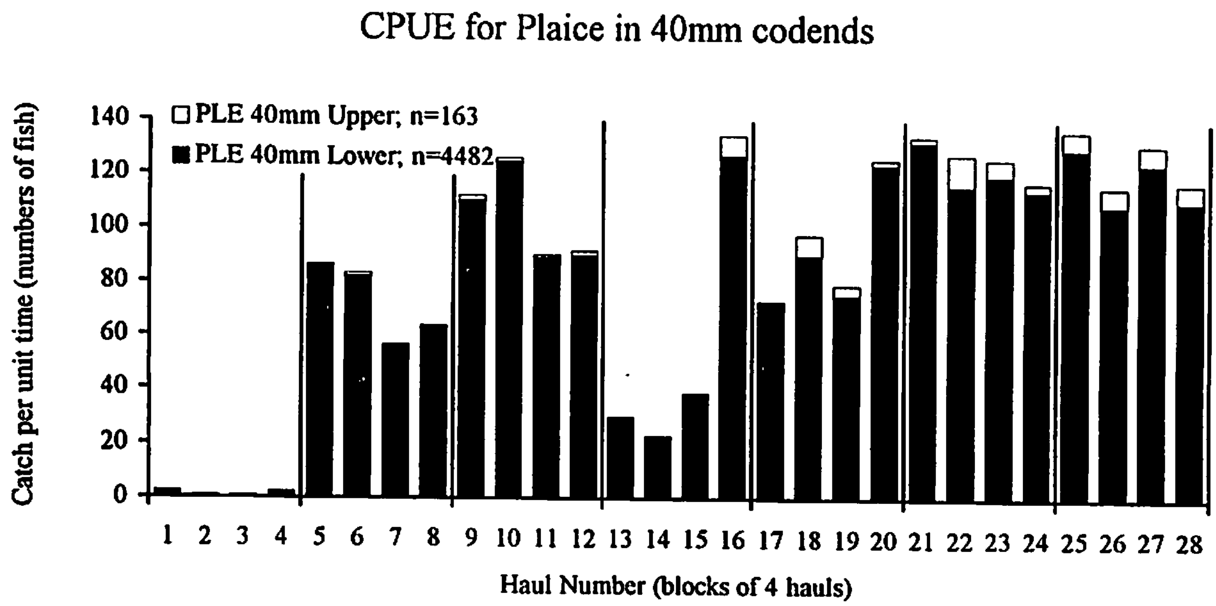



**Fig. 8 - Catch per unit effort (catch per hour) for plaice in 40mm codends**

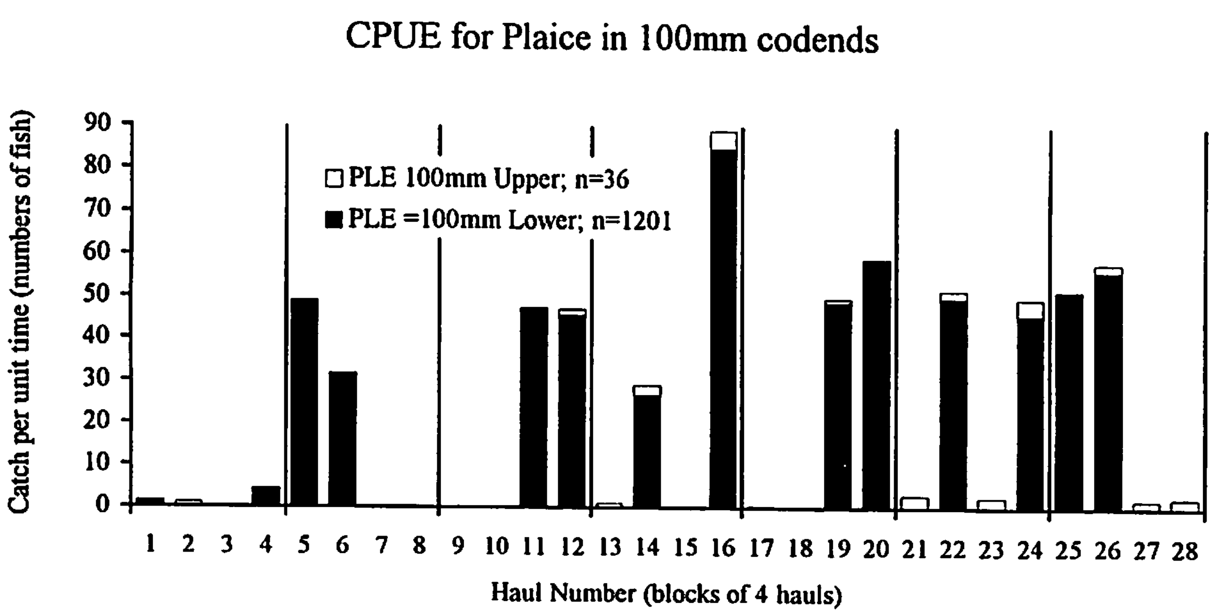



**Fig. 9 - Catch per unit effort (catch per hour) for plaice in 100mm codends**

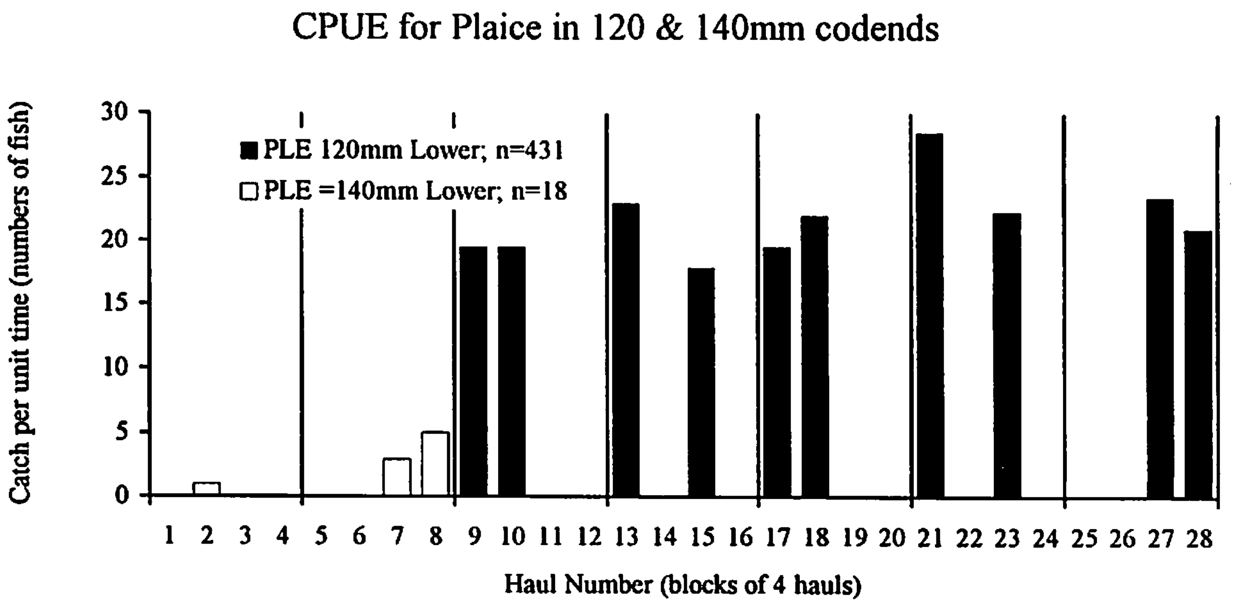



**Fig. 10 - Catch per unit effort (catch per hour) for plaice in 120mm & 140mm codends**

**40mm and 100mm codends**
Haddock predominated in the catches made with the 40mm codends in the first block. This coincided with the lowest catches of plaice taken with the 40mm codends and with the 100mm codends. In the 100mm codends the catches of haddock were relatively consistent. Whiting were caught consistently throughout the entire trial in the 40mm codends. These catches were much more sporadic with the 100mm codends, however.

These catch per effort results illustrate the strength of the 'blocks' experimental design. Despite variation in catch composition between blocks, all codend combinations have been fished in each block (with the exception of the 100mm/140mm combination; see Table 1, section 2.3 and Trials Narrative, Appendix I). Any variation in catches has therefore tended to be restricted to between individual blocks, rather than within any individual block.

## 4.2 Length Frequency Distributions

These are shown in figures 11 to 16 as aggregate length-frequency distributions by mesh size and codend position. With the exception of whiting in the 100mm codend adequate numbers of fish were observed in either the upper or lower codends to give valid length frequency curves. Comparison with the previous study shows that considerably larger numbers of smaller fish were captured in the small mesh codends in this study. This was expected because the smaller mesh size used in this study was 40mm rather than the 60mm size used in the previous study.

### 4.3 Selectivity of Target Species

*Note:*

i. The '50% retention length' or 'L50' for a particular species and mesh size in a codend is the fish length at which 50% of that fish species entering the codend are retained. Also given for 25% and 75% values.

ii. The 'Selection Range' (SR) is the difference between the L25 and L75.

iii. The selection factor for a particular species in a codend is the ratio of the L50 and the measured mean mesh size.

Cotter et al. (1994) describe fully the selectivity of all codends and species for which it was possible to obtain data on L50 and separation levels on a haul by haul basis for both this study and the previous study. This report has therefore concentrated on additional observations on selectivity relevant to gear technology. It is of particular importance to ensure that the design of the gear is optimised to take advantage of the behaviour and morphology of the species under consideration. This includes:

i. Ensuring that the separator panel gives adequate vertical separation at the mouth of the trawl.

ii. Ensuring that the selectivity device (in this case the mesh sizes of the twin codend configuration) is suitable for the size range of species concerned.

iii. The codend mesh opening is suitable for the morphology of the species and that the selectivity in terms of L50 and selection factor accord with the requirements of management.

Point (iii) is adequately described by Cotter et al. (1994). This report will therefore concentrate upon discussing vertical separation and selectivity.

### 4.4 Vertical Separation

The 1m distance between the footrope and the separator panel was not varied in any of the trials. Thus the results obtained in this trial are comparable with those from the previous trial (see Table 1, Seafish Report No. 441 (1994) and this report, Table 2 and figure 19).

Whiting and plaice were common to both studies and the two sets of results are consistent. Around 60-70% of whiting were captured in the upper codend in both studies, whilst >93% of plaice and flatfish were captured in the lower codend.

The majority of whiting and haddock were found in the upper codends. The separation for haddock in this trial was better overall than for whiting with 70-80% of haddock in the upper codends. Thus on the basis of these results, separation of plaice and other flatfish from haddock and whiting is feasible, but the separation rate was less for haddock than for whiting.

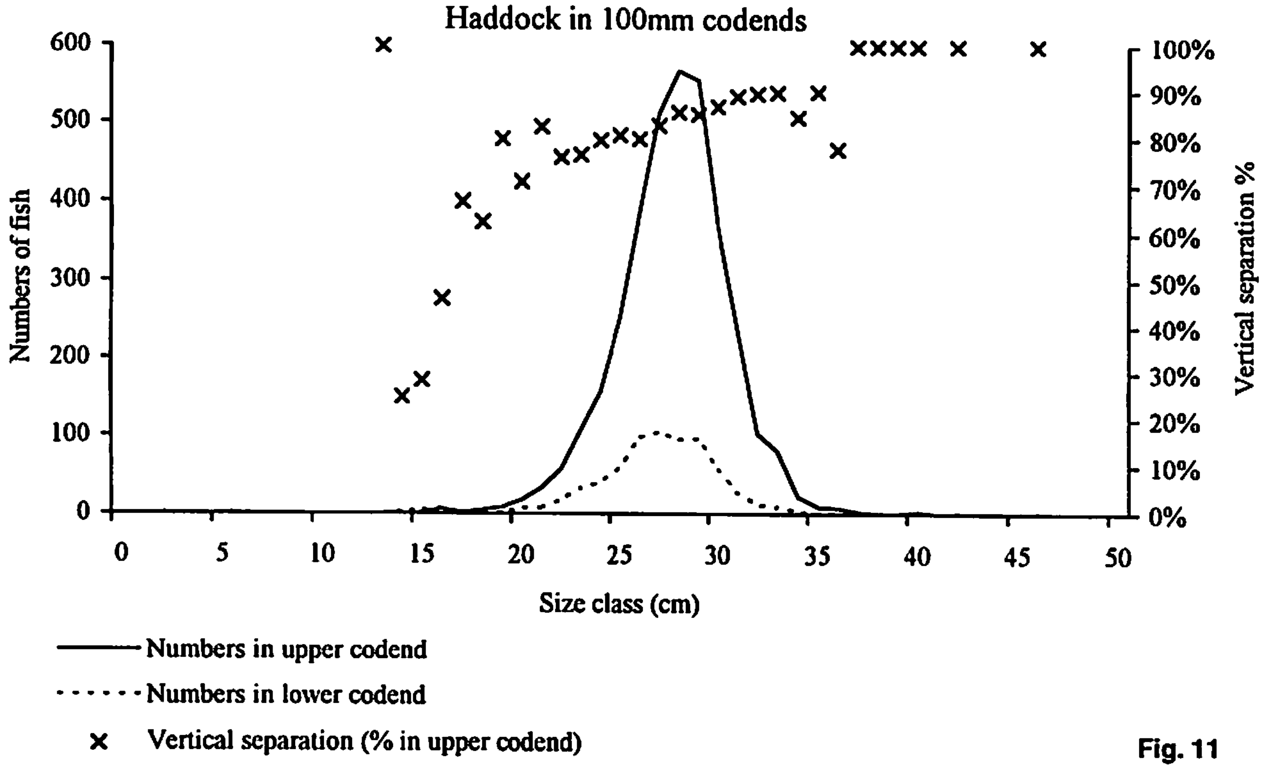
The vertical separations (%) with respect to fish length are described in figures 11-16. It can be clearly seen that this attribute is not constant. For haddock in 100mm codends and whiting in 40mm codends there is an apparent trend towards a higher separation in the larger fish size range, but satisfactory statistical correlations could not be found. If selectivity and vertical separation can both be optimised then the separator trawl will become a very attractive tool for use as a technical conservation measure.

For haddock in 100mm mesh, vertical separation to the upper codend ranges from 70% at 20cm to 90% at 33cm; for whiting in 40mm mesh, it ranges from 50% at 10cm to 80% at 23cm. Similar effects were observed for whiting in the previous trial, when it was found that the cumulative curve for the lower codends was displaced to the left of that for the upper codends (Seafish Report No. 441 section 5.2.3 & figure 26). A binomial fit using the logit link function confirms this trend, although the correlation is poor for haddock. This poor correlation could be due to:

i. The shoals being stratified with a higher proportion of smaller fish in the lower part of the shoal, thus resulting in a higher proportion of small fish in the catches in the lower codend.

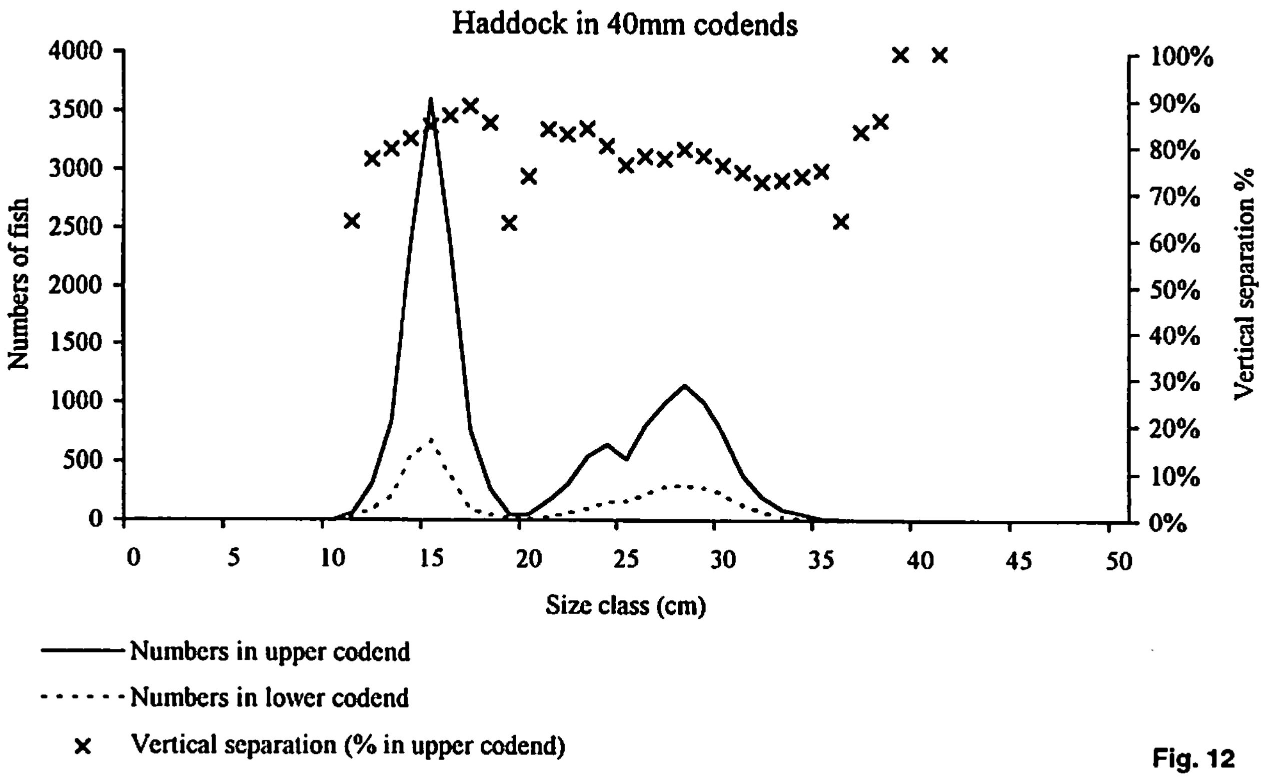
ii. The lower codends retain a higher proportion of small fish; this could be due to inherent differences in selectivity between lower and upper codends due to their relative positions.

In order to investigate this effect further the respective selectivities of the upper and lower codends were compared.



Haddock in 100mm codends
Numbers of fish
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
Size class (cm)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Vertical separation %
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in upper codend)


Fig. 11



Haddock in 40mm codends
Numbers of fish
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
40
45
50
Size class (cm)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Vertical separation %
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in upper codend)


Fig. 12

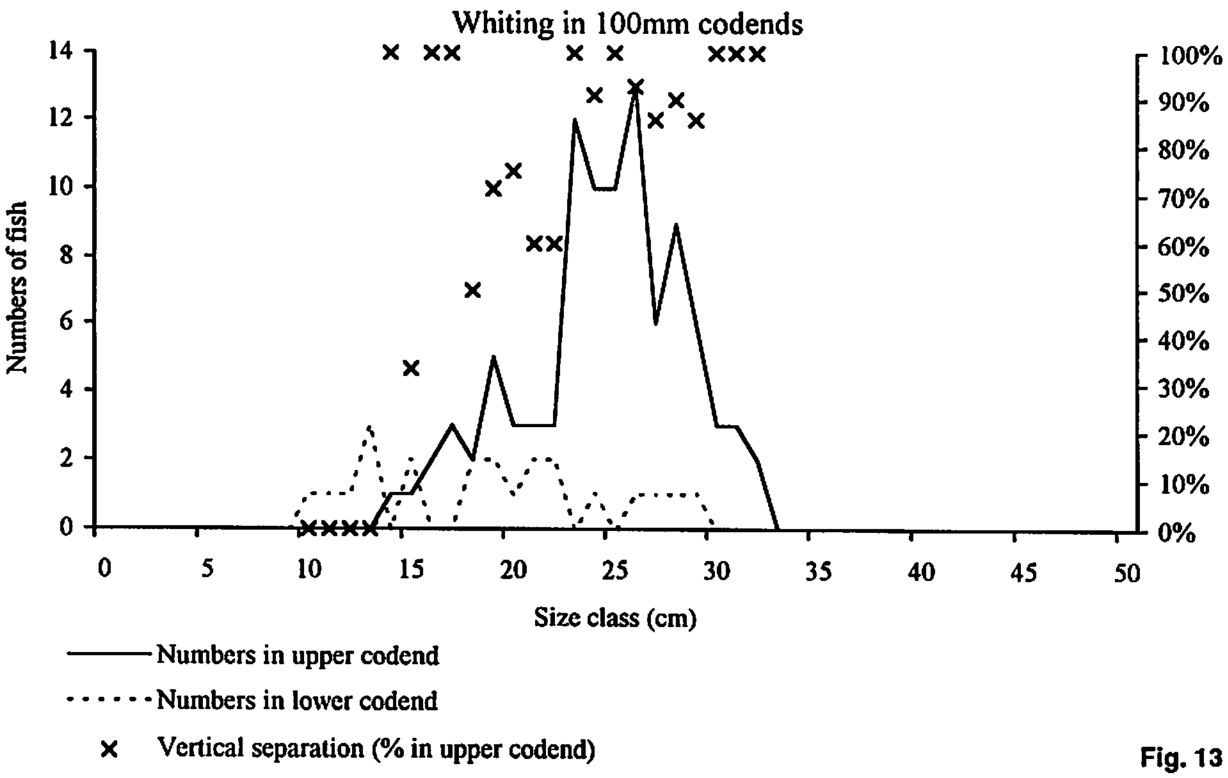

Whiting in 100mm codends
Numbers of fish
Vertical separation %
Size class (cm)
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in upper codend)

Fig. 13

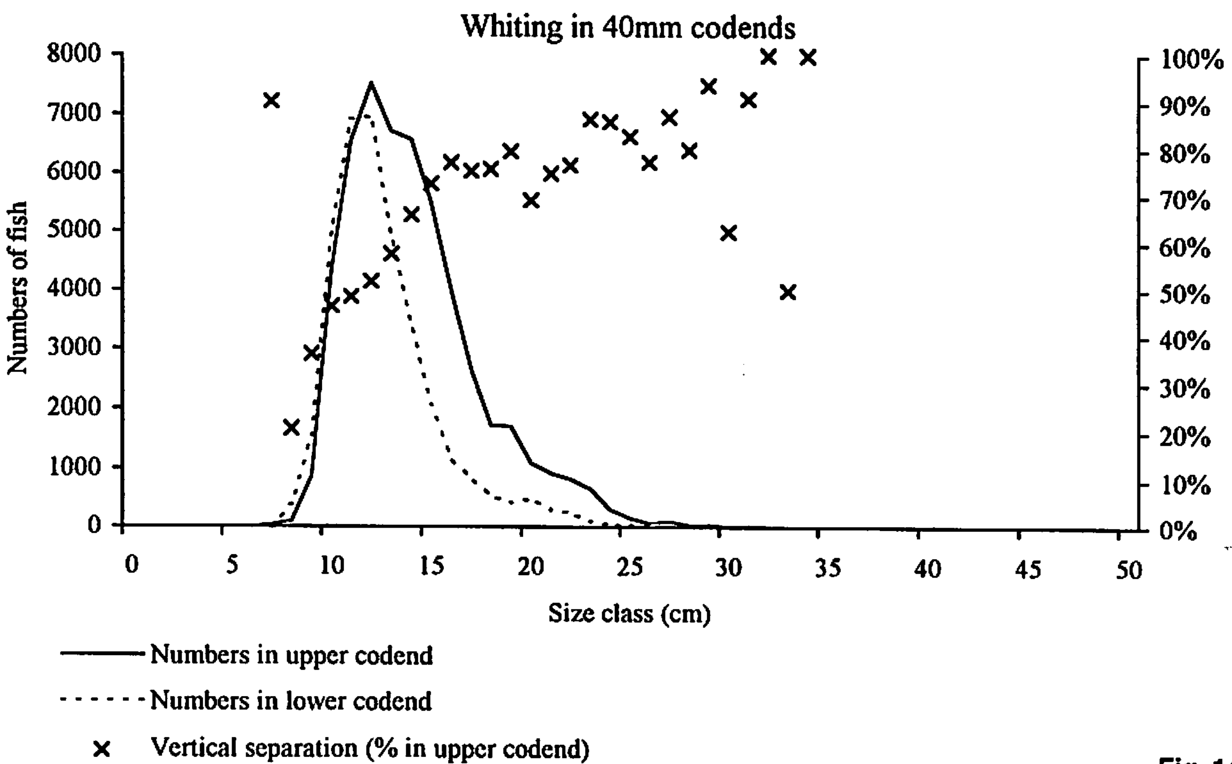

Whiting in 40mm codends
Numbers of fish
Vertical separation %
Size class (cm)
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in upper codend)

Fig. 14

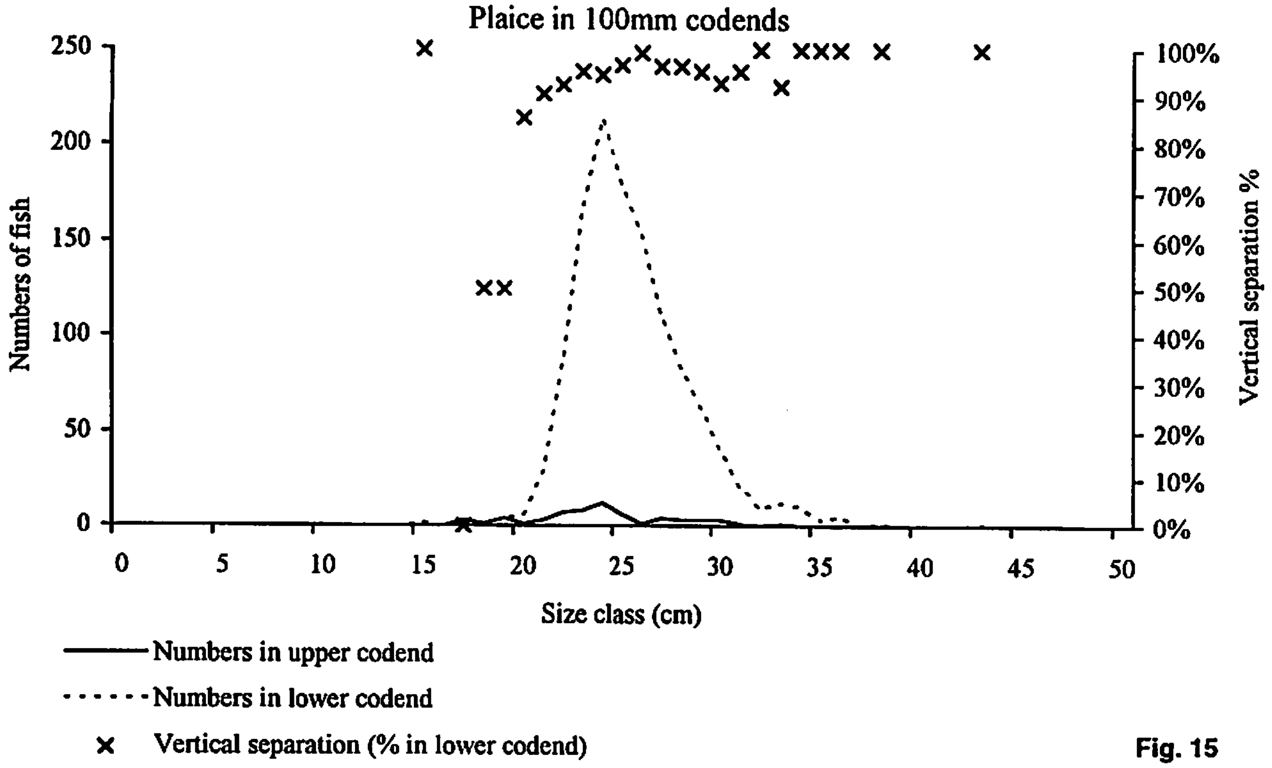

Plaice in 100mm codends
Numbers of fish
0
50
100
150
200
250
Vertical separation %
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
5
10
15
20
25
30
35
40
45
50
Size class (cm)
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in lower codend)

Fig. 15

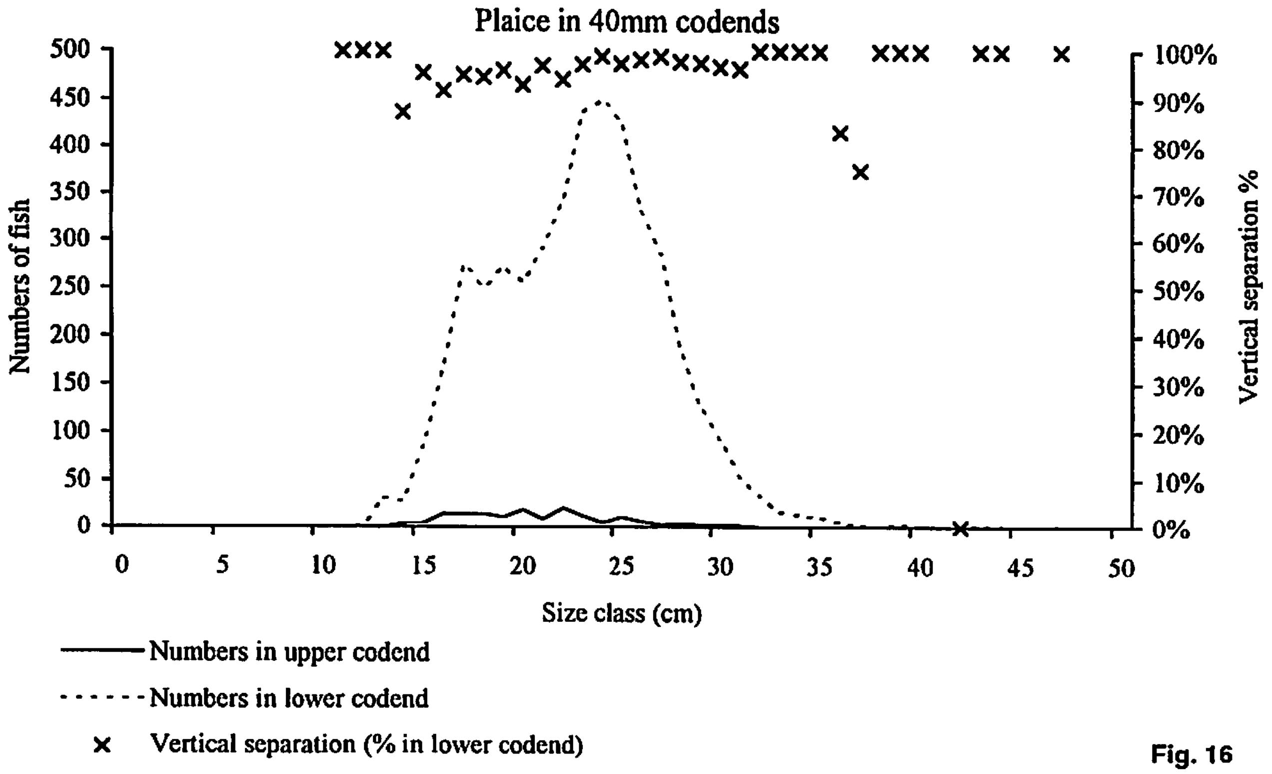

Plaice in 40mm codends
Numbers of fish
0
50
100
150
200
250
300
350
400
450
500
Vertical separation %
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
5
10
15
20
25
30
35
40
45
50
Size class (cm)
Numbers in upper codend
Numbers in lower codend
Vertical separation (% in lower codend)

Fig. 16

**Table 2**
**Separation levels between upper and lower codends for haddock, whiting, plaice and all flatfish combined**

| Target species | Mesh size | | Numbers of fish: Below MLS | Above MLS | Total | Percent: Below MLS | Above MLS | Vertical Separation % |
|---|---|---|---|---|---|---|---|---|
| Haddock: | 40mm | Upper | 16845 | 1516 | 18361 | 91.7% | 8.3% | 81.2% |
| | | Lower | 3729 | 510 | 4239 | 88.0% | 12.0% | 18.8% |
| | 100mm | Upper | 1300 | 402 | 1702 | 76.4% | 23.6% | 71.1% |
| | | Lower | 580 | 113 | 693 | 83.7% | 16.3% | 28.9% |
| | 120mm | Lower | 106 | 37 | 143 | 74.1% | 25.9% | n/a |
| | 140mm | Lower | 7 | 2 | 9 | 77.8% | 22.2% | n/a |
| Whiting: | 40mm | Upper | 52356 | 207 | 52563 | 99.6% | 0.4% | 59.7% |
| | | Lower | 35462 | 32 | 35494 | 99.9% | 0.1% | 40.3% |
| | 100mm | Upper | 38 | 17 | 55 | 69.1% | 30.9% | 71.4% |
| | | Lower | 19 | 3 | 22 | 86.4% | 13.6% | 28.6% |
| | 120mm | Lower | 3 | 0 | 3 | 100.0% | 0.0% | n/a |
| | 140mm | Lower | 0 | 0 | 0 | 0.0% | 0.0% | n/a |
| Plaice: | 40mm | Upper | 145 | 18 | 163 | 89.0% | 11.0% | 3.5% |
| | | Lower | 3650 | 832 | 4482 | 81.4% | 18.6% | 96.5% |
| | 100mm | Upper | 25 | 11 | 36 | 69.4% | 30.6% | 2.9% |
| | | Lower | 844 | 357 | 1201 | 70.3% | 29.7% | 97.1% |
| | 120mm | Lower | 161 | 270 | 431 | 37.4% | 62.6% | n/a |
| | 140mm | Lower | 6 | 12 | 18 | 33.3% | 66.7% | n/a |

| Target species | Mesh size | | Numbers of fish: Port side | St'b'd side | Total | Vertical Separation: Port side | St'b'd side |
|---|---|---|---|---|---|---|---|
| All Flatfish Combined | 40mm | Upper | 111 | 85 | 196 | 4.5% | 3.0% |
| | | Lower | 2352 | 2733 | 5085 | 95.5% | 97.0% |
| | 100mm | Upper | 40 | 23 | 63 | 5.3% | 4.1% |
| | | Lower | 711 | 538 | 1249 | 94.7% | 95.9% |
| | 120mm | Lower | 216 | 227 | 443 | n/a | n/a |
| | 140mm | Lower | 12 | 6 | 18 | n/a | n/a |

*Flatfish comprises Lemon sole, Dover sole, Turbot, Brill and Plaice*

**4.5 Selectivity of Haddock in Upper and Lower Codends**
The previous study (Seafish Report No. 441, section 5.2.2) found that the slope of the selectivity curve for whiting of the upper codend was significantly steeper than the slope of the selectivity curve of the lower codend but that there was no significant difference in the intercept. In order to examine whether this effect occurred for haddock the selectivity curves for the upper and lower 100mm mesh codends were compared (see figure 17). Both the slope and intercept were examined by Generalised Linear Model (GLM). It was indicated that there was a significant difference between the intercepts ($p<0.001$). This results in the selectivity curve from the upper codend being displaced to the right, resulting in a significantly higher L50 in the upper codend. These results should be treated with caution because any possible dependancy between length groups will distort this model.

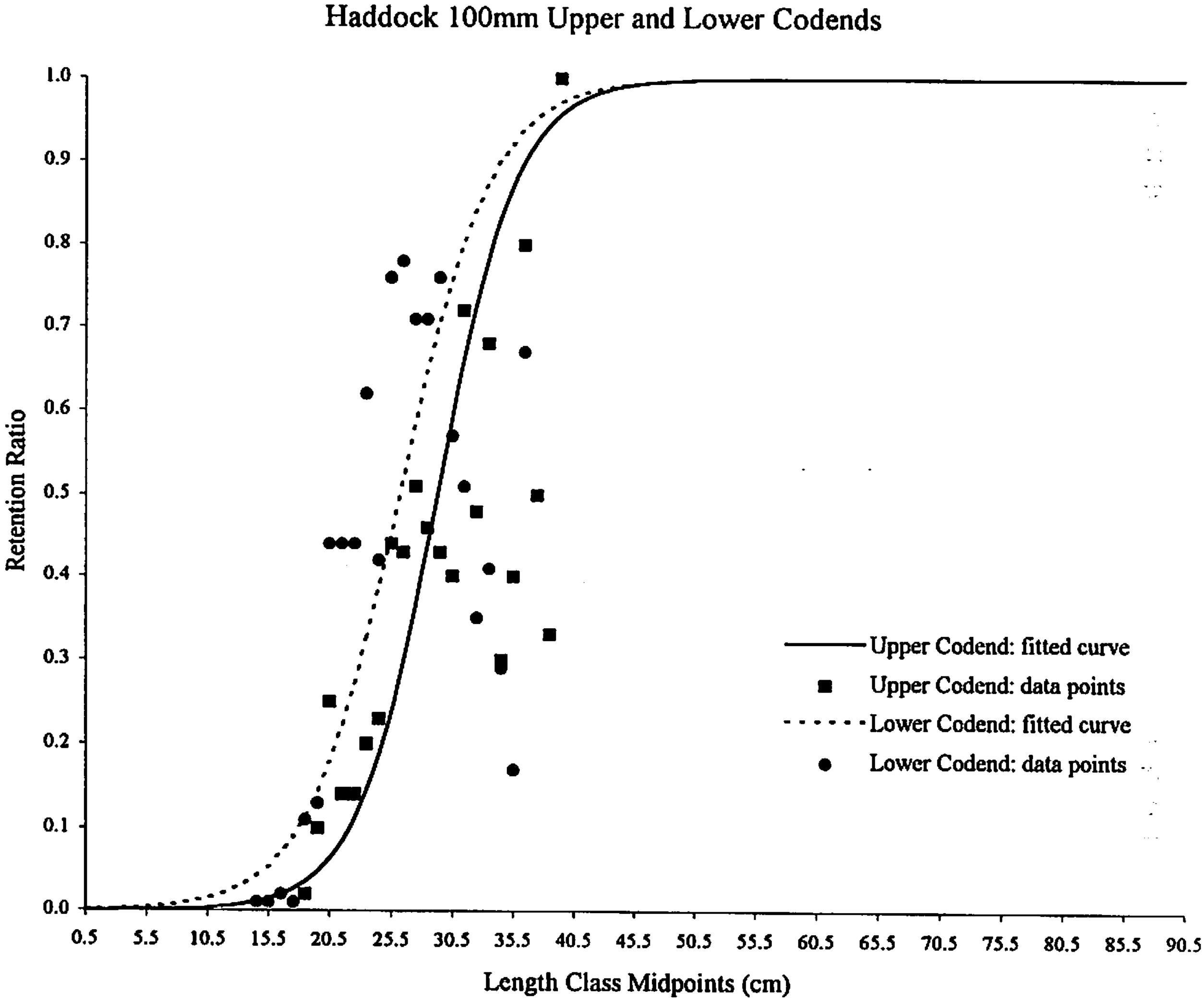
Thus, although the difference between the curves for haddock is due to a difference in the intercept, rather than the gradient, as for the whiting curves in the first trial, the effect for both cases is that the L50 is displaced to the right. This indicates that in both trials there was some difference in the selectivity characteristics of the upper and lower codend by virtue of position.

**4.6 Selectivity of Plaice in Upper and Lower Codends**
The vertical separation attribute dominates the selectivity for plaice (see figure 18). Very few fish entered the upper codend (3%) and so plaice cannot be considered in the same way as haddock. The steep gradient of the 100mm lower codend curve gives the impression that the codend is apparently selective for plaice, but the size distribution for plaice (figure 15) shows that the size range encountered was narrow with >95% in the range 20cm-33cm. This narrow size range gives a misleading impression of the selectivity for plaice.

**4.7 The Use of 40mm Mesh as a Reference Mesh Size**
Trial 1 used 60mm mesh as a reference; trial 2 used 40mm mesh. The use of this small mesh was to ensure that a representative sample of a fish population was taken (see section 2.2.2). However, use of this smaller mesh meant that very large quantities of undersized fish were caught, making both handling of the gear and data collection on board the vessel more difficult than in the previous trial. For whiting in 60mm mesh, 45% (3650 fish) were below MLS; for whiting in 40mm mesh, 99.6% (52,356 fish) were below MLS. For plaice in 60mm mesh, 46% (144 fish) were below MLS; for plaice in 40mm mesh, 81.4% (3650) were below MLS.

The use of 40mm mesh instead of 60mm for construction of reference codends appeared to gain little data accuracy, which is supported by the findings of O'Neill (1995).

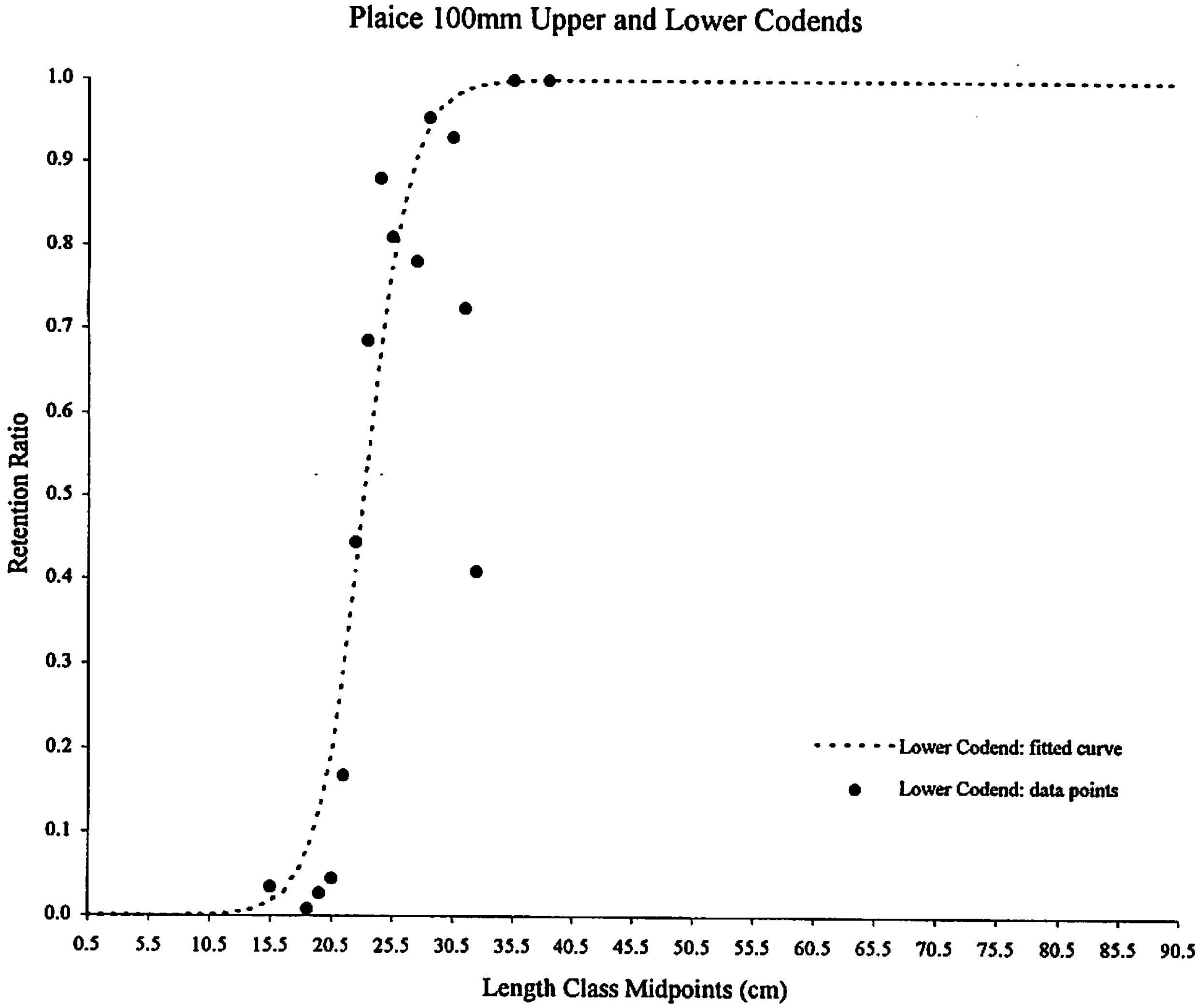
**4.8 The Assessment of Selectivity in Large Mesh Sizes**
Assessment of selectivity occurring when using large mesh sizes (>120mm) is difficult to achieve because many of the UK mixed species fisheries no longer provide adequate quantities of fish in the appropriate size ranges.




| Criterion | Upper Codend | Lower codend | Upper + Lower codends |
|---|---|---|---|
| 100mm: L50 | 29.3mm | 26.2mm | 28.7mm |
| 100mm: L25 | 25.7mm | 22.1mm | 25.0mm |
| 100mm: L75 | 32.9mm | 30.4mm | 32.5mm |
| 100mm Selection Factor | 2.9 | 2.6 | 2.9 |
| 100mm Selection Range | 7.2 | 8.3 | 7.5 |
| 100mm: No. in SR | 1378 fish | 535 fish | 1989 fish |
| 40mm: No. in SR | 2960 fish | 790 fish | 3981 fish |
| 100mm Total numbers | 1702 fish | 693 fish | 2395 fish |
| 40mm Total numbers | 10947 fish | 2525 fish | 13472 fish |

*HADDOCK IN 100mm CODEND*

**Fig. 17**




| Criterion | Upper Codend | Lower codend | Upper + Lower codends |
|---|---|---|---|
| 100mm: L50 | 22.7mm | 23.1mm | 23.1mm |
| 100mm: L25 | 20.3mm | 21.4mm | 21.4mm |
| 100mm: L75 | 25.2mm | 24.7mm | 24.7mm |
| 100mm Selection Factor | 2.3 | 2.3 | 2.3 |
| 100mm Selection Range | 4.9 | 3.3 | 3.4 |
| 100mm: No. in SR | 16 fish | 330 fish | 348 fish |
| 40mm: No. in SR | 36 fish | 674 fish | 711 fish |
| 100mm Total numbers | 36 fish | 1201fish | 1237 fish |
| 40mm Total numbers | 94 fish | 2338 fish | 2432 fish |

*PLAICE IN 100mm CODEND*

**Fig. 18**

A Comparison of Vertical Separations:
Trial 1 (Whitby, March 1994) and Trial 2 (Moray Firth, November 1994)

| Species | Mesh size | Vertical separation (% in Lower Codend) | |
|---|---|---|---|
| | | Trial 1, Whitby | Trial 2, Moray Firth |
| Haddock | 40mm | - | 19% |
| | 60mm | - | - |
| | 100mm | - | 29% |
| Cod | 40mm | - | 68% |
| | 60mm | 88% | - |
| | 100mm | 91% | 75% |
| Whiting | 40mm | - | 40% |
| | 60mm | 31% | - |
| | 100mm | 43% | 29% |
| Plaice | 40mm | - | 97% |
| | 60mm | 97% | - |
| | 100mm | 94% | 97% |
| All Flatfish | 40mm | - | 97% |
| | 60mm | 97% | - |
| | 100mm | 93% | 96% |

*60mm reference codend was used only in Trial 1, Whitby*
*40mm reference codend was used only in Trial 2, Moray Firth*

**Fig. 19**

A Comparison of Selectivity Criteria: Retention Lengths
Trial 1 (Whitby, March 1994) and Trial 2 (Moray Firth, November 1994)

| Species | Mesh size | Retention lengths (cm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Trial 1 | | | Trial 2 | | |
| | | L75 | L50 | L25 | L75 | L50 | L25 |
| Cod | 100mm Lower | 35.9 | 32.6 | 29.4 | - | - | - |
| | 140mm Lower | 74.4 | 64.7 | 54.9 | - | - | - |
| | 100mm Upper | 43.6 | 37.7 | 31.8 | 33.9 | 29.3 | 25.7 |
| Whiting | 100mm Lower | 34.3 | 30.5 | 26.7 | 30.4 | 26.1 | 22.1 |
| | 100mm Upper + Lower | 41.5 | 35.8 | 30.2 | 32.5 | 28.8 | 25.0 |
| | 100mm Upper | - | - | - | 25.2 | 22.7 | 20.3 |
| Plaice | 100mm Lower | - | - | - | 24.7 | 23.1 | 21.4 |
| | 100mm Upper + Lower | - | - | - | 25.0 | 23.0 | 21.2 |
| | 140mm Lower | 39.0 | 35.0 | 31.0 | - | - | - |

**Fig. 20**

# 5. Commercial Considerations

Vertical separation is a more important attribute to fishermen than differences in selectivity between upper and lower codends. Separator trawls are usually used when there is a need to separate incompatible parts of the catch, for example, flatfish/roundfish, prawns/fish and high levels of debris/delicate species.

Figures 11-16 show that vertical separation may be dependant on fish size, so the performance of the gear is likely to be different when working on different 'runs' of fish of the same species (see section 4.4, 'Vertical Separation').

It can be confirmed that, as in trial 1, the presence of a separator panel in a trawl does not hinder its deployment. The panel is at little risk to damage, and if it is constructed with its own frame rope the panel can be removed if required (Seafish Report No. 441, section 6.2). However, it could be difficult to provide accurate legislation for use of separator panels.

The upper and lower codends and extensions were made in identical lengths in order to be comparable. However, Arkley et al (1995) indicated that there was evidence to suggest that the upper codend could be masking escapes from the lower codend. This argument is supported in observations made during the second trial (see section 4.5). To avoid the risk of masking in a commercial application of a separator trawl, the lower codend would be made longer than the upper. This extra length may cause some minor handling problems for smaller vessels, however.

The use of 140mm mesh and 120mm mesh codends would have severe consequences for fishermen, as it caught so few fish. The numbers of baskets of fish caught are given below for mixed fish sizes and species (see Appendix IV, Haul Details):

**Table 3 - Mean numbers of baskets per haul for each codend type**

| Codend | | 40L | 100L | 120L | 140L | 40U | 100U |
|---|---|---|---|---|---|---|---|
| Number of baskets | Mean: | 4.7 | 1.7 | 1 | 0.3 | 3.7 | 0.9 |
| | Std Dev: | 1.7 | 0.5 | 0.3 | 0.1 | 1.7 | 0.5 |

A twin-rigged separator trawl with four codends is not likely to find a niche in commercial fishing due to the complicated nature of the gear. However, it is an excellent tool for obtaining selectivity data, as it allows many cross-comparisons between different codends to be made.

## 6. Conclusions

i. The separator trawl divides the total catch into two fractions whose composition is dependant on the type of fish behaviour exhibited at the mouth of the net. Different codends can be used on each of these fractions with much more effective results than by applying a single codend to the whole catch. The separator trawl is therefore a useful means of enhancing the effectiveness of mesh size regimes in the mixed species fishery which was prosecuted.

ii. Separation levels were determined for haddock, whiting, plaice and all flatfish species combined. For haddock in 100mm mesh, vertical separation to the upper codend was 71%. For whiting in 100mm mesh, vertical separation to the upper codend was also 71%. Very few cod were caught. With the 40mm small-meshed upper and lower reference codends, 75% of cod (68 fish) were found in the lower codend. Vertical separation to the lower 100mm codend for plaice and for all flatfish combined was 97% and 96% respectively. Whiting were the most frequently encountered species.

iii. The vertical separation data and the estimated selectivity parameters from this trial are comparable with those of the previous trial made off Whitby (see figures 19 and 20). This indicates that the separator trawl can perform consistently in different fisheries, despite the use of different ground gears and the exploitation of different fish populations.

iv. There is evidence to suggest that upper and lower codends in identical mesh sizes have different selectivity properties, purely due to their position.

## 7. Acknowledgements

Seafish would like gratefully to acknowledge the following:

i. The skipper and crew of *MFV HEATHER SPRIG (BCK181),* for providing their vessel and expert seamanship during the trials.

ii. Dr John Cotter for his helpful advice in the design of the experiment and for the statistical analysis of these trials.

iii. Mr Trevor Boon of MAFF DFR, Lowestoft, for his assistance with the measurement of fish and logging of data.

iv. Mr Jack Robertson and Mr Peter Barkel of SOAFD, Aberdeen, for providing their expertise in operating the SOAFD underwater TV and obtaining some remarkable video footage of the gear underwater.

These trials were financed by the Ministry of Agriculture, Fisheries and Food.

# 8. References and Bibliography

**References:**

Arkley, K., W. Lart and J. Swarbrick, 1995, 'Sea Trials to Evaluate Selectivity of Separator Trawls used to Catch Mixed White Fish Species', Report No. SR441, Sea Fish Industry Authority, Hull.

Cotter, A. J. R., T. W. Boon and C. G. Brown, 1995, 'Statistical Aspects of trials of a Separator Trawl using a Twin Rig Trawler', MAFF Dir. Fis. Res., Lowestoft. (Unpub).

Millar, R. B. and S. J. Walsh, 1992, 'Analysis of trawl selectivity studies with an application to trouser trawls', Fis. Res. 13 , pp205-220.

O'Neill, F. G. and R. J. Kynoch, 1995, 'The Effect of Cover Mesh Size and Cod-End Catch Size on Cod-End Selectivity', Scottish Fisheries Working Paper No. 4/95, SOAFD, Aberdeen.

**Bibliography:**

Galbraith, R. D. and J. Main, 1989, 'Separator panels for dual purpose fish/prawn trawls', Scottish Fisheries Information Pamphlet No. 16, DAFS (SOAFD), 8pp.

Main, J. and G. I. Sangster, 1982, 'A study of separating fish from *Nephrops norvegicus* L. in a bottom trawl', Scottish Fisheries Research Report No. 24, DAFS (SOAFD), 8pp.

Main, J. and G. I. Sangster, 1985, 'Trawling experiments with a two-level net to minimise the undersized gadoid by-catch in a Nephrops fishery', Fisheries Research, 3: 131-145.

Main, J. and G. I. Sangster, 1981, 'A study of fish capture process in a bottom trawl by direct observations from a towed underwater vehicle', Scottish Fisheries Research Report No. 23, DAFS (SOAFD), 23pp.

Main, J. and G. I. Sangster, 1991, 'A different approach to covered codend selection experiments' Scottish Fisheries Working Paper No. 4/91, DAFS (SOAFD), 9pp.

Robertson, J. H. B., A. M. Shanks and R. J. Kynoch, 1990, 'The design and testing of a divided trawl for comparative fishing experiments', Scottish Fisheries Research Report No. 49, DAFS (SOAFD), 13pp.

Stewart, P. A. M. and J. H. B. Robertson, 1985, 'Small meshed codend covers', Scottish Fisheries Research Report No. 32, DAFS (SOAFD), 11pp.

# APPENDIX I

## Trials Narrative

**Present:**

K. Arkley, Marine Technology, Seafish, Hull (set-up phase).

J. Swarbrick, Marine Technology, Seafish, Hull (all phases).

R. Horton, Marine Technology, Seafish, Hull (all phases).

T. Boon, Ministry of Agriculture, Fisheries and Food (MAFF) Directorate of Fisheries Research (DFR), Lowestoft (all phases).

J. Robertson, Scottish Office, Agriculture and Fisheries Department (SOAFD), Aberdeen (underwater observation phase).

P. Barkel, SOAFD, Aberdeen (underwater observation phase).

**Phases of the exercise:**

Phase 1: Set-up phase, 14 November.
Phase 2: Underwater observation phase, 15-17 November.
Phase 3: Fishing trial phase, 18-31 November.
Phase 4: Dismantling phase, 30 November.

**Phase 1: Set-up phase**
Twin 20.1m (66ft) trawls loaded onto the net drum on *MFV HEATHER SPRIG,* together with sweeps. Alternative codend arrangements stowed on board and made ready for use.

**Phase 2: Underwater observations**
Tuesday 15th November to Thursday 17th November. Underwater observations were made with the assistance of SOAFD personnel and ROV. Gear fine tuned for optimum behaviour.

**Phase 3: Fishing trial**
Friday 18th November. J. Swarbrick, R. Horton (Marine Technology, Seafish) and T. Boon (DFR Lowestoft, MAFF) joined *MFV HEATHER SPRIG* at 23:00. SOAFD RCTV and ROV equipment used for underwater verification of the performance of the experimental gear during the previous 3 days had been removed from the vesseL Weather forecast: wind SE gale 8 veering SW 4-5, incr. gale 8 occ. 9 later on Saturday. Following consultations with the skipper, it was decided to sail at 08:00 the following morning. Gale developed full strength about 23:00.

Saturday 19th November. Sailed Buckie 08:00. Measured 40mm and 120mm codends (ICES gauge) and found the mean mesh size for the nominal 120mm codends to be 111mm with a high degree of variation in mesh sizes. Attempted to source a new codend of 120mm mesh size. Mean for the nominal 40mm codends was 38mm, and for the 100mm codends the means were exactly

100mm. It was decided that it would be appropriate to omit hauls containing 120mm variants (until such time as a replacement 120mm codend could be supplied if possible). The 140mm codend was deployed in blocks of four hauls to its suitability to the size range of fish on the grounds. Weather fine; WNW moderate swell. Managed to obtain 2 hauls of 2 hours duration each on grounds about 9 miles N of Fraserburgh. About 7 baskets of mixed small haddock and whiting were taken in the upper 40mm codends on each haul. Vertical separation was 90% for haddocks in small codend. Scanmar was used all hauls. Bad forecast for tomorrow (W gale 8). Finished hauls at about 17:00, and in view of the poor forecast it was decided to dock in Fraserburgh for the night. Arrived Fraserburgh at about 20:10.

Sunday 20th November. Sailed Fraserburgh 04:15 and made first shot at 06:10. Wind SW4; sea W mod. Made 2 hauls of 2 hours each about 9 miles north of Fraserburgh. Fishing was very poor; attempted to move northwards to different grounds in response to reports of better fishing from other vessels, but bad weather head-to-wind prevented this. Completed a block of 4 hauls with the 140mm codend. Weather deteriorated rapidly, wind W 7-8; sea rough out of any lee. Forecast was for strong westerly winds for the next 3 days. Following consultations with the skipper and crew, it was decided to put into Buckie for the night - arrived 17:20.

Monday 21st November. Sailed Buckie 03:20, heading for Beatrice oil field, north side of Moray Firth, about 18 miles NW of Buckie. Successfully made 4 hauls to complete a block of four using the 140mm codend. Catches comprised plaice, haddock and whiting. No other vessels in the vicinity reported any significant cod catches. Size range of roundfish on the grounds was found to be not ideally suited to 140mm, but the 140mm provided good data for plaice. As another 120mm codend had been successfully sourced, further hauls were to be made in blocks of 4 using 120mm mesh. Weather good compared with previous forecasts. Separator panels gave good vertical separation between good quality haddock and any other haddock of the same size but in poor condition (disease and ectoparasites) as well as for very small group 0 haddock. It was intended to examine catch data for 100mm and 40mm upper codends to check for any back-pressure in the 40mm codends. Dark hauls proved to give better catches of haddock than daylight hauls, so following appropriate consultations it was proposed that further work in this fishery be carried out during hours of darkness to take advantage of this. Vessel returned to Buckie to collect new 120mm codend; arrived Buckie at 20:50.

Tuesday 22nd November. In Buckie: checked to see if 40mm upper codend was losing large haddock compared with the upper 100mm codend, and hence an indication of 'wash-back' in the extension. The data from the previous 2 blocks showed that the 40mm was better at retaining large fish than the 100mm, i.e. the 100mm was losing them as a result of escapes. New 120mm codend found to be 120 mesh circumference, 59 meshes long; required dimensions were 100 mesh circumference, 50 meshes long. Ten meshes were gathered into each lastridge and 10.5 meshes were removed from the extension section in order to match the length and circumference of the discarded 120mm codend. Sailed from Buckie at 12:55 to fish during the night; weather fine, sea slight. Arrived Beatrice oilfield grounds 18 miles NW of Buckie at 16:00 and made first shot at 16:30. Weather forecast was poor for the following day (W 5-7 occ gale 8).

Wednesday 23rd November. Successfully completed another block of 4 hauls entirely in the dark, taking advantage of a showing of haddock. Departed Beatrice grounds at 04:30 and arrived Buckie at 07:00. Weather deteriorating; WNW 7 to gale 8. This had caused some delay to further operations. Spare part for load cell equipment collected in Buckie. Fish landed : 2 boxes of poor quality haddock, half a box of plaice, 6.4kg (1 stone) each of cod and lemon sole, and 19kg (3 stone) of monk, which made £129. It was the intention to sail early next morning to put in a block of 4 day hauls, weather permitting.

Thursday 24th November. Sailed Buckie at about 04:00 and arrived on grounds 12 miles NNW of Buckie at about 06:00, and the first shot made at 06:05. Wind SW 3-4; sea slight SW, but freshening. Successfully made another block of 4 hauls using the 120mm codend, with the dawn and dusk hauls yielding the best catch. Fishing was still very poor, with fractions of a basket being taken in the large meshed codends. Although this fishery had been established as essentially a night fishery, it was found difficult at this stage to resume night work again without losing potential day fishing time, and so the decision was made to move further offshore to potentially more productive grounds. This took advantage of a forecast weather window (SW 3-4). There was the option of resuming night operations after the proposed weekend break if the offshore grounds were unproductive.

Friday 25th November. Arrived on West Bank grounds 40 miles north of Fraserburgh and made first shot at about 04:45. Winds light (SW 1) at first. Came fast after 90 minutes on sand ridges, with no net damage. On hauling, it was found that the catch comprised mainly borderline whiting in the upper codends, and so it was decided to shift grounds 10 miles to the southwest before re-shooting for the start of the next block. This haul was invalidated.

Arrived new ground about 35 miles NNW of Fraserburgh at about 08:45. Made a very disappointing haul comprising monk, rays and dogfish (lesser spotted), with a couple of dozen whiting mixed in. The haul was quantified in bulk form, but as the catch comprised irrelevant species it was not measured and the haul was invalidated. It was decided that at this halfway stage in the trial the best use of the remaining time was to alternate the nets from side to side (to confound any possible net bias), re-measure the codend meshes and resume night fishing operations on the Beatrice oilfield grounds, Moray Firth, where catches of haddock had been taken previously during this exercise. ETA 16:00, dusk. During the net swap, two shackles at the leading ends of the combination sweeps were replaced due to the pins bending, and two smashed headline floats of 20cm (8 inch) diameter were replaced.

Successfully completed another block of 4 hauls on the Beatrice ground. Five blocks had been completed with two charter days left. Because of the scarcity of fish, it was likely that these remaining two days would be spent fishing at night on these grounds. Vessel proceeding toward Buckie harbour, ETA 07:00 Saturday morning.

Saturday 26 November. Arrived Buckie 07:30. Landed for Saturday's market and made £379. The rest of the morning was spent catching up on sleep, with the afternoon as time off.

Sunday 27 November. Time off.

Monday 28th November. Morning given as time off; afternoon departure for night fishing operations on the Beatrice oilfield grounds. Sailed Buckie about 14:30 and made first dark shot at 17:17. Suspected that the first haul had a twisted upper small meshed codend, as there were very few small fish in that codend. Haul counted as valid, due to small fraction of catch in question.

Successfully made another block of 4 hauls in the dark on the Beatrice oilfield ground. A better run of haddock was encountered that on previous occasions. Returning to Buckie, ETA 08:00.

Tuesday 29th November. Sailed Buckie at about 13:00 and made first shot at 16:40 on the Beatrice oilfield ground. Successfully completed another block of 4 hauls in the dark. Weather flat, oily calm. Fishing still very poor, with the maximum catch for the night being 6 baskets taken in a 40mm codend. Arrived back in Buckie at about 07:45. In the afternoon, the trawl gear was offloaded onto the quay and the ground gears were disassembled in readiness for loading onto transportation the following morning.

Wednesday 30th November. Made another set of codend mesh measurements with the following codends:

Two 40mm codends
Two 100mm codends
One 120mm codend
One 140mm codend

**Phase 4: Dismantling phase**
Stripped down fishing gear. Prepared gear for loading onto lorry.

Thursday 1st December. Loaded gear onto lorry; Seafish team then departed 10:00 for Hull, arrive 19:30.

# APPENDIX II

## Codend Mesh Measurements (mm)

**[Key to abbreviations at end]**

| 40mm mesh (top c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | New, wet | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | 1 | | | | | |
| 33 | | | | | | |
| 34 | | | | 1 | | 1 |
| 35 | 1 | 1 | | 1 | | 3 |
| 36 | 1 | 3 | | 2 | 1 | 5 |
| 37 | 6 | 7 | | 5 | 12 | 6 |
| 38 | 6 | 5 | 4 | 7 | 6 | 2 |
| 39 | 2 | 4 | 5 | 3 | 1 | 2 |
| 40 | 2 | | 8 | 1 | | 1 |
| 41 | | | 3 | | | |
| 42 | 1 | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 37.7 | | | | | | |

| 40mm mesh (top c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | |
| 33 | | | | | | |
| 34 | | | | | | |
| 35 | 3 | | | | | |
| 36 | 3 | 1 | | | 1 | |
| 37 | 3 | 2 | 3 | 3 | 3 | 3 |
| 38 | 7 | 8 | 4 | 1 | 9 | 10 |
| 39 | 3 | 8 | 8 | 2 | 3 | 7 |
| 40 | 1 | 1 | 5 | 14 | 4 | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 38.2 | | | | | | |

| 40mm mesh (top c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | |
| 33 | | | | | | |
| 34 | | | | 1 | | |
| 35 | | | | | | 3 |
| 36 | | | | 1 | 1 | 2 |
| 37 | 2 | 8 | 2 | 14 | 10 | 5 |
| 38 | 6 | 9 | 4 | 3 | 8 | 4 |
| 39 | 4 | 1 | 6 | 1 | 1 | 3 |
| 40 | 7 | 2 | 8 | | | 3 |
| 41 | 1 | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 38 | | | | | | |

| 40mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | New, wet | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | 1 |
| 33 | | | | | | |
| 34 | | | | | 2 | |
| 35 | | | 2 | 2 | 5 | 2 |
| 36 | 3 | | 2 | 1 | 2 | 1 |
| 37 | 6 | 3 | 8 | 4 | 4 | 8 |
| 38 | 7 | 10 | 5 | 11 | 2 | 7 |
| 39 | 3 | 7 | 3 | 1 | 5 | 1 |
| 40 | 1 | | | 1 | | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 37.5 | | | | | | |

| 40mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | |
| 33 | | | | | | |
| 34 | | | | | | |
| 35 | | 1 | | 1 | | |
| 36 | 7 | 2 | 8 | 3 | 2 | 6 |
| 37 | 5 | 9 | 6 | 5 | 10 | 4 |
| 38 | 7 | 7 | 5 | 4 | 7 | 9 |
| 39 | 1 | | 1 | 5 | 1 | 1 |
| 40 | | 1 | | 2 | | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 37.2 | | | | | | |

| 40mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | |
| 33 | | | | | | 1 |
| 34 | | | | | 1 | 1 |
| 35 | | | 2 | | 2 | 4 |
| 36 | 1 | 3 | 5 | 1 | 1 | 6 |
| 37 | 4 | 9 | 3 | 4 | 9 | 4 |
| 38 | 11 | 7 | 4 | 10 | 6 | 3 |
| 39 | 3 | 1 | 6 | 5 | 1 | 1 |
| 40 | 1 | | | | | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 37.2 | | | | | | |

| 100mm mesh (top) | | | | | | |
|---|---|---|---|---|---|---|
| | Used, wet | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | 1 | | | | | |
| 95 | | | | | | |
| 96 | | 1 | | | | 1 |
| 97 | 4 | 1 | 1 | 2 | 3 | |
| 98 | 2 | 4 | 1 | 2 | 3 | 2 |
| 99 | 2 | 4 | 3 | 2 | 3 | 4 |
| 100 | 7 | 8 | 8 | 9 | 5 | 9 |
| 101 | 2 | 2 | 3 | 4 | 3 | 3 |
| 102 | 1 | | 3 | 1 | 3 | 1 |
| 103 | | | 1 | | | |
| 104 | 1 | | | | | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 99.7 | | | | | | |

| 100mm mesh (top) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | | | | | | |
| 95 | | | | | | |
| 96 | | | | | | |
| 97 | 1 | 1 | 2 | | | |
| 98 | 2 | | | 1 | 2 | |
| 99 | 2 | 3 | 1 | 6 | 4 | 4 |
| 100 | 10 | 6 | 6 | 3 | 9 | 10 |
| 101 | | 3 | 5 | 2 | 4 | 3 |
| 102 | 4 | 3 | 4 | 5 | 1 | 1 |
| 103 | 1 | 1 | 1 | 2 | | 2 |
| 104 | | 3 | 1 | | | |
| 105 | | | | 1 | | |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 100.5 | | | | | | |

| 100mm mesh (top) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | | | 1 | | | |
| 95 | | | 1 | | | |
| 96 | | | | 1 | 3 | 1 |
| 97 | | | | | 1 | |
| 98 | | | 1 | 3 | 3 | |
| 99 | 1 | 2 | 4 | 5 | 6 | 4 |
| 100 | 8 | 7 | 6 | 6 | 3 | 14 |
| 101 | 2 | 7 | 6 | 2 | 3 | 1 |
| 102 | 5 | 4 | 1 | 3 | | 1 |
| 103 | 4 | | | | 1 | |
| 104 | | | | | | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 21 |
| mean= 100.2 | | | | | | |

| 100mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Used, wet | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | | | | | | |
| 95 | | | 1 | | 1 | |
| 96 | | 2 | 2 | 2 | | |
| 97 | 2 | 1 | 5 | 1 | | |
| 98 | 1 | 1 | 4 | 3 | 1 | 1 |
| 99 | 5 | 6 | 7 | 4 | 5 | 4 |
| 100 | 4 | 4 | 1 | 7 | 10 | 8 |
| 101 | 3 | 3 | | 1 | | 1 |
| 102 | 3 | 3 | | | 1 | 6 |
| 103 | | | | 2 | 1 | |
| 104 | 2 | | | | 1 | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 99.5 | | | | | | |

| 100mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | | | | | | |
| 95 | | | | | | |
| 96 | 1 | | | | | |
| 97 | | | | 2 | | |
| 98 | 4 | 2 | 1 | 2 | | 2 |
| 99 | 3 | 4 | 3 | 5 | 4 | 5 |
| 100 | 7 | 9 | 9 | 8 | 8 | 3 |
| 101 | 2 | 1 | 3 | | 2 | 5 |
| 102 | 3 | 3 | 3 | 3 | 6 | 5 |
| 103 | | 1 | 1 | | | |
| 104 | | | | | | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 100.2 | | | | | | |

| 100mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 91 | | | | | | |
| 92 | | | | | | |
| 93 | | | | | | |
| 94 | | | | | | |
| 95 | | | | | | |
| 96 | | | | | 2 | |
| 97 | | 1 | 4 | | | |
| 98 | 2 | | 2 | 2 | 2 | 2 |
| 99 | 1 | 1 | 6 | 3 | 1 | 2 |
| 100 | 6 | 7 | 7 | 8 | 7 | 3 |
| 101 | 4 | 4 | | 4 | 2 | 6 |
| 102 | 4 | 6 | 1 | 3 | 5 | 4 |
| 103 | 1 | | | | 1 | 1 |
| 104 | 1 | 1 | | | | |
| 105 | 1 | | | | | 2 |
| 106 | | | | | | |
| 107 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 100.3 | | | | | | |

| 140mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Used, dry | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 137 | 2 | | | | 2 | |
| 138 | 1 | 1 | | | 1 | |
| 139 | 1 | 3 | | | | 1 |
| 140 | 8 | 3 | 1 | | 5 | 4 |
| 141 | 1 | | | | 2 | 1 |
| 142 | 2 | 3 | 5 | 3 | 8 | 6 |
| 143 | | 2 | 4 | 2 | 2 | 4 |
| 144 | 2 | | 3 | 2 | | 2 |
| 145 | 1 | 2 | 4 | 6 | | 1 |
| 146 | | 2 | | 1 | | |
| 147 | 2 | 1 | 1 | | | |
| 148 | | 2 | 2 | 1 | | 1 |
| 149 | | 1 | | 3 | | |
| 150 | | | | 2 | | |
| 151 | | | | | | |
| 152 | | | | | | |
| 153 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 142.8 | | | | | | |

| 140mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 137 | | | | | | |
| 138 | | | | | | |
| 139 | | | | | | |
| 140 | | | | | | |
| 141 | | | | | | |
| 142 | | | | | | |
| 143 | | | | | | |
| 144 | | | | | | |
| 145 | | | | | | |
| 146 | | | | | | |
| 147 | | | | | | |
| 148 | | | | | | |
| 149 | | | | | | |
| 150 | | | | | | |
| 151 | | | | | | |
| 152 | | | | | | |
| 153 | | | | | | |
| TOT | | | | | | |
| | | | | | | |

| 140mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 137 | | | | | | |
| 138 | 1 | | | | | |
| 139 | | | | | 1 | |
| 140 | 3 | 3 | 1 | 3 | 1 | 3 |
| 141 | 1 | 2 | 3 | | 2 | 2 |
| 142 | 5 | 2 | 2 | 4 | 3 | 7 |
| 143 | 1 | 2 | 2 | 3 | 1 | 3 |
| 144 | 4 | | 3 | 1 | 5 | 1 |
| 145 | 2 | 3 | 4 | 5 | 2 | 1 |
| 146 | | 3 | 2 | 1 | 2 | 3 |
| 147 | 3 | 2 | 3 | 3 | 3 | |
| 148 | | 1 | | | | |
| 149 | | | | | | |
| 150 | | 2 | | | | |
| 151 | | | | | | |
| 152 | | | | | | |
| 153 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 143.7 | | | | | | |

| 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Dry, new | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 101 | | | | | | |
| 102 | | | | | 1 | |
| 103 | | | | | | |
| 104 | | | 1 | | | 1 |
| 105 | 4 | | | 1 | | |
| 106 | | 2 | | | | |
| 107 | 4 | | 1 | | 2 | |
| 108 | | | 2 | 8 | | |
| 109 | 3 | | 2 | 1 | 3 | 3 |
| 110 | 4 | 4 | | 2 | 3 | 4 |
| 111 | 1 | 3 | 2 | 3 | 2 | 1 |
| 112 | 1 | 5 | 1 | 1 | 3 | 4 |
| 113 | 1 | 2 | 1 | | 2 | 1 |
| 114 | 2 | 1 | 4 | 1 | 3 | 3 |
| 115 | | 2 | 4 | 2 | | 1 |
| 116 | | 1 | | 1 | 1 | 2 |
| 117 | | | 1 | | | |
| 118 | | | 1 | | | |
| 119 | | | | | | |
| 120 | | | | | | |
| 121 | | | | | | |
| 122 | | | | | | |
| 123 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 111 | | | | | | |

| 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Re-test, dry, new | | | | | |
| | LHS | | Mid | | RHS | |
| mm | U | L | U | L | U | L |
| 101 | | | | | | 1 |
| 102 | | 1 | | 1 | | |
| 103 | | | | | 3 | 1 |
| 104 | 1 | | | | | |
| 105 | 1 | | 1 | | | 1 |
| 106 | 1 | 2 | 2 | 2 | 1 | |
| 107 | 3 | | 2 | 3 | 4 | 3 |
| 108 | 9 | 5 | 7 | 5 | 4 | 6 |
| 109 | 1 | 4 | 1 | 3 | 1 | 6 |
| 110 | 7 | 9 | 7 | 5 | 7 | 4 |
| 111 | 8 | 6 | 5 | 6 | 4 | 4 |
| 112 | 7 | 5 | 4 | 8 | 10 | 9 |
| 113 | 2 | 3 | 5 | 4 | 7 | 4 |
| 114 | 2 | 7 | 7 | 4 | 1 | 5 |
| 115 | 4 | 1 | 5 | 5 | 4 | 3 |
| 116 | 1 | 1 | 1 | 1 | | 1 |
| 117 | 1 | 2 | | | | |
| 118 | 1 | | | | 1 | |
| 119 | | | | | | |
| 120 | | | | | 1 | |
| 121 | | | | | | |
| 122 | | | 1 | | | |
| 123 | | 1 | | | | |
| TOT | 49 | 47 | 48 | 47 | 48 | 48 |
| mean= 111 | | | | | | |

| 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 101 | | | | | | |
| 102 | | | | | | |
| 103 | | | | | | |
| 104 | | | | | | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| 108 | | | | | | |
| 109 | | | | | | |
| 110 | | | | | | |
| 111 | | | | | | |
| 112 | | | | | | |
| 113 | | | | | | |
| 114 | | | | | | |
| 115 | | | | | | |
| 116 | | | | | | |
| 117 | | | | | | |
| 118 | | | | | | |
| 119 | | | | | | |
| 120 | | | | | | |
| 121 | | | | | | |
| 122 | | | | | | |
| 123 | | | | | | |
| TOT | | | | | | |
| | | | | | | |

| SOAFD 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Used, dry | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 107 | | | | | | |
| 108 | | | | | | |
| 109 | | | | | | |
| 110 | | | | | | |
| 111 | | | | | | |
| 112 | | | | | | 1 |
| 113 | 3 | 1 | 1 | 1 | 1 | 1 |
| 114 | 3 | 4 | 2 | 1 | | 2 |
| 115 | 1 | 7 | 5 | 11 | 6 | 8 |
| 116 | 7 | 4 | 10 | 4 | 10 | 5 |
| 117 | 2 | 3 | 1 | 3 | 1 | 2 |
| 118 | 3 | | | | 2 | 1 |
| 119 | | | 1 | | | |
| 120 | 1 | 1 | | | | |
| 121 | | | | | | |
| 122 | | | | | | |
| 123 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 115.5 | | | | | | |

| SOAFD 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | Halfway stage | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 107 | | | | | | |
| 108 | | | | | | |
| 109 | | | | | | |
| 110 | | | | | | |
| 111 | | | | | | |
| 112 | | | | | | |
| 113 | | | | | | |
| 114 | | 1 | | 2 | | |
| 115 | 6 | 7 | 4 | 8 | 4 | 3 |
| 116 | 6 | 3 | 4 | | 1 | 3 |
| 117 | 4 | 4 | 3 | 4 | 5 | 7 |
| 118 | 3 | 3 | 8 | 6 | 6 | 3 |
| 119 | 1 | 1 | 1 | | | 3 |
| 120 | | 1 | | | 3 | |
| 121 | | | | | | 1 |
| 122 | | | | | 1 | |
| 123 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 116.7 | | | | | | |

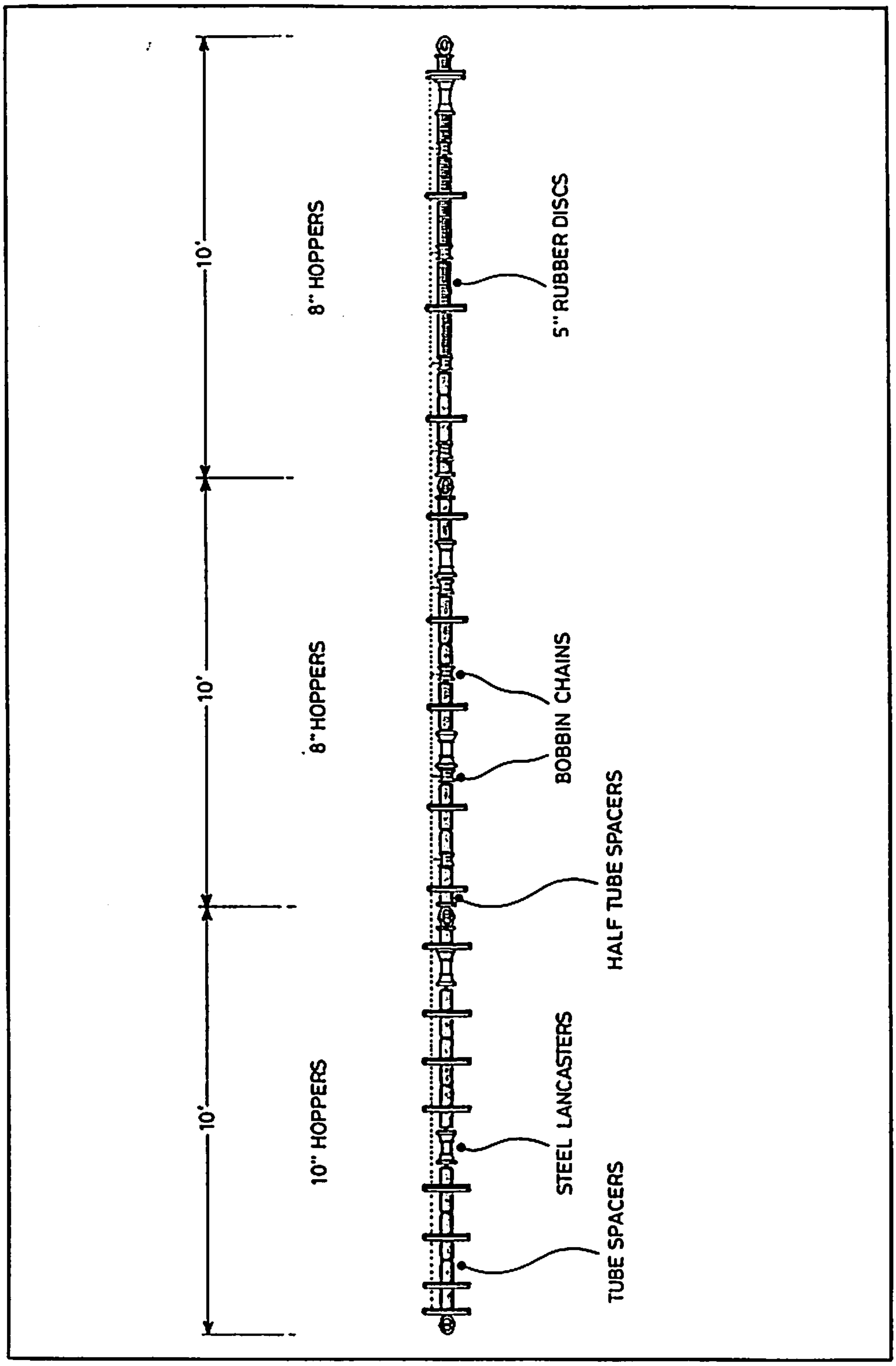
| SOAFD 120mm mesh (bottom c/e) | | | | | | |
|---|---|---|---|---|---|---|
| | End of trial | | | | | |
| | Top | | Mid | | Btm | |
| mm | U | L | U | L | U | L |
| 107 | | | | | | |
| 108 | | | | | | |
| 109 | | | | | | |
| 110 | | | | | | |
| 111 | | | | | | |
| 112 | | | | | 1 | |
| 113 | | 4 | | 4 | 2 | 3 |
| 114 | | 1 | 1 | 2 | 2 | 2 |
| 115 | 2 | 5 | 11 | 9 | 9 | 4 |
| 116 | 7 | 1 | 7 | 1 | 3 | 6 |
| 117 | 3 | 8 | | 4 | 1 | 2 |
| 118 | 5 | 1 | 1 | | 2 | 3 |
| 119 | 3 | | | | | |
| 120 | | | | | | |
| 121 | | | | | | |
| 122 | | | | | | |
| 123 | | | | | | |
| TOT | 20 | 20 | 20 | 20 | 20 | 20 |
| mean= 115.7 | | | | | | |

Key: c/e = codend

U = Upper surface of codend
L = Lower surface of codend
Top = Region of mesh near to joining round with the extension
Mid = Region of mesh halfway along the codend from either end
Btm = Region of mesh near to the codline at the codend tip
TOT = Total number of observations
mean = mean mesh size from all observations

# APPENDIX III

## Gear Modifications in Trial 2, November 1994




Modified Ground Gear Rig MFV 'Heather Sprig' Separator Trawl Trials–Nov.'94.

# APPENDIX IV
## Haul Details

| Haul & block (1-7) | | Date | Port | | Starboard | | Shot time | Haul time | Bulk catch baskets | | | | Ground |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Net | U/L | Net | U/L | GMT | GMT | PU | PL | SU | SL | |
| 1 | | 19-Nov-94 | A | 40/40 | B | 100/100 | 12:08 | 14:08 | 7.00 | 2.66 | 0.33 | 1.50 | Fine, mud |
| 2 | 1 | 19-Nov-94 | A | 100/140 | B | 40/40 | 15:52 | 16:52 | 0.75 | 0.25 | 7.00 | 2.00 | Fine, mud |
| 3 | | 20-Nov-94 | A | 40/40 | B | 100/140 | 06:10 | 08:10 | 3.75 | 1.50 | 0.25 | 0.25 | Fine, mud |
| 4 | | 20-Nov-94 | A | 100/100 | B | 40/40 | 10:01 | 12:02 | 0.50 | 0.75 | 5.50 | 2.50 | Fine, mud |
| 5 | | 21-Nov-94 | A | 100/100 | B | 40/40 | 06:00 | 08:00 | 1.33 | 2.00 | 3.75 | 6.00 | Fine, sand |
| 6 | 2 | 21-Nov-94 | A | 40/40 | B | 100/100 | 09:23 | 11:22 | 1.50 | 5.00 | 0.13 | 1.25 | Fine, sand |
| 7 | | 21-Nov-94 | A | 40/40 | B | 100/140 | 12:36 | 14:38 | 1.00 | 4.50 | 0.75 | 0.25 | Fine, sand |
| 8 | | 21-Nov-94 | A | 100/140 | B | 40/40 | 15:51 | 18:01 | 1.25 | 0.50 | 4.00 | 5.00 | Fine, sand |
| 9 | | 22-Nov-94 | A | 100/120 | B | 40/40 | 16:30 | 18:30 | 1.33 | 0.50 | 2.25 | 4.66 | Fine, sand |
| 10 | 3 | 22-Nov-94 | A | 40/40 | B | 100/120 | 19:57 | 21:57 | 3.00 | 6.33 | 1.00 | 1.00 | Fine, sand |
| 11 | | 22-Nov-94 | A | 40/40 | B | 100/100 | 23:04 | 01:03 | 3.66 | 5.50 | 1.25 | 1.75 | Fine, sand |
| 12 | | 23-Nov-94 | A | 100/100 | B | 40/40 | 02:11 | 04:14 | 0.50 | 1.33 | 3.75 | 6.50 | Fine, sand |
| 13 | | 24-Nov-94 | A | 40/40 | B | 100/120 | 06:05 | 08:05 | 4.00 | 3.25 | 0.50 | 1.25 | Fine, mud |
| 14 | 4 | 24-Nov-94 | A | 40/40 | B | 100/100 | 09:26 | 11:26 | 1.25 | 1.50 | 0.12 | 1.00 | Fine, mud |
| 15 | | 24-Nov-94 | A | 100/120 | B | 40/40 | 12:58 | 14:59 | 0.12 | 0.50 | 2.25 | 2.50 | Fine, mud |
| 16 | | 24-Nov-94 | A | 100/100 | B | 40/40 | 16:05 | 18:05 | 1.00 | 1.75 | 4.00 | 4.00 | Fine, mud |
| Invalid | | 25-Nov-94 | A | 100/120 | B | 40/40 | 04:58 | 06:30 | n/a | n/a | n/a | n/a | Fine, mud/sand |
| Invalid | | 25-Nov-94 | A | 100/120 | B | 40/40 | 09:48 | 10:51 | 0.33 | 1.50 | 3.00 | 4.00 | Fine, mud/sand |

| Haul & block (1-7) | | Date | Port | | Starboard | | Shot time | Haul time | Bulk catch baskets | | | | Ground |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Net | U/L | Net | U/L | GMT | GMT | PU | PL | SU | SL | |
| 17 | | 25-Nov-94 | B | 100/120 | A | 40/40 | 16:25 | 18:25 | 1.20 | 1.00 | 2.50 | 4.50 | Fine, sand |
| 18 | 5 | 25-Nov-94 | B | 40/40 | A | 100/120 | 19:55 | 21:55 | 2.25 | 4.25 | 1.00 | 0.75 | Fine, sand |
| 19 | | 25-Nov-94 | B | 40/40 | A | 100/100 | 23:01 | 01:01 | 3.00 | 4.50 | 0.50 | 1.75 | Fine, sand |
| 20 | | 26-Nov-94 | B | 100/100 | A | 40/40 | 02:13 | 04:13 | 0.75 | 1.75 | 3.00 | 5.75 | Fine, sand |
| 21 | | 28-Nov-94 | B | 100/120 | A | 40/40 | 17:17 | 19:17 | 1.75 | 1.25 | 2.00 | 6.00 | Fine, sand |
| 22 | 6 | 28-Nov-94 | B | 40/40 | A | 100/100 | 20:40 | 22:40 | 5.00 | 6.00 | 1.50 | 2.00 | Fine, sand |
| 23 | | 28-Nov-94 | B | 40/40 | A | 100/120 | 23:41 | 01:34 | 7.25 | 7.00 | 2.25 | 1.25 | Fine, sand |
| 24 | | 29-Nov-94 | B | 100/100 | A | 40/40 | 03:07 | 05:07 | 1.50 | 2.50 | 5.75 | 7.00 | Fine, sand |
| 25 | | 29-Nov-94 | B | 40/40 | A | 100/100 | 16:40 | 18:40 | 5.00 | 6.75 | 1.50 | 2.50 | Fine, sand |
| 26 | 7 | 29-Nov-94 | B | 100/100 | A | 40/40 | 19:52 | 21:52 | 1.00 | 2.00 | 3.50 | 5.00 | Fine, sand |
| 27 | | 29-Nov-94 | B | 40/40 | A | 100/120 | 23:24 | 01:24 | 4.00 | 6.00 | 1.00 | 1.50 | Fine, sand |
| 28 | | 30-Nov-94 | B | 100/120 | A | 40/40 | 02:36 | 04:36 | 0.33 | 1.00 | 2.50 | 6.00 | Fine, sand |

| Haul & block (1-7) | | Position shot | Position haul | Tow speed | Depth (fm) | Warp out (fm) | Wind | Sea |
|---|---|---|---|---|---|---|---|---|
| 1 | | 057°50'39N 002°04'66W | 057°52'32N 001°56'93W | 2.5 | 55fm | 125fm | W 2-3 | WNW slight |
| 2 | 1 | 057°51'30N 001°58'10W | 057°49'64N 002°07'44W | 2.5 | 51fm | 125fm | W 3 | NW & SE slt. |
| 3 | | 057°50'17N 002°11'13W | 057°50'51N 002°02'47W | 2.5 | 55fm | 125fm | SW 4 | W mod |
| 4 | | 057°52'34N 001°57'12W | 057°50'15N 002°04'68W | 2.5 | 47fm | 125fm | W 4 | W mod/rough |
| 5 | | 057°58'13N 003°14'45W | 058°02'64N 003°14'25W | 2.5 | 28fm | 75fm | SW 3 | SW slight |
| 6 | 2 | 058°02'90N 003°14'70W | 057°58'21N 003°13'12W | 2.4 | 29fm | 78fm | WSW 4 | W slight |
| 7 | | 057°55'80N 003°14'10W | 058°00'87N 003°14'94W | 2.3 | 32fm | 78fm | SW 4 | SW slight |
| 8 | | 058°01'70N 003°15'30W | 057°57'32N 003°15'29W | 2.3 | 30fm | 78fm | SW 4 | SW slight |
| 9 | | 057°55'08N 003°13'46W | 057°59'97N 003°16'68W | 2.4 | 32fm | 78fm | SW 2 | SW v slight |
| 10 | 3 | 058°00'10N 003°15'40W | 057°56'09N 003°14'85W | 2.6 | 28fm | 78fm | SW 3 | SW slight |
| 11 | | 058°56'40N 003°14'20W | 058°00'80N 003°16'51W | 2.4 | 29fm | 78fm | SW 3 | SW slight |
| 12 | | 058°00'50N 003°15'80W | 057°55'71N 003°13'71W | 2.5 | 29fm | 78fm | SW 3 | SW slight |
| 13 | | 057°51'12N 003°08'52W | 057°52'59N 003°00'29W | 2.7 | 42fm | 125fm | SW 4-5 | SW mod |
| 14 | 4 | 057°52'40N 002°58'50W | 057°53'01N 003°07'27W | 2.5 | 46fm | 120fm | W 4 | W mod |
| 15 | | 057°50'60N 003°07'70W | 057°50'71N 002°58'39W | 2.5 | 46fm | 125fm | W 5 | W slight-mod |
| 16 | | 057°50'60N 003°02'20W | 057°48'07N 003°09'40W | 2.5 | 48fm | 120fm | W 3 | W slight |
| Invalid | | 058°17'88N 002°03'19W | 058°18'99N 001°56'57W | 2.5 | 49fm | 128fm | SW 1 var | None |
| Invalid | | 058°13'94N 002°15'34W | 058°09'28N 002°18'99W | 2.5 | 53fm | 128fm | SSW 2 | SSW slight |

| Haul & block (1-7) | | Position shot | Position haul | Tow speed | Depth (fm) | Warp out (fm) | Wind | Sea |
|---|---|---|---|---|---|---|---|---|
| 17 | | 057°55'99N 003°13'11W | 057°59'94N 003°18'52W | 2.5 | 34fm | 78fm | WSW 3 | SW slight |
| 18 | 5 | 057°58'90N 003°17'20W | 057°54'70N 003°11'88W | 2.7 | 30fm | 78fm | WSW 2 | W slight |
| 19 | | 057°54'60N 003°13'30W | 057°59'38N 003°15'76W | 2.5 | 32fm | 78fm | W 1 | Slight |
| 20 | | 057°58'60N 003°13'60W | 057°53'77N 003°14'77W | 2.4 | 29fm | 78fm | W 1 | Slight |
| 21 | | 057°58'15N 003°12'26W | 058°02'34N 003°14'53W | 2.5 | 29fm | 78fm | W 2 | W slight |
| 22 | 6 | 058°02'10N 003°13'70W | 057°57'26N 003°14'48W | 2.5 | 28fm | 78fm | W 3 | W slight |
| 23 | | 057°58'10N 003°14'50W | 058°03'31N 003°13'99W | 2.5 | 28fn | 78fm | W 3 | W slight |
| 24 | | 058°03'20N 003°13'10W | 057°58'49N 003°14'89W | 2.5 | 27fm | 78fm | W 2 | W slight |
| 25 | | 057°58'30N 003°12'56W | 058°02'66N 003°15'61W | 2.5 | 28fm | 78fm | SW 1 | None |
| 26 | 7 | 058°02'30N 003°15'80W | 057°57'23N 003°13'85W | 2.5 | 29fm | 78fm | Calm | None |
| 27 | | 057°57'30N 003°14'30W | 058°02'28N 003°12'18W | 2.5 | 29fm | 78fm | Calm | None |
| 28 | | 058°01'10N 003°13'60W | 057°56'58N 003°09'52W | 2.5 | 29fm | Warp | Calm | None |

# APPENDIX V

## Monitored Gear Parameters

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| A | 1 | 40/40 | 4.18 | 8.80 | 72.2 | 229 | 90 | 2.55 |
| A | 3 | 40/40 | 4.04 | 8.89 | 87.9 | 229 | 101 | 2.27 |
| A | 6 | 40/40 | 3.42 | 7.67 | 65.9 | 137 | 51 | 2.68 |
| A | 7 | 40/40 | 3.40 | 7.72 | 61.5 | 143 | 59 | 2.44 |
| A | 10 | 40/40 | 3.12 | 7.13 | 59.3 | 143 | 51 | 2.79 |
| A | 11 | 40/40 | 3.22 | 7.14 | 59.4 | 143 | 53 | 2.69 |
| A | 13 | 40/40 | 3.60 | 9.05 | 80.6 | 229 | 77 | 2.98 |
| A | 14 | 40/40 | 3.62 | 7.71 | 79.0 | 229 | 84 | 2.72 |
| A | 17 | 40/40 | 3.49 | 8.75 | 66.6 | 143 | 62 | 2.29 |
| A | 20 | 40/40 | 3.51 | 8.90 | 56.1 | 143 | 59 | 2.44 |
| A | 21 | 40/40 | 3.32 | 8.25 | 64.4 | 143 | 53 | 2.69 |
| A | 24 | 40/40 | 3.31 | 8.89 | 58.0 | 143 | 49 | 2.89 |
| A | 26 | 40/40 | 3.29 | 7.80 | * | 143 | 53 | 2.69 |
| A | 28 | 40/40 | 3.16 | 7.52 | * | 143 | 48 | 3.00 |
| | | | mean 3.48<br>std dev 0.31 | mean 8.16<br>std dev 0.7 | mean 67.58<br>std dev 10.2 | | | mean 2.65<br>std dev 0.23 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| B | 2 | 40/40 | 3.35 | 8.90 | 78.7 | 229 | 90 | 2.55 |
| B | 4 | 40/40 | 3.56 | 8.70 | 78.5 | 229 | 86 | 2.66 |
| B | 5 | 40/40 | 3.60 | 8.80 | 79.6 | 137 | 51 | 2.68 |
| B | 8 | 40/40 | 3.50 | 7.66 | 70.6 | 143 | 70 | 2.05 |
| B | 9 | 40/40 | 3.48 | 7.63 | 90.3 | 143 | 59 | 2.44 |
| B | 12 | 40/40 | 3.43 | 7.35 | 58.1 | 143 | 53 | 2.69 |
| B | 15 | 40/40 | 3.17 | 5.16 | 83.7 | 229 | 84 | 2.72 |
| B | 16 | 40/40 | 3.58 | 8.88 | 74.8 | 220 | 88 | 2.50 |
| B | 18 | 40/40 | 3.40 | 8.82 | 65.3 | 143 | 55 | 2.60 |
| B | 19 | 40/40 | 3.41 | 8.88 | 62.8 | 143 | 59 | 2.44 |
| B | 22 | 40/40 | 3.19 | 8.88 | 63.0 | 143 | 51 | 2.79 |
| B | 23 | 40/40 | 3.28 | 8.88 | 63.8 | 143 | 51 | 2.79 |
| B | 25 | 40/40 | 3.28 | 6.99 | * | 143 | 51 | 2.79 |
| B | 27 | 40/40 | 3.30 | 7.10 | * | 143 | 53 | 2.69 |
| | | | mean 3.4<br>std dev 0.14 | mean 8.05<br>std dev 1.12 | mean 72.43<br>std dev 9.98 | | | mean 2.6<br>std dev 0.2 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| A | 4 | 100/100 | 3.55 | 8.81 | 78.5 | 229 | 86 | 2.66 |
| A | 5 | 100/100 | 3.70 | 8.82 | 79.0 | 137 | 51 | 2.68 |
| A | 12 | 100/100 | 3.32 | 7.20 | 58.5 | 137 | 53 | 2.59 |
| A | 16 | 100/100 | 3.27 | 8.88 | 74.8 | 229 | 88 | 2.60 |
| A | 19 | 100/100 | 3.42 | 8.89 | 62.8 | 143 | 59 | 2.44 |
| A | 24 | 100/100 | 3.31 | 8.89 | 58.0 | 143 | 49 | 2.89 |
| A | 26 | 100/100 | 3.29 | 7.80 | * | 143 | 53 | 2.69 |
| | | | mean 3.41<br>std dev 0.16 | mean 8.47<br>std dev 0.69 | mean 68.6<br>std dev 9.93 | | | mean 2.65<br>std dev 0.14 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 100/100 | 4.08 | 8.79 | 72.2 | 229 | 90 | 2.55 |
| B | 6 | 100/100 | 3.47 | 7.62 | 65.9 | 137 | 59 | 2.34 |
| B | 11 | 100/100 | 3.40 | 7.23 | 59.4 | 143 | 53 | 2.69 |
| B | 14 | 100/100 | 3.75 | 7.68 | 79.0 | 229 | 84 | 2.72 |
| B | 20 | 100/100 | 3.48 | 8.88 | 56.1 | 143 | 59 | 2.44 |
| B | 24 | 100/100 | 3.18 | 8.88 | 58.0 | 143 | 49 | 2.89 |
| B | 26 | 100/100 | 3.29 | 6.98 | * | 143 | 53 | 2.69 |
| | | | mean 3.52<br>std dev 0.3 | mean 8.01<br>std dev 0.82 | mean 65.1<br>std dev 9.04 | | | mean 2.62<br>std dev 0.19 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| A | 9 | 100/120 | 3.52 | 7.71 | 90.3 | 143 | 59 | 2.44 |
| A | 15 | 100/120 | 2.98 | 9.07 | 83.7 | 229 | 84 | 2.72 |
| A | 18 | 100/120 | 3.52 | 8.85 | 65.3 | 143 | 55 | 2.60 |
| A | 23 | 100/120 | 3.22 | 8.82 | 63.8 | 143 | 51 | 2.79 |
| A | 27 | 100/120 | 3.24 | 7.20 | * | 143 | 53 | 2.69 |
| | | | mean 3.3<br>std dev 0.23 | mean 8.33<br>std dev 0.82 | mean 75.78<br>std dev 13.25 | | | mean 2.65<br>std dev 0.13 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| B | 10 | 100/120 | 3.34 | 7.22 | 59.3 | 143 | 51 | 2.79 |
| B | 13 | 100/120 | 3.16 | 8.91 | 80.6 | 229 | 77 | 2.98 |
| B | 17 | 100/120 | 3.39 | 8.67 | 66.6 | 143 | 62 | 2.29 |
| B | 21 | 100/120 | 3.24 | 7.78 | 64.4 | 143 | 53 | 2.69 |
| B | 28 | 100/120 | 3.19 | 7.32 | * | 143 | 48 | 3.00 |
| | | | mean 3.26<br>std dev 0.1 | mean 7.98<br>std dev 0.77 | mean 67.73<br>std dev 9.11 | | | mean 2.75<br>std dev 0.29 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| A | 2 | 100/140 | 3.29 | 9.03 | 79.9 | 229 | 90 | 2.55 |
| A | 8 | 100/140 | 3.45 | 7.69 | 70.6 | 143 | 70 | 2.05 |
| | | | mean 3.37 | mean 8.36 | mean 75.23 | | | mean 2.3 |

| Net | Tow | Codend U/L | Headline height (m) | Wingend spread (m) | Door spread (m) | Warp out (m) | Depth (m) | Warp to Depth ratio |
|---|---|---|---|---|---|---|---|---|
| B | 3 | 100/140 | 3.95 | 9.16 | 87.9 | 229 | 101 | 2.27 |
| B | 7 | 100/140 | 3.48 | 7.67 | 61.5 | 143 | 59 | 2.44 |
| | | | mean 3.72 | mean 8.42 | mean 74.7 | | | mean 2.36 |