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marine scotland

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Published by Marine Scotland Science

ISSN: 2043-7722

DOI: 10.7489/1891-1

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Effects of a Lifting Bag on Nephrops Selectivity

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Summary

Twin trawl trials were conducted in the West Coast of Scotland to examine the selectivity of Nephrops (*Nephrops norvegicus*) with regards to codends of the following mesh size and construction:

- 80 mm diamond mesh codend of 4 mm single Brezline polyethylene (PE) twine both with and without a lifting bag (here designated 80 mm and 80 mmL respectively).
- 100 mm diamond mesh codend of 5 mm double Brezline (PE) twine both with and without a lifting bag (100 mm and 100 mmL).

The results can be summarised as follows:

- For Nephrops, increasing the mesh size and removing the lifting bag improves the selective performance of the gear and the analysis suggests that the codends can be ranked from least to most selective as follows; 80 mmL, 100 mmL, 80 mm and 100 mm. We are not able to show this in a statistical sense as the side of the twin trawl on which the test codend was fished influenced the number of Nephrops caught and as a result the subsequent analysis was unable to calculate 95% confidence bands.
- For whiting (*Merlangius merlangus*), selectivity improves with increasing mesh size and removal of the lifting bag. There was no side effect.
- For haddock (*Melanogrammus aeglefinus*) only the presence/absence of a lifting bag proved significant. There was no influence of mesh size, which is probably due to the small sizes of haddock caught, and there was no side effect.

Introduction

The Fishing Industry Science Alliance (FISA) is a joint initiative between industry and science initiated in 2012. The alliance draws on the combined expertise of fishermen and scientists to support research that delivers more sustainable and effective Scottish fisheries and that furthers scientific knowledge. With the landing obligation for Nephrops having come into force on January 2016 there is a requirement that there will be no discarding of Nephrops by TR2 vessels, thus it is important to understand the selectivity of modern Nephrops gears. With this in mind Mallaig and North West Fisherman's Association (MNWFA) put forward a proposal along with Marine Scotland Science (MSS) for a study into the impact of lifting bags (also known as strengthening bags) on Nephrops selectivity. A previous FISA study in 2014 has already looked into the effects of mesh size and twine number on Nephrops selectivity (Drewery *et al*. 2015).

A meta-analysis of Nephrops trawl selectivity has shown that lifting or strengthening bags reduce selectivity (ICES WKNEPHSEL 2007) and directed trials in whitefish gears have shown similar results for haddock (Kynoch *et al*., 2004), but up until now there have been few directed trials of this type with definite conclusions for Nephrops.

In conjunction with MNWFA two industry standard codend sizes were chosen for the study: 80 mm and 100 mm which are both are routinely used in the TR2 sector. In terms of twine thickness and twine number industry standards were again chosen with the 80 mm codend (102 open meshes round) using single 4 mm Brezline and the 100 mm codend (88 open meshes round) using double 5 mm.

Materials and Methods

The twin trawl method was used to perform selectivity trials. A small mesh (control) codend was fished on one side and one of the test nets on the other. Fish caught in the control codend are assumed to be representative of the total population of catch of all species. Catches from the test are compared to catches from the control and expressed as a proportion retained of the total population. MFV Rebecca Jeneen OB38 was chartered and the trials were undertaken over the period 4th-15th July 2015 on commercial west coast Nephrops grounds. The target species for all hauls was Nephrops; however, certain species of commercial whitefish were worked up as available to supplement the study.

The twin-rig fished by the Rebecca Jeneen utilised a matched pair of Faithlie disc nets incorporating 250 mm and 300 mm discs. These had a fishing circle of 440 x 100 mm (nominal size) meshes and were constructed from 4 mm braided PE. Sweeps were 12.2 m of 16 mm wire tops and 18 mm wire bottoms incorporating 76 mm rubbers, 3 m of 16 mm long link chain and 27.4 m of 16 mm wire with 76 mm rubbers. The trawls were fished using a three-warp system utilising size 5 Bison doors and a 500 kg roller clump. This is a commonly used configuration amongst TR2 vessels in the North and South Minch.

The mesh sizes of the test codends were chosen to reflect as far as possible those of a commercial net that had been actually fishing for some time. Many codends are bought 5-8 mm oversize on the understanding that with usage the meshes shrink towards the regulation size. Thus for these trials the sizes chosen were 3-4 mm over the nominal size which equated to between 3.3-4.0% larger in both cases. Inside mesh measurements were made pre- and post-trial using the Omega gauge on wet netting (Table 5). The control net used a codend and extension constructed from 40 mm mesh.

Lifting bags used in the west coast Nephrops fishery are a mixture of commercially available or 'off the shelf' and those constructed by local fishers who build or customise their own trawls. The attachment of lifting bags to codends is regulated under Commission Regulation EEC 3440/84 (see footnote[1]) which allows some variation in design. As such it was not possible to choose a lifting bag that was 'typical' of all cases. Both lifting bags trialled here are commercially available, are rigged to an industry standard and are used by Nephrops fishers in the South Minch (although what proportion of the total actually does use the model trialled is not known). The lifting bag for the 80 mm codend is made from 200 mm double 5 mm PE twine. It is 50 meshes round and 16.5 meshes long which equates to approximately 3.3 m in length. That for the 100 mm codend is made from 235 mm double 5 mm PE twine. It is 50 meshes round and 14.5 meshes long or approximately 3.4 m in length. Approximate full mesh measurements were made by stretching a section of net tight and measuring knot centre to knot centre over a known number of meshes followed by averaging. Dimensions and mesh measurements are summarised in Table 4.

Trials were conducted in the North and South Minch on commercial Nephrops grounds. Exact choice of fishing area was decided on a day to day basis utilising the experience of the skipper and taking into account the weather and local fishing reports. Most hauls lasted between 2 and 3 hours with the vessel generally towing at its normal fishing speed of 2.6 – 2.8 kts. To minimise tidal effects on the geometry of the twin trawl, hauls were conducted, as far as possible, either with or against the tide. To counter possible net bias the test and control codends were swapped at appropriate intervals to ensure the test net was trialled on both port and starboard sides. To eliminate variation that could arise from rigging and re-rigging, all hauls during the first half of the trials were with codends incorporating a lifting bag which was then removed for the remainder of the study. Wingspread outputs from Scanmar sensors attached

[1] Extract from Commission Regulation EEC 3440/84 Article 6 on strengthening (lifting) bags
'A strengthening bag is a cylindrical piece of netting completely surrounding the codend of a trawl and which may be attached to the codend at intervals. It shall have at least the same dimensions (length and width) as that part of the codend to which it is attached. The mesh size shall be equal to at least twice that of the codend.'

to the wingtips were recorded. Headline height, however, was not recorded as this design of net has a lower headline than the accepted threshold for reliable information from scanmar height units (~3m).

On completion of each haul both codends were lifted free of the water and processed separately. For each codend all Nephrops were removed from the catch. To counter any potential sorting bias they were then placed into a large tub where they were mixed thoroughly in seawater to homogenise the size classes. They were then removed into baskets and left to stand for a short while to allow shedding of excess water. A total weight was recorded prior to subsampling using calibrated Unisystem sea-going scales. Samples varied between approximately 4-16 kg depending on the size makeup of the samples, corresponding to around 400 individual Nephrops measurements per codend per haul. The carapace length (cl) to the mm below was recorded for Nephrops. This is the minimum length from the inside of the eye socket to the posterior margin of the carapace. Most hauls contained a moderate component of commercial demersal fish including many juveniles in the control codend. Thus to supplement this study haddock, whiting, cod (*Gadus morhua*), and witch (*Glyptocephalus cynoglossus*) were additionally sorted from the catch, weighed and measured. Where juvenile haddock and whiting were encountered in great abundance they were subsampled by weight. Other species and invertebrates forming the remainder of the catch were recorded as a bulk weight. Table 1 summarises catches weight per side.

Data Analysis

For each species, the catch rate of the test gears relative to the control gear were estimated and compared using the mixed model smoothing methodology of Fryer *et al*. (2003). The analysis was restricted to hauls for which 8 length classes were caught by the test and control gears combined; and a minimum of 10 fish caught in the control gear. A smoother was fitted to model the log catch rate of the test gear relative to the control gear for each haul. The amount of smoothing was determined using Akaike's Information Criterion (AIC) and ranged from a window width of 15–25 length classes, depending on the species. The length classes to which the smoothers were fitted was restricted to the largest minimum and smallest maximum median length range values calculated for the four test gears sampled (Table 6). This was to ensure variables with larger ranges do not force smoothers to be fitted to variables that had insufficient data.

Bi-directional stepwise regression was then used to determine which categorical variables were significant. Four variables were considered: codend mesh (80 mm or 100 mm), lifting bag (present or absent), side that the test trawl fished (port or starboard) and the fishing ground (North Minch or South Minch). An intermediate model was first fitted to the data in which the intercepts and slopes depended on codend mesh and lifting bag and their two way interaction.

The model was then increased in a forwards stepwise procedure by including variables in the regression model one by one (test side or fishing area), if they were statistically significant based on the Tmax statistic from the bootstrap hypothesis tests, then the most significant was added. If no addition could be made then the model was simplified in a backwards stepwise regression where variables or interactions were removed one by one, if they prove to be statistically insignificant, the most insignificant was removed. The process was repeated until no further variables or their interactions could be added or removed (Table 7).

The final model determines which categorical variables (if any) should be used for plotting relative catch rate graphs. The results are presented in Figures 1 to 5 where the relative catch rate is shown as the proportion of fish retained in the test gear at each length as compared to the control net. A value of one indicates that the test gear caught the same number of fish at that length compared to the control. Catch rates significantly different from unity (the control) are plotted in a solid line, those not significantly different are plotted in a dashed line (pointwise 5% significant level).

Results

A total of 45 hauls were undertaken of which 41 were considered valid. The valid hauls consisted of 10 hauls (5 on port side, 5 on starboard side) with each of the 80 mm, 80 mmL and 100 mm codends and 11 (5 on the port side and 6 on starboard) with 100 mmL. The port net had a mean wingspread of 7.0m while the starboard net had a mean of 7.1m (Table 3). Apart from two days of westerly gales which necessitated fishing off Trotternish to the east of Skye at the very beginning of the trials conditions were calm and settled throughout. Catches of Nephrops off Trotternish were moderate only and the trials then covered various grounds in the South Minch in an effort to reproduce numbers more consistent with commercial fishing (Figure 6). All hauls were, however, successful in catching some Nephrops and overall some 41000 individuals were measured during the course of the trials along with 4809 haddock, and 9261 whiting. In certain areas, particularly to the east of Tiree a large proportion of the Nephrops caught were of an extremely small average size.

All test cases exhibited a reduction (18-92%) of the overall bulk catch as compared to the control. As expected the reductions tended to be largest in the 100 mm test cases and smallest in the 80 mm (Table 1 and 2). However, this reduction varied widely depending upon the makeup of by-catch in the control net and catches with a relatively high component of juvenile mackerel (*Scomber scombrus*) and blue whiting (*Micromesistius poutassou*) had the largest reductions as compared to those where the bycatch was largely lesser spotted dogfish (*Scyliorhinus canicula*).

Many hauls exhibited a component of 0-group (<1 year old) whiting and haddock in the control net along with small amounts of bigger individuals of both species. In the test net 0-group fish were generally few in number. Due to lack of larger whiting and haddock encountered during these trials selectivity results are available only for relatively small fish: approximately 15-25 cm and 16-23 cm respectively.

Overall there were enough Nephrops and whiting to produce selectivity information for all four test codends with somewhat more limited data for haddock. These trials encountered some by-catch cod, however, numbers were too low and individual fish too large to produce selectivity data. Likewise witch numbers were too low to successfully analyse. Both cod and witch catch weights were incorporated into the remainder catch weight (column 'other' in Table 1) for the purposes of this report. For each species where there were sufficient data the results are summarised as follows:

Nephrops

All 41 hauls were included in the analysis. Codend mesh size, lifting bag and test side were all found to have a significant effect ($p = 0.011$, 0.000 and 0.000 respectively). When the test net was fished on the port side it retained/caught more Nephrops (Figure 1) than on the starboard side (Figure 2). Therefore, to simplify the effect of mesh size and lifting bag the results for each side were combined (Figure 3). Unfortunately the modelling software is unable to calculate the standard error/confidence bands when the side variable is combined. Hence the analysis is unable to identify whether the mesh-lifter gears are significantly different from the control. It does, however, clearly show that the use of smaller 80 mm mesh and/or lifting bag increases retention rates. At a carapace length of 35 mm, the catch rates of the 100 mm, 80 mm, 100 mmL and 80 mmL codends are approximately 56%, 66%, 73% and 86% respectively.

Haddock

Catches of haddock in the South Minch were a lot lower compared to the initial hauls carried out in the North Minch. Thirteen hauls from the South Minch were excluded from analysis due to a lack of numbers/length classes. Many of the other hauls that passed the minimum requirements still had quite low numbers. Only the presence/absence of the lifting bag proved to be significant ($p = 0.006$). The use of the lifting bag significantly increased the catches over the whole range. Retention at 20 cm without a lifting bag was 36.4% compared to 62.5% with a lifting bag (Figure 4).

The fishing area and test side effects were borderline but not significant ($p = 0.057$ and 0.055 respectively). No effect was found with mesh size and this is probably due to the small sizes of haddock on the grounds most of which would be expected to escape from both 80 and 100 mm mesh size codends.

Whiting

Catches of whiting were relatively consistent through the cruise. All 41 hauls were included in the analysis. The results are as expected with both codend mesh size and use of the lifting bag proving significant (p = 0.001 for both). The 100 mm test caught significantly fewer whiting than the control at all lengths (15.5 - 25.5 cm). Whiting at lengths ≥ 25 cm were not significantly different for both the 100 mm and 80 mmL tests. For the 80 mm test whiting ≥ 24 cm were not significantly different from the control. In general, the use of smaller mesh and/or lifting bag increases retention rates. At a length of 20 cm in the order of observed decreasing selectivity (100 mm, 100 mmL 80 mm, and 80 mmL) the corresponding catch rates are approximately 3%, 14%, 23% and 33% (Figure 5).

Discussion

Increasing the mesh size and removing the lifting bag improves the selection of Nephrops. The least selective gear is the 80 mmL and the most selective is the 100 mm. The relative catch rates of the 100 mmL and the 80 mm codends are similar which suggests that the selective improvement by increasing mesh size is offset by using a lifting bag. As with trials of Drewery *et al*. (2015) on mesh size and twine number, it is noticeable that the smallest size classes of Nephrops (<30 mm cl) although showing sizeable reductions as compared to the control net may not respond significantly to changes in mesh size or presence/absence of a lifting bag. The 80 mm, 100 mm and 100 mmL cases show similar selective properties over this size range and demonstrate that a large proportion of the smaller Nephrops do not escape through these diamond mesh codends.

The analysis is complicated by the catch rates of the test gears being greater when they were on the port side. While a difference in the catching performance between the two sides of a twin-trawl rig is not unusual it is not clear, in this instance, what is causing it. It's possible that the marked side difference for the 80 mmL test case may be due to the fact that it was fished on the starboard side in the North Minch when sheltering from stormy conditions but with moderate movement of the vessel and fished on the port side around Tiree in absolute calm weather and with no movement of the vessel. In fully calm conditions the codend is much more stable and there may be less sifting of Nephrops through the meshes than there may be when it is pulsing in poorer conditions.

The morphology of Nephrops means that clear-cut selectivity results are often difficult to obtain especially where diamond meshes are concerned (Briggs 1986). Nephrops are not thought to have the same escape imperative or swimming abilities as whitefish. The whiting results are similar to those of Drewery *et al*. (2015) who showed that in the 80 mm codend the catch rate of 20 cm fish was 27% while here it is 23%, and that in the 100 mm codend the catch rate was 8% while here it is 3%. For haddock the trials were relatively data-poor with some of the test cases encountering very few of this species. The presence/absence of the lifter proved significant however, with the test cases utilising a lifter retaining more than those without. No side effects for whiting or haddock were observed which may indicate that their escape abilities overcame any differences in fishing ability between the two sides. All test cases showed moderate to very large reductions in overall bulk catch reduction showing that a lot of by-catch is removed where these are in use. The degree of reduction is, however, very dependent on the species and size makeup of the by-catch.

Commission Regulation EEC 3440/84 is loosely defined and allows for variation in mesh size of the lifting bag as well as well as variation in the overall size of the bag itself as compared to the dimensions of the codend section to which it is attached. Both of these factors will affect potential obstruction of the codend meshes in different ways. Whether the codend is rigged tight (lifting bag and section of codend covered both with the same stretched length and circumference) or slack (stretched length and/or circumference of bag larger than that of the section of codend it covers) will have an additional effect on obstruction and thus the selectivity overall (Stewart *et al*. 1985). A lifting bag constructed from heavier twine, applicable to the 80 mmL test case here (5 mm compared to 4 mm), will also increase obstruction as will the increase in twine number used in the construction (double compared to single).

Acknowledgements

The authors would like to express their thanks to Robert Summers, and the crew of the fishing vessel Rebecca Jeneen for their help and expertise during the trials.

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Appendix: Tables and Figures

Note: for the relative catch rate figures below a solid line denotes where the catch rate is significantly different from 100%. A broken line shows where the rate is not significantly different.

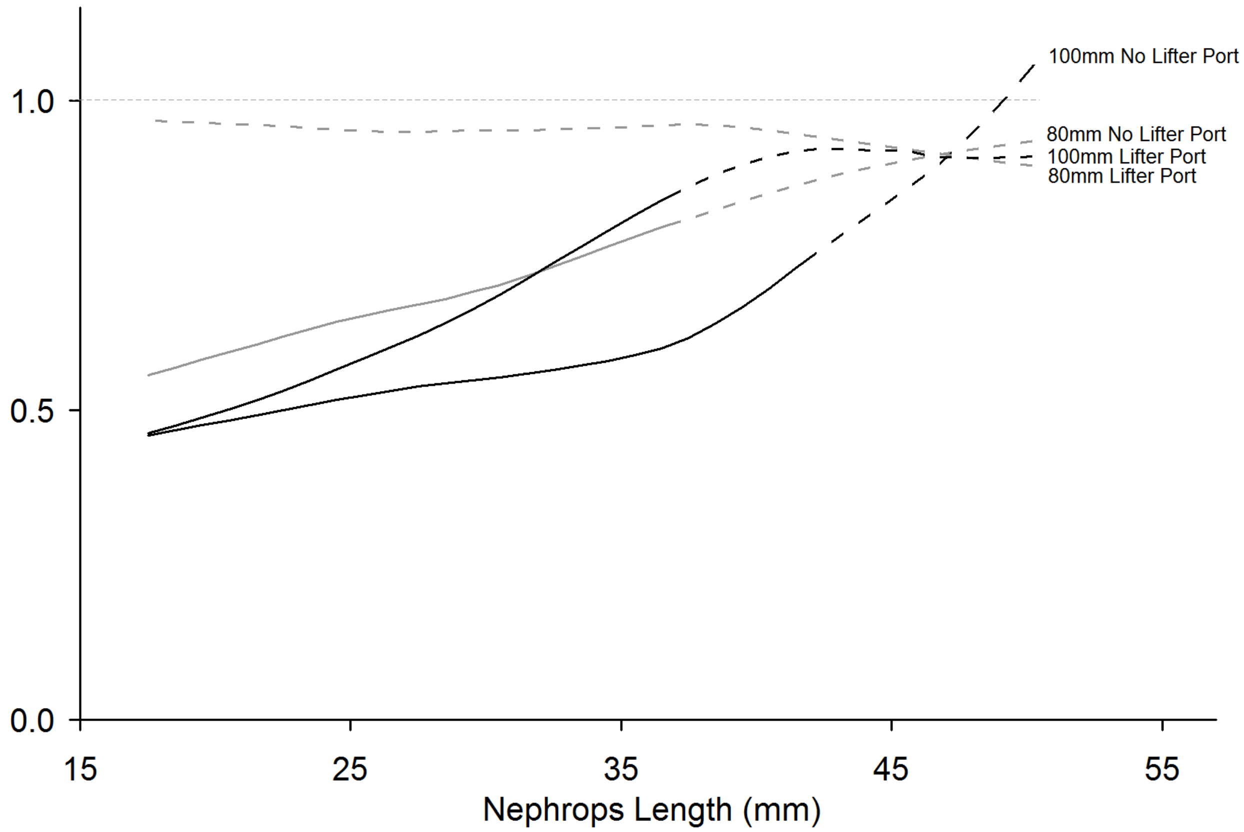

Figure 1. The relative catch rate of Nephrops by codend fished on port side from smoothed data.

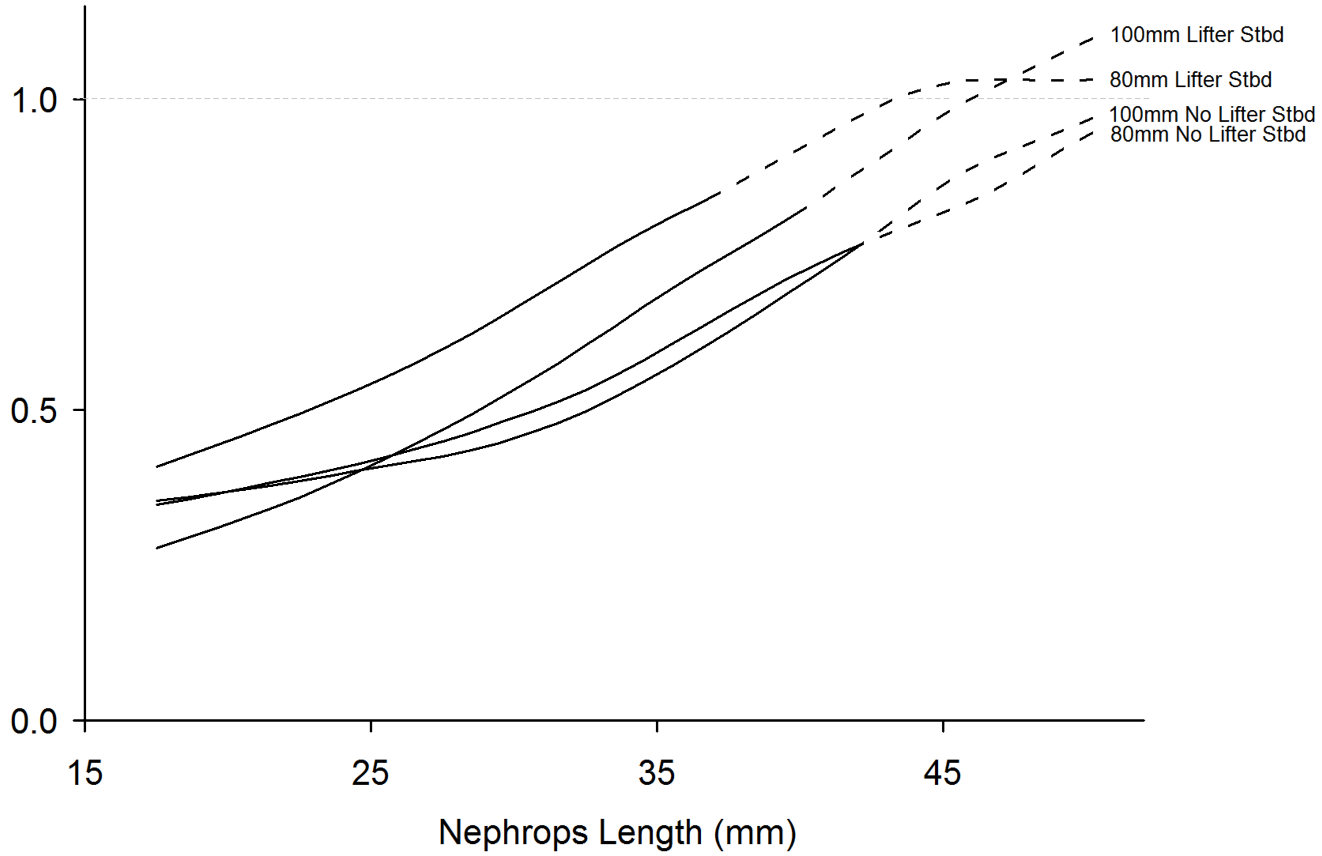

Figure 2. The relative catch rate of Nephrops by codend fished on starboard side from smoothed data.

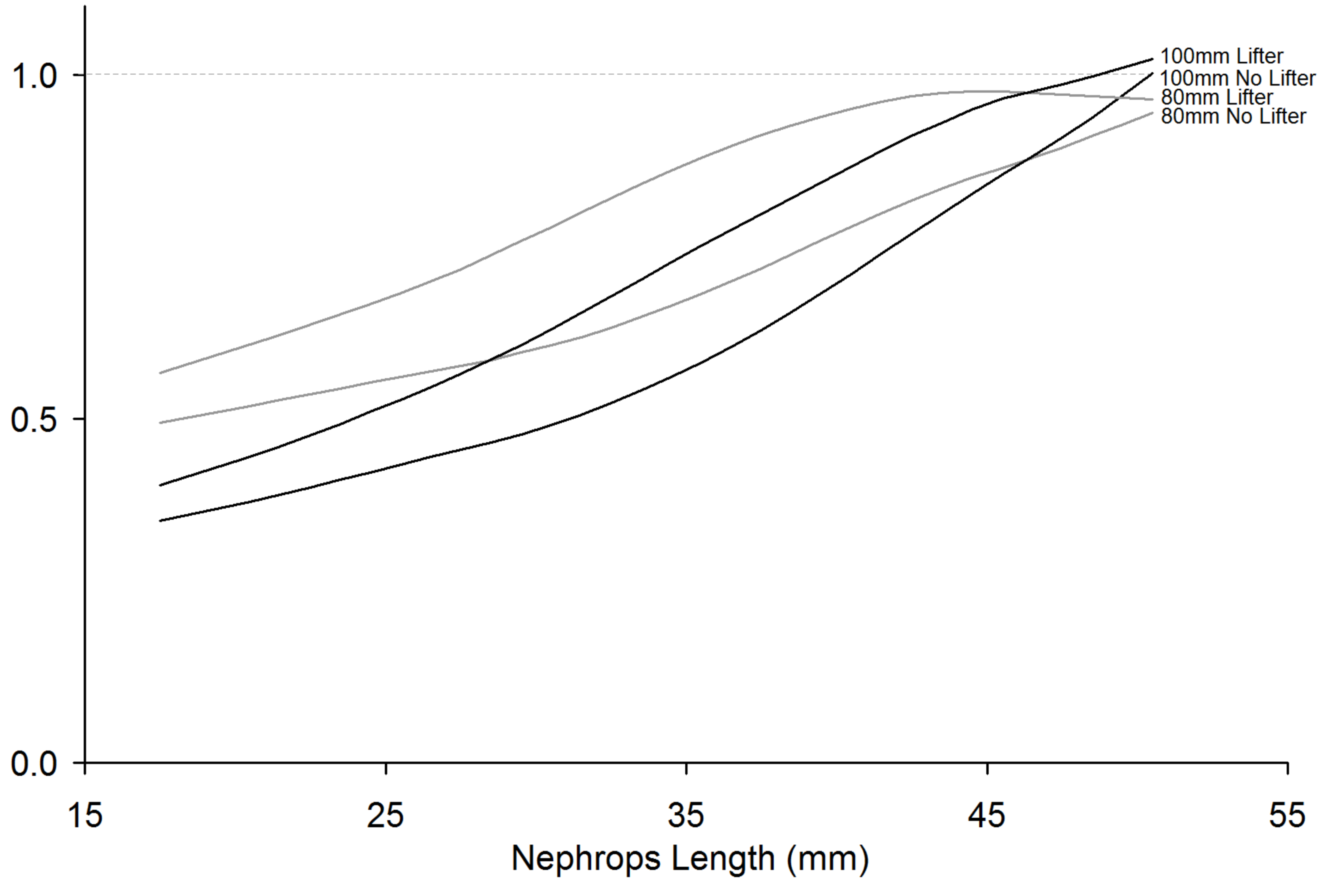

Figure 3. Estimated relative catch rate for Nephrops with results combined for both sides. The standard error about the catch rate curves could not be calculated due to the effect of combination; therefore, no indication of significance or non-significance can be given in this graph.

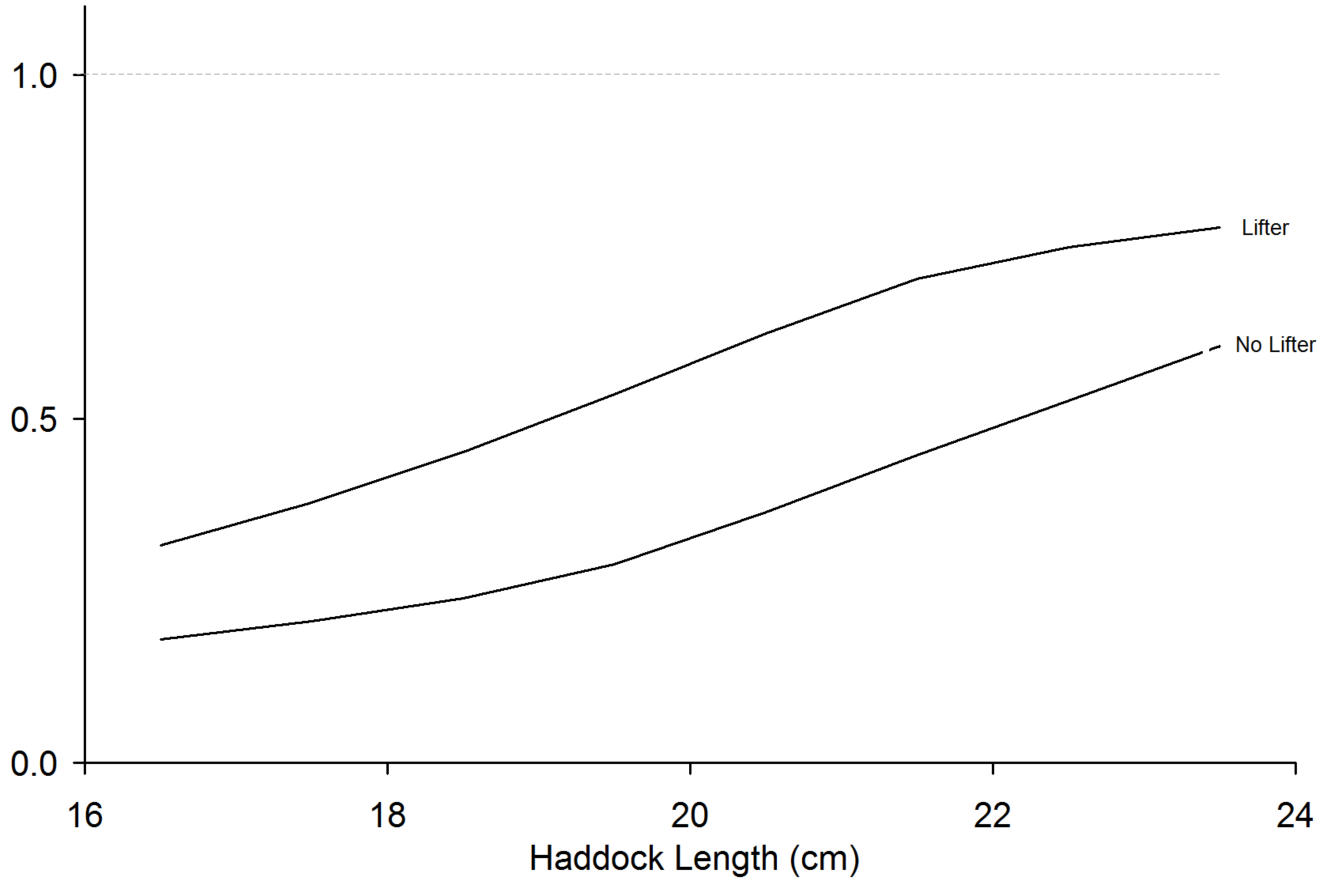

Figure 4. Estimated relative catch rate for haddock from smoothed data.

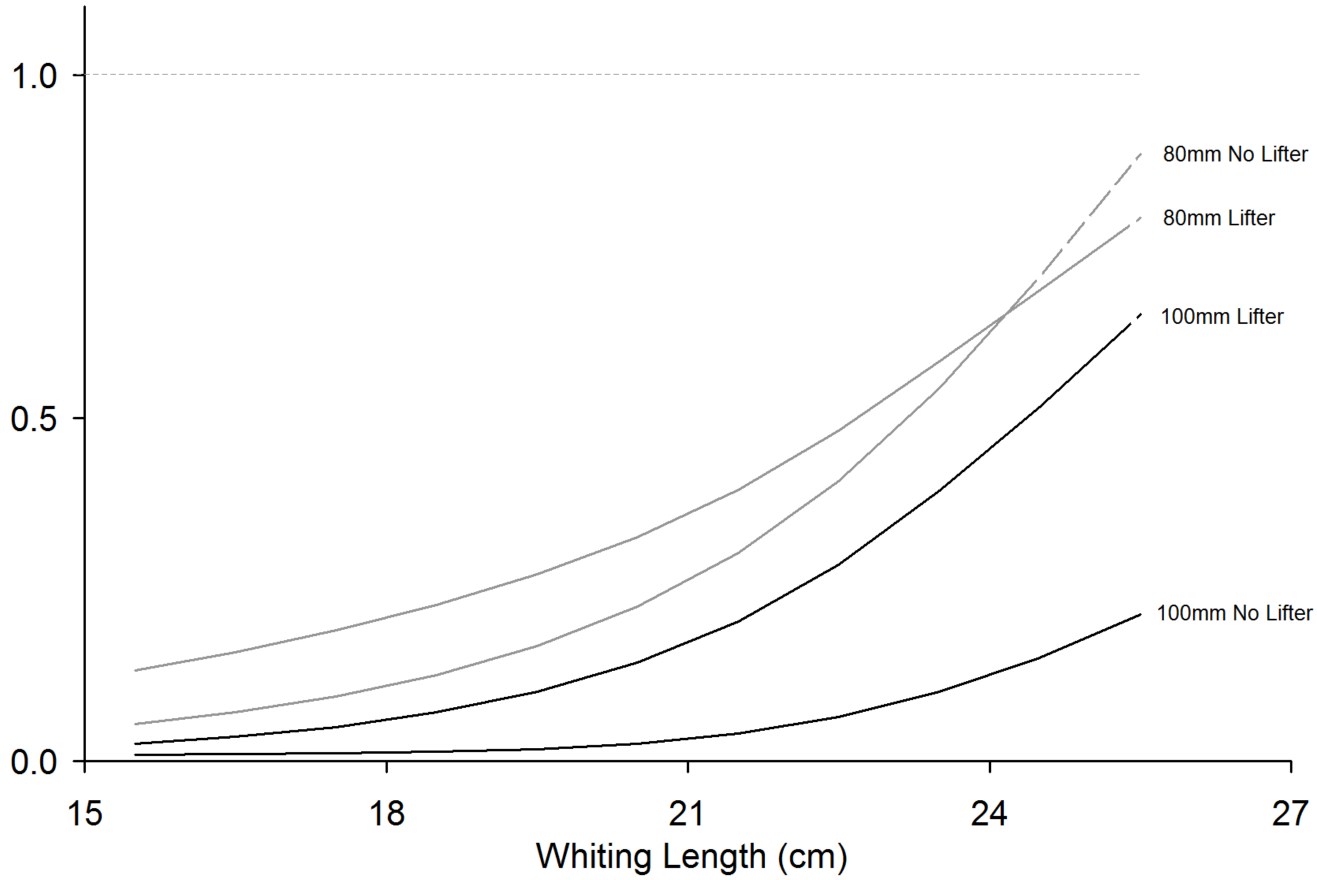

Figure 5. Estimated relative catch rate for whiting from smoothed data.

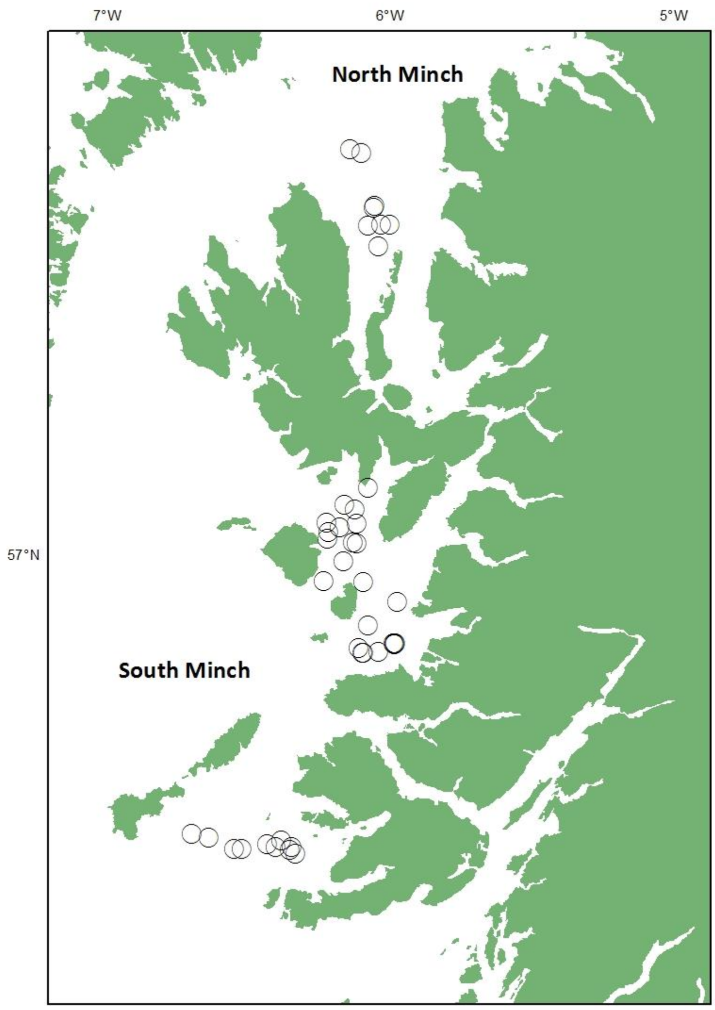

Figure 6. Approximate midpoints (open circles) of hauls undertaken during the trials.

Haul No.	Config. Tested	Control Net Nep	Had	Whi	Other	Totals Control	Test Net Nep	Had	Whi	Other	Totals Test	% wt. Red.
1	80L Stbd	40.3	64.3	36.6	82	**223**	29.1	32.9	8.2	27	**97**	56
2	80L Stbd	60.3	74.3	7.8	85	**227**	65.4	52.1	4.5	24	**146**	36
3	80L Stbd	78.7	220.2	56.7	356	**712**	66.6	93.8	9.4	24	**194**	73
4	80L Stbd	94.2	110.8	21.1	152	**378**	85.0	61.3	5.9	94	**246**	35
6	80L Stbd	50.3	96.9	4.8	302	**454**	39.1	76.1	2.6	37	**155**	66
7	100L Stbd	61.0	52.4	1.0	126	**240**	37.3	41.2	0.4	40	**118**	51
8	100L Stbd	75.8	114.8	71.1	111	**373**	45.1	47.1	2.2	18	**112**	70
9	100L Stbd	49.2	69.5	4.5	92	**215**	55.3	39.0	1.3	36	**131**	39
10	100L Stbd	93.2	2.5	31.0	138	**265**	68.7	1.2	4.2	40	**114**	57
11	100L Stbd	49.5	0.6	18.1	170	**238**	37.6	0.4	1.6	95	**135**	43
12	100L Stbd	57.9	6.7	13.0	73	**150**	41.0	7.4	4.8	42	**95**	37
13	100L Port	60.2	5.2	10.4	193	**269**	38.1	3.2	2.8	20	**64**	76
14	100L Port	88.8	18.1	37.7	221	**366**	67.8	15.5	3.3	50	**137**	63
15	100L Port	38.7	26.2	44.4	102	**211**	30.9	22.2	4.6	35	**93**	56
16	100L Port	46.5	3.1	17.8	311	**378**	41.1	2.6	1.7	34	**80**	79
17	100L Port	17.9	2.6	5.2	406	**432**	12.5	2.9	2.4	18	**36**	92
19	80L Port	48.3	2.3	39.4	51	**141**	53.5	2.5	32.8	6	**41**	71
20	80L Port	48.4	1.8	41.6	51	**143**	53.4	2.8	34.3	21	**112**	22
21	80L Port	96.9	0.9	57.1	86	**241**	75.4	4.0	51.1	44	**174**	28
22	80L Port	104.4	1.5	63.7	65	**235**	108.0	0.2	63.1	21	**192**	18
23	80L Port	91.6	1.8	39.6	72	**205**	83.6	1.5	20.4	21	**126**	39
24	80 Port	83.3	1.5	51.3	39	**175**	75.9	1.2	39.9	10	**127**	27
26	80 Port	84.9	1.7	32.3	38	**157**	58.6	6.6	27.2	29	**121**	23
27	80 Port	67.0	1.2	25.7	66	**160**	48.4	2.8	24.4	6	**82**	49
28	80 Port	78.7	2.2	20.5	87	**188**	62.5	0.7	12.8	38	**114**	40
29	80 Port	47.1	0.0	13.4	41	**101**	32.8	0.0	10.3	16	**59**	42
30	100 Port	174.6	4.5	41.9	251	**472**	117.5	0.8	0.5	35	**154**	67
31	100 Port	62.6	3.6	41.9	371	**479**	42.1	1.2	0.3	50	**94**	80
32	100 Port	38.6	4.7	29.8	221	**294**	23.2	1.1	0.4	15	**40**	87
33	100 Port	76.3	0.2	5.9	150	**232**	53.9	0.1	0.1	15	**69**	70
34	100 Port	154.8	5.8	40.6	181	**382**	92.4	1.2	0.2	18	**112**	71
35	100 Stbd	122.6	5.9	35.6	201	**365**	82.6	1.3	0.5	20	**104**	71
36	100 Stbd	153.7	4.0	24.4	182	**364**	97.7	2.2	1.2	10	**111**	70
37	100 Stbd	132.5	11.2	32.4	122	**298**	57.1	4.3	5.1	36	**102**	66
38	100 Stbd	120.7	7.9	53.8	120	**302**	67.0	1.6	2.1	36	**106**	65
40	100 Stbd	68.7	2.9	26.8	150	**248**	46.4	1.0	0.6	15	**63**	75
41	80 Stbd	97.5	2.7	11.0	156	**267**	58.7	1.6	2.0	40	**103**	62
42	80 Stbd	113.5	0.7	37.6	210	**362**	86.5	0.2	3.4	20	**110**	69
43	80 Stbd	168.9	1.6	39.3	160	**370**	112.8	1.1	4.8	26	**144**	61
44	80 Stbd	102.6	2.4	12.5	100	**217**	46.2	1.2	3.8	56	**107**	51
45	80 Stbd	94.6	1.5	22.2	126	**244**	49.6	0.3	3.2	126	**179**	27

Table 1. Weight (kg) of Nephrops (Nep), haddock (Had), whiting (Whi), and other commercial species, non-commercial species and invertebrates (Other) along with the overall bulk weight reduction by haul number and test configuration (mesh size, presence/absence of lifting bag and whether fished port or starboard on the twin-rig). Missing haul numbers refer to foul hauls.

Haul No.	Config. Tested	% weight reductions Nep	Had	Whi
1	80L Stbd	28	49	78
2	80L Stbd	-8	30	43
3	80L Stbd	15	57	83
4	80L Stbd	10	45	72
6	80L Stbd	22	21	45
7	100L Stbd	39	21	60
8	100L Stbd	41	59	97
9	100L Stbd	-12	44	72
10	100L Stbd	26	52	87
11	100L Stbd	24	27	91
12	100L Stbd	29	-11	63
13	100L Port	37	39	73
14	100L Port	24	15	91
15	100L Port	20	15	90
16	100L Port	12	15	90
23	80L Port	9	17	48
24	80 Port	9	21	22
26	80 Port	31	-288	16
27	80 Port	28	-133	5
28	80 Port	21	67	38
29	80 Port	30	-	23
30	100 Port	33	83	99
31	100 Port	33	66	99
32	100 Port	40	77	99
33	100 Port	29	33	99
34	100 Port	40	79	100
35	100 Stbd	33	79	99
36	100 Stbd	36	46	95
37	100 Stbd	57	62	84
38	100 Stbd	44	80	96
40	100 Stbd	32	66	98
41	80 Stbd	40	40	82
42	80 Stbd	24	77	91
43	80 Stbd	33	32	88
44	80 Stbd	55	50	70
45	80 Stbd	48	83	86

Table 2. Retention (% by weight) for the three main commercial species caught. It is important to note that these retention values will apply only to the length frequencies encountered during each haul.

Haul	Port	Starboard	Haul	Port	Starboard
1	7.2	7.3	24	7.2	7.3
2	7.0	7.2	26	7.2	7.2
3	6.8	6.9	27	7.2	7.3
4	7.2	7.2	28	6.9	7.2
6	7.1	7.3	29	7.1	7.1
7	7.2	7.3	30	6.9	7.0
8	7.2	7.4	31	6.8	7.0
9	7.1	7.3	32	6.9	7.1
10	7.2	7.1	33	7.1	7.2
11	6.8	6.9	34	6.7	7.0
12	7.0	7.3	35	7.0	7.1
13	7.2	7.3	36	6.9	7.1
14	7.1	6.8	37	7.0	7.0
15	7.2	7.2	38	6.9	6.9
16	6.9	7.2	40	6.9	7.0
17	6.9	7.1	41	6.8	6.9
19	6.9	7.0	42	6.8	7.0
20	7.2	7.1	43	7.1	7.0
21	7.3	7.3	44	7.1	7.0
22	7.3	7.3	45	7.0	7.1
23	7.1	7.3			

mean overall values - Port: 7.0m Starboard: 7.1m

Table 3. Mean wingspreads (m) by haul and overall.

Codend Nominal	Codend Material	Codend Inside Mesh	Codend Full Mesh	L. Bag Inside Mesh	L. Bag Full Mesh	Ratio Inside Mesh	Ratio Full Mesh	Lifting Bag Material	Lifting Bag Length	Codend Covered	Ratio
80mm	4mm single	83mm	90.5mm	178mm	200mm	2.4	2.2	5mm double	3.3m	3.2m	1.03
100mm	5mm double	103mm	117mm	214mm	235mm	2.1	2.0	5mm double	3.4m	3.3m	1.03

Table 4. Test codend and lifting bag specifications. All codends and straight sections were constructed from Brezline (PE). The mesh ratio is the ration of 2x codend full mesh measurement to lifting bag full mesh measurement. Full mesh and lifting bags lengths should be regarded as approximate.

Codend Mesh	Mean Size Pre-Trials	Mean Size Post-Trials
80 mm	82.6	80.9
100 mm	103.7	101.0

Table 5. Mean codend mesh measurements (30 measurements on each of top and bottom sheet over the area of selectivity during the trials). All measurements were taken with a standard Omega gauge on wet meshes.

Species	Test	No. of hauls	AIC window	Median length range
Nephrops	-	41	35	15.5 : 55.5
	80mm	10	37	15.5 : 53.5
	80mmL	10	35	14.5 : **50.5**
	100mm	10	**25**	15.5 : 56.5
	100mmL	11	41	**17.5** : 58.5
Haddock	-	28	**15**	15.5 : 25.5
	80mm	3	<11	**16.5 : 23.5**
	80mmL	7	15	14.5 : 44.5
	100mm	9	15	15.5 : 23.5
	100mmL	9	13	15.5 : 28.5
Whiting	-	41	**15**	14.5 : 27.5
	80mm	10	19	**15.5** : 25.5
	80mmL	10	13	**15.5** : 37.5
	100mm	10	15	14.5 : **25.5**
	100mmL	11	11	14.5 : 26.5

Table 6. Parameters predicted for smoother fitting. Window and median length range values in bold were used for overall fitting.

Species	Final model	Stepwise regression	P-value
Nephrops	~ 1 + M + L + S	Add M:L	0.445
		Add M:S	0.685
		Add L:S	0.752
		Add A	0.417
		Drop M	0.011
		Drop L	0.000
		Drop S	0.000
Haddock	~ 1 - L	Add M	0.839
		Add A	0.057
		Add S	0.055
		Drop L	0.006
Whiting	~ 1 + M + L	Add A	0.058
		Add S	0.085
		Add M:L	0.059
		Drop M	0.001
		Drop L	0.001

Table 7. Results of the bidirectional stepwise regression. For ease the variables have been abbreviated (M = codend mesh, L = Lifting bag, S = test side, A = fishing area).