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Comparing the selectivity of different cod end configurations in the Farne Deeps *Nephrops* trawl fishery

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Executive Summary

This work was carried out as part of the Fisheries Science Partnership (FSP) programme. The twin rig trawler *Nimrod* was chartered to undertake trials in a *Nephrops* (*Nephrops norvegicus*) fishery. Eleven days of fishing trials were conducted in the Farne Deep (FU6: IVb; 38E8,38E9,39E9,40E8 and 40E9) fishing grounds off the North-East coast of England in November and December 2017. This enabled catch comparisons of five cod ends of varying mesh size, twine thickness and circumference to be examined. The primary objective of this work was to compare the catch rates of these cod ends as those conforming to the latest licence conditions were suggested to be counterproductive by the industry. These measures were introduced in April 2016 following concerns of historical overexploitation of *Nephrops* in the Farne Deep¹. The specific object of the project was to develop an optimum cod end construction to reduce catches of small *Nephrops*. A total of 27 hauls were completed for eleven days fishing, with 26 of these considered valid for examination.

The introduction of new licence conditions² in the fishery in April 2016, brought in two changes in net construction for single rig vessels, firstly an increase in cod end mesh size from 4mm/80mm to 5mm/90mm and secondly a reduction in cod end circumference, from 120 meshes to 100 meshes. Vessel operators introduced a further change by opting for a compact braided twine used in the construction of the new cod ends. This was to prevent shrinkage of mesh size and ensure compliance with the measures. After several months many skippers felt that these new cod ends were detrimental and in fact counterproductive, stating that more, smaller *Nephrops* and fin fish were being caught.

With the limited time available, four cod end configurations were selected for comparison. The intention was for catches from the selected cod ends to be compared with a fine mesh reference cod end. However, the reference cod end constructed from 35mm mesh affected the performance of the trawl adversely when it was compared against a cod end complying with current regulations. The cod end which was compliant with current regulations was selected as the reference cod end, against which others were compared. A cod end of 4mm standard braided twine, 80mm mesh, 120 meshes around (pre-2016 cod end for single rig vessels) was operated for nine hauls over three days. A further three days and eight hauls compared a cod end of 4mm standard braided twine, 90mm mesh, 100 meshes around. The final two days of the charter compared a cod end of 5mm standard braided twine, 90mm mesh, 120 meshes around constructed without selvages over 5 hauls.

Although the conclusions are limited to the data from 26 hauls, the skippers' fears of the new technical measures being counterproductive could not be supported by the trials. The cod end compliant with current regulations did not demonstrate either an increase or decrease in selectivity. However, enhancements in selectivity for *Nephrops* were demonstrated with one of the cod ends tested. A cod end of 120, 90mm meshes circumference, 5mm standard braided twine constructed without selvages reduced the catch of small *Nephrops* (between 22mm and 33mm carapace length) by 20%.

¹ ICES. 2015. ICES Advice 2015, Book 6, 2015. 6.3.26/6.3.26 Norway lobster (*Nephrops* spp.) in Division IVb, FU6 (Central North Sea, Farne Deep),

² Cod Plan European Council Regulation (EU) 1342/2008 ,1243/2012.

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1 Introduction

1.1 The Fisheries Science Partnership

The Fisheries Science Partnership (FSP) is a Defra-funded collaborative research programme of scientific research between the UK fishing industry and scientists. Since it was established in 2003 the programme has undertaken around 100 projects, covering annual time-series surveys of stocks subject to traditional assessments and *ad hoc* projects on, e.g., gear selectivity, discard survival, tagging and migration, and fishery development. A full description of the aims and all completed reports of the FSP programme can be found on the Cefas website (www.cefass.defra.gov.uk). Charter of suitable fishing vessels for projects approved by Defra and its FSP steering committee. It is arranged through an open tendering procedure, with scientific and operational work plans developed in line with the agreed and commissioned project between Cefas and the selected vessel.

Fishing gear selectivity has featured highly in the FSP programme and both scientists and industry continue to seek ways of improving gear design to minimise discarding. This work investigates the selectivity of demersal trawls used to target *Nephrops* by exploring changes in the construction of cod ends.

1.2 Background

Following concerns of historical overexploitation of *Nephrops* (*Nephrops norvegicus*) in the Farne Deep (IVb: 38E8,38E9,39E9,40E8 and 40E9), new license conditions aimed at reducing the overall fishing pressure on the stock were introduced in April 2016.

The conditions introduced were:

- Vessels will be required to use a cod end of minimum mesh size of 90mm using single twine of no more than 5mm and 100 meshes around.
- Only single-rig vessels of 350kW (476hp) or less will be permitted to fish within 12nm of the coast.
- Multi-rig vessels (vessels with three or more rigs) will be prohibited from operating within the Farne Deep. Twin rig vessels will be permitted to operate outside 12nm of the coast.
- No vessel will be permitted to use gear with multiple cod ends per rig.

Previously, single-rig vessels used a cod end with minimum mesh size of 80mm and 120 meshes around, usually of 4mm twine. Multi and Twin-rig vessels used the same construction with a minimum mesh size of 100mm.

To assist vessels to comply with the new regulations a grant of 50% of the cost of new cod ends was made available for those opting to use a mesh of 95mm. This resulted in a dilemma for net constructors as neither 90/5mm nor 95/5mm netting was readily available to purchase, and the minimum order values needed for special production runs were prohibitive. Not wishing to be left with unsalable stock the fishermen's opinion was canvassed. Most intimated that they would need 90mm cod ends and assurance that this would stay legal and not shrink. Shrinkage occurs when fine grains of the sea bed material enters the twine, filling spaces, thickening and contracting it, exposure to sunlight and temperature variations*. To comply with the new conditions the cod ends were constructed using a compacted braided twine. This has been developed to have no spaces in it for fine grains to lodge. Whilst alleviating the shrinkage problem it results in a less flexible twine.

*E.S. Strange, Mesh Shrinkage in Fishing Nets. Marine Laboratory, Aberdeen

During DCF trips in 2016, skippers told observers that since complying with the new regulations they could see no difference in the size of *Nephrops* caught. Some felt that the regulations were counterproductive, and they were catching smaller *Nephrops* and fin-fish than before. Many could see no reason for the reduction in the number of meshes around the cod end from 120 to 100 and felt this also contributed to catching smaller individuals of all species. One skipper's proposal of a project to investigate this was accepted by the FSP steering committee.

1.3 Objective

The aim of this project was to generate evidence that will inform on an optimum cod end construction to reduce catches of small *Nephrops* in the Farne Deeps *Nephrops* trawl fishery.

The specific object of the project was to compare, using a catch comparison method, the catch rates of *Nephrops* and other main species caught between four different cod ends onboard a commercial twin rig *Nephrops* otter trawler.

2 Materials and Methods

2.1 Vessel

Following an open tendering process, the fishing vessel *Nimrod* (BH 227) (Figure 1) was awarded a contract to undertake the survey work associated with this project over a period of 10 days. MFV *Nimrod* is a 16.50m wooden-hulled trawler/seiner based at Amble, in the northeast of England. Landings were made into Amble and Blyth.



Figure 2.1.1: Nimrod BH227, L.O.A. 15.5m, NT 40.5, 289KW.

2.2 Gear

The vessel's own commercial trawls made by Boris Net Co Ltd were used in a twin-rig configuration for the trial. Apart from the experimental modifications, both trawls were of identical construction; the trawls had a 450-mesh x 80 mm fishing circle, with ground gear of 46m constructed from 6 and 15cm rubber discs. Both trawls had a Square Mesh Panel of 100mm T45 in the regulation position i.e. within 12m of the cod line. All cod ends for the trial were made by Boris Net Co Ltd. For the duration of the trials the port net cod end remained unaltered and changes of cod end were made to the starboard net. The trawls were towed using a 3-warp towing system with a 500kg clump centre weight and spread using Bison No.6 doors connected to the nets by 92meter combination spreaders. To reduce any port/starboard bias it has been common practice for gear trials of this type to have the test trawl fished on both sides. Time and weather constraints did not allow for this, but observations made on a DCF catch sampling trip carried out after these trials indicated that both nets fished similarly.

2.2.1 Gear and weather monitoring

The vessel had a Notus® gear monitoring system onboard. This was used to monitor door and net spread, with sensors on both doors and the clump. Wind speed and direction was recorded from a Furuno RD30 weather station.

2.3 Area and period of the survey

Tows of 2-4 hours duration, i.e. typical of normal commercial practice, were conducted in the Farne Deeps fishing grounds off the North-East coast of England. Towing speed was on average between 2.5 and 3.3 knots. All fishing took place in the statistical rectangles 39E8, 40E8 and 40E9 (ICES area IVb), bottom depths ranged between 68m and 104 m (Appendix 4.3). The area of the main *Nephrops* fishing grounds within the Farne Deeps is classed as Functional Unit 6 (FU6) in the North Sea *Nephrops* stock assessment and is relatively small and highly localised. Fishing took place during daylight and darkness, however because *Nephrops* catches were negligible during darkness, priority was placed on achieving daylight tows.

Fishing took place between the 20th of November and the 6th of December 2017. Trials took place on eight consecutive days from the 20th of November till they were interrupted by Northerly gales. Fishing resumed on the 4th of December till the 6th. A total of 27 hauls were completed representing 68 hours 35 minutes fishing time over 11 days. An invalid tow was recorded when one net was torn on haul 22. Data from 26 hauls representing 66 hours and 37 minutes was considered valid.

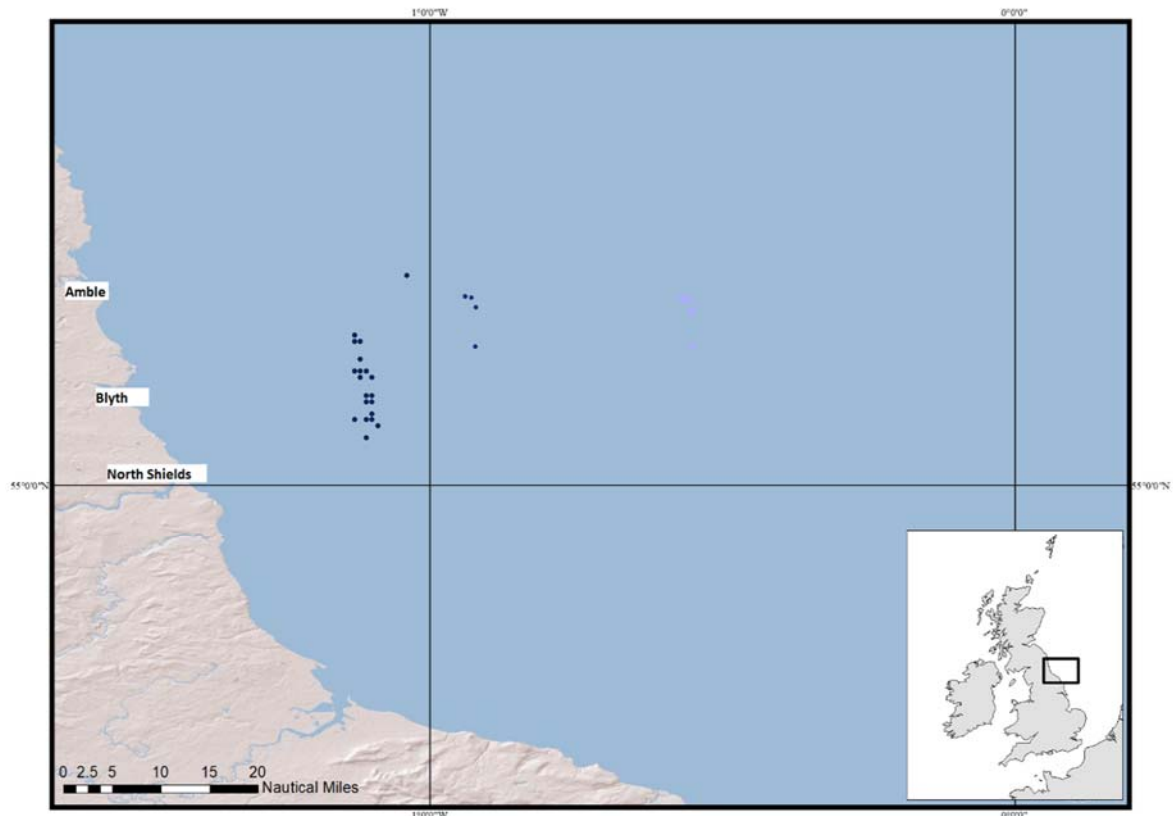


Figure 2.3.1: Area of the survey. (Hauling positions indicated)

(See Appendix 5.3 for shooting and hauling depths, times and exact positions.)

2.4 Experimental Design

The aim of the experimental trials was to compare the catch rates of a reference cod end against those of other cod ends (See Appendix 5.4.). Current and past regulation cod ends were examined along with two other cod ends. As mesh size, twine diameter and number of meshes in circumference had been changed in the new regulations it was not feasible to examine every combination possible. It was decided to examine two cod ends where only two of the variables were changed. (D; mesh size and circumference, E; mesh size and twine diameter.)

- A. Reference cod end: 2.5 twisted twine, 35mm mesh.
- B. Current single rig regulations: 5mm compact braided twine, 90mm mesh. 100 meshes around.
- C. Pre-2016 single rig regulations: 4mm standard braid twine, 80mm mesh. 120 meshes around.
- D. Experimental cod end: 4mm standard braided twine, 90mm mesh. 100 meshes around.
- E. Experimental cod end: 5mm standard braided twine, 90mm mesh. 120 meshes around, no selvages.

Following discussions with the skipper, the experimental plan was agreed:

- The trial would take place over 10 consecutive days.
- Commercial fishing patterns would be followed if catches could be cleared and sampled within the duration of a tow.
- All cod ends provided were to be examined (Table 2.4.1).

Problems were encountered in the first two days during hauls 1 to 4 comparing cod ends A and B. Each net was under spreading (port wing end to starboard wing end distance reduction) by 3 meters compared with normal operations. The skipper stated that he had seen this when a weight was caught by one net and the spread was reduced for both, he felt that these four tows did not represent the normal performance of his trawls. Hauls were made at varied speeds and state of tide, but the under spread was constant. It was thought that the reference cod end (A) could be responsible by increasing the drag of the net it was attached to so for day three it was removed and another cod end (C) used. The spread immediately returned to the expected 47-49 meters.

For the rest of the trials catch rates were to be compared against cod end B.

TRIAL	Hauls	Cod ends used		Construction Comparison
1	1-4	B	A	5mm compact braided 90mm x100 v 2.5 twisted 35mm v
2	5-13	B	C	5mm compact braided 90mm x100 v 4mm standard braided 80mmx120
3	14-21	B	D	5mm compact braided 90mm x100 v 4mm standard braided 90mm x100
4	23-27	B	E	5mm compact braided 90mm x100 v 5mm standard braided 90mm x120

Table2.4.1: Summary of cod ends used during the trial.

2.5 Sampling Plan

A fixed routine for handling and sorting the catch was maintained throughout the trials. Catches from the modified and current control nets were kept separate. The cod-ends of both trawls were drawn up to the vessel's stern then the port trawl's cod end was discharged into the reception hopper and the contents removed via conveyor to baskets on the deck. The starboard trawl's cod-end was then discharged into the empty hopper. The catch from the port trawl was processed first. The crew sorted the catch as they would normally, with the exception that all material usually discarded was retained in baskets for sampling as the "discard fraction". On completion of sorting the port cod end, all retained fish and *Nephrops* were removed from the deck to the fish hold. The discard fraction was sampled and then discarded, the contents of the starboard cod end were then processed in the same manner.

Cefas observers sampled using standard techniques. For each haul all fin-fish species caught were measured to the nearest cm below, the *Nephrops* carapace length was measured to the nearest mm

below. Sub sampling was necessary for *Nephrops* and the discard fraction, but sub samples reflected the total catch composition and raising factors were calculated.



Figure 2.5.1: Discharging the cod end into the hopper showing a typical catch.

2.6 Data analysis

For each trial, total numbers-at-length were raised to haul. Length-weight relationships were applied to the numbers at length data to calculate catch weights. The number and weights of the main species caught for the current used 90 mm gear and the absolute differences (modified trawl-current trawl) and % differences (((modified trawl- current trawl)/current trawl) *100) caught by the different modified cod ends are presented in Table 3.2.1 and 3.2.2. A percentage difference of 100% means that a double amount was caught in the experimental trawl.

Catch comparison analyses were performed using the software tool SELNET as recommended by STECF (STECF 2014). Information about the SELNET software can be obtained by consulting (Sistiaga et al. 2010, Eigaard et al. 2011, Frandsen et al. 2011, Wienbeck et al. 2011, Herrmann et al. 2012, Madsen et al. 2012, Sala et al. 2015). SELNET offers a variety of size selection models and methods for analysis; the present analysis is based on double bootstrap technique. The modelled proportion (r) of the cod end catch in the experimental trawl (C_{exp}) and the catch in the current regulations trawl (C_{tra}) at each length can be expressed as:

$$r = \frac{C_{exp}}{C_{exp} + C_{tra}}$$

The estimated model outputs were translated into the significant difference in the number caught between the modified and current regulations trawls for each species and trial. At each length, where the model output gave significant differences between the two trawls, the percentage difference in the number caught between the two trawls was converted into a weight difference using length-weight conversion coefficients. These significant number and weight differences were summed across the collected lengths to calculate the total observed significant number and weight difference for each species and trial. The observed significant number and weight difference is presented and its relative contribution to the current species catch number and weight for each trial (Table 3.2.3).

3 Results

3.1 Fishing activity

Tows were on average 2.5 hours in duration and were comparable over all hauls. Depth increased gradually from 78m at the beginning of the trials to 98m at the end, reflecting a gradual shift eastward on the fishing grounds. Although the net was under spreading in Trial 1, more animals per haul were caught in comparison with the other trials (Table 3.1.1). Number of hauls were low in trial 1 and 4. Trial 2 and 3 were based on almost double the number of hauls in trial 1 and 4.

TRIAL	Number of HAULS	Average Depth (m)	Average Tow duration (h:mm)	Total fishing time (h:mm)	Catch/ Haul Current Number	Total catch Current Number	Diff in total catch between modified and current Number	% Diff in total catch from current Number
1	4	78	02:31	10:06	10984	43938	6294	14
2	9	79	02:22	21:25	7971	71738	5446	8
3	8	81	02:47	22:18	8217	65735	-9866	-15
4	5	98	02:33	12:48	5636	28180	-2722	-10
Total	26	83	02:33	66:37	8061	209591	-848	0

Table 3.1.1 Overview of fishing activity showing the number of hauls, depth, tow duration, fishing time and the total catch and catch per haul in the current regulated gear and absolute and relative differences between a modified gear and current used gear in each trial Negative values mean there is a reduction in the modified gear.

3.2 Catch comparisons

3.2.1 Overview:

Overall the highest increase in numbers of all species, when compared with a cod end net of 90mm based on current regulations, at 14%, was seen for trial 1, when using a 35mm mesh cod end. Also, in trial two, where the pre-2016 regulations 80 mm mesh was used, an increase of 8% was noted. Reductions of -15% and -10% respectively were seen in trial 3 and 4 (Figure 3.2.1). In these trials the current regulations net of 90mm was used and changes were made either to twine diameter or number of meshes in the circumference of the cod end.

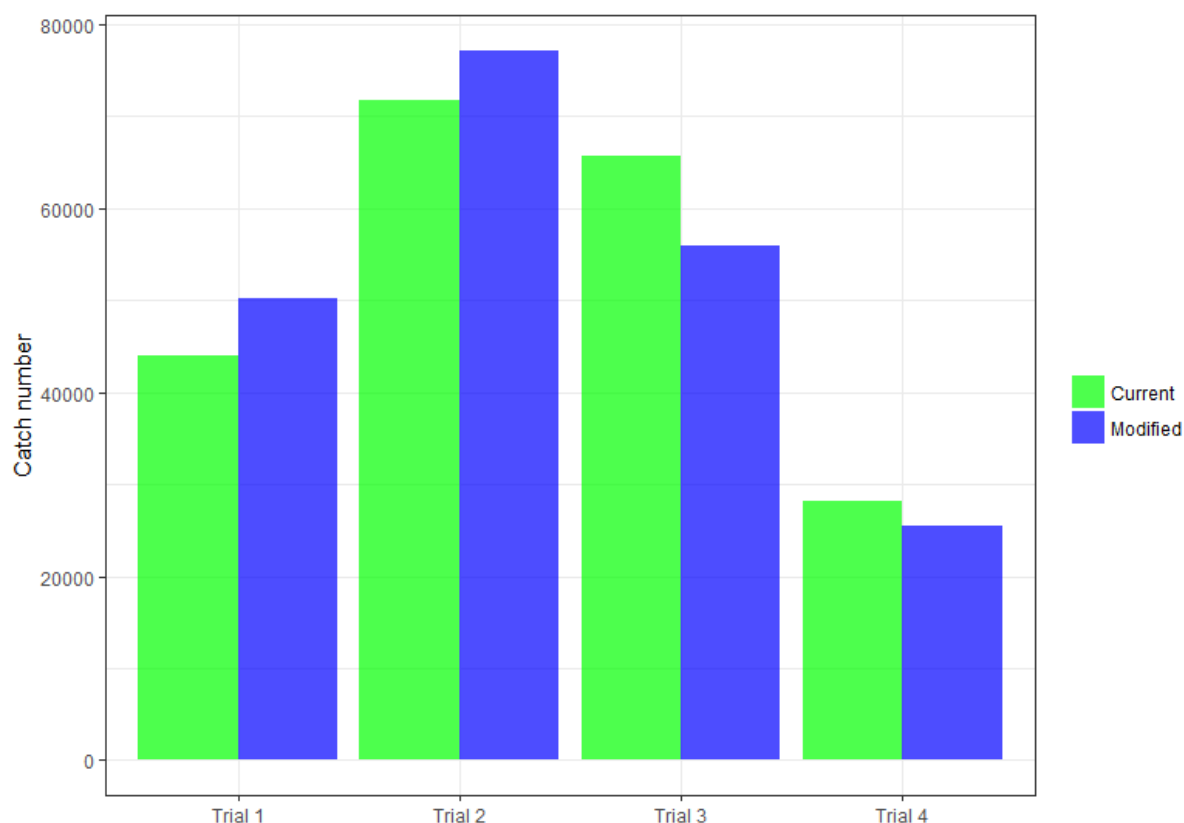


Figure 3.2.1: Overall differences in catch numbers (all species) between trials 1,2,3 and 4.

The most abundant species was *Nephrops* (NEP) with 342,192 individuals or 6,923kg caught in total, followed by whiting (WHG) with 25,496 individuals or 3,419kg (Table 3.2.1 and 3.2.2). Focus for statistical analysis was set on 7 species: *Nephrops* (NEP), cod (COD), dab (DAB), haddock (HAD), lemon sole (LEM), plaice (PLE), and whiting (WHG) (See Appendix 4.5 for list of all species caught).

SPECIES	TRIAL 1			TRIAL 2			TRIAL 3			TRIAL 4		
	Current catch		%	Current catch		%	Current catch		%	Current catch		%
	Number	Diff	Diff	Number	Diff	Diff	Number	Diff	Diff	Number	Diff	Diff
NEP	33269	2453	7	60812	3557	6	59924	10359	-17	19745	-959	-5
WHG	3303	-68	-2	4114	887	22	1981	-8	0	2614	662	25
PLA	2447	3652	149	2105	426	20	1030	359	35	2355	-1150	-49
DAB	1280	701	55	2066	203	10	1034	156	15	2042	-886	-43
NOP	1277	-461	-36	254	79	31	165	-24	-14	438	-152	-35
CDT	650	-157	-24	729	76	10	282	26	9	82	-17	-21
FRR	527	495	94	243	69	28	202	-60	-30	77	-22	-29
LEM	80	65	81	168	70	42	83	73	89	210	-84	-40
PLE	94	-36	-38	190	77	41	183	48	26	56	6	11
OCT	94	-5	-6	161	-22	-14	201	-46	-23	42	-24	-57
COD	80	-29	-36	95	31	33	118	41	35	110	-17	-16
NSQ	38	-7	-18	119	6	5	142	-17	-12	19	8	42
GUG	120	-36	-30	96	6	7	27	-3	-11	60	8	13
HAD	42	-27	-64	123	-33	-27	51	-15	-30	62	-23	-36
WIT	63	-35	-56	40	54	136	30	-1	-4	25	-5	-20

Table 3.2.1 The catch number in the currently used 90mm cod end (Current), the number difference between the current and modified trawl, and the percentage difference to the currently used cod end for the top 15 most abundant species by number. Negative values mean there is a reduction in number in the modified trawl.

SPECIES	TRIAL 1			TRIAL 2			TRIAL 3			TRIAL 4		
	Current catch weight		%	Current catch weight		%	Current catch weight		%	Current catch weight		%
	(kg)	Diff	Diff	(kg)	Diff	Diff	(kg)	Diff	Diff	(kg)	Diff	Diff
NEP	629	99	16	1220	26	2	1145	-167	-15	485	6	1
WHG	414	23	6	513	127	25	289	-2	-1	364	111	31
DAB	83	19	23	139	10	7	77	15	20	146	-66	-45
PLA	87	67	78	98	19	20	51	23	44	110	-54	-49
COD	17	-2	-11	41	2	5	47	16	35	37	-7	-20
PLE	24	-13	-55	45	18	41	47	4	9	14	1	7
MON	12	-7	-62	28	-3	-12	38	-15	-39	10	7	71
LEM	10	5	50	23	7	29	13	13	97	22	-8	-38
CDT	25	-6	-25	31	1	3	11	1	8	3	0	-14
FRR	20	23	119	13	4	30	10	-1	-10	4	-1	-25
CUR	24	-24	-100	26	-5	-18	3	11	382	1	4	305
NOP	23	-9	-41	8	2	28	6	-1	-18	11	-3	-29
HAD	5	-3	-52	18	-8	-46	10	0	-1	16	-2	-13
NSQ	3	0	9	10	2	17	15	3	18	2	2	83
TUB	4	3	85	10	0	4	10	1	11	3	4	127

Table 3.2.2 The catch weight (kg) in the currently used 90mm cod end (Current), the weight difference between the modified and current trawl, and the percentage difference to the currently used cod end for the top 15 most abundant species. Negative values mean there is a reduction in weight in the modified trawl. Top 15 species by weight (kg).

TRIAL	SPECIES	Length (cm)		Estimated % Diff to current by number	Current Number	Diff Number	Observed % Diff to current Number	Current Weight (kg)	Diff Weight (kg)	observed % Diff to current Weight (kg)
		min	max							
1	DAB	6	14	542	257	459	178	6	10	162
	DAB	25	25	-87	14	-12	-87	2	-2	-87
2	HAD	13	51	-47	123	-36	-29	18	-10	-55
	WHG	24	26	26	2027	519	26	271	70	26
3	COD	15	23	194	0	22	100	0	1	100
	DAB	24	27	297	12	23	195	2	4	228
	LEM	22	26	147	20	28	141	4	5	138
4	HAD	41	47	1710	0	2	100	0	2	100
	NEP	2.2	3.3	-31	8188	-1630	-20	137	-25	-18

Table 3.2.3 Significant differences from SELNET comparisons for specific lengths per selected species.

3.2.2 TRIAL 1: Current regulations 90 mm/5mm compact braided 100 mesh vs 35 mm intended reference cod end.

The modified 35mm cod end caught slightly more, 7% by number, 16% by weight, *Nephrops* (Figure 3.2.2). The increase was most obvious at 3.5-4.5 cm and not at the expected smaller length range (Figure 3.2.4). This increase was not significant after statistical analysis, showing that using a fine mesh cod end did not increase catches of *Nephrops*. While this may indicate that all available *Nephrops* are being retained by the current gear, i.e. there is no size selection, it was observed that the net was not fishing correctly which will have affected its fishing performance.

Other differences in catch were long rough dab (PLA) +149%, dab (DAB) +55%, lemon sole (LEM)+81% and four bearded rockling (FRR) +94% by number. Dab was the only further analysed species that significantly increased. More than double the amount of small dab (+178% by number), between 6 and 14cm, was noted. A decrease -87% in dab of 25cm, is also observed. However, caution is required as it is at a single length and low numbers were recorded (Table 3.2.3).

3.2.3 TRIAL 2: Current regulations 90 mm/5mm compact braided, 100 mesh vs pre-2016 regulations 80 mm/ 4mm standard braided,120 mesh

When comparing the current regulations and pre-2016 regulations gear, the latter caught slightly more, 6% by number, 2% by weight of *Nephrops* (Figure 3.2.2). After statistical analysis no significant difference in the *Nephrops* catch was found between the two gears (Figure 3.2.4).

The catch of most species increased in the pre-2016 regulations gear. For example, plaice (PLE) and lemon sole (LEM) increased by approximately 40%, cod (COD) by 33% and whiting (WHG) by 22% by number. For cod the increase in weight was only 5% indicating that more small cod are caught with the pre-existing gear. Also, for lemon sole and whiting the increase is seen at lengths that are mostly discarded (Figure 3.2.5). Statistical analysis of the whiting catch showed a significant increase of 26%, between 24 and 26 cm in the pre-2016 80 mm cod end. With the current measures fewer small whiting are caught. Haddock were reduced significantly in the pre- 2016 existing gear by -29% by number from across the whole length range, but low numbers are recorded (Figure 3.2.4).

3.2.4 TRIAL 3: Current regulations 90 mm/5mm compact braided, 100 mesh vs 90mm/4mm standard braided, 100 mesh

The modified cod end showed the biggest reduction (-17% by number and -15% by weight, 167 kg) in *Nephrops* (NEP) across the four trials (Figure 3.2.2). Especially *Nephrops* of about 3 cm are markedly reduced. However, this difference was not significant after statistical analysis (Figure 3.2.4).

In the modified cod end when considering weight and number long rough dab (PLA), dab (DAB), lemon sole (LEM) and cod (COD) all increased by more than 10%. Plaice (PLE) increased by 26% by number and 9% by weight. Statistical analysis showed that cod between 15-23cm, dab between 24-27 cm and lemon sole between 22-26cm significantly increased with 100, 195 and 141 % by number respectively (Table 3.2.3), all at lengths that are mostly discarded. Whiting (WHG), and haddock (HAD) catches seem similar when considering weight (Figure 3.2.3).

3.2.5 TRIAL 4: Current regulations 90 mm/5mm compact braided, 100 mesh vs 90mm/5mm standard braided, 120 mesh selvedge-less

In Trial 4 *Nephrops* (NEP) by number reduced by 5%. There was a significant decrease of 20% for small *Nephrops*, between 2.2cm and 3.3cm in carapace length (Figure 3.4). Total amounts are lower in comparison with trial 2 and 3 because of the lower number of hauls, 5, executed for this trial (Figure 3.2.2).

In the modified cod end, the Northern squid catch (NSQ) increased in both weight 83% and numbers 42% but numbers were low, and a few larger individuals influenced this result. Whiting catches increased by 25% and 31% by numbers and weight. All other species showed a reduction in numbers between 16% for cod (COD) and 57% for octopus (OCT). Haddock (HAD) catches, between 41-47cm, significantly increased by 100%. this was based on low catch numbers and did not reflected in the general result which showed a reduction of haddock by number and weight with -36% and -13% respectively.

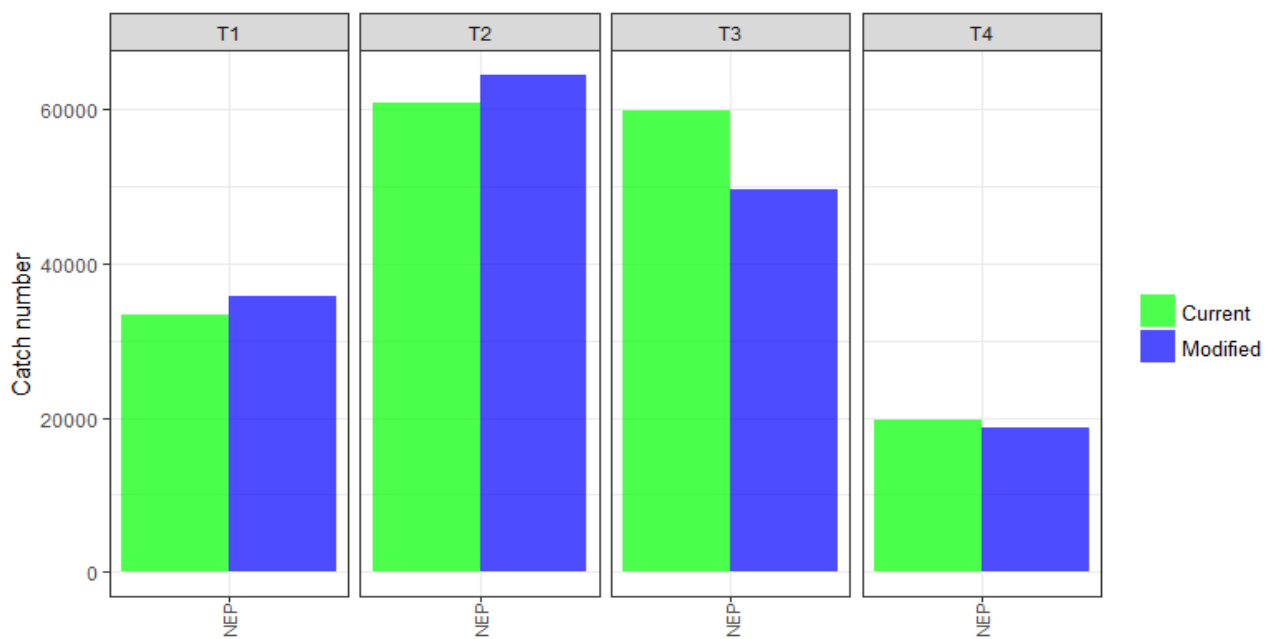


Figure 3.2.2: Catch by numbers for *Nephrops*, (NEP).

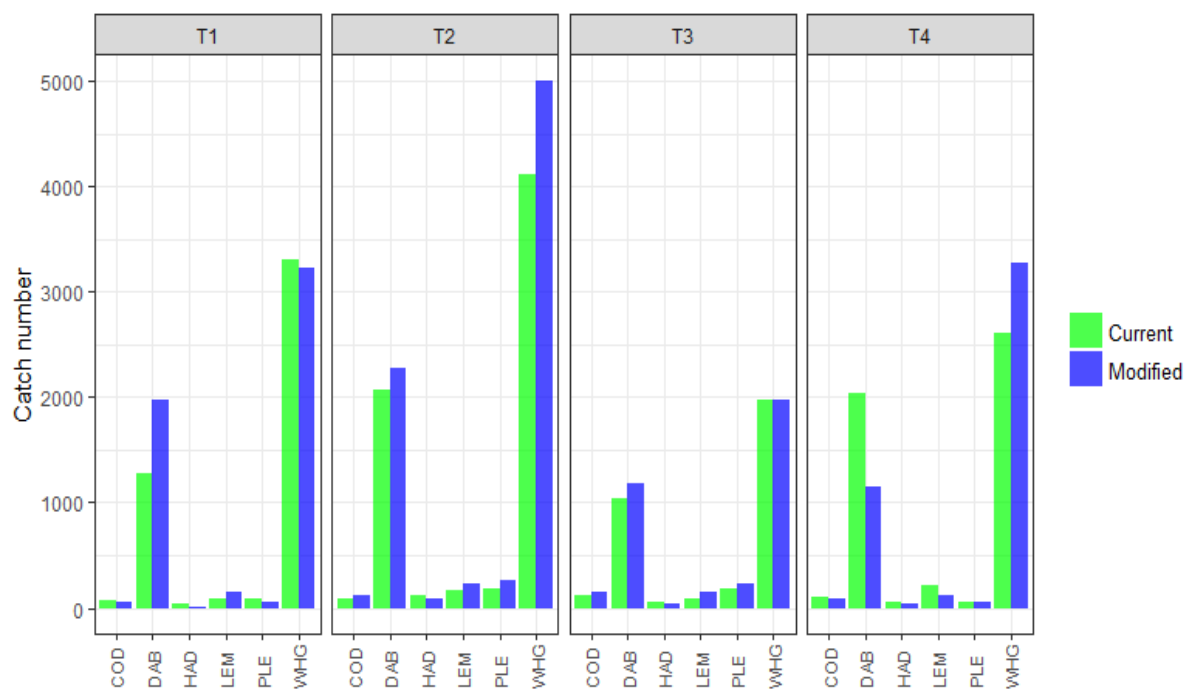


Figure 3.2.3: Catch by numbers for cod (COD), dab (DAB), haddock (HAD), lemon sole (LEM), plaice (PLE) and whiting (WHG).

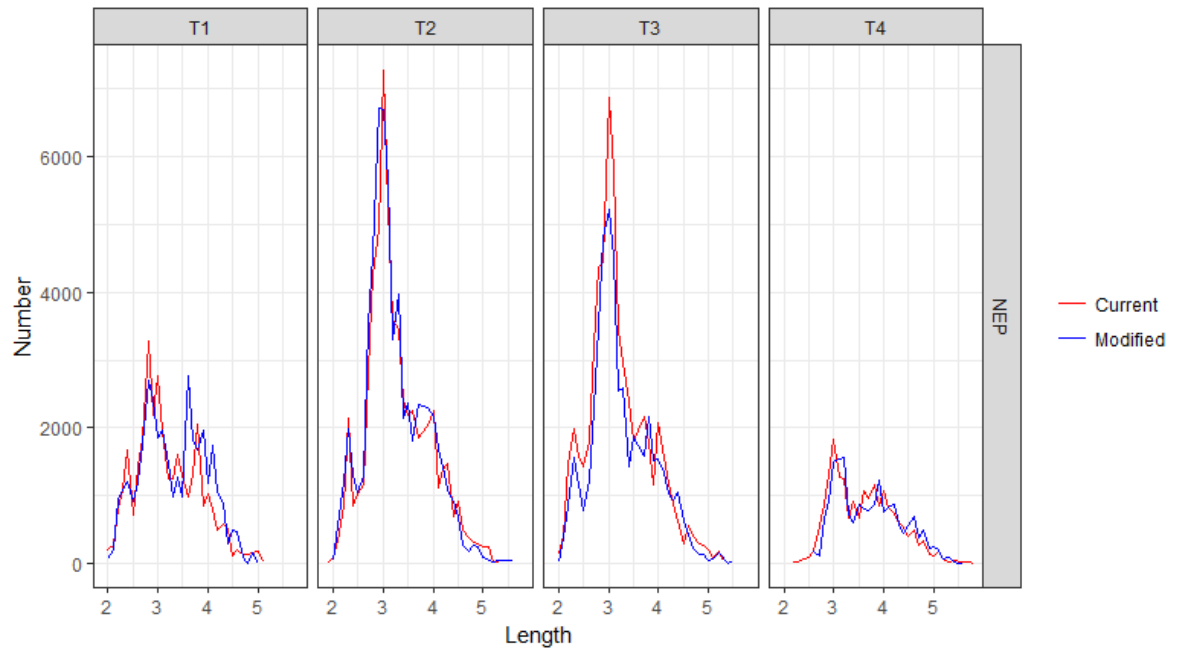


Figure 3.2.4: Length frequencies by number for *Nephrops* (NEP).

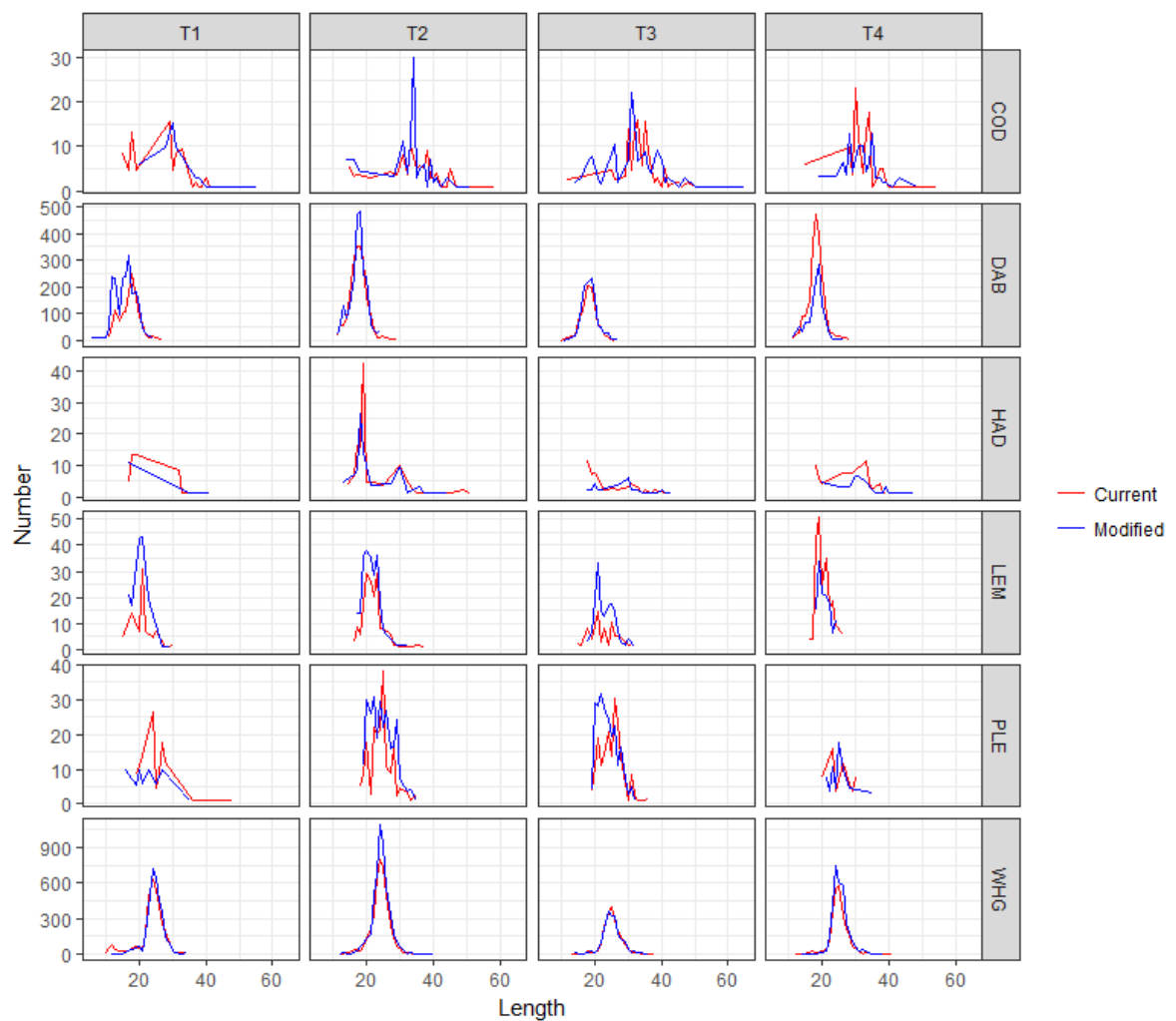


Figure 3.2.5: Length frequencies by numbers for cod (COD), dab (DAB), haddock (HAD), lemon sole (LEM), plaice (PLE) and whiting (WHG).

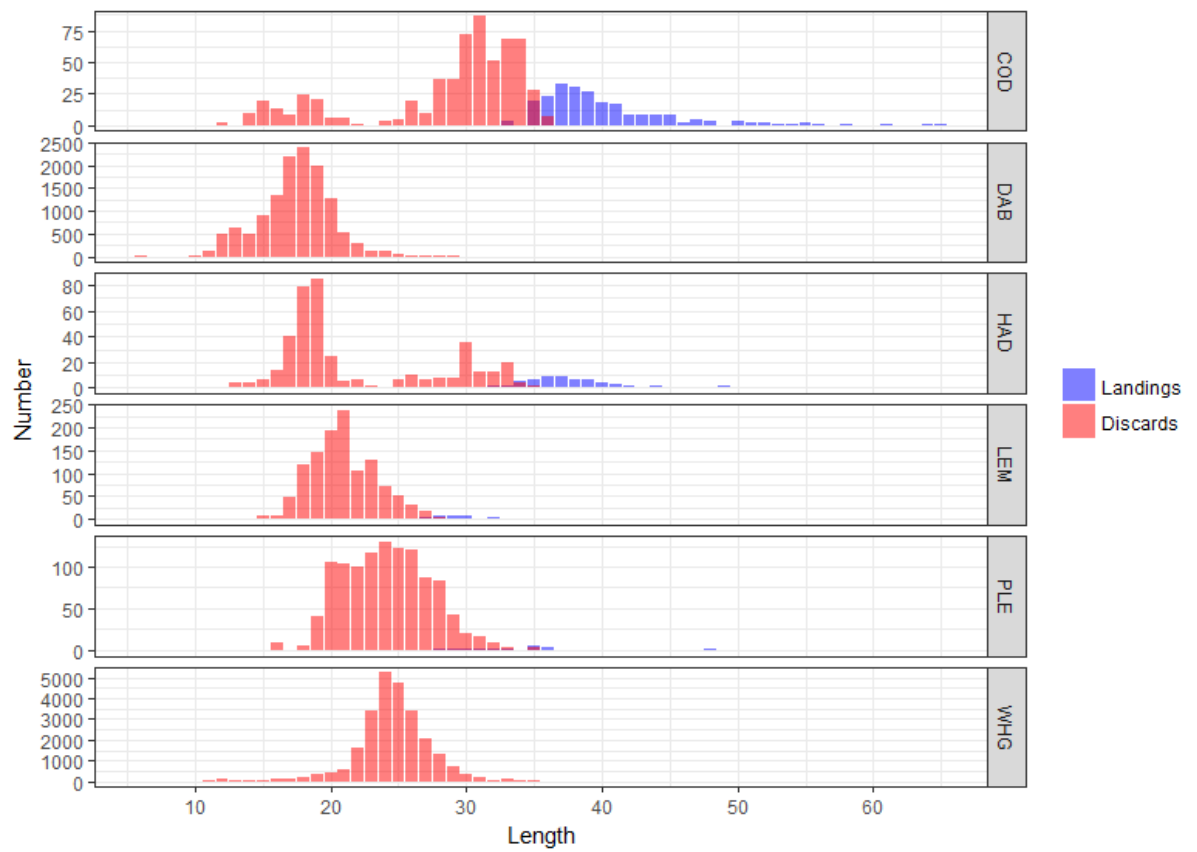


Figure 3.2.6: Total discards and landings for fin fish. (Summed trials 1-4

4 Discussion

The introduction of new regulations in 2016 introduced changes to the mesh size, twine thickness and to the cod end circumference. Vessel operators introduced a further change by opting for a compact braided twine as this was a twine thickness many were unfamiliar with and shrinkage was a major concern. Many fishermen operating in this fishery felt that the new regulations were detrimental to the selectivity of the trawl and were in fact counterproductive. This result did not support the observations of the fishermen with regard to *Nephrops* and found no differences between the current and previous cod end designs, significant differences were identified for whiting. Significantly fewer small whiting was caught with the currently legislated cod end compared with the cod end typically used before 2016.

In total, four cod end configurations were selected for comparison. Three cod ends were compared against one conforming to the current regulations (90mm mesh, 5mm twine, 100 meshes in circumference). One tested cod end was based on the cod ends previously used by many skippers (80mm, 4mm, 120 meshes in circumference), another reduced the twine thickness relative to the new regulation (90mm, 4mm twine, 100 meshes) and the third design tested the effect of increasing cod end circumference relative to the new regulatory cod end (90mm, 5mm twine, 120 mesh in circumference). The only significant difference in selectivity for *Nephrops* was observed for this last modification. The cod end constructed of 120 90mm meshes circumference, 5mm standard braided twine constructed without selvages reduced the catch of small *Nephrops* (between 22mm and 33mm) by 20%. Standard practice is to have a selvedge on each side of the cod end formed by taking 3 meshes from the top and bottom sheet of netting and braiding them together, reducing the circumference by 12 meshes.

The following conclusions can be drawn from this study

- The trial showed that the introduction of new regulations has not changed the selectivity of the trawl towards *Nephrops*. The new cod ends catch no more, or less, *Nephrops* than the cod ends used before April 2016.
- The introduction of new regulations has not increased the catching of small fin fish.
- The trial showed that the introduction of new regulations has reduced catches of small whiting under the minimum landing size (25% reduction at 24-26cm in length in observed hauls).
- It is possible to increase the selectivity for *Nephrops* by cod end design, compared with the currently used cod end, 20% fewer small *Nephrops* were caught when using a cod end with 90mm mesh size made of 5mm standard braided twine and 120 meshes in circumference constructed without selvages.
- It is a combination of mesh size, twine composition and circumference that enhances selectivity in a *Nephrops* fishery.

5 Appendices

5.1 Detailed Operations Plan

THE CENTRE FOR ENVIRONMENT, FISHERIES AND AQUACULTURE SCIENCE
(Lowestoft Laboratory, Suffolk, NR33 0HT, England)

This document describes the agreements reached by all parties at a planning meeting held in Amble 04/09/2017 and by telephone 19/09/2017.

Detailed Operations Plan

**FISHERIES SCIENCE PARTNERSHIP – FSP (2017-18) (55) COMPARISON OF 2016 FARNE DEEPS
COD-END REGULATIONS AGAINST PREVIOUS COD-END REGULATIONS IN THE FARNE DEEPS
NEPHROPS FISHERY**

Vessel: Nimrod BH227

Skippers: David and Steven Handyside

Principal Investigator: Frank Armstrong

Aim:

The primary objective of this project will be to compare the 2016 cod end regulations used in the *Nephrops* fishery against the previous regulated cod ends to assess if the expected benefits are being delivered. The aim of the project is to develop an optimum cod end construction to reduce catches of small *Nephrops*.

Fishing gear:

- 46m Twin *Nephrops* trawls.

Area and period of operation:

- The work will take place between October and December 2017
- The vessel will sail from and return to Blyth or Amble.
- The trials will be conducted in ICES Area IVb and it is expected that most of the fishing will take place in statistical rectangles 38E8 or 39E8.

Fishing activities:

- The skipper has the experience of fishing and the grounds and should advise where the trials should take place.
- The fishing programme should be agreed by the skipper and the principal investigator.
- The number of tows may be reduced on a given day as dictated by sea condition, volume of catch, gear damage, as agreed by the skipper and the principal investigator.
- If days at sea are lost due to adverse weather conditions and/or mechanical failure, then they should be rescheduled for completion at the earliest opportunity.
- Discarded species will be retained in baskets to ensure the accuracy of quantities before discarding.
- The components of the catch from each cod end must be kept separate.
- If the vessel encounters large catches there may be a requirement for the vessel to suspend deploying the gear until the previous haul has been processed, to keep the catch from each haul separate.
- The conditions and details of the ITT, contract and dispensation will be upheld.

Legalities and quota:

- Fishing will be “off quota”. All tows carried out under the charter will be for testing the experimental gear; no other fishing will take place on these days.

- Undersized fish can be retained on board for measuring but must not be landed.
- The relevant dispensation will be issued by the MMO and will be carried on board the vessel for the duration of the trials. It will be made available to any Marine Enforcement Officer on request.
- The dispensation will only be valid if the terms of the issued document are met.
- For E- logbook completion the reason for sailing (anticipated activity in some e-logs) given in the Departure (DEP) message must be “SCR” (Scientific Research) and not “FSH” (Fishing). This identifies the trip as one subject to Quota dispensation.
- Sorting and recording the catch:
- The entire catch must be made available for sampling.
- The crew will be required to assist in sorting the catch and will prepare the retained portion for sale.

Data to be recorded by the skipper:

- Date
- Tow number
- Shooting and hauling times and shooting and hauling position (latitude and longitude to the nearest minute)
- Shooting and hauling depth
- Weather conditions
- Average speed over the ground
- Time and position of any significant change in tow direction
- Log sheets for recording this information will be provided by the principal investigator at the start of the trials.
- The skipper should maintain a diary of activities not recorded in any of the above for each tow.

Data to be recorded by Cefas observers:

- Observers will record length frequencies of all retained and discarded fish species, separately for each cod end used.
- All hauls will be sampled during the trials.
- Where catch quantities are high observers will sub-sample and record accurate raising factors.
- The principal investigator will maintain a diary of activities, to produce a draft cruise report for submission to Cefas immediately after the cruise. The cruise narrative will be written at sea and read, agreed and signed by the skipper (the report will bear the sentence “seen in draft by skipper”).

Safety:

- Safety takes priority over all other aspects of the charter.
- The skipper has ultimate authority on board and is responsible for ensuring the safety of the vessel and all parties on board.
- The attached “Working hours and safety at sea” document sets out the provisions and requirements for Cefas observers.
- Provision of sales notes:
- A copy of the landings/sales notes is required by Cefas to enable 95% of the total agreed price (including VAT) to be paid and should be provided to the principal investigator.

Contacts:

It is the responsibility of the principal investigator to contact the local MMO office (and IFCA office if necessary) to advise the start and end of the trials prior to departure, and to notify the Cefas shore-based contact on sailing and landing.

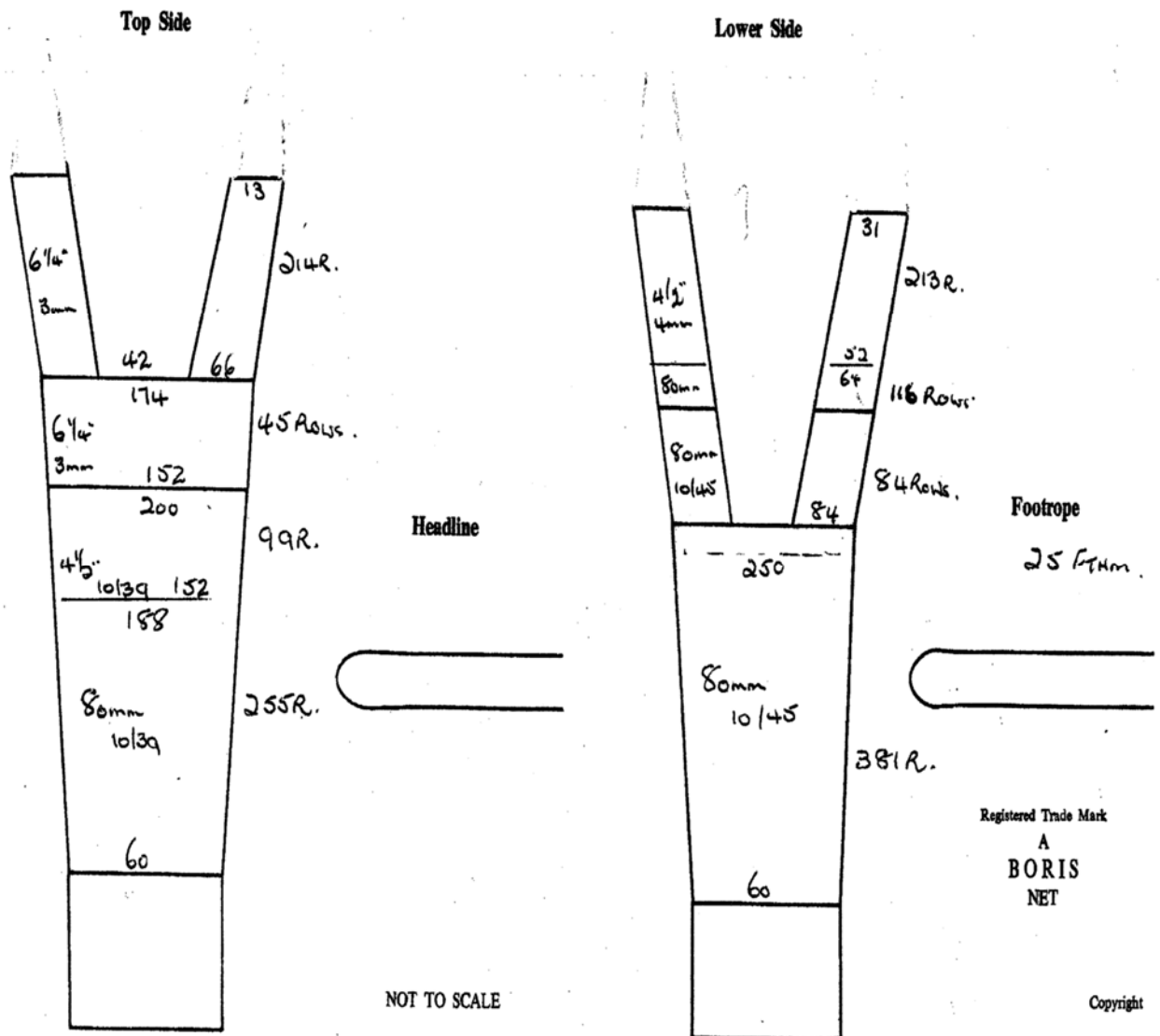
5.2 Net Plan

500 x 80mm.

BORIS NET CO., LTD.
COPSE ROAD, FLEETWOOD, LANCs.

FY7 GRP.
Telephone 4891

TO ORDER PARTS PLEASE
QUOTE NUMBER IN CIRCLES



5.3 Shooting and hauling times, depths and positions

Tow	Tow Date	Shot Time	Depth (m)	Lat. Deg./min.	Lon. Deg./Min.	Haul Time	Depth (m)	Lat. Deg./min.	Lon. Deg./Min.	Tow Duration Hrs/mins
1	20/11/17	07:15	84	55 8	-1 8	09:15	88	55 15	-1 10	2:00
2	20/11/17	09:50	84	55 16	-1 11	12:50	79	55 25	-1 13	3:00
3	21/11/17	07:27	75	55 24	-1 12	09:32	71	55 24	-1 12	2:05
4	21/11/17	10:15	71	55 19	-1 12	13:16	75	55 21	-1 12	3:01
5	22/11/17	07:27	77	55 23	-1 13	09:30	73	55 18	-1 12	2:03
6	22/11/17	10:03	70	55 18	-1 12	12:03	77	55 24	-1 13	2:00
7	22/11/17	12:37	77	55 24	-1 13	14:39	73	55 19	-1 12	2:02
8	23/11/17	07:25	71	55 20	-1 13	09:40	84	55 14	-1 11	2:15
9	23/11/17	10:12	86	55 14	-1 11	12:37	79	55 8	-1 11	2:25
10	23/11/17	13:12	81	55 8	-1 10	16:14	86	55 15	-1 11	3:02
11	24/11/17	07:28	71	55 20	-1 10	09:37	88	55 14	-1 10	2:09
12	24/11/17	10:12	88	55 14	-1 10	13:04	71	55 19	-1 12	2:52
13	24/11/17	13:35	71	55 18	-1 12	16:12	77	55 11	-1 13	2:17
14	25/11/17	07:31	73	55 18	-1 12	09:53	82	55 11	-1 11	2:22
15	25/11/17	10:26	84	55 11	-1 11	12:46	79	55 18	-1 10	2:20
16	25/11/17	13:24	84	55 18	-1 10	15:51	86	55 11	-1 10	3:27
17	26/11/17	07:39	75	55 17	-1 20	11:04	84	55 10	-1 9	3:25
18	26/11/17	11:37	84	55 10	-1 9	16:02	86	55 12	-1 10	4:05
19	27/11/17	07:22	71	55 20	-1 13	09:34	88	55 14	-1 11	3:12
20	27/11/17	10:10	88	55 14	-1 11	12:20	75	55 19	-1 11	2:10
21	27/11/17	13:11	75	55 19	-1 11	16:08	68	55 19	-1 13	2:57
22	04/12/17	07:27	72	55 13	-0 45	09:25	86	55 19	-0 47	1:58
23	05/12/17	07:28	95	55 34	-1 2	09:55	92	55 23	-0 55	2:27
24	05/12/17	10:31	102	55 31	-0 56	12:45	97	55 31	-0 57	2:14
25	05/12/17	13:19	95	55 31	-0 56	16:06	95	55 31	-0 56	2:47
26	06/12/17	07:50	93	55 20	-0 57	10:43	104	55 29	-0 55	2:53
27	06/12/17	11:17	104	55 30	-0 56	13:44	102	55 35	-1 4	2:27

Haul 22 invalid.

5.4 Cod end constructions

5.4.1 Cod end A

2.5mm twisted twine, 35mm mesh size. This was intended to be the reference cod end but was only used on tows 1-4. (See 2.3)



5.4.2 Cod end B

5mm compact braided twine, 90mm mesh size, 100 meshes around. This is the current regulations cod end for single rig vessels in the Farne Deeps and was used in all tows in the trials.



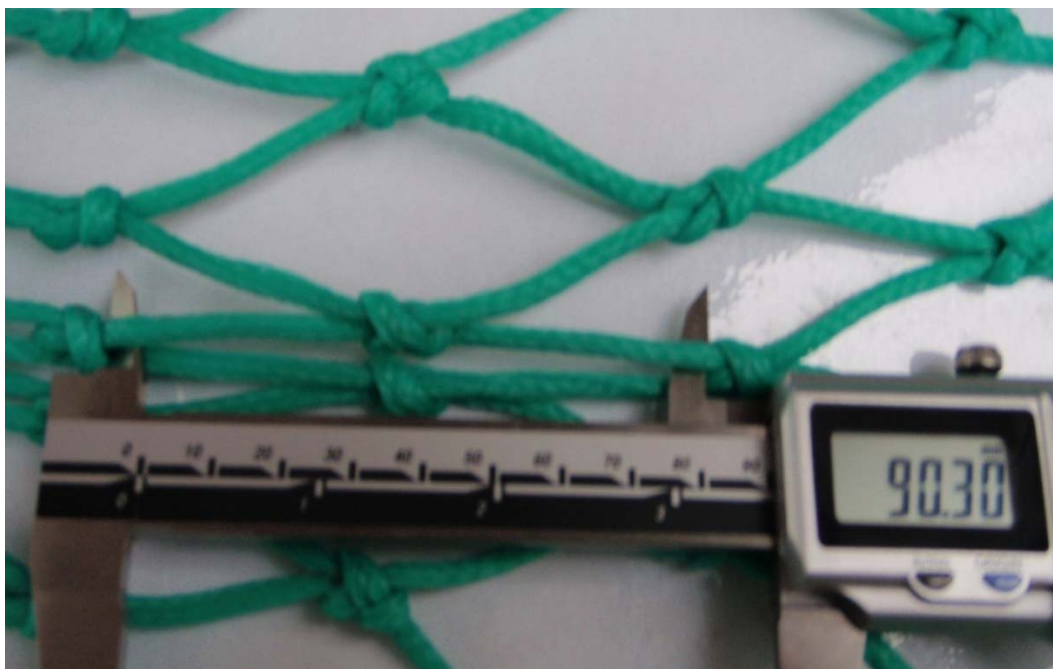
5.4.3 Cod end C

4mm standard braided twine, 80mm mesh, 120 meshes around. This is the pre-2016 regulations cod end for single rig vessels.



5.4.4 Cod end D

4mm standard braided twine, 90mm mesh, 100 meshes around.



5.4.5 Cod end E

5mm standard braided twine, 90mm mesh, 120 meshes around constructed without selvages.



5.5 List of fish species caught

Common name	Scientific name	Cefas code
Anglerfish, or Monk	<i>Lophius piscatorius</i>	MON
Bib, or Pout	<i>Trisopterus luscus</i>	BIB
Brill	<i>Scophthalmus rhombus</i>	BLL
Common dragonet	<i>Callionymus lyra</i>	CDT
Cod	<i>Gadus morhua</i>	COD
Cuckoo ray	<i>Leucoraja naevus</i>	CUR
Dab	<i>Limanda</i>	DAB
Dover sole	<i>Microchirus variegatus</i>	SOL
Edible crab	<i>Cancer pagurus</i>	CRE
Four-bearded rockling	<i>Enchelyopus cimbrius</i>	FRR
Grey gurnard	<i>Eutrigla gurnardus</i>	GUG
Haddock	<i>Melanogrammus aeglefinus</i>	HAD
Hake	<i>Merluccius</i>	HKE
Imperial scaldfish	<i>Microstomus kitt</i>	ISF
Lemon sole	<i>Loligo vulgaris</i>	LEM
Ling	<i>Scyliorhinus canicula</i>	LIN
Lesser spotted dogfish	<i>Lepidorhombus whiffiagonis</i>	LSD
Long rough dab	<i>Hippoglossoides platessoides</i>	PLA
Mackerel	<i>Scomber scomberus</i>	MAC
<i>Nephrops</i>	<i>Nephrops norvegicus</i>	NEP
Northern squid	<i>Pleuronectes platessa</i>	NSQ
Norway pout	<i>Trisopterus esmarkii</i>	NOP
Octopus	<i>Octipodidae</i>	OCT
Plaice	<i>Trisopterus minutus</i>	PLE
Pollack	<i>Pollachius virens</i>	POL
Poor cod	<i>Pecten maximus</i>	POD
Red mullet	<i>Ommastrephidae</i>	MUR
Saithe (Coley, Black Jack)	<i>Arnoglossus laterna</i>	POK
Thick back sole	<i>Trigla lucerna</i>	TBS
Thornback ray	<i>Scophthalmus maximus</i>	THR
Tub gurnard	<i>Trachinus draco</i>	TUB
Turbot	<i>Echiichthys vipera</i>	TUR
Witch	<i>Glyptocephalus cynoglossus</i>	WIT
Whiting	<i>Merlangius merlangus</i>	WHG



Centre for Environment Fisheries & Aquaculture Science



Cefas

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