

# ***Fisheries Science Partnership: 2017/18***

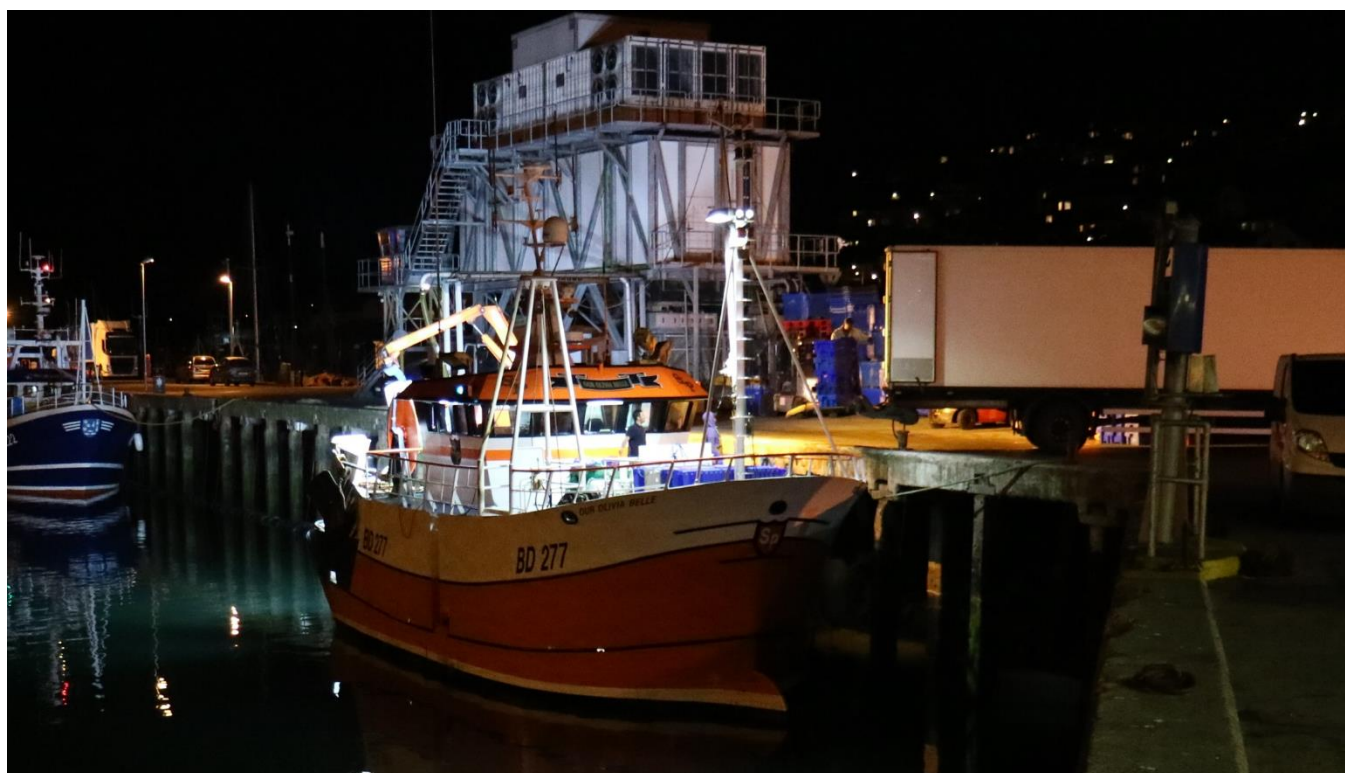
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Final Report

## **Cod End Mesh Size Trials in the SW Otter Trawl Fishery**

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## Executive Summary

Eleven days of sea trials comprising 40 tows were successfully completed on board the twin-rig otter trawler '*Our Olivia Belle*' (BD277) in the Western English Channel in August 2017 allowing catch comparisons of cod end mesh sizes ranging from 48mm to 128mm stretched mesh with those of the standard 85mm stretched mesh. The main aim of the project was to evaluate the use of larger cod end mesh as a means of selectively reducing catches of haddock in the SW trawl fishery.

1. A cod end with nominal mesh size of 85mm was tested against nominal 45mm, 110mm, and 120mm. The catches were dominated by haddock, but catches of five other key commercial species were sufficient to conduct statistical analyses of the effect on changing cod end mesh size. The thick twine diameter used in the construction of the 100mm cod end meant that it was not directly comparable with the other cod ends, and is likely to have demonstrated lower selectivity than had it been constructed of thinner twine.
2. There was no significant difference in haddock catches between 85mm and 45mm cod ends, indicating that there were no small haddock on the fishing grounds during the trial. Catches for other species such as red gurnard, megrim and whiting were much higher when using the smallest mesh cod end.
3. Increasing the cod end mesh size from 85mm reduced overall catches, and catches were generally less when using 120mm cod end compared with 110mm. The reduction in catches was length dependent, with increasing reductions in catches of smaller fish with increasing cod end mesh size.
4. Most of the haddock caught on the trial were discarded due to quota restrictions. Catches of unwanted haddock were significantly reduced when using cod end mesh sizes of 110mm and 120mm. However, at these mesh sizes, there were significant reductions in the catches of marketable sizes of other species.
5. For example, cod end mesh sizes of 110mm and 120mm, resulted in the loss of a significant quantity of lemon sole at marketable lengths (66% and 93%) respectively. Lemon sole is a target species for around half of the year for vessels in this fishing area, therefore increasing cod end mesh size to these sizes would have a considerable negative economic effect.
6. Increasing the cod end mesh size to 110 and 120mm is not an appropriate measure to reduce catches of unwanted haddock, when targeting species such as lemon sole.

## Contents

Executive Summary.....	3
1. Introduction.....	5
2. Aims.....	5
3. Experimental Plan & Methods.....	6
<b>3.1 Fishing gear</b> .....	7
<b>3.2 Fishing Operations</b> .....	8
<b>3.3 Analyses</b> .....	10
<b>4.1 Fishing activity</b> .....	12
<b>4.2 Summary overview in differences in fish catches between cod ends</b> .....	12
<b>4.3 Economic impact</b> .....	30
5. Discussion.....	30
6. Industry Comments.....	31
7. Conclusions.....	31
References.....	33
Appendices.....	34
Appendix 1. Details of Fishing Activity.....	344
Appendix 2. List of species caught.....	345
Appendix 3. Catch numbers at length for six main species.....	346
Appendix 4. Estimates of the total number of fish caught by species for each mesh size.....	347
Appendix 5. Estimates of average numbers of fish caught per hour by species and mesh size.....	348
Appendix 6. Detailed Operations Plan.....	349

## 1. Introduction

The Fishery Science Partnership (FSP) is a Defra-funded programme of scientific research between the UK fishing industry and scientists. The FSP aims to build a positive working relationship between the industry and scientists, whilst providing evidence for fisheries management issues. Since it was established in 2003, the programme has undertaken numerous projects including fishing gear selectivity trials, examinations of spatial patterns and catch compositions, investigations into new fisheries and time-series of relative abundance of commercial species. A full description of the development and aims and all completed reports of the FSP programme can be found at the Cefas website<sup>1</sup>.

Since the announcement of a phased landing obligation (also known as the discard ban) within European waters starting in January 2015, many vessel owners have experimented with different fishing practices to try and avoid exhausting their quota prematurely. This has included adjusting the design and construction of the gear, changing fishing grounds, and only fishing during daylight hours. The landing obligation is a key reform within the new Common Fisheries Policy (CFP) which was agreed by all Member States. It is designed to end the practice of throwing away dead fish, and to safeguard the future of stocks and the fishing industry. When the discard ban was ratified, it was clear that fishing practices would have to adapt to improve selectivity and/or survivability of unwanted catch. With the approaching implementation of the demersal landing obligation, which will cover all fisheries by 2019, there remains a need to find ways of modifying the selectivity of demersal trawls to enable vessel operators to continue fishing within the management framework posed by the switch to catch quotas and a ban on discarding. Further, this needs to be achieved within the limits of economic viability and operational common sense.

The SW otter trawl fishery has seen large catches of haddock since 2013, and vessels have struggled to find ways of directing effort on other species without exceeding haddock quota allocations. This study is the latest in a series of trials looking at the effect of technical modifications on trawl selectivity and focusses on modifying the mesh size of the cod end.

## 2. Aims

The main aim of the project was to evaluate the use of larger cod end mesh as a means of selectively reducing catches of haddock in the SW trawl fishery. A secondary aim was to determine the absolute selectivity of different cod end mesh sizes with a trawl design typically used in this fishery.

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<sup>1</sup> <http://webarchive.nationalarchives.gov.uk/20150203151336/http://www.cefas.defra.gov.uk/publications-and-data/scientific-series/fisheries-science-partnership-reports.aspx>

### 3. Experimental Plan & Methods

Previous Cefas gear trials aimed at reducing the haddock discards that have affected much of the SW otter trawl fleet in recent years showed that the introduction of square mesh panels with large mesh size (155mm), in the body of the trawl, resulted in losses of haddock across its size range but also unacceptable losses of other marketable species (Forster, 2015). Other trials with square mesh panels of smaller mesh (~110mm), located in the cod end, were size selective for haddock but also resulted in limited loss of marketable catches and are not suited to releasing larger haddock (Catchpole, 2014,2015).

Modifications made to the trawl intended to allow haddock to escape in many of the gear trials conducted in recent years in the SW fishery are based on a mix of industry experience and trial and error. Trials with separator panels (in SWOT, FSP, ASSIST projects) has provided knowledge of the behaviour of fish encountering trawl gear in this fishery (e.g. Catchpole, 2010, 2015). While much attention has been afforded to testing trawls fitted with whole sections or panels made of large and/or square mesh placed in various parts of the trawl, very few scientific records, surprisingly, could be found of trials in the SW of large cod end diamond mesh that demonstrated what happens to the catch of haddock and other commercially important species as cod end mesh size is progressively increased within a given fishery.

Catch composition data collected by skippers from five different vessels during the SW Otter Trawl Discards project (Catchpole, 2010) providing some information on the effect of increasing diamond cod end mesh size from the standard 80/85mm to 100mm. As the title suggests, the aim of the SWOT project was to reduce discards, which, broadly speaking, means unwanted parts of the catch, including undersized, over-quota, and unmarketable fish. The trawl modification on some of these vessels was not limited to an increased cod end mesh, however. All vessels were single-rig trawling. The two Newlyn-based vessels taking part in the SWOT project that compared cod end mesh size fished very similar grounds to those fished during the present trials, and experienced 50% reductions in the discards of whiting, plaice, pout whiting, and lesser spotted dogfish, and virtually 100% loss of lemon sole and gurnard. The other three vessels that looked at the effect of increased cod end mesh size in the SWOT project were fishing east of the Lizard, where losses were not as pronounced. The effect on haddock landings and discards on these vessels varied considerably.

Gear trials attempting to show the effects of modification in design or construction on catch rates and selectivity face a number of obstacles that can detract from a successful, reliable demonstration. The obvious one is the limited duration of trials which makes it difficult to cover the many and frequent variations in fishing conditions that exist in a mixed fishery. Unfortunately, trials that took place 5 years or more ago in a different fishery, have limited relevance to the present set of trials. Then there is the issue of the fishing operation - the standard and modified rigs fishing equally over the course of the trials, i.e. maintaining the same net opening, headline height, and bottom contact, and encountering the same numbers, distribution, and behaviour of fish! Furthermore, meshes can become clogged, or can close up under strain, and this alters the selective properties of the gear significantly.

Selectivity of a fishing gear is a measure of that part of the fish population (in terms of species and size) that is retained. The composition of the fish population on any given set of grounds can vary

from trip to trip – it may vary from haul to haul – so, estimates of selectivity should be qualified by season and fishery, at least.

Most gear trials conducted in the SW otter trawl fishery in recent years have looked at comparative or relative selectivity, with haddock as the principal focus. It had originally been suggested that larger cod end meshes should be tested against a small mesh (45mm) cod end throughout these trials to catch a much larger proportion of the haddock population. If the total population of fish entering the test cod end can be estimated, it is possible to determine absolute selectivity. However, clogging of cod end meshes early in the tow was a very real concern to vessel operators, meaning that some smaller fish might be caught but larger, stronger-swimming fish might escape capture altogether. A twin-rig can also become distorted when one bag is much fuller, thereby creating more drag, than the other. This would not only confound estimates of absolute selectivity over the size range of haddock, it would hinder direct comparisons between the larger mesh sizes of interest and the standard commercial cod end. Obtaining a comparison of catches with large cod end mesh sizes was deemed more important than determining absolute selectivity, but a number of tows testing a small mesh cod end against the standard mesh size would be done as a feasibility for future work.

While the outcome of using a cod end mesh up to 50% larger than presently used may be obvious to some, it has not been documented. The proposal, therefore, was to test a series of cod end meshes, ranging from 45mm to 120mm nominal stretched mesh, against the standard commercial mesh size (85mm inside mesh).

The Ilfracombe-based twin-rig trawler, FV *'Our Olivia Belle'* (BD277), was chartered for the fishing trials, which took place in the Western English Channel over the period 20 - 31 August 2017. With an overall length of 14.95 m, and main engine rated at 358 KW, the vessel tows a twin-rig of 12 fm (22 m) demersal trawls at a speed of 2.5-3.2 knots over the ground, achieving a door spread of about 160 m.

### 3.1 Fishing gear

The trawls in current use by the vessel were based on a Granville trawl design; they were found to be in acceptable condition and suitable for the purposes of the trials. One rig was fitted with a standard commercial cod end made of nominal 85mm stretched mesh netting in 3.5 mm single braid twine. Test cod ends were made up by the vessel owners to be fitted on the other rig. The mesh sizes tested were, nominally, 45, 100, 110, and 120mm stretched mesh. Measurements of the inside mesh size taken during the trials gave the following dimensions:

Nominal mesh size (mm)	Inside stretched mesh (mm)	Twine
45	48	2.5mm Ø single twisted
85	85	3.5mm Ø single braided
100	97	6.0mm Ø single braided
110	111	3.5mm Ø single braided
120	128	5.0mm Ø single braided

When towing twin trawls with different cod end mesh sizes, it is important to account for the effect of drag on trawl opening, spread, and symmetry. Small mesh cod ends will create more drag unless

thinner twines are used, as was the case in these trials. Even so, comparing the drag created by the different cod ends was beyond the scope of this project, and remains one of the possible sources of error. The small mesh cod end (nominal 45mm mesh), normally used in the N Devon squid fishery, was also fitted with a cover bag made of 90mm diamond mesh. All other cod ends consisted solely of the stated mesh.

Another important consideration in these trials was cod end circumference to ensure that meshes would open to the same degree. This was discussed with the trawl maker, and counts of the number of meshes round were taken to check the likely circumference for each cod end.

The main dimensions of the trawls and deployment details were as follows:

- Footrope length: 22m (each trawl)
- Fishing circle: 300 meshes (115mm mesh)
- Ground gear: Rockhopper with 8" rubber discs
- Bridles: 22m of 32mm  $\varnothing$  combination rope + 9m of chain
- Sweeps: 110m of 26mm  $\varnothing$  combination rope
- Trawl wire paid out: 275m
- Estimated door spread @ 3 kt: 160m
- Clump centre weight: 600kg
- Mesh size of main body of net: 115mm (2.5mm diameter twine)
- Mesh size of wings and square: 150mm

The trawl plans are shown in Figure 1.

### **3.2 Fishing Operations**

The plan of fishing is set out in the Detailed Operations Plan appended. A minimum of ten tows with each test mesh were planned.

The main concern was to find a broad size range of haddock and in reasonable concentrations. Four 3-day trips were planned, fishing continuously round the clock, to cover grounds stretching between Lizard Point and the Isles of Scilly, and out as far as 20 miles offshore.

In order to minimise bias at the experimental design stage, it was decided to change the test cod end every other tow rather than attempt to complete ten tows with each mesh size in turn. This would ensure that (a) each mesh size was tested over the same range of sea conditions, states of tide, fishing area, and time of day, and that (b) the effects of any significant changes in fishing conditions and the fish population taking place from day to day would be applied equally to each mesh size.

It was intended to fit acoustic sensors on the trawl to monitor headline height, bottom contact, and wing-end spread to confirm that the fishing performance of each rig was comparable throughout the trials. Unfortunately, the equipment intended for this project was unavailable due to an overlap with another set of gear trials.

Catch sampling would follow standard Cefas sampling procedures, and the crew would allow all parts of the catch to be sampled before any discarding took place. Raising factors were applied when it was not practically possible to sample the whole catch.



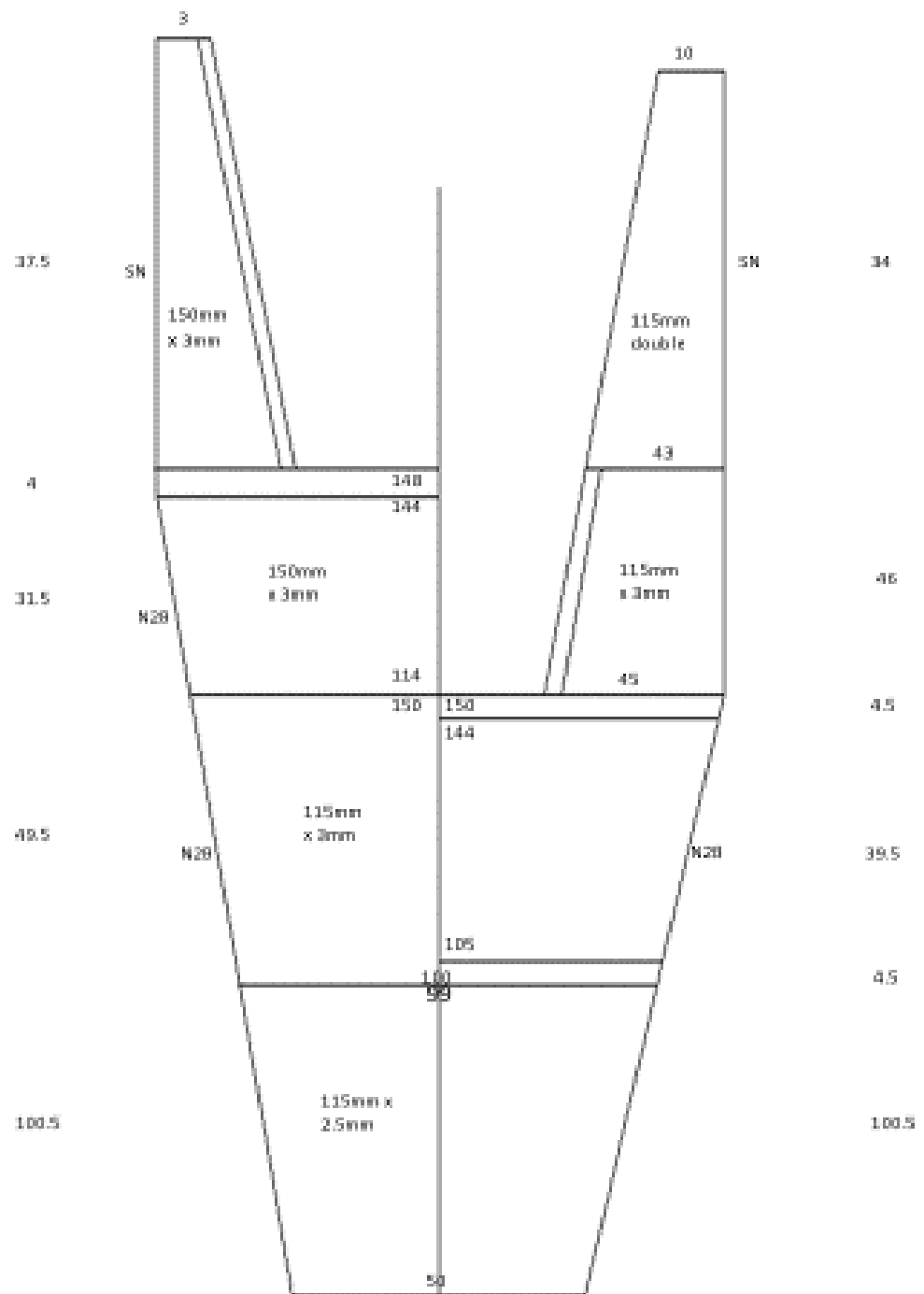


Figure 1. Net plan for the Modified Granville Trawl (courtesy Steve Taylor, JS Fishing Tec Ltd, Torrington). Numbers either side of the trawl denote the number of meshes long for each section. The top sheet is on the left hand side of the plan; bottom sheet on the right. Numbers above and below each section denote the number of meshes across. Mesh size and twine diameter are given in millimetres. The cutting rate on the inside of the wings is on the bar (AB); on the outside of the wings is all side knots; and the tapered sections going back towards the cod end is one side knot: two bars (N2B). The cod end plans are not shown

### 3.3 Analyses

For each trial, total numbers-at-length were raised to haul. The length based data was converted to biomass using length-weight coefficients from relevant scientific surveys (Silva et al., 2013). The number and weights of the main species caught for the standard gear and the absolute differences (modified trawl-standard trawl) and % differences  $((\text{modified trawl} - \text{standard trawl}) / \text{standard trawl}) * 100$  caught by the different modified cod ends are presented in Table 2 and 3. A percentage difference of 100% means that the experimental trawl took double the catch compared with the caught the standard trawl.

Two approaches were applied to analyse the results in more detail:

1. A statistical catch comparison analyses using SELNET
2. A comparison of catch rates (catch numbers per hour) between the cod ends

#### 1. Statistical Analysis using SELNET

Further detailed analysis was undertaken for selected species, based on their commercial importance and contributing most to the total catch. Six species were selected, haddock, red gurnard, megrim, plaice, whiting and lemon sole. The raised catch numbers at length distributions for the standard and experimental trawls are given for these six species (Appendix 3). The six species were selected for analysis for all 4 trials. The statistical differences in catches for each of species at each length between the standard and experimental trawls were determined using the computer software SELNET (SElection in trawl NETting). SELNET is a flexible software tool developed to acquire, analyse, and simulate size selectivity and catch data for towed fishing gears (Wienbeck et al., 2011; Herrmann et al., 2013; Wienbeck et al., 2014; Brcic et al., 2015). SELNET enables the analysis of data for gear trial designs that involve multiple compartments (Sistiaga et al., 2010). Here, landings and discards from the standard and modified nets were treated as four 'compartments' allowing for the total catch to be compared between the standard and experimental trawls.

Models were fitted to the haul data after converting the data to the proportion of numbers of fish at each length caught in the experimental trawl, relative to the total catch, in both the modified and standard trawl; i.e. when the catches of a species at a length were equal in the two trawls, the proportion of numbers of fish in the modified trawl was 0.5. Logistic curves were fitted to the haul data using standard maximum likelihood estimation. If the fit statistics indicated it was unlikely that the logistic curve would be able to describe the experimental data, another type of selection curve would be used. The sampled hauls were analysed for each trial with an approach that considered both within-haul and between-haul variation. An outer bootstrap resample with replacement was included to account for between-haul variation, while an inner bootstrap with replacement accounted for within-haul variation (Sistiaga et al., 2010). In each run (species-trial combination), 100 bootstrap repetitions were conducted to estimate the bca (bias corrected and accelerated) percentile 95% confidence intervals (Sala et al., 2015). The method identified the length ranges with significant deviations in size selection between the standard and experimental trawls.

The model obtained the mean selection curve and the between-haul variation in the parameters describing the mean curve. The analyses followed the procedure described by (Fryer, 1991), which is based on the assumption that the results from single hauls are samples from a multivariate distribution, describing the between-haul variation in the selection process. This stage also included an investigation of the total cod end catch as a linear fixed effect on the selection process.

The output from the model gives, at each length, the proportion caught in the experimental trawl as a proportion of the total number caught in the experimental and standard trawl. Around this best fit model, upper and lower 95%CI were produced. A significant reduction was shown where the upper 95%CI fell below 0.5, i.e. at these lengths significantly fewer fish were caught in the experimental trawl. A significant increase was identified where the lower 95%CI was above 0.5, i.e. at these lengths significantly more fish were caught in the experimental trawl.

The model outputs were translated into the significant difference in the number caught between the experimental and standard 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 weight differences were summed across lengths to calculate the total significant weight difference for each species and trial. The significant weight difference is presented and its relative contribution to the standard species catch weight for each trial (Table 4). These differences are shown in the context of the lengths of fish selected to be landed (retained) and discarded from the control trawl during the all the trials.

## 2. A comparison of average catch rates between the cod ends

Average catch rates for each cod end mesh size were calculated from the total numbers of fish estimated for all hauls divided by the overall duration of fishing for that mesh size. Catch rates are expressed as numbers per hour and catch weights (kg) per hour. This allows a simple comparison to be made between cod ends but relies on the assumption that the frequent swapping of cod ends adequately smooths out variations in the population of fish that might be encountered between hauls in different trials. The average catch rates determined for the standard 85 mm cod end are based on all 40 hauls, whereas those for 48 mm, 97 mm, 111 mm, and 128 mm are based on 10, 10, 11, and 9 hauls, respectively.

Length frequency data, standardised to numbers at length per hour fished, was used to assess the selective properties of the different cod ends.

Length frequency distributions are presented graphically as (a) the percentage frequency, and (b) the cumulative percentage frequency, against total length. Plotting percentage frequency, rather than raised catch numbers, allows easier comparison between different cod end mesh sizes and species as the range on the y-axis is constant. The cumulative percentage frequency plot gives a 'selectivity ogive' from which the 50% retention length ( $L_{50}$ ) and the selection range ( $L_{25-75}$ ) values can be obtained and used to compare the selectivity characteristics of each cod end mesh size.

## 4. Results

### 4.1 Fishing activity

Four trials testing four different cod end mesh sizes were undertaken between 21<sup>st</sup> August and 1<sup>st</sup> September 2017 in ICES sub-area VIIIE (statistical rectangles 28E3 and 28E4). Between 9-10 hauls were sampled for each trial (Table 1). As haul 37 with a 111mm cod end mesh size was invalid, we only used 10 tows in trial 3 for statistical data analysis. The duration of night-time tows was shortened to avoid catching too much haddock. The plan to change the test cod end for the three larger mesh sizes every other tow was made possible by virtue of the helpful crew and, as a result, there were no interruptions to the fishing plan. Tow duration with the small mesh cod end began at 1 hour, particularly during hours of darkness, anticipating that clogging and excessively large catches would affect fishing performance prematurely. Tow duration during the day was about two-thirds of that determined for tows with the larger mesh cod ends.

Table 1. Summary of fishing activity showing the spread of effort between light and dark for each cod end mesh size.

TRIAL	Mesh size of cod end nominal (measured) (mm)	Fishing time (hrs)			Number of tows			Mean tow duration (hrs)	
		Light	Dark	Total	Light	Dark	Total	Light	Dark
1	45(48)	10.75	4.42	15.17	5	5	10	2.15	0.89
2	100(97)	13.17	11.08	24.25	4	6	10	3.29	1.85
3	110(111)	20.84	8.91	29.75	6	5	11	3.47	1.78
4	120(128)	18.25	6.08	24.33	5	4	9	3.65	1.52
Control	85(85)	63.01	30.49	93.50	20	20	40		
Total number of catch samples sorted							80		

### 4.2 Summary overview in differences in fish catches between cod ends

The 20 most abundant species caught, according to highest total catch weight (being the sum of the modified and standard cod end), are listed in Table 2 and 3. The most dominant commercial species was haddock (HAD) followed by gurnards (GUG, GUR, TUB), megrim (MEG), whiting (WHG), monk fish (MON), plaice (PLE) and lemon sole (LEM) and sole (SOL). These 8 species made up 87% of the catch weight and 70% of the catch numbers. Haddock accounted for 65% of the catch weight and 28% of the catch number. Night-time catches frequently exceeded the capacity of the pounds, even when tow duration was limited to 1 hour. Differences in catch rates relative to the standard 85mm cod end for the most dominant 20 species are illustrated in Figure 2 and 3 and Table 2 and 3.

A general increase in catch weight when decreasing the cod end mesh size from nominal 85 to 45mm in the experimental trawl in trial 1 is noted. Species with increased catches were gurnards (GUG, GUR) (+386%, +362%), lesser spotted dogfish (LSD) (+474%), common dragonet (CDT) (+4,599%) and poor cod (POD) (+7,357%). To a lesser extent, whiting (WHG) (+289%) and megrim (MEG) (+109%) catches also increased. Catches of haddock only slightly increased with +3% (Table 2).

In trial 2, the differences between the standard 85mm and the modified 100mm cod end mesh were less striking. Reductions were seen in 9 out of the 20 main species, as well as increases in the other 11 species. Reductions were most obvious in weights for boarfish (BOF) -56%, whiting (-45%) and haddock (-1%). Unexpected overall increases were seen for grey and red gurnard (+57% and +87%) and, to a lesser extent, cuckoo ray (CUR) (+61%) (Table 2).

In trial 3 and 4 catches decreased with increasing mesh size for most species. Clearly haddock decreased with 82 and 92% in trial 3 and 4. Other species that decreased were red gurnards (-74 and -96%), lemon sole (-33 and -76%), megrim (-43 and -75%) and whiting (-82 and -96%). The efficiency with which some of the species of little, or no, commercial value, such as lesser spotted dogfish, dragonet, and boarfish, can be lost (between 86-97% trial 3 and 96-99% in trial 4) with larger mesh cod ends is evident. Also, grey gurnards, mostly discarded, decreased by 85% and 98% in trial 3 and 4 respectively (Table 2). The statistical significance of these general observations were explored using a catch comparison analyses for key species caught in sufficient numbers.

Table 2. Catch weight of the standard 85mm, the weight difference with the experimental trawl and the percentage difference to the standard trawl for 20 most abundant species (sorted from high to low). Negative value is a reduction in weight in the experimental trawl.

SPECIES	TRIAL 1: 45mm			TRIAL 2: 100mm			TRIAL 3: 110mm			TRIAL 4: 120mm		
	Weight 85mm (kg)	Diff Weight (kg)	% Diff	Weight 85mm (kg)	Diff Weight (kg)	% Diff	Weight 85mm (kg)	Diff Weight (kg)	% Diff	Weight 85mm (kg)	Diff Weight (kg)	% Diff
HAD	3474	98	3	7640	-80	-1	4267	-3293	-77	3868	-3371	-87
GUG	307	1187	386	867	491	57	782	-676	-86	461	-450	-97
LSD	156	740	474	278	-16	-6	350	-304	-87	260	-250	-96
GUR	78	282	362	243	211	87	289	-215	-74	137	-132	-96
MEG	138	151	109	206	-15	-7	206	-88	-43	258	-195	-75
CDT	20	900	4599	48	26	55	36	-35	-97	21	-21	-98
CUR	58	22	37	137	84	61	192	-91	-47	86	2	2
POD	9	670	7357	58	7	13	19	-18	-98	23	-23	-99
WHG	53	152	289	187	-84	-45	65	-54	-82	78	-75	-96
BOF	38	48	126	265	-149	-56	47	-43	-93	29	-29	-99
MON	43	-10	-23	31	20	63	114	-36	-31	46	1	2
PLE	28	37	130	55	18	33	62	-9	-14	43	4	10
LEM	24	-1	-6	73	-36	-49	57	-19	-33	57	-39	-67
SDR	18	-1	-8	33	9	28	17	5	30	18	-5	-26
ISF	1	102	13743	1	7	1079	2	-2	-100	2	-2	-97
CRE	1	0	18	6	-5	-80	1	0	-3	3	73	2751
TUB	8	-6	-70	8	3	35	18	-5	-29	10	-7	-65
HKE	2	6	253	32	-26	-82	10	-9	-94	14	-13	-96
SOL	10	9	90	13	-8	-60	6	-3	-55	15	-13	-89
BLL	4	0	-11	6	1	14	20	-2	-10	5	2	45

Table 3. Catch number in the standard 85mm, the number difference with the experimental trawl, and the percentage difference to the standard trawl for 20 most abundant species (sorted from high to low). Negative values means there is a reduction in weight of the experimental trawl.

SPECIES	TRIAL 1: 45mm			TRIAL 2: 100mm			TRIAL 3: 110mm			TRIAL 4: 120mm		
	Number 85mm	Diff Number	% Diff	Number 85mm	Diff Number	% Diff	Number 85mm	Diff Number	% Diff	Number 85 mm	Diff Number	% Diff
HAD	7913	41	1	15160	-299	-2	9614	-7853	-82	8698	-7973	-92
GUG	3582	18606	519	9519	6920	73	8024	-6847	-85	5099	-4973	-98
LSO	398	4746	1194	757	-215	-28	913	-837	-92	571	-558	-98
GUR	937	5884	628	2673	2912	109	2855	-2166	-76	1644	-1589	-97
MEG	574	841	147	941	-219	-23	815	-486	-60	1159	-999	-86
CDT	245	15476	6329	654	338	52	506	-495	-98	283	-278	-98
CUR	68	58	85	161	133	83	230	-98	-43	141	-17	-12
POD	164	18106	11040	1179	73	6	435	-428	-98	481	-476	-99
WHG	146	730	501	629	-377	-60	165	-145	-88	209	-203	-97
BOF	1165	1262	108	6428	-3562	-55	1162	-1089	-94	749	-745	-99
MON	61	-31	-50	61	-6	-10	80	-34	-42	68	-27	-40
PLE	68	111	163	152	52	34	149	-44	-29	118	-14	-12
LEM	99	24	24	292	-149	-51	240	-113	-47	256	-210	-82
SDR	72	130	181	150	-74	-49	48	-1	-1	77	-48	-62
ISF	15	3078	20520	16	185	1156	65	-65	-100	43	-42	-98
CRE	18	12	67	118	-90	-76	120	-90	-75	46	17	36
TUB	18	-13	-72	14	5	36	33	-10	-30	18	-10	-56
HKE	13	47	372	139	-101	-73	50	-47	-94	83	-82	-99
SOL	27	35	130	34	-22	-65	15	-9	-60	37	-35	-95
BLL	3	-1	-33	4	3	75	14	0	0	4	0	0

Figure 2. Weight difference with the corresponding standard trawl of 85mm for the 20 most abundant species:

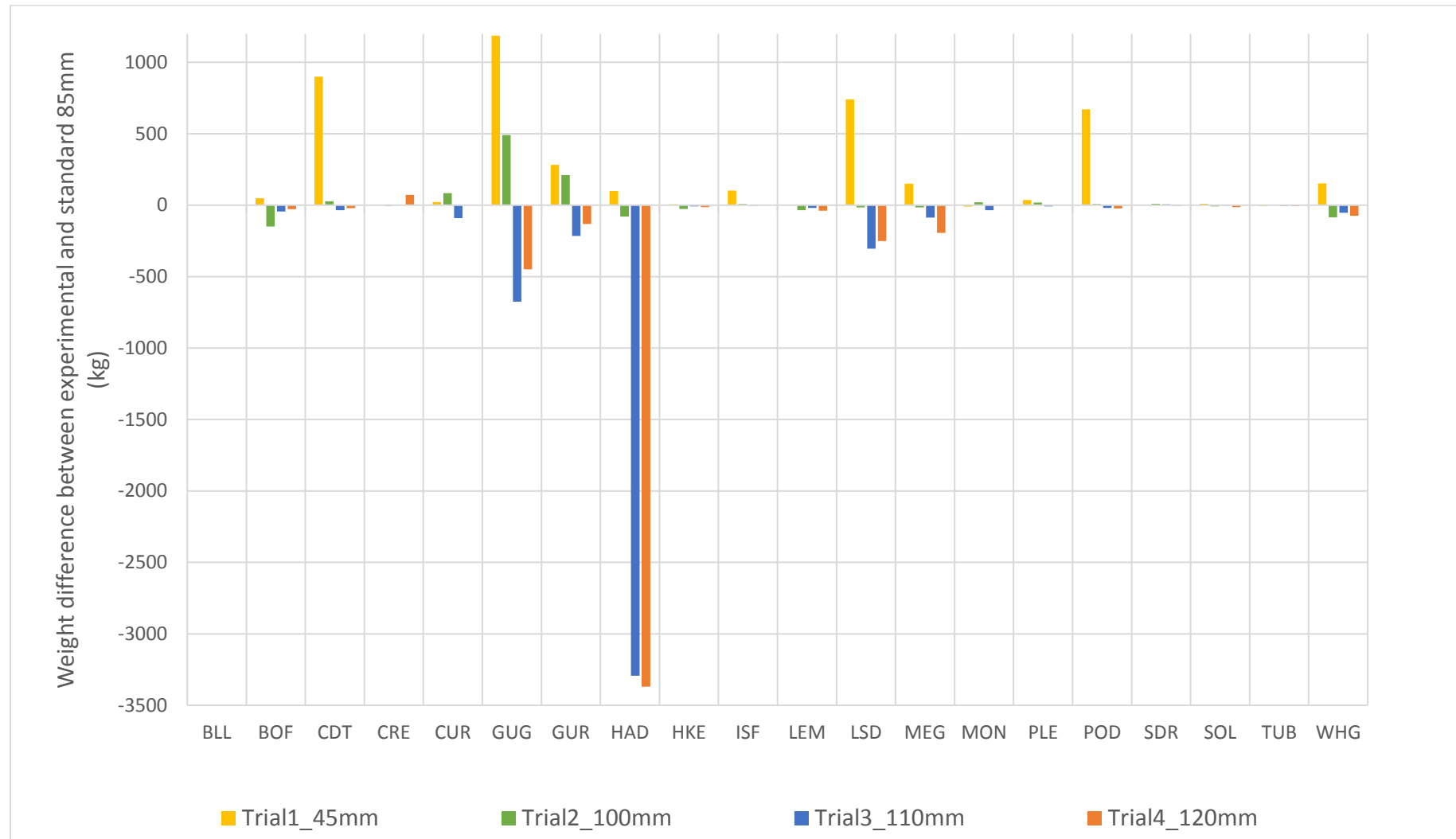
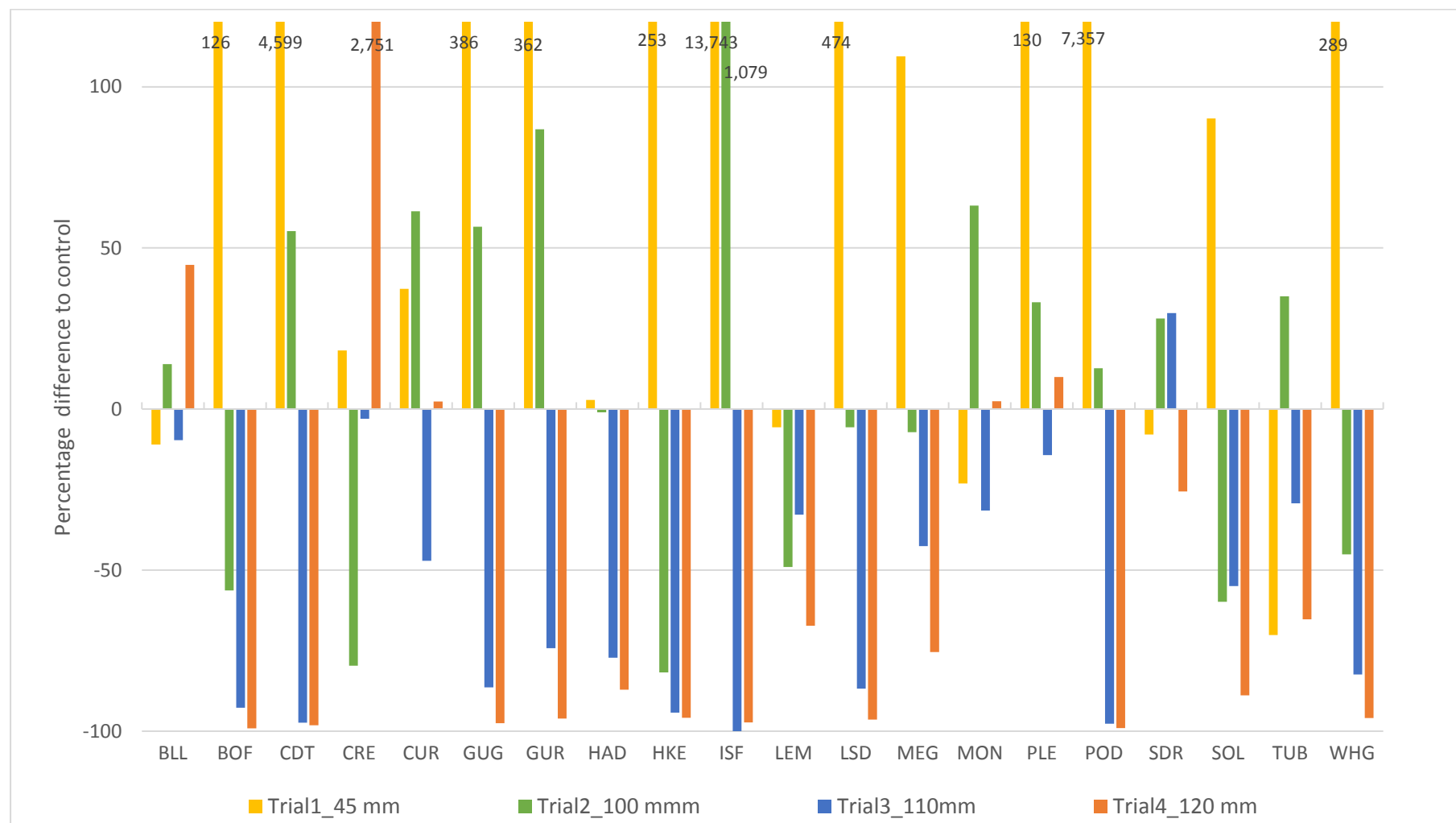




Figure 3. Percentage difference in catch weight to standard trawl of 85mm for 20 most abundant species (positive y axis stops at 120%, values greater that 120% are given)



## 1. Statistical catch comparison analyses using SELNET

The statistical analysis (SELNET catch comparison length analysis) was performed on 6 species: red gurnard, megrim, haddock, plaice, whiting and lemon sole. There were 15 significant reductions in trials 2, 3 and 4 and 9 significant increases in trials 1 and 2 (Table 4).

### Comparing nominal 85mm cod end (control) with 45mm:

The SELNET analysis, gave statistically significant increases in catches for three species, megrim, red gurnard and whiting in the 45mm cod end compared with the 85mm cod end. For the latter two the increase was seen mostly at a lower length range in comparison with the standard trawl, 9-21cm and 21-32cm respectively (Table 4, Appendix 3) at which more than twice the weight of fish were caught with the smaller mesh size. The 45mm cod end did not catch significantly different quantity of haddock than the 85mm, indicating that small haddock were absent during the period of the trial.

Table 4: Statistically significant results for main species in the catch in the four trials comparing 85mm cod end with 45mm (Trial 1), 100mm (Trial 2), 110mm (Trial 3) and 120mm (Trial 4):

TRIAL	SPECIES	Sig. Length range (cm)	Catch Number Standard 85mm	Diff Numbers	% Diff by Numbers	Catch Weight Standard (kg)	Diff Weight (kg)	% Diff by Weight
1	GUR	9-21	777	11126	1433	53	118	543
	MEG	24-32	361	685	190	62	20	176
	WHG	21-32	50	1250	2501	13	37	1299
2	GUR	17-21	1648	2095	127	105	33	129
	LEM	22-27	196	-105	-54	42	-17	-54
	MEG	22-28	428	-263	-62	53	-15	-58
	PLE	28-32	27	90	338	9	3	407
	PLE	37-43	19	-18	-92	14	-4	-96
	GUR	17-26	2724	-2065	-76	260	-61	-73
	HAD	25-49	9571	-7427	-78	4205	-978	-78
3	LEM	20-26	151	-105	-70	26	-9	-66
	MEG	21-33	542	-468	-86	92	-42	-76
	PLE	39-40	0	6	222	0	4	100
	PLE	29-32	85	-54	-64	32	-13	-57
	WHG	30-41	153	-138	-91	57	-28	-91
	GUR	15-28	1638	-1579	-96	136	-94	-96
	HAD	55-59	2	17	845	4	8	710
4	HAD	24-46	8608	-7747	-90	3759	-2168	-90
	LEM	32-33	3	5	169	1	1	185
	LEM	19-29	233	-223	-96	47	-37	-93
	MEG	20-36	1036	-960	-93	195	-132	-89
	PLE	36-36	3	5	166	2	0	166
	PLE	26-29	43	-32	-76	12	-2	-75
	WHG	24-40	185	-182	-98	62	-42	-98

#### Comparing nominal mesh size 85mm with 100, 110, 120mm:

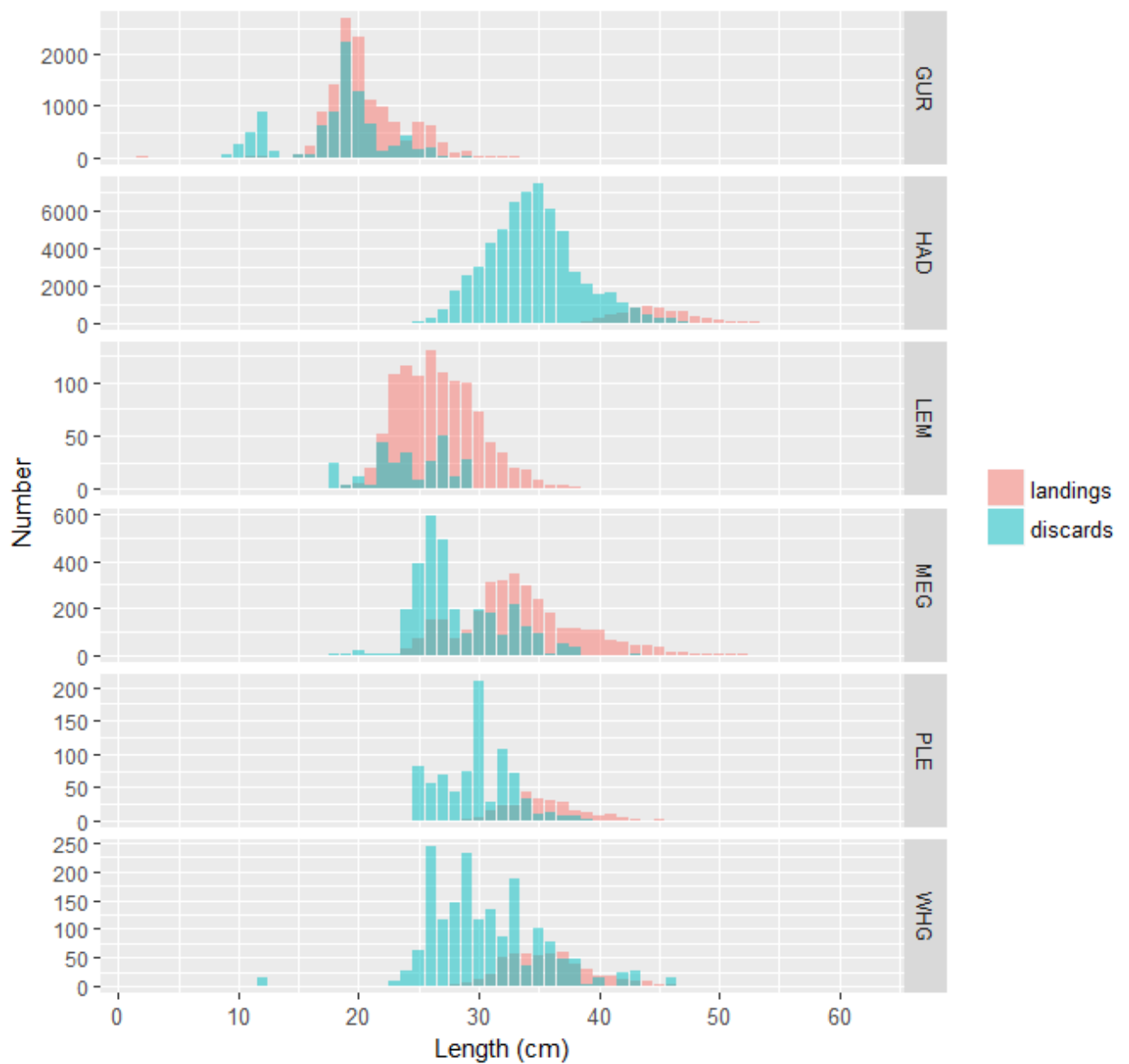
In trial two, where a nominal 100mm mesh was tested against the 85mm cod end, results are varying.

The catch rate of haddock for the 100mm cod end was similar to the standard cod end. One reason for this may be the thicker, stiffer twine used to make the 100mm cod end, i.e. 6mm diameter twine compared to 3.5mm, might have resulted in a relative smaller mesh opening. This may also explain the significant increase of 129% seen for red gurnards (17-21cm) in the 100mm cod end.

Significant reductions of 54% and 58% were observed for lemon sole and megrim. The reductions were mainly situated in the lower half of their length range (22-27 and 22-28cm), indicating escapement when increasing mesh size (Appendix 3). The lengths of fish caught that were retained and discarded across all trials are shown in Figure 4. However, it is unknown what the influence was of the additional quota received by the vessels during the trial on the catch sorting behaviour, and therefore, this may not have been representative of normal practice. During the trial lemon sole was usually landed at the length range for which a reduction in catch was observed, therefore these reductions were of marketable sized fish. For plaice, the results are contradictory with a significant increase at lower lengths and reduction at higher lengths (although based on few fish).

In Trials 3 and 4 (cod end nominal mesh 110, 120mm compared with 85mm) catches further decreased compared with the standard trawl. After statistical analysis, significant decreases were observed for all 6 species i.e. red gurnards, haddock, lemon sole, megrim, plaice and whiting (Table 4) in comparison with the standard 85mm cod end mesh. Between 57 and 91% weight reductions in trial 3 and 75-98% weight reductions in trial 4. The increase in cod end mesh sizes to 110mm and 120mm, demonstrated a reduction in lemon sole at marketable lengths of 66% and 93% respectively. There was a significant reduction in catch weight in haddock of almost 1 tonne in Trial 3 and over 2 tonnes in trial 4. The reductions were at length ranges (24-46cm) in trial 3 and 25-49cm in Trial 4. These fish were mostly discarded but the fish at the higher end of this range were retained (Figure 4). The reduction in whiting catches occurred at lengths where most of these species were discarded. The reductions in megrim and lemon sole (at lengths 19-29cm and 20-35cm respectively in trial 4) include marketable individuals. Although the length range is narrower in trial 3 for these species (20-26 and 21-33 respectively). For plaice, lemon sole and haddock significant increases were also observed but only for the largest lengths, and there are based on a low number of individuals with 3, 3 and 2 fish caught in standard trawls of trial 4. Therefore, these results should not be used as an indication of the performance of the trawl towards these length groups.

Figure 4. Number at length of landings and discards for the 6 species over all trials



## 2. A comparison of average catch rates between the cod ends

The standardised catch rates, expressed as numbers caught per hour and weights caught per hour, for each cod end are shown in Table 5. This provides a simple way of comparing the different cod ends.

Overall catch rates - Number caught per hour					
Species	Mesh size (mm)				
	45(48)	85(85)	100(97)	110(111)	120(128)
MON	1.98	2.87	2.52	1.34	1.66
BOF	159.92	101.64	118.80	1.93	0.18
CDT	1036.26	18.05	40.95	0.35	0.21
GUG	1462.62	280.46	690.58	29.21	5.16
GUR	449.64	86.72	236.33	18.27	2.26
HAD	524.27	442.62	613.36	58.76	29.82
LEM	8.11	9.49	8.41	2.24	1.89
LSD	339.02	28.20	22.97	2.05	0.51
MEG	93.28	37.32	30.97	10.10	6.58
PLE	11.80	5.19	8.70	3.26	4.25
POD	1204.35	24.15	51.63	0.24	0.21
SOL	4.09	1.21	0.58	0.13	0.08
SQC	0.07	1.19	1.07	1.43	0.41
WHG	57.68	12.28	10.43	0.64	0.25

Overall catch rates - Weight (kg) caught per hour					
Species	Mesh size (mm)				
	48	85	97	111	128
MON	2.24	2.59	2.80	2.18	2.01
BOF	7.12	4.06	6.02	0.10	-
CDT	67.77	1.48	3.41	-	-
CUR	5.92	5.94	11.00	3.66	4.21
GUG	94.07	24.27	53.94	2.55	0.44
GUR	24.94	8.22	20.09	2.01	0.23
HAD	226.76	198.27	300.41	31.36	19.69
LEM	1.41	2.11	2.02	0.74	0.72
LSD	60.56	11.70	11.70	1.38	0.41
MEG	17.92	8.07	7.74	3.29	2.37
PLE	3.51	1.67	2.63	1.38	1.63
POD	40.80	1.06	2.43	-	-
SOL	4.09	1.21	0.58	0.13	0.08
SQC	-	-	-	-	-
WHG	12.17	3.73	3.82	0.33	0.12

Table 5 Overall catch rates of the more dominant species for light and dark tows combined.

This approach assumes that the same composition of fish was encountered on the different trials. The influence of this assumption was considered to have been reduced by regularly switching between the

cod ends being compared. However, the catch rates of haddock were not consistent in the standard trawl when tested against all the other cod ends. Almost double the amount of haddock was caught when the standard 85mm cod end was tested against the 100mm cod end (Trial 2) compared with the other cod ends. Therefore, caution needs to be taken as the mean catch from the standard trawl is overestimated when comparing with the modified cod ends in trial 1, 3 and 4 and underestimated in trial 2. It explains why the statistical method suggests very little difference in catches of haddock in Trial 2, whereas the mean catch method gives a 50% increase in the 100 mm cod end.

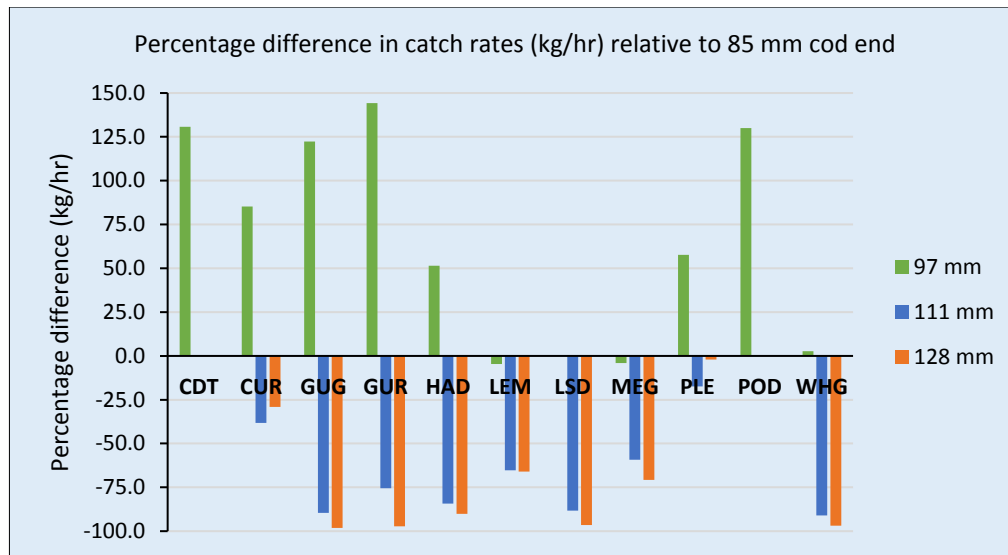


Figure 5. Bar chart of the percentage difference in catch rates by the larger mesh cod ends for the more dominant species relative to the standard 85mm cod end. Data from light and dark tows were combined.

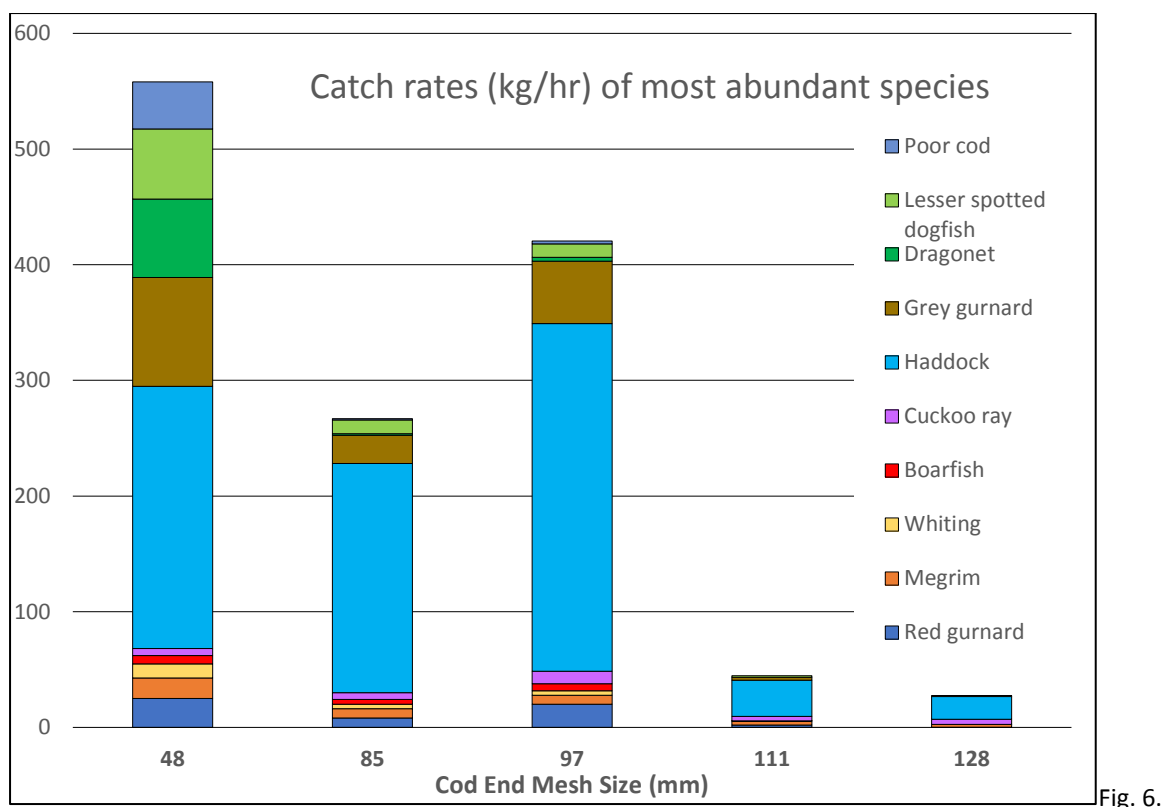


Fig. 6. Stacked bar chart showing the combined catch rates (kg/hr) of the most abundant species at each cod end mesh size.

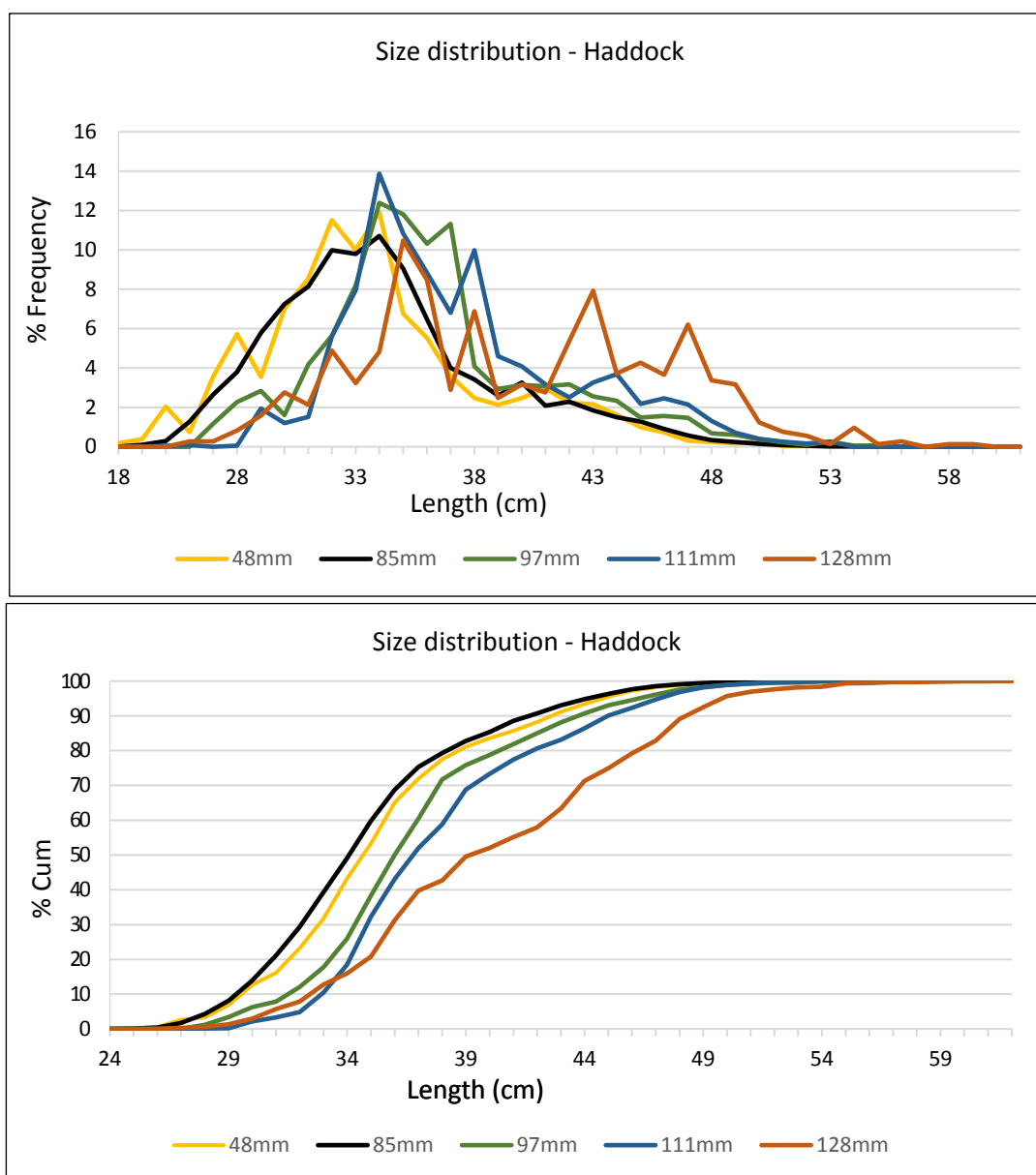
Estimates of the total number and average catch rates of each species at each mesh size are given in Appendix 4. These are summarised for the dominant species in table 5. Differences in catch rates relative to the standard 85 mm cod end are illustrated in figure 5. The dominance of haddock in the catches at all mesh sizes is illustrated in figure 6. There were poor catches of other commercial species namely, whiting, megrim, monk, lemon sole, plaice, and squid.

As stated above, the 48 mm cod end did not appear to catch any fewer large haddock than the 85 mm and 97 mm cod ends. The 48 mm cod end did not catch any smaller haddock than those caught by the larger mesh cod ends. Under these conditions, it may have been possible to use the 48 mm cod end as standard, but catches would have taken longer to sort and sample, and no extra information on the selectivity of small haddock (<18 cm) would have been obtained because they were absent.

The catch rate of haddock for the 97 mm cod end was greater than that for the standard cod end. One reason is that the calculated standard trawl is underestimated. In line with the previous analysis also the thicker, stiffer twine used to make the 97 mm cod end might have resulted in a smaller mesh opening and consequently in an increased or rather similar catch of haddock. Also catch rates increasingly reduced when increasing the mesh size to 111 and 128 mm.

Standardised length frequency data, and cumulative length frequency data are presented for the following species: haddock, megrim, lemon sole, plaice, grey gurnard, and lesser spotted dogfish. Low catch numbers of commercial species other than haddock prevent a clear assessment of the selective properties of different cod end mesh sizes. The efficiency with which some of the species of little, or no, commercial value, such as lesser spotted dogfish, dragonet, and boarfish, can be lost with larger mesh cod ends is, however, quite evident from appended tables of numbers caught.

## Haddock



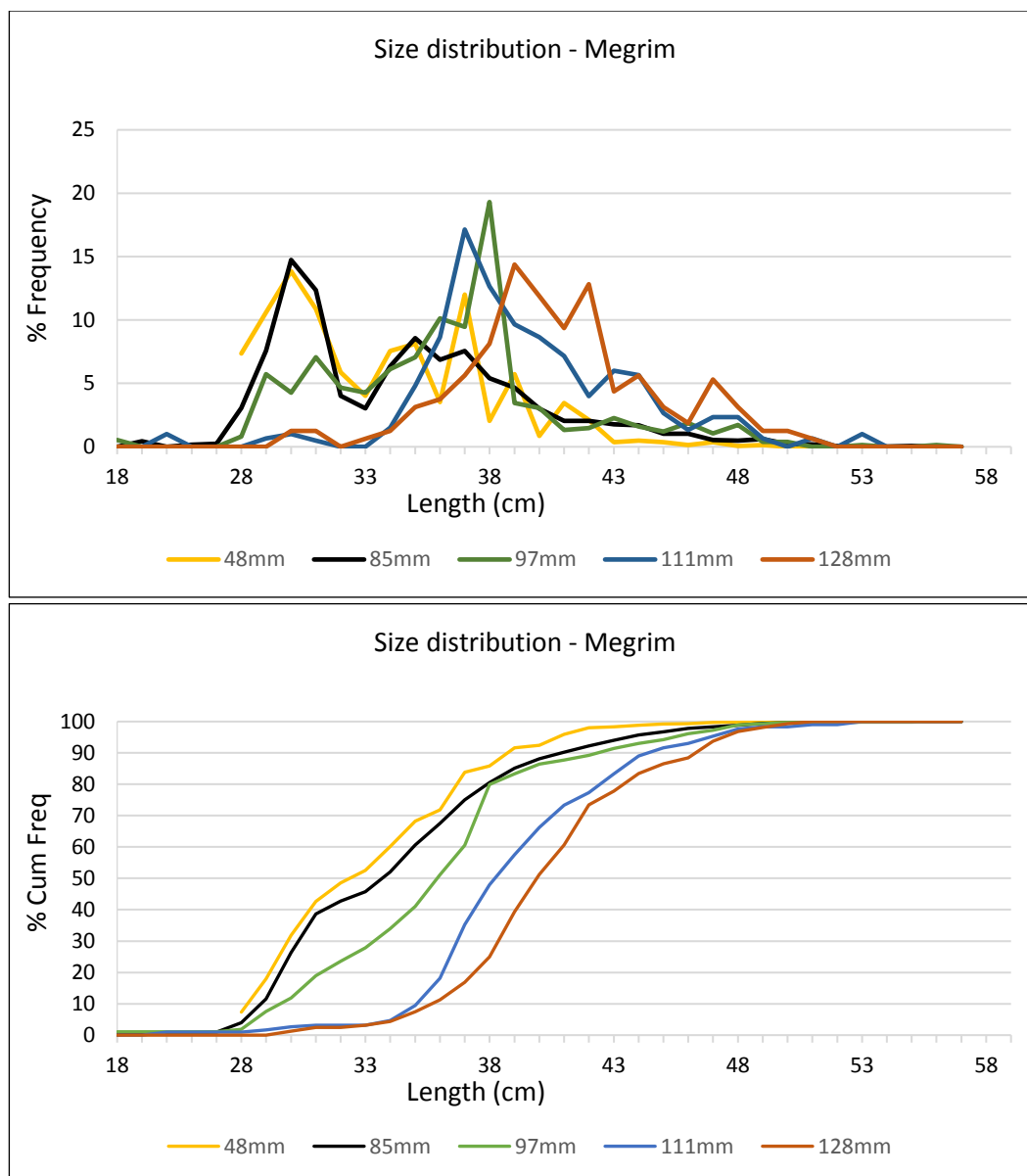
Mesh	48	85	97	111	128
Catch rate (N/hr)	524.3	443.6	613.4	58.8	29.8
L <sub>50</sub>	33.5	33.0	35.0	35.5	38.0
L <sub>25</sub> -L <sub>75</sub>	5.0	5.4	5.0	5.7	9.5

The first observation of note is that the smallest haddock caught in the trials was 18cm – not in the 48mm cod end but in the 85mm cod end. The smallest haddock caught in the 48mm cod end was 24cm. Both plots show that the size distributions for these two cod ends was very similar, providing evidence for the virtual absence of the small haddock anticipated at the planning stage of this project, and ruling out the possibility of determining absolute selectivity for haddock. The results can only allow relative selectivity to be described for the size range of haddock caught. There do not seem to be great differences in L<sub>50</sub> between the 48mm and 85mm cod ends, and the 97mm and 111mm cod ends. There



is, however, a striking reduction in the catch rates of haddock in the 111mm and 128mm cod ends compared to the three smaller cod ends.

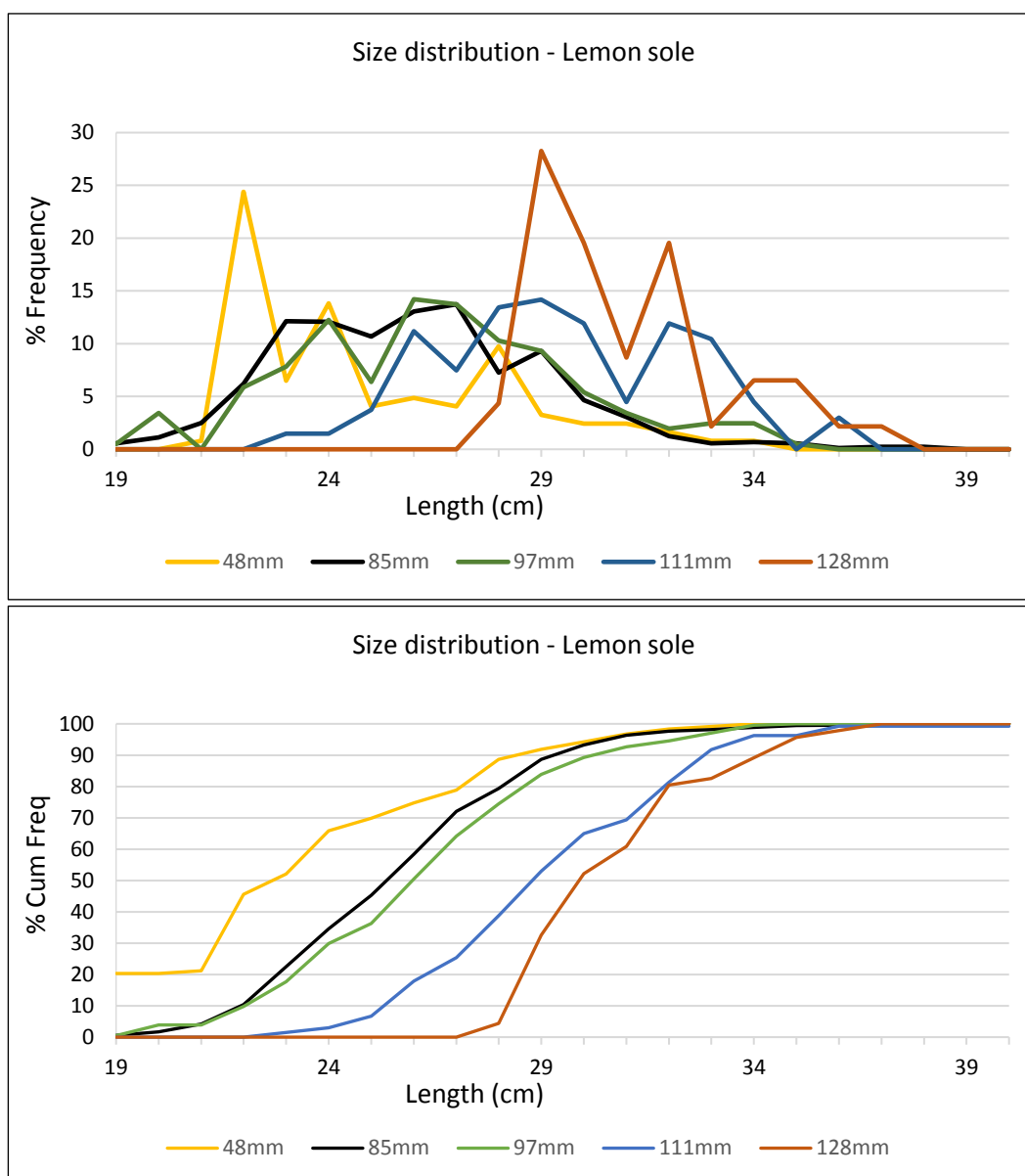
### Megrim



Mesh	48	85	97	111	128
Catch rate (N/hr)	93.3	37.3	31.1	10.1	6.6
L <sub>50</sub>	32.0	33.6	35.8	38.0	39.8
L <sub>25</sub> -L <sub>75</sub>	6.8	7.0	5.0	5.0	4.7

The size distributions of megrim caught in the 48mm and 85mm cod ends were very similar. The 50% retention length shows a steady increase with increasing cod end mesh size as expected, but there is a significant reduction in catch rates of megrim in the 111mm and 128mm cod ends. Catch rates in the 85mm cod end were sufficient to show that there would be a significant loss in earnings if either of these large mesh cod ends were used.

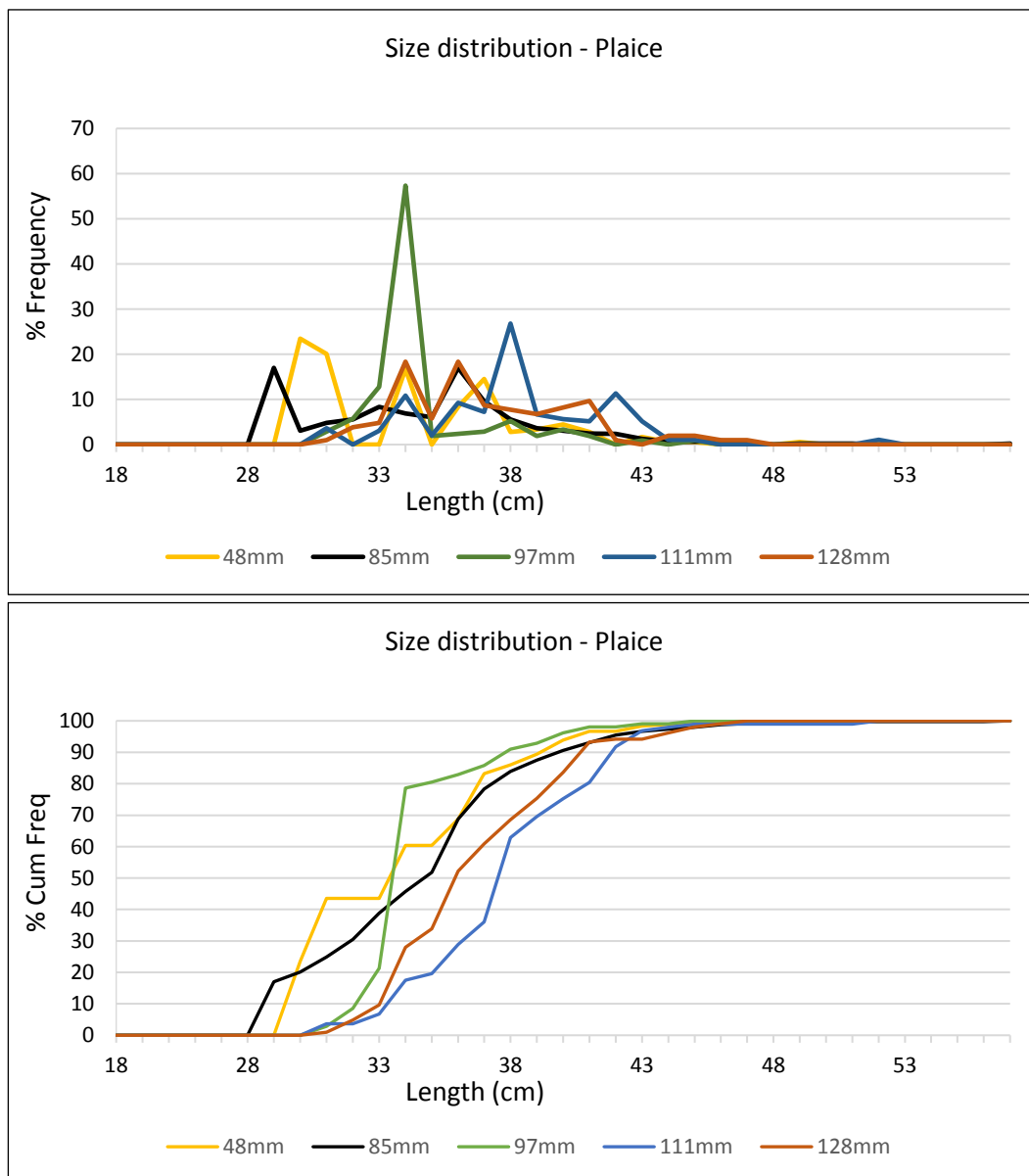
## Lemon sole



Mesh	48	85	97	111	128
Catch rate (N/hr)	8.1	9.5	8.4	2.2	1.9
L <sub>50</sub>	22.6	25.4	26.0	28.8	29.9
L <sub>25</sub> -L <sub>75</sub>	4.8	4.2	4.4	4.8	3.1

The size curves show that lemon sole smaller than 24cm length (equivalent to market grade 5) would be virtually eliminated from catches with a cod end mesh of 111mm or greater. A shift from the current standard cod end of 85mm mesh to a 100mm mesh would probably have minimal impact on lemon sole catches, as indicated by the very similar L<sub>50</sub> values, however, catch rates observed during this set of trials were low, so results may be inconclusive in this respect.

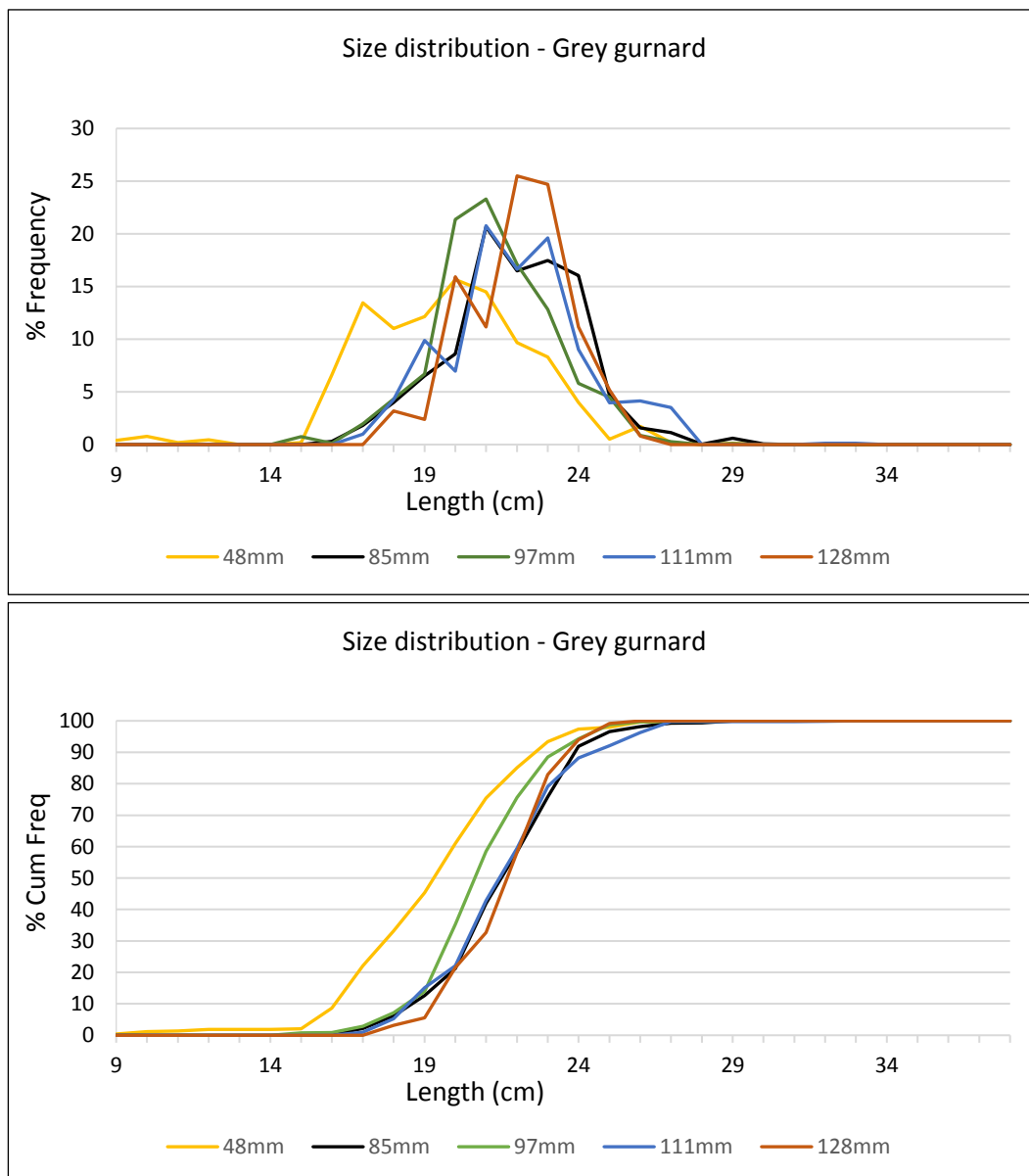
## Plaice



Mesh	48	85	97	111	128
Catch rate (N/hr)	11.8	5.2	8.7	3.3	4.3
L <sub>50</sub>	33.3	34.5	33.4	37.4	35.8
L <sub>25</sub> -L <sub>75</sub>	6.4	5.5	0.7	4.5	5.3

Size selectivity of plaice does not appear to be affected much by increasing cod end mesh size, although catch rates were very low during this set of trials. A similar trend to that observed for megrim could be expected.

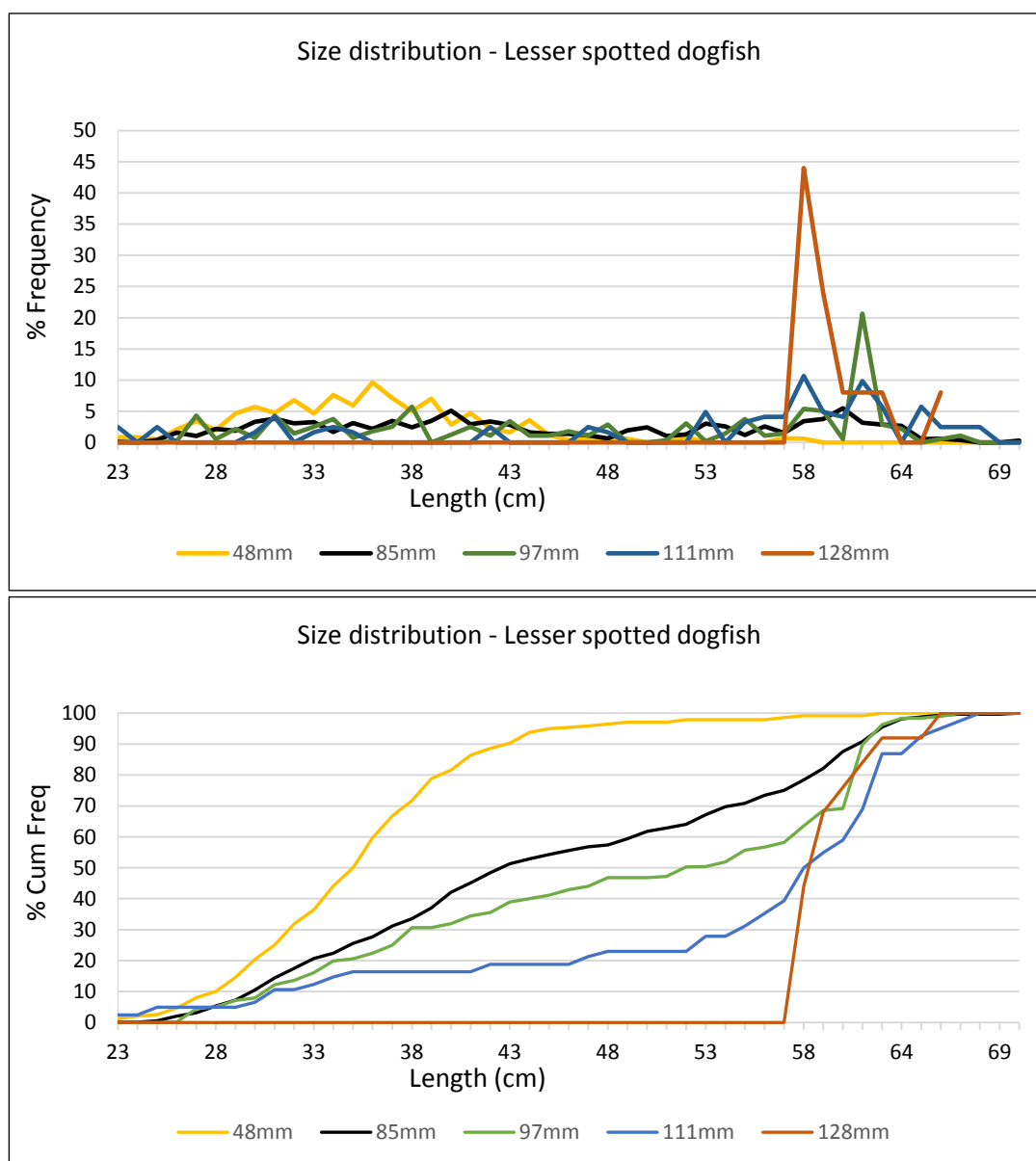
## Grey gurnard



Mesh	48	85	97	111	128
Catch rate (N/hr)	1462.6	280.5	690.6	29.2	5.2
L <sub>50</sub>	19.2	21.4	20.6	21.4	21.6
L <sub>25</sub> -L <sub>75</sub>	3.7	2.8	2.5	2.5	2.5

There would appear to be little change in size selectivity of grey gurnard by increasing cod end mesh size beyond 85mm. Catch rates, however, are greatly reduced in the 111mm and 128mm cod ends.

## Lesser spotted dogfish



Mesh	48	85	97	111	128
Catch rate (N/hr)	339.0	28.2	23.0	2.1	0.5
L <sub>50</sub>	35.0	42.5	52.0	57.8	58.1
L <sub>25</sub> -L <sub>75</sub>	7.2	22.2	24.5	10.0	3.5

Increasing cod end mesh size appears to be an effective means of reducing catches of lesser spotted dogfish. Many SW otter trawlers are plagued with this species for much of the year. A shift to a 110mm cod end would almost eliminate catches of fish below about 55cm length. The release of lesser spotted dogfish, which appears to survive being caught in trawls extremely well, and the prospect of continued abundance on fishing grounds in the SW is not considered desirable by many in the catching sector, although it makes sorting of the catch easier and probably improves the quality of other, more important catch species.

### 4.3 Economic impact

The species commanding the highest prices were monk, squid, and lemon sole (Table 6). Although these species did not feature significantly in the catches during these trials, it is expected that there would be a drastic reduction in the retention of squid and the small and medium grades of lemon sole with a cod end mesh size of 110mm and above compared to the standard 85mm cod end. Data from this study indicate that catch rates of lemon sole were reduced overall by 65%, with a statistically significant reduction of 35% in weight of fish 20-26cm at 110mm and 79% reduction in fish 19-29cm, and of whiting, by about 90% when jumping to this larger cod end mesh. From earlier studies (e.g. FSP, 2017), it was concluded that the selectivity of whiting and squid in the SW otter trawl fishery show similar trends, so it is likely that the revenue from squid would suffer similar losses.

Table 6: The prices obtained at first sale for the commercial species caught in highest volume over the course of the trials.

Species	Price range (£/kg)		
	Landing 25 <sup>th</sup> August	Landing 29 <sup>th</sup> August	Landing 4 <sup>th</sup> September
Lemon sole	5.60	3.50 (small) – 6.50 (medium)	3.00 (small) – 7.50
Monk	9.70	9.00	5.00 – 9.00
Gurnards	4.10 (tub gurnard)	1.20	1.50
Whiting	1.80	1.20	0.50 – 1.00
Megrim	2.20	1.70 (small) – 4.00 (medium)	1.30 – 3.50
Haddock	3.00	2.00 – 2.50	1.70 – 2.50
Squid	13.00	7.00 – 8.50	6.00 – 8.00
Cuckoo ray		2.00	2.20
Plaice	3.30	0.60 (small) – 2.60 (medium)	0.70 – 2.40 (large)

## 5. Discussion

The primary aim of these gear trials was to look at the changes in overall catch composition, and the likely impact on the value of landings, whilst attempting to reduce the retention of haddock with increasing cod end mesh size. No other modification was made to the trawl. The trials on FV *Our Olivia Belle* generated a sizable body of data on the cod end selectivity for haddock across a range of diamond mesh sizes. Sufficient numbers and sizes of haddock were encountered throughout the trials for the differences in catch composition that were observed in the test trawl relative to the standard trawl to be significant. All sampled tows were judged to be valid in the skipper's opinion and according to the catch volumes in each cod end. However, a lack of measurements to demonstrate comparable geometry and bottom contact of each trawl may detract from the statistical significance of differences seen in the catch composition at each cod end mesh size.

Compared to the standard 85mm cod end, it appeared that increasing the cod end mesh size to 97mm (nominal 100mm) made little difference to the catch rates of most species, although the thick twine used in the construction of this cod end will have influenced the results. Whereas an increase to

111mm (nominal 110mm), and above, resulted in a significant reduction to the catch rates of many species. The SW otter trawl fishery targets a multitude of species throughout the year, and vessels depend on these being available all year-round, even though the exact mix of species may change from season to season. In the face of further reductions in the haddock quota, and with the full implementation of the Landing Obligation in January 2019, it is unlikely that otter trawlers would be able to operate profitably in the SW if use of such large cod end mesh sizes became a legally-enforceable technical measure.

It should be mentioned that the results obtained from this 11-day trial may not be representative of what might take place in the SW otter trawl fishery at other times of the year, and trials would need to be extended to understand the effect of increased cod end mesh size on catch composition more fully.

## 6. Industry Comments

The vessel owner and skipper emphasised what is already understood about the limitations of conducting a set of gear trials for such a short period when the fishery is composed of so many variables. These trials should be carried out over a full year, as a minimum, and on a range of fishing grounds, if the effects of increasing cod end mesh size are to be fully understood.

With respect to the generally higher catch rates seen with the 97mm cod end compared to the standard cod end, the skipper confirmed the importance of **twine thickness**, **construction**, and **material** in modifying cod end selectivity, in addition to mesh size. In this set of trials, the twine used to construct the 97mm cod end was 6mm diameter, compared to 3.5mm for the 85mm cod end, and it is suspected that mesh opening could have been reduced even though the internal mesh size was greater. The skipper provided more recent corroborative comment relating to cod ends used in the 2017-18 cuttle season. Operators of the otter trawlers working out of Brixham and Plymouth targeting cuttle have fitted the thicker twined cod ends to maximise catches of cuttle, both adults and juveniles, and squid. Discards of finfish are thought to have been correspondingly greater.

## 7. Conclusions

1. Eleven days sea trials comprising 40 tows were successfully completed in August-September 2017 in the Western English Channel allowing the effect of increasing cod end mesh size on the retention of haddock to be recorded.
2. A cod end with nominal mesh size of 85mm was tested against 45mm, 110mm, and 120mm. the catches were dominated by haddock, catches of other key commercial species were sufficient conduct statistical analyses of the effect on changing cod end mesh size. The thick twine diameter used in the construction of the 100mm cod end meant that it was not directly comparable with the other cod ends, and is likely to have demonstrated lower selectivity than had it been constructed of thinner twine.

3. There was no significant difference in haddock catches between 85mm and 45mm cod ends, indicating that there were no small haddock on the fishing grounds during the trial. Catches for other species such as red gurnard, megrim and whiting were much higher when using the smaller mesh cod end.
4. Increasing the cod end mesh size from 85mm generally reduced overall catches, and catches were generally less when using 120mm cod end compared with 110mm. the reduction in catches was length dependent, with increasing reductions in catches of smaller fish with increasing mesh size.
5. Most of the haddock caught on the trial was discarded due to quota restrictions. Catches of unwanted haddock were significantly reduced when using cod end mesh sizes of 110mm and 120mm. however, at these mesh sizes, there were significant reductions in the catches of marketable sizes of other species.
6. For example, cod end mesh sizes of 110mm and 120mm, resulted in the loss of a significant quantity of marketable catches of lemon sole which would have a considerable negative effect on the fleet as this is a key target species for the otter trawlers in this fishing area.
7. Increasing the cod end mesh size to 110 and 120mm is not an appropriate measure to reduce catches of unwanted haddock, when targeting species such as lemon sole.



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## Appendices

- Appendix 1. Details of Fishing Activity
- Appendix 2. List of species caught
- Appendix 3. Catch numbers at length for six main species
- Appendix 4. Estimates of the total number of fish caught by species for each mesh size.
- Appendix 5. Estimates of average numbers of fish caught per hour by species and mesh size.
- Appendix 6. Detailed Operations Plan

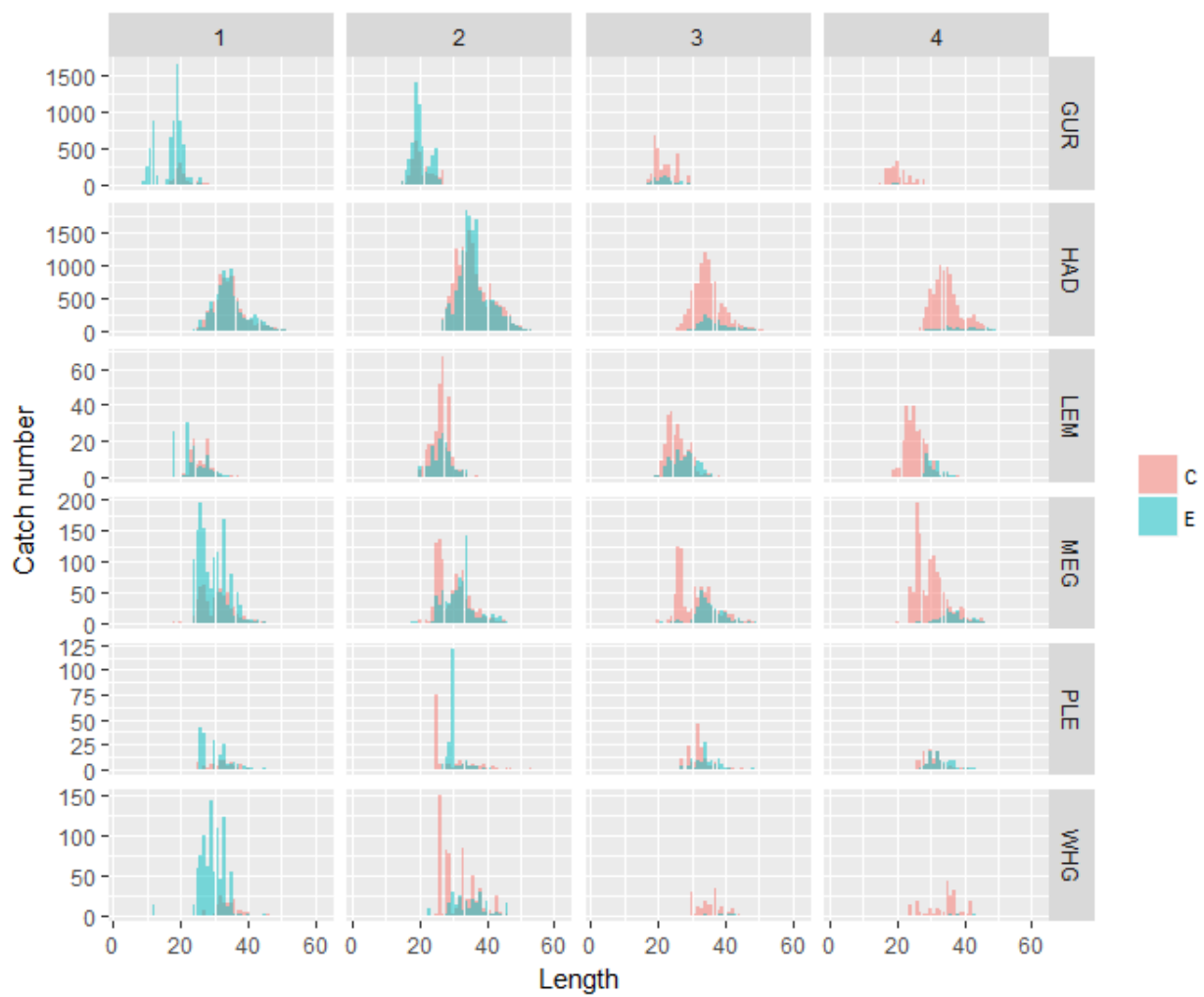
# Appendix 1. Details of Fishing Activity

Tow No.	Test cod end mesh	Dark or Light	Date	Time shot	Lat.		Lon.		Depth (m)	Tow speed (kt)	Wind	Sea	Date	Haul time	Lat.		Lon.		Depth (m)	Tow duration (hr)
					Degree	Minute	Degree	Minute							Degree	Minute	Degree	Minute		
1	100	Light	21/08/2017	12:30	49	53	5	33	73	2.8	WSW 1-2	SLIGHT	21/08/2017	16:15	49	53	5	46	55	3.75
2	100	Light	21/08/2017	17:00	49	53	5	45	77	2.7	SW 1-2	SLIGHT	21/08/2017	20:40	49	53	5	27	71	3.67
3	110	Dark	21/08/2017	22:15	49	52	5	30	71	2.9	SW 1-2	SLIGHT	22/08/2017	01:00	49	52	5	54	77	2.25
4	110	Dark	22/08/2017	03:50	49	52	5	51	79	2.8	ESE 3-4	SLIGHT	22/08/2017	05:05	49	50	5	46	79	1.25
5	120	Light	22/08/2017	11:00	49	50	5	28	73	2.7	ESE 4	MOD	22/08/2017	14:30	49	53	5	46	77	3.50
6	120	Light	22/08/2017	15:50	49	51	5	46	79	2.6	ESE 4	MOD	22/08/2017	19:10	49	51	5	26	75	3.33
7	100	Dark	22/08/2017	22:00	49	52	5	33	75	3.0	W 1-2	SLIGHT	22/08/2017	23:30	49	53	5	42	81	1.00
8	100	Dark	23/08/2017	02:15	49	50	5	42	81	2.8	SW 2-3	SLIGHT	23/08/2017	03:10	49	50	5	50	84	0.92
9	110	Light	23/08/2017	08:50	49	52	5	30	75	2.3	WSW 3-4	MOD	23/08/2017	12:25	49	49	5	44	81	3.58
10	110	Light	23/08/2017	13:00	49	48	5	43	81	2.4	WSW 3-4	MOD	23/08/2017	17:00	49	52	5	29	75	4.00
11	120	Dark	23/08/2017	23:30	49	50	5	32	81	3.0	WSW 1-2	SLIGHT	24/08/2017	00:20	49	50	5	37	79	0.75
12	120	Dark	24/08/2017	01:10	49	49	5	38	79	2.8	WSW 1-2	SLIGHT	24/08/2017	02:00	49	50	5	44	81	0.83
13	120	Dark	24/08/2017	02:40	49	50	5	47	82	3.2	W 1-2	SLIGHT	24/08/2017	03:25	49	51	5	51	82	0.75
14	100	Dark	24/08/2017	23:55	49	41	5	26	93	3.0	W 1	CALM	25/08/2017	01:15	49	40	5	32	88	1.33
15	100	Dark	25/08/2017	01:55	49	39	5	36	90	2.8	W 1	CALM	25/08/2017	05:15	49	37	5	50	97	3.33
16	110	Light	25/08/2017	08:00	49	40	5	47	93	3.0	S 1	CALM	25/08/2017	12:10	49	43	5	30	84	4.17
17	110	Light	25/08/2017	13:40	49	43	5	25	84	3.0	SW 1	CALM	25/08/2017	17:20	49	42	5	46	88	3.67
18	110	Dark	25/08/2017	19:20	49	40	5	36	90	3.0	V 0	CALM	25/08/2017	23:10	49	43	5	17	84	3.83
19	120	Dark	26/08/2017	01:25	49	42	5	25	84	3.0	V 0	CALM	25/08/2017	05:10	49	46	5	43	86	3.75
20	120	Light	26/08/2017	07:25	49	47	5	49	88	3.1	V 0	CALM	26/08/2017	11:20	49	48	5	30	82	3.92
21	100	Light	26/08/2017	13:40	49	49	5	31	84	3.2	V 0	CALM	26/08/2017	17:20	49	48	5	51	84	3.67
22	100	Dark	26/08/2017	18:40	49	51	5	53	84	2.9	N 1-2	CALM	26/08/2017	22:10	49	50	5	35	81	3.50
23	45	Dark	27/08/2017	01:00	49	53	5	40	75	2.6	N 2-3	SLIGHT	27/08/2017	01:25	49	53	5	42	77	0.42
24	45	Dark	27/08/2017	02:30	49	52	5	47	77	2.9	N 2-3	SLIGHT	27/08/2017	03:00	49	52	5	49	79	0.50
25	45	Light	29/08/2017	15:15	49	52	5	32	73	3.0	NNW 4-5	MOD	29/08/2017	16:15	49	52	5	35	75	1.00
26	45	Light	29/08/2017	17:15	49	53	5	39	75	2.9	NNW 4-5	MOD	29/08/2017	19:20	49	52	5	48	73	2.08
27	45	Dark	30/08/2017	00:30	49	48	5	34	77	2.8	NNW 3-4	MOD	30/08/2017	01:30	49	48	5	39	79	1.00
28	45	Dark	30/08/2017	03:05	49	50	5	47	82	2.6	NNW 3-4	MOD	30/08/2017	04:15	49	51	5	54	84	1.17
29	45	Light	30/08/2017	09:30	49	53	5	46	77	2.7	NW 1-2	SLIGHT	30/08/2017	12:10	49	54	5	34	75	2.67
30	45	Light	30/08/2017	13:20	49	52	5	34	77	2.4	W 3	MOD	30/08/2017	16:10	49	52	5	44	75	2.83
31	45	Light	30/08/2017	18:00	49	55	5	44	73	2.5	W 4-5	MOD	30/08/2017	20:10	49	54	5	34	71	2.17
32	45	Dark	31/08/2017	00:40	49	47	5	49	84	2.6	W 5	MOD	31/08/2017	02:00	49	47	5	43	86	1.33
33	100	Dark	31/08/2017	05:05	49	47	5	47	86	2.3	W 4-5	MOD	31/08/2017	06:05	49	48	5	53	84	1.00
34	100	Light	31/08/2017	11:10	49	46	5	43	84	2.7	W 2-3	SLIGHT	31/08/2017	13:15	49	48	5	32	86	2.08
35	110	Light	31/08/2017	15:00	49	51	5	32	77	2.4	W 2-3	SLIGHT	31/08/2017	18:15	49	51	5	46	81	3.25
36	110	Dark	31/08/2017	22:50	49	49	5	43	82	2.2	NW 2	SLIGHT	31/08/2017	23:40	49	48	5	47	84	0.83
37	110	Dark	01/09/2017	03:50	49	48	5	59	86	2.7	NW 2-3	SLIGHT	01/09/2017	04:35	49	48	5	55	84	0.75
38	110	Light	01/09/2017	08:05	49	50	5	44	81	2.4	NNW 2-3	SLIGHT	01/09/2017	10:15	49	50	5	37	81	2.17
39	120	Light	01/09/2017	11:10	49	52	5	36	79	2.5	N 3	SLIGHT	01/09/2017	14:50	49	52	5	51	77	3.67
40	120	Light	01/09/2017	15:45	49	53	5	49	77	2.4	NW 2-3	SLIGHT	01/09/2017	19:35	49	54	5	36	71	3.83

## Appendix 2. List of fish species caught

Common name	Scientific name	Cefas code
Anglerfish, or Monk	<i>Lophius piscatorius</i>	MON
Anchovy	<i>Engraulis encrasiolus</i>	ANE
Argentine	<i>Argentinidae</i>	ARG
Bib, or Pout	<i>Trisopterus luscus</i>	BIB
Brill	<i>Scophthalmus rhombus</i>	BLL
Blonde ray	<i>Raja brachyura</i>	BLR
Boarfish, or Zulu	<i>Capros aper</i>	BOF
Common dragonet	<i>Callionymus lyra</i>	CDT
Cod	<i>Gadus morhua</i>	COD
Conger	<i>Conger conger</i>	COE
Edible crab	<i>Cancer pagurus</i>	CRE
Crawfish	<i>Palinurus spp</i>	CRW
Cuckoo ray	<i>Leucoraja naevus</i>	CUR
Cuttlefish	<i>Sepia officinalis</i>	CTC
Dab	<i>Limanda limanda</i>	DAB
Nurse hound, or Bull huss	<i>Scyliorhinus stellaris</i>	DGN
Grey gurnard	<i>Eutrigla gurnardus</i>	GUG
Red gurnard	<i>Aspitrigla cuculus</i>	GUR
Haddock	<i>Melanogrammus aeglefinus</i>	HAD
Hake	<i>Merluccius merluccius</i>	HKE
Horse mackerel	<i>Trachurus trachurus</i>	HOM
Imperial scaldfish	<i>Arnoglossus imperialis</i>	ISF
John Dory	<i>Zeus faber</i>	JOD
Lemon sole	<i>Microstomus kitt</i>	LEM
Ling	<i>Molva molva</i>	LIN
Common squid	<i>Loligo vulgaris</i>	LLV
Lesser spotted dogfish	<i>Scyliorhinus canicula</i>	LSD
Mackerel	<i>Scomber scombrus</i>	MAC
Megrim	<i>Lepidorhombus whiffiagonis</i>	MEG
Red mullet	<i>Mullus surmuletus</i>	MUR
Northern squid	<i>Loligo forbesii</i>	NSQ
Flying squid spp.	<i>Ommastrephidae</i>	OMX
Plaice	<i>Pleuronectes platessa</i>	PLE
Pollack	<i>Pollachius pollachius</i>	POL
Poor cod	<i>Trisopterus minutus</i>	POD
Saithe (Coley, Black Jack)	<i>Pollachius virens</i>	POK
King scallop	<i>Pecten maximus</i>	SCE
Scaldfish	<i>Arnoglossus laterna</i>	SDF
Shagreen ray	<i>Leucoraja fullonica</i>	SHR
Spiny spider crab	<i>Maja squinado</i>	SCR
Common skate	<i>Dipturus batis</i>	SKT
Starry smooth hound	<i>Mustelus asterias</i>	SDS
Spotted ray	<i>Raja montagui</i>	SDR
Dover sole	<i>Solea solea</i>	SOL
Sand sole	<i>Pegusa lascaris</i>	SOS
Thick back sole	<i>Microchirus variegatus</i>	TBS
Thornback ray	<i>Raja clavata</i>	THR
Tub gurnard	<i>Trigla lucerna</i>	TUB
Turbot	<i>Scophthalmus maximus</i>	TUR
Greater weever	<i>Trachinus draco</i>	WEG
Lesser weever	<i>Echiichthys vipera</i>	WEL
White bellied angler	<i>Lophius budegassa</i>	WAF
Whiting	<i>Merlangius merlangus</i>	WHG
Blue whiting	<i>Micromesistius poutassou</i>	WHB

Appendix 3: Catch (numbers) at length (cm) for the six main species in trial 1,2,3 and 4 for the standard control (C) and modified experimental (E) cod end.



Appendix 4. Estimates of the total number of fish caught by species for each mesh size (all tows combined).

SPECIES	Mesh size Total fishing time	DARK					LIGHT				
		48	85	97	111	128	48	85	97	111	128
		4.42	30.49	11.08	8.91	6.08	10.75	63.01	13.17	20.84	18.25
MON		20	125	39	13	15	10	144	22	28	26
ARG		90	3					3	82		
BIB		1	98	13	7	3		2			
BLL			5	2	2	2	2	20	6	11	2
BLR			1						6		
BOF		2058	8526	1894	46	4	368	977	987	12	1
CDT		780	379	578	3		14940	1308	415	8	5
COD			2	1				1	1		
COE						1					
CRE			229		5	35	30	73	34	19	27
CRW								2			
CTC		14		1			11	8	4		
CUR		82	431	160	64	82	44	168	146	56	42
DAB		44	75		3	4	31	114	18	1	1
DGN										2	
GUG		9840	10483	8118	239	90	12348	15741	8629	631	36
GUR		2508	2648	2763	158	4	4313	5461	2968	386	51
HAD		7917	38839	14207	1623	662	36	2546	667	125	64
HKE		56	221	11		1	2	62	28	2	
HOM		1800	82								
ISF		828	38	165			2265	102	36		1
JOD			8	2	4			34	3	13	1
LEM		22	210	24	13	7	101	678	180	54	39
LIN			1								
LSD		506	685	230	5	4	4637	1952	327	56	9
MAC		24									
MEG		47	564	203	56	27	1368	2925	548	245	133
MUR								1			
OMX				32	5			8	3	1	2
PLE		84	186	122	12	19	95	300	89	86	85
POD		13140	1633	1148	6	4	5130	626	104	2	1
POK							1				
POL			1			2		3			
SCE			13		3	7		1		4	
SCR											1
SDR			191	30	21	10	201	155	49	24	19
SDS		1						1			
SHR				1							
SKT			6								
SOL		60	76	11	3	2	2	37	3	1	
SOS			16	2			61	56	5	5	
SQC			30	11	6	6	1	81	15	37	4
TBS		534		16			302				
THR							1	2			
TUB			28	5	7	1	5	55	19	11	7
TUR			1					5	1	2	
WAF		2	4	4		1	2	18	2	8	3
WEG								1	1		
WEL							86				
WHB		90									
WHG		734	963	157	9	4	141	185	96	10	2

Appendix 5. Estimates of average numbers of fish caught per hour by species for each cod end mesh size.

SPECIES	Mesh size	DARK					LIGHT				
		48	85	97	111	128	48	85	97	111	128
MON		4.52	4.10	3.52	1.40	2.38	0.93	2.28	1.67	1.32	1.42
ARG		20.36	0.10	0.00	0.00	0.00	0.00	0.04	6.23	0.00	0.00
BIB		0.23	3.21	1.17	0.79	0.49	0.00	0.03	0.00	0.00	0.00
BLL		0.00	0.16	0.18	0.22	0.33	0.19	0.32	0.46	0.53	0.11
BLR		0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00
BOF		465.61	279.64	170.94	5.16	0.58	34.23	15.51	74.94	0.55	0.05
CDT		176.47	12.44	52.17	0.28	0.00	1389.77	20.76	31.51	0.38	0.27
COD		0.00	0.07	0.09	0.00	0.00	0.00	0.02	0.08	0.00	0.00
COE		0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
CRE		0.00	7.50	0.00	0.56	5.76	2.79	1.15	2.58	0.91	1.48
CRW		0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
CTC		3.17	0.00	0.09	0.00	0.00	1.02	0.12	0.30	0.00	0.00
CUR		18.55	14.14	14.44	7.18	13.40	4.09	2.67	11.09	2.66	2.30
DAB		9.95	2.46	0.00	0.28	0.58	2.88	1.81	1.37	0.05	0.05
DGN		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
GUG		2226.24	343.81	732.63	26.77	14.72	1148.65	249.81	655.20	30.25	1.97
GUR		567.42	86.85	249.37	17.68	0.66	401.21	86.66	225.36	18.52	2.79
HAD		1791.22	1273.82	1282.21	182.15	108.80	3.35	40.41	50.65	6.00	3.51
HKE		12.67	7.25	0.99	0.00	0.16	0.19	0.98	2.13	0.10	0.00
HOM		407.24	2.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ISF		187.33	1.23	14.89	0.00	0.00	210.70	1.61	2.73	0.00	0.05
JOD		0.00	0.26	0.18	0.45	0.00	0.00	0.53	0.23	0.62	0.05
LEM		4.98	6.87	2.17	1.40	1.15	9.40	10.75	13.67	2.59	2.14
LIN		0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSD		114.48	22.47	20.76	0.56	0.58	431.35	30.98	24.83	2.69	0.49
MAC		5.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEG		10.63	18.51	18.32	6.23	4.44	127.26	46.42	41.61	11.76	7.29
MUR		0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
OMX		0.00	0.00	2.89	0.56	0.00	0.00	0.13	0.23	0.05	0.11
PLE		19.00	6.08	11.01	1.29	3.04	8.84	4.76	6.76	4.10	4.66
POD		2972.85	53.55	103.61	0.62	0.66	477.21	9.93	7.90	0.07	0.05
POK		0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
POL		0.00	0.03	0.00	0.00	0.33	0.00	0.05	0.00	0.00	0.00
SCE		0.00	0.43	0.00	0.28	1.15	0.00	0.02	0.00	0.19	0.00
SCR		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
SDR		0.00	6.26	2.71	2.30	1.64	18.70	2.46	3.72	1.15	1.04
SDS		0.23	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
SHR		0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SKT		0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOL		13.57	2.49	0.99	0.34	0.33	0.19	0.59	0.23	0.05	0.00
SOS		0.00	0.52	0.18	0.00	0.00	5.67	0.89	0.38	0.24	0.00
SQC		0.00	0.98	0.99	0.67	0.99	0.09	1.29	1.14	1.75	0.22
TBS		120.81	0.00	1.44	0.00	0.00	28.09	0.00	0.00	0.00	0.00
THR		0.00	0.00	0.00	0.00	0.00	0.09	0.03	0.00	0.00	0.00
TUB		0.00	0.92	0.45	0.79	0.16	0.47	0.87	1.44	0.53	0.38
TUR		0.00	0.03	0.00	0.00	0.00	0.00	0.08	0.08	0.10	0.00
WAF		0.45	0.13	0.36	0.00	0.16	0.19	0.29	0.15	0.38	0.16
WEG		0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.00	0.00
WEL		0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00
WHB		20.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WHG		166.06	31.59	14.17	1.01	0.66	13.12	2.94	7.29	0.48	0.11

## DETAILED OPERATIONS PLAN

### Cod End Mesh Size Trials for the SW Otter Trawl Fishery.

(Fisheries Science Partnership 2017-18: Project MF071)

**Aim:**

To determine the selectivity of different cod end meshes in the English SW otter trawl fishery, with reference to haddock. Information on catch composition will indicate the optimal cod end mesh size when the Landing Obligation is fully implemented.

**Charter vessel:** MFV 'Our Olivia Belle' BD277

**Charter vessel skipper:** Danny Wharton

**Project Manager:** Rob Forster

**Responsibilities:**

- The Skipper has ultimate authority on board, and is responsible for ensuring the safety of the vessel and all persons on board.
- The Skipper has the experience of fishing and the grounds, and should advise where and how the fishing trials should take place.
- The fishing programme will be agreed by the Skipper and the Project Manager.
- The Project Manager has authority on the scientific work undertaken during the charter, and the observations needing to be recorded.
- Safety takes priority over all other aspects of the charter.

**Planned departure dates and duration:**

- Up to a maximum of 15 days of sea trials to take place between 1<sup>st</sup> August and 30<sup>th</sup> September 2017.
- Planned start date is 14<sup>th</sup> August.
- Fishing will begin with 2-3 one-day trips to check trawl geometry with net sensors and to carry out comparative tows with the fine mesh cod end. The remainder of the sea trials should consist of 4 three-day trips to enable fishing to take place further offshore to access a range of grounds and fishing conditions.
- The vessel will work out of Newlyn, Cornwall for the duration of the trials.

**Safety**

- On the first day, run through accident and emergency procedures as part of induction and orientation for scientific crew. Identify actions to be taken by crew if necessary.
- Make sure scientific crew know safe areas during hauling/shooting/landing operations.
- Life jackets and PLBs to be worn on open deck areas.

**Fishing area and activities:**

- It is expected that most fishing will take place in ICES area VIIIE, statistical rectangles 28E3 and 28E4.
- Tow duration should, in general, follow normal commercial practice, i.e. about 4 to 4½ hrs. During the initial trial period with the fine mesh cod end, tow duration will start at 30 minutes and increase in 30-minute steps, depending on catch quantities and mesh blockage.



- During the main part of the trials, test cod ends will be changed after every two hauls to ensure all mesh sizes can be tested over the full range of fishing conditions encountered.
- Fishing can be suspended as dictated by weather and time needed to sort catches.
- Days at sea lost due to adverse weather and/or mechanical failure must be rescheduled for completion at the earliest opportunity.

#### **Dispensation:**

- A dispensation has been issued by the MMO and will be carried on board the vessel for the duration of the sea trials. It will be made available to any Marine Enforcement Officer on request.
- Fishing is 'on quota', i.e. any fish caught in excess of the vessel's quota will have to be discarded at sea. A limited scientific quota has been issued that permits a total of 1000 kg of haddock and 200 kg of cod to be landed over the course of the trials in addition to the vessel's own monthly quota.
- The skipper must ensure that the combined allowance of scientific quota and the vessel's own allowance is not exceeded.
- Undersized fish can be retained on board for measuring but must not be landed.
- No fishing to take place unless recorded by the Cefas observer.
- All fishing activity during the FSP project, and catches made, must be recorded as such in the vessel's official logbook, i.e. for vessels required to complete paper logbooks the code 'SCR' should be written in the margin or, for vessels with e-logbooks, the 'reason for sailing' (or 'anticipated activity') given in the departure message must be 'SCR' (Scientific Research), and not 'FSH' (Fishing).
- Cefas will provide a paper copy of the dispensation before sailing.

#### **Fishing gear to be used:**

- Twin-rigged otter trawls (based on a Granville trawl design) as currently used on 'Our Olivia Belle' – each rig having a foot rope length of 10 fm and fitted with the vessel's own rockhopper ground gear.
- Each trawl will be identical in every aspect of design and construction apart from the cod ends. Trawls must be in good condition at the start of the trials, and spare panels of netting and twine should be carried to enable repairs to be carried out at sea.
- One rig will be fitted with a standard commercial cod end made of nominal 85 mm stretched mesh netting in 4 mm single braid twine.
- Test cod ends supplied by the vessel owners to be fitted on the other rig will include (approximate mesh size measurements): 45, 100, 110, and 120 mm. Cod ends will be measured by the MMO with an approved gauge before sailing.

#### **Working pattern:**

- The catch from each trawl must be kept separate when brought on board (e.g. placed in separate pounds) and during subsequent sorting to enable the species composition of each rig to be recorded separately.
- The entire catch must be made available for sampling.
- The crew will be required to sort the catch following normal commercial practice, except that all sizes of commercial species will be retained for recording.
- No discarding shall take place until the observers have completed sampling, or until the 'OK' is given.
- Non-commercial species, invertebrates and other by-catch to be estimated as a combined volume, e.g. number of 5 stone baskets, excluding guts from retained catch.
- The observer will attempt to record numbers and length of all retained fish, unless catch quantities are such that sub-sampling is required.

#### **Rest periods:**

- The aim will be to make as much use of the time available as possible for fishing.
- Sufficient rest periods should be given to observers and crew to ensure work is carried out safely.
- Sufficient food, drink, and meals will be provided to meet the needs of observers and crew.

**Data to be recorded by the skipper:**

- Logbook entries in accordance with requirements of the dispensation.
- A copy of the landings/sales notes is needed by Cefas to enable 95% of the total agreed price (including VAT) to be paid.
- During the fishing trials, the skipper should record (*log sheets will be provided by Cefas*):
  - Time, position and depth for the start and end of each tow
  - Sea and wind conditions
  - Average tow speed
  - Tow duration
  - Rough estimate of bulk catch for each trawl
  - Any damage to either net, or suggestion that either net is not fishing properly
  - Weight (stones/kilos) or volume (baskets) of main categories of retained catch in each trawl.

**Contacts and procedures (responsibility of Project Manager):**

- Contact the local MMO office to advise the start of trials 1 day before sailing.
- Contact the Cefas Shore-Based Contact (07831 319362) on sailing and landing.

I agree with the contents of this Detailed Operations Plan, and am willing to participate in these trials on these terms.

..... (Skipper, MFV 'Our Olivia Belle')                      ..... (Date)

..... (Project Manager, Cefas)                      ..... (Date)

