Testing cod end and square mesh panel configurations in the English SW otter trawl fishery

Fisheries Science Partnership – FSP (2020-2021)
MF082

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1. Executive Summary

These gear trials took place as part of the Defra funded Fisheries Science Partnership research programme. The is a demand for evidence on the performance of more selective trawl configurations to inform on proposed changes to technical measures regulations in the southwest otter trawl mixed fishery. The aim of the trials was to obtain data on the differences between the currently permitted and proposed new trawl configurations, principally to move from the widespread use of 80mm mesh cod end to a default of 100mm.

For this purpose, two trials lasting 6 days each took place in ICES Division 7e on the twin-rig otter trawler Rockfisher (SU6) in the months of October to December 2020. The vessel conducted simultaneous comparative tows of the control gear and two experimental gears. The first trial compared two trawls, both with 100mm cod ends, and one with an 80mm square mesh panel (SMP) and the other with 100mm SMP. A total of 19 paired hauls were collected for this trial. The second trial compared 100mm cod end with an 80mm SMP to an 80mm cod end with an 80mm SMP (as normally used by the vessel). A total of 14 paired hauls were completed for the second trial.

In the first trial, catches were comparable overall, but we observed that a 100mm SMP is significantly more selective for whiting than an 80mm SMP. This reinforces the results of similar trials and supports the regulated use of 100mm mesh size SMP.

In the second trial, the 80mm cod end trawl with 80mm SMP was highly selective for marketable sized Common (Dover) sole but had poor selectivity towards other species. In this trial there was a commercial focus on sole, but most of the catch (~90% by number) was of undersized and non-marketable unwanted catches of other fish species. The trawl with 100mm cod end and 80mm SMP, caught 4.4 times less unwanted fish. However, there was also a significant reduction in catches of marketable sole, which reduced the value of the landed catch substantially. Therefore, an increase in cod end mesh to 100mm would have significant benefits from reducing unwanted catches and discard mortality, but there is likely to be a reduction in efficiency for vessels focussed on catching sole.

The levels of unwanted catch when using the scraper trawl design with 80mm cod end trialled here make it difficult to justify its continued use in a sole directed fishery. This is the currently permitted trawl specification; however, its use is based on retained EU regulations that are difficult to interpret and enforce. It would be beneficial to improve the definition of a sole directed fishery, and this should be based on what is caught rather than landed.

Furthermore, recognising that moving to 100mm cod ends will likely have economic impact for those fishers that have a commercial focus on sole, other otter trawl designs may be more appropriate. For example, dedicated sole trawls, typically with a triple-rig configuration have a very low headline and a narrow swept-area, which means there is no herding of species, such as roundfish or plaice, into the trawl, and unwanted catches can escape over the top of the trawl, while sole catches are maintained. It is suggested that, where sole is the primary focus for fishers, more specialised trawl designs are considered to enable the continued use of 80mm mesh cod ends.

2. Introduction

2.1. 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 numerous (c. 100) trials, covering annual surveys of stocks subject to traditional assessments and ad hoc trials 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 data hub (http://data.cefas.co.uk/). FSP projects are approved by the FSP steering committee, which includes Defra, Cefas and representatives of the fishing industry. Participating vessels are selected through a competitive open tendering procedure.

2.2. Background

Discarding fish back to the sea that are caught during commercial fishing is considered wasteful by fishers, conservationists and fisheries managers alike, as some discards are returned dead or dying.

The UK officially left the EU on 31st January 2020, and the UK Government has stated in the 2020 Fisheries Act its commitment to minimise unwanted catches and discarding. The EU landing obligation regulations were transposed into UK regulations as retained EU law. The UK can now develop discard policies independently of the EU, but the current regulations will continue to be in force until they are changed.

The retained landing obligation regulation came into force on January 1st, 2014, and introduced a discard ban, or landing obligation for regulated species. Quotas currently place a cap on fishing mortality, requiring all catches (not just landings) to be deducted from the quota and once the quota allocation for a species is reached, fishing activities must stop. To maximize revenue from quotas, fishers need to avoid catching undersized or low-value fish that will be deducted from their quota for little or no profit as they will result in a premature end to a fishing season.

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 and maximise revenue from quotas. In this FSP we are specifically interested in otter trawlers operating in the English south west mixed demersal fishery.

Vessels using bottom seines and otter trawls in ICES Divisions 7b-k are currently required to use a default minimum mesh size of 100mm diamond mesh in their cod ends. However, there are specific conditions under which 80mm cod ends, sometimes in conjunction with an 80mm square mesh panel (SMP), can be used (The European Commission, 2019). This flexibility has meant that most fishing activity is conducted using the smaller mesh option, with relatively few vessels using the default minimum. This is in part due to the difficulty in interpretation and enforcement of the existing regulation which refers to directed fisheries which are not defined.

For example, 80mm cod ends can be used in directed fishing for hake (*Merluccius merluccius)*, megrim and anglerfish (*Lophius spp)*, or directed fishing for whiting, mackerel and species not subject to catch limits, using bottom trawls, where square mesh panel of at least 120 mm shall be fitted. Also, for directed fishing for sole and species not covered by catch limits, 80mm cod ends are permitted when used in conjunction with a square mesh panel of at least 80 mm.

The legislation is considered difficult to interpret for fishers and for enforcement agents due to the differences in rules for different target species. This is partly due to the unclear definition of “directed fishing” in the legislation. To further reduce bycatch, improve ease of understanding across different regions as well as improve gear selectivity there is a move towards simplifying the legislation which would lead to most bottom seines and otter trawlers using 100mm cod ends.

A previous gear trial carried out by Cefas looked at various mesh sizes in the otter trawl industry in the South West of the UK (Forster et al., 2018). This trial showed that increasing cod end mesh size was effective at reducing unwanted catches but also reduced catches of marketable fish. The trial presented here builds on this evidence by investigating further the proposed 100mm cod end mesh size.

2.3. Objective

The specific objectives of this study were to provide evidence on the selective performance of a 100mm cod end compared with the currently permitted 80mm cod end in the mixed otter trawl fishery of ICES area 7e, and assess the effect of adding a 100mm square mesh panel to a trawl with a 100mm cod end.

2.4. COVID-19

The FY 2020-21 FSP projects were undertaken amidst the Covid-19 pandemic, which presented a series of challenges for project staffing, communications and fieldwork. In some cases this necessitated changes to project scope or delivery timetables. Fieldwork planning and delivery involved a concerted collaborative effort by the survey/trip managers, the Cefas Covid-19 mitigation team and industry partners, to ensure all work was carried out in accordance with Covid-19 infection control measures.

3. Methods

3.1. Sea Trials

Following an open tendering process, the fishing vessel Rockfisher SU6 based in Brixham was awarded a contract to undertake the survey work associated with this project over two sets of 6 days each (Figure 1). The vessel is a 9.9m steel-hulled demersal twin rigged otter trawler with a 4.26m beam and 0.6m draft.

Figure 1 Rockfisher SU6 9.9m twin rigged otter trawler

3.2. Gear Used

The Rockfisher is set up with a standard twin-rig trawl following the dimensions in Figure 2. The vessel has worked with single-rig gear in the past, but now uses twin-rig gear due to increased fuel efficiency and perceived improved survival of unwanted catches. The normal configuration is given in Figure 2. The twin trawl was a 7 fathom (12.8m) scraper trawl (flat trawl), with an estimated headline height of 8ft (2.4m), rubber discs on the ground gear, and with a wingspread of estimated 32 ft (9.75m) spread per rig, so 64ft in total (19.5m).

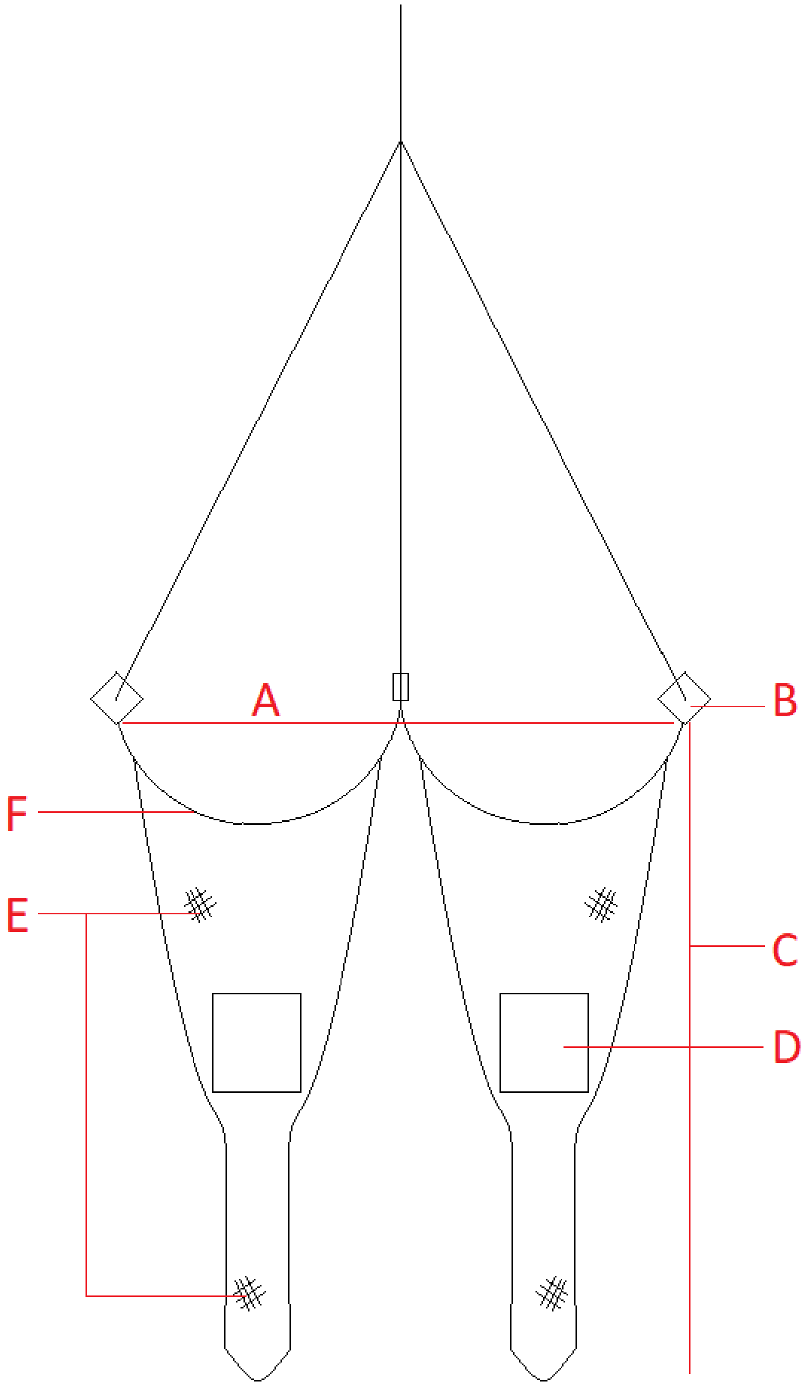

Figure 2 Main measurements on Rockfisher SU6 trawl set up. A: 21m spread between doors, B: Bison size 4 doors, C 12.8m length, D: Square Mesh Panel, 20 meshes wide, 3m

long, 6 meshes from cod end and 6 meshes from side, E: Diamond 80mm mesh throughout, F: 11m footrope

3.3. Area and conditions of the survey

The trials took place in ICES Division 7e at similar locations around Lyme Bay as seen in Figure 3. During the first trial, due to poor fishing, there was one day of fishing off the coast near the Isle of Wight. However, due to the restrictions imposed upon us with the coronavirus pandemic we were not able to repeat this due to long sailing times and limits on the hours allowed at sea under COVID mitigation measures.

Towing speed and depth were comparable between trials (see Table 1). The wind varied from 2.5 mph to 25 mph. Tow duration was on average 1h longer in trial 2.

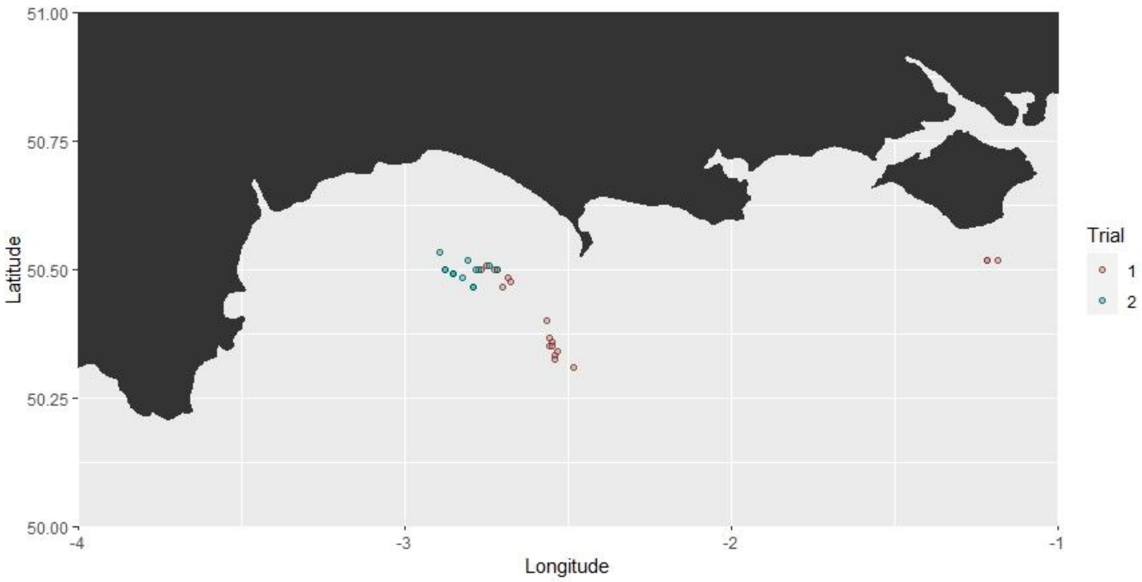

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Figure 3 Map of midpoint locations of each haul

Trial	Hauls	Average Depth (m)		Average Towing Speed (knots)		Average Tow Duration (h:min:sec)	
1	19	37.3	± 5.8	1.8	± 0.3	1:38:41	± 0:38:01
2	14	36.2	± 3.6	1.8	± 0.4	2:33:26	± 0:43:49

Table 1 Fishing Activity During Trial 1 and 2

3.4. Experimental design

The aim of the experimental trials was to look at the comparative selectivity of different cod end and SMP combinations. A twin-rig trawl was towed with different cod ends and square mesh panels simultaneously, and the catches from each rig compared.

When the practical field trials were conducted there was a deviation from the plan to compare a 100mm cod end with 80mm cod end and then a 100mm cod end with a 100mm cod end combined with a 100mm SMP. The field trials conducted were as follows:

Trial 1:

100mm cod end combined with 80mm SMP (100CE+80SMP; control)

vs

100mm cod end combined with 100mm SMP (100CE+100SMP; experimental).

Trial 2:

100mm cod end combined with 80mm SMP (100CE+80SMP; control)

vs

80mm cod end combined with 80mm SMP (80CE+80SMP; experimental).

The deviation from the plan meant that we were not able to assess the effect of increasing from 80mm to 100mm in a trawl without a SMP, or the effect of introducing a 100mm SMP to a 100mm cod end trawl. The experiments conducted assessed the effect of changing from 80mm to100mm cod end in a trawl with a 80mm SMP, and the effect of increasing the mesh size of a SMP from 80mm to 100mm when using a 100mm cod end.

For Trial 2, as the vessel was already using 80mm cod end with 80mm SMP, we retained the 80mm SMP to be able to compare the 80mm cod end with the 100mm cod end without any deviation between the SMPs.

All cod ends were identical in construction (material, colour, no lifting bags), apart from the mesh size & twine diameter, so that any differences in catch will be a result only of this change. The cod ends were new and unused before the trial. To start with the two 100mm cod ends were used to ensure equal wear.

Cod ends were measured at the start and end of the trial to get an exact mesh size and measure any shrinkage or change in the mesh size.

The 100mm SMP was constructed so as to be 100mm from the external part of the knot rather than the internal part of the knot as per MMO guidance. This meant when measured by the MMO the inside mesh was just over 95mm.

3.5. Sampling plan

A fixed routine for handling and sorting the catch was maintained throughout the trials. Catches from the two cod ends were always kept separate. The nets were drawn either side of the vessel and emptied into separate hoppers. 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”. Processed wanted catch and unwanted catch from each cod end were kept separate till all quantities and details had been recorded.

Cefas observers sampled using standard techniques. For each haul, all fish species caught were measured to the nearest cm below. Sub sampling was necessary on occasions when the fish catch was large, but sub samples reflected the total catch composition and raising factors were calculated. Additionally, benthos was separated from the discarded fish, identified down to group level, and counted. Pictures and written records of the litter was also collected, however this is not detailed in the present report.

3.5.1. Trial 1: 100CE+80SMP vs 100CE+100SMP

The first trial compared two simultaneously 100mm diamond mesh cod ends with 5mm monofilament twine, one of which was mounted with the 80mm SMP (=control) already present on the trawl and the other had a 100mm SMP (=experimental). These nets were measured both before and after the trial ended to observe any shrinkage by the marine management organisation using an OMEGA gage.

The trial took place over the course of 6 days, between the 9/10/2020 and the 25/11/2020. Due to bad weather, we were not able to group the trial days any closer together although that was the intention. The 100mm SMP was on the starboard side for 3 days and 9 hauls, and the other 3 days and 10 hauls the SMP was swapped to the port side.

Due to poor fishing throughout the trial, we attempted fishing one night in an area off the coast of the Isle of Wight. The sailing time to and from was limiting and this was not repeated. All the other hauls took place around Lyme Bay.

Net	Size Before Trial (mm)	Size After Trial (mm)
100mm Cod end **ID: 000164**	105.3	101.4

100mm Cod end **ID: 000125**	106.3	102.2
100mm Square Mesh Panel	95.6	95.4

Table 2 Sizes in mm of Experimental and Control Gear for Trial 1

3.5.2. Trial 2: 80CE+80SMP vs 100CE+80SMP

The second trial compared the 100mm diamond mesh cod end with 5mm monofilament twine and 80mm SMP from the first trial (=control), to the currently used 80mm diamond mesh cod end with a 4mm monofilament twine and 80mm SMP (=experimental). These nets were again measured both before and after the trial ended to observe any shrinkage by the marine management organisation using an OMEGA gage.

The trial took place over the course of 6 days, between the 29/11/2020 and the 12/12/2020. Due to bad weather, we were not able to group the trial days any closer together although that was the intention. The 100mm cod end was on the starboard side 3 of the days and 8 of the hauls, and the other 3 days and 6 hauls the 100mm cod end was swapped to the port side.

Net	Size Before Trial (mm)	Size After Trial (mm)
100mm Cod end **ID: 000125**	102.2	101.7
80mm Cod end **ID: 000118**	82.8	80.4

Table 3 Sizes in mm of Experimental and Control Gear for Trial 2

3.6. Data Analysis

The results were compiled in Excel and plotted graphically in R.

For each trial, total numbers-at-length were raised to haul. Length-weight relationships (Silva et al., 2013) were applied to the numbers at length data to calculate catch weights. The number and weights of the main species caught for the gear and the absolute differences (experimental trawl - control trawl) and % differences (((experimental trawl- control trawl)/control trawl) *100) caught by the different modified cod ends are presented in Table 4and 5 A percentage difference of 100% means that a double amount was caught in the experimental trawl.

Catch comparison analyses between the control and experimental gear in both trials were performed using the software tool 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 (Brčić et al., 2015; Wienbeck et al., 2011, 2014). SELNET enables the analysis of data for gear trial designs that involve multiple compartments (Sistiaga et al., 2010). In this study discards and landings in control and experimental gear each resemble one compartment resulting in four compartments being analysed.

SELNET offers a variety of size selection models and methods for analysis; the present analysis is based on double bootstrap technique. 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), 1000 bootstrap repetitions were conducted to estimate the bca (bias corrected and accelerated) percentile 95% confidence intervals. The method identified the length ranges with significant deviations in size selection between the standard and experimental trawls.

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 in section 4.4.

4. Results

4.1. Total fish catches

4.1.1. Catches landed (retained) and discarded, Trial 1 and 2

The total numbers of fish retained and discarded by species are given in Annexes 8 and 9. The main species of commercial interest was sole for both trials. In Trial 1, the two cod end and square mesh panel configurations caught a comparable number of fish, 2097 (100CE+80SMP) and 1977 (100CE+100SMP). The discard rate (by number) for both trawls was 88%. In Trial 2, the 100CE+80SMP caught fewer fish than the 80CE+80SMP, 679 and 2764 respectively; the overall discard rates (by number) were 85% and 92%. In both trials, plaice, grey gurnard, dab, lesser spotted dogfish and whiting made up most of the unwanted catches of fish. The discard rate for sole was 2% or less in both trials.

A summary of total retained (landed) weights (kg) is detailed in Table 6. Most notably in Trial 2, more fish, specifically sole (62%), were landed when using the 80CE+80SMP compared to the 100CE+80SMP. However, this configuration generated 4.4 times more discards (by number). When using the 80CE+80SMP, for each sole landed, 17 fish were discarded, compared with 12 discarded fish when using the 100CE+80SMP. It was also observed that when using the same configuration of 100CE+80SMP in the two trials, the catches were very different, with fewer landings in Trial 1.

Species	Trial 1 Experimental 100mm cod end 100mm SMP	Trial 1 Control 100mm cod end 80mm SMP	Diff	%Diff	Trial 2 Experimental 80mm cod end 80mm SMP	Trial 2 Control 100mm cod end 80 mm SMP	Diff	%Diff
BLL	0	1	-1	-100	12	18	6	50
DAB	1	1	0	0	5	8	-3	-38
LEM	1	1	0	0	3	2	1	50
MON	1	10	-9	-90	9	5	4	80
PLE	20	25	-5	-20	28	22	6	27
SOL	43	38	5	13	112	69	43	62
WHG	6	5	1	20	6	2	4	200

Table 4 Total Calculated Landed Weights caught (kg) across both trials for most abundant species

4.1.2. Trial 1: 100CE+80SMP vs 100CE+100SMP

Lesser Spotted Dogfish *Scyliorhinus canicula* (LSD) and Plaice *Pleuronectes platessa* (PLE) were by far the most abundant by weight across both gears during the trial (Figure 3). By number, plaice was the most present species and accounted for 30% of the catch (Table 4). Although by numbers gurnards (GUG) represented a significant portion of the catch (20%), by weight they did not as most were less than 10cm long. Catches of plaice and grey gurnards were similar between trawls. There was a notable difference in catch for the Lesser Spotted Dogfish (LSD), which were caught 66% more in the 100CE+100SMP than the 100

CE+80SMP by weight but reduced with -23% by number. There was a difference between the control and experimental for monkfish (MON), but this was due to one very large monk caught in the control trawl. Sole (SOL) made up less than 5% of the catch, and 8% more by number were caught by the experimental gear. Differences in catch were observed for whiting (WHG) and cuttlefish (CTC), with lower catches in the experimental trawl.

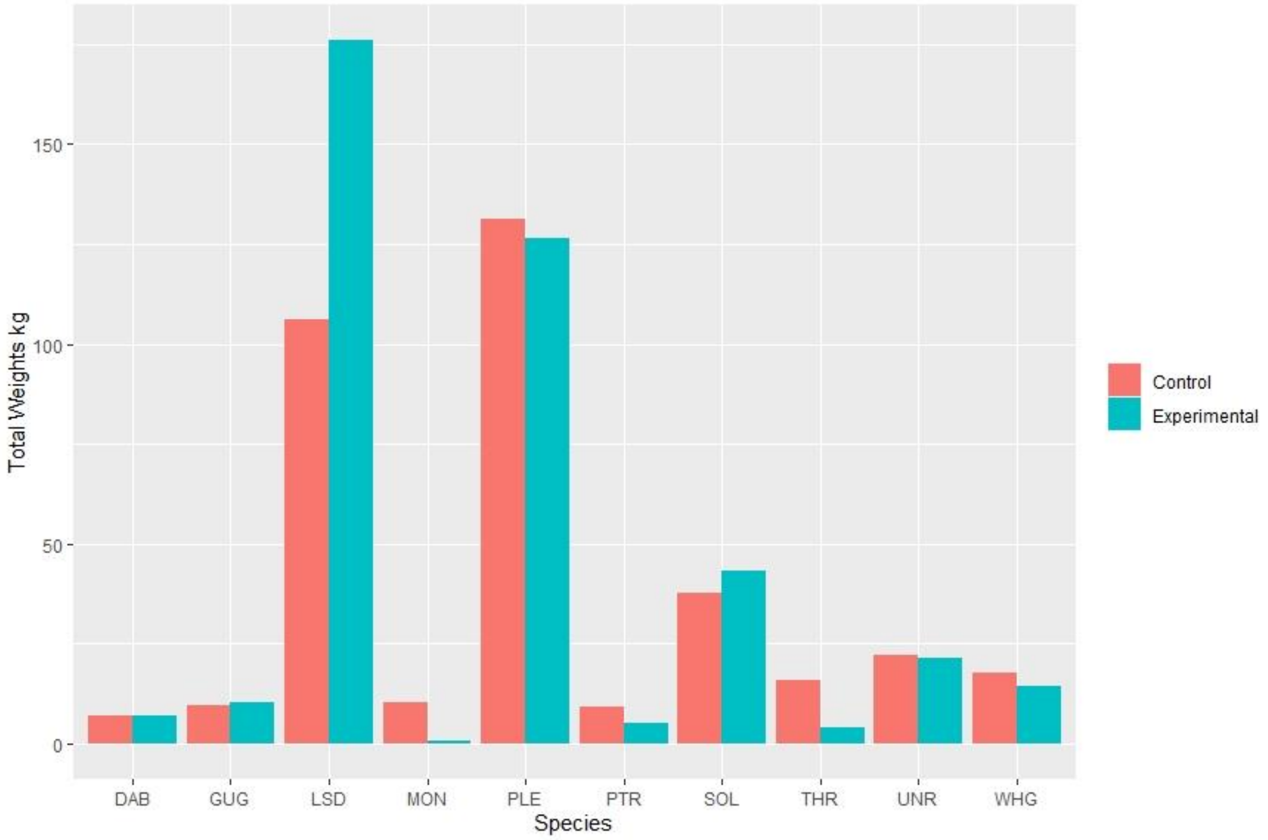

Figure 3 Total Catch Weights of Most Abundant Species by weight Trial 1: Control: 100mmCE +80SMP vs Experimental: 100CE+100SMP

Species	Control (Numbers)	Experimental (Numbers)	Control (kg)	Experimental (kg)	Diff (Numbers)	% Diff (Numbers)	Diff (kg)	% Diff (kg)
PLE	605	615	131	127	10	2	-4	-3
GUG	395	379	10	10	-16	-4	0	0
SCR	317	287	N/A	N/A	-30	-9		
LSD	148	113	106	176	-35	-24	70	66

SOL	90	98	38	43	8	9	5	13
WHG	90	76	18	15	-14	-16	-3	-17
CTC	82	56	N/A	N/A	-26	-32		
DAB	65	70	7	7	5	8	0	0
CDT	67	56	2	2	-11	-16	0	0
POD	33	50	1	2	17	52	1	100
SDS	33	26	N/A	N/A	-7	-21		
THR	33	24	16	4	-9	-27	-12	-75
CRE	26	19	N/A	N/A	-7	-27		
GUR	24	19	N/A	N/A	-5	-21		
BIB	9	16	N/A	N/A	7	78		
JOD	11	13	3	2	2	18	-1	-33
SCE	7	14	N/A	N/A	7	100		
MON	10	4	10	1	-6	-60	-9	-90

Table 5 Total Catch Trial 1 100mmCE+80SMP (control) vs 100mmCE+100 SMP (experimental). Excluding any species where less than 10 individuals were caught over the whole trial. NA where there was no length/weight calculation possible.

4.1.3. Trial 2: 80CE+80SMP vs 100CE+80SMP

Plaie (PLE), Dover Sole (SOL), lesser-spotted dogfish (LSD), Dab (*Limanda limanda,* DAB), Whiting (*Merlangius merlangus,* WHG) and Thornback Rays (*Raja clavata* THR) were the most abundant species by weight caught in both gears (Figure 4, Table 5). The 80CE+80SMP caught more fish than the 100CE+80SMP with the exceptions of Brill (*Scophthalmus rhombus,* BLL), Conger Eel (*Congridae,* COE) and Thornback ray. Catch weights and numbers are higher when using the smaller cod end mesh of 80mm. Catches of sole doubled by number and increased with 64% by weight. Also, plaice (PLE), dab (DAB), grey gurnards (GUG), and whiting (WHG) were substantially higher in the 80CE+80SMP, with +34%, +159, +470 and 978% respectively by number. Increases by weight were less drastically indicating that especially more small fish were caught.

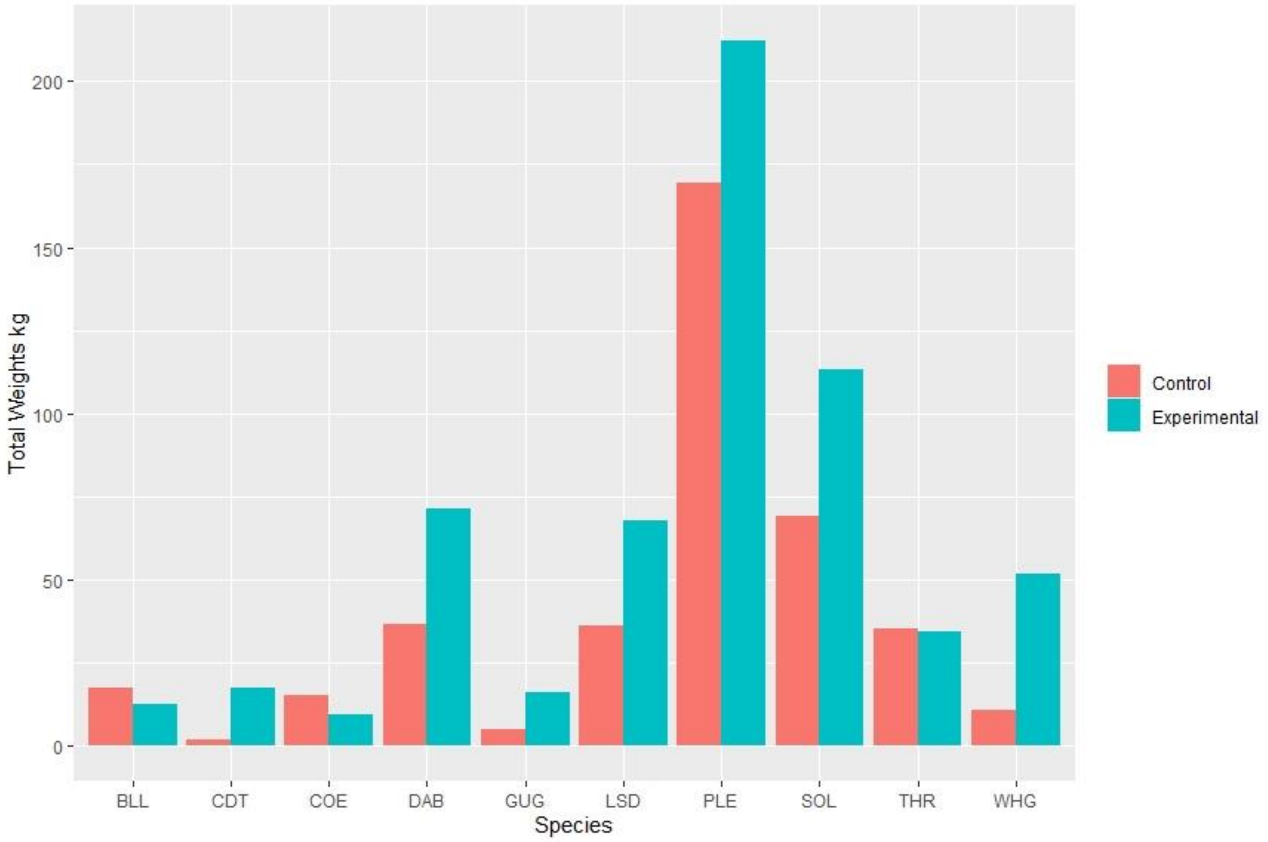

Figure 4 Total Catch Weights of Most Abundant Species Trial 2: 100CE+80SMP (control) vs 80CE+80SMP (experimental).

Species	Control (Numbers)	Experimental (Numbers)	Control (Weights, kg)	Experimental (Weights, kg)	Diff (Numbers)	% Diff (Numbers)	Diff (kg)	% Diff (kg)
PLE	850	1136	169	212	286	34	43	25
DAB	362	938	37	71	576	159	34	92
GUG	168	958	5	16	790	470	11	220
SOL	192	386	69	113	194	101	44	64
CDT	49	528	2	17	479	978	15	750

WHG	64	451	11	52	387	605	41	373
THR	254	248	35	34	-6	-2	-1	-3
SCR	179	174	N/A	N/A	-5	-3	-	-
LSD	56	105	36	68	49	88	32	89
POD	12	149	0.5	5	137	1142	5	900
SOT	16	85	N/A	N/A	69	431	-	-
BIB	23	57	N/A	N/A	34	148	-	-
TUB	9	58	N/A	N/A	49	544	-	-
JOD	25	39	1	2	14	56	1	100
SDF	18	45	N/A	N/A	27	150	-	-
MON	32	20	8	10	-12	-38	2	25
LLV	7	31	N/A	N/A	24	343	-	-
BLL	22	14	18	12	-8	-36	-6	-33
LEM	6	17	1	4	11	183	3	300
SDG	0	11	N/A	N/A	11		-	-

Table 6 Total Catch Trial 2 100mmCE+80SMP (control) vs 80mmCE+80SMP (experimental). NA where there was no length/weight calculation possible. Species with less than 10 individuals per trial were excluded.

4.2. Benthos catches

Figure 5 shows the total catch of benthos across all species. It is interesting to note that in Trial 1 far less benthos was caught overall (by an order of magnitude) than in Trial 2. In Trial 1 there was more benthos caught in the 100CE+80SMP (control) and in Trial 2 there was more benthos in the smaller 80CE+80SMP (experimental). However, a paired t-test on the numbers only (excluding the species) showed that for Trial 1 the difference was not significant (p=0.14; control mean 210, SD 275; experimental mean 146, SD 148). For Trial 2 the results are not technically significant although the p value is very small (p=0.068; control mean 325, SD 217; experimental mean 224, SD 136).

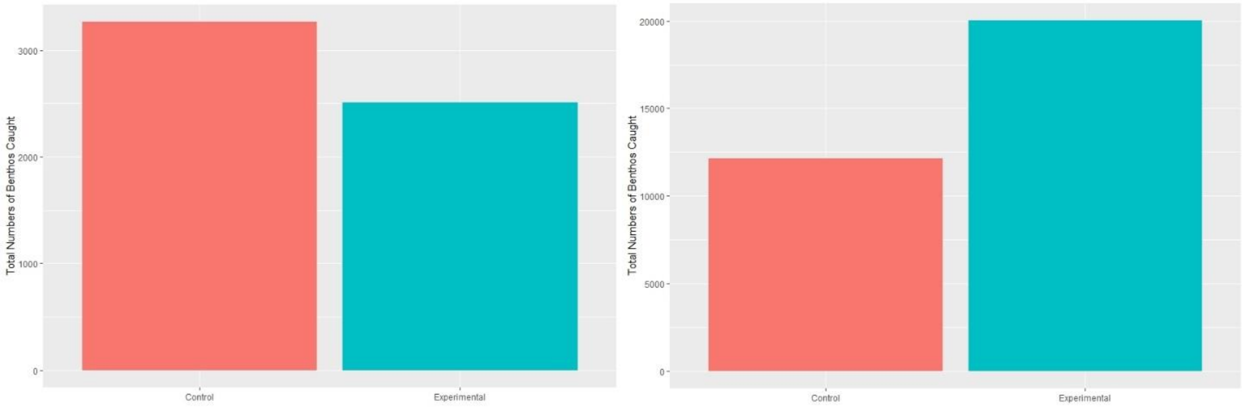

Figure 5 Total benthos catch for Trial 1 on the left-hand side and Trial 2 on the right hand-side

4.3. Length Frequency

Length frequencies of key species across both trials are shown in Figure 6.

4.3.1. Trial 1: 100CE+80SMP vs 100CE+100SMP

The length frequencies for plaice and grey gurnards (GUG) were comparable. For sole, few fish beneath MCRS were caught and only in the 100CE+80SMP. There was a peak of whiting (WHG) caught just above MCRS in the 100 CE+80SMP, but not in the experimental 100CE+100SMP, and there were more undersized whiting caught in the experimental gear 100CE+100SMP. Finally, the cuttlefish (CTC) length frequency was similar in both gears but with the 100CE+ 80SMP catching more than the 100CE+100 SMP.

4.3.2. Trial 2: 80CE+80SMP vs 100CE+80SMP

Fewer plaice, whiting and sole below the MCRS were caught by the 100CE+80SMP compared with the 80CE+80SMP. Also, fewer small grey gurnards were caught by the 100CE+80SMP. For sole, there were also fewer smaller fish above the MCRS caught by the 100CE+80SMP compared to the 80CE+80SMP. Catches of THR were similar.

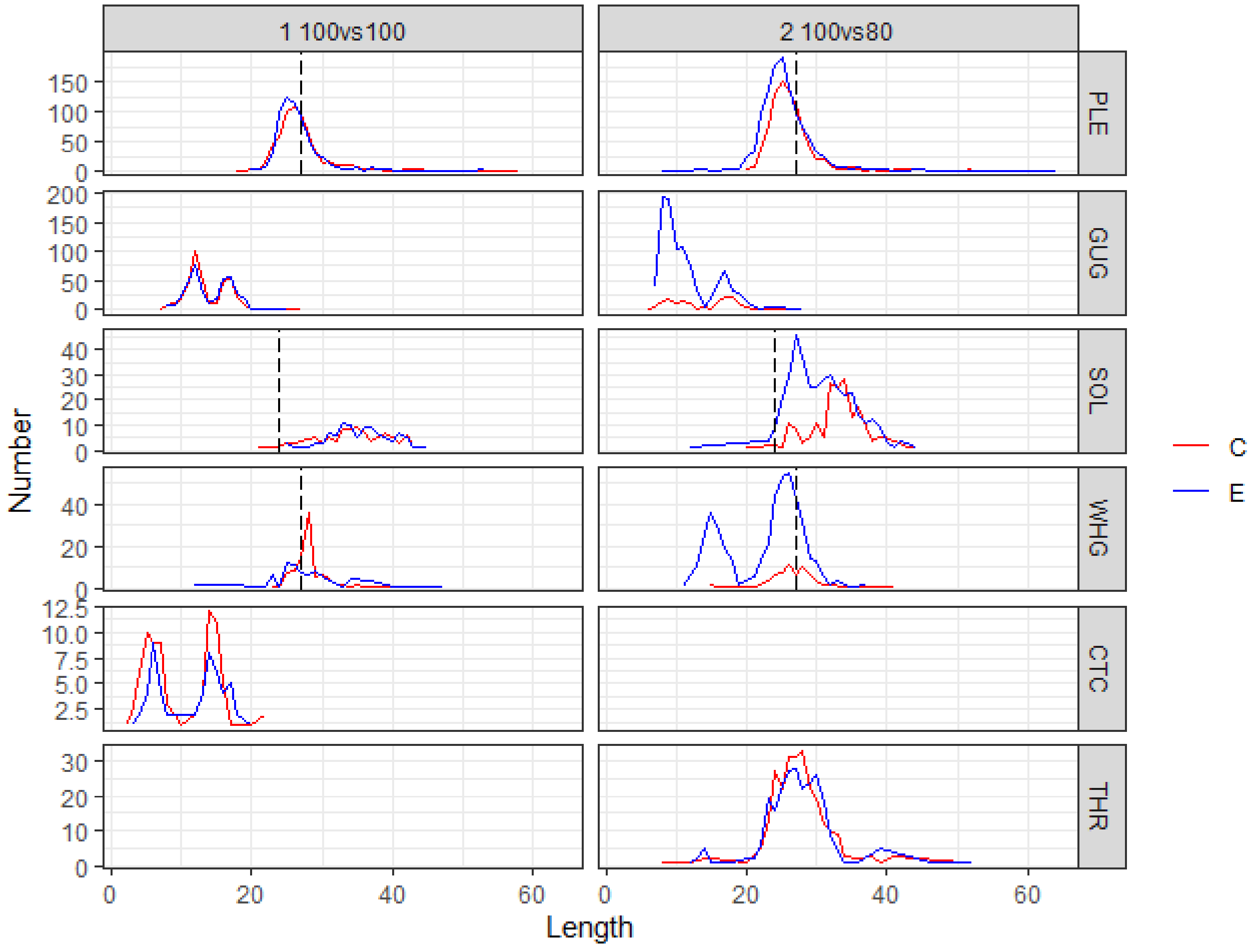

Figure 6 Length Frequency plots of total catch of most abundant species in both trials. C: Control, E: Experimental, dotted line represents the minimum conservation reference sizes (MCRS). Trial 1: 100CE+100SMP (experimental) vs 100CE+80SMP (control). Trial 2: 100CE+80SMP (control) vs 80CE+80SMP (experimental).

4.4. Selnet outputs

Selnet was run on 5 key species. Grey gurnards (GUG), plaice (PLE), sole (SOL) and whiting (WHG) where caught in the highest numbers in both trials. Additionally, thornback ray (THR) was included in trial 2. Significant differences in length-dependent catches are summarised in Table 6. Selnet results were consistent with the visual observations of the length frequencies.

The only statistically significant results in Trial 1 (Figure 7) were found for whiting. There was an small increase of small whiting between 12 and 24 cm by the 100CE+100SMP (experimental), and a significantly fewer whiting were caught by the 100CE+100SMP in the length range 28-30cm compared to the 100CE+80SMP (control). This length range coincides with the length at which most whiting were caught (Figure 6). Therefore, increasing the mesh size of the square mesh panel from 80mm to 100mm demonstrated an increase in release of whiting.

Trial	Species	Sign. Lengths	%Diff Modelled Numbers	Control Number	Diff Number	%Diff Number	Control Weight (kg)	Diff Weight (kg)	%Diff Weight	Total Weight Control (kg)
1	WHG	12 -- 24	2012	2	12	611	0	1	363	19
1	WHG	28 -- 30	-53	47	24	51	9	-5	-51	19
2	GUG	6 -- 20	295	189	731	387	4	9	202	5
2	PLE	8 -- 23	1037	135	148	110	21	20	97	217
2	SOL	22 -- 33	191	111	156	141	34	38	112	83
2	WHG	11 -- 31	534	83	393	474	13	38	294	15

Table 6 Statistically significant results for main species in the catch. Trial 1: 100CE+100SMP (experimental) vs 100CE+80SMP (control). Trial 2: 100CE+80SMP (control) vs 80CE+80SMP (experimental).

In Trial 2 (Figure 8) significant more fish were caught in 4 out of 5 key species were found when with the 80mm cod end configuration compared with the 100mm cod end. Catches were less than half in the length ranges where significant differences were observed for gurnards (GUG), plaice (PLE), Sole (SOL) and Whiting (WHG) in the 100CE+80SMP compared with the 80CE+80SMP (Table 6). These differences were mostly for small and undersized fish, with the exception of sole, where fewer fish above the MCRS were caught when using the 100CE+80SMP.

Significantly fewer gurnards and whiting across the main length range, 6-20cm and 11-31cm respectively, were caught using the 100CE+80SMP; the MCRS for whiting is 30cm. Fewer plaice between 8 and 23cm, were caught with the 100CE+80SMP compared to the 80CE+80SMP (MCRS is 27cm). For sole there were significantly fewer sole in the length range 22-33cm (MCRS is 24 cm).

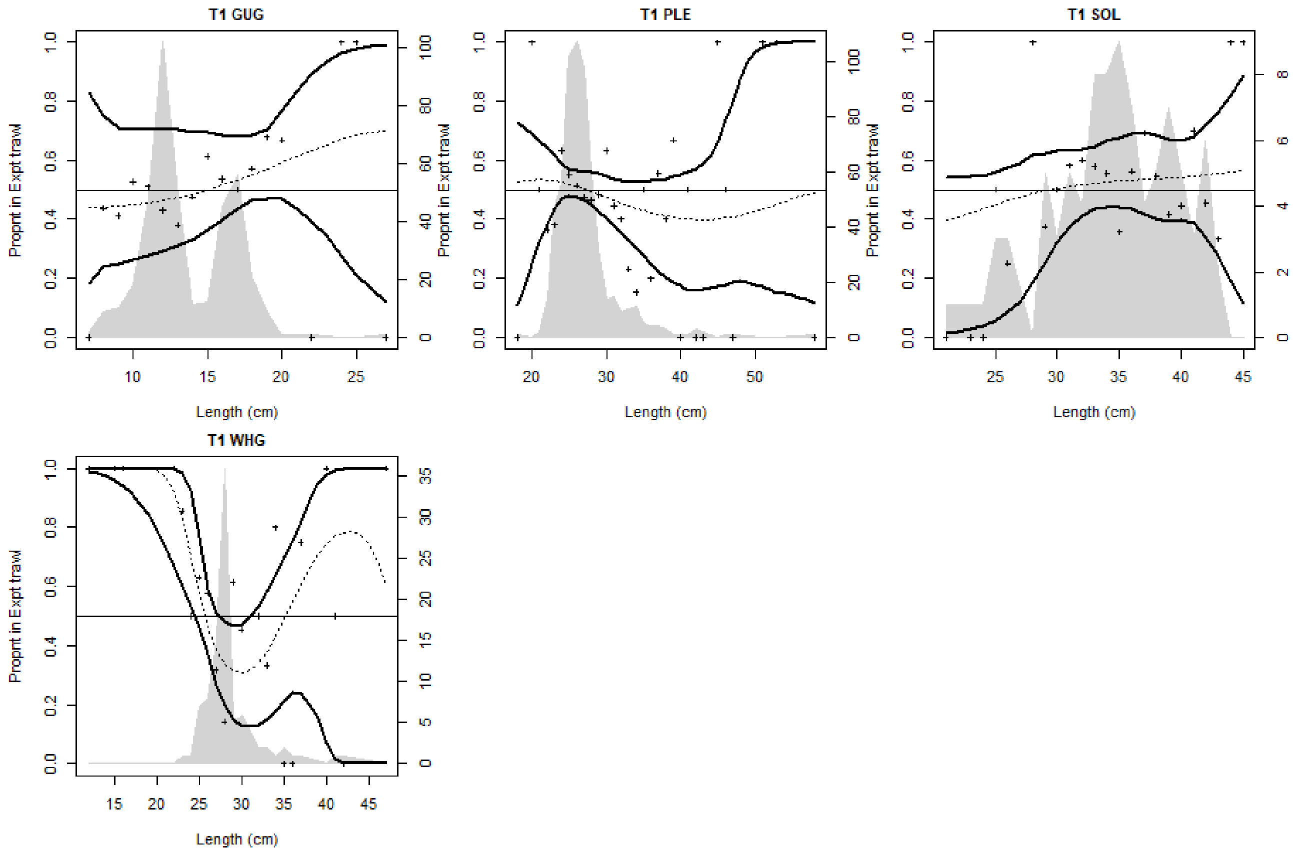

Figure 7 Results from the SELNET catch comparison analysis in Trial 1: 100CE+100SMP (experimental) vs 100CE+80SMP (control). Interpretation: a value of 0.5 indicates an equal split between the top (cover) cod end and the bottom (commercial) cod end. Cross points are pooled experimental proportions and the bold lines around the modelled curve (dotted lines) represent the 95% confidence regions. The length frequency from the control trawl is given

(grey shading) to provide context of the result. Therefore, when the modelled dotted line is above the 0.5 level more at this length were retained in the experimental trawl.

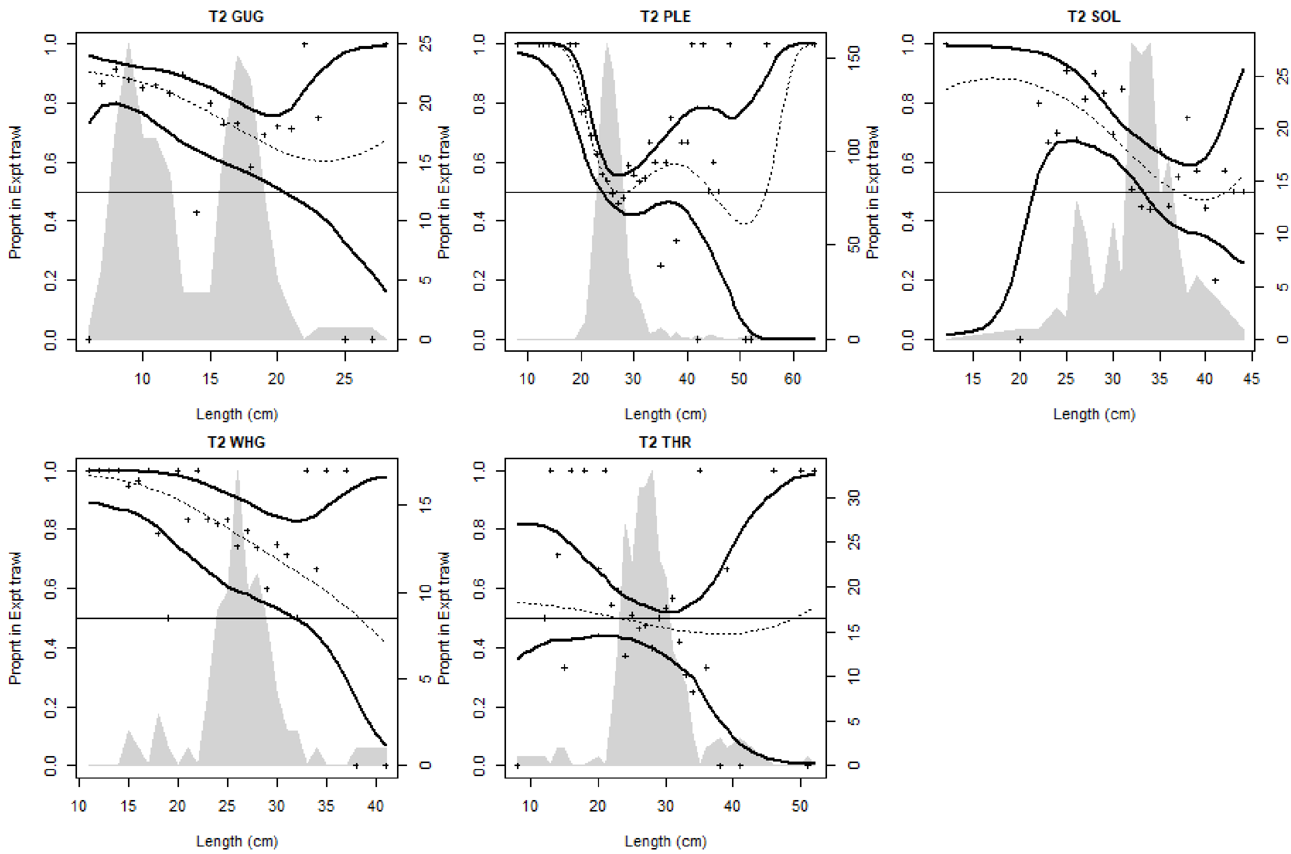

Figure 8 Results from the SELNET catch comparison analysis Trial 2: 100CE+80SMP (control) vs 80CE+80SMP (experimental) . Interpretation: a value of 0.5 indicates an equal split between the top (cover) cod end and the bottom (commercial) cod end. Cross points are pooled experimental proportions and the bold lines around the modelled curve (dotted lines) represent the 95% confidence regions. The length frequency from the control trawl is given (grey shading) to provide context of the result. Therefore, when the modelled dotted line is above the 0.5 level more at this length were retained in the experimental trawl.

5. Discussion

Two trials comparing different cod end and square mesh panel configurations in the English SW otter trawl fishery were conducted during the period October to December 2020. In the first trial, two trawls with 100mm cod ends were compared, one with an 80mm SMP and an 100mm SMP. In the second trial, a trawl with a 100mm cod end and 80mm SMP was compared with a trawl with an 80mm cod end and 80mm SMP (currently permitted and widely used in the fishery).

5.1. Trial 1 100CE+80SMP vs 100CE+100SMP

Overall, the catches of the 100CE+80SMP) and 100CE+100SMP were comparable. The main significant result from Trial 1 was the decrease in whiting between 28 and 30cm when using the larger SMP. This supports the notion that whiting escape from SMPs and the size of escaping fish can be influenced by the mesh size of the panel. Many other studies have also found that SMP's increase the likelihood of juvenile whiting especially but also other round fish escaping through them (Graham et al., 2003; Özdemir et al., 2012; Vogel et al., 2017). Graham et al., (2003) showed that best position for haddock and whiting to escape was 3–6 m from the cod-line. Another paper found that bringing the SMP forward to 6-9m from 12-15m also increased the likelihood that whiting would escape (Vogel et al., 2017). The SMP in this study was placed within 3m of the cod-line, increasing the likelihood of juvenile whiting to escape as observed. This study indicates that a SMP of 100mm is more effective at reducing catches of whiting under the MCRS than an 80mm SMP.

5.2. Trial 2: 100CE+80SMP vs 80CE+80SMP

In accordance with previous trials (Forster et al., 2018) there were significant differences in both numbers and weights caught across the majority of species where the 80CE+80SMP catches were more than twice the amount of the 100CE+80SMP in key species. The smaller mesh cod end generated 4.4 time more discards overall (by number). The discard rate was 92% (by number) for the 80CE+80SMP and 85% for the 100CE+80SMP.

For plaice, fewer individuals were caught in 100CE+80SMP compared with the 80CE+80SMP between 8 and 23cm. The MCRS for plaice is 27cm; the change in plaice catch did not impact landings of plaice. There was significantly less sole caught above MCRS in the 100CE+80SMP compared with the 80CE+80SMP. The affected length range of sole was between 22-33cm (MCRS for sole is 24cm). Therefore, the landings value from the 100CE+80SMP was substantially less than from the 80CE+80SMP.

The 80CE+80SMP scraper trawl was well tuned to catching sole, which was the main species of commercial interest to the skipper, and had a discard rate of 2%; however, this gear was unselective for other species. For each sole landed, 17 fish were discarded when using the 80CE+80SMP, compared with 12 discarded fish when using the 100CE+80SMP. Therefore, the 100mm cod end configuration reduced catches of discards by 32% for each sole landed. While this indicates that an improvement in overall selectivity can be achieved with an increase in cod end mesh size, any additional fishing effort needed to catch the sole quota should be considered, as this could undermine improvements in selectivity.

It is recognised that discarded fish do not necessarily die, and evidence shows that for some species discard survival rates can be reasonable and can be enhanced by short towing times and swift return of unwanted catches to the sea. For example, survivability of plaice in the English channel has been found to be good, especially in winter months, at above 60% (Morfin et al., 2017). In the trials presented here large number of plaice were discarded (largest discarded plaice were 35cm), because the skipper preferred to retain only the largest fish for market due to price. Observations onboard the vessel indicated that plaice were in healthier condition when using the 100CE+80SMP compared with the 80CE+80SMP, likely due to the smaller catch volumes and fewer small plaice. Improvements in selectivity are likely to improve chances of survival of released catches and generating data on the health condition of released catches should be included in future gear trials.

Finally, the benthos count was not statistically significant (p=0.068) but there was a visible difference in the cleanliness of the catch, with the smaller mesh size cod end catching more benthos overall. There have been trials in the past that attempted to reduce the benthos bycatch which would also allow the fauna to recover better from the effects of trawling (Fonteyne & Polet, 2002). Benthos is an often-overlooked metric in gear trials but are an important indicator of the effect of the trawling on the seabed and reducing benthos could potentially improve fish quality and health condition of released fish.

5.3. Conclusions

The 80mm cod end trawl with 80mm SMP was highly selective for marketable sized Common (Dover) sole but had poor selectivity towards other species. In this trial there was a commercial focus on sole, but most of the catch (~90% by number) was of undersized and non-marketable catches of other fish species.

When compared with a trawl with 100mm cod end and 80mm SMP, the amount of unwanted fish in the catch from the larger mesh cod end was lower by 4.4 times. However, there was also a significant reduction in catches of marketable sole, which reduced the value of the landed catch substantially.

Therefore, an increase in cod end mesh to 100mm would have significant benefits from reducing unwanted catches and discard mortality, but there is likely to be a reduction in efficiency for those vessels that are focussed on catching sole. If additional fishing effort were required to catch the sole quota, this could reduce the selectivity benefits of using a 100mm cod end and the extra fishing time would reduce the efficiency of these vessels.

The levels of unwanted catch when using the scraper trawl design with 80mm cod end trialled here make it difficult to justify its continued use in a sole directed fishery. This is the currently permitted trawl specification; however, its use is based on retained EU regulations that are difficult to interpret and enforce. It would be beneficial to improve the definition of a sole directed fishery, and this should be based on what is caught rather than landed.

Furthermore, recognising that moving to 100mm cod ends will likely have an economic impact for those fishers that have a commercial focus on sole, other otter trawls designs may be more appropriate. For example, dedicated sole trawls, typically with a triple-rig configuration, have a very low headline height, around 0.75m, compared with ~2.4m in the scraper trawl, and a narrow swept area, as this gear is operated with no sweeps and brides.

This means that there is no herding of species, such as roundfish or plaice, into the trawl, and unwanted catches can escape over the top of the trawl, while sole catches are maintained. It is recommended that, where sole is the primary focus for fishers, these specialised trawls are considered and evaluated to enable the continued use of 80mm cod ends.

Lastly, in the first trial, we also observe that an 100mm SMP is more selective towards whiting than 80mm SMP, supporting the regulated use of this mesh size.

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8. Annex 1 Retained and discarded catches by number Trial 1

Trial 1	100CE+80SMP		100CE+100SMP		Trial 1	100CE+80SMP		100CE+100SMP		Trial 1	100CE+80SMP		100CE+100SMP	
Species code	Retained	Discard	Retained	Discard	Species code	Retained	Discard	Retained	Discard	Species code	Retained	Discard	Retained	Discard
PLE	50	555	40	575	SDR		9		8	BLL	1			
GUG	1	394	1	378	MON	7	3	3	1	DGS				1
SCR		317		287	TUB	2	4	1	4	TSC		1		
LSD		148		113	SDF		5		5	COE				1
SOL	88	2	97	1	SOT		5		3	BKS		1		
WHG	16	74	15	61	PTR		5		3	POD		1		
CTC	53	29	48	8	UNR		4		4	TRF		1		
DAB	6	59	8	62	LEM	3		3	1	STF		1		
CDT		67		44	POG		2		2	SMF				1

Trial 1	100CE+80SMP		100CE+100SMP		Trial 1	100CE+80SMP		100CE+100SMP		Trial 1	100CE+80SMP		100CE+100SMP	
POD		33		50	CUR				4	STN		1		
SDS		33		26	BLR			1	2	TUR	1			
THR	2	31		24	BSE				3	WAF	1			
CRE	5	21	5	14	TBS		1		1	CTL			1	
GUR	1	23		19	TBY		2			GPF				1
BIB	1	8	1	15	LLV			2		ATS		1		
JOD	2	7	3	10	JOD	2								
SCE		7	2	12	SMH				2					

9. Annex 1 Retained and discarded catches by number Trial 2

Trial 2	***80CE+80SMP***		***100CE+80SMP***		***Trial 2***	***80CE+80SMP***		***100CE+80SMP***		***Trial 2***	***80CE+80SMP***		***100CE+80SMP***	
species code	*Retained*	*Discard*	*Retained*	*Discard*	***species code***	*Retained*	*Discard*	*Retained*	*Discard*	***species code***	*Retained*	*Discard*	*Retained*	*Discard*
PLE	*13*	*484*	*12*	*215*	***JOD***	*1*	*25*		*17*	***TUB***		*4*		
GUG		*537*		*54*	***TUB***	*1*	*31*		*2*	***COE***		*1*		*3*
DAB	*16*	*441*	*19*	*100*	***LLV***	*20*		*5*		***CRE***	*1*	*1*		*1*
CDT		*326*		*7*	***SDF***		*21*		*2*	***PTR***		*1*		*1*
WHG	*9*	*251*	*1*	*8*	***BIB***		*13*		*1*	***MAC***		*2*		
THR		*129*		*88*	***MON***	*6*		*4*	*3*	***SCE***			*2*	
SOL	*150*	*3*	*50*		***BLL***	*4*		*5*		***POG***		*1*		
SCR		*64*		*36*	***UNR***		*5*		*2*	***CTL***			*1*	
POD		*90*		*1*	***LEM***	*5*	*1*			***SDR***				*1*
LSD		*52*		*28*	***GOBY***		*6*			***BKS***	*1*			

Trial 2	80CE+80SMP		100CE+80SMP		Trial 2	80CE+80SMP		100CE+80SMP		Trial 2	80CE+80SMP		100CE+80SMP	
SOT		44		7	CTC	2		3		SDS		1		
										TUR	1			

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