Assessment of an increase in codend mesh size and reduced codend circumference in an Irish *Nephrops* fishery

Fisheries Conservation Report

Ireland's Seafood Development Agency

May 2018

Assessment of an increase in codend mesh size and reduced codend circumference in an Irish *Nephrops* fishery

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Key Findings

Increasing codend mesh size from 80 to 90 mm reduced catches of very small whiting < 20 cm by 60%, and *Nephrops* catches by 33% by weight and 23% by value.

1

Results from BIM and other studies suggest that restricting 90 mm to the codend and not the extension piece could assist in maintaining *Nephrops* while reducing whiting catches.

2

Decreasing the circumference of an 80 mm codend from 120 to 80 meshes reduced catches of small *Nephrops* < 25 mm carapace length by 30% but reduced catches of whiting < 20 cm by just 15%.

3

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Introduction

The *Nephrops* fishery accounts for the majority of whiting catches in the Irish Sea, most of which are below the minimum conservation reference size (MCRS) of 27 cm. Given low quotas (46 tonnes for 2018) and relatively high catch estimates (~217 tonnes in 2016) by Irish vessels (MI, 2017), whiting has major potential to choke the *Nephrops* fishery when the landing obligation is fully implemented on 1st of January 2019.

Irish vessels currently employ measures in the rear part of the trawl consisting of a 300 mm square mesh panel (SMP) in two (BIM, 2014) or four panel (SELTRA sorting box) (Tyndall et al., 2017) sections to reduce cod catches in compliance with the Irish Sea cod management plan. These measures are highly effective in reducing catches of species such as whiting and haddock but are ineffective for very small, < 20 cm whiting which can form a major component of whiting catches (ICES, 2017). The Swedish grid can be effective in reducing catches of very small whiting but also eliminates most of the commercial fish catch, can reduce *Nephrops* catches (Cosgrove et al., 2016) and can be associated with handling difficulties (Graham and Fryer, 2006).

BIM and the Irish Fishing Industry recently tested a range of other measures in an attempt to address this issue. These include: net panels to guide whiting towards large square mesh panels in the top of the trawl (McHugh et al., 2017), floating Dyneema bridles and fish scaring ropes which potentially reduce herding of fish species ahead of the trawl (Browne et al., 2017). Unfortunately these measures failed to reduce catches of < 20 cm whiting.

In terms of other measures to reduce catches of very small whiting, the European Commission recently proposed an increase in codend mesh size from 80 to 90 mm in the Irish Sea (EC, 2017). Reductions of ~60% of whiting < 20 cm and 11% of market sized *Nephrops* were observed in a previous codend mesh size study conducted in the Irish Sea *Nephrops* fishery (Cosgrove et al., 2015). However, the fishing gear employed during that trial is not the same as the gear currently employed by Irish vessels in the Irish Sea. Square mesh panels with 120 mm mesh size were employed in Cosgrove et al. (2015) whereas square mesh panels with 300 mm mesh are currently employed by Irish vessels in the Irish Sea. Also, vessels currently employ the same mesh size in the extension piece between the codend and tapered section whereas increases in mesh size in Cosgrove et al. (2015) were restricted to the codends.

The mesh size employed in square mesh panels has a major impact on the selectivity of gadoid fish species that come into contact with the panel (Fryer et al., 2016). This suggests that a 120 mm SMP is likely to accumulate substantially higher catches compared with a 300 mm SMP. The ability of diamond mesh codends to reduce undersize fish catches depends on the mesh size, codend circumference and the accumulated catch (Herrmann et al., 2007). In addition to these factors, the amount of netting with larger mesh size that *Nephrops* are exposed to, e.g. the extension piece, is likely to affect *Nephrops* catches. Hence, we aimed to assess an increase in codend mesh size in the Irish Sea *Nephrops* fishery taking into account current technical conservation measures and gears employed by the Industry. Reduced codend circumference is known to improve selectivity of gadoid species (Fryer et al., 2016) and thought to improve *Nephrops* selectivity (ICES, 2007) so this was also tested as a potential measure to deal with small whiting.

Methods

A catch comparison trial was completed on board a 23 m quad-rig trawler targeting *Nephrops* in the western Irish Sea (Figure 1) during February 2018. The quad-rig was towed using three warps with outer and split sweeps between the trawl doors and a centre clump weight (Figure 2).

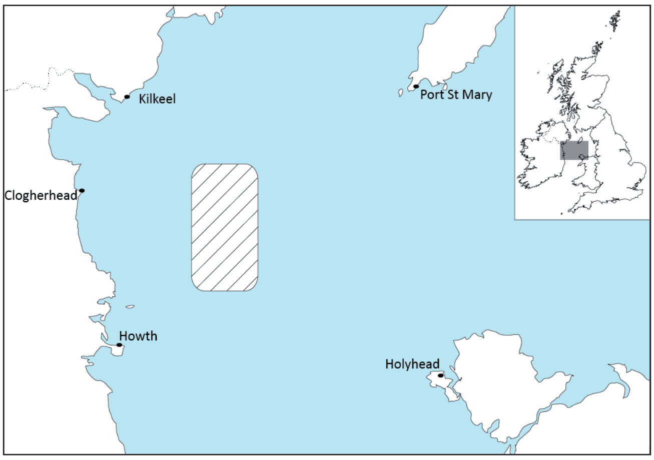

Figure 1. Trial location (hatched area)

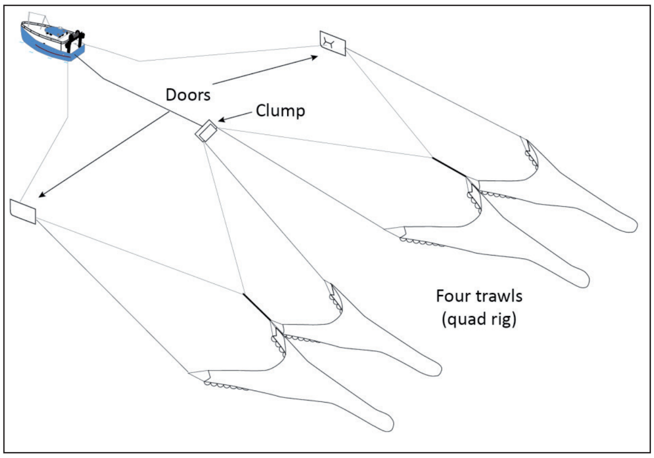

Figure 2. Graphical illustration of a quad-rig configuration

Fishing gear

The vessels own trawl gear (Table 1) was used and comprised four 42 m (footrope length) *Nephrops* trawls with 160 mm mesh in the upper wing-ends and 80 mm in the remainder of the top and bottom panels. A 3 m long 300 mm square mesh panel was fitted to each net with the rearmost edge located 9 m from the codline.

Four new codends and extension pieces were constructed for this trial, three with 80 mm nominal and one with 90 mm nominal mesh size (Figure 3). The control codend was constructed using 80 mm mesh size and the maximum permitted circumference of 120 meshes round (80x120). The 90 mm experimental codend was also constructed with the maximum permitted circumference of 100 meshes round (90x100) as per normal Industry practice. Two experimental 80 mm codends were constructed with a reduced circumference of 80 and 100 meshes round (80x80 and 80x100). Each of the four codends measured 49.5 meshes in length. Strengthening bags and lifting ropes were present as per commercial practice.

The circumference of each extension piece matched the circumference of the codend to which it was attached. The length of the extension piece used on the 80x120 measured 32.5 meshes long and varied for each of the experimental codends so as to account for differences in mesh size and ensure the rearmost edge of the SMP was located no more than 9 m from the codline. For each of the experimental codends, a short 6 mesh long tapering adaptor section was attached ahead of the extension piece, to compensate for reduced circumference and to facilitate connection to the trawl. Measured mesh sizes obtained with an Omega gauge (Fonteyne et al., 2007) averaged ~86 to 87 mm for the 80 mm codends and 95 mm for the 90 mm codend (Table 1). Single compact polyethylene twine of 4 and 5 mm diameter were used to construct the extension pieces and codends respectively.

Control and experimental codends were rotated daily over the course of the trial so that each codend was attached to each of the four nets for three hauls. This permitted any potential differences in fishing power depending on net position to be accounted for in analyses.

Sampling and Analysis

The total catches from each gear were weighed and sorted at haul level for commercial species with random representative subsamples also taken for whiting and *Nephrops* to facilitate length-frequency comparison. Total lengths (TL) of commercial fish species were measured to the nearest cm below and *Nephrops* carapace length (CL) was measured to the nearest mm below. Although sex sampling was not conducted, the exploitation rate between sexes is similar for *Nephrops* in the Western Irish Sea (MI, 2017), and hence, the length-weight relationship used for males in Briggs et al. (1999), $X = 0.00032CL^{3.21}$, was used to obtain estimated *Nephrops* weights in relation to CL for comparative purposes. A length-weight relationship for whiting, $X = 0.0060TL^{3.1070}$, from (Silva et al., 2013) was applied to obtain estimated whiting weights in relation to TL also for comparative purposes. The commercial value of *Nephrops* catches were estimated using prices obtained from sales notes for the trip. A Generalised Additive Model (GAM) was used to predict the proportion of overall *Nephrops* and whiting catches at length retained in the larger mesh 90x100 gear compared with the standard control 80x120 gear.

Table 1. Vessel and gear specification

Engine power (kw)	328
Trawl type	Quad-rig *Nephrops*
Door manufacturer	MacDuff
Door weight (kg)	450
Clump weight (kg)	800
Sweep length (m)	70 (50+20)
Trawl manufacturer	Pepe Trawls Ltd.
Warp diameter (mm)	18
Headline length (m)	38
Footrope length (m)	42
Fishing-circle (meshes × mm)	400 × 80
Measured codend mesh size (mm)	
80x120	86.1
90x100	95.4
80x100	86.4
80x80	86.7

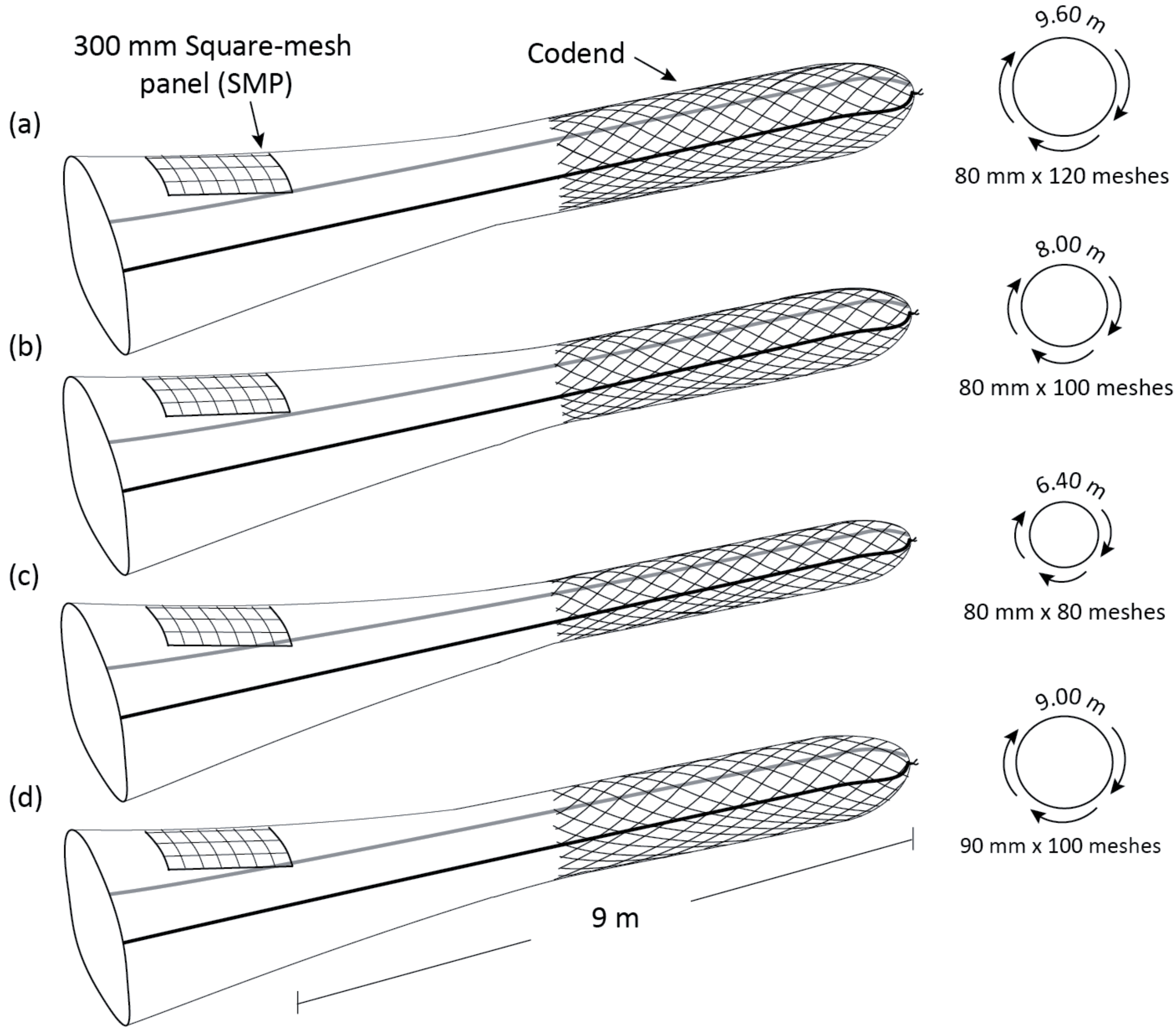

Figure 3. A graphical illustration of the four codends used during the trial with their respective mesh size and circumference (m)

RESULTS

A total of 12 hauls were carried out over four days. Mean haul duration, towing speed and depth fished were 4 h, 3 kt and 94 m respectively. The wind speed encountered during the trial ranged from an estimated 19 to 38 km/h, Beaufort Force 3 to 5. Wind direction at the beginning of the trial was westerly and gradually backed (turned clockwise) to the southeast by the end of the trial. The numbers of whiting and *Nephrops* measured were 8,323 and 13,132 out of a total estimated catch of 17,956 and 93,532 individuals respectively. The main commercial species caught during the trial were *Nephrops* and whiting. Catches of whiting and *Nephrops* were highest in the 80x120 and lowest in the 90x100 gears (Table 2). Most of the whiting catch was < 20 cm (Figure 4).

Mesh size

The 90 mm mesh codend significantly reduced whiting < 20 cm by 60% in weight compared with the 80 mm codend (Table 3) (Figure 5). *Nephrops* catches were reduced by 33% in weight and 23% in commercial value compared with the 90 mm mesh. The reduction was more evident for smaller *Nephrops* with a 56% reduction in *Nephrops* < 25 mm CL by weight (Table 4). The GAM model confirmed that the proportions of *Nephrops* retained by the 90 mm mesh gradually increased in relation to carapace length (Figure 5).

Table 2. Total species catch weights (kg) in test gears (codend mesh size (mm) x codend circumference (no. of meshes round))

Species	80x120	90x100	80x100	80x80	Total
Bulk catch	2119	1826	2136	2091	8172
Nephrops	494	330	459	430	1713
Whiting	283	165	257	250	954
Cod	79	61	68	93	301
Haddock	52	53	60	53	217
Monkfish	18	44	60	67	189
Flatfish	25	22	37	27	110
Ray	12	6	12	13	43
Lesser spotted dogfish	600	585	648	527	2359
Fish discards	37	38	38	40	153
Non fish discards	372	381	361	400	1514

Table 3. Estimated counts (N) and weights (kg) of whiting in test gears (codend mesh size (mm) x codend circumference (no. of meshes round))

	80x120	90x100	80x100	80x80
Total count (N)	5530	2572	4856	4997
Δ 80x120 (%)		*-53*	*-12*	*-10*
≥ 27 cm TL (N)	190	140	166	192
Δ 80x120 (%)		*-26*	*-13*	*1*
< 27 cm TL (N)	5340	2432	4690	4806
Δ 80x120 (%)		*-54*	*-12*	*-10*
< 20 cm TL (N)	4360	1724	3483	3755
Δ 80x120 (%)		*-60*	*-20*	*-14*
Total weight (kg)	270	153	258	257
Δ 80x120 (%)		*-43*	*-4*	*-5*
≥ 27 cm TL (kg)	41	32	35	41
Δ 80x120 (%)		*-20*	*-14*	*2*
< 27 cm TL (kg)	229	121	223	215
Δ 80x120 (%)		*-47*	*-3*	*-6*
< 20 cm TL (kg)	144	57	117	122
Δ 80x120 (%)		*-60*	*-19*	*-15*

Δ = difference from

Table 4. Estimated counts (N), weights (kg) and value (€) of *Nephrops* in test gears (codend mesh size (mm) x codend circumference (no. of meshes round))

	80x120	90x100	80x100	80x80
Total count (N)	28087	16819	25528	23098
Δ 80x120 (%)		*-40*	*-9*	*-18*
≥ 25 mm CL (N)	21196	13813	20055	18242
Δ 80x120 (%)		*-35*	*-5*	*-14*
< 25 mm CL (N)	6892	3006	5473	4855
Δ 80x120 (%)		*-56*	*-21*	*-30*
Total weight (kg)	444	295	415	383
Δ 80x120 (%)		*-33*	*-6*	*-14*
≥ 25 mm CL (kg)	396	274	378	350
Δ 80x120 (%)		*-31*	*-5*	*-12*
< 25 mm CL (kg)	48	21	37	33
Δ 80x120 (%)		*-56*	*-22*	*-30*
Total value (€)	1956	1508	1903	1799
Δ 80x120 (%)		*-23*	*-3*	*-8*
≥ 25 mm CL (€)	1866	1470	1833	1737
Δ 80x120 (%)		*-21*	*-2*	*-7*
< 25 mm CL (€)	89	39	70	63
Δ 80x120 (%)		*-57*	*-22*	*-30*
> 31 mm CL - whole (€)	1385	1169	1367	1324
Δ 80x120 (%)		*-16*	*-1*	*-4*
≥ 20 ≤ 31 mm CL - tails (€)	571	340	536	476
Δ 80x120 (%)		*-40*	*-6*	*-17*

Δ = difference from

Codend circumference

The experimental gears with 80 mm mesh size and reduced circumference (80x80 and 80x100) reduced whiting < 20 cm catches by up to 19% in weight compared with the 80x120 gear (Table 3). The 80x80 gear reduced catches of small *Nephrops* < 25 mm CL by 30% and market sized *Nephrops* > 25 mm CL by 14% by weight. Most of the losses were of tail grade *Nephrops* so the reduction in total commercial value of the *Nephrops* catch was lower at 8% (Table 4).

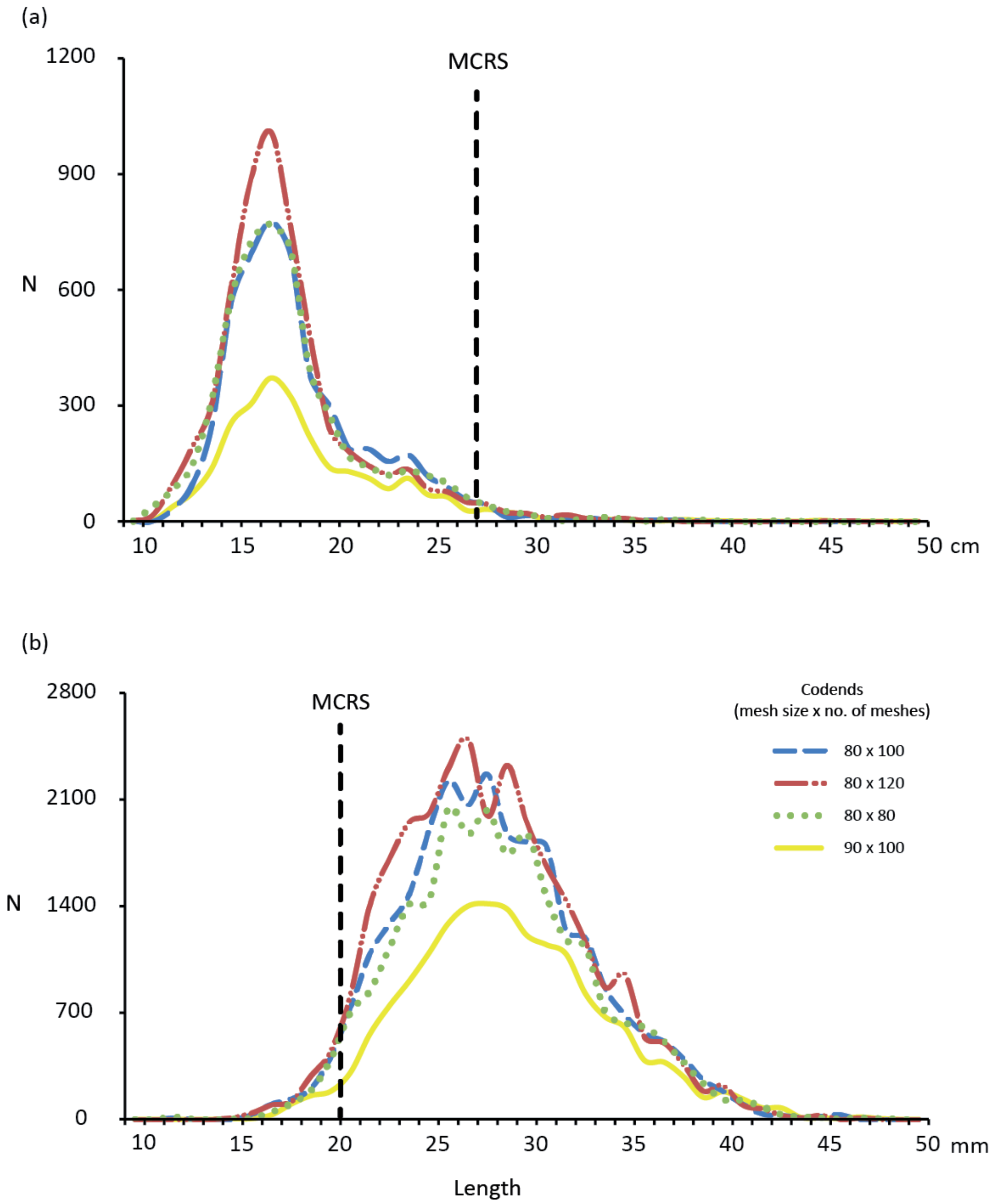

Figure 4. Length frequency plots of (a) Whiting and (b) *Nephrops* retained with trial gears

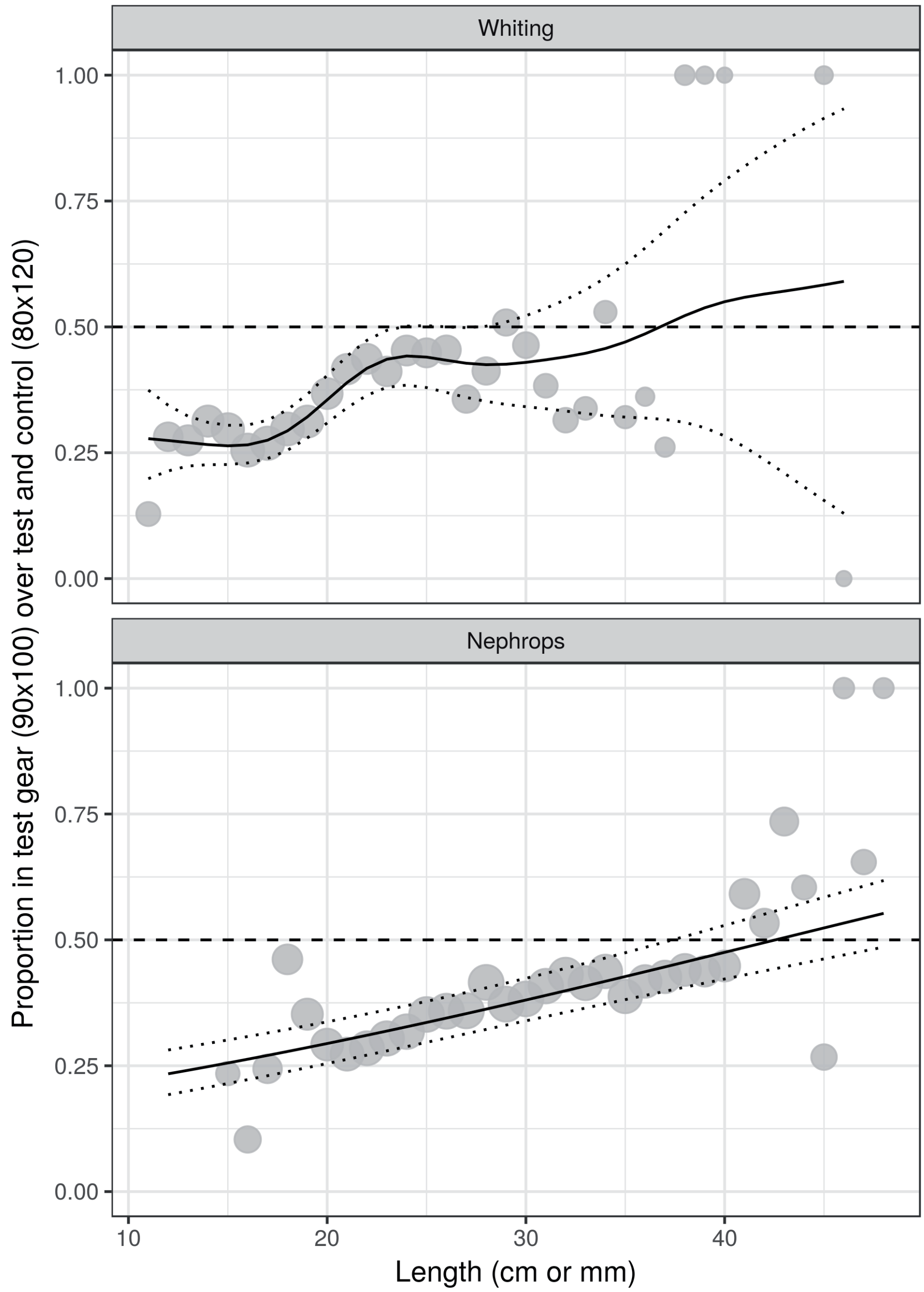

Figure 5. Overall raised proportions of catch at length for whiting (top) and *Nephrops* (bottom) retained in the 90x100 (points) and predicted overall mean proportions from the GAM (solid line). Dotted lines represent the upper and lower 95% confidence intervals. Equal proportions are shown as dashed horizontal lines at 0.5. Proportions > 0.5 indicate higher retention in the experimental 90x100 gear and < 0.5 indicates higher retention in the control 80x120 gear.

Discussion

The increase in mesh size from 80 to 90 mm achieved a substantial 60% reduction in whiting < 20 cm, but also reduced *Nephrops* catches by 33% in weight and 23% in value. A previous assessment of an increase in codend mesh size from 80 to 90 mm in the Irish Sea demonstrated a reduction in whiting < 20 cm by around 60% and a smaller reduction in *Nephrops* catch weight and value by 11% and 7% respectively (Cosgrove et al., 2015). No reduction in *Nephrops* < 25 mm CL occurred in the latter study compared with a 56% reduction in the current study. The overall bulk catch for the same number of hauls was ~43% higher in the 2015 study compared with the current study. This could be due to the smaller 120 SMP but also due to the seasonal difference in species abundance and catch rates. Higher bulk catch weights lead to greater codend mesh openings and fewer small *Nephrops* retained (Browne et al., 2017). Hence, the major differences in catches of small *Nephrops* between the two studies cannot be explained by differences in bulk catch weights.

The most likely explanation for the difference in *Nephrops* catches between the two studies was the use of 90 mm mesh in the extension piece as well as the codend in the current study. *Nephrops* are known to move relatively passively along the bottom sheet of the trawl (Catchpole and Revill, 2008), and the more contact they have with larger mesh, the more likely they are to escape the trawl (Frandsen et al., 2010).

Retaining smaller 80 mm mesh in the bottom sheet of an extension piece used in association with a 90 mm codend might assist in maintaining catches of *Nephrops* while reducing small whiting. This could work well in the SELTRA with a four panel codend. The SELTRA retains more *Nephrops* than a standard trawl (Tyndall et al., 2017) which would help offset any losses associated with a 90 mm codend. Also the four panel codend effectively halves the width of the bottom panel compared with a two panel codend thereby further reducing *Nephrops* contact with larger mesh as they roll along the bottom of the trawl.

Reduced codend circumferences showed a lot of potential for improving selectivity of *Nephrops*. Marginal reductions in small whiting might be improved on with higher bulk catches but results suggest that this measure is unlikely to be consistently effective as a management measure to deal with the whiting issue.

Acknowledgements

BIM would like to thank, the owners, skipper and crew of the trial vessel for their assistance during the trial. We have refrained from naming them due to use of their economic data. Additional thanks are extended to Gerard Dougal for assistance with sampling and gear modifications during the trial. This work was funded by the Irish Government and part-financed by the European Union through the EMFF Operational Programme 2014-2020 under the BIM Sustainable Fisheries Scheme.

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