Assessment of rigid sorting grids in an Irish quad-rig trawl fishery for *Nephrops*

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Key findings:

- **Modified sorting grids to reduce catches of small *Nephrops* and a traditional 'Swedish grid' to reduce fish catches were assessed in a quad-rig trawl fishery for *Nephrops*.**
- **The '*Nephrops* sorting grids' worked well, achieving substantial reductions in catches of small *Nephrops* while retaining fish catches.**
- **Larger reductions in small *Nephrops* occurred in the *Nephrops* sorting grid with a larger cod-end mesh size of 75 mm compared with a 70 mm cod-end in the other *Nephrops* sorting grid. Further reductions are likely using an 80 mm cod-end.**
- **In the context of the landing obligation, optimising *Nephrops* catches in this manner provides more opportunity to catch larger more valuable *Nephrops* and maximise profits over the course of a fishing season.**
- **Further work to assess the benefits of a 'composite' grid with small spacings in the bottom and large spacings in the top of the grid, is planned in 2016. This work will further assist in optimising *Nephrops* catches and reducing unwanted fish catches.**

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Introduction

As part of the new Common Fisheries Policy, EU regulation 1380/2013, an obligation to land all catches of demersal species which are subject to catch limits commenced in January 2016. The principal aim of this new policy is to incentivise lower levels of unwanted catches and to gradually eliminate discards. In terms of impacts on the Irish fishing industry, the Landing Obligation (LO) predominantly applies to *Nephrops* fisheries in all Irish waters, the whiting fishery in the Celtic Sea, and the haddock fishery in the Irish Sea and in the Northwest (ICES Division VIa). An increase in fishing opportunities has been factored into 2016 quota allowance for these species to take into account the fact that fish which were previously discarded will legally be required to be landed. Based on differences between total landings and catch advice, this 10% quota uplift provides a major opportunity to the Irish fishing Industry to increase the value of their landings provided unwanted catches can be minimised. From 2017, it is likely that there will be a gradual phasing in of requirements to land other species up until 2019 when the regulation will apply to all quota species.

BIM is engaged in a work programme to provide a range of gear based options to fishers and managers which have potential to reduce unwanted catches of below minimum conservation reference size (MCRS) and over quota fish. Successful implementation of such measures can reduce economic impacts of the LO and in some cases lead to improved profitability at vessel level (Cosgrove *et al.*, 2015). Recent studies conducted by BIM demonstrated significant reductions in whitefish species in the *Nephrops* fishery by using a quad-rig instead of a twin-rig trawl (BIM, 2014b), or a 300 mm square mesh panel (SMP) (BIM, 2014a). BIM also demonstrated significant reductions in unwanted catches of small *Nephrops*, improved profitability and stock sustainability, through an increase in minimum cod-end diamond mesh size from 70 to 80 mm in the *Nephrops* fishery (Cosgrove *et al.*, 2015).

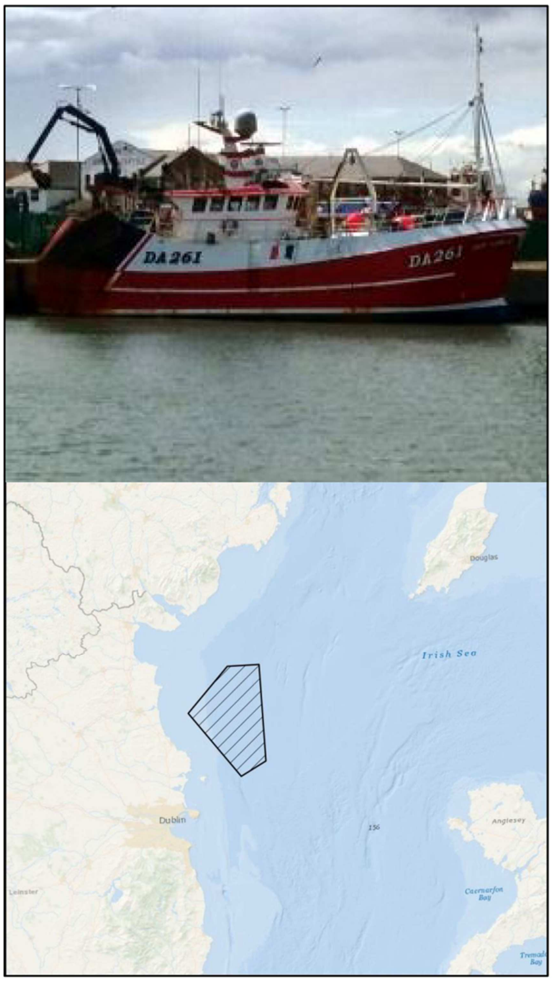

Figure 1. Trial vessel and area of operation

Here, we test a customised rigid *Nephrops* sorting grid to provide a further option to reduce unwanted catches of small *Nephrops*. The “Swedish grid” is a proven device for substantially reducing or, in some cases, effectively eliminating catches of fish species, while maintaining *Nephrops* catches across all size classes (Catchpole *et al.*, 2007; Nikolic *et al.*, 2015; Valentinsson and Ulmestrand, 2008). Successful trials have also previously been carried out to reduce catches of small *Nephrops* by reducing the space between the bars and allowing small *Nephrops* which pass through the grid to escape the trawl (Anon, 2001; SLU, 2015). Here, we aim to test the practicalities and performance of a *Nephrops* sorting grid with small spacings in the bottom of the grid to reduce catches of small *Nephrops*, and a reinforced gap at the top to retain fish species.

Methods

Fishing operations

Table 1. Gear specification

Trawl type	Quad-rig *Nephrops*
Trawl manufacturer	Pepe Trawls Ltd.
Head-line length (m)	27.4
Foot-line length (m)	32.9
Fishing circle (m)	380 X 80
Sweep length (m)	50 + 20
Warp diameter (mm)	20
Door spread (m)	68.6
Door type	Dunbar 7'6"
Door weight (kg)	492
Clump weight (kg)	680

The trial was carried out on board MFV Our Lass II a 22 m multi-rig *Nephrops* trawler operating in the Western Irish Sea, in ICES Division VIIa (Figure 1). A total of 12 hauls were carried out over a 4 day period commencing on the 21st of September 2015. Fishing operations approximating normal commercial hauls were carried out with haul duration, towing speed and depth of ground fished averaging 4:55 hours, 3.0 knots and 84 m respectively. Fishing gear consisted of a quad–rigged 18 fathom *Nephrops* trawl set up, using a triple warp and centre clump arrangement. Three hinged rectangular rigid sorting grids (1.25 X 0.7 m) mounted in separate nets were tested during the trial: Two identical Nephrops sorting grids (NSG1 and NSG2) with vertical bars spaced 15 mm apart in the lower half, an escape hole in the bottom sheet to the rear of the lower half of the grid, and a reinforced opening in the top section of the grid were deployed. The 15 mm spacing in the *Nephrops* sorting grid was considered suitable given that previous UK trials using this device found that associated reductions in small *Nephrops* predominantly occurred between 24 and 26 mm carapace length (CL) (Anon, 2001). This corresponds well to a MCRS of 25 mm CL in Irish waters outside the Irish Sea, which is also the size at which discarding commenced in the Irish Sea in recent years (MI, 2015). A triangular section of mesh was removed directly below and aft of the *Nephrops* sorting grids and an excluder panel of 30mm diamond mesh ensured that sorted *Nephrops* did not re-enter the cod-end.

A traditional Swedish grid with 35mm horizontal bar spacing in the top and bottom halves and an escape hole in the top sheet forward of the grid was also tested. The Swedish grid was obtained from the trial vessel and had a gap measuring 15 cm vertically at the bottom of the grid with a view to reducing the grid digging into soft muddy substrates and 'mudding up' the catches.

All grids were mounted at an angle of 45° in a 2 m long, 160 mesh circumference section, using 80 mm single 4 mm diameter polyethylene diamond mesh. The grid section was attached to the tapered section of the net 10 m from the cod-line. Three 20 cm trawl floats were attached to the top of the grids for flotation (Figure 2).

The three nets with sorting grids along with a control net had diamond mesh cod-ends constructed with single 6 mm polyethylene twine. Mean omega mesh gauge measurements in relation to these cod-ends were: NSG1 70.1mm, NSG2 75.1, Swedish Grid 70.7mm, and Control 72.7mm.

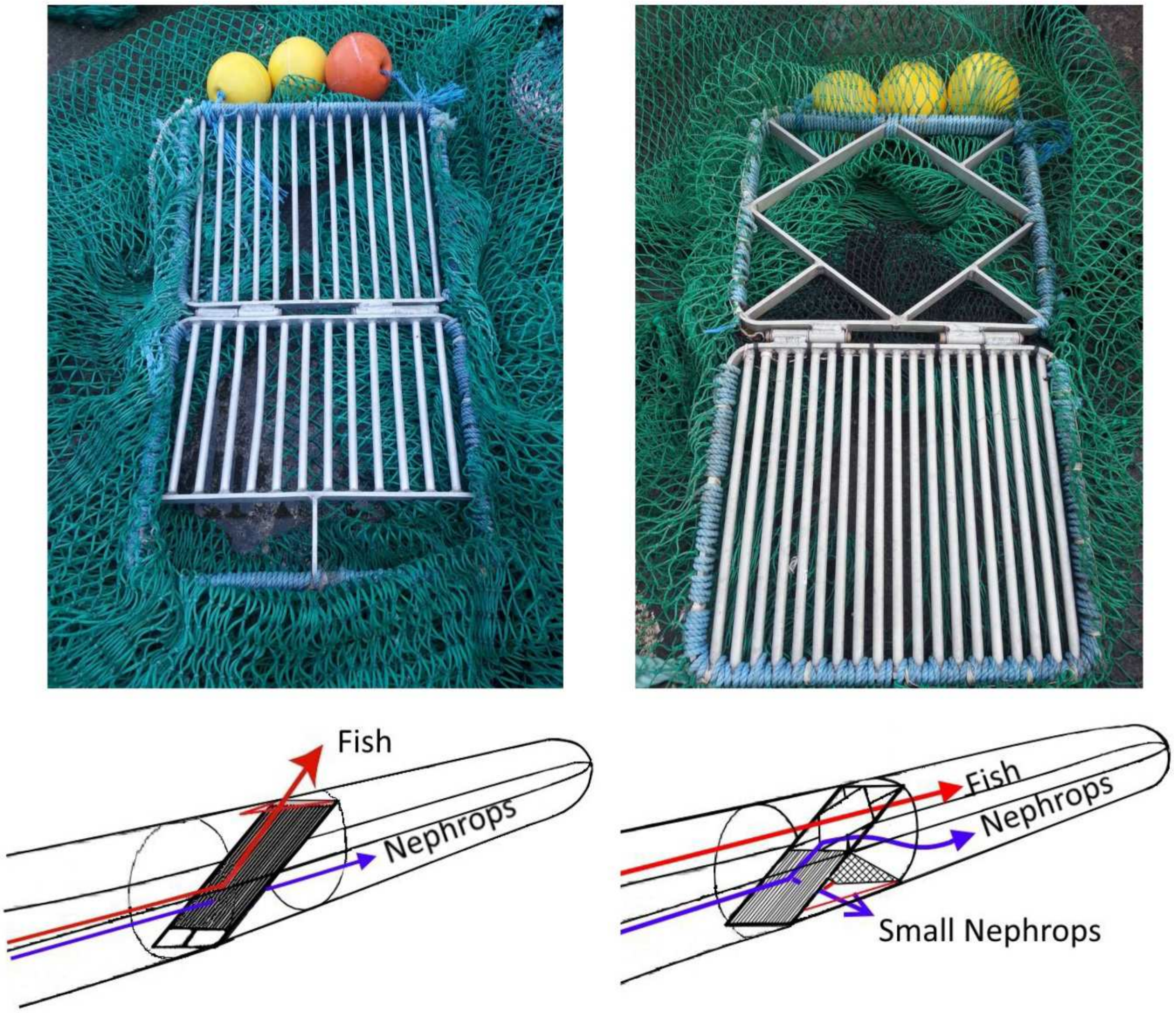

Figure 2. Swedish grid (left) and *Nephrops* sorting grid (NSG) (right) pictured from the front and outlined from the side. Line drawings edited from (SLU, 2015) with permission from the Swedish University of Agricultural Sciences

Grids and their associated cod-ends were rotated daily so that each cod-end was attached to each of the 4 nets for a minimum of one day or 3 hauls. Hence, potential differences in fishing power depending on net position could be accounted for in subsequent analyses. The mesh size in the top and bottom panels behind the head-line and in the lower wing ends was 80 mm, while meshes in the upper wing-ends were 160 mm. Apart from the grids no other selectivity devices such as square mesh panels were present in the nets during the trial.

Sampling and analysis

Total catches and randomly selected representative subsamples were weighed. Subsamples were separated to species level with all commercial fish species measured to the nearest cm below. The quantity of *Nephrops* in each subsample was weighed and a representative subsample was randomly selected for measurement to the nearest mm below (Carapace Length (CL)). Digital callipers linked wirelessly to a Toughbook pc were used to sample a total of 19,850 *Nephrops* out of a total estimated catch of 593,647 individuals caught during the trial. Although sex sampling was not conducted, the exploitation rate between sexes is similar for *Nephrops* in the Western Irish Sea (MI, 2014), 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 in relation to cod-end mesh size. Tables and length frequency distributions were constructed for total numbers, weight, and value of *Nephrops* and key fish species caught using different cod-end mesh sizes. *Nephrops* data were analysed using length frequency distributions and quantities of landings in different size grades retained in each test gear. A recently developed mulitinomial modelling approach which facilitates comparison of catches in more than two gears (Browne *et al.*, 2015) was used to examine significant differences in the proportional catches of *Nephrops* across size classes between different gears.

Results

Nephrops

Raised weights of *Nephrops* in relation to different test gears and relevant size grades are outlined in Table 2 and Figure 3, while modelled proportions of *Nephrops* are outlined in Figure 4. The *Nephrops* sorting grids caught significantly less small *Nephrops* compared with the Swedish grid (Figure 4), e.g. a 24% reduction of *Nephrops* <= 31 mm CL was achieved by NSG2 compared with the control net, where as a 2 % reduction occurred for the Swedish grid (Table 2).

Significantly higher catches of small *Nephrops* occurred in NSG1 compared with NSG2 (Figure 4) with e.g. a 26% reduction in *Nephrops* < 25 mm CL in NSG1 compared with a 35% reduction in NSG2 (Table 2).

Little difference occurred in catches of larger *Nephrops* between the control net and *Nephrops* sorting grids. For example NSG1 retained just 3% less *Nephrops* > 31 mm (the size at which whole *Nephrops* are retained) compared to the control net. Losses of smaller marketable *Nephrops* (tails) were more prevalent with for example 12% less *Nephrops* >= 25 mm CL retained in NSG1 compared with the control net (Figure 3 b & 4, Table 2).

Losses of larger *Nephrops* were prevalent in the Swedish grid compared with the control net e.g. an 11% reduction in *Nephrops* > 31 mm CL compared with the control net (Table 2).

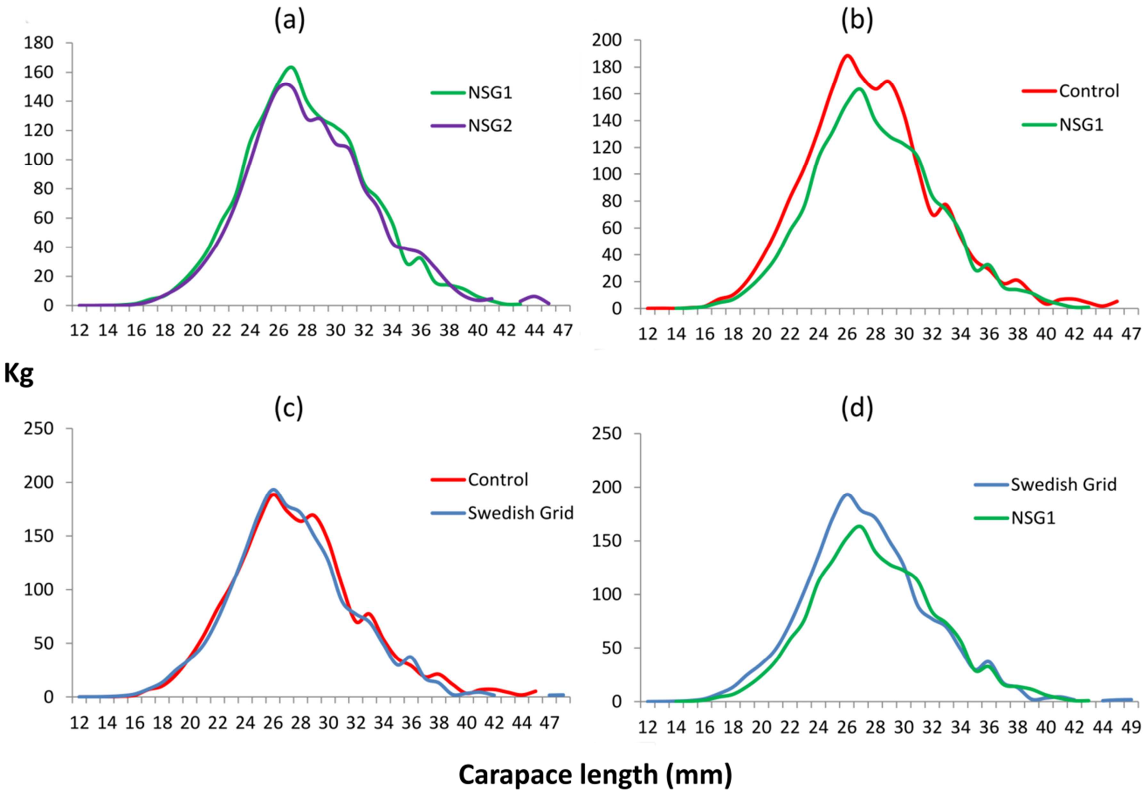

Figure 3. Length frequency plots of raised weights of *Nephrops* in relation to: two identical *Nephrops* sorting grids with 15 mm bar spacing and different cod-end mesh sizes, NSG1 (70.1 mm) and NSG2 (75.1 mm); a Swedish grid with 35 mm bar spacing and 70.7 mm cod-end mesh size; and a control net with 72.7 mm cod-end mesh size.

Table 2. Estimated *Nephrops* weights in relation test gears

	Control	NSG1	NSG2	Swedish Grid	Grand Total
Estimated weights (kg)	1908	1620	1526	1834	6888
Δ 70 mm (%)		15	20	4	
< 25 mm CL	454	335	293	445	1528
Δ 70 mm (%)		26	35	2	
>= 25 mm CL	1454	1285	1232	1389	5360
Δ 70 mm (%)		12	15	4	
<=31	1562	1286	1194	1525	5567
Δ 70 mm (%)		18	24	2	
>31	346	334	332	309	1321
Δ 70 mm (%)		3	4	11	

Δ = Difference from

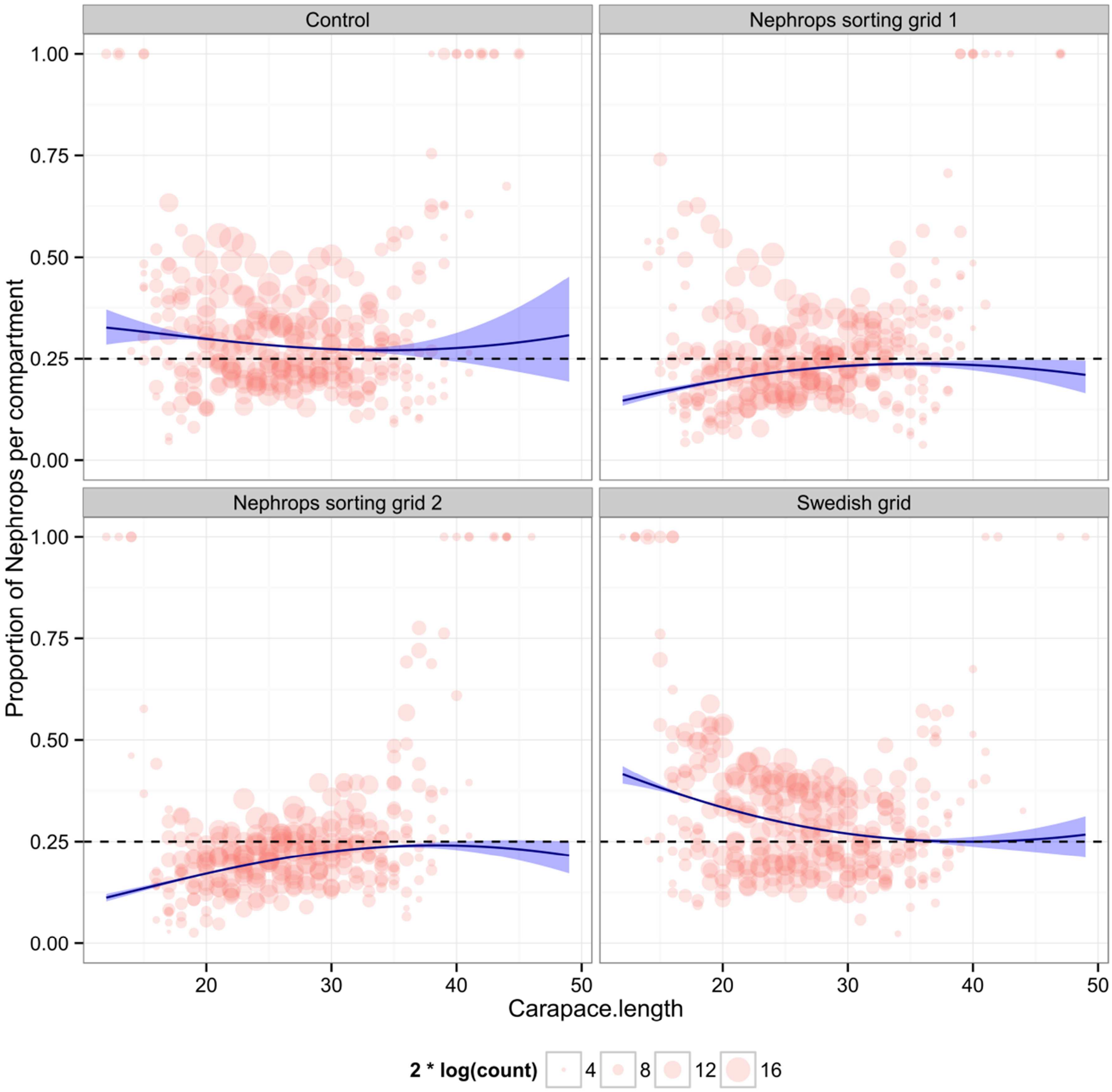

Figure 4. Proportion of *Nephrops* catch retained in numbers per haul for each test gear with fitted multinomial model with bulk weights set to the mean bulk per compartment, and associated re-sampled 95% confidence intervals. Null hypothesis of equal retention is displayed as the dashed line at 0.25.

Fish

Table 3. Quantities of fish species (kg) retained in the control net, *Nephrops* sorting grids (NSG1 & NSG2), and Swedish grid

Species	Control	NSG1	NSG2	Swedish grid
Whiting	183	228	219	42
Cod	75	27	89	0
Haddock	42	46	58	4
Monkfish	27	17	35	1
Mixed flatfish	18	19	19	2
Skates and rays	8	6	25	11
Lesser spotted dogfish	356	328	485	122
Other	15	11	21	11
Total	723	682	951	192

Total catch weights of fish species caught in test gears are outlined in Table 3. Similar catch quantities of fish species occurred in the control and the *Nephrops* sorting grids due to the large opening in the top half of the grid. Major reductions in fish catches were observed in the case of whiting, cod, haddock, monkfish, mixed flatfish, and lesser spotted dogfish in the Swedish grid compared with the test gears. Little difference was apparent in catches of skates and rays between the Swedish grid and other test gears which may be due to such species passing through the gap at the bottom of the Swedish grid. Length frequency distributions of key commercial species retained during the trial are outlined in Figure 5. Little difference in length compositions of whiting or haddock occurred between the control and *Nephrops* sorting grid while cod catches were too sporadic to assess in detail.

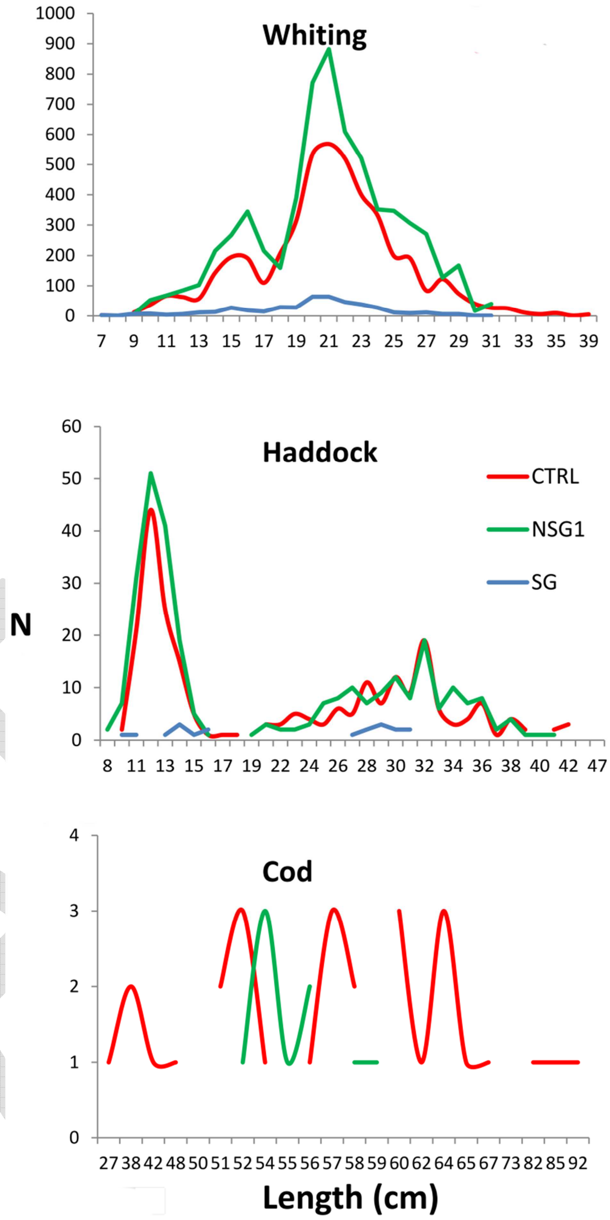

Figure 5. Length frequency distributions of key species retained in the control net (CTRL), *Nephrops* sorting grid (NSG1), and Swedish grid (SG)

Discussion

In terms of practicalities, no foul ups or major problems were reported with the grids deployed in the quad-rig set up. The participating vessel has extensively used sorting grids while engaged in quad-rig trawling in the past and this experience greatly assisted in smooth roll out of the fishing trial. The practicalities of using a rigid sorting grid have previously been outlined by BIM in a detailed specification of the device in a single-rig trawl set up. Deployment in poor weather or in very muddy areas may raise additional challenges for utilising grids in quad-rig versus single-rig trawling. However, deployment of grids in quad-rig trawling is also advantageous as if a potential blockage due to entanglement of fish or debris occurs in one grid, the other grids/nets will continue to fish. The reinforced opening in the top of the *Nephrops* sorting grids also performed well with no buckling reported.

The *Nephrops* sorting grids performed well, achieving substantial reductions in small Nephrops while retaining fish catches. Differences in catches of small *Nephrops* between the two *Nephrops* sorting grids can be explained by the larger cod-end mesh size of 75.1 mm in NSG1 compared with 70.1 mm in NSG1. Larger cod-end mesh sizes are known to catch proportionally less small *Nephrops* (Cosgrove *et al.*, 2015). Results suggest that some smaller *Nephrops* passed over the *Nephrops* sorting grids into the cod-ends where they had a greater chance of escapement in the larger meshed cod-end. Hence further reductions in catches of small *Nephrops* can be expected if larger cod-end mesh sizes e.g. 80 mm are deployed in conjunction with a *Nephrops* sorting grid.

Most of the losses of marketable *Nephrops* in the *Nephrops* sorting grids occurred for *Nephrops* <= 31 mm CL which are normally tailed and are of substantially lower value compared with larger grades of *Nephrops*. Cosgrove *et al.* (2015) modeled the economics of reduced catches of similarly sized *Nephrops* in an 80 mm cod-end compared with a 70 mm cod-end over the course of a fishing season. They found that reduced catches of such *Nephrops* afforded an extra opportunity to catch increased quantities of larger more valuable *Nephrops*, resulting in an increase in profitability over the course of a fishing season. Further reductions in small *Nephrops* using a *Nephrops* sorting grid are likely to afford additional opportunity to catch larger more valuable *Nephrops* resulting in further improvements in profitability over the course of a fishing season.

The occurrence of *Nephrops* sliding over the bars and out of the escape hole is likely a major factor contributing to losses of large *Nephrops* from the Swedish grid. A number of measures may have potential to deal with this issue. A small gap at the top of the grid may assist in retaining *Nephrops* while continuing to guide unwanted fish species out of the escape hole. A further hole in the top panel of the net to the rear of the grid could provide an opportunity to *Nephrops* which escape the trawl to re-enter, with potentially minimal impact on more buoyant fish species. A small net panel or lip at the top of the grid could also assist in retaining *Nephrops* while permitting fish to escape. Species such as skates and rays could pose problems in the case of the latter approach and all of these measures require further assessment.

There is no evidence that the *Nephrops* sorting grids assisted in reducing catches of small fish, while the Swedish grid reduced fish catches across all size classes. Utilisation of the gap in the bottom of the Swedish grid is potentially problematic in relation to bycatch of skates and rays and other species such as cod. It was not possible to determine the effect of this gap on catches of cod due to a lack of such fish on the fishing grounds during the current study (Figure 5). It should be noted however that this gap is not permitted in Sweden, where rigid sorting grids are widely in use, due to fears of increased mortality of cod (Valentinsson and Ulmestrand, 2008). It will not be possible to incorporate such a gap in the *Nephrops* sorting grid, as this would result in large reductions in *Nephrops* catches.

Conclusion

The *Nephrops* sorting grid worked well in that it substantially reduced catches of small *Nephrops* while retaining fish catches without any major device integrity or handling issues in the quad-rig trawl setup. Utilisation of the *Nephrops* sorting grid in conjunction with larger cod-end mesh sizes such as 80 mm should result in further reductions in catches of small *Nephrops*. The device is likely to be particularly beneficial in optimising the size of *Nephrops* catches with a view to maximising profitability over the course of a fishing season. Under the LO, most of the small *Nephrops* which were formally discarded are legally required to be landed from January 2016. Hence, any reductions in below MCRS or small marketable *Nephrops* (tails) are likely to be offset by increased opportunity to catch more valuable, larger *Nephrops* over the course of a fishing season (Cosgrove *et al.*, 2015).

Depending on the species and scale of the problem, *Nephrops* vessels that have issues with unwanted catches of fish species could use a 300 mm SMP to the rear of the *Nephrops* sorting grid. This additional measure should result in major reductions in catches of gadoid fish species across all size classes while potentially retaining catches of valuable species such as monkfish (BIM, 2014a) with little impact on catches of marketable *Nephrops* (BIM, 2003; BIM, 2014a). As the 300 SMP retains a portion of fish catches across all size classes, some below MCRS fish will continue to be retained. These catches will fall under the landing obligation which will result in some of these catches being deducted from vessel quotas, potentially resulting in associated losses in profitability.

Unfortunately no technical conservation measure is currently available which can retain catches of marketable *Nephrops* and fish while effectively mitigating below market size catches of these species. Results of the current study suggest that it is possible to optimise *Nephrops* catches while eliminating catches of juvenile and/or low quota fish species by using a 'composite' sorting grid with 15 mm spacing in the bottom and 35 mm spacing in the top half of the grid. This type of device is likely to be particularly beneficial in situations where Nephrops vessels are affected by low quota for fish species. Further work to assess the catch composition, measures to reduce losses of marketable *Nephrops,* and the economics of the composite grid is planned in 2016.

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