Review of alternative measures; Northern Nephrops trawl fisheries

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# Executive Summary

This review covers measures, designed to reduce bycatch of principally whitefish species cod, haddock and whiting in Nephrops trawl fisheries, tested and implemented over the past 20 years. Thirty-two trials are reviewed and documented in the accompanying spreadsheet and their results are discussed in this document. All of these trials have been carried out on commercial vessels with the result that the viability and benefits in terms of selectivity and improvements in quality of the catch have been assessed under commercial. Eight of the measures derived from the trials have been introduced as legal selectivity options within the fisheries. There are links to the information sheets on each trial and the Seafish gear database for more information.

The review covers preselection measures, where the fishing strategy and/or design of trawl means that the fish do not enter the gear, and post selection measures, where the gear is designed to enhance the fishes’ ability to escape once inside the gear:

* Preselection measures include introduction of a real time reporting system for certain bycatch species, which is designed to enable fishers to avoid areas of high bycatch through real time closures, to the design of the trawl with reduced headline height and other features to avoid fish entering the trawl.
* Post selection measures include the statutory requirements for square mesh panels, and an enhanced version of the square mesh panel known as the ‘SELTRA box’ which includes a selective section placed close to the cod end, and various grids or inclined separator panels, designed to direct the fish away from the Nephrops and either select them in a larger cod end or out of the trawl altogether.

Selectivity effects varied by species and size ranges within species. The effects of the measures varied between species and could be related to the differences in fish behaviour. Haddock and whiting tend to respond to the trawl by swimming upwards in the trawl mouth in response to the ground gear and hence are more likely to escape over a low headline height trawl or through square mesh panels in the forward part of the trawl. Cod enter the trawl closer to the seabed and tend to drift slowly back towards the codend staying stationary in the trawl for long periods of time. They have been observed to rise, but their rate of ascent was slower that the other gadoids and further aft (towards the rear) in the trawl compared to other gadoids. There is ongoing research into innovative methods, such as the use of light to stimulate fish to enhance selectivity.

The review discusses further work which could be carried out to understand which of the measures are currently in use in the trawl fisheries that catch the bycatch stocks in the different regions, and further analysis of stock assessment. Also, an analysis of commercial catch and research survey data to build an understanding of where and when the use of these measures may be most beneficial both in Nephrops trawl and other fisheries. This information could be used by regional management groups such as the Fisheries Management and Conservation Group (FMAC) to devise and promote appropriate measures to reduce bycatch in regional trawl fisheries.

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# Introduction

The MSC Fisheries Assessment Methodology requires that fisheries adequately take into account the MSC Principles & Criteria, in relation to gear selectivity, namely that fisheries should:

“**make use of fishing gear and practices designed to avoid the capture of non-target species (and non-target size, age, and/or sex of the target species); minimise mortality of this catch where it cannot be avoided, and reduce discards of what cannot be released alive”** (Criterion 3B.12).

In addition, FAO (1995), states that;

“selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to conserve the population structure and aquatic ecosystems and protect fish quality. **Where proper selective and environmentally safe fishing gear and practices exist, they should be recognized and accorded a priority in establishing conservation and management measures for fisheries.”**

To ensure this, the MSC has recently added a “Review of alternative measures” to several performance indicators to encourage the development and implementation of technologies and operational methods that minimise mortality of unwanted catch or ETP species”, the desired outcomes being:

* To motivate fishers to continually “think smart” about their impact on the environment (species and habitats); both in delivering the sustainable impact most efficiently - and continuing to reduce their impact beyond that.
* To balance this desire with efficiency by not spending a lot of money and time generating only marginal improvements.

To achieve this for species, the scoring issue has been added to the P1 Harvest Strategy (PI 1.2.1) and P2 Species Management PIs (PI 2.1.2, 2.2.2, 2.3.2 see Table 1) requiring fisheries to continually review alternative measures to encourage the development and implementation of technologies and operational methods that minimise mortality of unwanted catch or ETP species, taking into account the practicality of the measures, their potential impact on other species and habitats and on the overall cost of implementing the measures.

Fisheries need to either review alternative measures that are shown to minimise mortality of the species or species group in question. Fisheries also need to consider alternative measures to reduce impacts on habitats. Fisheries should also take account of the potential for both positive and negative impacts of alternative measures on species and habitats when considering whether such measures should be implemented.

Alternative measures should avoid capture of the species in the first place or increase its survivability if released. Alternatively, in the case of in-scope species, they could utilise the unwanted catch in some way so that it would no longer be ‘unwanted’. If there are no unwanted species, the scoring issue on reviewing alternative measures does not need to be scored in that PI.

**Alternative Measures Definition:** Fishing gear and practices that have been shown to minimise the rate of incidental mortality of the species or species type to the lowest achievable levels.

**Alternative Measures Scoring** **Guideposts;**

**SG 60** There has been **a review** of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock/secondary species/ ETP Species.

**SG 80** There is a **regular** review of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock/secondary species/ ETP Species and they are implemented as appropriate.

**SG 100** There is a **biennial** review of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock/secondary species/ ETP Species., and they are implemented, as appropriate.

Table 1 Tabulation of scoring guideposts

|  |  |  |
| --- | --- | --- |
| **Performance indicator and scoring issue** | **Species group** | **Comment** |
| 1.2.1 Harvest strategy f | Target species | Almost all trials report effect of Selectivity devices on Nephrops |
| 2.1.2 Primary species management strategy e | Main species | Varies by Functional Unit; see Main Bycatch species tab on Nephrops\_Bycatch\_researchV329072021.xls. |
| 2.2.2 Secondary Species management strategy e | Secondary species |  |
| 2.3.2 ETP species management strategy e | ETP species | Only ETP species mentioned here is spurdog. ETP information to be added |

# Method

In this review a search was carried out for all measures for fish bycatch reduction using technical measures in Nephrops trawl fisheries, which directly control the design and deployment of the gear, including selectivity devices and mesh sizes and also seasonal and area closures applicable to the main bycatch species in Nephrops trawls.

The sources were the EU discardless website (<http://www.discardless.eu/selectivity_manual>) and research and development organisations, [Seafish gear database](https://www.seafish.org/responsible-sourcing/fishing-gear-database/), [SFF GITAG](https://www.sff.co.uk/gitag-2/) and the [Northern Ireland gear trials](https://www.facebook.com/nigeartrials) and also the scientific literature. The results are listed on the Measures and trials tab on the accompanying spreadsheet; Nephrops\_Bycatch\_researchV329072021.xls.

The columns on this spreadsheet are as follows:

* Author and date; this is used to identify the trials in the review below
* The type of measure, whether it is a legal requirement or option or other measure
* Whether the measure is designed to select the fish before they enter the gear; preselection or after entry; post selection.
* The region where the trial was carried out
* The type of gear and size of vessel (where available) used in the trial
* The experimental mechanism being tested, and the control gear used as separate columns
* Selection changes in terms of percentage difference in weight by species above and below the minimum conservation reference size (MCRS) or other size grouping where the information is available.
* Any note from the authors in relation to selection by species
* The type of management for each species examples; Quota, MCRS, Landing obligation, prohibited, none.
* A brief summary of the trial results, merged across the species where appropriate
* Links to the trial summary and the appropriate page on the Seafish gear database.

As the spreadsheet can be filtered by any of these columns to enable easy reference to trials that are effective for example the different species.

Not all authors indicate the level of statistical significance using p values, but if they state that they had a reduction of a given species in the summary factsheet without a caveat, this was taken as sufficient indication of statistical significance. However, it is recommended that source papers be obtained if further action is to be taken based on this review. The controls used for the different trials are not always the same, so the percentage reductions shown are not directly comparable between trials; see below. In order to aid guidance on how many hauls are required to establish a statistically valid result, statistical power calculations using data from previous trials would be useful.

# Results

The results indicate that the issue of bycatch in *Nephrops* trawls has been a major topic of research in European waters over the past 20 years. Around 32 trials are documented on the spreadsheet with eight of these now a legal requirement or option in at least one part of the Northern *Nephrops* region (another eight are in place but the original experiments are not yet documented in this set).

## Types of bycatch avoidance measures

These can be divided into pre and post selection measures. Preselection measures (coloured light blue on the spreadsheet) are measures designed to select the fish before entry to the gear and post-selection measures (coloured dark blue on the spreadsheet) are modifications to the gear which select the fish once it is inside the gear.

## Preselection

These measures are designed to avoid the fish entering the gear, by avoiding setting gear where there are known concentrations of bycatch species or designing gear which takes advantage of behavioural differences between species to select against the bycatch species. The methods have the advantage that contact between the gear and the fish is minimised. There may be a small energy cost to the fish in avoiding the trawl.

### Regional avoidance schemes

#### North Sea

Recently specific measures for [cod avoidance](https://www.gov.uk/government/publications/uk-national-north-sea-cod-avoidance-plan) measures have been implemented in the UK EEZ to avoid catching an abundance of cod. These include, spawning closures, real time reporting (RTR) real time closures (RTC) triggered by an abundance of cod in the catches, use of a minimum mesh size of 120 mm in all areas of Scottish waters except for muddy areas where Nephrops is targeted, encouragement to use selectivity measures further than the measures in place and to use remote electronic monitoring of catches to aid quota management. Whilst spatial measures are difficult to quantify, previous experience of using spatial measures such as RTCs (particularly during the Cod Recovery Plan) demonstrates that such measures can have an observable effect on cod mortality and biomass.

These measures cover UK vessels and EU vessels fishing inside the UK Exclusive Economic Zone.

#### West of Scotland

In the West of Scotland a programme of real time reporting of catches of cod, whiting and spurdog is being developed. Software has been developed (see [Fisheries Innovation Scotland](https://fiscot.org/trial-of-fisheries-bycatch-reduction-tool-on-the-west-of-scotland-new-app-now-available/)) to enable the fishers to pool information on high levels of catches of these species, to enable other fishers to avoid ‘hot spots’ of these species.

#### Irish Sea

The Northern Ireland fishing industry, via its two producer organisations are in the process of advancing a project that is aiming to develop a tool that will allow vessels to communicate occurrences of unwanted catch between each other. At this stage, the NI industry is in discussions with prospective software/ app developers and will seek to have formal discussions with individual skippers once social distancing restrictions are eased.

### Gear technology for preselection

In Nephrops trawl fisheries most of the research into pre selection measures has been carried out on reducing the [headline height](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/headline-height/) from around 2 metres to around 1 metre in order to exploit the Nephrops’ closer proximity to the seabed compared with fish and/or the use of [coverless trawls.](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/coverless-trawls/) The ‘cover’ of trawl is the area of the top panel which extends forward of the lower panel and footrope designed to prevent the escape of fish upwards ahead of the gear. Designing the gear without this feature provides a potential escape route for the fish.

Experiments have also been carried out on multi rigged trawls, comparing one half of a [quad rig trawl set up (](https://www.seafish.org/responsible-sourcing/fishing-gear-database/gear/multi-rig-quad-rig/)two trawls) with half of a twin trawl (one trawl) (BIM 2014b). The quad rig resulted in lower fish catches and higher Nephrops catches (see below). Lower fish catches in the quad rig may be related to such pre-selection features as lower headline height (see section 4.2), reduced sweep length, a narrower fishing circle and altered herding effects in the quad compared to the twin-rig. Increased Nephrops catches in the quad-rig may be related to improved ground contact, an altered sweep arrangement ahead of the nets or other differences in the performance of trawls.

#### Haddock and whiting

There is evidence that these species can be selected against by a reduction of headline height and/or coverless trawls. However, the results for these species vary across the length range, with some authors reporting a reduction in these two species across the length range (Dunlin and Rees, 2003) whilst for others most of the reduction in the larger fish above MCRS (Kynock et al 2011). Recent work by Northern Ireland gear trials (Northern Ireland Gear trials 7) indicates that coverless trawls can reduce the catch of smaller whiting (10-14 cm) whilst retaining larger (19-28 cm). However, almost all of these size ranges are below the MCRS of 27 cm for whiting.

The results for quad rig compared with twin rig for these species vary between the trials carried out in the Celtic Sea (BIM, 2014b), where there was a significant reduction in haddock in the quad rig gear but no reduction in whiting, compared with the North Sea trials (Revill et al, 2009) where whiting catches were significantly reduced in the quad rig (haddock results not presented). However, the North Sea trial did not analyse whiting catches by length group. The Celtic Sea trial does not indicate significant differential selectivity across the length groups for haddock, but it does for cod (see below).

#### Cod

Studies of selectivity of cod have been hampered by small numbers of cod encountered.

Kynock et al., (2011) comparing a 2 m and 1 m headline height trawls in a parallel haul twin rig configuration found no significant difference between the cod catches in these two trawls. The studies in the Celtic (BIM, 2014b) and North Seas (Revill et al., 2009) both found substantial reductions in cod in quad rig compared with twin rig (61% and 46% by weight respectively). However, the Celtic Sea study found that the reduction was very length dependent. Small cod are retained in proportionately greater numbers in the quad rig compared with larger cod compared with the twin rig (see Figure 1). Quad-rig may be more efficient at catching juveniles of certain fish species as was the case was the case for cod in this study. Higher proportions of smaller fish and Nephrops in the Quad-rig raise some concerns in relation to the Landings Obligation and stock conservation.

However, the North Sea study did not observe this effect with equal reductions of cod across the whole length range (<20 cm to 70+ cm).

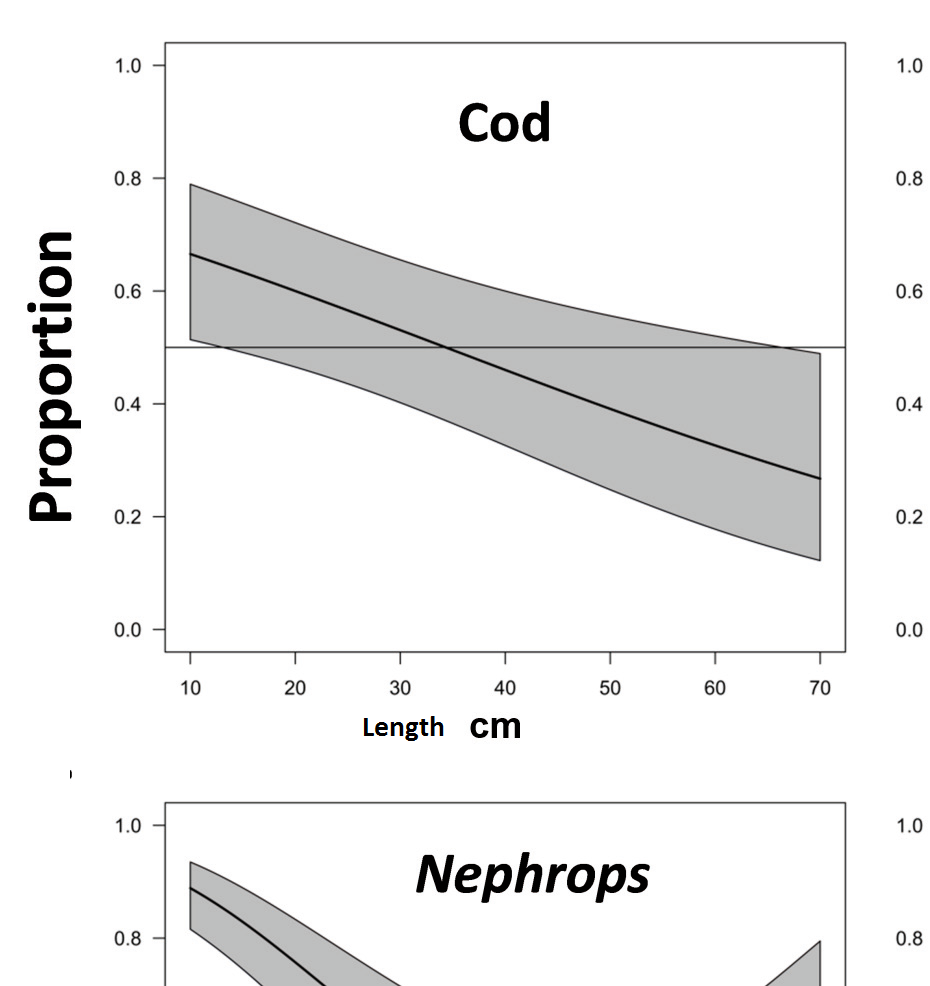


Figure 1 Catch comparison curves for cod comparison between quad and twin rig. Observations that fall on the 0.5 line indicate that the proportion caught in each of the gears is equal. Observations above the line show that more fish are caught in the Quad-rig and observations below the line show that more fish are being caught in the Twin-rig. Grey shaded areas either side of the curve illustrate the 95% confidence limits (from BIM 2014b).

#### Nephrops

With the exception of Kynock et al., (2011) all the preselection trials caught either more than or equal quantities by weight of Nephrops when compared with the control;

* Norther Ireland Gear trials 7 coverless trawl caught 140% more Nephrops than the control.

* Dunlin and Reese, (2003) reduced headline height and coverless trawl caught equal quantities of Nephrops in the experimental gear compared with the control
* Revill et al., (2009) caught 95% more Nephrops in the ½ quad rig compared with the ½ twin rig
* BIM (2014b) caught 54% more Nephrops in the ½ quad rig compared with the ½ twin rig

However, a length-based analysis showed that the additional Nephrops caught in the quad rig (BIM 2014b) were small; see Figure 2.

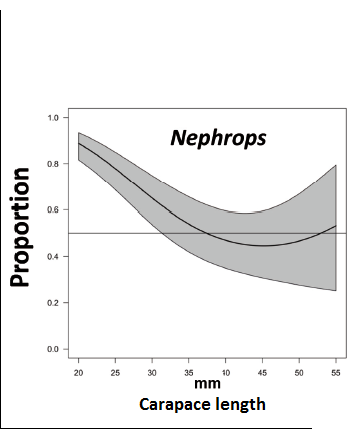


Figure 2 Catch comparison curves for Nephrops comparison between quad and twin rig. Observations that fall on the 0.5 line indicate that the proportion caught in each of the gears is equal. Observations above the line show that more fish are caught in the Quad-rig and observations below the line show that more fish are being caught in the Twin-rig. Grey shaded areas either side of the curve illustrate the 95% confidence limits (from BIM 2014b).

These results indicate that reducing the quantity of fish caught in the trawl through preselection methods does not always imply a loss of Nephrops and some designs catch more Nephrops. However, there is likely to be some work required to tune the trawl effectively to ensure that it catches and retains Nephrops efficiently (Dunlin, pers com).

#### Other species

The main resource species reported in these trials are cod, haddock, whiting and Nephrops. Other species are tabulated, for example hake were reduced by 42% in the quad rig compared with the twin rig experiment (BIM, 2014b).

## Post selection

These are divided into legal requirements or options and experimental devices.

### Legal requirements and options

The legal requirement under [EU 2019/1241](https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1241&from=EN) is for a minimum mesh size of for directed fishing for Nephrops (Norway lobster) at least 80 mm mesh with square mesh panel of at least 120 mm or sorting grid with a maximum bar spacing of 35 mm or equivalent selectivity devices as legal options fitted. For UK vessels cod end twine diameter is also regulated at a maximum of 4 mm diameter for double twine and 6 mm for single twine.

The legal options (see links to Seafish gear database for further information) are as follows;

* The [SELTRA box](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/seltra-box-square-mesh-panel/)  which is a section of the extension of the trawl with four seams to form a box shaped section, with a top panel of either a large diamond mesh (the 270 mm SELTRA) or large square mesh (the 300 mm SELTRA) to encourage small fish to escape from a trawl before entering the cod-end.
* The Swedish grid, an inclined ridged grid which deflects fish upwards through an aperture in the upper panel forward of the cod end, whilst the bar spacing allows Nephrops to pass into the cod end. Although available as an option, these gears are not much used by UK and Irish boats because of handling issues.
* [Inclined netting grids and panels of netting](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/inclined-netting-grids/) fitted inside a trawl set at an angle so that it guides certain species upwards through escape panels or into an upper cod end with a more selective configuration and allows other species to pass through the panel meshes and into the codend. Several different designs (see [Amity net grid](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/amity-net-grid/) and [Cefas net grid](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/cefas-net-grid/) and the [Faithlie Cod avoidance panel](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/f-cap-faithlie-cod-avoidance-panel/)) have been developed to suit different fisheries. The [Flip-Flap design](http://halieut.agrocampus-ouest.fr/gears/images/composition/pdf/106.pdf) incorporates several specific features. These are (i) the 160 mm mesh size netting in the top wing and top sheet netting panels; (ii) the flip-flap netting grid and fish outlet hole and (iii) the 200 mm square mesh panel fitted forward of the fish outlet hole; for full details see Marine Scotland Science (2012c).
* [Inclined separator panels](https://www.seafish.org/responsible-sourcing/fishing-gear-database/selective-device/inclined-separator-panels/) are designed to separate the catch of into bottom living species (that is Nephrops) and species which swim higher (that is whitefish such as cod, haddock and whiting) in the water column and direct them into two separate cod ends. The separate cod ends can be different mesh sizes which enables the two sections of the catch to be selected independently in the two cod ends. If the vessel is short of quota for whitefish, the upper cod end can be left open.

The experimental trials using these approaches are reviewed by species below;

#### Cod

The 300 mm SELTRA four panel sorting box set three metres from the cod end has been shown to be more successful than the control 300 mm square mesh panel set nine metres from the cod end (Tyndal et al., 2017) at selecting cod, with the reduction in cod catch by weight in the SELTRA being 81% in the SELTRA compared with the control.

Flip-Flap gear (Marine Scotland Science 2012c) has also been shown to reduce catches of cod by 73% by weight when compared with a standard scraper gear fitted with a 130 mm square mesh panel 12-15 m from the cod line. The selectivity was length dependent with larger fish selecting better than smaller fish. At the minimum landing size (MLS) of 35cm there is a 33% reduction by number, and at 87cm (maximum size analysed) the reduction is 76% in comparison with the standard gear.

The Faithlie Cod Avoidance inclined separator panels Panel (FCAP) (Marine Scotland 2012 a,b) showed effective reductions in cod catches by between 62% for the larger and 35% and smaller outlets. The Amity Selector Panel trawl has proven successful at separating whitefish including cod from Nephrops (SFF ND) and the upper cod end size has been found to be optimal at 110 mm mesh (GTAG, 2020a) although other upper cod end mesh sizes could be used.

Swedish grids (BIM, 2015a; Marine Scotland Science, 2010) successfully reduced cod catches by 100% compared with standard gear (70 mm mesh cod end with a square mesh panel).

### Haddock and whiting

The legal options, the SELTRA 300 mm sorting box (Tyndall et al., 2017), Swedish grid (BIM, 2015a; Marine Scotland Science 2010), the inclined netting grids (Marine Scotland Science 2012a,b,c) and the inclined separator panels all showed reductions in these species when compared with the controls they were tested against. The only exception is the SELTRA270 mm + 90 mm Square Mesh Panel (SMP) compared with the control 300 mm SMP positioned 9-12 m from the cod end (Northern Ireland gear trials 2) which showed no reduction in whiting (haddock not measured).

### Nephrops

With the exception of the Faithlie cod avoidance panel (Marine Scotland Science 2012 a,b) where the effect of the panel on Nephrops catches was not measured, none of the legal option gears are reported to have lost more than 4.5% of Nephrops compared with their respective controls. The SELTRA 300 mm sorting box (Tyndall et al., 2017) is reported as increasing the catch of Nephrops above the MCRS (20 mm), with decreases in catches of Nephrops below the MCRS by when compared with these gears.

### Other species

The main aim of most of these trials was to reduce the catches of cod, haddock and whiting, but some trials reported reductions in catches of other species. The SELTRA 300 mm sorting box was considered not to be selective for anglerfish on the grounds of the size of this species but reported as reducing catches of lesser spotted dogfish by 75% when compared with a 300 mm square mesh panel (SMP) control and 91% compared with a non SMP control. Commercial flatfish were reduced by 55% for 300 mm SMP and 69% for non SMP controls respectively (Tyndall et al, 2017).

## Experimental gears

### Grids, coverless trawls, SELTRA

Montgomerie and Briggs (2012) tested a series of devices in single and twin rig trawls in the Irish Sea including variations on the Swedish Grid, four panel 'SELTRA' style codends, coverless trawl, and a plastic grid, compared with the statutory gear in use at the time.

The main criterion for success was to reduce cod catches, but also the study reported issues with gear handling; suitability of grids for use with net drums and other aspects, and issues with blocking of the grids by seabed debris and larger fish, causing losses of Nephops. The variant found most effective was the SELTRA four panel codend extension with square mesh in the top panel. This is the approach taken in Tyndall et al., (2017) in the trials reported above.

### Cod end configurations

#### Haddock, whiting and Nephrops

Marine Scotland (2015) compared three mesh sizes on a standard Nephrops trawl in West of Scotland waters;

* 80mm diamond mesh codend of 4mm single PE twine,
* 100mm diamond mesh codend of 5mm double PE twine, and
* 120mm diamond mesh codend of 5mm double PE twine

Increasing mesh sizes reduced discards of Nephrops, haddock and whiting. For Nephrops: in the 80mm mesh codend most selectivity occurs over the lower size range (< 38mm); in the 100mm codend some selectivity also occurs over 39-47mm size range; and in the 120mm codend catch reduction occurs across the full length range.

Reductions in whiting catches have been reported due to reducing the meshes round from 120 to 80 in an 80 mm cod end, reducing the cod end circumference. Smaller whiting were most affected with a 14% reduction. However, there was a 14% reduction (by weight) in the Nephrops catch (BIM 2018a).

Increasing the cod end mesh size from 80 to 90 mm with a corresponding decrease in the number of meshes round produced conflicting results. BIM (2018b) using quad rig on a large 23.5 m vessel found a reduction in weight of whiting catches of 47% above the MCRS and 60% below 20 cm, with 33% reduction in Nephrops catches. In contrast NI gear trails 1 comparing the same cod ends on a twin rig 14 m vessel found a 51% increase in whiting catches, but a similar 31% reduction in Nephrops. The results of the experiments on smaller (< 10 m vessels) were similar to the results obtained by BIM (2018b). Whilst the reduction in catches in Nephrops in these three trials is likely to preclude implementation of this measure, this does illustrate the need to take into account possible anomalies and variations between vessel sizes and power.

Removing the lifting bag from 110 mm and 120 mm codends reduces the catches of smaller sizes of haddock (Marine Scotland Science, 2004). There is no effect on the large haddock sizes ranges (> 42 cm), and no information on Nephrops.

#### Other gear configurations

Three other configurations have been tested;

* A modified Nordmore grid (BIM 2015c) using a 70 mm codend. There was a reduction in the catches of small Nephrops, but no reduction in fish
* An increase in the mesh size of the whole trawl from 80 to 120 mm (GTAG 2020b). In this case the only fish species to show a reduction was dab, the results for cod, haddock and whiting being not significantly different. There were substantial reductions in whole Nephrops and Nephrops tails.
* A full-length separator trawl included in a rock hopper gear. There was insufficient separation of the round fish species from Nephrops to make this worthwhile (GTAG 2020c)

#### Lights

Three sets of experiments have been reported;

1. Young’s (2016) carried out a scoping study in the Farn deeps fishery in 2016 in which 4-6 LED light rings (<https://sntech.co.uk/>) where six of the light rings were secured to the perimeter of the square mesh panel. The theory is that the lights around the square mesh panel improve the fishes’ ability to detect the panel and that the smaller fish escape out of the panel

[Sntech are continuing trials on bycatch reduction in Nephrops trawls](https://sntech.co.uk/blog/asl-ms-youngs-and-sntech-partner-up-to-support-british-fi%5b…%5dersal-fishery-towards-bycatch-reduction-and-msc-certification/).

1. Southworth et al., (2020), using queenie trawls in the Isle of Man fishery, compared both LED lit around the perimeter of the 300 mm square mesh panel and unlit square mesh panels with a diamond mesh control net towed in parallel. A total of 58 paired (116 tows) were undertaken on two grounds, one of which was relatively shallow at 29-40m and the other at 45-90m. In this fishery, the effect of lights appears to be related to depth, with a significant reduction in haddock catches occurring in deeper waters when the square mesh panel was illuminated.
2. NI Gear trials 3 and 5, tried two variations of LED lights. Using a SELTRA 270 in a twin rig configuration and 15 green lights on the belly of the trawl, designed to induce the fish to swim upwards resulted in a 200% increase in catches of whiting and a 16% increase in catches of Nephrops. Use of 15 blue lights in an inclined netting grid resulted in a loss of Nephrops and whiting of 26% and 35% respectively.

These results indicate that there is some response to light, particularly at depth, but that there is a need for a better understanding of the behavioural response of the bycatch and target species to the lights used, which would aid the approach to design of these experiments. [ICES WGFTFB (2020)](https://doi.org/10.17895/ices.pub.8022) are building a community of researchers who are using light as a fisheries selectivity tool and develop resources to support this research and aggregate and synthesize global information on this subject.

### Effects on catch handling and quality

Reducing the proportion of fish mixed together with Nephrops in the catches either through the use of a coverless trawl (Jacklin, 2005) or a SELTRA (Tyndall et al., 2017), improves working conditions for the crew by reducing sorting times and improving quality of Nephrops.

# Discussion

These results are discussed in terms of the implication of pre-selection on the comparative trials discussed in this review, and in terms of the behaviour of the species studied. The main drivers behind this research have been the requirement to control bycatches of cod under the cod recovery plans, and the overall incentive to reduce discards under the landing obligation.

## Implication of pre-selection

These results show clearly how the different designs of trawl vary in the way in which they preselect the catch before it reaches the cod end. This is particularly marked where quad rig is compared with twin rig, but it would also apply when a coverless and/or low headline height trawl was used. Therefore, a selective device used in a twin rig trawl may produce a different catch composition when used in a quad rig trawl, because the catch composition of the fish entering these two types of trawls is likely to be different. The presence or absence of a square mesh panel forward of selective devices in the cod end is likely to have a similar effect.

These factors, and the use of control configurations and vessel specifications which can vary between areas mean that experimental configurations which work in one area may not perform in the same way in another.

## Fish behaviour

To achieve differential selection of fish and shellfish species in the catch differences in behaviour of these species can be exploited. Krag et al., (2014) review the literature on differential behaviour in the of whitefish and Nephrops in trawls. The main distinguishing features are;

* Nephrops use most of their energy in in front of the trawl, trying to outswim the trawl using rapid tail flips. Once in the trawl body they tend to adopt a more passive behaviour and can be observed rolling along the lower panel of the trawl.
* Haddock, whiting and saithe tend to swim upward to rise above the ground gear in the trawl mouth.
* Cod and flatfish tend to enter the trawl closer to the seabed. The rather limited observations of cod in trawl nets indicates that they drift slowly back towards the codend staying stationary in the net for in the net for long periods of time. They have been observed to rise as the other gadoids do but their rate of ascent was far slower and further aft in the trawl compared to that of other gadoids.

Coverless and/or low headline height trawls have been generally more successful for reducing haddock and whiting catches than for cod. This is consistent with the behaviour of cod discussed above. However, for quad rig where headline height would be expected to be lower (about 80 cm for quad rig compared with 130 cm for twin rig for gear used by Northern Ireland vessels Ben Collier pers com) there appears to be selection in favour of smaller cod and against larger cod, suggesting a length based escape response or stratification, with smaller cod being closer to the seabed and/or less likely to escape.

The success of the SELTRA four panel sorting box in reducing cod catches when compared with a square mesh panel further forward in the trawl is also consistent with the observations that the cod tend to delay their escape response until further aft in the trawl. The inclined netting grids, Swedish grid and inclined separator panels are designed to select whitefish close to the cod end and have been shown to be successful for cod, haddock, and whiting.

## Application to Northern Nephrops fisheries

The spreadsheet tab ‘Main bycatch species by FU’ highlights the main bycatch issues as defined by the MSC standard for main species, distributed by Functional Unit (mean 2018-2019). Several factors contribute to this distribution:

* The spatial distribution of the stocks. The distribution of stocks may change in response to variation in environmental factors such as temperature, and density dependent processes where stocks may expand or contract their range in response to changes in their abundance (example Zengguang et al., 2018).
* The spatial distribution of fishing, which is likely to vary from year-to-year dependent on the abundance of the Nephrops stock and other factors.
* The status of the stocks and the availability of quota for the bycatch species.
* The enforcement of the management measures such as the landing obligation.
* The gear designs in use within the fisheries on these stocks, including those mitigation measures designed to reduce bycatch, as reviewed in this report.

Therefore, the imperatives for bycatch reduction may vary over time in the various regions. Also, in there are other fisheries exerting mortality on these bycatch species. To design a regional approach to bycatch reduction, there is a need to understand, for each region, the proportions of each bycatch stock being caught by the different fisheries.

* 1. Governance of fisheries in Scottish waters

The [Fisheries Management and Conservation Group (FMAC)](https://www.gov.scot/groups/fisheries-management--conservation-group-fmac/), which replaces the Scottish Fisheries Council (SFC), builds on the Conservation Credit Steering Group (CCSG) and is a decision-making body and discussion forum concerned with all issues connected to sea fisheries management (in Scotland). The remit of FMAC includes the development of measures designed to better conserve and sustainably exploit stocks of seafish, and to enable fishermen and other persons with an interest to contribute to such development. Indeed, it is through this process that Scottish Government have provided [updated guidance](https://www.gov.scot/publications/fishing-vessel-landing-obligation-guidance-2021/) and direction to the Scottish Fleet on an annual basis as the developing challenges of the Landings Obligation have been met.

Through this process, specific measures (technical and spatial) are considered to address challenges that are arising for the coming year and a range of potential solutions are developed. One such example is the development of a Scottish Cod Avoidance Plan which contributes to the [UK Cod Avoidance Plan for 2021](https://www.gov.uk/government/publications/uk-national-north-sea-cod-avoidance-plan). The technical measures and sea area exemptions developed through this process are incorporated into fishing licences with effect from 1 January 2021.

Through this annual cycle, FMAC provides an opportunity for regularly reviewing measures that are relevant to Fishery Improvement Plans

# Conclusions

This review has revealed the extent of scientific and technological research and development which has taken place over the past two decades to find means to reduce catches of whitefish in demersal trawl fisheries for Nephrops. The main drivers behind this research have been the requirement to control bycatches of cod under the cod recovery plans, and the overall incentive to reduce discards under the landing obligation.

Key findings of this review are;

* Many of these gears have proved successful in reducing bycatches of cod, haddock and whiting, and there is now a clear body of knowledge of fish behaviour in relation to the selectivity trawls and some of the gears developed are included in legislation. There is ongoing research into innovative methods, such as the use of light to stimulate fish to enhance selectivity.
* Because most of the research has been carried out on commercial fishing vessels, the practical and commercial viability of the various methods is well described. The research has also found improvements in quality of the catches and speed of handling on deck when using gears designed to improve selection.
* The levels of bycatch and species composition are likely to vary between regions and from year to year. Other fisheries interact with the bycaught stocks. For these reasons there is a need to build an approach to mitigation of bycatch into regional plans for the fisheries, reviewed on a regular basis as in the UK Cod avoidance plan. As a first step it would be useful to gain an overview of the types of mitigation measures in use in the different regions.

# Further work

This study has identified several successful measures which have been designed and implemented in the Nephrops trawl fisheries to reduce bycatch, particularly cod, haddock and whiting. It is suggested that further information be gathered on a regional basis:

* To understand how these measures are used it would be useful to gather information on their uptake within the fisheries. A survey of the via questionnaire to find out which gears and mitigation measures are in use, and what factors may act as incentivise or disincentives to use these gears.
* Further analysis of stock assessment, commercial catch and research survey data to build an understanding of where and when the use of these measures may be most beneficial both in Nephrops trawl and other fisheries.

This information could be used by regional management groups such as the Scottish Fisheries Management and Conservation Group (see above) to devise and promote appropriate measures to reduce bycatch in regional trawl fisheries

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