Assessment of a dual codend with net separator panel in an Irish *Nephrops* fishery

Fisheries Conservation Report

December 2016

BIM Ireland's Seafood Development Agency

Assessment of a dual codend with net separator panel in an Irish *Nephrops* fishery

Ronán Cosgrove[1], Daragh Browne[1], Peter Tyndall[1], Matthew McHugh[1], Martin Oliver[1], Coilin Minto[2], Brian Burke[2], Mike Montegomerie[3]

Key Findings

Catches of undersize whiting and haddock in the dual codend with net separator panel were reduced by 72% and 49% respectively compared with a standard trawl. 1

Aside from a 37% reduction in marketable whiting, no reductions of marketable catch occurred for any other species. 2

Separation of key retained fish species by weight into the top codend consisted of 82% of flatfish, 83% of haddock, 90% of cod and hake, 94% of whiting, and 98% of monkfish. 3

Selectivity of different fish species can effectively be altered without reducing *Nephrops* catches. 4

By removing the top codend, the gear can used as a fish exclusion device when fish quotas are low. 5

Automated species separation greatly reduced catch sorting times and improved fish quality. 6

The dual codend with net separator panel has major potential to address a range of challenges posed by the landing obligation. 7

1. Irish Sea Fisheries Board (BIM), New Docks, Galway, Ireland. Email: cosgrove@bim.ie
2. Galway Mayo Institute of Technology, Dublin Road, Galway, Ireland.
3. Seafish, Origin Way, Europarc, Grimsby, N.E. Lincs, DN37 9TZ, United Kindgdom.

Introduction

A range of measures have recently been tested by BIM and the Irish fishing Industry in order to reduce unwanted catches and provide options to address landing obligation requirements in the *Nephrops* fishery.

In relation to the main target species, an increase in minimum mesh size from 70 mm to 80 mm was found to substantially reduce catches of undersize *Nephrops* (Cosgrove *et al*., 2015a), and a new regulation in that regard is due to come into force in January 2017. For fish species, measures such as the 300 mm square mesh panel (BIM, 2014), SELTRA panel, and rigid sorting grid (Cosgrove *et al*., 2016) have all been shown to substantially reduce catches of whiting and haddock while retaining *Nephrops*. However, the latter gears are not size selective i.e. they reduce catches of big as well as small fish, nor are they species selective in that valuable catches such as flatfish can also be substantially reduced.

A variety of fishing gear modifications which use a separator or guiding, panel or grid with two independent codends have been used to separate catches of *Nephrops* and fish into two independent (dual) codends, facilitating size and species selectivity in *Nephrops* trawls (e.g. Graham and Fryer, 2006; Hillis, 1983; Main and Sangster, 1985). Field trials of these devices were largely successful but were considered unlikely to be commercially adopted under a landings based management system (Graham and Fryer, 2006) where unlimited discarding was permitted. The EU landing obligation (LO) is a new catch based management policy which aims to incentivise lower levels of unwanted (undersize and over quota) catches and is gradually being phased in until 2019 when it will apply to all species subject to quotas. Discarding is highly restricted and most undersize fish subject to quotas, must be landed and counted against quotas, but cannot be sold for human consumption. Furthermore, fishing vessels may be subject to early cessation of fishing effort or "choking" once a quota for an individual species is reached. Raising major challenges for vessels across Europe, the new policy provides renewed impetus for uptake of measures such as the dual codend system which can substantially reduce unwanted catches while retaining wanted catches thereby minimising economic loss.

Working with the Scottish Fishermen's Federation, UK seafood authority Seafish recently developed a new dual codend system with a 4 panel extension piece fitted with an inclined square mesh panel leading to the codends. Field trials have initially focussed on maximising separation of *Nephrops* and fish species into the two codends with excellent results (Pers. Comm. Mike Montgomerie). In collaboration with Seafish, BIM sought to build on the Scottish Industry's good work by applying the knowledge gained from previous BIM studies to optimise the selectivity of the separated species in the two codends. Haddock in the Celtic Sea (Cosgrove *et al*., 2015b), and whiting in the Irish Sea (Poseidon, 2013) have previously been identified as key potential choke species in *Nephrops* fisheries in those areas. Hence, efforts to improve selectivity in the top codend focussed primarily on those species. Separation rates of key species into the two codends were assessed to better understand the gear's performance and potential options to deal with other species. Catch at length and catches during day and night time were assessed to examine potential length dependent or diel behavioural differences in relation to the net separator panel. Finally, practical benefits of the gear such as improved fish quality and reduced catch sorting times are discussed.

Figure 1. The trial vessel, the MFV Stella Nova

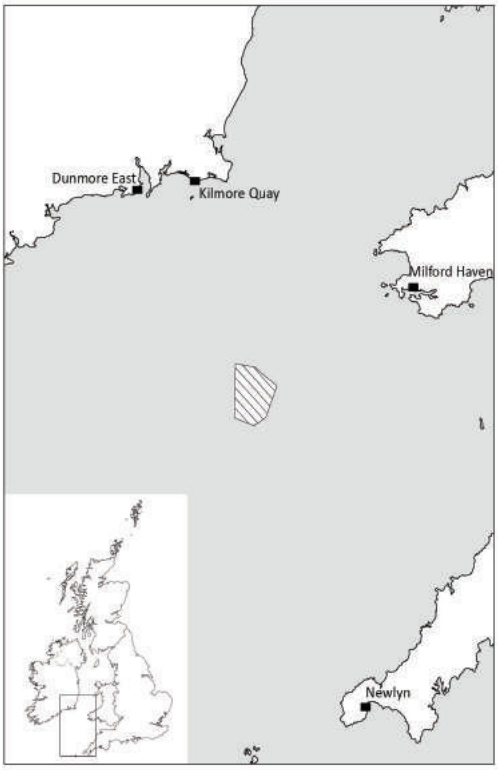

Figure 2. Trial location

Methods

Fishing operations and gear

The trial was carried out on board MFV Stella Nova, a 23.5 m multi-rig *Nephrops* trawler (Figure 1) operating in ICES Division VIIg (Figure 2). A total of 13 tows were carried out over a five-day period commencing 8th October 2016 approximating typical commercial fishing conditions with haul duration, towing speed and fishing depth averaging of 5.5 h, 2.88 kn and 106 m respectively.

The vessel engaged in quad-rig trawling but just two of the trawls were used for the purposes of the trial. Standard two-panel *Nephrops* trawls were towed using a three-warp system with a 900 kg roller centre clump and spread using Thyboron Type II otter boards. The mesh size in the top and bottom panels behind the headline and in the lower wing ends of the trawl was 80 mm while meshes in the upper wing ends were 160 mm. The trawls were fished using 50 m single combination sweeps and 20 m double bridles giving an overall sweep line length of 70 m (Table 1). Standard (control) and dual codend gear configurations were attached to the two trawls. The control gear consisted of a standard two-panel codend, where each panel was constructed using 60 × 49 meshes (length × width) of 80 mm (nominal) diamond mesh.

The dual codend consisted of an adapter section, a four-panel separator section, 2 x extension pieces, and 2 x two-panel codends. The adapter section was ~9.3 m long and used to attach the net's two-panel belly section to the four-panel separator section. The separator section was ~9.3 m long and was located between the adapter section and the extension pieces. The extension pieces consisted of 2 x ~4.5 m sections that were used to join the four-panel separator section to the two-panel codends. Each panel of the lower codend was constructed using 60 × 49 meshes of 80 mm diamond mesh, while each upper codend panel was constructed using 40 × 58 meshes of 90 mm T90 mesh. The separator section consisted of two inclined panels forming an apex, eight meshes from the top panel. The anterior inclined panel was a square mesh panel consisting of 8 × 32 meshes of 300 mm square (T45) mesh, constructed with 4 mm ø single PE twine) and fixed at ~30°. The posterior panel was 49 × 54 meshes of 80 mm diamond mesh constructed with 2 mm ø single PE twine and fixed at ~18° (Figure 3).

Using the protocol from Fonteyne *et al.* (2007), the Omega gauge was used to measure codend mesh sizes (Table 2). The dual codend and control gears were rotated once during the trial so that potential differences in fishing power associated with net position could be assessed. Further rotations were not possible due to the complex arrangement of the dual-codend gear. No square mesh panels were present to facilitate a clear understanding of the selective properties of the test gear.

Table 1. Overview of the trawl gear used during the trial

Trawl type	Quad-rig *Nephrops*
Trawl manufacturer	Pepe Trawls Ltd
Headline length (m)	37
Footrope length (m)	42
Fishing circle	420 × 80 mm
Sweep-line length (m)	50 + 20
Warp length (m)	320
Warp diameter (mm)	20
Door spread (m)	101
Door manufacturer	Thyboron Type II
Door weight (kg)	549
Clump weight (kg)	900 (roller)

Table 2. Codend characteristics

Characteristic	Control	Lower codend	Upper codend
Mesh orientation	Diamond	Diamond	T90
Nominal mesh size (mm)	80	80	90
Measured mesh size (mm)	87	87	90
Standard deviation (mm)	2.06	2.14	2.02
Codend circumference (mesh no.)	120	120	80
Single twine thickness (mm)	6	6	6

Sampling and analysis

Total catches were weighed and sorted to species level. The total weight of each commercial species was recorded in addition to the weight of a random representative subsample. The total weight of cumulated non-commercial species such as mixed flatfish, small pelagic species and crabs was also obtained. Total lengths (TL) of commercial fish species were measured to the nearest cm below while *Nephrops* carapace lengths (CL) were measured to the nearest mm below. Digital callipers linked wirelessly to a Toughbook pc were used to sample a total of 10,714 *Nephrops* out of a total estimated catch of 287,796 individuals caught during the trial.

Tables and length-frequency distributions were constructed for total estimated numbers and weights of key species caught during the trial. Due to relatively low catch rates, black and lemon sole, megrim, plaice, and turbot were combined and categorised as flatfish. Length-weight relationships available from the Marine Institute and Fishbase.org were used to estimate catch weights of key species above or below minimum conservation reference size (MCRS) for comparative purposes. It was not possible to determine rates of species separation directly from the dual codend gear due to differences in mesh configuration and selectivity in the two codends. Hence, catches in the lower codend of the dual codend gear were compared with catches in the control gear to estimate species separation rates in the dual codend. Multinomial modelling of proportional catch at length (Browne *et al*., 2015) was used to statistically assess differences in catches of key species in the three codend compartments. Development of stimulation devices such as the net separator panel aimed at improving the efficiency of selective devices should account for potential day and night differences in behaviour in relation to the fishing gear (Krag *et al*., 2010; Krag *et al*., 2016) so a day/night factor was included in the model.

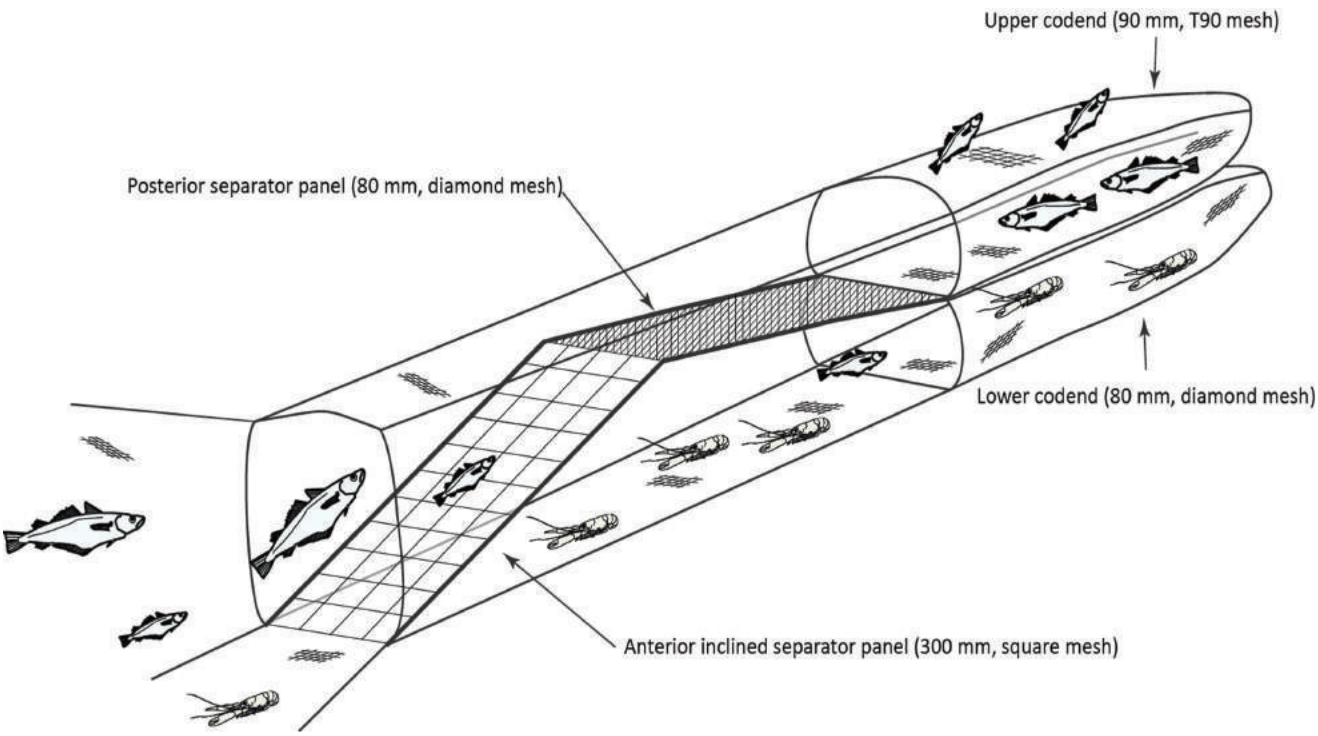

Figure 3. The dual codend with net separator panel. Illustration by Matthew McHugh, BIM

Results

The main commercial species caught during the trial were *Nephrops*, whiting and haddock, while the largest overall reductions in catches in the dual codend occurred for whiting and hake (Table 3). Categorisation of the main commercial species in relation to minimum conservation reference and market sizes revealed major reductions in catches of undersize whiting and haddock with a minor reduction in undersize *Nephrops* in the dual cod end compared with the control gear. Apart from a 37% loss in market sized whiting (>32 cm), no loss of marketable catches occurred for the main species caught during the trial (Table 4, Figure 4). Estimated separation of commercial fish species in the dual codend gear ranged from 82% of flatfish to 98% of monkfish. An estimated 14% of *Nephrops* were separated into the top codend (Table 5). Multinomial modeling of the proportions of catch at length in the three codend compartments confirmed significant differences in catches of undersize haddock and whiting in the upper codend of the dual codend gear compared with the control gear. Inclusion of a day/night factor in the model did not reveal any significant differences in catches of undersize haddock and whiting, but showed significant reductions in *Nephrops* caught in the lower codend of the dual codend gear during night compared with day-time (Figure 5). No significant effect of net position was found so this was excluded from the model.

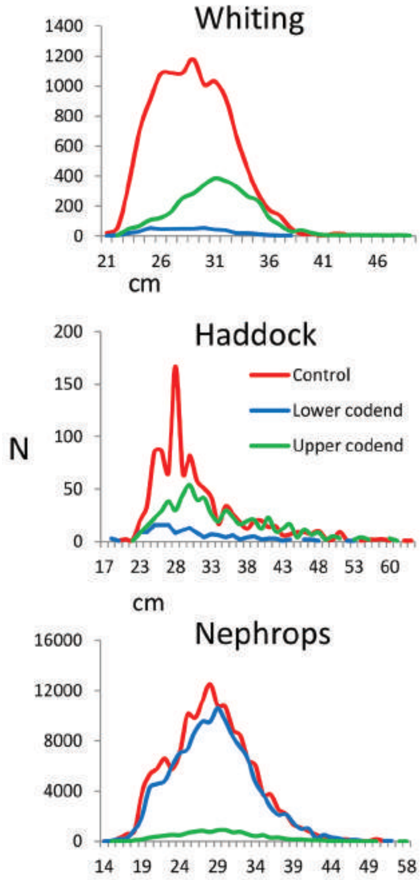

Figure 4. Length frequency distributions of key species

Table 3. Quantities of species caught during the trial

Species	Control (kg)	Dual codend (kg)	Difference (%)
Whiting	2402	1040	-57
Hake	36	19	-46
Bulk	8398	6353	-24
Lesser spotted dogfish	1434	1339	-7
Nephrops	2603	2437	-6
Haddock	369	362	-2
Flatfish	60	64	6
Cod	149	177	19
Monkfish	129	171	32

Table 4. Estimated total quantities of key species in relation to minimum conservation reference (MCRS)* and market sizes**

Species	Category	Control (kg)	Dual codend (kg)	Difference (%)
Whiting	< 27 cm*	371	60	-84
	≥ 27 cm*	1938	894	-54
	< 32 cm**	874	553	-37
	≥ 32 cm**	1435	401	-72
Haddock	< 30 cm*	100	52	-49
	≥ 30 cm*	254	277	9
Nephrops	< 25 mm*	325	289	-11
	≥ 25 mm*	2103	2094	0

Table 5. Estimated species separation in the dual codend gear by comparing catches in the lower codend with the control codend

Species	Control (kg)	Lower codend (kg)	Seperation (%)
Monkfish	129	3	98
Whiting	2402	154	94
Cod	149	15	90
Hake	36	4	90
Haddock	369	62	83
Flats Total	60	11	82
Lesser spotted dogfish	1434	445	69
Nephrops	2603	2231	14

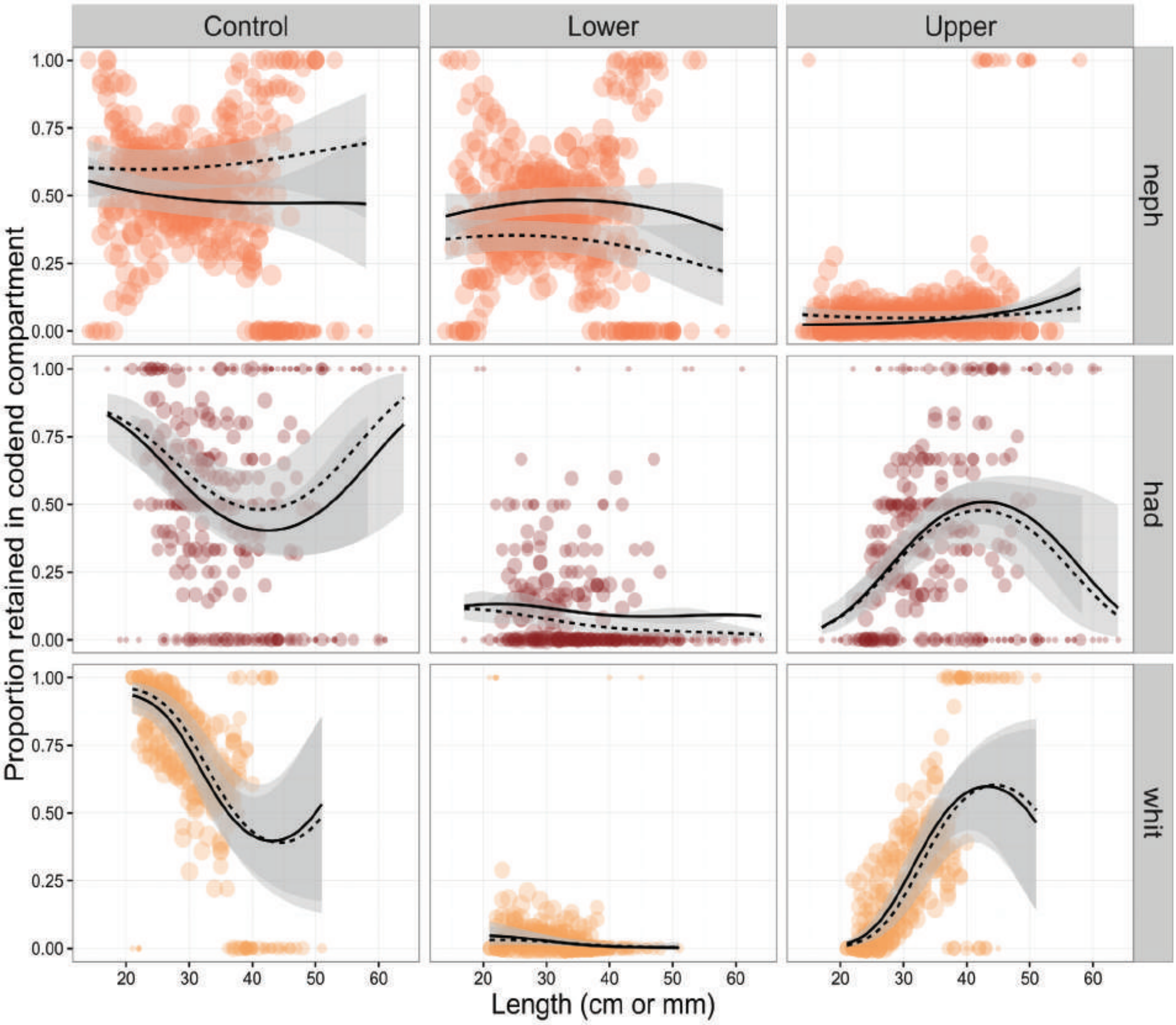

Figure 5: Proportion of catch per length-class retained in the three codend components. Points represent the data, and lines and bands the fitted and 95% confidence intervals on the fitted proportions respectively. Predicted day-time and night-time proportions are shown as solid and dashed lines, respectively. The size of the point is proportional to the log of the count.

Discussion

The dual codend with net separator worked very well as a device for mitigating bycatch of undersize fish. Utilising 90 mm T90 mesh in the top codend significantly reduced catches of undersize haddock by ~50%, and undersize whiting by over 70% compared with the control trawl. As expected some reductions in catches of smaller market sized whiting occurred in the 90 mm T90. However, in terms of the LO, whiting is likely to primarily be an issue for *Nephrops* vessels operating in the Irish Sea where discarding of < MCRS whiting has traditionally been very high, and where the quota has been low e.g. 46 t in 2016 (MI, 2015). Hence, the dual codend is likely to be particularly beneficial in that area where loss of market sized whiting is not an issue.

Importantly, there was no reduction in catches of ≥ MCRS *Nephrops* in the dual cod end compared with the control haul. The observed reduction in < MCRS *Nephrops* could have been associated with the extra length and four-panel configuration of the dual codend gear which may have provided more opportunity for smaller *Nephrops* to escape the trawl. In terms of species separation, an estimated 14% of the *Nephrops* catch in the dual codend was separated into the upper codend where it is likely that some of this catch was lost through the T90 mesh. It may be possible to reduce the amount of *Nephrops* passing into the upper codend by incorporating a drop-down section made up of large square mesh in the posterior separator panel. Given this level of separation, and lack of an overall loss of ≥ MCRS *Nephrops*, it is likely that the dual codend was more effective at catching *Nephrops* compared with the control gear. Catch weight is known to influence the opening of codend meshes (Robertson and Stewart, 1988) and affect codend size selectivity of *Nephrops* (Browne *et al.*, 2015). Hence, lower catch weights associated with substantial reductions in quantities of fish in the dual codend are likely to have resulted in increased *Nephrops* catches compared with the control trawl.

The absence of a significant difference in catches of < MCRS whiting and haddock in the upper codend during day or night time bodes well for the effectiveness of this test gear in separating these species regardless of operational time of day, and is generally in agreement with previous research on this issue (Krag *et al.*, 2010). A significant reduction in catches of *Nephrops* in the lower compartment of the dual codend during night time is difficult to explain given that *Nephrops* are thought to drift passively along the middle of the lower sheet of the trawl, tumbling with no apparent control (Catchpole and Revill, 2008). However, this result does not negatively affect the overall performance of the test gear.

The performance of the separator panel in separating key fish species into the top codend was excellent. This means that selectivity can be altered for different species e.g. a larger mesh size could be used in the top cod end for even greater reductions in catches of undersize whiting, haddock or other species. Also, in situations where fish quotas are very low, the top codend can be removed to allow fish to escape from the trawl while retaining *Nephrops*. Utilising this gear measure as a fish exclusion device may be preferable to using a rigid sorting grid which can be subject to handling difficulties e.g. when hauling the gear over the net drum.

Figure 6. Top to bottom, typical catches from the control, upper and lower codends in the dual codend

Automated species separation in the dual codends greatly reduced catch sorting times, and likely improved catch quality by minimising contact between the jagged edged *Nephrops* and soft skinned fish (Figure 6). Increased catch sorting time is a major challenge facing vessels under the LO due to requirements to grade catches of < MCRS fish by species. Hence, the dual codend gear could be extremely beneficial in that regard. Enhanced fish quality is likely to result in improved prices for the catch, an additional incentive to use the gear.

The dual codend with net separator panel has major potential to address a range of challenges posed by the LO but some legislative changes are needed to maximise benefits and use of this measure. In terms of current legislative requirements, under EC regulation No. 850/98 vessels targeting *Nephrops* are generally limited to using nets of the same mesh size range. Depending on the species composition, these mesh size ranges are 70 mm to 79 mm, and 80 mm to 90 mm. Ability to use larger mesh sizes in the top codend would make sense to facilitate greater reductions in fish catches when needed, but regional agreement on such an approach would likely be required. In addition Irish regulation S.I. No. 518 of 2015 limits the total number of codends to four on Irish vessels so a change to this law would be required to permit quad-rig vessels to use the dual codend gear. In the short term, quad-rig vessels are, however, permitted to use the gear as a fish exclusion device by removing the top codend.

References

BIM. 2014. Assessment of a 300 mm square-mesh panel in the Irish Sea *Nephrops* fishery. Irish Sea Fisheries Board (BIM), Fisheries Conservation Report. 5 pp.

Browne, D., Minto, C., Cosgrove, R., Burke, B., McDonald, D., Officer, R., Keatinge, M. 2017. A general catch comparison method for multi-gear trials: application to a quad-rig trawling fishery for *Nephrops*. ICES Journal of Marine Science (In Press).

Catchpole, T., Revill, A. 2008. Gear technology in *Nephrops* trawl fisheries. Reviews in Fish Biology and Fisheries. 18, 17-31.

Cosgrove, R., Browne, D., McDonald, D., Curtin, R., Keatinge, M., 2015a. Assessment of an increase in cod-end mesh size in the Irish Sea *Nephrops* fishery. Irish Sea Fisheries Board (BIM), Fisheries Conservation Report. 16 pp.

Cosgrove, R., Graham, N., Moore, S.J., Kelly, E., Curtin, R., Keatinge, M., 2015b. At sea simulation of the operational and economic impacts of the landing obligation on Irish demersal fisheries. Report to the Discard Implementation Group. 13 pp.

Cosgrove, R., Browne, D., McDonald, D., 2016. Assessment of rigid sorting grids in an Irish quad-rig trawl fishery for *Nephrops*. Irish Sea Fisheries Board (BIM), Fisheries Conservation Report. 9 pp.

Fonteyne, R., Buglioni, G., Leonori, I., O'Neill, F.G. 2007. Review of mesh measurement methodologies. Fisheries research. 85, 279-284.

Graham, N., Fryer, R. 2006. Separation of fish from *Nephrops* norvegicus into a two-tier cod-end using a selection grid. Fisheries research. 82, 111-118.

Hillis, J. 1983. Experiments with a double cod-end *Nephrops* trawl. ICES CM, B29.

Krag, L.A., Holst, R., Madsen, N., Hansen, K., Frandsen, R.P. 2010. Selective haddock (*Melanogrammus aeglefinus*) trawling: Avoiding cod (*Gadus morhua*) bycatch. Fisheries Research. 101, 20-26.

Krag, L.A., Herrmann, B., Feekings, J., Lund, H.S., Karlsen, J.D. 2016. Improving escape panel selectivity in *Nephrops* directed fisheries by actively stimulating fish behaviour. DOI 10.1139/cjfas-2015-0568. Canadian Journal of Fisheries and Aquatic Sciences (In Press).

Main, J., Sangster, G. 1985. Trawling experiments with a two-level net to minimise the undersized gadoid by-catch in a *Nephrops* fishery. Fisheries Research. 3, 131-145.

MI. 2015. The Stock Book 2015 : Annual Review of Fish Stocks in 2015 with Management Advice for 2016. Galway, Ireland, 624 pp.

Poseidon. 2013. A case study review of the potential impact of proposed CFP discard reform. Poseidon report to Seafish UK. 55 pp.

Robertson, J., Stewart, P. 1988. A comparison of size selection of haddock and whiting by square and diamond mesh codends. ICES Journal of Marine Science. 44, 148-161.

Acknowledgements

BIM would like to thank Niall and Seamus Connolly, the skipper and crew of the Stella Nova, and Ger Dougal for their assistance with 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.

BIM Ireland's Seafood Development Agency

GMIT INSTITIÚID TEICNEOLAÍOCHTA NA GAILLIMHE-MAIGH EO GALWAY-MAYO INSTITUTE OF TECHNOLOGY

SEAFISH the authority on seafood

Bord Iascaigh Mhara
An Cheannoifig,
Bóthar Crofton,
Dún Laoghaire,
Co. Bhaile Átha Cliath.
A96 E5A2

Irish Sea Fisheries Board
Head Office,
Crofton Road,
Dún Laoghaire,
Co. Dublin.
A96 E5A2

T +353 (0)1 214 4100
F +353 (0)1 284 1123
www.bim.ie