July 2021

Preliminary assessment of a box trawl in the Irish *Nephrops* fishery

Fisheries Conservation Report

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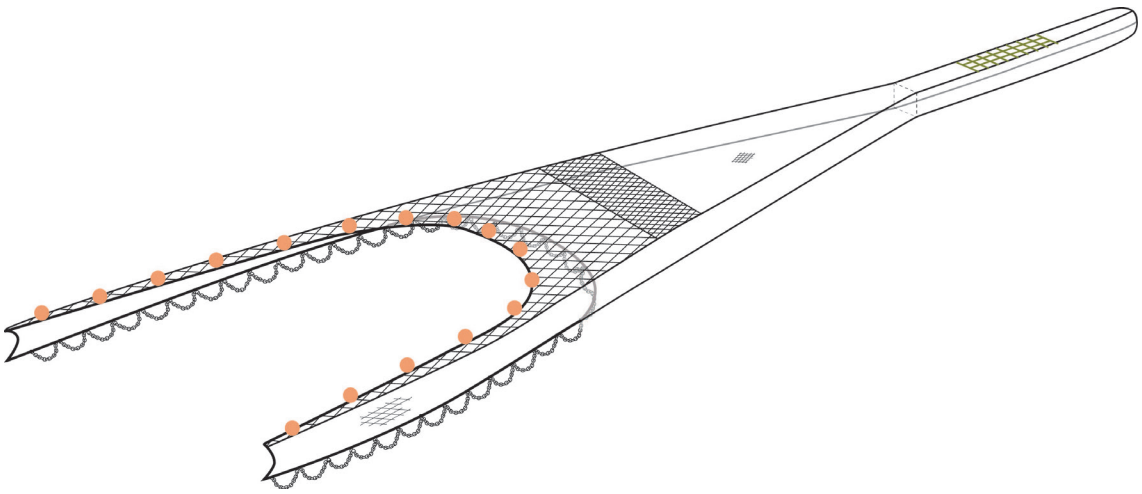
Key findings

Slight increase in *Nephrops* catches in the four-panel 'box' trawl compared with the traditional two-panel trawl

No effect of large mesh in the top sections of the box trawl on *Nephrops* catches

Further testing of the effects of large mesh in the box trawl on unwanted fish catches planned

Assessment of potential reductions in drag and fuel use in the box trawl also planned



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

Climate change and the need for improved carbon efficiency are key fisheries environmental challenges. A previous global assessment found fisheries are generally on the lower end of the carbon emissions scale for animal-based protein production, but fossil fuel dependence needs to be addressed (Parker and Tyedmers 2015). Nationally, climate change targets, bycatch reduction and marine biodiversity protection underpinned by cutting edge scientific and technological innovation are key priorities under the Programme for Government 'Our Shared Future'.

Towed bottom-contact gears such as bottom trawls are subject to increased drag resulting in greater fuel use and emissions compared with other fishing methods. Potential gear modifications to improve carbon efficiency in trawls include off-bottom methods such as pelagic or semi-pelagic rigs. These have potential to reduce drag and fuel use in fisheries targeting demersal species such as whiting, haddock and hake which swim above the seabed. More incremental approaches are required for benthic species like *Nephrops* where ground contact needs to be maintained.

Nephrops trawls are traditionally constructed to target *Nephrops* and mixed fish species. Since the introduction of the landing obligation, Irish vessels often incorporate gear modifications such as enlarged-mesh escape panels in the codend to reduce or avoid fish bycatch (BIM 2014; Tyndall et al. 2017). Working in collaboration with PEPE Trawls and the Connollys from Supreme Fishing Ltd, BIM commenced work on a new trawl design to enhance bycatch reductions throughout the trawl and improve carbon efficiency in the *Nephrops* fishery.

The aim of the resulting four-panel 'box trawl' is to provide more robust net geometry which facilitates greater use of enlarged mesh in the top sheet and wings. This can potentially reduce unwanted fish catches before they arrive in the codend but also lower drag and fuel use by using less netting and through improved hydrodynamics from increased water flow.

We carried out preliminary testing of the new *Nephrops* box trawl through a series of four trials. These trials aimed to isolate any differences in catch performance between the new four-panel compared with the traditional two-panel trawl, and the effects of large mesh sections in the four-panel trawl.

Methods

Trials were conducted on board the MFV Emerald Shore (DA137), a 16.89 m vessel targeting *Nephrops* in the Western Irish Sea between November 2020 and May 2021 (Figure 1). The vessel fished a half-quad configuration which comprised a two-warp system connected to a pair of otter boards with 70 m outer sweeps and an inner split 'Y' configuration (Figure 2). The quad-rig is the most-commonly used trawl configuration on Irish vessels targeting *Nephrops*. The half-quad set up facilitated simultaneous testing of two different trawls with results representative of both half-quad and standard quad-rig configurations.

Three different trawls were tested (Table 1) with different mesh sizes used in the upper sections of the trawls over the course of the trials The four-panel SELTRA codend which works well with the four-panel trawl was used in all but the last trial where a 300 mm SMP was used was used on one of the trawls. (Table 2; Appendices 1 – 4). Four simplified catch comparisons were conducted with the following aims:

- **Trial 1** – Test the effect on catches of a basic (no extra-large mesh) four-panel trawl compared with a standard two-panel trawl. The SELTRA was used in the two-panel trawl to help isolate catch effects to trawl design (four v two panel)
- **Trial 2** – Test catch effects of large 300 mm mesh in the upper wings and cover sheet, and 160 mm mesh in the top sheet of a modified four-panel trawl compared with a basic four-panel trawl
- **Trial 3** - Test the effects of further extending the 300 mm mesh into top sheet in the modified four-panel + trawl
- **Trial 4** – Test the final iteration of the modified four-panel (+) trawl against the standard two-panel trawl commonly used by Industry.

The float configuration on the headline of the modified four-panel trawl was changed from a float rope in Trial 2 to conventional floats in Trials 3 and 4. This was because the crew noticed mud on the float rope at the wingends and suspected that headline height and gear spread were reduced. At the end of the catch comparison trials a GO-PRO camera with lights was mounted on the headline of the modified trawl to capture footage of fish escaping through the large mesh in the cover and top sheets.

Figure 1. MFV Emerald Shore (DA 137) and trial location (hatched area) within the Irish Sea

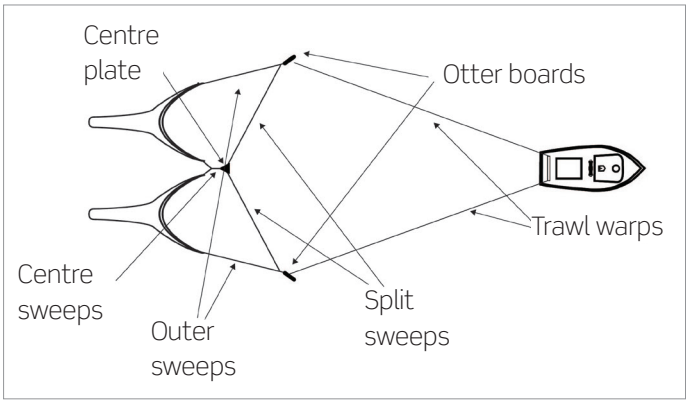


Figure 2. Graphical representation of the half-quad configuration used in the trial

Table 1. Gear characteristics of the trawls used in the four trials

	Four-panel	Modified four-panel	Standard
Trawl type		*Nephrops*	
Trawl configuration		Half quad	
Headline length (m)		37	
Estimated headline height (m)		1	
Footrope length (m)		42	
Fishing-circle (meshes × mm)		400 x 80	
Number of panels in trawl	4	4	2
Door manufacturer & model		Thyboron Tyson	
Average door spread (m)		44	

Codend type	SELTRA		Standard
SMP Mesh size (mm)	300		300
SMP position	4.5 - 7.5m from codline		9 - 12m from codline
SMP size (mesh × mesh)	18 x 4		18 x 7
No of panels	4		2
Nominal mesh size (mm)	80		80
Measured mesh size (mm)	87	85	84
Codend circumference (mesh no.)	120	120	120

Table 2. Characteristics of the main panel modifications used in the four trials (see Appendices 1 – 4 for further details)

Panel	Trial 1		Trial 2		Trial 3		Trial 4	
Panel	two-panel (mm)	four-panel (mm)	four-panel (mm)	Modified four-panel (mm)	four-panel (mm)	Modified four-panel + (mm)	two-panel (mm)	Modified four-panel + (mm)
Upper wings	160	160	160	300	160	300	160	300
Cover sheet	160	160	160	300	160	300	160	300
*Top sheet	80	80	80	160	80	300	80	300
$Top sheet	80	80	80	160	80	160	80	160
Escape panel	SELTRA	SELTRA	SELTRA	SELTRA	SELTRA	SELTRA	SMP	SELTRA

**Front half of top sheet. $Rear half of top sheet*

Catch sampling was completed by the skipper and crew in line with COVID-19 sampling protocols. Catches of large and tailed *Nephrops* were weighted separately. Tails weights were multiplied by 3 to obtain tailed *Nephrops* whole weight (EU 2011). Due to low catch rates, key species catch weights were compared using tables and histograms of total catches. Due to variable numbers of hauls between trials, catch weights were standardised to 11 hauls for comparative purposes. Catches less than 10 kg in both gears were omitted.

Results

A total of 49 valid hauls were completed: 12 in Trial 1, 13 in Trial 2 and Trial 3, and 11 in Trial 4. Haul duration, depth and towing speed ranged from 4:42 - 4:50hr, 39.32 - 69.50 m, and 2.79 - 2.90 kt.

Trial 1

There was a slight increase in tailed *Nephrops* in the four-panel trawl (Figure 3, Table 3). Little difference occurred in fish catches (Figure 4, Table 3).

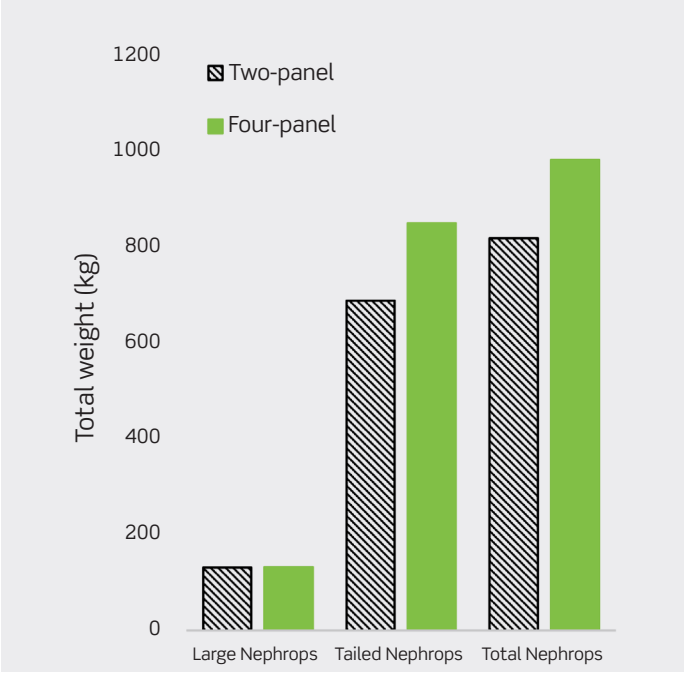


Figure 3. Trial 1 - Nephrops catches

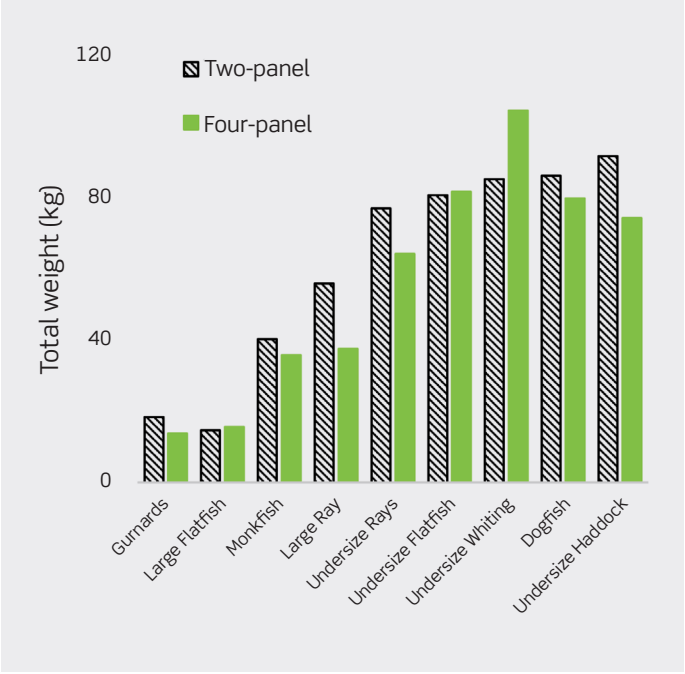


Figure 4. Trial 1 - Total fish catches

Table 3. Trial 1 - Total catches

Species	Two-panel (kg)	Four-panel (kg)	Difference (%)
Large *Nephrops*	131	132	1
Tailed *Nephrops*	688	850	24
Total *Nephrops*	819	982	20
Gurnards	18	14	-25
Large flatfish	15	16	-6
Monkfish	40	36	-11
Large Ray	56	38	-33
Undersize Rays	77	64	-17
Undersize Flatfish	81	82	-19
Undersize Whiting	85	105	23
Dogfish	86	80	-7
Undersize Haddock	92	74	-19

Trial 2

There was a slight decrease in *Nephrops* and substantial reductions in fish catches in the modified four-panel trawl compared with the basic four-panel trawl (Figures 5 and 6; Table 4). *Nephrops* catches were lower in Trial 2 compared with Trial 1 e.g., a 19% reduction was observed in the basic four-panel trawl between trials.

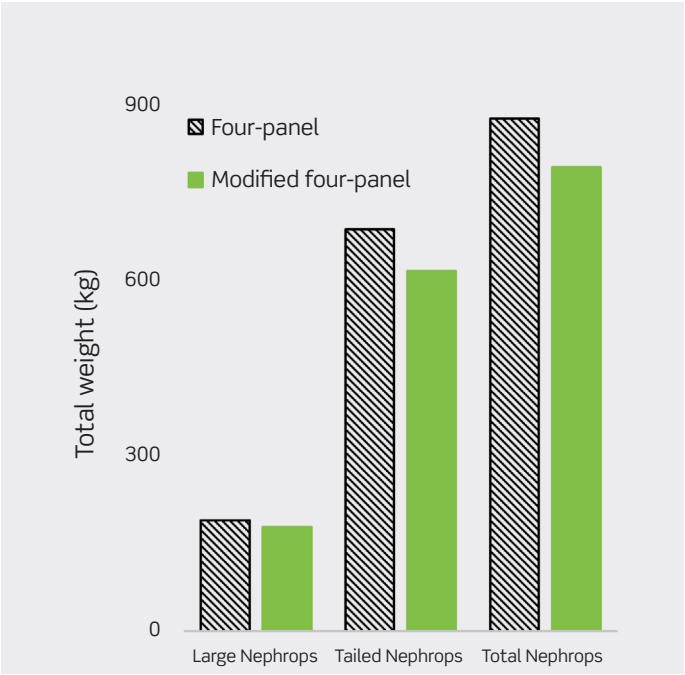


Figure 5. Trial 2 - Nephrops catches

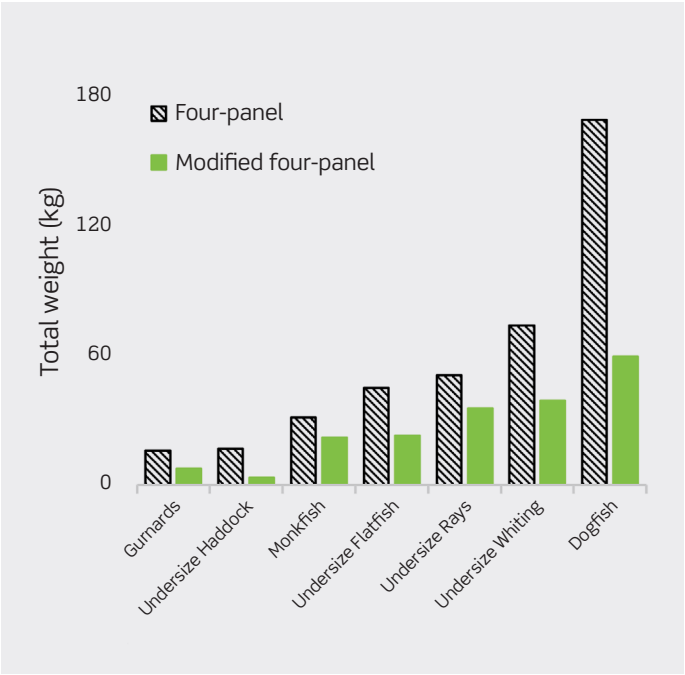


Figure 6. Trial 2 - Total fish catches

Table 4. Trial 2 - Total catches

Species	Four-panel (kg)	Modified Four-panel (kg)	Difference (%)
Large *Nephrops*	190	178	-6
Tailed *Nephrops*	689	617	-10
Total *Nephrops*	877	795	-9
Gurnards	16	8	-53
Undersize Haddock	17	3	-80
Monkfish	31	22	-30
Undersize Flatfish	45	23	-49
Undersize Rays	51	36	-30
Undersize Whiting	74	39	-47
Dogfish	168	59	-65

Trial 3

Little difference in *Nephrops* and fish catches generally occurred in the modified four-panel+ compared with the modified four-panel trawl (Figures 7, 8; Table 5). Catches were low in both gears, but 50% less undersize haddock were observed in the modified four-panel+ trawl. Total *Nephrops* catches were greater than Trial 2 and similar to Trial 1 e.g., 949 and 982 kg (3.5% difference) in the basic four-panel trawls in Trials 1 and 3.

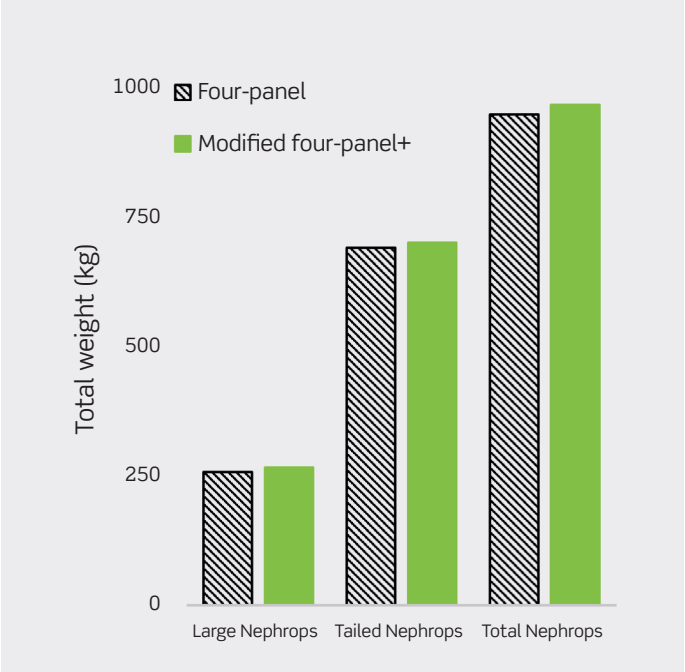


Figure 7. Trial 3 - Nephrops catches

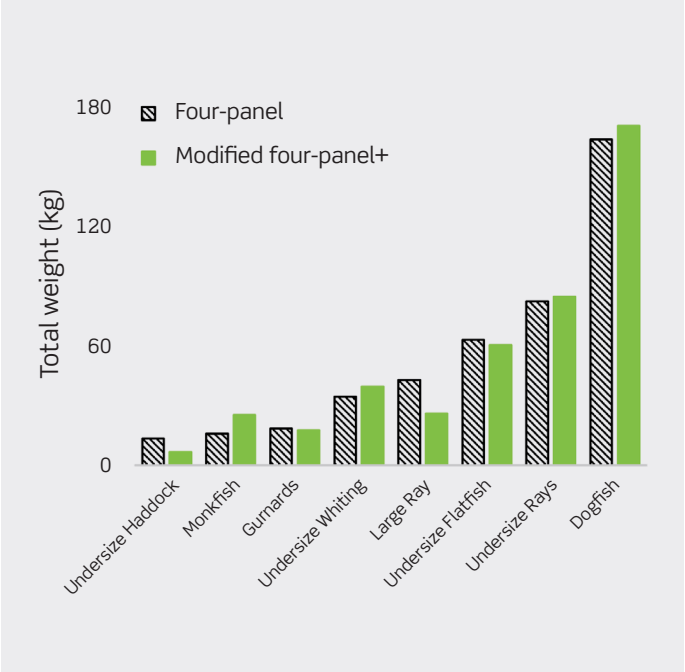


Figure 8. Trial 3 - Total fish catches

Table 5. Trial 3 - Total catches

Species	Four-panel (kg)	Modified Four-panel+ (kg)	Difference (%)
Large *Nephrops*	258	267	3
Tailed *Nephrops*	690	701	1
Total *Nephrops*	949	967	2
Undersize Haddock	14	7	-50
Monkfish	16	25	58
Gurnards	19	18	-5
Undersize Whiting	35	40	15
Large Ray	43	26	-39
Undersize Flatfish	63	61	-4
Undersize Rays	83	85	3
Dogfish	165	172	4

Trial 4

There was a slight increase in tailed *Nephrops* and substantial decreases in most fish species in the modified four-panel+ trawl compared with the two-panel trawl with 300 mm SMP trawl (Figures 12, 13, Table 6). *Nephrops* catches were substantially greater than previous trials.

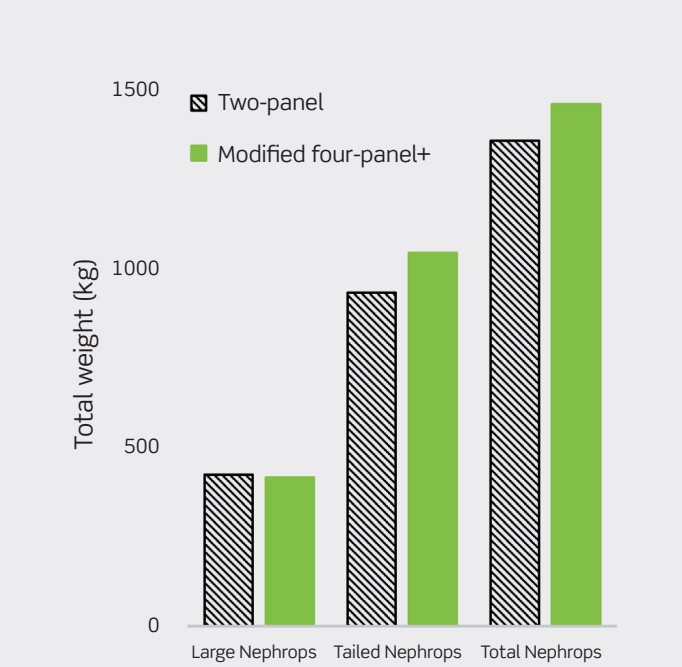


Figure 9. Trial 4 - Nephrops catches

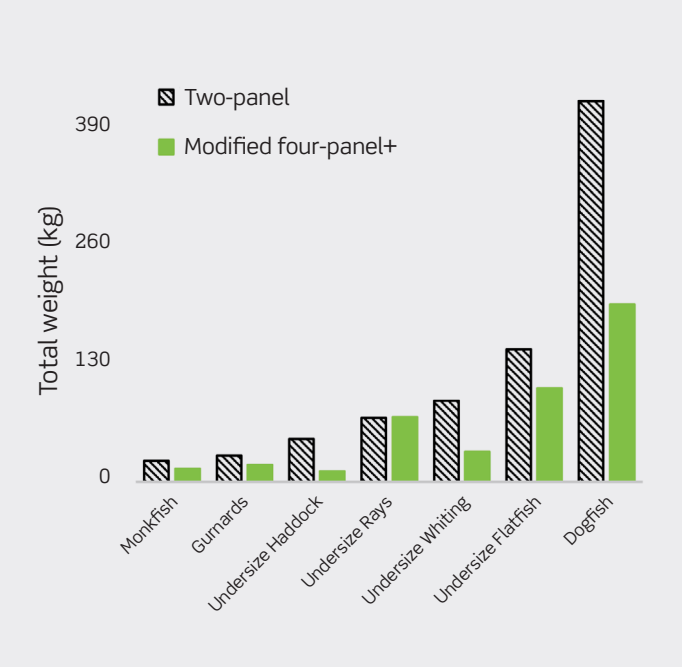
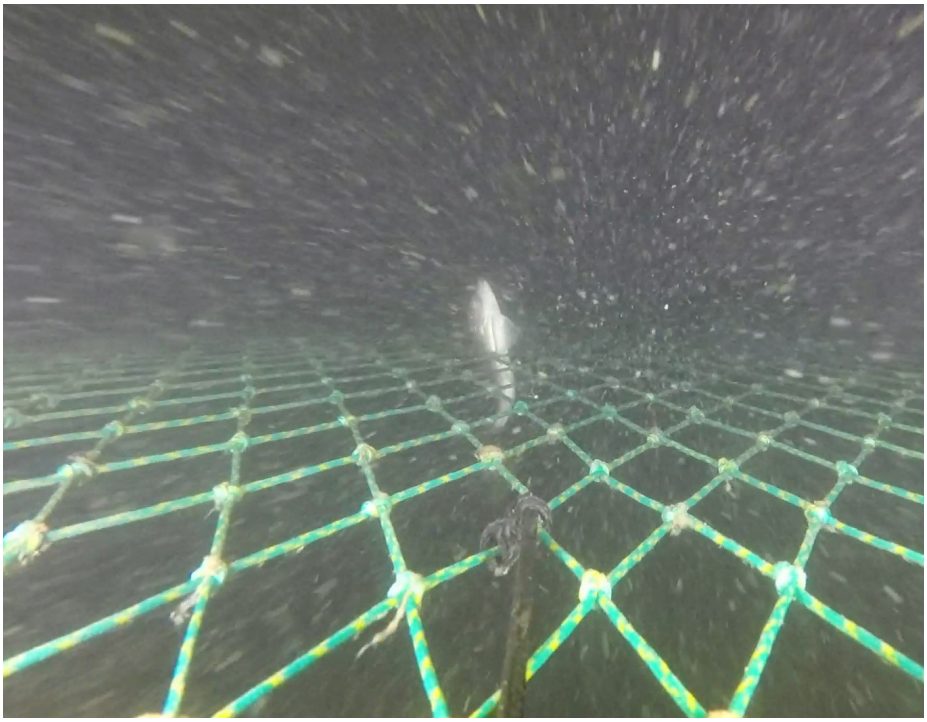


Figure 10. Trial 4 - Total fish catches

Table 6. Trial 4 - Total catches

Species	Two-panel (kg)	Modified four-panel+ (kg)	Difference (%)
Large *Nephrops*	424	416	-2
Tailed *Nephrops*	933	1,044	12
Total *Nephrops*	1,357	1,460	8
Monkfish	21	13	-38
Gurnards	26	17	-35
Undersize Haddock	43	11	-75
Undersize Rays	63	64	2
Undersize Whiting	80	30	-62
Undersize Flatfish	130	92	-29
Dogfish	373	174	-53



Camera footage showed fish sporadically escaping from the 300 mm mesh section in the cover and top sheet (Figure 11).

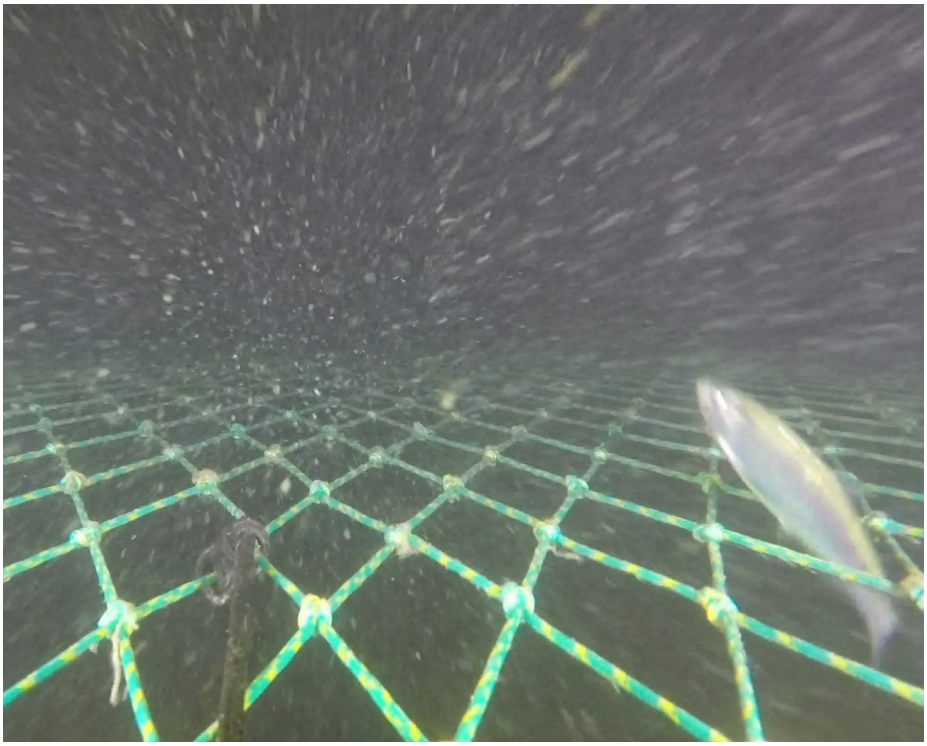


Figure 11. Screen grabs from a video showing fish escaping through the large 300 mm mesh in the trawls anterior section

Discussion

The four-panel 'box trawl' improved *Nephrops* catches compared with the two-panel trawl in this preliminary assessment. Trial 1 isolated the effects of the two trawls by using the same mesh sizes and codends. *Nephrops* catches were 20% greater in the four-panel trawl. Although more comprehensive sampling is needed, the study vessel continued to use the box trawl after the trial and reported consistently greater catches with the box trawl. Improved *Nephrops* catches can greatly assist in driving uptake of this novel gear and could help improve fuel and carbon efficiency through reduced fishing time.

Greater *Nephrops* catches may be a result of improved gear ground contact. Four-panel trawls are thought to have improved hydrodynamics, better maintain their shape, and have greater stability (Suuronen et al. 2012). This potentially stabilises the footrope on the seabed leading to improved catches of benthic *Nephrops*.

Extending enlarged 300 mm and 160 mm mesh into the top sections of the trawls had no effect on *Nephrops* catches as demonstrated in Trials 3 and 4. Trial 2 was considered invalid due to issues with the headline flotation. This was supported by a 19% reduction in *Nephrops* catches in the same gear between Trial 1 and 2, and a subsequent recovery in catches in Trial 3, although localised population differences could have contributed to these differences.

The four-panel trawl generally had similar fish catches compared with the two-panel trawl as demonstrated in Trial 1. With the exception of haddock, extending large mesh into the top sections of the four-panel trawl had little impact on fish catches as demonstrated in Trial 3. Although catches were low, a 50% reduction suggests potential enhanced escapement of undersize haddock in the extended large mesh in the modified box trawl in Trial 3.

Little difference in undersize whiting catches with the larger mesh in the top sheet is supported by other BIM studies which suggest that very small whiting may be relatively passive after they pass over the split or V-sweep arrangement in the quad-rig configuration (Browne et al. 2018). Bottom-orientated species, such as lesser-spotted dogfish, rays and flatfish. are likely to enter the trawl relatively low down and are unlikely to escape through enlarged mesh near the mouth of the trawl.

Trial 2 was invalid and reductions in fish catches in Trial 4 were likely due to enhanced performance of the SELTRA compared with the 300 mm SMP (Tyndall et al. 2017). Camera work showed sporadic fish escapement through the enlarged mesh in the box trawl. Due to low abundance on the grounds, the effects of the four-panel trawl remain unknown, however, for large haddock and whiting.

More testing of the large-mesh box trawl is planned in an area with greater abundance of gadoid species to properly assess the potential benefits of this gear on reducing unwanted catches. We also plan to examine potential reductions in drag and fuel use.

Acknowledgements

BIM would like to thank Niall and Seamus Connolly and crew of the MFV Emerald Shore for a successful collaboration. Thanks also to Eamonn Howard and staff of Pepe Trawls Ltd for their design work in constructing and modifying the trawls. 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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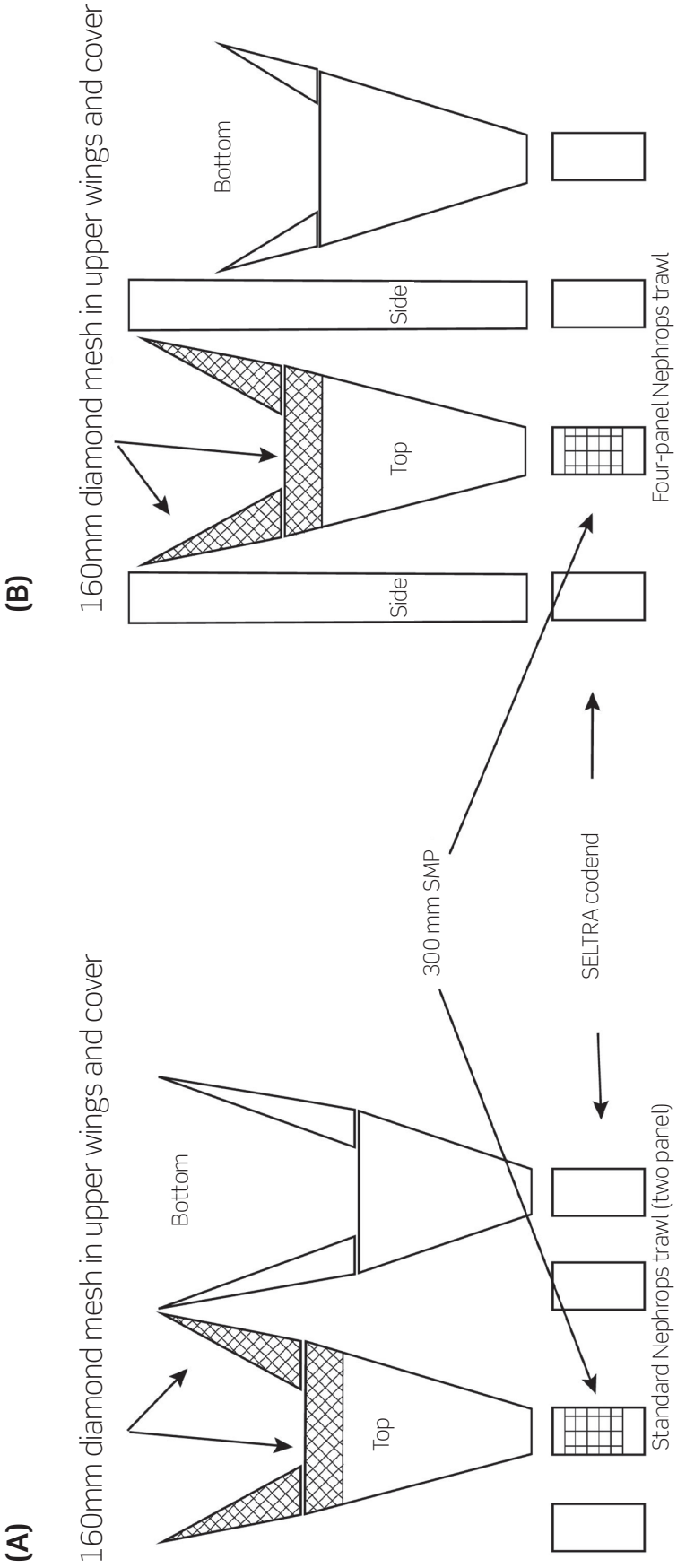
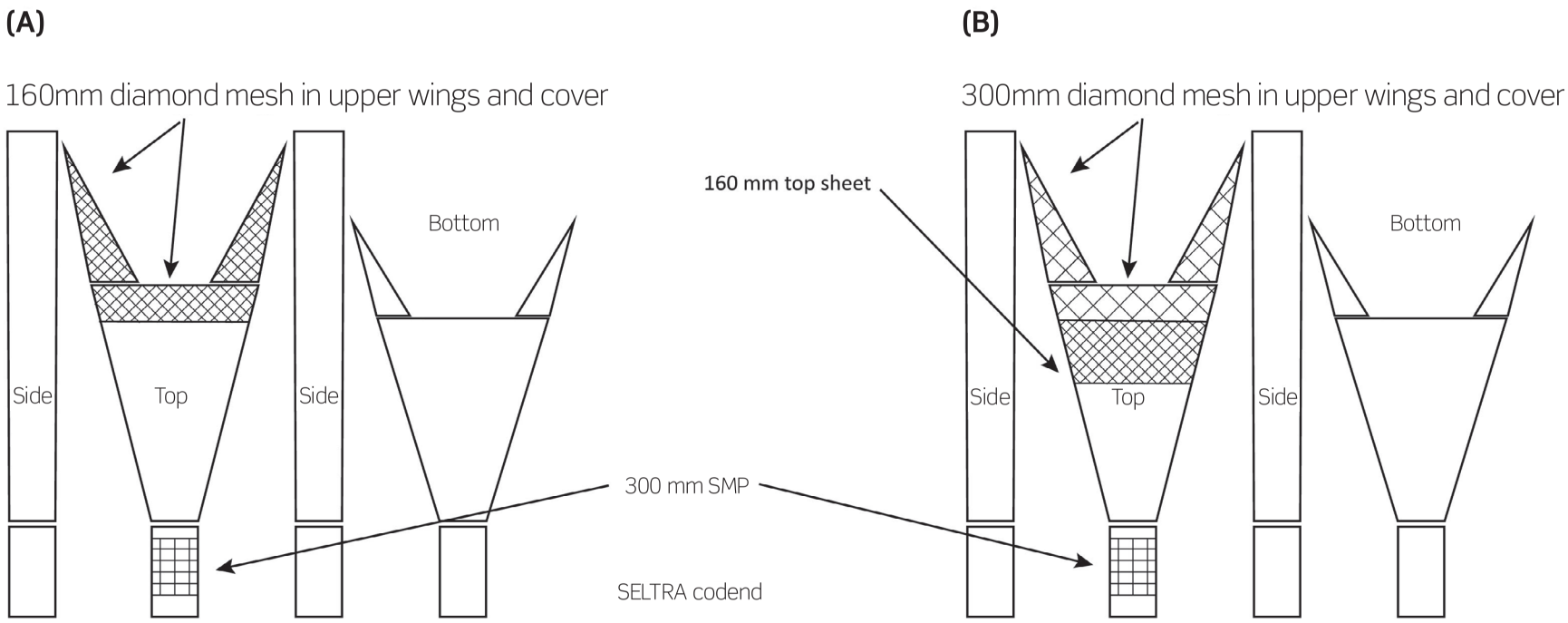
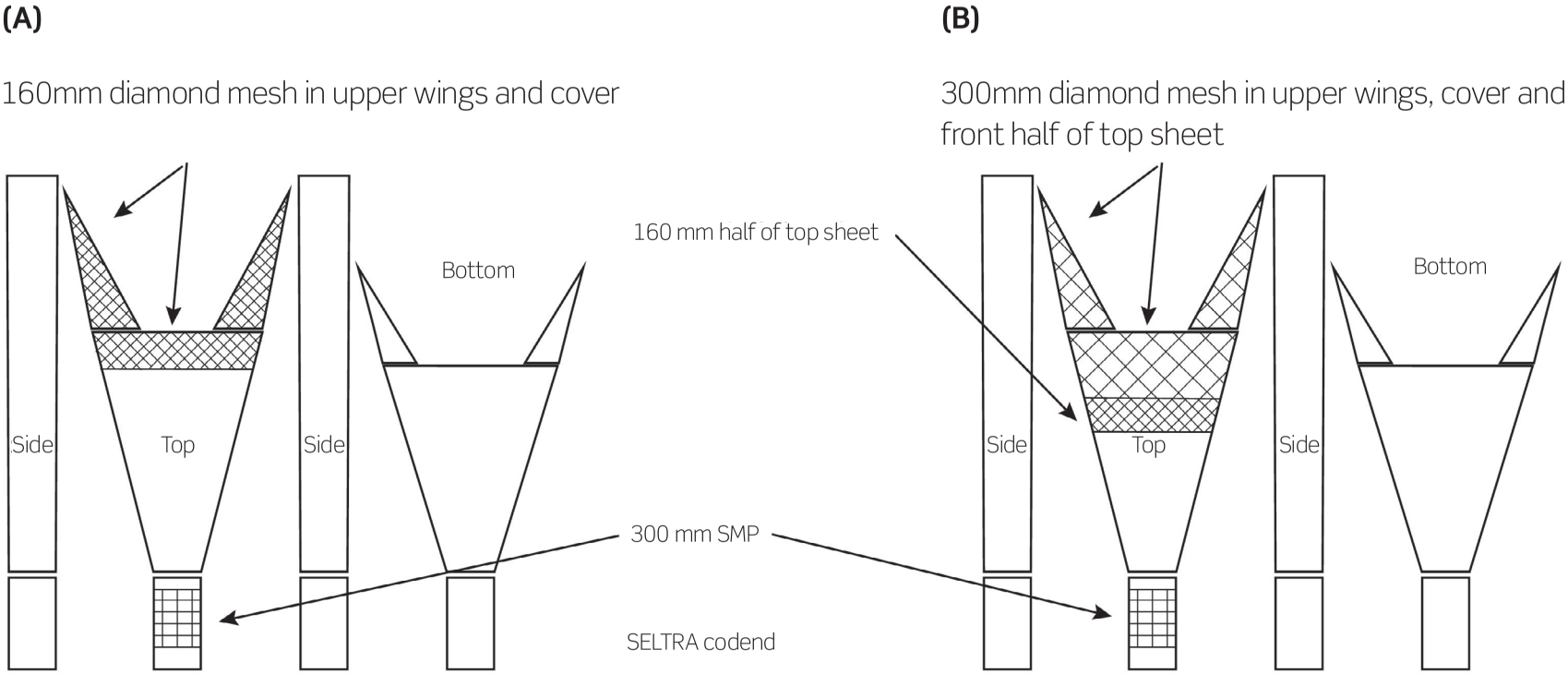
Appendices



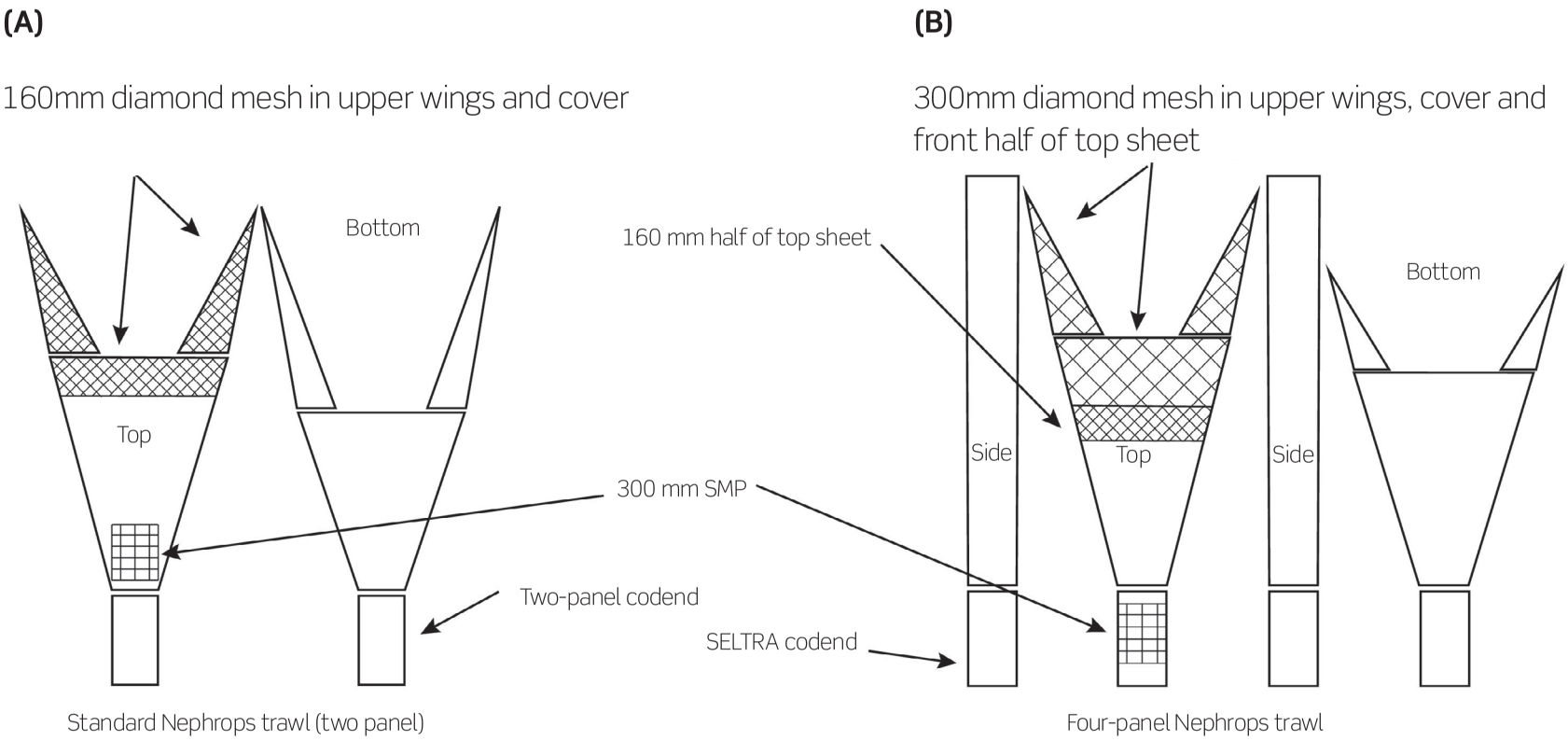
Appendix 1. Trial 1: (A) two-panel trawl with 160 mm mesh in upper wings and cover; (B) four-panel trawl with 160 mm mesh in upper wings and cover. Both trawls used a SELTRA codend.



Appendix 2. Trial 2: (A) four-panel trawl with 160 mm mesh in upper wings and cover; (B) modified four-panel trawl with large (300 mm) mesh in upper wings and cover with smaller (160 mm) mesh in top sheet. Both trawls used a SELTRA codend.



Appendix 3. Trial 3: (A) four-panel trawl with 160 mm mesh in upper wings and cover; (B) modified four-panel+ trawl with large (300 mm) mesh in upper wings, cover and front half of top sheet, with smaller (160 mm) mesh in second half of top sheet. Both trawls used a SELTRA codend.



Appendix 4. Trial 4: (A) two-panel trawl and codend with 160 mm mesh in upper wings and cover, a 300 mm square mesh panel (SMP) is place 9–12 m from the codline; (B) modified four-panel+ trawl with large (300 mm) mesh in upper wings, cover, and front half of top sheet, with smaller (160 mm) mesh in second half of top sheet and a SELTRA codend.

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