Preliminary assessment of a semi-pelagic trawl to target mixed demersal fish species in the Celtic Sea

Fisheries Conservation Report

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BIM Ireland's Seafood Development Agency

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Key Findings

- Semi-pelagic trawling is operationally possible for mixed demersal fish species
- The commercial viability of this method has not yet been proven
- Optimising the trawl configuration is key to developing optimal catching performance

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Introduction

BIM are working closely with the Irish fishing industry on developing gear-based technical solutions which address key environmental issues. Fuel prices have increased considerably in the past few years and are likely to continue to rise in line with the EU transition away from reliance on fossil fuels in the seafood sector. Hence, it is essential to catch fish at the lowest rate of fuel consumption (litres of fuel used per kilogram of fish caught) possible. Additionally, the imminent marine protected areas (MPAs) act proposes to protect 30% of EU/Irish waters by 2030 by limiting seabed interactions with potential bans on mobile fishing gears (EU 2023). Using modified or new fishing gears to mitigate these high energy demands, and seabed interactions will be a key focus over the coming years.

Currently Irish whitefish trawlers typically use bottom trawls or seines to capture fish and there has been limited work done on the capture of demersal species with other mobile gears, e.g., semi-pelagic trawls. Semi-pelagic trawls offer the opportunity to remove some or all the trawl configuration from the seabed, potentially reducing drag and seabed interaction.

Typically, semi-pelagic trawling for demersal species focusses on spawning aggregations that potentially maximise capture (especially for cod), for example in the Irish Sea (Fox et al. 2005) and Clyde Estuary (Turrell et al. 2016). Under more conventional fishing operations it is likely that demersal fish reactions to a semi-pelagic trawl will be very different to a bottom trawl, fish will have more options to escape compared to demersal trawls and their behaviour will likely impact their selectivity (Madsen et al. 2010; Rosen et al. 2012).

Artificial lights offer a potential method for improving catch and energy efficiency in terms of kg of produce per litre of fuel. However, reactions will vary depending on the species, time of year, and light used; fish can display negative or positive phototaxis i.e., they move away from or toward the light. BIM previously assessed lights on the headline of a whitefish trawl, where there was a 51% increase in haddock catches with lights at night (Oliver et al. 2023). The addition of lights to the trawl headline is a simple inexpensive option that has great potential to improve efficiency and offset any potential catch loss associated with reduced herding ability of the semi-pelagic trawl.

This study aimed to assess the practicalities of targeting mixed-demersal fish species with a semi-pelagic trawl in the Celtic Sea. The trials focus was on the gears operational performance to assist with the ongoing development (in collaboration with Swan Net Gundry–SNG) of a customised off-bottom trawl for the capture of mixed demersal species.

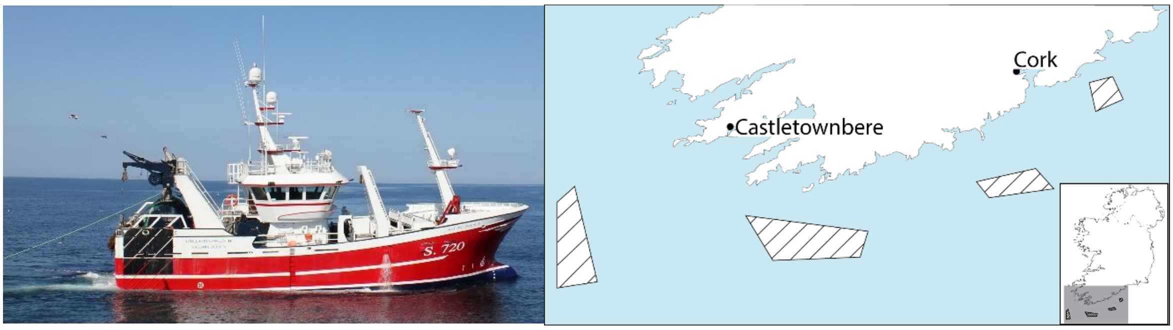

Figure 1. Trial vessel and location (hatched areas)

Methods

<u>Fishing methods</u>

The semi-pelagic trawl trial was conducted onboard a 26 m vessel (Dillon Owen II) targeting mixed-demersal fish species in the Irish sector of ICES Divisions 7g and 7j in the Celtic Sea in March 2024 (Figure 1).

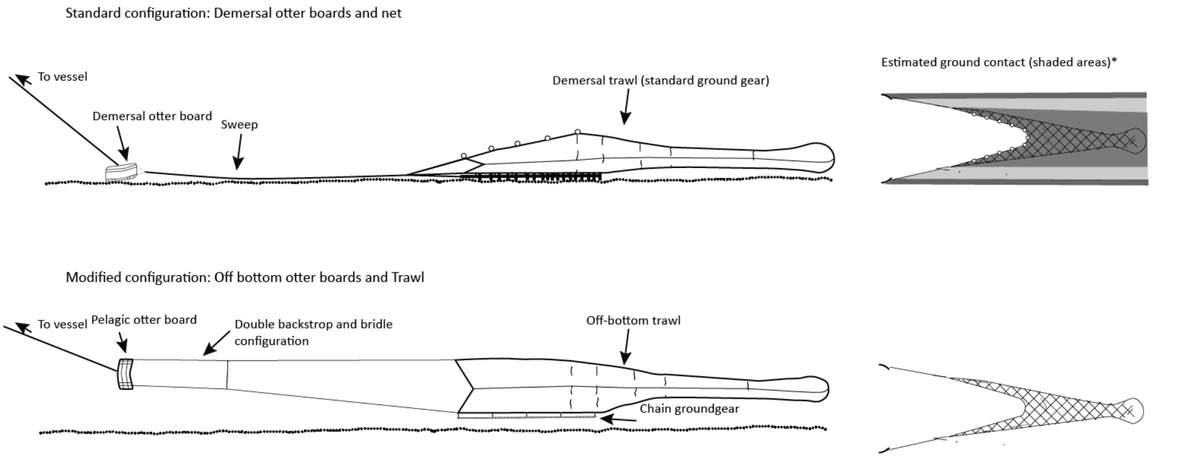

Figure 2. Graphical representation of the differences between a standard demersal trawl and a semi-pelagic trawl

The semi-pelagic trawl configuration assumes that all components are off the seabed, which contrasts with demersal trawl configurations where all components are in contact with the seabed (Figure 2).

For this trial we used the same trawl configuration as used in the Irish sea fishery (e.g. Fox et al. 2005) but did not focus on aggregated fish i.e., operation was akin to bottom trawling whereby fish are herded into the trawl. The trawl has a predicted opening of 51 × 29 m (width × height) is a four-panel design with the upper and lower panels identical, which allows the trawl to be flipped if/when wear occurs (e.g., top panel becomes bottom panel). The trawls ground gear consisted of single chain (12 mm) attached at 2 m intervals to the fishing line with 60 cm chain droppers.

The trawl was in six clear sections: 1, Mouth–800 mm mesh; 2, hex mesh–400 mm; 3, Body–200 mm mesh; 4, tapering section 100 mm mesh; 5, extension 100 mm mesh; 6, codend–100 mm T90 mesh. The high-aspect trawls doors (4.5 m^2) were rigged with double back strops (20 m) and a double bridle (20 m) configuration. The trial vessel was rigged with Dyneema warp. To assist with opening the trawl mouth chain clump weights were added on the trawl's lower wings and floats to the upper wings (directly above the clump weights).

Green Lindgren-Pitman lights were were used to evaluate their effectiveness in increasing selectivity (Figure 3). Twenty green lights were placed along the centre section of the headline at 1 m intervals.

<u>Experimental design</u>

Due to rigging and logistical constraints, it was not possible to conduct alternate hauls using bottom and semi-pelagic trawls. Instead, we periodically (2 rings just after dawn and 5 rings just before dusk) used a seine to qualitatively compare catch rates. The trial was designed as a catch comparison using the alternate haul method (Wileman et al., 1996), whereby the trawl was deployed with artificial lights on the headline (test) and without artificial lights on the headline (control). Hauls were planned as two day– and two night–time hauls to assess any differences in selectivity with and without lights, where by one day and one night used lights.

Operational data

Operational data including fuel use (l/hr), engine load (%) and speed over ground (SOG) (Kts) were collected by skipper up to six times per haul. During fishing operations, the skipper used a third wire headline sensor and periodically varied the warp length to maintain the trawl close to the seabed.

Seabed contact was not directly observed; however, we assume that because the trawl's ground gear was a single length of 12 mm chain that offers minimal protection that in the event of the net contacting the seabed there will likely be some damage to the net or there will be obvious wear/rubbing marks on the chain from contact with the substrate. Additionally, photos of the trawls doors shoes ware taken before and after the trial to assess any contact through wear/rubbing marks.

Catch sampling

Random representative samples of fish were taken from the conveyor belt around the start, middle, and end of catch sorting. All random samples were weighed, and sampled fish were separated to species level, measured to the nearest cm below and raised to estimated bulk weights for each haul to provide length frequency distributions. Length weight relationships (Silva et al., 2013) were used to derive total catch weights by species. To account for the discrepancy in haul numbers (i.e., 6 with lights off and 7 with lights on) the catches were standardised to catches per seven hauls for the length frequency analysis. This meant raising the catches for control (lights off) hauls to seven for comparison with the test (lights on) with seven hauls.

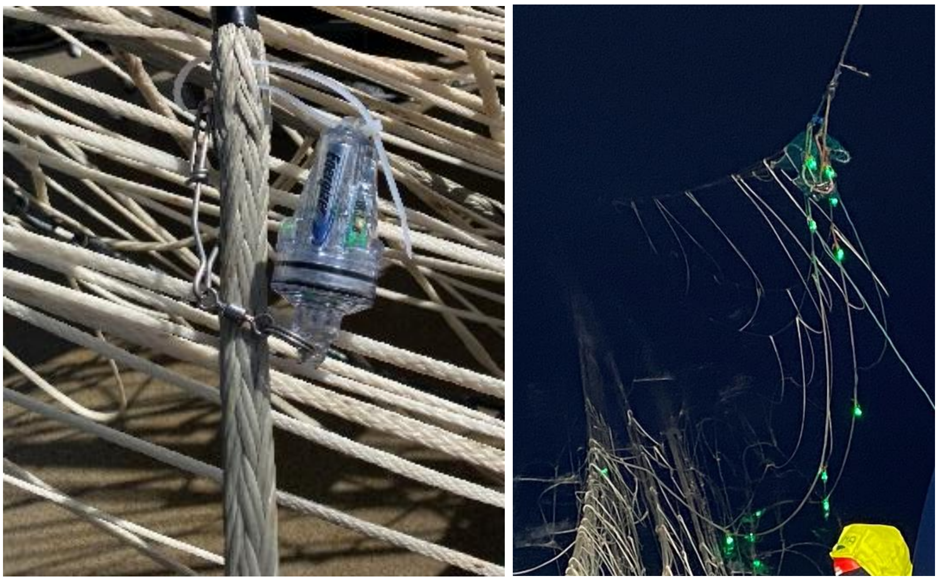

Figure 3. One of the green lights (Lindgren-Pitman) attached to the headline (left) and being deployed at night (right)

Table 1. Gear characteristics for gears used during the trial

	Semi pelagic	Seine
Trawl door (m^2)	4.5	na
Ground gear (material)	Chain	Rope
Ground gear Chain (mm)	12	na
Ground gear dropper (m)	0.6	na
Warp length range (m)	125 –275	na
Warp diameter (mm)	22	na
Seine rope length	na	3700
Seine rope thickness (mm)	na	44
Sweep (m) doubles	20	55
Back strops (m) doubles	20	na
Chain clump (kg)	120–240	na
Mesh size codend (mm)	100 T90	100 T90
Twine thickness (mm)	4 x 2	4 x 2

Table 2. Mean operational data for the semi-pelagic trawl with Standard Deviation (StdDev)

Parameter	mean	StdDev
Haul duration (Hr:min)	03:05	0.01
Fishing depth (m)	124.21	39.02
Warp shot (m)	114.37	118.28
Fuel (l/Hr)	99.64	12.95
Load engine (%)	52.98	6.37
Headline Height (m)	11.7	3.04
Door spread (m)	104.07	13.86
Speed Over Ground SOG (kts)	3.66	0.49

Results

For the semi-pelagic trawl, a total of 13 valid hauls were carried out over five consecutive fishing days on board the vessel. Mean, haul duration, vessel speed, and depth fished during the trial were 3 hrs 05 min, 3.6 kt and 124.21 m respectively (Table 2). Seven additional hauls were completed using the seine.

To keep the semi-pelagic trawl close to (but off) the seabed the warp length was constantly monitored and adjusted during each tow by up to ± 45 m. The third wire sensor (Figure 4) output also enabled the skipper to additionally monitor how close the trawls was to the seabed through observations of the footrope echo relative to the seafloor echo. The semi-pelagic trawl's headline height was monitored via the third wire sensor (Figure 4) and ranged from 6.8–20.1 m with an average of 11.7 m (Table 2). The trawl door spread ranged from 76.8–137.2 m with an average of 104.7 m (Table 2).

Overall catches were low for the duration of the trial for both the semi-pelagic and seine gears (Table 3). The main commercial fish species caught with the semi-pelagic trawl were mixed pelagic, haddock, hake, representing 97% of the total catch by weight (Table 3). Due to the low catches, it was not possible to assess a day night effect.

The seine caught more of the target species than the semi-pelagic trawl (Table 3). While overall the semi-pelagic trawl's catches for hake and haddock were low, there was an average increase per haul for haddock (67%) and hake (80%) catches when using the lights (Table 3; Figures 5 & 6).

Table 3. Mean catch per haul

	Semi pelagic–SP (kg)				Seine (kg)	SP v Seine
Species	Lights off	Lights On	On/Off %	Overall	Overall	%
Haddock	18	30	67	24	87	-72
Hake	10	18	80	15	147	-90
Mixed pelagics	204	304	49	258	23	×10
Other commercial	7	8	14	8	19	-58
Non commecial	1	1	0	1	6	-83

- $Black pollock, Cod, Red Mullet, Spotted ray, Lemon sole, brill, witch, plaice, megrim,
- #Common skate, Red, tub and grey gurnard, Pouting
- *Blue Whiting, Scad, Boarfish, Mackerel, Herring

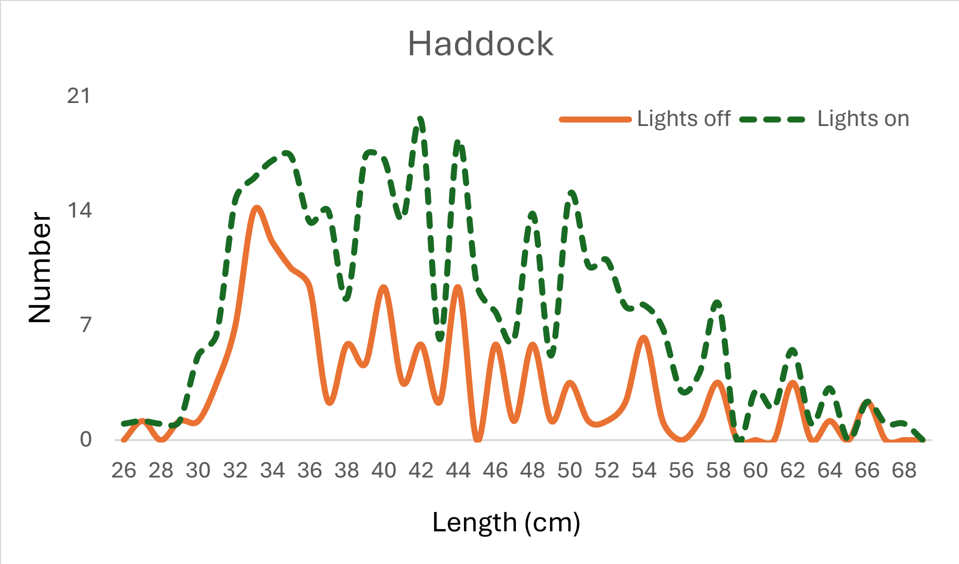

Figure 5. Standardised haddock length frequencies for lights off and lights on hauls

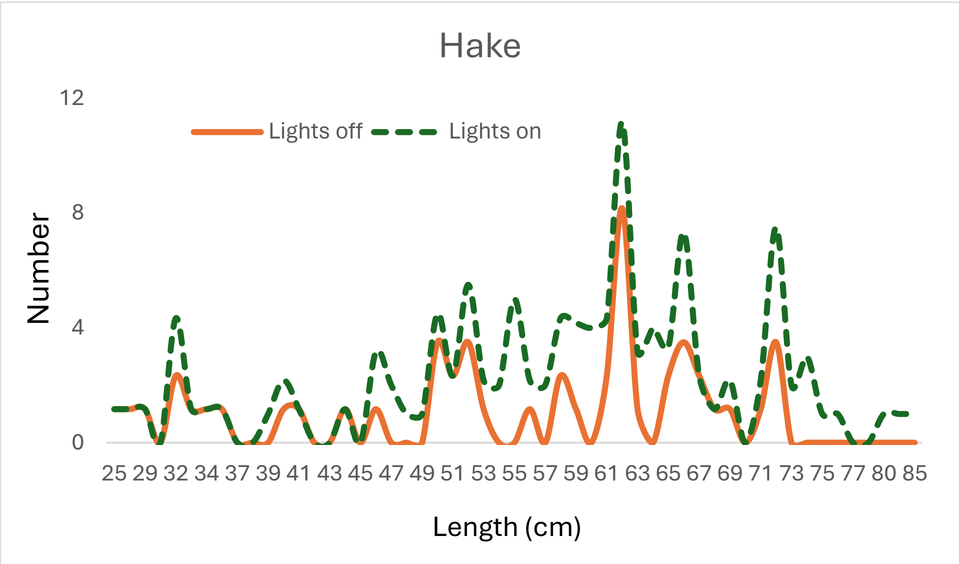

Figure 6. Standardised hake length frequencies for lights off and lights on hauls

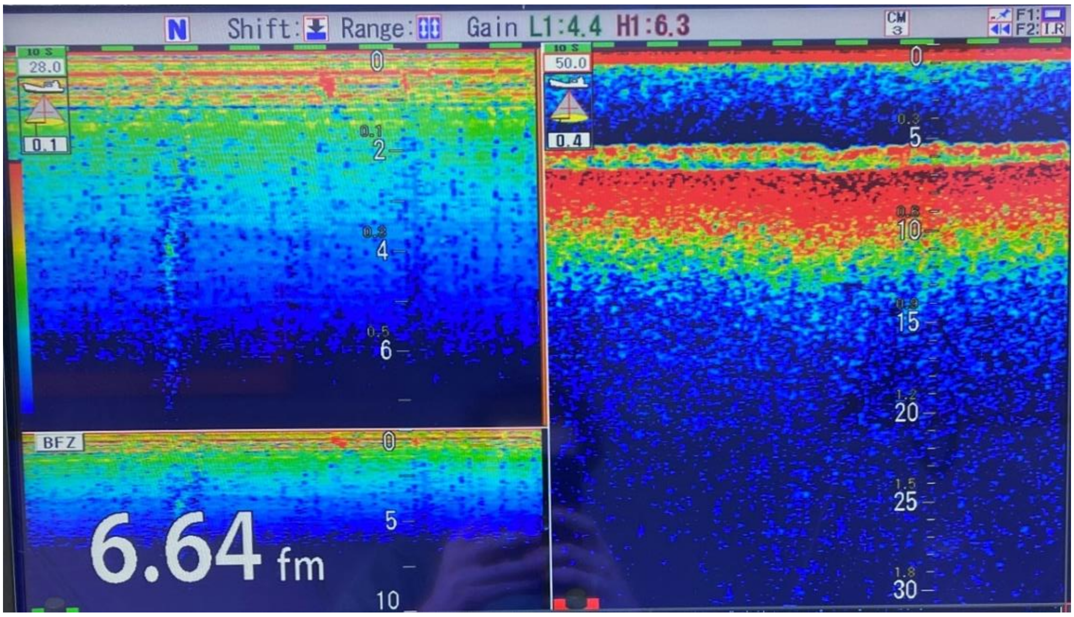

Figure 4. Graphical output from third wire sensor

Discussion

The trial demonstrated that it is operationally if not commercially viable to catch mixed demersal fish species with the semi-pelagic trawl configuration used in this study. While the semi-pelagic trawl gave relatively consistent operational results it is likely that it was not operating at optimal opening (i.e., 51 × 29 m). The trawl's headline height was likely not at optimum height for this trawl, and this might have reduced the trawl's catching efficiency. However, the overall height would still have been greater than most demersal trawls and operationally this requires investigation and might be related to the shorter bridle/sweep configuration used.

Operating the semi pelagic trawl took a little more work than a typical bottom trawl; the warp length was constantly adjusted to ensure the trawl held its position in the water column. This warp length adjustment meant the skipper was busier than they would have been when using a bottom trawl, which means that any relief (watch) would need to be equally competent. Notwithstanding the extra work in maintaining trawl position the semi-pelagic trawl's onboard handling was comparable to that of a typical bottom trawl: the only difference was the insertion/removal of the headline sensor (third wire) before/after shooting and hauling the trawl. The trawl took up considerably less space on the net drum, due to the absence of floats and the shorter bridles (bottom trawls typically have > 200 m bridle and sweep configurations).

However, notwithstanding the successful operation of the semi-pelagic trawl a full evaluation was not possible because fish abundances were low during the trial and a detailed comparison with a bottom trawl was not possible. While the seine captured considerably more of the target species, likely because it was on the seabed, it too caught much less than expected. While it is unsure to why fish abundances were low during the trial, other behavioural factors might have influenced fish numbers. Many demersal fish are known to change their position in the water column and vertical separation of catches in fishing gears is known to vary diurnally (during day and night) (Krag et al., 2010).

Mixed pelagic species were on occasion caught in large numbers. This was somewhat unexpected but conversations with other vessel skippers following the trial revealed that pelagic species were in high numbers in some of the areas we fished forcing them to move on. This semi-pelagic trawl has a similar configuration (e.g. large anterior meshes) to many pelagic nets and will likely have similar catching ability for pelagic fish species and greater fish densities in the water column should benefit it.

While very few demersal fish were caught the use of lights continues to show potential. The greater quantities of larger haddock retained with lights follow a similar trend as observed by Oliver et al. (2023) when also using lights on a trawl headline. This is encouraging and offers a potentially simple modification that can assist with improving selectivity of the semi-pelagic trawl and needs to be fully evaluated in further studies.

While seabed contact was not assessed the semi-pelagic trawl and its doors are assumed to have no (minimal) contact with substrate due to no damage to the net and the minor rubbing marks (approx. 10% of the door length) on the inside edge of the starboard door. This observation of the doors is somewhat corroborated in work by Lomeli and Wakefield (2019) where raising the doors and sections of the sweeps off the bottom reduced door/sweep seafloor interactions by >85% over their length.

The semi-pelagic trawl configuration should also reduce energy consumption. The larger anterior meshes would reduce towing resistance and fuel consumption during the trawling operation. Additionally, semi-pelagic trawl doors can reduce fuel usage by up to 17%, and pelagic nets for demersal species can lower energy consumption per kg caught fish (Grimaldo et al. 2015). While energy efficiency was not assessed during the trial, due to lack of a suitable comparative gear configuration, it is to be considered in future studies.

A significant change in fishing tactic is required to effectively catch demersal species with a semi-pelagic trawl, compared to a bottom trawl. During the capture process bottom trawls rely on, seabed contact, sweep length, otter board spread, and sweep angle. Sand clouds created by the trawl doors and sweeps create a visual cue that keep the fish in the trawl's path. Moving the trawl away from the seabed will mean less of a visual cue (e.g., no sand clouds) to keep the fish in the trawl's path and these trawls rely on fish reactions to the netting for capture and the larger meshes herd the fish. Hence semi-pelagic trawls for demersal species tend to have larger meshes (up to 3.8 m) in their anterior section and generally have much larger diameters (larger trawl openings, fishing circles) compared to conventional demersal trawls with meshes rarely larger than 0.3 m. It is therefore likely that there will be significant differences in catching performance between demersal and pelagic trawls when targeting demersal species.

Overall, the skipper was pleased with the trial and some considerations for future work were:

- Constantly monitoring, vessel speed, trawl height relative to the seabed and door spread are important; trawl height can be adjusted varying the warp length.
- Having a sensor to assess headline and fishing line height (from the seabed) is required during fishing.
- Door height and or contact sensors would be advantageous to assess seabed interactions.
- Availability of a suitable bottom trawl configuration (for comparison) to assess energy efficiency.
- Maximising the wingspread and headline height, e.g., have targets to aim for.

BIM are working with SNG on a new off-bottom trawl that will advance the design used here to be more appropriate for demersal species. The trawl will have anterior meshes up to 1600 mm, the top and bottom panels will be different (i.e., slight cover on top panel) and the bridle (between the net and doors) will include webbing (extra-large mesh panels) to assist with herding. The trawl is expected to be ready towards the end of 2024 with testing proposed in the first half of 2025.

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