Preliminary assessment of MLD off-bottom trawl doors in the Irish Nephrops fishery

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Preliminary assessment of MLD off-bottom trawl doors in the Irish Nephrops fishery

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Key Findings

- Doors remained off the seabed for 89% of haul times
- Wingend spread was reduced but no reduction in swept area
- Further work needed on optimisation of off-bottom doors with different trawl configurations

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Introduction

The recent communication from the European Commission on Energy Transition of the EU Fisheries and Aquaculture sector outlines how increases in energy efficiency are needed in the short to medium term while a transition away from reliance on fossil fuels is required in the longer term.

BIM is working with the Irish Fishing Industry to develop more energy efficient fishing gears. As outlined in BIMs recent carbon footprint report, fuel use and carbon emissions are relatively low in the seafood sector, but the Nephrops fishery is on the higher end of the scale in terms of energy use (Dallaghan et al., 2023).

Work is ongoing on the development of more hydrodynamic trawls and modified rigging ahead of the nets which improve energy efficiency. BIM is also testing off-bottom doors. Doors are typically responsible for around 30% of gear drag (Sterling and Eayrs 2010) and lifting them off the seabed has major potential to significantly reduce drag and energy use.

The model tested was provided by MLD from Denmark. MLD develop high-aspect trawl doors which can be controlled from the wheelhouse primarily for the pelagic industry but have recently developed a 1.75 m^2 prototype off-bottom version for the demersal sector. Here, we conducted preliminary trials on MLD doors in the Irish *Nephrops* fishery.

Methods

We tested the doors over 5 days on board the MFV Emerald Shore, a 16.89 m vessel targeting *Nephrops* in the Western Irish Sea in October and December 2022 (Figure 1; Table 1). The vessel fished a half-quad configuration which comprised a two-warp system connected to a pair of trawl doors with 70 m outer sweeps and an inner split and centre sweep 'Y' configuration (2×50 + 20 m) (Figure 2; Table 1).

Full or half-quad-rig trawls are currently the main the gear configurations used in Irish Nephrops fisheries due to consistent ground contact and catch efficiency. There was a small adjustment to the conventional sweep and bridle configuration to allow the MLD doors to lift off the substrate and to permit the half-quad configuration to maintain ground contact. For each MLD trawl door, the bridles (with two attachment points) comprised two 3 m lengths (100 mm) of long-link chain attached to its top and bottom, while the sweeps were lengthened with 6 m (100 mm long-link) chain (Figure 3).

We primarily focussed on getting the MLD doors to work correctly but we also conducted two hauls using conventionally rigged low-aspect trawl doors (hereafter standard doors) with a three-point bridle attachment. The dimensions of the trawl doors are presented in Table 2.

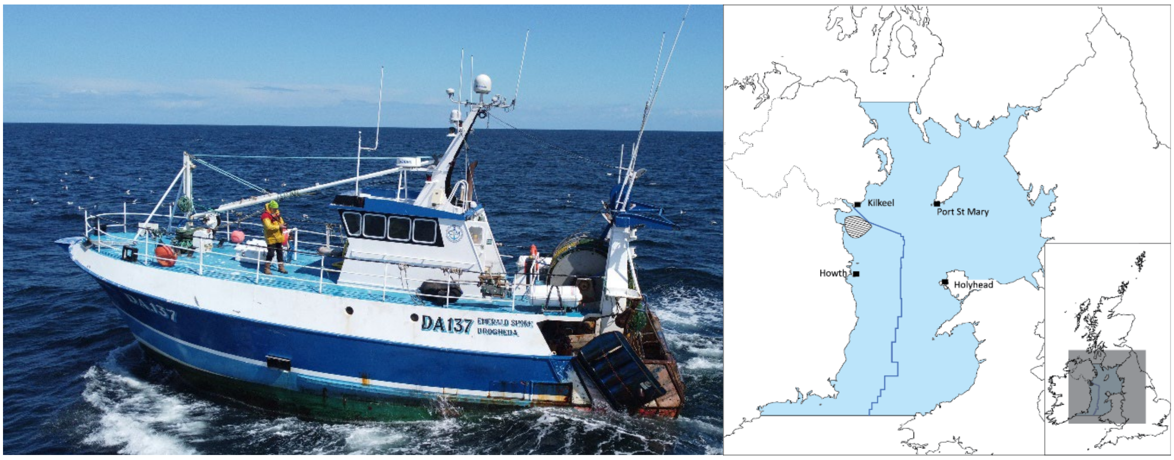

Figure 1. MFV Emerald Shore (DA 137) and trial location (hatched area) within the Irish Sea

Table 1 Vessel and trawl gear characteristics for standard and MLD TSS trawl door trial

Vessel	Emerald Shore (DA137)
Length (m)	16.89
Engine (kW)	269
Trawl type	*Nephrops*
Trawl manufacturer	Pepe Trawls
Trawl configuration	Half quad
Headline length (m)	37
Estimated headline height (m)	1
Footrope length (m)	42
Fishing-circle (meshes × mm)	400 × 80
Number of panels in trawl	4
Codend type	Four-panel
SMP Mesh size (mm)	300
SMP position	4.5–7.5 m from codline
SMP size (mesh × mesh)	18 × 4
No of panels	4
Nominal mesh size (mm)	80
Measured mesh size (mm)	84
Codend circumference (mesh no.)	120

Prior to starting the trial, modifications to the stern/gantry of the vessel were required to allow the MLD doors to be deployed and retrieved. Due to the high aspect ratio of the MLD doors it was considered easier to haul them up to the stern of the vessel rather than to the side of the gantry which is more common with low-aspect trawl doors (see cover photo).

Due to rigging constraints, it was not possible to alternate hauls between the MLD and standard doors. Instead, we spent one day setting up, three consecutive fishing days with the MLD doors, and one with the standard doors. We restricted comparisons to operational data due to the imbalance in sampling and time-area differences. To maximise consistency across operational data comparisons, the trial was completed during similar tidal cycles.

Table 2. Characteristics of the off-bottom MLD and standard trawl doors used in the trial

Parameter	MLD	Standard
Length (m)	0.79	1.90
Height (m)	2.20	1.21
Area (m2)	1.74	2.25
Aspect ratio	2.78	0.64
Weight in air (kg)	300	360

Marport wing end and door sensors along with a flow sensor were deployed on the nets. Load sensors were placed ahead of the doors on the warps (i.e., off the gantry) to estimate differences in drag between the MLD and standard doors. Fuel usage was recorded manually by the skipper up to six times per haul along with other key variables from the instrument display in the wheelhouse. A transducer was clipped to the warp just below sea surface to communicate with the MLD doors. We estimated differences in the swept area based on average wing end spread and vessel speed as follows:

Average wingspread (m) × average vessel speed (meters per second) × time (60 seconds)

The MLD doors have onboard altimeters and adjustable flaps (via electric actuators) that are controlled by an active Proportional-Integral-Derivative (PID) feedback system. The PID system changes the position of the doors in the water column by adjusting the flap openings by comparing the altimeter data to a pre-set target height above the seabed. Setting up the MLD doors involved running through a series of checks to make sure that the onboard system (e.g., computer and flap actuators) was working correctly. The MLD doors were programmed to operate at 3 m altitude off the seabed and from the digital display in the wheelhouse it was possible to control the altitude and door spread. The MLD's onboard altimeter recorded door height every 20 seconds. The minimum recorded altitude from the seabed was 0.7m with altitudes below this assumed to be at seabed level. Wire warps were used with the MLD doors for the first 5 hauls with Dyneema® warps used for hauls 6 and 7.

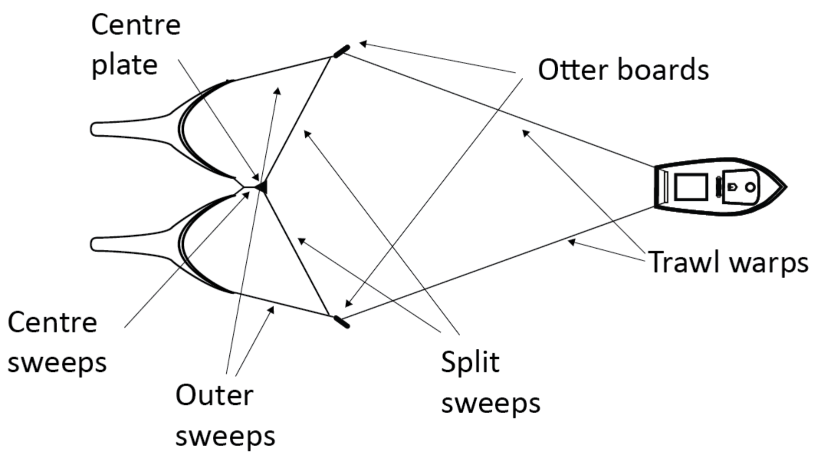

Figure 2. Half quad-rig configuration used in the trial

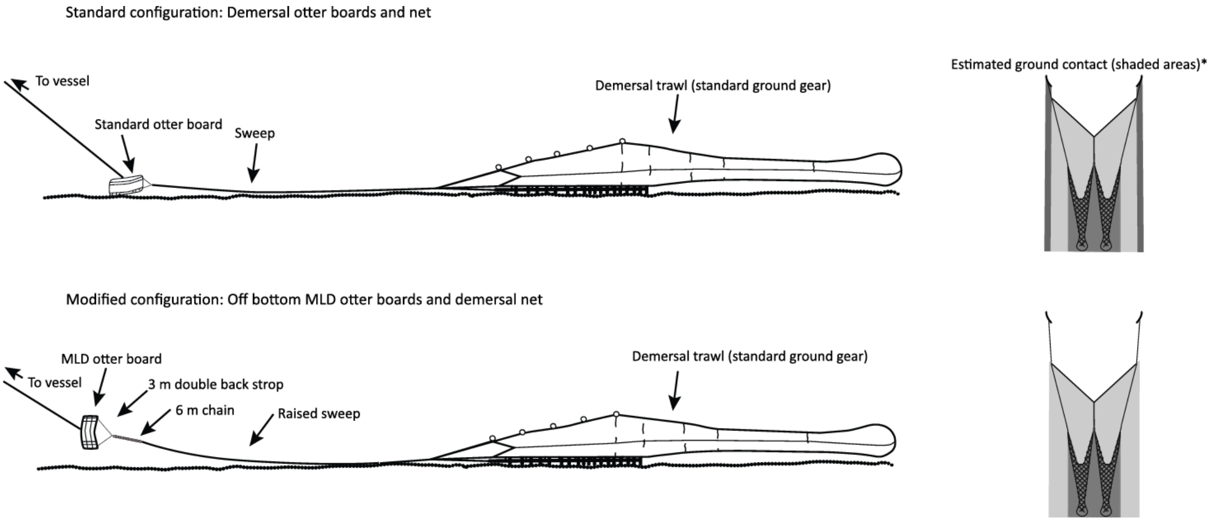

Figure 3. Graphical representation of the differences between the on and off bottom door configuration (*darker shading represents greater contact).

RESULTS

A total of 9 valid hauls - 7 with the MLD, and 2 with the standard trawl doors - were carried out. Mean haul duration and depth fished during the trial were 2 hrs 45 min and 33 m. The main species caught were Nephrops, haddock, plaice, whiting, thornback ray, squid, and dogfish.

There was a slight reduction in fuel use with the MLD doors although this was quite variable as indicated by the relatively high standard deviation (Table 3). Vessel speed was 16% greater with the MLDs as the skipper tried to keep the doors off the seabed.

There was no increase in engine revs with the MLD doors. The load or drag was slightly lower with the MLD doors although was quite variable with both sets of doors. Wingend and door spread were slightly lower with the MLDs although little difference occurred in swept area (Table 3). The MLD doors were off bottom for 89% of the time with an average altitude of 1.64 m (Table 3; Figure 4).

Table 3. Mean operational and gear performance data with standard deviation (±).

Operational parameters	Standard	MLD	Difference (%)
Fuel (l/Hr, per vessel)	40 (±2.67)	37 (±5.01)	-8
Engine speed (RPM)	1423 (±36.38)	1392 (±67.01)	-2
Vessel Speed (kts)	2.63 (±0.15)	3.05 (±0.37)	16
Wing-end spread (m)	14 (±0.0)	12 (±0.80)	-14
Trawl door spread (m)	47 (±1.53)	43 (±5.49)	-9
Load (kgf)	2691 (±238.84)	2528 (±215.37)	-6
Warp shot (m)	113 (±17.68)	109 (±15.67)	-4
Swept area (m^2 per min)	1137 (–)	1130 (–)	-1
Average altitude (m)	0 (–)	1.64 (0.99)	—

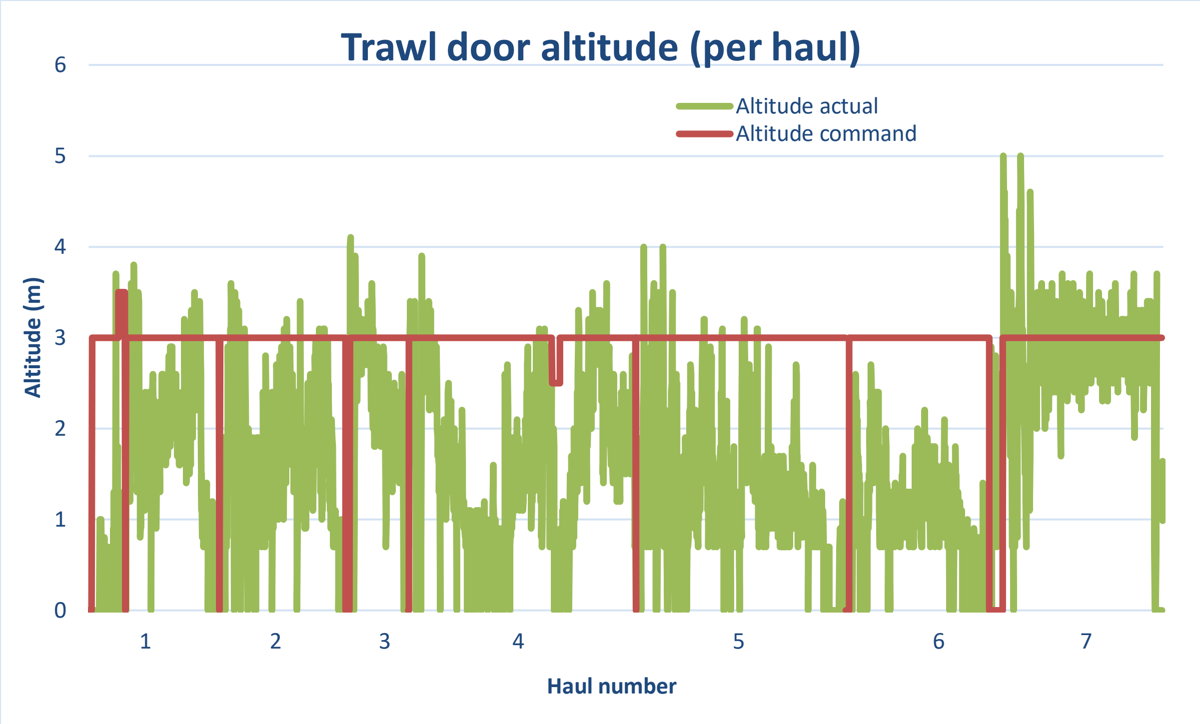

Figure 4. Observed (green line) and wheelhouse-set (red line) altitude of MLD doors above the seabed

DISCUSSION

The MLD doors remained off the seabed for around 90% of deployment periods. There were some software issues, and the altitude was lower than expected although this improved when Dyneema® warps were added towards the end of the trial. More commonly used with pelagic trawl doors, the light Dyneema® warps likely reduced the downward force compared with heavier wire warps.

The skipper increased towing speed from his usual 2.5 kts up to 3 kts to help keep the MLD doors off the bottom and needed to pay a lot of attention to keep them operating correctly. Fuel was down by 8% compared with conventional doors and no increase in engine revs occurred despite the greater speed.

Recent trials of the MLD doors in Denmark showed an 18% reduction in fuel compared with standard doors in a demersal trawl fishery when both sets of doors were towed at 3 kts (Eighani et al. 2023). A greater reduction in fuel use with the MLD doors would likely have occurred in the current study if the standard doors were towed at 3 kts instead of 2.5kts.

Trawl wingend spread was down by around 14% with the MLDs but this was at least partially offset by the increase in speed which resulted in no difference in swept area. However, wingend spread would need to be optimised to maximise performance of the off-bottom doors.

Eighani et al. (2023) used a single-rig trawl configuration with the MLD doors and observed a greater wingspread compared to the conventional trawl doors when using a standard sweep length. In contrast to single-rig trawl configurations, half and full quad-rig configurations used in the Irish Nephrops fishery uses split sweeps (Figure 2). The lengths of chain we added to the sweep and bridle configuration assisted with lifting the MLD doors of the seabed but may also have affected the door and wingend spreads. Further work would be needed to optimise performance of the MLD doors in relation to different trawl configurations.

Focused primarily on the practicalities and operational performance, it was not possible to analyse the catches in detail, but the MLD system did catch prawns. Further testing would also be needed to assess the catching performance.

In comparison with other trawl components (e.g., sweeps, ground gear) trawl doors are generally considered to have the greatest impact on seabed sediments (Kaiser et al., 2003). Trawl doors impact the substrate by leaving distinctive tracks that can be up to, 2 m wide and 0.3 m deep (e.g., Linnane et al. 2000). The MLD doors greatly reduced ground contact and further improvements should be possible in this regard. Tangling of the transducer cable and the warp during hauling, slowed down retrieval of the gear and resulted in unnecessary ground contact which could be improved with some modification.

Despite some challenges around optimising the MLD system and gear performance over a short time period, the trial demonstrated that off-bottom doors have potential to improve energy efficiency in the Nephrops fishery. Given the potential benefits, a number of door manufacturers are stepping up research in this area and BIM plans to continue working with the fishing industry on testing and developing options in the Irish Nephrops fishery.

ACKNOWLEDGEMENTS

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