Ireland's Seafood Development Agency

Preliminary assessment of reduced-drag Pluto trawl doors

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Preliminary assessment of reduced-drag Pluto trawl doors

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Key Findings

- Reduced load which is linked to fuel and carbon use
- Reduced swept area which is linked to gear performance
- Optimising door size in relation to vessel and gear size might improve gear performance
- Good potential to reduce seabed impacts

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INTRODUCTION

BIM is working with the Irish Fishing Industry to develop more energy efficient fishing gears in line with the European Union's decarbonisation of fisheries and aquaculture, and rising fuel prices.

Development of more efficient vessel designs, marine engines and use of alternative fuel sources is ongoing. Gear-based energy efficient work in the *Nephrops* fishery where trawl ground contact must be maintained includes development of more hydrodynamic trawls (McHugh et al. 2022A) and modified rigging ahead of the nets (Browne et al. 2022). Work is also ongoing on ways to increase energy efficiency on board vessels targeting demersal fish through pair trawling (McHugh et al. 2022B, Oliver et al. 2023A), lights on the headline (Oliver et al. 2023B) and a new project developing an off-bottom trawl.

BIM also previously tested reduced-drag MLD otter doors with some promising results (McHugh et al. 2023). Doors are typically responsible for around 30% of gear drag (Sterling and Eayrs 2010) and using hydrodynamically designed versions has major potential to significantly reduce energy use and carbon emissions.

Here, we test another model of reduced-drag doors. The 'Pluto doors' from Polar and Marine Ecological solutions (https://mar-eco.eu) are primarily made from plastic (50:50 blend of recycled and virgin plastic) with an attached metal shoe to add weight and protection. The doors have an innovative design and are fully reversible, for example, the metal shoe can be removed from the bottom of the port door and placed on its top edge turning it into a starboard door, once it's flipped over.

METHODS

We focussed on the practicalities of optimising the performance of the Pluto doors. Fishing was carried out on board the MFV Karen Mary, a 11.6 m vessel operating in Galway Bay using a single trawlto target *Nephrops* and whitefish (Figure 1, Table 1). We conducted two trials, Trial 1 in a Nephrops fishery, Trial 2 in a whitefish fishery. The Pluto doors are high aspect (taller than long) and unlike other similar doors that tend to be unstable these are likely to be very stable when on the seabed due to a low centre of gravity and most of their weight being in the shoe at the base. We tested the Pluto doors against two models of conventional low-aspect (longer than tall) trawl doors (hereafter doors A and B). A similar back strop configuration and attachments were used for all doors and the key characteristics of the trawl doors are presented in Table 2.

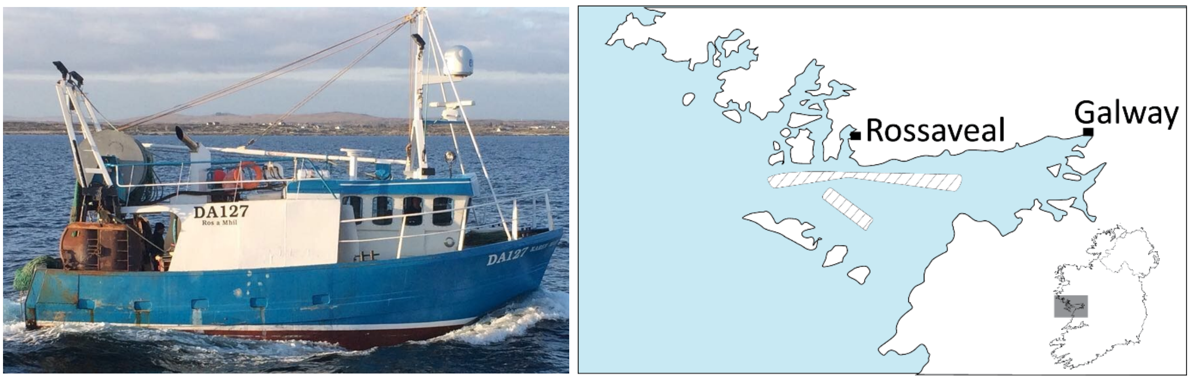

Figure 1. MFV Karen Mary (DA 127) and trial location (hatched area) within Galway Bay

Table 1. Vessel and trawl gear characteristics for standard and Pluto trawl door trial

Vessel	Karen Mary (DA127)
Length (m)	11.6
Engine (kW)	150
Trawl type	*Nephrops* and whitefish
Trawl manufacturer	Marine Suppliers
Trawl configuration	Single
Headline length (m)	37
Estimated headline height (m)	1
Footrope length (m)	42
Fishing-circle (meshes × mm)	400 × 80
Number of panels in trawl	2

Table 2. Characteristics of the Pluto and standard (A and B) trawl doors used in the trials.

Parameter	Pluto	Standard A	Standard B
Length (m)	0.92	1.60	1.75
Height (m)	1.20	0.97	1.25
Area (m^2)	1.10	1.55	2.10
Aspect ratio	1.30	0.61	0.71
Weight in air (kg)	124	148	300

Trial 1. The 1.1 m^2 Pluto doors were compared against 1.6 m^2 Standard A doors used with standard 37 m (18 mm) combination (wire and rope) sweeps in a *Nephrops* fishery. The same trawl and rigging were used with both trawl door models.

A key consideration of Trial 1 was the Pluto door weight. Being new on the market very little was known about their optimal settings in terms of gear spread and door lift. The Pluto doors were 24 kg (16%) lighter than the Standard A doors in air (up to 66 kg and 45% lighter in water). Following discussions with Polar doors and some basic assessments at different settings, the Pluto doors appeared to operate best at the lowest point on the centre setting (Figure 2). This towing point allowed the doors to be more inclined to move towards the seabed (because the top of the door effectively rolls out), which is useful as the water gets deeper. In addition to the towing point attachment, the backstrops were adjusted so the upper one was one shackle (approx. 5 cm) shorter than the lower one. This allowed the doors to have a slight lift (i.e., seabed contact focused more on the rear of the door).

Initially it was difficult to confirm trawl ground contact. We deployed a Marport high-definition trawl explorer (HDTE) sensor on the headline to help indicate when the net touched the seabed (Figure 3). This helped optimise gear performance when the net hit the seabed: Initially, when the net got close to the seabed, the skipper would slow down briefly to let it touch the seabed and then return to normal towing speeds with the net on the seabed. However, this was not considered practical and the warp to depth ratio was subsequently increased from ~3.5:1 to ~ 5:1 to ensure the Pluto doors had seabed contact. Typically, a warp to depth ratio of 3.5–4:1 is used with conventional doors, and a greater warp to depth ratio is used to ensure that trawl components are heavier on the seabed.

When the Pluto doors were shown to be working, i.e. easily reaching the seabed with consistent door and wing spread, 18 m extra sweeps were added to the configuration (total length now 55 m) to help maintain seabed contact. The slightly longer sweep allowed assessment at more conventional warp to depth ratios.

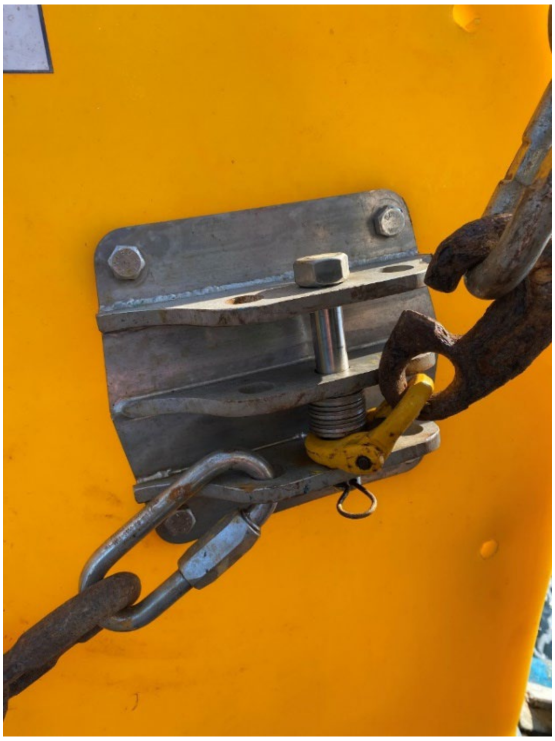

Figure 2. A photo of the optimum towing attachment (yellow hammerlock with G-hook below the washers) on the Pluto door towing point.

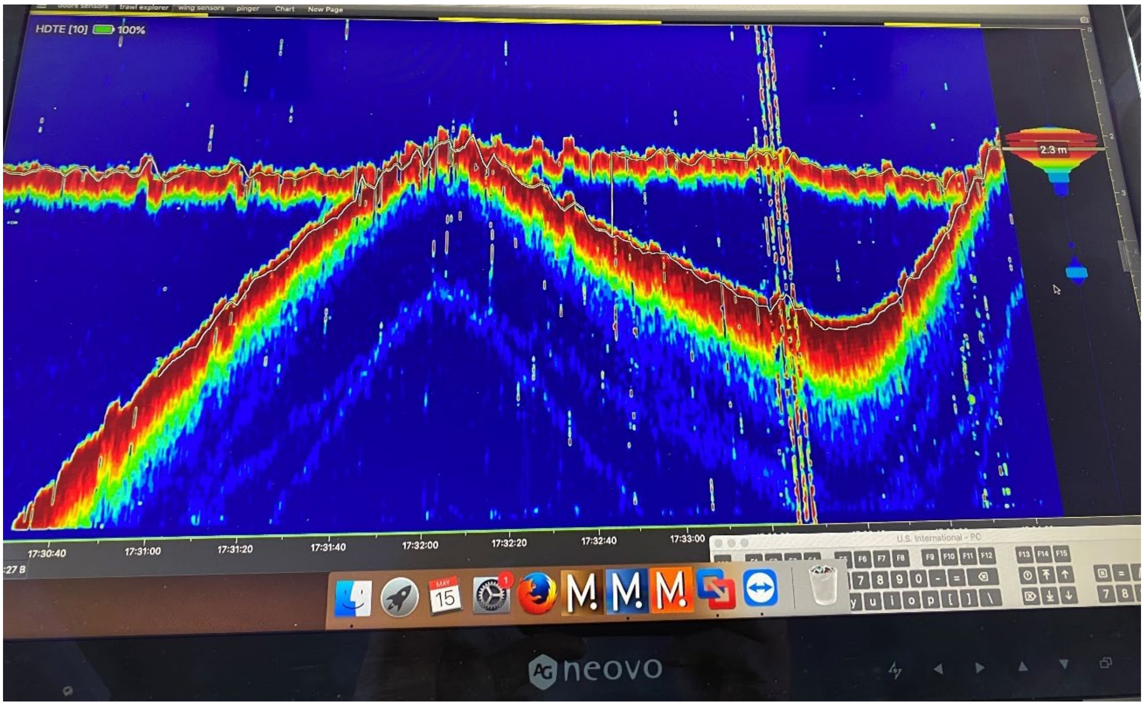

Figure 3. Output from the Marport HDTE sensor used to confirm seabed contact. Horizontal line is the trawl ground gear, and the oscillating line is the seabed.

Trial 2. We compared the Plutos with 2.1 m^2 Standard B doors with 69 m (22 mm) combination sweeps in a whitefish fishery. The Pluto doors were retained at the same settings for towing point and back strops as Trial 1 and the Standard B doors were rigged as normal by the skipper. The longer sweeps provided an opportunity to assess the additional weight of the longer sweeps and whether the warp to depth ratio could be returned to more conventional ratios (i.e., 3.5/4:1). Catches were separated into broad categories (i.e., mixed flatfish, Spurdog, dogfish, spider crab, ray and skate, and debris) and their bulk weights estimated.

For both Trial 1 and 2, Marport wing end and door sensors along with a HDTE sensor (just behind the headline) were deployed. Load sensors were deployed to estimate differences in drag between the Pluto and standard doors. We attached them with wire grippers (Figure 4) hung from the gantry using a 3 m length of chain and attached to the warps. Key variables, engine revs (RPM) and vessel speed over ground (SOG), were recorded from the instrument display in the wheelhouse; it was not possible to recorded fuel usage due to the absence of a fuel meter.

The swept area was estimated using door or wing spread for both the standard A and B doors based on their target species. For Standard A the wingspread was used as is typical for non-herding species like *Nephrops*, while for Standard B the door spread was used which is common for herding species (e.g., fish). The formula used to calculate swept area is as follows:

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

Figure 4. Loadcell with chain and gripper attached to warp.

RESULTS

A total of 32 valid hauls – 22 with the Pluto, and 7 and 3 with standard doors A and B, respectively - were carried out over 9 days fishing.

Trial 1. Although quite variable, the average load for the Pluto doors was down 11% when compared with Standard doors which contributed to a slight decrease of 6% in engine revs (RPM) (Table 3). The average door spread was down by 3.66 m (10%) for the Pluto doors and a 13% lower bridle angle contributed to less spreading force by the doors and a lower wingspread (Table 3). The average wingspread was reduced by 8% (1.55 m) for the Pluto doors when compared with the Standard doors A. This lower wingspread resulted in a reduction of 92 m^2 (7%) in the swept area in the Pluto doors (Table 3).

Trial 2. The average load for the Pluto doors was down 23% when and compared with Standard doors B, which contributed to a decrease of 5% in engine revs (RPM) (Table 4). Here the Pluto doors are 48% smaller (less surface area) than the Standard B doors and the average door spread was reduced by 25% (14.4 m), which reduced the swept area by 24% with the Pluto doors (Table 4). Here, as in Trial 1 there was likely less-spreading force by the doors that meant a 37% lower bridle angle and an average wingspread that was reduced by 8% (3.35 m) during the trial (Table 4). The average depth to warp ratio was 3.81:1 with the Pluto doors bringing it more in line with the industry's normal ratio of 3.5–4:1. There was a 15% difference between the average Standard B (263 kg, ±92—Standard deviation) and Pluto door (224 kg, ±83) bulk catches.

Table 3. Operational and gear performance data in Trial 1

Operational parameters	Standard A	Pluto	Difference (%)
Size (m^2)	1.6	1.1	-31
Weight (kg)	148	124	-16
Mean depth (m)	47.43 (21.40*)	37.31 (6.76)	-21
Mean warp to depth ratio	4.19 (1.05)	4.77 (0.37)	14
Mean door spread (m)	37.74 (3.19)	34.08 (2.37)	-10
Mean wing spread (m)	18.43 (1.21)	16.88 (1.10)	-8
Mean load (Kgf)	1,305 (134)	1,168 (158)	-11
Mean Engine revs (RPM)	1,191 (43.93)	1,116 (24.15)	-6
Mean speed over ground (SOG) (m s^{-1})	1.31 (0.08)	1.34 (0.06)	2
Swept area (m^2 per min)	1,449 (–)	1,357 (–)	-7
Bridle angle (^{O})	15	13	-13

*(Standard deviation in brackets)

Table 4. Operational and gear performance data In Trial 2

Operational parameters	Standard B	Pluto	Difference (%)
Size (m^2)	2.1	1.1	-48
Weight (kg)	300	124	-69
Mean depth (m)	39.43 (4.25*)	44.95 (7.42)	14
Mean warp to Depth ratio	4.24 (1.17)	3.81 (0.27)	-10
Mean door spread (m)	57.43 (4.04)	43.04 (3.80)	-25
Mean wing spread (m)	19.88 (1.62)	16.53 (1.38)	-17
Mean headline height (m)	0.74 (0.67)	0.83 (0.28)	12
Mean load (Kgf)	1,480 (107)	1,134 (93)	-23
Mean engine revs (RPM)	1,252 (32.00)	1,184 (68.95)	-5
Mean speed over Ground (SOG– m s^{-1})	1.29 (0.06)	1.31 (0.08)	2
Swept area (m^2 per min)	4,445 (–)	3,383 (–)	-24
Bridle angle (^{O})	16	10	-37

*(Standard deviation in brackets)

DISCUSSION

In both trials, the Pluto doors reduced drag which is linked to fuel and carbon use but also reduced swept area which is linked to gear performance. The doors were slightly undersized for the trial vessel and gear. Optimising the door size in relation to vessel and gear size might improve gear 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 Pluto doors were in light contact with the seabed. From video recordings and observations of the trawl door shoes after deployment, it appears that the Pluto doors were contacting the substrate for approximately one third of the shoe length, while the other doors were in contact for up to 90% of their shoe lengths. Hence, the Pluto doors have excellent potential to reduce seabed impacts.

There was a large difference between the Pluto and Standard B doors for both door and wing spread which resulted in a reduction in swept area with the Pluto door configurations. Optimising the swept area of the trawl configuration to maximise target species catches will be a key objective when using the Pluto doors.

The trial vessel skipper liked how stable the gear looked when hauling and shooting with the Pluto doors and was generally positive regarding their performance. Further testing would be needed to robustly assess catching performance with the Pluto doors.

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