June 2022

Artificial light on the raised-fishing line in a Celtic Sea mixed-demersal fishery

Fisheries Conservation Report

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Key findings

Significant 65% reduction in cod

Substantial reductions in market sized whiting and hake

Reductions in larger haddock

Lights on the raised-fishing line currently commercially unviable due to loss of marketable catches

The raised fishing line remains an important gear option for reducing unwanted catches of cod, skate and rays, and other species in the Celtic Sea

Rialtas na hÉireann
Government of Ireland

Có-mhaoinithe ag an Aontas Eorpach
Co-funded by the European Union

Introduction

BIM previously conducted a preliminary assessment of artificial light on the raised-fishing line (RFL) line in the Celtic Sea mixed demersal species fishery in 2021 (Oliver et al., 2021). In line with COVID-19 protocols, work was conducted on a self-sampling basis with catch weights for key species obtained for RFL gear with and without lights mounted on the fishing line.

Comparable results were obtained with omni-directional Lindgren-Pitmann® green (LPG) lights and SNTECH lights pointing towards the trawl headline: Substantial reductions in haddock occurred when the trawl mouth or area around the fishing line was illuminated. A small reduction in whiting catches occurred when the fishing line was illuminated. However, whiting and cod catches were relatively low during the trial.

Results were encouraging given that quotas can be substantially higher for whiting compared with haddock in the Celtic Sea e.g., whiting - 4073 t compared with haddock - 2413 t in 2020 (EU, 2020) with potential for vessels to choke on haddock before sufficient quantities of whiting are caught.

Further assessment of the RFL with light was needed given low catches of cod and whiting, and the absence of catch at length information from the previous trial. Here, we conduct a full-scale assessment of lights on RFL gear with artificial lights in the Celtic Sea mixed demersal fishery.

Methods

Fishing operations and gear

The trial was conducted on board the MFV Northern Celt (SO472), a 25m single-rig trawler targeting mixed-demersal fish species in the Irish sector of ICES Divisions 7g and 7j in the Celtic Sea during five days in March 2022 (Figure 1). Alternate hauls were conducted using RFL gear with artificial lights (test) and without artificial lights (control) (Figure 2). Based on previous studies, the trawl was fitted with an additional bridle attached between the fishing line and the upper bridle to improve trawl stability (McHugh et al., 2019). The trawl's ground gear was constructed of 40 cm (16 inch) rubber discs, and it was fitted with a 120 mm diamond mesh codend and extension piece in line with current regulations. The fishing line was raised from the ground gear using 1-meter-long chain and polysteel rope droppers (Table 1, Figure 2).

Figure 1. The trial vessel MFV Northern Celt (SO 472) and trial location (hatched area)

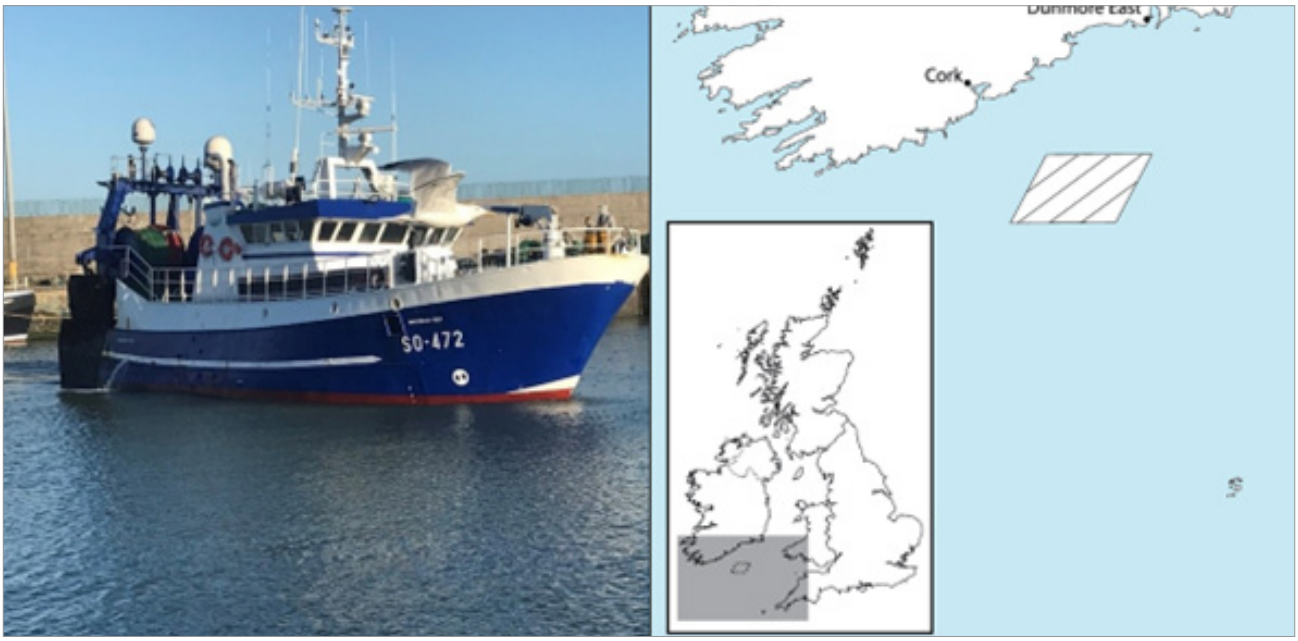
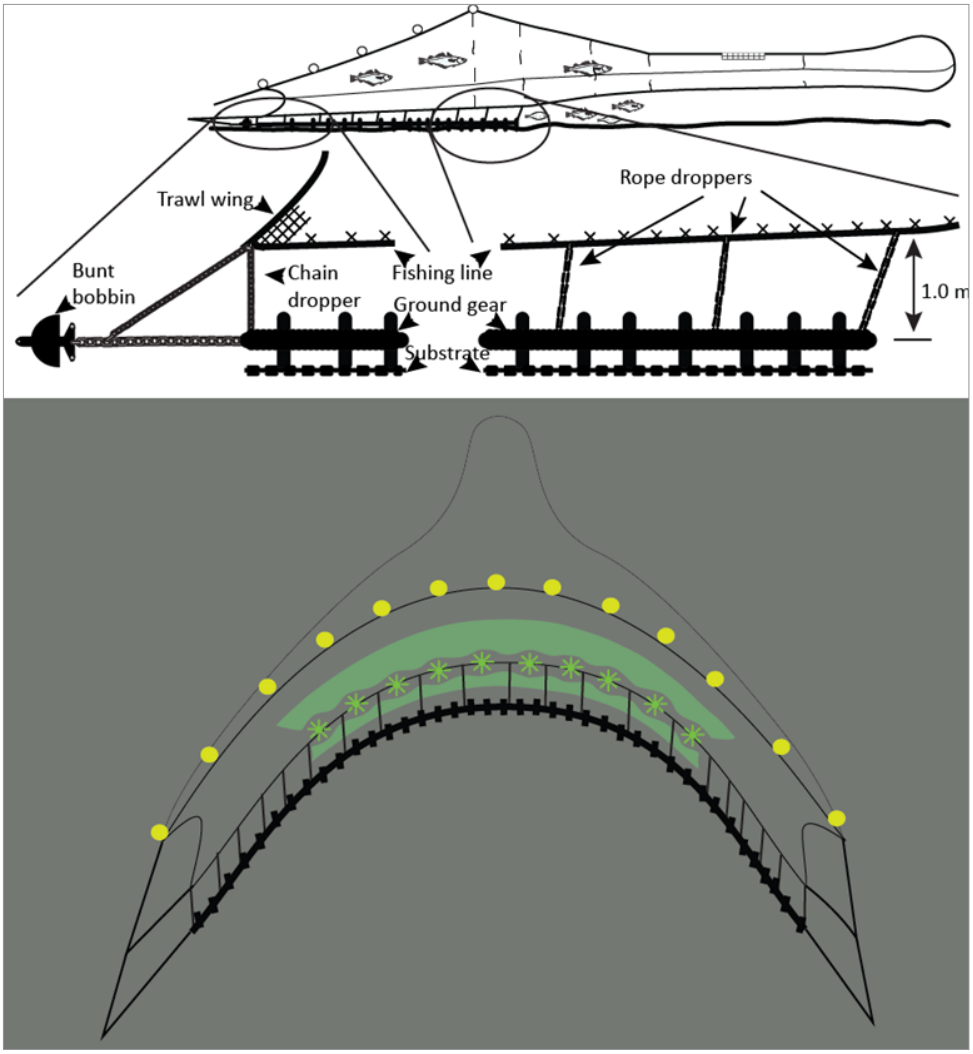


Figure 2. RFL with artificial light on the fishing line



Artificial Light

The LPGs have a depth rating of 850 meters, emit 0.5 – 2 lux and the battery lasts up to 350 hours. 20 LP lights were attached to the fishing line centred around the bosom of the trawl at ~ 1 meter spacing between each light. The lights were attached using 3 mm Polyethylene (PE) twine and cable ties. All lights were taken off the fishing line between hauls to prevent damage from the net drum.

Sampling and analysis

Cod, haddock and whiting were chosen as key species in line with requirements in relation to demonstration of equivalent selectivity when assessing alternative gear options in EU fisheries (EU, 2019).

Total catches from each haul were separated at species level and weighed. All quota species were measured with random representative sub-samples obtained where required. Total lengths (TL) of commercial fish species were measured to the nearest cm below. Non-commercial species such as lesser spotted dogfish, gurnards and crabs were weighed but not measured.

Table 1: Gear characteristics

Trawl configuration		Single rig
Door spread (m)		93
Door type		Bison
Door weight (kg)		1000
Headline length (m)		41.1
Fishing line length (m)		30.4
Ground gear		Hopper discs
Chain droppers (mm)		11 x 1000
Rope droppers (mm):	Singles doubles	109 55
Warp diameter (mm)		22
Diamond cod end nominal mesh size (mm)		120
Measured codend mesh size (mm)		132
Nominal twine thickness (mm)		4 (double)
Number of floats on headline		48
Fishing circle (meshes x mm)		720 x 120
Trawl manufacturer		John Cavanagh

Initial modeling used consecutively matched alternate test and control hauls in line with optimal experimental design for single-rig trawl catch comparison experiments (Browne et al., 2021). Due to significant between haul variability, we also tried an alternative approach.Bootstrapping 10,000 iterations of randomly matched hauls with replacement was used to derive the mean fitted curves and confidence intervals (Sistiaga et al., 2016). These models were then compared using a deviance goodness of fit test.

For both consecutively matched and bootstrapped methodologies, the count in the test gear was modelled as a binomial generalized additive mixed model (GAMM). As counts were sub sampled, an offset was applied for the proportion of the catch in either codend where applicable (Holst and Revill, 2009).

Previous research on RFL gear demonstrated variable diurnal results (Krag et al., 2010). To account for this in the current study, matched hauls were evenly divided between day and night with time of day included in the consecutively matched model. Due to potential time of day imbalances from sampling tows with replacement, the time-of-day term was removed from the bootstrap model.

In finalised catch curves, the null hypothesis of equal catch efficiency between gears was rejected for a given length-class, when the confidence limits associated with the prediction on the length-class did not overlap the reference value of 0.5 (50% catch probability).

Table 2. Total catch weights and percentage differences

Species	Control (kg)	Test (kg)	Difference (%)
Cod	437	165	-62
Whiting	449	248	-45
Haddock	2473	2146	-13
Hake	198	92	-53
Non-commercial species*	123	112	-9
White pollack	98	56	-43
Flatfish**	79	74	-6
Monkfish	72	37	-49
Rays***	66	60	-9
Ling	50	29	-42

Non-commercial species*: Gurnards, lesser spotted dogfish, and non-fish catches (crabs and seaweed)
Flatfish**: Megrim, witch, turbot, brill, plaice, lemon sole and black sole
Rays***: Spotted, thornback and cuckoo ray

Results

A total of 16 hauls consisting of 8 test and 8 control deployments were completed during the study. Mean haul duration, towing speed, and depth fished during the trial were 3 hrs, 3 kts, and 83 m, respectively. The weather was mixed with wind speeds of 6 to 49 km^{-h}.

The main commercial fish species caught were cod, whiting and haddock which showed overall reductions in weight of 62%, 45%, and 13% respectively in the test gear. Reductions in weight across all other species caught during the study were also observed in the test gear (Table 2).

Table 3. Goodness of fit test results

Species	Bootstrap	Matched
Cod	58.7	60.7
Haddock	164.5	376.7
Whiting	47.6	52.5

The bootstrap modeling method achieved a better fit with lower deviance for all key species (Table 3). Catch curves for key species generally displayed downward trends with reduced catches of larger size cod, whiting and haddock in test hauls. Confidence Intervals were relatively large likely due to elevated levels of between haul variability. Significant reductions in cod and whiting occurred at lengths greater than around 60 and 40 cm respectively. No significant difference was observed for haddock although fewer larger haddock (~ > 40 cm) were retained in the test gear (Figure 3).

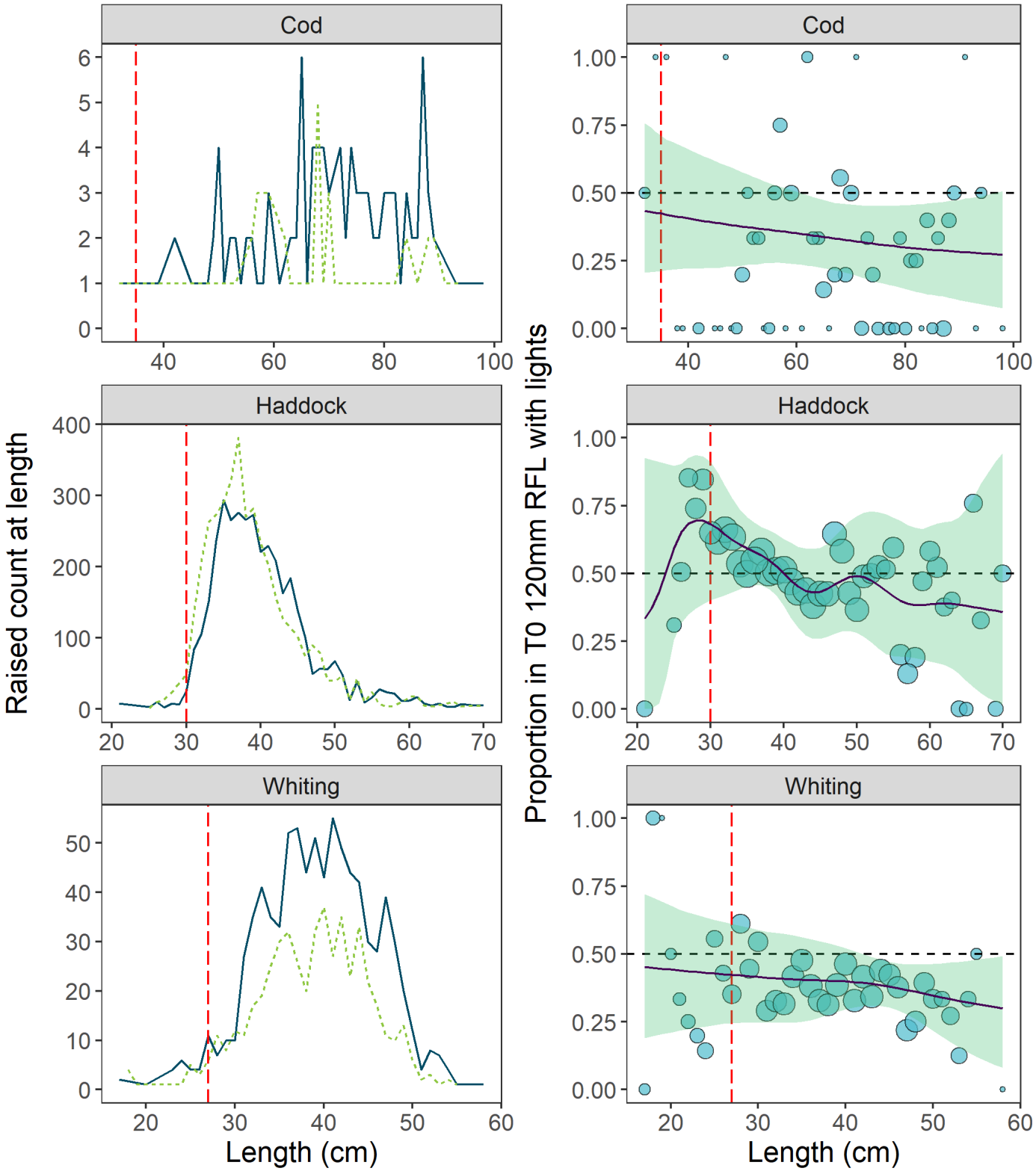


Figure 3. Length frequencies (LF) (left) and catch curves (right) for key species. Green hatched line represents the test gear and solid navy line represents the control gear in the LF plot. Overall proportion of catch per length class of key species in the test gear are outlined in the catch curves. Points represent the empirical raised proportions over all hauls with point sizes proportional to the raised counts. Fitted average (solid line) and 95% confidence intervals (green band) come from the bootstrapped model. Vertical lines represent the minimum conservation references.

Discussion

The significant reduction in cod with lights on the RFL is a positive finding. Previous trials have shown that the standard RFL reduces cod catches by 30 to 40% compared with a traditional trawl with the fishing line mounted directly on the ground gear. A further 65% reduction in the RFL in the current study suggests that catches of cod – a low quota species in the Celtic Sea - are effectively minimised on the RFL with lights.

However, the lights also substantially reduced catches of market sized whiting and hake and may reduce larger haddock. Vessels operating in this fishery are already struggling to maintain commercial viability due to high fuel prices, low quota for haddock and inability to catch the whiting quota due to relatively large minimum codend mesh and square mesh panel (SMP) sizes. Formerly categorised as a choke species, and as observed in the current study (Table 2), haddock is currently the main target species in the Celtic Sea mixed demersal species fishery. Further reductions in catches of haddock and other species would likely render the fishery commercially unviable.

Catch curves generally demonstrated size dependency in relation to ability of fish to react to the lights with fewer large cod, haddock and whiting retained in the RFL with lights. Bigger fish were likely more capable of dipping under the fishing line in response to the lights compared with smaller fish.

Results for haddock differ between the current and previous preliminary study on the effect of lights on the RFL. For example, observed catches of market size haddock were reduced by 74% with the LPG lights on the RFL in the previous study (Oliver et al., 2021). In the current study, most haddock were market sized but catches were reduced by just 13% in the RFL with lights (Figure 3).

Species and site-specific differences in reactions of species such as haddock to lights in fishing gear are known to occur (Southworth et al., 2020). The areas of operation and depths fished were similar between the two studies. There were differences in the codend mesh size and SMP configuration between studies, but this is unlikely to have such a large effect on proportional differences in catches between test and control gears across studies.

Gear trials in Oliver et al (2021) and the current study were conducted in different years. However, work was conducted at the same time of year towards the end of April which coincides with the haddock spawning period between February and May. Haddock behaviour in relation to fishing gear is known to vary in relation to spawning period. For example, SMPs have been found to be least effective post spawning when haddock are in poor condition (Fryer et al., 2016). Annual variability in timing of spawning or other unknown environmental factors may have caused the differences between studies.

Whatever the cause, if in the future vessels were capable of catching the whiting quota, and reductions in haddock were needed, more consistent results would need to be achieved before the lights could be considered an effective method of avoiding haddock on the RFL.

The RFL gear remains a technically effective gear option for reducing low quota cod and plaice, and biologically sensitive skates and rays in the Celtic Sea. Uptake of this gear has been low due to loss of marketable catches and the fact that the same codend mesh sizes and square mesh panels are required whether the RFL is used or not. Although lights may not be a commercially viable additional management measure at present, given its broader biodiversity benefits, incentives for continued use of the RFL in the Celtic Sea should be explored.

Acknowledgements

BIM would like to thank Adrian McClenaghan and the crew of the MFV Northern Celt for a successful collaboration. This work was funded by the Irish Government and part-financed by the European Union through the EMFAF Operational Programme 2021 - 2027 under the BIM Sustainable Fisheries Scheme.

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