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Preliminary assessment of artificial light on the raised-fishing line

Fisheries Conservation Report

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Key findings

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.

Effective reductions in haddock and cod at the trawl mouth would help towards a case for codend meshes which selectively retain and optimise utilisation of Celtic Sea whiting.

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Introduction

The raised-fishing line is a gear-based technical measure for trawlers targeting mixed-demersal fish species in the Celtic Sea (EU, 2021). The gear was tested and developed by BIM and the Irish fishing industry through a series of gear trials and a flume tank workshop.

The gear substantially reduced cod, flatfish species and undersize haddock and whiting while retaining market size whiting and haddock. The RFL works by creating a gap between the fishing line and the ground gear permitting low swimming fish such as cod, flatfish, skates and rays to escape at the mouth of the trawl (McHugh et al., 2017; 2018; 2019). Species such as cod and plaice are subject to low quotas while some skate and ray species are protected in the Celtic Sea.

In recent years, underwater artificial light has been shown to influence fish behaviour and reduce unwanted catches in a variety of fisheries (Nguyen and Winger, 2019). Research in the US (Hannah et al., 2015; Lomeli et al., 2018; Lomeli et al., 2020) showed how artificial light can influence fish behaviour and reduce unwanted catches at the mouth of the trawl, suggesting potential application to the RFL. Here we conduct a preliminary assessment of artificial lights on the RFL with a view to enhancing reductions in unwanted catches. Effects on target species are also considered.

Methods

Fishing operations and gear

A study was conducted onboard the MFV Foyle Warrior, a 25 m single-rig vessel targeting mixed-demersal fish species in ICES Divisions 7g and 7j in the Celtic Sea between 19th – 23rd April 2021 (Figure 1). Hauls were conducted on an alternate-haul basis using RFL gear with and without lights. Outlined in Table 1, the gear was deployed in a similar manner to McHugh et al. (2019) but chain was used to construct droppers instead of combination rope, and additional flotation was added to the fishing line to counteract the weight of the chain. McHugh et al. (2019) used an 80 mm codend with 120 mm square-mesh panel (SMP) in line with legislation at the time.

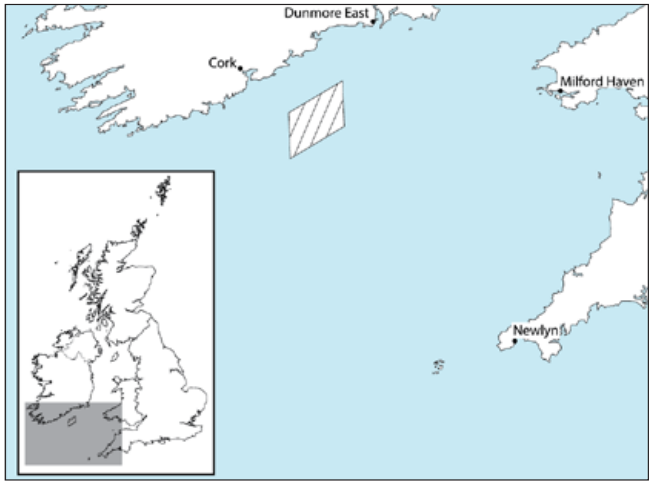

Figure 1: Study vessel and study location in the Celtic Sea

Table 1: Gear specification

Gear configuration		Single rig
Headline height (m)		6
Door spread (m)		93
Door type		Bison
Door weight (kg)		900
Headline length (m)		38
Fishing line length (m)		30.5
Ground gear		Hopper discs
Chain droppers (mm)		11 x 1000
Sweep length -	singles (m)	109
	doubles (m)	46
Warp length average (m)		288
Warp diameter (mm)		22
Cod end and SMP nominal mesh size (mm)		110 and 160
Twine thickness (mm)		4
Number of floats on headline		60
Fishing circle (meshes x mm)		740 x 120
Trawl manufacturer		John Cavanagh

Artificial lights

Green coloured lights were chosen in line with previous studies using artificial light at the mouth of the trawl (O'Neill and Summerbell, 2019; Hannah et al., 2015; Lomeli et al., 2018; Lomeli et al., 2020).

Two types of green-LED lights were tested. Directional lights were supplied by Safetynet Technologies (SNTECH). The SNTECHs have a depth rating of 200 meters, are rechargeable, emit light at a maximum brightness of 80 lumens and the batteries last up to 60 hours at the brightest setting.

More omnidirectional lights were also tested. Lindgren Pitman (LP) 'electralume' lights have a depth rating of 850 meters, emit 0.5 – 2 lux and the battery lasts up to 350 hours. Comparison of these different light intensities is not straight forward but the SNTECHs are likely brighter than the LPs.

Trial design

Three separate trials were completed with 10 lights mounted ~1.5 meters apart on the fishing line. Trial 1 deployed SNTECHs pointing upwards away from the escape gap and towards the trawl mouth.

In Trial 2, SNTECHs pointed downwards towards the escape gap and away from the trawl mouth. Trial 3 deployed omnidirectional LPs which likely illuminated an area around the fishing line (Figure 2).

Catch sampling was completed by the skipper and crew in line with COVID-19 sampling protocols. Species catch weights were compared using tables and histograms with standard error bars. Other than cod, all species with catch weights less than 10 kg in both gears were omitted. Environmental data were recorded by the skipper of the vessel.

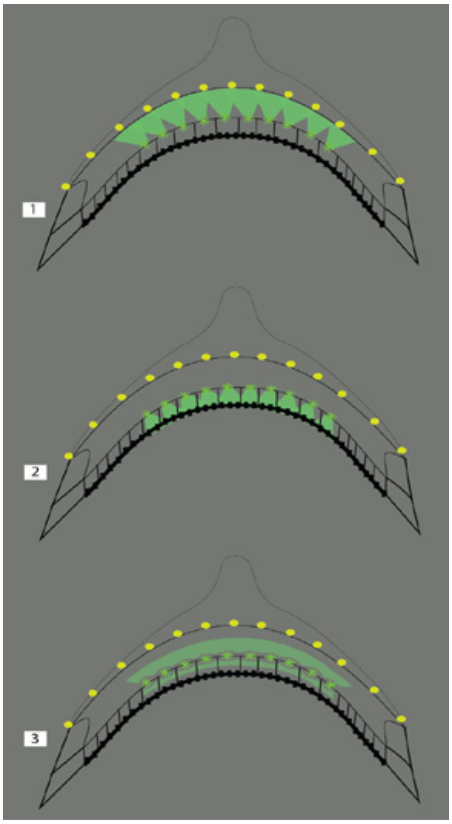

Figure 2: Light configuration Trials 1, 2 and 3 with lights on the RFL

Results

A total of six valid hauls were completed for each trial (18 hauls in total) over 5 days. Mean haul duration, towing speed, and depth fished during the study were 2 hr 58 min, 3.3 kt and 87 m, respectively.

In Trial 1, haddock catches were greatly reduced (Figure 3) e.g., undersize haddock were reduced by 77% when the SNTECH lights were deployed pointing upwards (Table 2). Whiting catches were low with little observed difference between gears. A substantial increase in lesser spotted dogfish occurred in the RFL gear with lights.

Trial 2 showed a substantial increase in haddock (Figure 4) e.g., catches of undersize haddock were 84% greater when the SNTECH lights pointed downwards (Table 3). Whiting catches were low but little difference occurred between gears. Again, catches of lesser spotted dogfish were substantially higher in the RFL gear with lights.

In Trial 3, Haddock were substantially reduced with LP lights on the fishing line (Figure 5) e.g., undersize haddock were reduced by 54% (Table 4). Whiting catches were greater in Trial 3 compared with Trials 1 and 2, and were slightly lower in the RFL gear with lights e.g., large whiting were reduced by 31%. In contrast to Trials 1 and 2, relatively little difference occurred in dogfish catches in Trial 3 possibly due to lower light intensity from the LPs.

Cod catches were low in all three trials. Environmental parameters were similar across all three trials (Table 5)

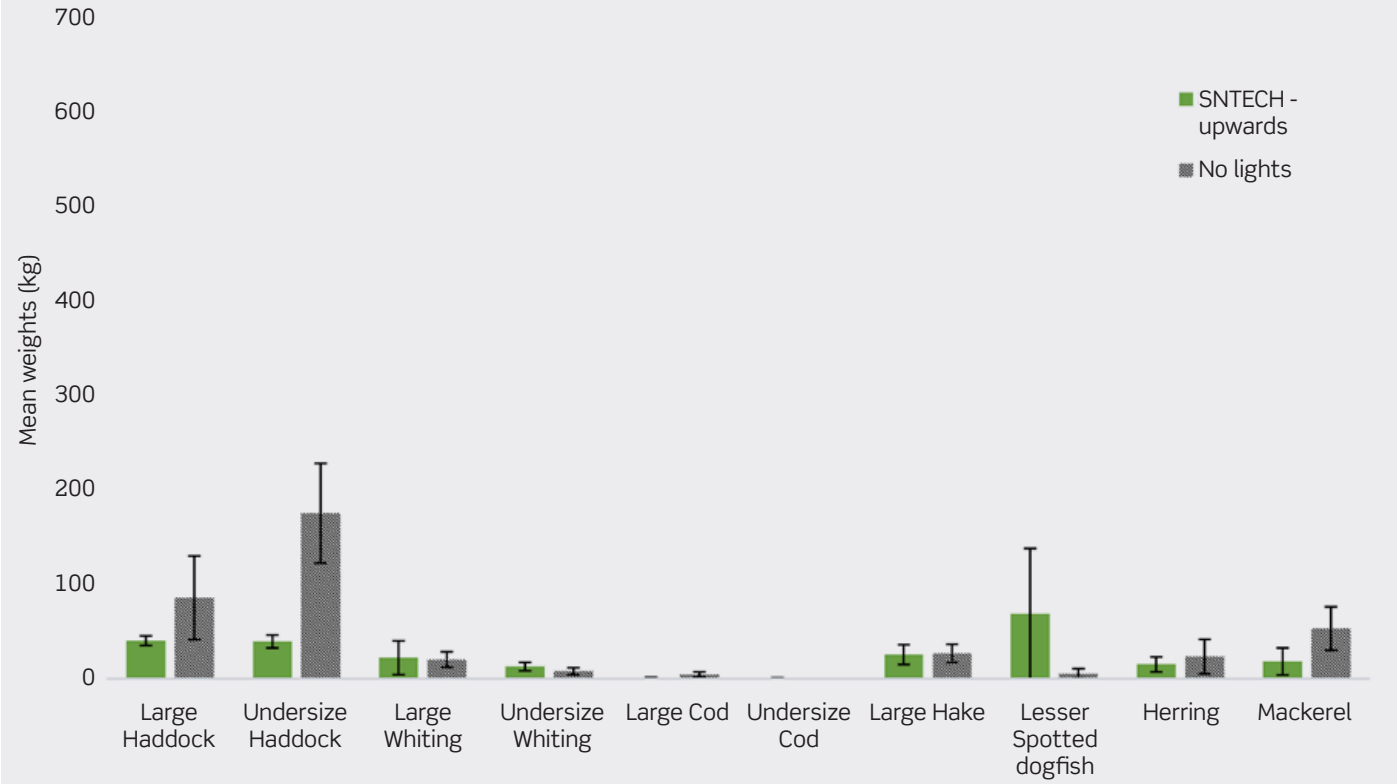

Figure 3. Trial 1 mean catches with standard error bars - SNTECHs upwards

Table 2. Trial 1 mean catches with standard error (± se) - SNTECHs upwards

	No lights (kg)	SE	SNTECH upwards (kg)	SE	Difference (%)
Large Haddock	86	44	40	5	-53
Undersize Haddock	176	53	40	7	-77
Large Whiting	21	8	23	18	10
Undersize Whiting	8	4	13	4	61
Large Cod	5	3	1	1	-86
Undersize Cod	0	0	1	1	
Large Hake	27	10	26	11	-5
Lesser spotted dogfish	6	5	69	69	≥100
Herring	24	18	16	8	-36
Mackerel	53	23	19	14	-65

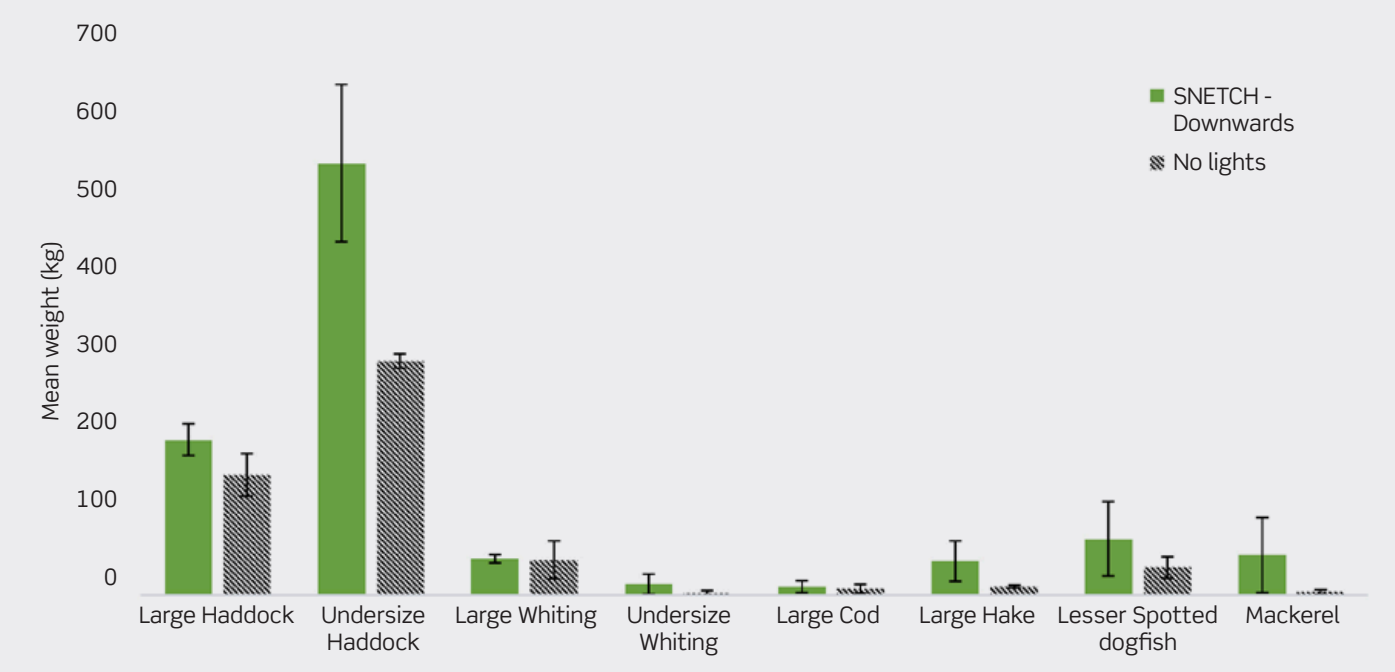

Figure 4. Trial 2 mean catches with standard error bars - SNTECHs downwards

Table 3. Trial 2 mean catches with standard error (± se) - SNTECHs downwards

	No lights (kg)	SE	SNTECH upwards (kg)	SE	Difference (%)
Large Haddock	153	27	198	21	29
Undersize Haddock	299	9	552	100	84
Large Whiting	45	24	46	5	4
Undersize Whiting	3	3	14	13	≥100
Large Cod	8	6	11	7	35
Large Hake	11	2	43	26	≥100
Lesser spotted dogfish	35	14	72	48	≥100
Mackerel	4	3	51	48	≥100

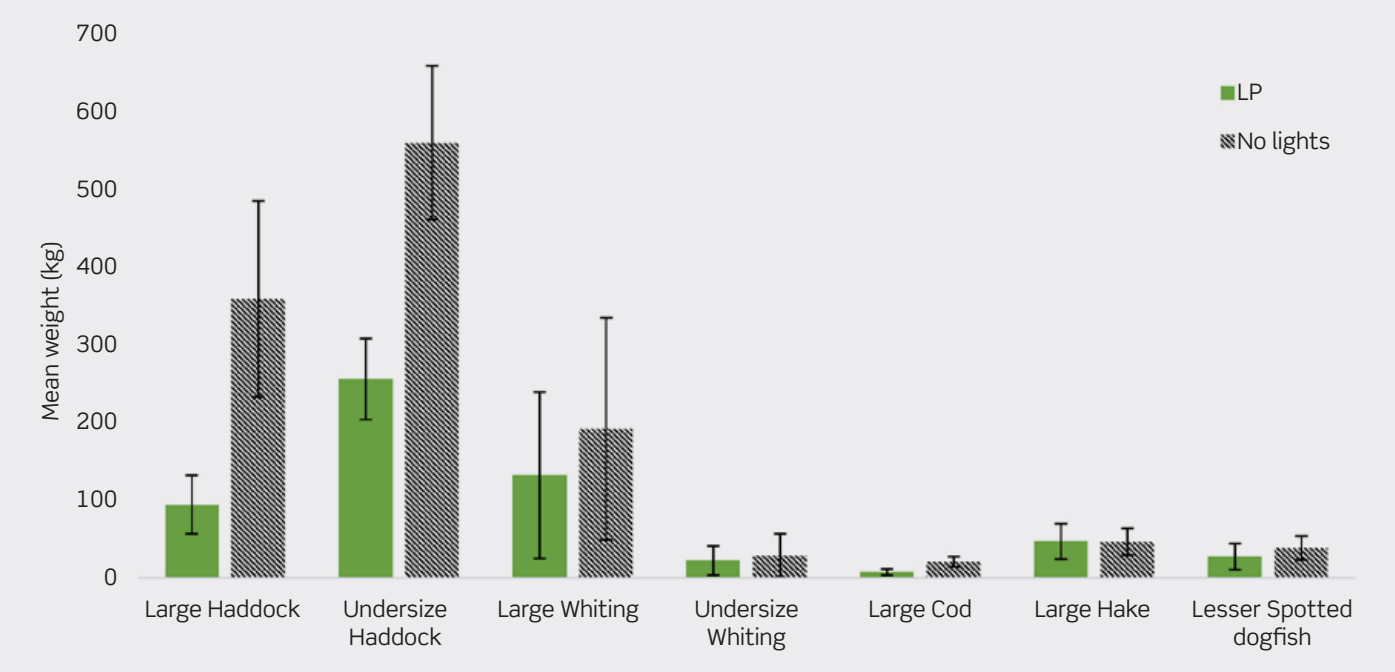

Figure 5: Trial 3 mean catches with standard error – LPs

Table 4: Trial 3 mean catches with standard error (± se) - LPs

	No lights (kg)	SE	SNTECH upwards (kg)	SE	Difference (%)
Large Haddock	359	126	94	38	-74
Undersize Haddock	560	99	256	52	-54
Large Whiting	192	143	132	107	-31
Undersize Whiting	29	28	22	19	-23
Large Cod	21	6	8	4	-64
Large Hake	47	17	47	23	1
Lesser spotted dogfish	39	15	28	17	-28

Table 5: Environmental data

At sea parameters	Value
Haul duration (mean) in min	155 - 194 (178)
Depth (mean) in m	81 - 91 (87)
Seabed substrate	Sand/ gravel
Wind speed (mean) in knots	0 – 19 (10.1)
Beaufort scale (mean) in force	0 – 5 (3)
Sea state	Calm – moderate
Bottom temperature (°C)	9.6

Discussion

Haddock, the main species encountered during the trial, clearly displayed a negative reaction to the lights. Substantially fewer haddock were caught with omnidirectional LP lights and with SNTECH lights pointing up towards the trawl mouth. Substantially more haddock were caught when SNTECHs were deployed pointing down towards the escape gap.

Whiting catches were generally low given the use of a 110 mm codend with a 160 mm SMP in line with current legal requirements. Reasonable quantities of whiting were caught in Trial 3 where a small reduction in whiting occurred with LP lights deployed on the fishing line. These behavioural reactions to light are in line with preliminary findings from ongoing Scottish lab experiments which show a stronger reaction to light from haddock compared with whiting (Pers. Comm. Emma Mackenzie, Marine Scotland).

Very few cod were caught during the trial, likely partly due to effectiveness of the RFL as a cod avoidance measure and partly due to low abundance. The Scottish lab experiments have also noted a strong negative reaction from cod to light. This bodes well for further reductions in cod in the RFL when they are more abundant on the fishing grounds.

Our results are encouraging given that quotas are 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). Codend and SMP mesh sizes have crept upwards in response to mixed species stock advice to the point where Celtic Sea whiting is an underutilised resource. Of the 4073 t in 2020, only 2100 t with an estimated value of €3 m were landed (BIM, 2020). Taking into account a 12% discard rate (MI, 2020), the Celtic Sea whiting stock was underfished by around 1500 t worth €2.1 m. Provided unwanted catches can successfully be avoided, increasing harvest of underutilised species is the best way of optimising yields from fisheries targeting demersal species (Hilborn et at., 2021).

The RFL is a proven cod avoidance measure. More testing is needed but incorporating lights on the RFL has major potential for substantially reducing haddock and further minimising cod catches. Effective avoidance of these lower quota species at the trawl mouth would help towards a case for codend meshes which selectively retain whiting. Previous BIM research demonstrated extremely good whiting selectivity and quality using 80 mm T90 mesh (Browne et al., 2016), a key option in this regard.

In terms of potential implementation, Green LEDs are a legal requirement on the fishing line in RFL gear in the US Oregon pink shrimp fishery where they are effective at reducing unwanted fish catches: https://www.dfw.state.or.us/mrp/shellfish/commercial/shrimp/docs/29th_APSR_2018.pdf

Lomeli et al. (2018) demonstrated similar fish bycatch reduction using 5, 10, and 20 green LEDs mounted on an RFL. The fishing line in the latter study was 22 m long compared with 30.5 m in the current study. Hence, we chose to use more lights to help ensure sufficient illumination along the entire fishing line.

Utilisation of lights is potentially a simple and inexpensive method of further enhancing RFL catch performance. Further length-based catch comparison work is planned in early 2022 to comprehensively assess the benefits of lights on the RFL.

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