Golden Ray Pisces trials 22/23 - Final Report

Authors: Tom Rossiter & Dr Craig Syms

June 2023

Precision Fishing for a **Sustainable Future**

Contents

Thanks

A special note of thanks must go to AFBI who provide data collection support to the project. WWF and Tesco Partnership for funding and project guidance. Whitby Seafoods for project guidance and making the Golden Ray available to the project and most of all Darren McClements and the crew of Golden Ray who went above and beyond to cooperate with the research team.

1. Overview

This project has seen SNTech's Pisces lights trialled in the Northern Ireland commercial Nephrops fishery over a 12-month period in an attempt to reduce unwanted finfish bycatch, one of the main objectives of the Nephrops FIP. 32 permutations of light setting were trialled on a fishing vessel targeting Nephrops, the Golden Ray and the catch sampled by observers to detect any change in the composition.

Aim: To Assess the impact of Pisces artificial light on the bycatch of whitefish in the nephrops fishery

Objectives: Under commercial conditions 32 different light settings (colour / brightness and flash rates) were trialled in an attempt to find a setting that will reduce unwanted bycatch, thus giving the nephrops fleet a tried and tested tool ready to be deployed in the fishery.

Outcomes/ Success would look like: A significant and measurable reduction in unwanted bycatch of finfish. This will be a 25% reduction given the methodology used.

Figure 1 MFV Golden Ray

2. SCOPE AND BACKGROUND

Scope and reason for trial:

The UK Nephrops fishery has undertaken a MSC pre-assessment. The assessment found issues that prevented the fishery from securing certification and subsequently a Fishery Improvement Project (FIP) was implemented under the Project UK FIP. Representatives of NGOs, the Nephrops catching, processing and retail sectors are participants of the FIP and are committed to assisting the fishery to resolve its issues and attain MSC accreditation. SNTech's Pisces lights have been identified as a potential solution to reducing bycatch and discards in the Nephrops fishery and as such would address Actions 2d, 6f &6g within the FIP workplan. The Pisces lights is a new market ready product that has undergone considerable scientific and technical assessment as a precision fishing tool, however there is a lack of commercial evidence to support the nephrops fleet from adopting the technology. By undertaking this project it is hoped that the barriers to adoption and the bycatch issues affecting the fleet can be overcome through precision fishing.

Science background

Targeted species/fishery: Nephrops norvegicus

Nephrops and other crustaceans have simple vision, and are likely to be colour blind. Nephrops show a peak light sensitivity of 515nm (Johnson et al 2002), which is green. However, even if light altered behaviour in crustaceans, this in unlikely to overcome the speed of a trawl and so target catch was expected to be maintained

Bycatch species:

Teleosts - a very large taxonomic group of fish have more advanced photoreceptor cells and vision than crustaceans. A combination of deterring, attracting and illuminating the trawl gear was trialled depending on the vessel's fishing objectives.

Behaviour trials

Previous light trials with trawl fishing gears have shown differing reactions of the main finfish species found in UK waters (cod, pollock etc). These findings guided the Pisces deployment plan and were combined with new fish behaviour learnings courtesy of the CatchCam underwater cameras deployed by the vessel and new learnings from other research projects.

Light-flash combinations and gear placement

SNTech's Pisces lights provide a range of colours, flash frequency and intensities. We examined four colours: Deep Blue, Blue, Green and White (which includes all wavelengths); at Constant, 2Hz, 8 Hz and 16 Hz each at the Normal intensity setting. This covers the range that is likely to be important at depth. Each of the Colour/Flash combinations were tested on the head rope of the vessel both facing down, and facing up/outward. The rationale for examining these combinations was based on initial commercial trials which indicated different effects depending on the gear and target species. For example, An Bord Iascaigh Mhara (BIM) conducted a selectivity trial which indicated that light direction on raised line gear had a positive effect, and is worth examining in more detail (Oliver et al. 2021). However it remains unclear what effects we were likely to detect on any particular vessel and gear/ground combination.

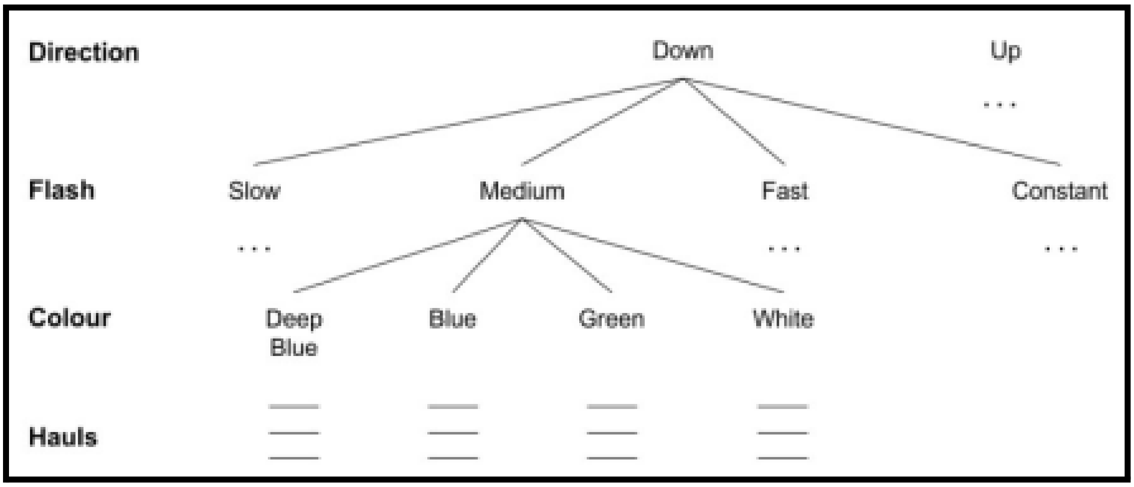

Figure 2. Experimental design was a 3 factor cross design in a paired design.

3. Methodology

The project ran for 12 months and fitted around the normal commercial operation of the vessel. The lights were deployed as per the Pisces deployment plan and were set for a full trip unless a significant shift in the plan was required such as shifting from facing down to facing up.

i. Underwater Camera

An underwater camera system (CatchCam) was provided to the vessel along with the Pisces lights. The camera was operated by the skipper and SNTech scientists and deployed across three of the trips. AFBI observers were not tasked with deploying the camera to minimise their task loading.The camera recorded activity in proximity to the Pisces lights. The footage was reviewed by the skipper and SNTech scientists and the insight about the performance of the gear, lights and fish behaviour were used to advise future deployment.

ii. Pisces Placement

SNTech supplied 15 Pisces lights, 3 charging cases and remote controls to the vessel. The lights were deployed by SNTech, Agri-Food and Biosciences Institute (AFBI) and the skipper as per the protocol set out in Figure 2. Trips yielded between 7 and 13 paired tows depending on the conditions, season and fishing patterns. Both nets (twin rig) were fitted with Pisces lights and follow an issued protocol working through the test plan set out above.

The Golden Ray is a twin rig vessel, which enabled all treatments to be run in a paired design. Light treatments were alternated between the nets after each tow to remove potential confounding due to starboard and port nets fishing differently. This approach has been found in simulation to best deal with spatial confounding within a fishing trip. Pisces lights were attached at the beginning of the fishing operation and removed at the end when they were placed back into the recharge case. 7 Pisces lights were attached to the net starting from the centre of the headline or fishing line and spaced out 2 metres apart, thus generating an effect similar to an arc shaped wall of light.

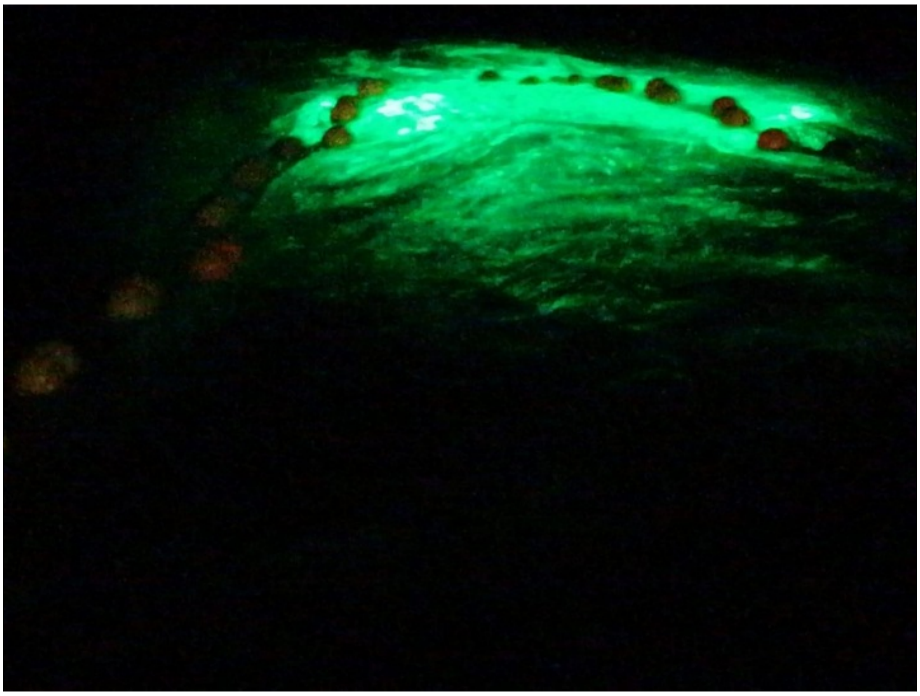

Figure 3. A net with Pisces lights deployed.

iii. Sampling protocol

A (40kg) representative sample consisting of two baskets from random sections of the hopper was taken from each net where possible and separated into categories (Nephrops, whiting, haddock, detritus, and other fish). If detritus or other fish were found to have a large component of a particular species such as spurdog or jellyfish, then these were recorded separately. AFBI observers were used throughout this project in order to provide independent observations but SNTech carried out the last trip due to a lack of suitable accommodation onboard the vessel.

The observer transcribed the data onto AFBI data sheets and submitted them to AFBI for entry into their system. SNTech received the QA/QC'd data from the AFBI data system. Data were screened and formatted into the SNTech format. Counts were multiplied up from the two-basket subsample, to an estimated value for each net. All of the hauls were ~5 hours long, so the values represent the count per net for 5 hours of effort.

iv. Statistical analysis

The experimental design consisted of paired samples, in which one net received the light treatment and the other served as a control. These treatments were interspersed within a trip between the port and starboard nets, and at different times of the day. This interspersion removed any confounding effects. The analytical model consisted of three fixed treatment factors: Colour, Flash rate, Direction, and a fourth factor that determined whether a net within a pair had the Light On or Off. The pairing of the nets was accounted for in the model by a random term corresponding to the unique Haul identifier within a Trip, and temporal variability between trips was modelled by a term corresponding to the trip identifier. The general form was thus:

$\text{Response} = \text{Colour}_F + \text{Flash}_F + \text{Direction}_F + \text{LightOnOff}_F + \text{Colour*LightOnOff}_F + \text{Flash*LightOnOff}_F + \text{Direction*LightOnOff}_F + \text{Haul (Trip)}_R + \text{Trip}_R$

The subscript F denotes a fixed factor, and subscript R denotes a random factor. The potential two-way interactions without Flash were not included as they are not interpretable in the experimental context and can simply be consigned to error. Higher order interactions were assumed to be zero. This is because of the low replication of some treatments, and the risk of model overparameterization. Given the absence of effect in general, this was not an unreasonable assumption.

Species abundances were right skewed and negative binomially distributed. In other words, there were many low values with occasional high catches in some samples. This required a modified analytical approach. Consequently, the model was analysed using the glmer.nb() function in the lme4 library (Bates et al. 2015). All tows were ~5 hours long, so there was no need for an effort offset term.

Differences in size frequency distributions were analysed using the same structural model as above. However, instead of abundance the response variable was the cumulative logit of the ordered fish lengths aggregated into 3 cm bins. The model was analysed in the Cumulative Link Mixed Model (clmm()) function in the R ordinal library (Christensen 2022).

4. Results

Pisces lights were deployed on 113 tows spread over the 12 months. A total of ~ 7000 kg of the catch was sampled and over 30,000 individual fish measured. The bycatch rate varied by ground and time of year. A total of 27 different species were sampled with Haddock and Whiting making up over 50% of the finfish by number.

Trip date	Number of tows
11-04-2022	8
11-07-2022	12
8-08-2022	10
29-08-2022	10
31-10-2022	9
13-11-2022	6
27-11-2022	8
10-12-2022	8
20-03-2023	9
27-03-2023	9
10-04-2023	10
24-04-2023	13
Total	113

Table 1. Numbers of tows sampled by trip.

A total of 96 hours of underwater footage was recorded on 3 separate trips. The footage was taken from the headline, the wing, square mesh panel and all around the codend. The footage was reviewed, and the informative clips were downloaded and stored. These were then edited into shorter clips based on themes.

Catch size

There was no effect detected from any of the light treatments on catch abundance of Haddock, Whiting and Mixed flatfishes (e.g., Figs. 4, 5) at the mouth of the net. Additionally, there was no effect of light treatment on catch of spurdog, which is a seasonally important albeit spatially and patchy bycatch species. The target catch abundance (Nephrops) showed no sign of impact from the light treatments. Sample sizes were sufficient to have detected an effect, if it were present. The lack of effect was demonstrated by near-complete overlap between catches in treatment and control nets across colours and flash frequencies.

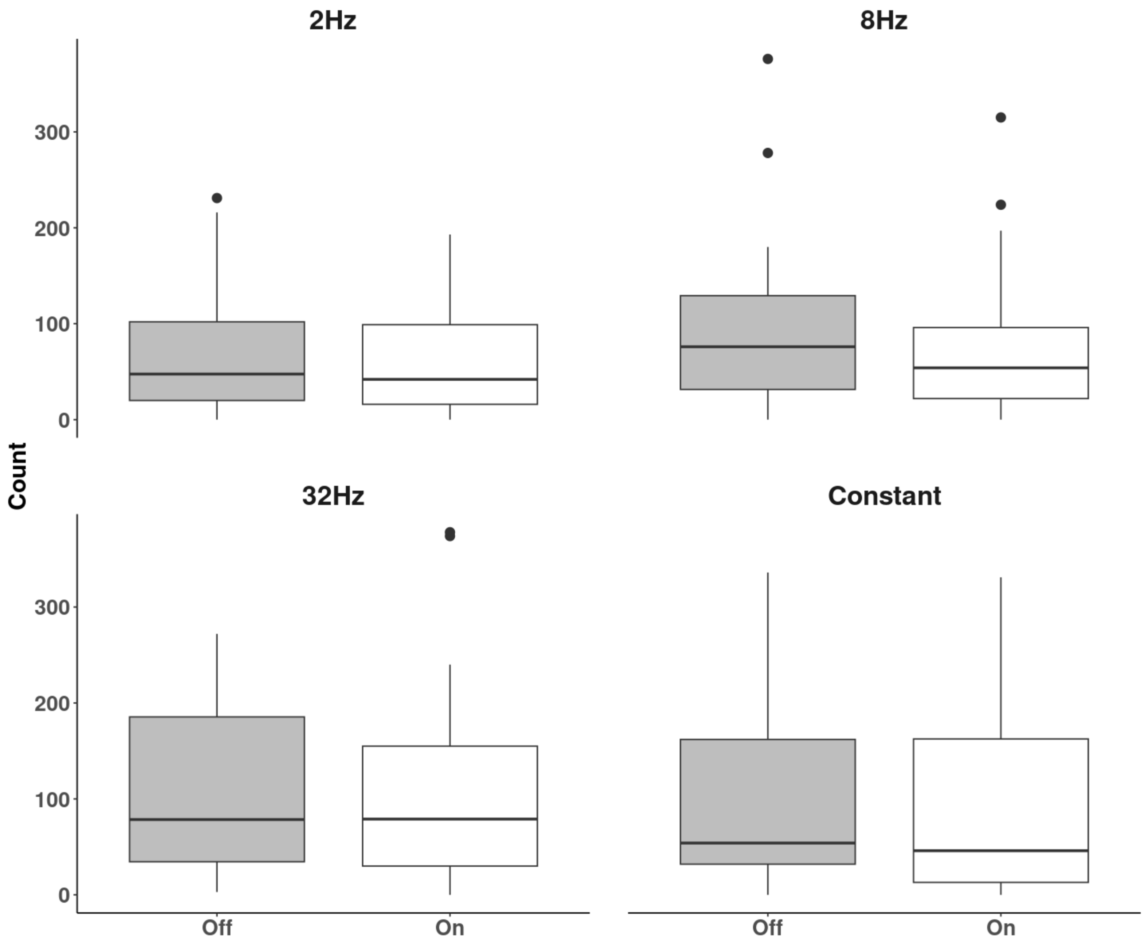

Figure 4. Haddock counts in lit and unlit nets. Counts are totals per net over 5 hours. Different colours are pooled and demonstrate no effect of Flash frequency on catches. Grey boxes are controls, white boxes are light treatments. The boxes span the 25th and 75th percentiles, and the whiskers extend 1.5x the interquartile range from the percentiles. These approximate the 95% confidence interval. Individual points are outliers beyond this range.

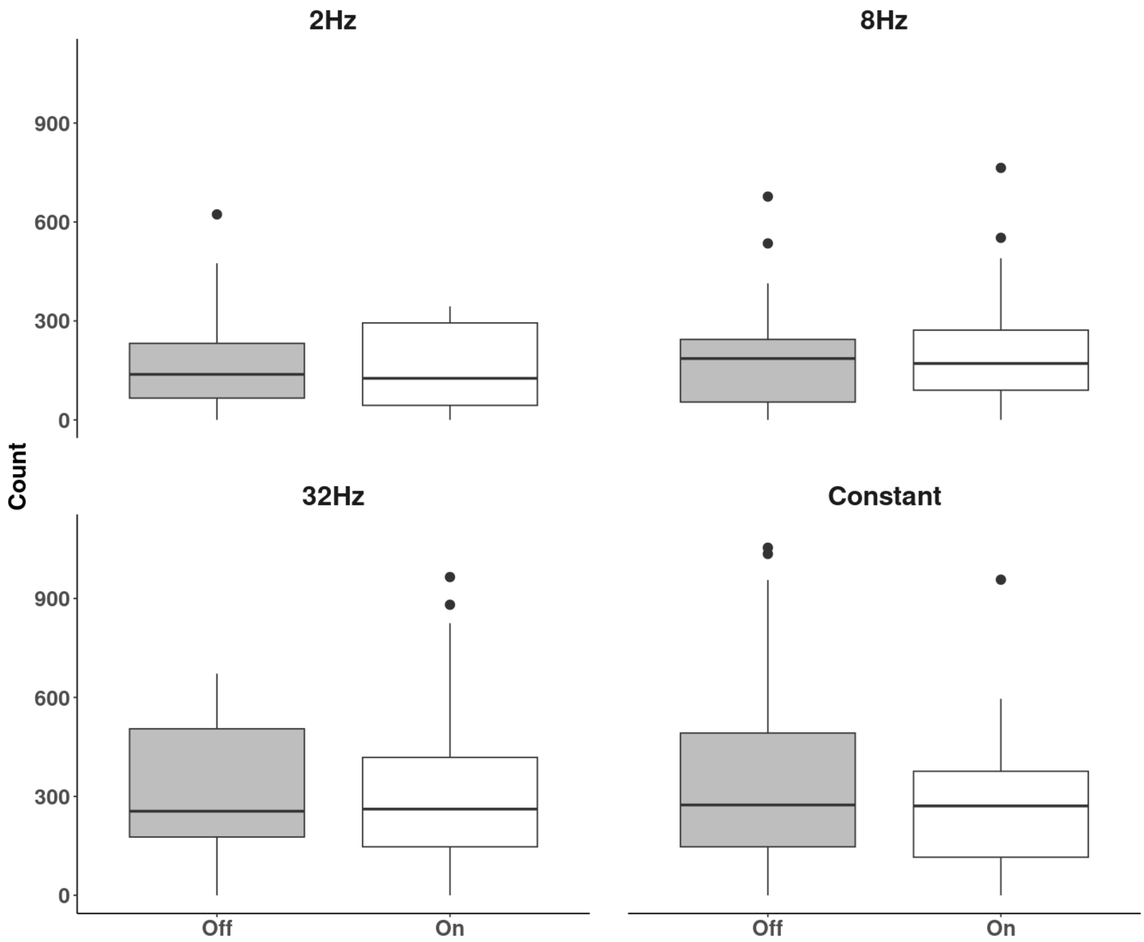

Figure 5. Whiting counts in lit and unlit nets. Key and description as above.

Size frequency

There was no evidence of any effect of lights on size selectivity either from the formal statistical tests, or the data plots (Figs. 6, 7). The most abundant bycatch species (by weights) were Haddock and Whiting. Each of these have sufficient mobility to be able to avoid the net as adults, however there was no evidence of any size-selectivity that might have obscured the count data.

The evidence strongly indicates that using lights to prevent fish from entering the net in this particular fishery and gear setup is unlikely to work. This suggests that alternative approaches might focus on facilitating fish escape from the net after they have been gathered, but before getting caught in the cod end. We have previously found the sediment cloud obscures visibility. But on the last trip we shifted to firmer ground, and the light treatment was shifted to an area near the codend and a modified escape panel (Tunc Grid). This resulted in a change of abundance and size frequency of haddock and whiting (Fig 6 & 7 - April ‘23)

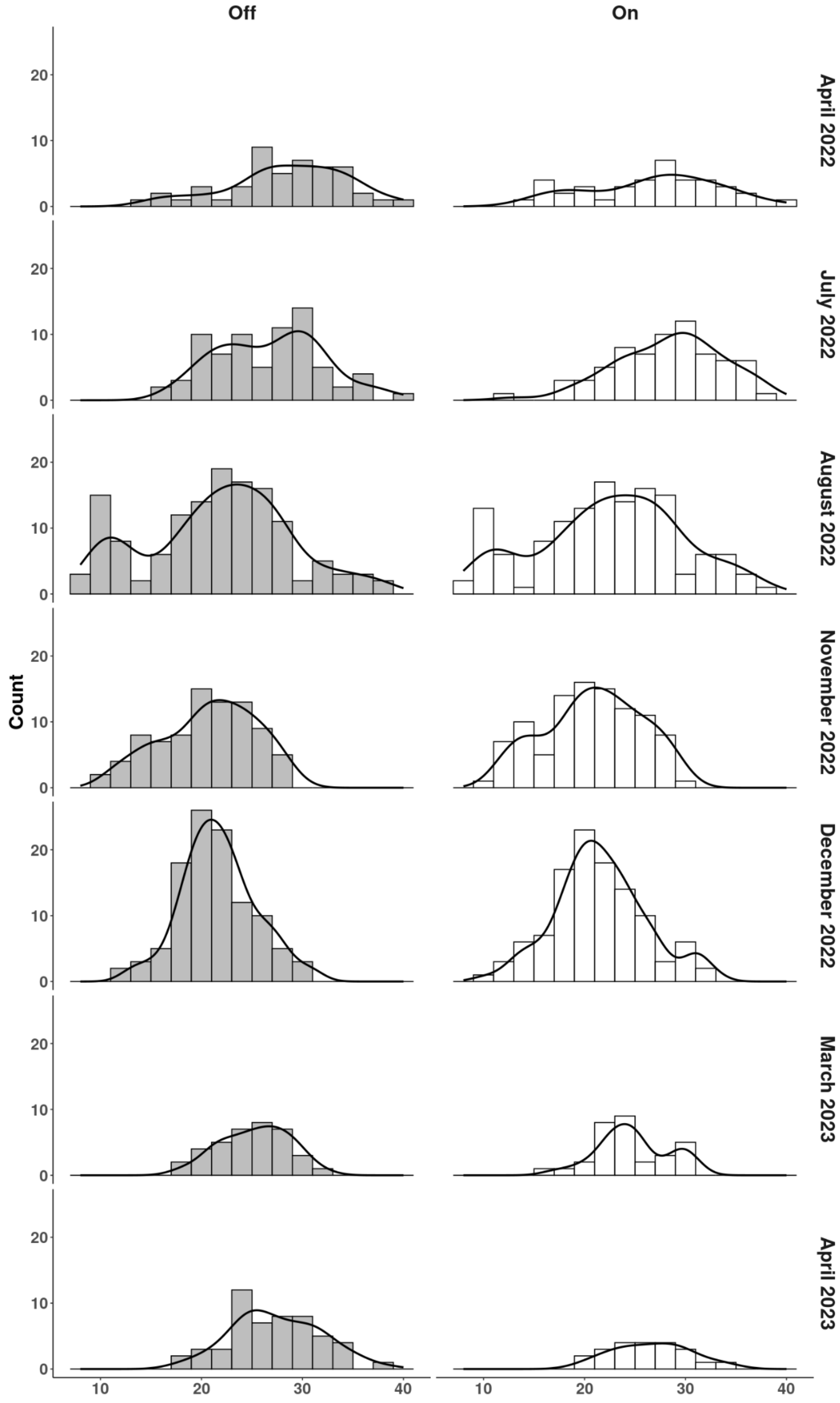

Figure 6. Haddock size frequency distributions in Control (grey fill) and lit (white fill) nets. Counts are standardized to 5 hauls (25 hours).

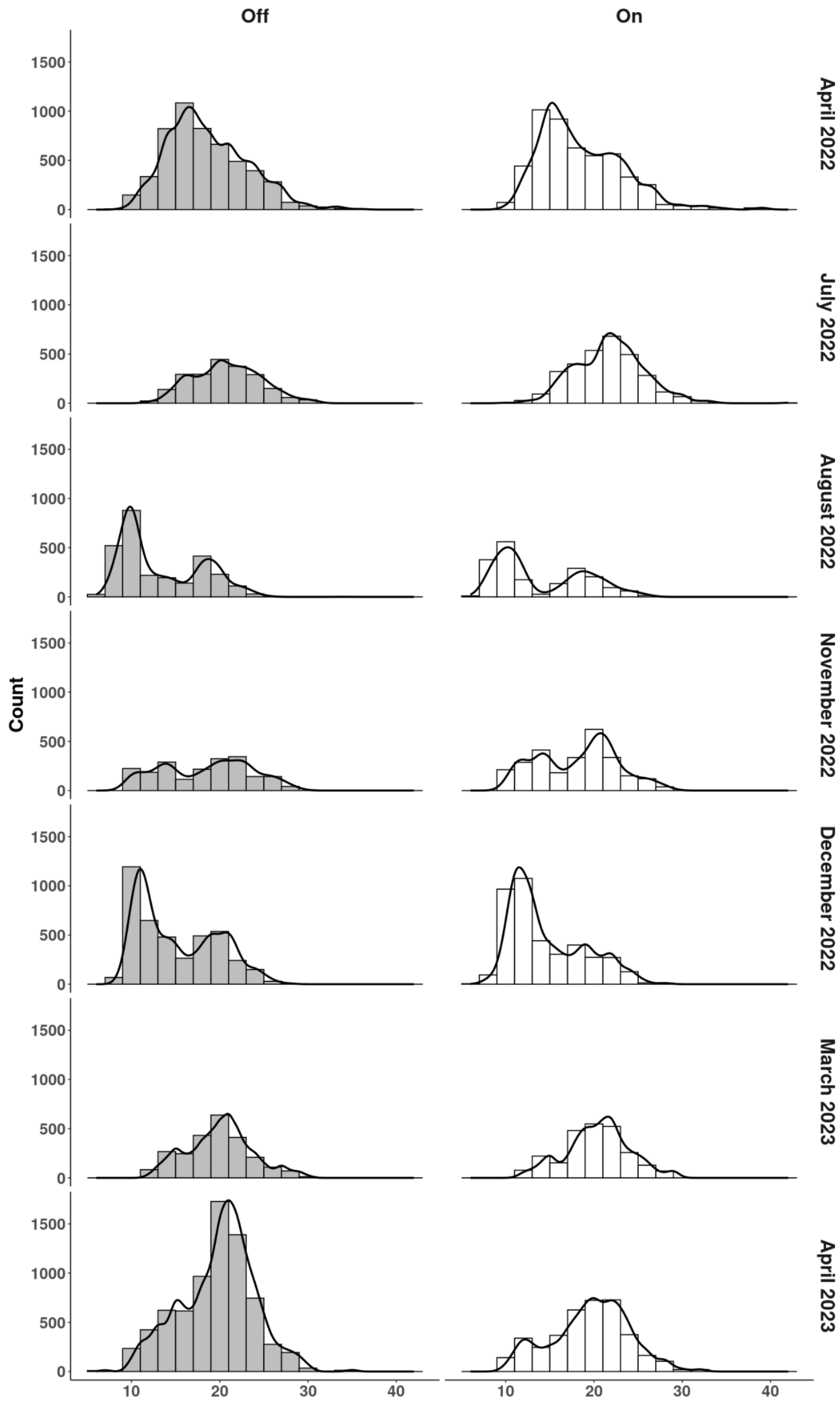

Figure 7. Whiting size frequency distributions in Control (grey fill) and lit (white fill) nets.

5. Discussion & Conclusions

i. Pisces lights

No change in target or bycatch catch rates were detected as a result of deploying the Pisces lights on the headline or foot rope (i.e. around the mouth of the net) regardless of the light colour or the flash rate. This was disappointing and somewhat surprising given the results found in other studies. Video evidence suggests that even if fish do see the lights in sufficient time, this is not associated with a perception of threat or suggestion of a course of action (e.g., movement to the side) that would respond to this threat.

Consequently, we shifted focus to the codend where the CatchCam footage showed that the finfish were aware of the danger and actively sought to escape from the trawl. Light from Pisces and or the CatchCam lamp was used to illuminate this part of the trawl and a large number of fish were observed. Haddock catches in the illuminated grid nets were ⅓ of the catches in control nets (21.1 ± 6.4 vs 60.1 ± 8.5). Similarly, there was a 20% reduction in Whiting catches in illuminated grid nets (385.3 ± 84.5 vs 482.3 ± 76.3). Both differences were statistically and biologically significant. We had not previously considered this because of the problems caused by sediment clouds on this section of the net, which may obscure light.

ii. Adaptable approach

This was a logistically challenging project. While the original design was to install Remote Electronic Monitoring system with on-board camera to minimise the need of human observers, it was rejected by potential participating fishing vessels. The project changed to deploy human observers with ABFI and it required a significant amount of observer and vessel time to complete the work and it was not always possible to align the two. The Golden Ray encountered serious engine failure in September and October and in January and February pre-existing observer commitments precluded them from carrying out trials. At no point did the project team panic, instead they reacted to the circumstances and adapted the plan to work with the opportunities available and delivered the project on time.

As the project proceeded, it became clear that placing the light around the mouth of the net was having no appreciable effect on the bycatch. The project team discussed this with the skipper Darren McClements and adapted the plan to focus on the area of the net which showed most promise based on the footage collected during earlier deployments. The flexibility of the vessel and the project itself allowed the team to react to new knowledge and pursue an area of new research albeit staying within the terms of the original proposal of testing the impact of artificial light on the bycatch in the fishery.

iii. Underwater Cameras

A key finding of the project has been the rapid learnings yielded by using the CatchCam underwater camera system during the trials. The underwater footage has removed the reliance on supposition and theorising about the results, to show what is actually happening. This has allowed the team to quickly understand why things were happening.

The CatchCam footage led the team to focus on the codend towards the end of the project as the footage demonstrated that the bycatch species are at their most active in this region of the gear. The footage surprisingly showed that the small fish were active and that the water speed was much less than the 3 knots that the vessel was towing the gear at. This ultimately led the team to test a small wire escape grid alongside artificial light on the last trip. The grid was lashed to the net very close to the cod end and provided a frame for the mesh to be stretched open against (without this the diamond mesh tends to close up and the fish have no escape route). Water clarity on this trip was generally poor due to the fluidising of the soft sediment, but when the water cleared unwanted bycatch could be clearly seen exiting the net.

Figure 8. Tunc Grid fitted to a trawl with CatchCam overlooking it.

The CatchCam also proved very useful for Skipper Darren. It was deployed on the net to give a view of the trawl set up and helped him on two occasions to resolve an issue with his gear and get it fishing correctly and much quicker than would normally be the case. This not only saved time that would have been spent on optimising his gear, but owing to the gear being modified to have less interaction with the sediment, reduced wear on his gear and has exciting potential reductions in sediment CO_2 emissions. The CatchCam was also instrumental in bringing more of the skippers expertise into the project, as the team and skipper worked together to determine what was happening and to develop a course of action to overcome challenges.

6. Recommendations & Next Steps

Methodology & Approach

The adaptive approach of this project was found to be very successful. At the outset there was a clear plan on what and how the team needed to trial the Pisces lights, but the plan had to remain adaptive throughout the project in response to external factors including day to day challenges found on fishing vessels. Results from the trials and the underwater camera footage were quickly analysed and the results were discussed among the team and used to guide the next phase of work. This resulted in the project team being fully engaged throughout, and importantly bringing the Skipper Darren McClements into guiding changes.

Artificial Light as a tool to reduce bycatch in Nephrops fishery

The 12-month trial was very thorough in its testing of artificial light on the nephrops trawl. The trial focused on the deployment of the lights around the mouth (entrance) to the net and no significant behavioural change was detected. The project switched to the codend and much more encouraging results were found including a variance in behaviour to different light frequencies.

As a next step, SNTech will carry out further commercial trials of lights and gear modifications in and around the codend and will also seek funding to undertake a fully scientific assessment of this approach.

Underwater Camera

SNTech's CatchCam was deployed during the trials as an aid to the trial team. This was found to be invaluable as it yielded quick insight into how the gear and the fish were interacting around the Pisces lights. It is a recommendation of this project that this technology be used in other similar projects and also that the fishing fleets should be encouraged to adopt this technology to aid them to find bycatch reduction solutions specific to their gears and boats.

Literature cited

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67, 1–48. https://doi.org/10.18637/jss.v067.i01

Christensen, R. H. B. (2022). ordinal—Regression Models for Ordinal Data. R package version 2022.11-16. https://CRAN.R-project.org/package=ordinal