August 2021

Fast-Tracking Gear Development with Side-Scan Sonar

Fisheries Conservation Report

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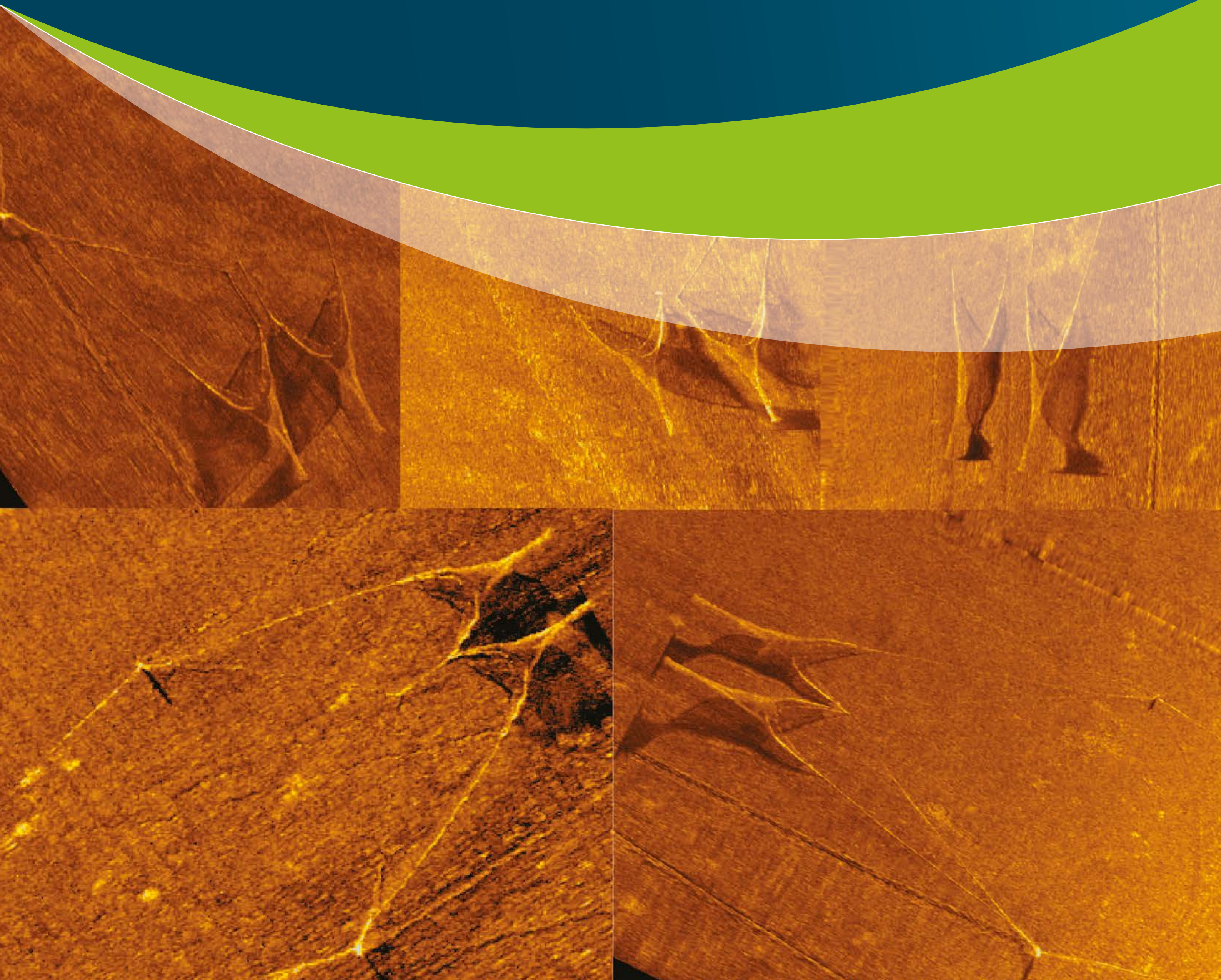
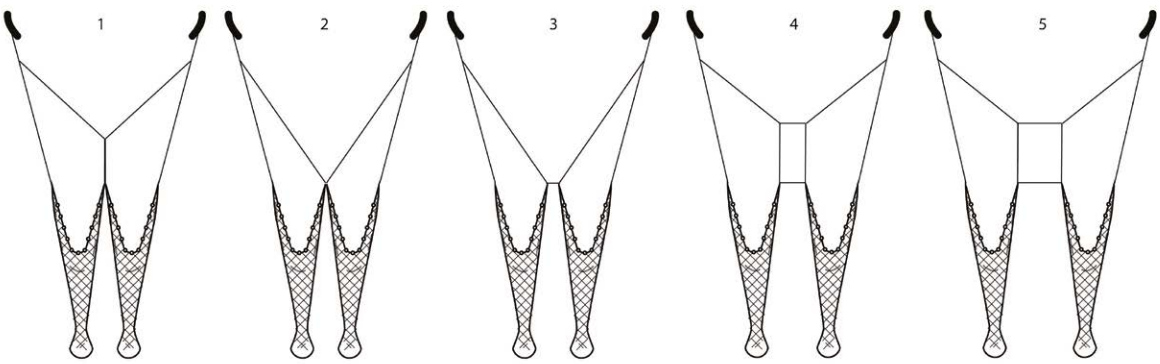


Key findings

The utility of side-scan sonar imaging as a powerful tool in visualising and assessing gear modifications was demonstrated.

This tool has major potential to assess gear modifications which aim to reduce bycatch, seabed impacts, and carbon emissions.

Further evaluation of the modified bycatch escape corridor tested in the current study is needed.



Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Introduction

The need to reduce impacts of bottom trawling on the seabed is a key fisheries environmental challenge. Drivers include a suite of international agreements and legal obligations around improved protection of biodiversity, marine habitats and carbon stores.

These include the EU Marine Strategy Framework (MSFD), Birds and Habitat Directives, the OSPAR Convention, the UN Convention on Biological Diversity and Sustainable Development Goals. Nationally, the Government aims to designate 30% of Irish maritime area as Marine Protected Areas (MPAs) by 2030.

This is also an economic challenge. Oil prices are set to increase in line with increasing reliance on renewables and exhaustion of cheap oil sources. Carbon taxes aside, the US government Energy Information Administration forecasts a 50% rise in oil prices by 2030 and a doubling of current prices by 2040. Ranking relatively high on fisheries fuel consumption, bottom trawlers stand to lose most if these predictions come to pass.

Gear modifications can reduce bottom trawl impacts and are needed to deal with the economic challenge of rising prices and depleting reserves of oil. The FAO advises that within the trawl system, the net is responsible for around 60 percent of energy use, with trawl doors at 30 percent, and warps and other cables at 10 percent (Barange et al., 2018). Gear technologists are striving to minimise drag and maximise fuel efficiency by altering these components but assessment of effects on gear performance is challenging.

Side-scan sonar is typically used to create an image of the seabed for detection, identification and mapping of underwater objects and bathymetric features. BIM use side-scan sonar to search for seed mussel during the annual seed mussel survey (e.g., Chopin and McCoy, 2021). Italian researchers have also used side-scan sonar to investigate bottom impact of fishing gears in the Adriatic (Lucchetti and Sala, 2012; Lucchetti et al., 2018). Here, we assessed the utility of side-scan sonar in visualising gear modifications in the Nephrops fishery.

Methods

BIM conducted a trial on the western Irish Sea prawn grounds (Figure 1) on the 18th and 21st of June 2021. The area of operation was relatively shallow in line with towfish data cable limitations. The ground is composed of a mixture of soft mud and harder substrates and is home to a Nephrops fishery during hours of darkness.

Fishing operations were conducted on board the 17 m MFV Ocean Breeze (D96). The vessel deployed twin Nephrops trawls in half-quad rig configuration (Figure 2). Fishing gear consisted of Bison-8 trawl doors, 22 mm diameter combination rope sweeps, and 37 m trawls with chain footrope.

A range of sweep modifications were conducted with the aim of assessing a bycatch escape corridor between the two trawls. This new bycatch reduction method is under development as a means of reducing unwanted whiting catches in the Irish Sea Nephrops fishery.

Table 1. Sweep configurations scanned during trial with length of constituent parts

Configuration	Outer sweeps (m)	V sweeps (m)	Inner sweep (m)	Escape gap (m)
1	70	50	20	
2	70		70	
3	70		70	1.8
4	70	50	20	1.8
5	70	50	20	4.6

Five different configurations were scanned during the trial (Table 1, Figures 5 - 9) with the following aims:

- 1 - A standard half-quad configuration was scanned as a baseline visualisation.
- 2 - V sweeps (see Figure 2) were removed with inner sweeps joining at the inner trawl wing-ends. This modification increases door and wing-end spread potentially improving gear performance.
- 3 - 1.8 m of chain was added between the ends of the inner sweeps to provide a gap and potential fish escape route between trawls.
- 4 - Following discussion with the skipper, we reintroduced the V sweeps and a second inner sweep with 1.8 m lengths of chain at the fore and aft joining points added for stability and replaced the escape gap with an escape corridor between the trawls.
- 5 - The length of chain between the joining points was increased to 4.6 m to increase the width of the escape corridor.

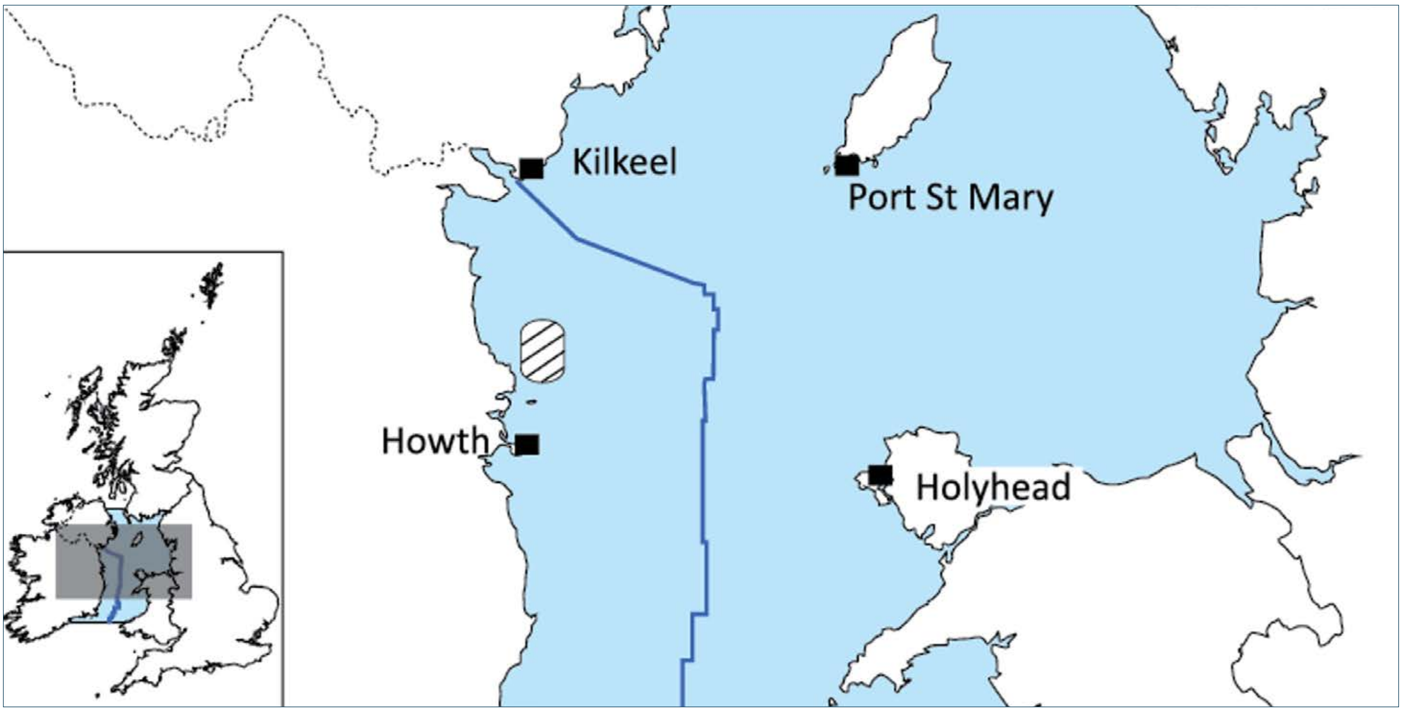


Figure 1. Trial location (hatched area)

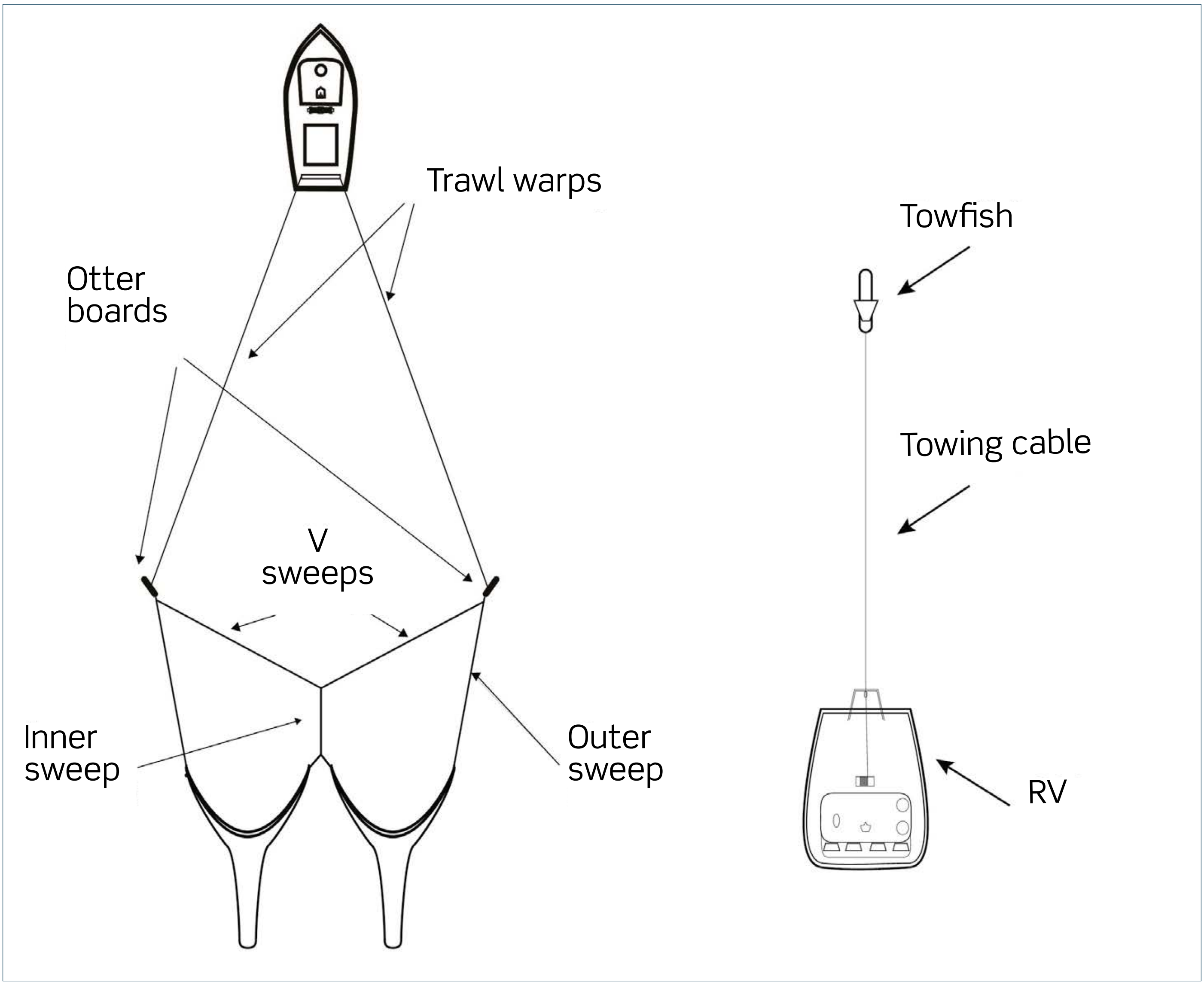


Figure 2. Graphical representation of the half-quad configuration and sidescan operations

Side-scan sonar operations were conducted on board the 12 m RV T.Burke II which BIM uses for mussel seed bed surveys and other aquaculture and inshore research (Figure 3). An Edgetech 4125 dual-frequency (400/900 kHz) side-scan sonar system comprising a towfish (Figure 4), 100 m of towing cable, topside processing unit, differential GPS and a laptop for data processing and display.

Although 900 kHz offers greater feature detail, its range is limited to 50 m either side of the towfish. 400 kHz provides optimal balance between image quality and increased range. At this frequency the horizontal and vertical beam angles are 0.46° and 50° respectively which equate to a maximum range either side of the towfish of 100 m.

Seabed depths ranged from 25 to 30 m and the towfish was deployed between 5 and 8 m from the seabed. From experience, the depth at which the towfish is deployed above the seabed is a key consideration. Exceeding 8 m decreases swath efficiency; the nadir or gap in the centre of the image increases and the towfish is potentially exposed to surface currents and propeller wash.

Figure 3. MFV Ocean Breeze (left) and RV T. Burke II (right)

Figure 4. Towfish being prepared for deployment from the RV T. Burke II

The Ocean Breeze (MFV) and T. Burke II (RV) skippers worked closely together communicating their speed and heading using VHF radio. MFV speed ranged from 2.6 to 3 knots while RV speed ranged from 4.0 to 4.2 knots. The two vessels passed on opposite parallel headings with the towfish deployed between 30 and 60 m from the nearest otter board (Figure 2).

The RV skipper noted difficulty in guaging distance between the RV and the MFV and its gear. This was needed to get as close to the MFV as possible while avoiding collision between the towfish and trawl warps. He resolved this by using the RV radar, monitoring trawl warp angles and MFV direction of travel to maintain a parallel course.

The distance of the towfish behind the RV was calculated using distance and offset from the GPS antenna to the towing point, the distance between the towing point and the surface of the water, the depth of the towfish and the length of cable deployed. Termed layback, this value is inputted to improve accuracy.

Acoustic image processing involved adjusting the gain and removing interference using Sonarwiz 6 software by Chesapeake Technology Inc. Resulting GEOTiff images were georeferenced using ArcGIS 10.8.

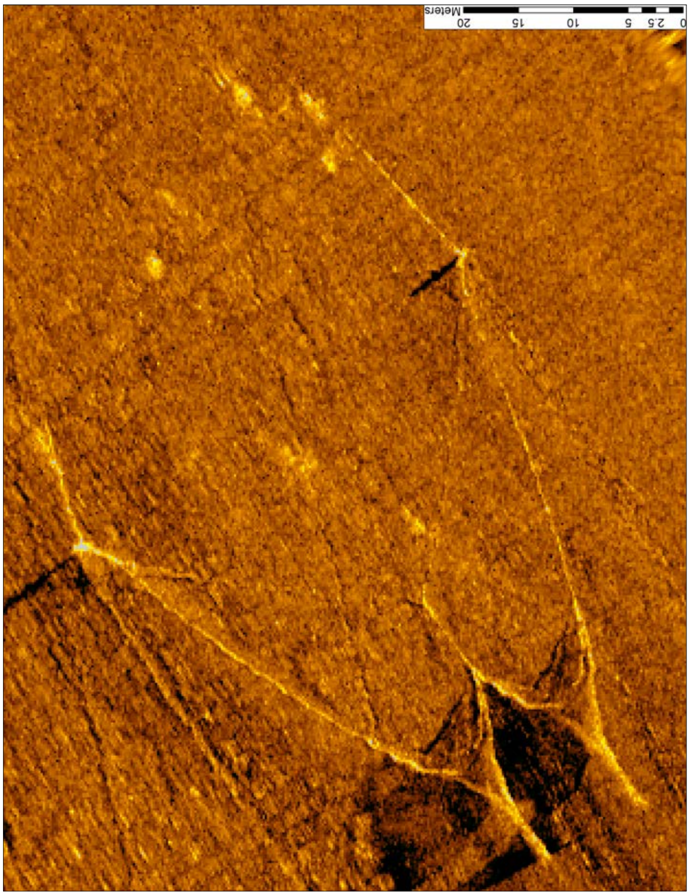


Figure 5. Configuration 1 - standard half-quad rig

Results

The weather throughout the trial was fine with very light winds and calm seas. In addition, the trial took place during neap tides. These conditions are considered ideal for the deployment of side-scan sonar as minimising unwanted movement of the towfish improves image quality.

On day 1, a standard half-quad rig (Configuration 1, Table 1, Figure 5) was scanned repeatedly to optimise deployment of the towfish and software settings. Day 2 was spent scanning four modified sweep configurations (Configurations 2 - 5, Table 1, Figures 6 - 9). There was some variability in the consistency of the imagery most likely due to differing speeds and headings of the two vessels.

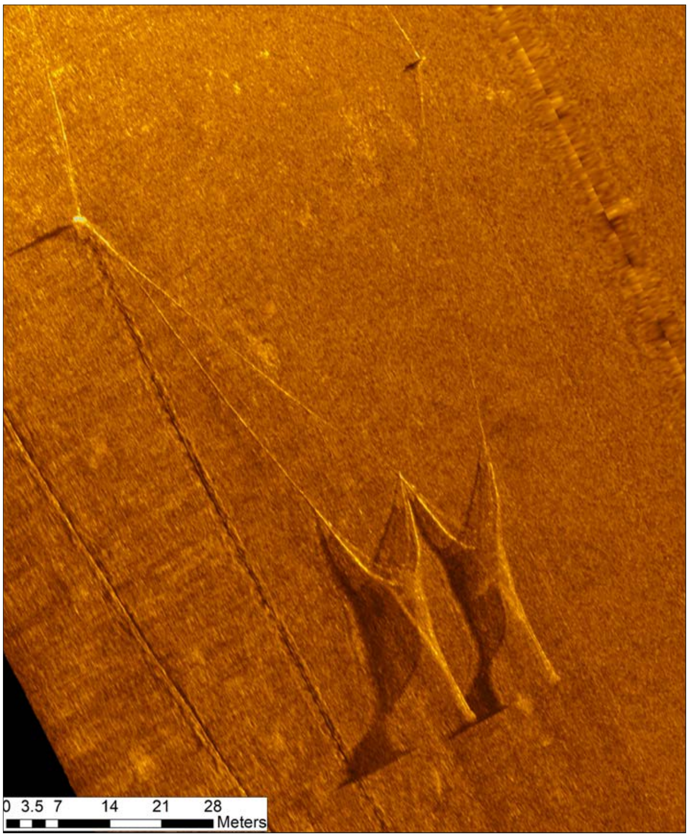


Figure 6. Configuration 2 - modified inner sweeps

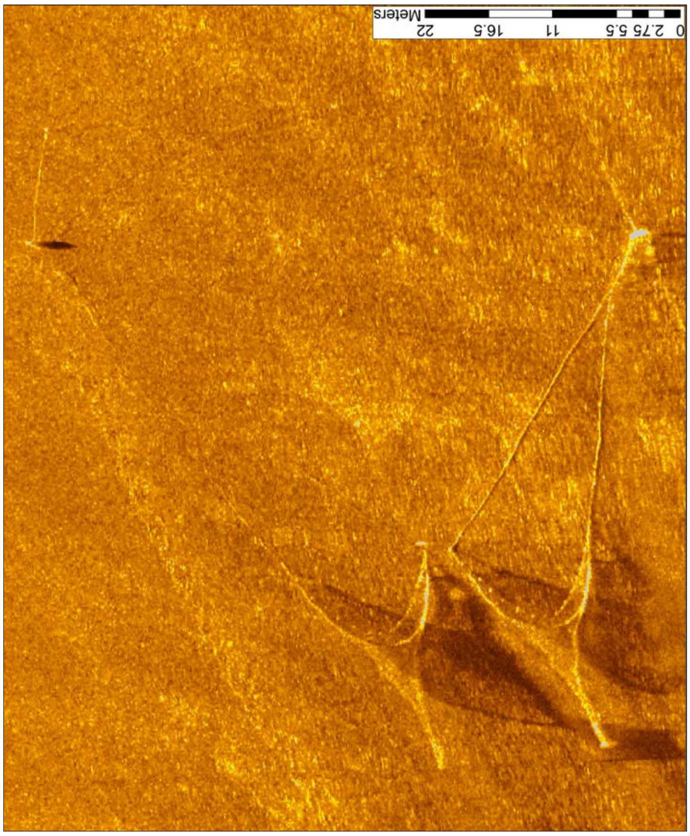


Figure 7. Configuration 3 - modified inner sweeps with 1.8 m escape gap

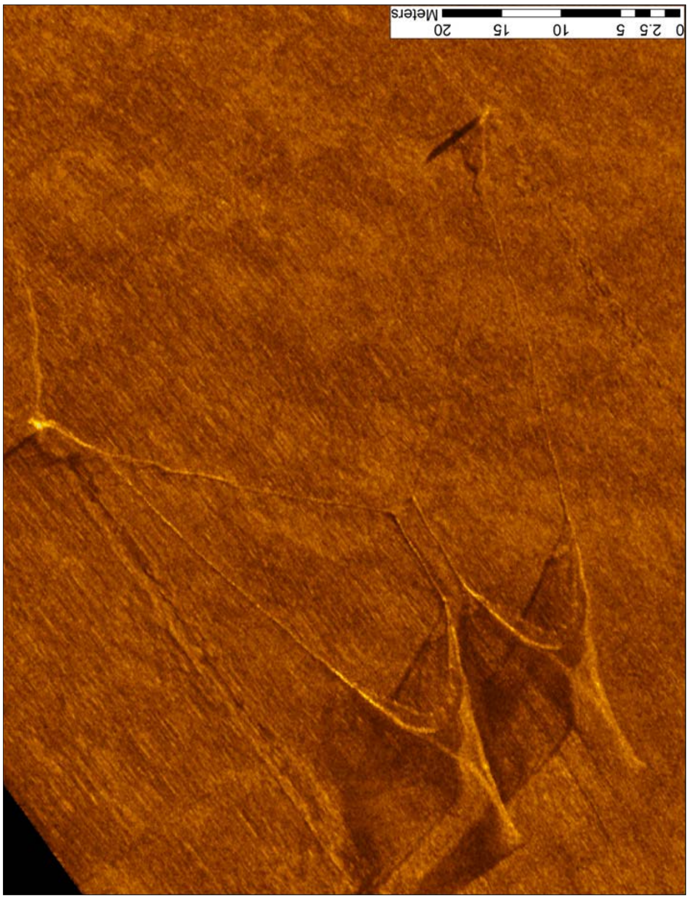


Figure 8. Configuration 4 - additional inner sweep with 1.8 m escape corridor

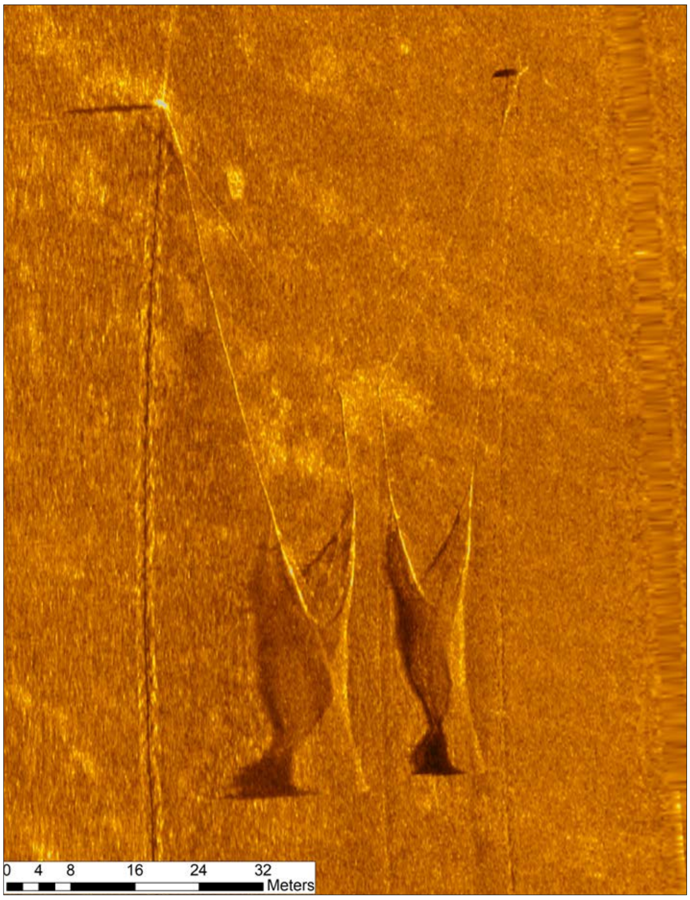


Figure 9. Configuration 5 - additional inner sweep with 4.6 m escape corridor

Discussion

Side-scan sonar imaging allowed rapid visualisation of multiple sweep configurations. For example, the MFV Skipper made some suggestions to improve gear performance based on the images of the third configuration. We subsequently altered and visualised two further gear modifications in less than one hour per modification. This demonstrates the utility of side-scan sonar as a tool in fast-tracking gear development.

Overall, the results suggest that it is possible to detect relatively fine scale differences in distance, angle and shape of sweeps and trawls. Further refinement of the deployment protocol would assist in improving the consistency of imagery. Potential also exists to quantify changes in gear components by calculating differences in shape, angle and length measurements using image analysis techniques. Acoustic telemetry sensors on otter boards and wing-ends would also help quantify changes and validate imagery.

Italian researchers were first to publish the results of side-scan sonar imaging of trawl gear (Lucchetti and Sala, 2012; Lucchetti et al., 2018). They detected mud plumes related to bottom disturbance which were not readily apparent in the images from this trial given the harder substrates encountered. Mud plumes and tracks can be used to assess the impact of gears on the seabed. Further extending the towfish cable would permit assessment of seabed impacts on muddy substrates in deeper waters.

In common with Lucchetti et al. (2018) the side-scan images from this trial showed off-bottom positioning of codends. The main focus of the current study was to observe rigging modifications ahead of the trawls. Hence, tow duration was kept short. High rates of wear on the bottom side of codends were observed in previous BIM trials in the same location as the current study indicating bottom contact at some point during hauls. Longer term side-scan monitoring of commercial hauls would greatly assist in understanding codend positioning. This could help mitigate seabed impact, fuel consumption and gear wear and tear.

The Italians found that deploying the towfish in the same direction as the trawl was optimal whereas in this study deployments from an opposite direction were found to result in more consistently clear images.

The escape gap or corridor developed during the current study aims to reduce unwanted whiting catches in the Irish Sea by directing or herding them along the V sweeps and between the two trawls. Imaging of the resulting modifications show that the sweeps and trawls maintain similar geometry when compared with the standard half-quad rig. These modifications were relatively simple to implement and require minimum investment.

Chain was used to join the fore and aft ends of the inner sweeps and form the escape corridor. Resulting plumes may reduce effectiveness as some fish could pass back over the inner sweeps into the trawl mouth. Widening the gap between the inner sweeps (Figure 9) or reducing bottom contact (Melli et al. 2020) may assist in this regard. Further evaluation of the bycatch escape corridor is needed using catch comparison methods.

Acknowledgements

BIM would like to thank Ciaran Powell (Skipper) and crew of the MFV Ocean Breeze for a productive collaboration. Thanks also to John Murphy, Skipper on board the RV T. Burke II, for his invaluable boat handling skills. This work is supported by the European Maritime and Fisheries Funding.

References

Barange, M., Bahri, T., Beveridge, M., Cochrane, K., Funge Smith, S., and Poulain, F. 2018. Impacts of climate change on fisheries and aquaculture - Synthesis of current knowledge, adaptation and mitigation options. Fisheries and Aquaculture Technical Paper. No. 627, Rome, FAO 630 pp.

Chopin, N., and McCoy, G., 2021. Seed Mussel Bed Post Fishery Survey 2020. BIM Aquaculture report, 32 pp.

Lucchetti, A. and Sala, A., 2012. Impact and performance of Mediterranean fishing gear by side-scan sonar technology. Canadian journal of fisheries and aquatic sciences, 69(11), pp.1806-1816.

Lucchetti, A., Notti, E., Sala, A. and Virgili, M., 2018. Multipurpose use of side-scan sonar technology for fisheries science. Canadian Journal of Fisheries and Aquatic Sciences, 75(10), pp.1652-1662.

Melli, V., Krag, L.A., Herrmann, B., Karlsen, J.D. and Feekings, J.P., 2020. Does the efficiency of a counter-herding device depend on seabed contact? Fisheries Research, 230, p.105686.

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