Assessment of pair-fishing operations in the Irish demersal seine fishery

Fisheries Conservation report

November 2023

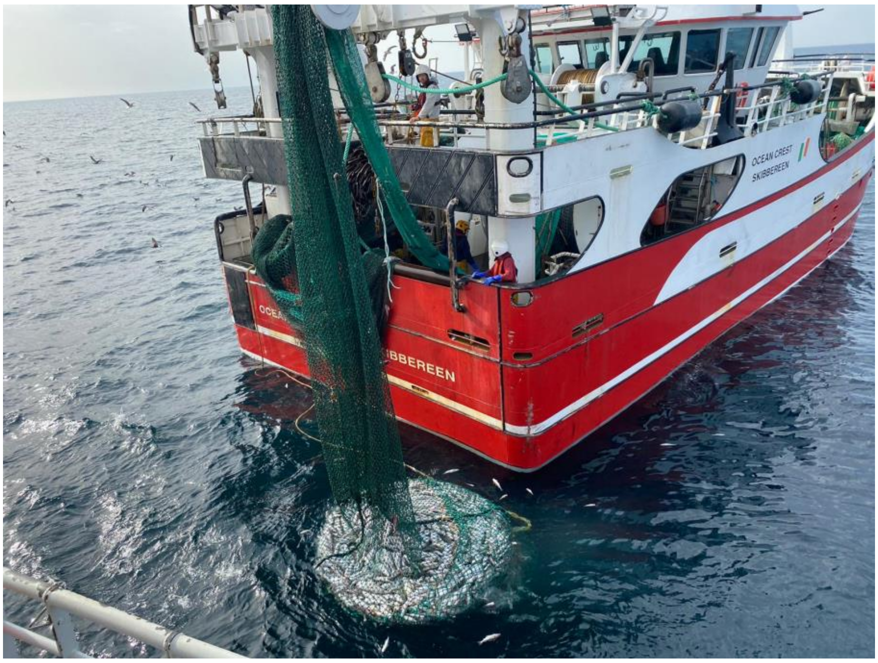
Martin Oliver*, Matthew McHugh, Daragh Browne, Rory Campbell, Ronan Cooney and Ronan Cosgrove

BIM, New Docks, Galway, ireland

*Email: martin.oliver@bim.ie

Key Findings

- 25% reduction in fuel use
- 25% reduction in greenhouse gas emissions
- 32% mean reduction in engine load
- In contrast to solo operations, pair-seining successfully caught fish during hours of darkness



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

Rialtas na hÉireann
Government of Ireland

Introduction

BIM and the Irish fishing industry are working to improve energy efficiency onboard commercial fishing vessels. Fuel prices are currently around 90 cent per litre and are likely to continue to rise in line with the EU transition away from reliance on fossil fuels in the seafood sector. Hence, it is essential to catch fish at the lowest rate of fuel consumption (litres of fuel used per kilogram of fish caught) possible.

Improving and upgrading vessels helps with more energy efficient operations as seen with the two new multipurpose vessels involved in the current trial, the MFV Ocean Crest and MFV Dillon Owen II. The Ocean Crest is fitted with an innovative Anglo Belgian Corporation (ABC) engine which runs a shaft generator supplying all the vessels energy requirements. The Dillon Owen II is fitted with highly fuel-efficient Caterpillar engine (3508C). Both engines meet IMO II emissions regulations and are capable of operating on alternative fuels such as biofuel.

Adjustments in fishing gear also play a vital role in improving energy efficiency. Seine netting is a key fishing method used by Irish vessels targeting mixed-demersal species such as haddock and hake. Currently, these vessels mainly operate as 'solo' vessels. A previous BIM assessment of pair trawling for haddock and hake demonstrated a 40 % reduction in fuel use, 29 % increase in fish catches and 32 % increase in profitability and concluded that 'pairing up' could also be of benefit to demersal seine netters (McHugh et al., 2022).

This study aimed to assess the practicalities and energy efficiency of pair seining in a fishery targeting mixed-demersal fish species in the Celtic Sea.

Methods

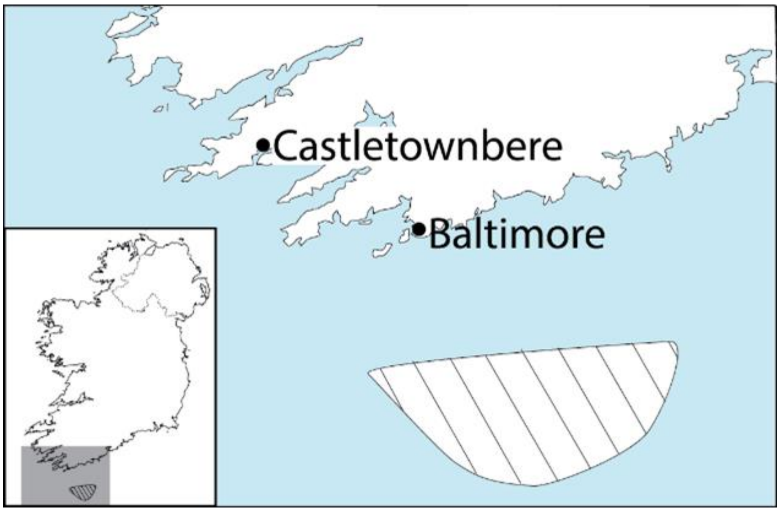


Figure 1. The trial location (hatched area)

Fishing methods

The pair-seine trial was conducted on board two Irish seiners of 26m and 27m targeting mixed-demersal fish species in the Irish sector of ICES Divisions 7g and 7j in the Celtic Sea in September 2023 (Figure 1).

Pair-seining is commonly used in Scotland and BIM met with an experienced Sottish pair-seine skipper to discuss how the method could be best implemented on board Irish vessels.

He recommended 660 meters of 60 mm seine (combination) rope and 259 meters of 32 mm wire between the net to the warp. The Scottish vessels typically fish using wire warp but the trial vessels in the current study were rigged with dyneema warp which has greater buoyancy. Chain clump weights used to counteract the buoyancy in the dyneema warp were added between the warp and wire and were deployed off-bottom (Table 1, Figure 2).

During solo fishing operations, seine rope on one side of the net is deployed, followed by the net and the seine rope on the other side of the net. In the pair operations, the lead vessel first deployed the net before transferring a line to the other vessel to pick up their side of the net. Once the two vessels were connected to the net, the seine ropes, wires, chain clumps, and warps were deployed and fishing commenced (Table 1, Figure 2).

Irish solo seine vessels typically restrict operations to daylight hours when they are most effective at fish herding. Fishing at nighttime is possible with pair-seining and a number of hauls were conducted partially during hours of darkness to compare hauls during daytime. Ten hauls, five day and five day/night which were conducted relatively close to each other temporally and spatially were selected for this purpose.

Table 1. Gear characteristics

	Pair	Solo
No. of vessels	Two	One
Ground gear	Hopper	Hopper
Seine rope length (m)	660	3700
Seine rope thickness (mm)	60	44
Wire length (m)	259	na
Chain doubles (m)	55	55
Warp length range (m)	319 - 364	na
Warp diameter (mm)	24 Dyneema	na
Sweep length (m) doubles	55	55
Chain clump (kg)	1000	na
Headline height (m)	9	8
Wingend spread range (m)	31 - 40	na
Ground gear	16“ rubber discs	14“ rubber discs
Mesh size codened (mm)	100 T90	100 T90
Twine thickness (mm)	4 x 2	4 x 2

<u>Operational data</u>

Due to rigging and logistical constraints, it was not possible to conduct alternate hauls using pair and solo seining. Instead, we compared operational data from pair-seining with subsequent solo seine trips conducted on the same grounds. Pair seining was conducted during night-time to assess catch rates during hours of darkness.

Operational data including fuel use (l/hr), engine load (%) and vessel distance (nm) were collected by skippers up to six times per haul during pair seining fishing. During subsequent solo seine trips in similar locations to the current trial, the skippers recorded fuel use (l/hr) and engine load (%) during fishing. We deployed Marport wing end and headline sensors during pair seining to obtain additional information on gear performance (Table 1).

Scope 1 greenhouse gas (GHG) emissions were estimated as carbon dioxide equivalents (kg CO_2 eqs./hour). These are regarded as direct emissions from sources owned or controlled by the operator (i.e., fuel use in engines, boilers and generators) (GHG, 2015) and were calculated using guidelines from the Intergovernmental Panel on Climate Change (IPCC) (EMEP/EEA, 2019) (Table 2).

Table 2. The emissions profile for 1 kg of diesel combusted in a fishing vessel

Fuel	Marine diesel oil (MDO)	
Substance	Emissions (kg/kg of diesel)	Source
Carbon dioxide (CO_2)	3.16	2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 3: Mobile Combustion 2006 IPCC
Methane (CH_4)	0.30	
Nitrous oxide (N_2O)	0.09	
Nitrogen oxides (NO_x)	0.08	EMEP Corinair 2019. Maritime navigation
Total as kg CO_2 eq./kg of diesel	3.20	Calculated as CO_2 eq.

Swept area and sweep divergence was calculated for fishing operations. Swept area provides a measure of the area fished by towed gears and is generally correlated with catches (Jones et al., 2021). Hence, estimation of this parameter contributes greatly towards assessment of efficiency of different gears.

Sweep divergence in pair vessels occurs where the sweeps join to the towing warps and we needed to derive the sweep angle to get this value (Seafish, 2010):

Vessel distance was initially used to obtain the sweep angle under the assumption that the warps continued at the same angle as the sweeps - angle A in Figure 2 - to the vessel. This angle was applied to the sweep length to estimate the sweep divergence. The following trigonometry function was used to calculate the sweep angle based on a right-angle triangle:

Sin (length of opposite)/ length of hypotenuse

where hypotenuse = sweep and warp length, opposite = (vessel distance - wing spread)/2

A second function was then applied to calculate the sweep divergence at the clumps:

Sweep divergence = (((Sin(sweep angle)) × sweep length) × 2) + wingspread

The pair trawl swept area (km^2) was subsequently calculated as:

Vessel speed (ms^{-1}) × haul duration (sec) × sweep divergence (km) ÷ 1000

It is assumed that the area covered when single seining is triangular shaped.

The area of a triangle is equal to half of the base times height, i.e. A = ½ × b × h

Here: ½ × 2370 × 5200 = 6.16 km^2. The 2370 m is equal to 10 rope coils (220 m), bridles (2× 55 m) and the headline length (60 m)

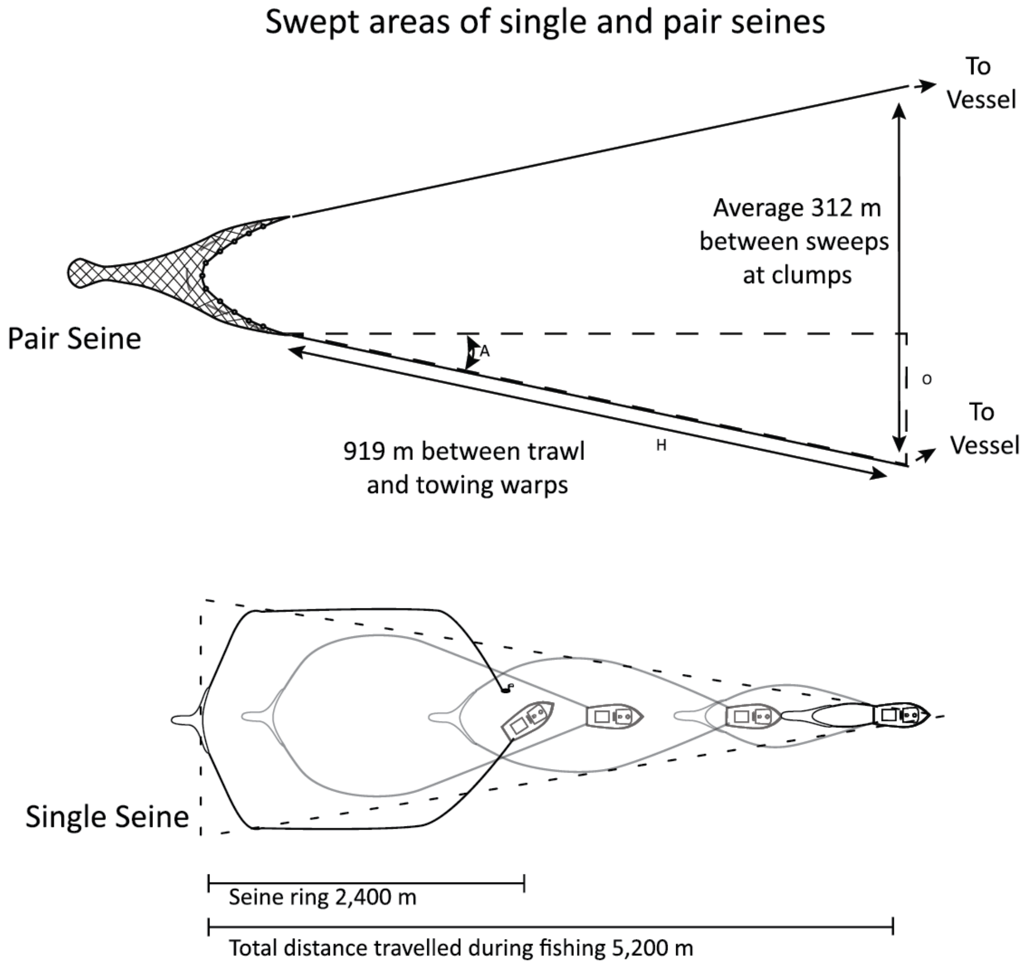


Figure 2. Example of fly-shoot seine operation (bottom). Swept area of both solo and pair-seines (top and bottom)

Figure 3. Trials vessels loading gear (top); skipper and crew splicing combination rope (middle left); skipper and BIM scientists discussing trial (middle right); pair-seine operations (bottom)

Catch sampling

It was not possible to accurately compare catches between pair and solo fishing operations due to temporospatial differences in operations and fish abundance. Instead, the skippers provided observations on catching performance, and we sampled catches from the pair seining operations to assess their catch composition.

Sampling started once the codend was emptied into the hopper onboard. Three random representative samples of fish were taken from the conveyor belt around the start, middle, and end of catch sorting. All random samples were weighed, and sampled fish were separated to species level, measured to the nearest cm below and raised to estimated bulk weights for each haul to provide length frequency distributions. Length weight relationships (Silva et al., 2013) were used to derive total catch weights by species and catches in relation to minimum conservation reference size (MCRS). Raised length frequencies for key species were plotted with MCRS overlayed.

Results

A total of 16 valid hauls were carried out over five consecutive fishing days on board the pair-seine vessels. Mean haul duration, vessel speed, and depth fished during the trial were 4 hrs 32 min, 2.9 kt and 89 m respectively. Wind speed was light for the duration of the trial ranging from 3 - 9 km^{-h}.

Both fuel use and greenhouse gas emissions were reduced by 25% in pair seining compared with solo seining. Mean engine load was a reduced by 32%. Swept area was 68% greater during pair seine operations (Table 3).

Table 3: Operational data during fishing. Mean with standard deviation presented where available

Vessel	Solo seine	Pair seine	Difference (%)
Fuel (l/hr) [sd]			
Dillon Owen	92 [6.7]	69 [2.7]	-25
Ocean Crest	100 [na]	75 [3.1]	-25
Engine load (%) [sd]			
Dillon Owen	53 [na]	36 [2.0]	-32
Ocean Crest	40 [na]	27 [2.7]	-33
Carbon (kg CO_2 eq./hr)			
Dillon Owen	259	195	-25
Ocean Crest	281	210	-25
Estimated swept area (km^2)	4.5	7.6	68

The main commercial fish species caught were haddock, hake, whiting, cod, monkfish, plaice and lemon sole, representing 86% of the total catch by weight (Table 4). Catches below MCRS were low at 1% for haddock and 0% hake, whiting and cod. Undersize plaice represented the highest percentage of undersize commercial fish caught at 11% but catches of plaice were relatively low overall and well within monthly quota allocations (Table 5; Figure 4).

The skipper's perception of the catches during pair fishing operations were that they were broadly similar to the combined catches of two solo vessels in recent trips. However, the pair-seine vessels continued to effectively catch fish during nighttime whereas nighttime hauls are not commercially viable in solo seine operations. For example, catches of haddock, the main target species remained consistent regardless of time of day (Table 6).

Table 4. Total combined catch weights for the pair seiners

Species	Weights (kg)
Haddock	11669
Hake	5954
Unwanted catches*	713
Whiting	686
Cod	478
Skates and rays**	202
Monkfish	169
Plaice	153
Lemon sole	149
Other flatfish species***	130
Ling	62
Tub and red gurnard	56
Black Pollock	51
John dory	28
White Pollock	24

*Scad, blue whiting, herring, lesser spotted dogfish, grey gurnard, mackerel, pouting, dab, boarfish
**Spotted ray, Blonde ray and flapper skate
***Turbot, brill, megrim, witch, black sole

Table 5: Catch weights in relation to minimum conservation reference size (MCRS)

Species	Weight (kg)	% > MCRS	% ≤ MCRS
Haddock	11668	99	1
Whiting	686	100	0
Hake	5954	100	0
Cod	478	100	0
Plaice	45	89	11

Table 6: Daytime compared with day/nighttime haddock catch weights

Day or Day/night	Weight (kg)	Time period (24hr)*	Tow duration (hrs)
Day	1693	12:30 - 17:40	05:10
Day	760	11:30 - 15:45	04:15
Day	96	11:30 - 16:25	04:55
Day	774	07:15 - 11:20	04:05
Day	891	06:00 - 10:05	04:05
Total	**4216**		22:30
Day/night	354	19:07 - 00:05	05:10
Day/night	2323	04:46 - 09:30	04:44
Day/night	102	05:43 - 10:10	04:27
Day/night	297	01:30 - 05:55	04:25
Day/night	1206	17:47 - 22:00	04:13
Total	**4281**		22:59

*Day time hours: 07:18 – 19:12
Night-time hours 21:09 – 05:20

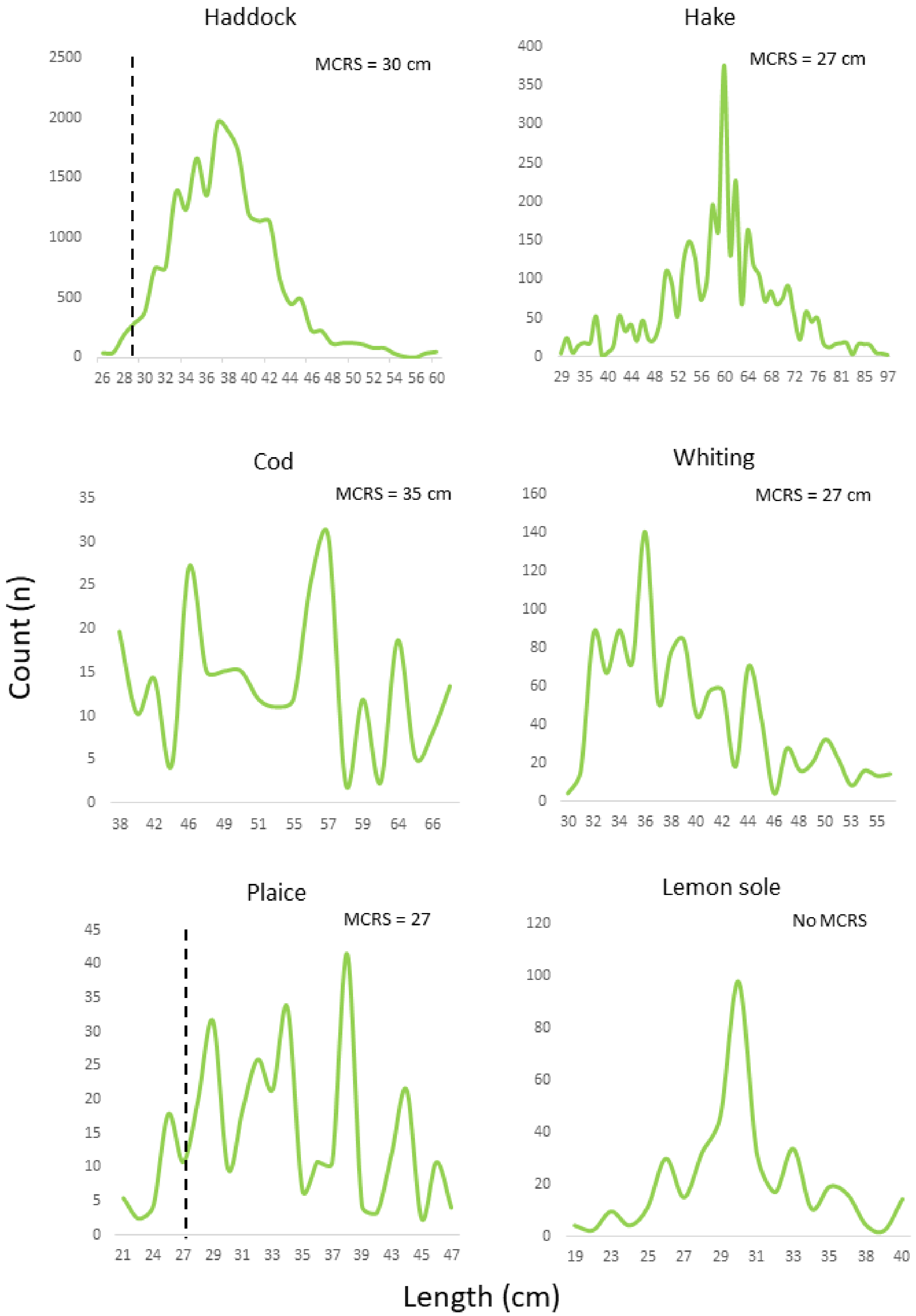


Figure 4. Raised length frequency distributions of key species (vertical dashed lines represent MCRS)

Discussion

The trial demonstrated that Irish solo seiners can successfully team up and catch fish effectively while greatly reducing fuel consumption, greenhouse gas emissions and engine load. This was the first time these vessels undertook pair-seining. The process worked well but some adjustments in vessel distance during fishing operations were made during the trial to find optimum sweep angle. The mean sweep angle observed for the pair vessels was 9°. The sweep angle is important for fish herding and catching ability. Sweep angle is typically around 13° in trawl fisheries (Eigaard et al., 2015). Further improvements in catch rates may be possible in future trips now that the vessels are operationally proficient in pair-seining. Smaller vessels in the Irish seine fleet may adapt rope and wire diameter to suit their pulling power.

Although not assessed in the current study, improved fuel efficiency during fishing will likely lead to improved profitability in a pair-seine fishery. Aside from the reduction in fuel associated with the gear modification, the ability of pair-seine vessels to catch fish during hours of darkness will likely lead to further improvements in energy efficiency and profitability; vessels may need to conduct fewer trips to catch their monthly quotas with less time spent steaming to fishing grounds and lower vessel maintenance costs.

Acknowledgements

BIM would like to thank the skippers Gerard Sheehy, Patrick and Owen O'Sullivan and crews of the MFV Ocean Crest and MFV Dillon Owen II for a successful collaboration. Thanks also to the quota management team from the Department of Agriculture Food and the Marine (DAFM) who were supportive of the initiative. This work was funded by the Irish Government and part-financed by the European Union through the EMFAF Operational Programme 2021 – 2027.

References

Eigaard, O.R., et al. 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv099.

EMEP/EEA, 2019. Air pollutant emission inventory guidebook. Technical guidance to prepare national emission inventories. EEA Report No 13/2019. 26pp.

GHG, 2015. The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard. Revised edition. 116pp.

Jones, A.W., Miller, T.J., Politis, P.J., Richardson, D.E., Mercer, A.M., Pol, M.V., and Roebuck, C.D. 2021. Experimental assessment of the effect of net wing spread on relative catch efficiency of four flatfishes by a four-seam bottom trawl. Fisheries Research, 244, 106106.

McHugh, M., Oliver, M., Browne, D., Cambell, R. and Cosgrove, R. 2022. Assessment of pair fishing towards more efficient targeting of demersal fish species. Irish Sea Fisheries Board (BIM), Fisheries Conservation Report, December 2022. 12 pp.

Seafish 2010. Bridle Angle and Wing End Spread Calculations. Seafish Factsheet. 6pp

Silva, J.F., Ellis, J.R., and Ayers, R.A. 2013. Length-weight relationships of marine fish collected from around the British Isles. Science Series Technical Report, Cefas Lowestoft, 150. 109