Marine Pollution Bulletin 192 (2023) 114918

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

The economic impacts of introducing biodegradable fishing gear as a ghost fishing mitigation in the English Channel static gear fishery

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A R T I C L E I N F O

Keywords:
Economic impacts
Biodegradable fishing gear
Abandoned, lost or discarded fishing gear
Channel
Incentives
Fishing efficiency

A B S T R A C T

We address the economic impacts of the role of Biodegradable Fishing Gear (BFG) as a mitigation measure for the ghost fishing impact of lost fishing gear, through scenarios based on industry interviews.

We find that the use of BFG is a technical challenge and not an economic problem. The majority of costs to fishermen in terms of BFG use are not related to investment and maintenance costs rather the impact of reduced fishing efficiency. At the Channel static gear fishery level, we estimate the costs of implementing BFG to be as high as £8 million. If the issue of fishing efficiency was resolved (i.e. BFG was a like-for-like) then the large negative costs could be overturned to between a cost of £880,000 and a small positive benefit of around £150,000. Considering the negative environmental impacts of lost gear, the benefits of BFG use over traditional fishing gear would grow exponentially.

1. Introduction

Marine litter represents one of the biggest threats to the health of oceans, considering its accumulation and dissemination from both land-based and ocean-based sources (European Commission, 2018). Marine litter is, therefore, one of the biggest threats to fisheries and the livelihood of fishermen. However, the fishing industry is a large contributor to the problem, with the European Commission (2018) estimating that as much as 27 % of marine litter in EU sea basins is caused by the so-called Abandoned, Lost or Otherwise Discarded Fishing Gear (ALDFG), which is defined as fishing gear that is not under the management of fishermen (for whatsoever reason e.g. by design or by accident). Therefore, the fishing industry is contributing to a problem that it is also directly affected by. Given ALDFG is a significant source of plastic waste in the marine environment, and that it can cause a variety of environmental problems (Gilman et al., 2021; Gilman et al., 2022) (perhaps for hundreds of years) after becoming ALDFG (e.g. ghost fishing, habitat/ ecosystem damage, navigation hazard, livelihood impact etc.), before breaking down into the arguably more damaging microplastic (Napper and Thompson, 2020).

Few estimates on the economic costs of marine litter at the sectoral level exist. For fisheries, the earliest attempts to address the economic cost of marine litter can be traced back to 1990 in Japan, based on a damage estimation method developed by Takehama (1990). Takehama (1990) estimated the damage of marine debris to equate to a cost to 0.3 % of Japan's fish catch (based on insurance pay outs from marine litter damage e.g. to propellers). McIlgorm et al. (2020), following the damage function developed by Takehama (1990), estimate the economic cost of marine litter in the APEC[1] region. They estimate the cost to be US$11 billion in 2015 assuming a linear exponential relationship. However, as proposed by Beaumont et al. (2019) it may be more appropriate to assume a non-linear exponential relationship between marine litter and impacts on fisheries i.e. each additional piece of marine litter has a greater impact than the piece before.

Hall (2000) reported that a combination of the costs of marine litter could result in cost impact of up to £30,000 per year for a single vessel. A study a decade later by Mouat et al. (2010) identified that 86 % of fishermen reported reduced catches due to marine litter, 82 % also reported contaminated catch and 95 % had snagged gear on debris on the seabed. Gear impacts aside, incidences of marine litter fouling propellers or blocking intake pipes were reported on average one time per vessel in the Scottish fishing industry (Mouat et al., 2010). In sum, the costs of marine litter are reported to be somewhere between €11.7 million and €13 million per year, which equates to 5 % of total revenue from fishing

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[1] Asia-Pacific Economic Cooperation Region.

https://doi.org/10.1016/j.marpolbul.2023.114918
Received 12 December 2022; Received in revised form 3 March 2023; Accepted 4 April 2023
Available online 16 May 2023

in Scotland, Fig. 1.

For other sectors, where more research has been conducted, notably tourism – studies by Mouat et al. (2010) and Trucost (2016) have attributed the cost of marine litter at between 2 and 5 % of GDP. In short, a global commitment is required to address the marine litter problem – and progress is being made in this regard.

However, as marine, maritime and land-based sectors are impacted to differing extents by marine litter (including by geographic location), actions to mitigate are likely to be delivered at the country level, with different interventions for different sources of plastic pollution. While other alternatives such as gear retrieval programmes and gear marking and mapping are currently in use, only BFG use and gear retrieval efforts can prevent the long-term impacts of ghost fishing (given some level of gear loss is unavoidable). Therefore, while much effort is currently directed towards finding solutions, a fishery specific example (as presented here) can make a useful contribution.

Overall, there is a general recognition that resolving the plastics problem is not a simple matter of banning plastics use. In fact, the complete replacement of plastic in the world economy is not a realistic (or even desirable) solution. The development of biodegradable fishing gear (BFG) could help both address the fishing industries contribution to marine litter and reduce the impacts of marine litter on the fishing industry as fishing gear with a reduced lifespan such as BFG can help address the environmental and economic impacts of ghost fishing, along with the other negative externalities of ALDFG.

However, research into biodegradability as a circularity aspect is sparse (albeit growing). The main theme that emerges suggests that biodegradability is not a 'key' circularity aspect to address the impacts of ALDFG (Brown et al., 2005; MRAG, 2020; OSPAR, 2020). Further, most (if not all) research that has focussed on the technical aspects of biodegradability (see e.g. Bae et al., 2012; Cerbule et al., 2022a, 2022b; Grimaldo et al., 2018; Grimaldo et al., 2019; Kim et al., 2014a) as a design feature of fishing gear has concluded issues around strength and flexibility and their impact on fishing efficiency (defined as the catch rate of target species per unit of fishing effort). In short, BFG is not put forward as a "silver bullet solution" when compared to alternatives (Wilcox and Hardesty, 2016). However, as the stock of ALDFG continues to increase, it is not clear that BFG is competing against any other mitigation measure that could be considered the panacea to mitigate ALDFG and the associated impacts. Therefore, BFG deserves renewed attention – particularly regarding mitigation efforts for ghost fishing, as this could help fishermen in their decision to invest in BFG (as ghost fishing is essentially in competition with commercial fishing).

The objective of this paper is to address the economic impacts of ghost fishing to the fishing industry and explore the role of BFG as a mitigation measure (primarily to help fishermen in their decision to engage with the experimental phase of BFG development).

The Channel fishery is a good study area to address the economic impacts of ghost fishing and BFG as a mitigation measure, as it is home to some high value and growing fisheries. Further, static gear use is commonplace and it is static type gears that are considered high risk in terms of becoming lost and the resultant impacts when unmanaged by fishermen (see Gilman et al., 2021). Therefore, even with a low level of ALFDG, the economic impact (in terms of the commercial value of fish lost to ghost fishing) could be substantial.

While other alternatives such as gear retrieval programmes and gear marking and mapping are currently in use and Extended Producer Responsibility (EPR) for fishing gear will become mandatory for EU Member States by the end of 2024, only BFG use and gear retrieval efforts can prevent the long-term impacts of ghost fishing (given some level of gear loss is unavoidable).

2. Methods

2.1. The model

The spreadsheet model builds on that proposed by Brown et al. (2005), who used the model to assess the economic costs and benefits of gear retrieval programmes in reducing the amount of ALDFG. Table 1 presents the information of the necessary variables and the data required for the model, split by gear use and costs, operational costs and earning data and the extent of gear loss and the costs associated with gear loss (following Brown et al., 2005). Subsequent tables then aggregate the dataset to generate an 'average' vessel from each sub-data set (e.g. <10 m pot) and then the sensitivity analysis and scenario development are performed on these 'average' vessels per sub-group, where BFG is added as a ghost fishing mitigation response. Our model follows the assertion made in several studies (e.g. Arthur et al., 2014; Bilkovic et al., 2014; Butler et al., 2013) that fisheries incur losses in revenue due to a reduction in their potential harvestable catch through ghost fishing. In other words, ghost fishing is in direct competition with commercial fishing and uncontrolled ghost fishing represents an ongoing and increasing economic cost to commercial fishermen.

The model is populated using primary data, with secondary sources

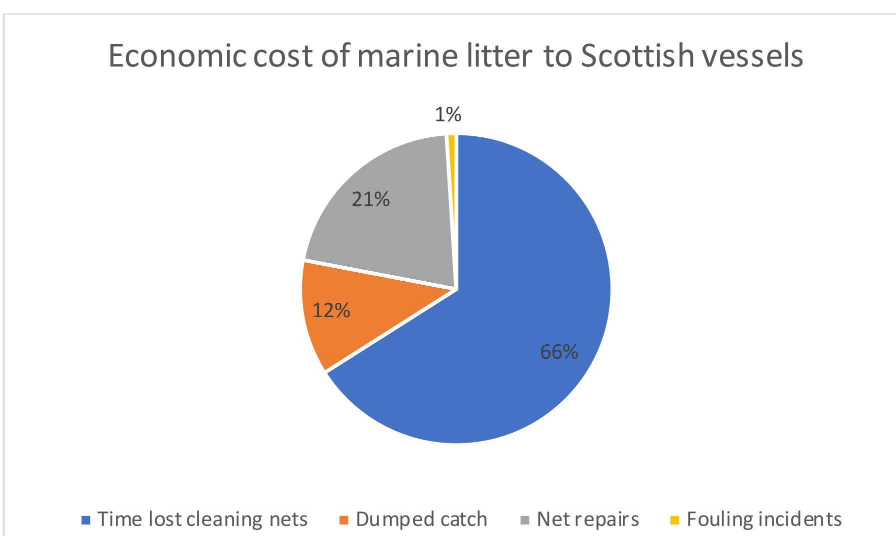

Fig. 1. Share of economic costs associated with marine litter to Scottish vessels.
Source: Mouat et al. (2010).

Table 1
Vessel level analysis: the cost of ghost fishing.

		Pot u10 m	Net u10 m
		10 m	9.98 m
Gear data			
1	Pots used/net length used (m)	1000	41,062
2	Pots per string/nets per tier	50	24
3	Number of strings/tiers	20	19
4	Average soak time (h)	Year round	60
5	Cost of each pot/net panel	£84	£100 per 100 yd. (91.44 m)
6	Cost of pots per string/ nets per tier	£1680	Not provided
7	Cost of pots/nets used	£84,000	Not provided
8	Cost of markers & floats per pot/net	Not provided	Not provided
9	Cost of markers & floats used per string/tier	£10	Not provided
10	Cost of markers & floats used	£200	Not provided
11	Total cost of pots/nets and markers/floats	£84,200	£44,906
12	Average life span of pots/nets (months)	90	48
13	Average life span of markers/floats (months)	Not provided	Some ropes 20–25 years old
Cost and earnings (per year)			
14	Landings (tonnes)	57.59	68.60
15	Revenue	£200,000	£200,000
16	Average value of landings (£per tonne)	£3473	£2915
17	Fishing expenses	£99,092	£97,373
18	Non fishing expenses	£43,095	£24,967
19	Total expenses	£142,187	£121,841
20	Net profit	£57,813	£78,159
21	Crew earnings	£59,016	£59,422
22	Value-added (crew earnings + profit)	£116,829	£137,581
23	Number of crew	3.0	3.5
24	Crew earnings per man	£19,672	£16,978
25	% of catch not quota controlled	100 %	5 %
26	Days fished	200	200
27	Hours fished	1600	1600
28	Value-added per hour	£73	£86
29	Crew earnings per hour	£37	£37
30	Value of non-quota catch per hour	£125	£119
31	Value added as % of revenue	61 %	69 %
32	Value added per tonne fish caught	£2112	£2002
33	Catch per string/tier (tonnes)	2.879	3.579
34	Catch per string/tier per day (tonnes)	0.014	0.018
Data on lost fleets and associated costs			
35	Gear lost per year	30/50 pots a year	2.5 tiers
36	Cost of gear lost	£3360	£2343
37	Time spent looking for nets (h)	8	24
38	% of time spent looking that would otherwise be fishing time	100 %	100 %
39	% of time spent looking that would otherwise be leisure time	0 %	0 %
40	Cost of lost leisure time	£0	£0
41	Cost of lost value added from fishing time lost	£584	£2064
42	Ghost fishing catch as % of total active catch	5 %	5 %
43	Value added lost from fish caught in ghost nets rather than by active gear	£6080	£6866
44	Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen)	£10,050	£11,268

used to fill in missing data. As well as the direct economic costs (e.g. investment in gear replacement), the model also considers the indirect economic and social costs of ghost fishing and the economic and social benefits of BFG use in the Channel static gear fishery. The model can be specified under various scenarios (and levels of sensitivity analysis), which is particularly useful to demonstrate to fishermen the potential gains from using BFG. However, it can also be constructed at the vessel level. Given the business model of a 6 m potter (e.g. amount of gear, landings, outgoings and incomings etc.) is different to that of a 10 m potter (or larger or any size in between), vessel level analysis is critical to demonstrate the role of BFG in mitigating ghost fishing to individual fishermen.

The model asserts that the status quo i.e. continued use of traditional fishing gear and the associated impact i.e. ghost fishing, can be improved upon (as the status quo is not the economic optimum). This may also be important considering that consumers are becoming ever more demanding that the food they consume is sourced sustainably. Therefore, we also consider the potential (attributed) benefits that can be attained by the fishing industry through using BFG. For example, the potential to achieve higher market prices for sustainable fish caught using BFGs, as some fishermen have demonstrated possible by developing new supply chains in response to the coronavirus pandemic e.g. selling catch directly to customers.

2.2. Stakeholder engagement

A market analysis conducted in the Channel fishery identified that the developmental phase of BFG (considering the current technical challenges e.g. fishing efficiency) should focus on the small-scale fleet using static gears including trap type gear e.g. pots and fixed nets e.g. gill nets (Drakeford et al., 2022).

Considering both gear types, the Channel fishery is home to around 1170 vessels, with almost 95 % of these vessels being 10 m and under (MMO, 2020a; MMO, 2020b). Of these, approx. 45 % hold a shellfish licence (MMO, 2020a; MMO, 2020b). While data is not available to estimate the number of set net fishermen in the fishery (we estimate this in the analysis to provide scale), around 40 % of the fishermen interviewed who use set net gear fished vessels 10 m and under. However, as we also collected data for over 10 m vessels we are also able to demonstrate the role of BFG in mitigating ghost fishing for these vessels.

Fishing organisations, representatives, authorities and private enterprises were invited to take part in our research through phone calls, emails and contact made at the quayside. While several fishermen's organisations and associations (and authorities e.g. IFCAs) were contacted, the Cornish Fish Producers Organisation (CFPO) engaged heavily with the project and we were able to engage 23 of their members providing 71.9 % of respondents. In total, there were 29 respondents representing 48 vessels of which 31 fished using static gear. These came from the following ports from West to East: Newlyn, Helford, Newquay, Padstow, Mevagissey, Clovelly, Plymouth, Bideford, Portsmouth and Shoreham. Respondents were interviewed for 15–20 min on their fishing activity, interaction with ALDFG and experience of BFG.

2.3. Data analysis

The spreadsheet model is built in Excel and provides a basis for the assessment of the economic costs of ghost fishing and potential mitigation measures and can be presented at the vessel, fleet and fishery levels. This is considered important as vessels that may appear to be the same (e.g. size, gear type, species targeted) may operate under different business models. A report by the New Economics Foundation (2018) reveals significant variance in economic performance in the UK fleet. Based on net profit margins, larger scale vessels are more profitable overall with an average profit margin of 19 %, although there is significant variation among both fleets and gear types. However, average profit margins are 0 % for some of the <10 m fleet segments. Further, some fleet segments are even operating with negative profits – reflecting the fact that for some smaller scale fishermen, fishing is as much a recreational activity as a commercial one (New Economics Foundation, 2018).

2.3.1. Vessel level analysis

The table below shows an example of a vessel level analysis (please see notes below for information).

Notes on model specification[2]:

1. The data required to populate the table and provide the result came from four sources:
    a. Primary data collected from surveys – Cells 1–7, 9–13, 15, 23, 25–27, 35–39, 41;
    b. Seafish (2021) multi annual UK fishing fleet estimates 2010–2020 – Cells 14, 17–21;
    c. Prices from online chandlery Coastal Nets (https://www.coastalnets.co.uk/) were used for cells 5–11 where the information was not provided – Cell 5–11;
    d. Calculated cells within the table – Cells 9–11, 16, 22, 24, 28–34, 40–41, 43–44;
    e. Cell 42, Ghost fishing catch as % of total active catch is a variable. This was not derived directly from the primary data but based on estimates derived from previous studies and assumptions based on the qualitative data collected in the surveys.

2. The data from Seafish allowed for the creation of estimates for a given vessel size band and gear type. This was then adjusted based on the yearly revenue provided in the primary data. This data was not collected in the primary data for two reasons:
    a. It was assessed that this would not be held by the respondents for recollection during the short interview due to the level of detail required;
    b. The data is of such a high level of commercial sensitivity that the respondents would be either unwilling to supply the data or it would present a barrier to their participation.

3. Cells 5 to 11 dealt with the cost of the nets. The respondents understood the cost of their nets in a variety of ways e.g. cost of replacement over time, whole cost, cost per net inclusive or exclusive of rigging. Therefore, these cells are populated/ unpopulated based on the information provided and the following assumption has been made to derive the figure in Cell 11.
    a. The data from the online chandlery was used to provide an estimate of an average figure of £84 per pot and £100 per 100 yd. of fully rigged net with £10 of accessories (floats, ropes, markers) per string used with the fishing gear where this was not information that the respondents were able to provide.

4. Cell 44, Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen), is the output from the calculations. It brings together the costs associated with replacing any lost gear, the value of any fishing lost due to the effects of ghost fishing and the cost of time lost to searching for and recovering lost gear.

2.3.2. Sensitivity analysis

The data collected allowed a sensitivity analysis to be undertaken by manipulating the following key variables:

- The value of potential catch lost to ghost fishing at different intensities. The lost value added was set at four levels (2.5 %, 5 %, 7.5 % and 10 %) of ghost fishing intensity;
- The impact of a loss of revenue associated with a reduction in fishing efficiency of biodegradable gear versus current gear. The analysis was performed using a decline in fishing efficiency of 5 %, 10 % and 20 % with the results shown for revenue and net profit. There is some offsetting from a reduced cost of lost catch to ghost fishing as revenue reduces so this is included in the results;
- The impact of increased costs associated with biodegradable gear versus current gear. These could include additional costs associated with a price premium over traditional gear and more regular replacement due to a shorter usable life. The analysis was performed using an increase of 5 %, 10 % and 20 % with the results shown for revenue and net profit. There is some fluctuation in the cost of lost catch to ghost fishing as net profit and therefore value-added declines, reducing the value of lost fishing time, while the increased gear cost raises the value of the gear lost;
- Increased revenue from an increase in market price for fish marketed as caught with biodegradable gear. The values used were 1 %, 2 % and 5 %. This small improvement to revenue has a significant effect on net profit while also raising the cost of ghost fishing as the catch lost is worth more.

2.4. Scenario development

These sensitivity analyses were used to create scenarios for a modelled 10 m and under vessel and an over 10 m vessel. Scenario 1A was low impact using a 5 % reduction in fishing efficiency and a 5 % increase in gear cost. Scenario 2A was a high impact scenario using a 20 % decrease in fishing efficiency and 20 % increase in gear cost. Scenario 1B and 2B were then created with a 1 % increase in the market price.

[2] Spreadsheets with full data and complete calculations are available from the authors if required.

Table 2
Fleet level analysis disaggregated by fleet segment.

	Pots u10 m (n = 7)	Pots o10 m (n = 1)	Nets u10 m (n = 8)	Nets o10 m (n = 6)	Net and Pot u10 m (n = 8)	Net and Pot o10 m (n = 1)
Pots used/net length used (m)	950 (Min 100/Max 1700/SD 482.2)	840	14,328 m (Min 1463 m/Max 114,625 m/SD 13,977.8 m)	40,447 m (Min 17,000 m/Max 67,374 m/SD 25,246.1 m)	791 pots (Min 100/Max 1500/SD 562.3) 12,406 m net (Min 3000 m/Max 22,531 m/SD 5676.1 m)	1200 pots 12,000 m net
Total cost of pots/nets and markers/floats	£75,069 (Min £3400/Max £143,083/SD £41,741.8)	£67,410	£15,669 (Min £1600/Max £44,906/SD £15,286.3)	£44,234 (Min £18,591/Max £73,681/SD £27,609.4)	£80,589 (Min £14,540/Max £141,333/SD £46,728.1)	£114,063
Ave. lifespan pots (months)	86 (Min 48/Max 96/SD 18.8)	96			60 (Min 60/Max 120/SD 23.6)	81
Ave. lifespan nets (months)			18 (Min 4/Max 48/SD 16.3)	13 (Min 12/Max 18/SD 2.7)	12 (Min 12/Max 24/SD 4.9)	14
Revenue	£147,917 (Min £37,500/Max £200,000/SD £67,275.9)	£60,000	£91,667 (Min £15,000/Max £200,000/SD £74,744.0)	£456,250 (Min £150,000/Max £750,000/SD £288,945.6)	£170,000 (Min £35,000/Max £285,000/SD £113,137.1)	£285,000
Total expenses	£105,159 (Min £26,660/Max £142,187/SD £47,828.9)	£36,270	£55,844 (Min £9138/Max £121,841/SD £45,534.4)	£402,373 (Min £132,287/Max £661,435/SD £254,825.1)	£114,725 (Min £23,620/Max £192,333/SD £76,350.7)	£235,569
Crew earnings	£43,647 (Min £11,065/Max £59,016/SD £19,851.8)	£11,349	£27,235 (Min £4457/Max £59,422/SD £22,207.4)	£147,211 (Min £48,398/Max £241,991/SD £93,229.7)	£50,286 (Min £10,353/Max £84,303/SD £33,466.0)	£84,365
Net profit	£42,757 (Min £10,840/Max £57,813/SD £19,447.0)	£23,730	£35,823 (Min £5862/Max £78,159/SD £29,209.6)	£53,877 (Min £17,713/Max £88,565/SD £34,120.5)	£55,275 (Min £11,380/Max £92,667/SD £36,786.4)	£49,431
Value-added (crew earnings + profit)	£86,405 (Min £21,905/Max £116,829/SD £39,298.7)	£35,079	£63,058 (Min £10,319/Max £137,581/SD £51,416.9)	£201,088 (Min £66,111/Max £330,556/SD £127,350.2)	£105,561 (Min £21,733/Max £176,971/SD £70,252.5)	£133,795
Value-added per hour	£56 (Min £27/Max £73/SD £20.3)	£44	£43 (Min £9/Max £86/SD £29.0)	£126 (Min £41/Max £207/SD £79.6)	£68 (Min £23/Max £111/SD £41.4)	£84
Cost of gear lost	£2992 (Min £33/Max £4500/SD £1520.3)	£480	£513 (Min £0/Max £2343/SD £931.0)	£17 (Min £0/Max £100/SD £40.8)	£6177 (Min £0/Max £13,104/SD £6517.2)	£13,104
Cost of lost value added from fishing time lost	£792 (Min £55/Max £1825/SD £654.3)	£175	£258 (Min £0/Max £2064/SD £729.6)	£0 (Min £0/Max £0 SD £0.0)	£990 (Min £109/Max £1725/SD £810.6)	£1305
Ghost fishing catch as % of total active catch	5 %	5 %	5 %	5 %	5 %	5 %
Value added lost from fish caught in ghost nets rather than by active gear	£4320	£1754	£3153	£10,054	£5278	£6690
Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen)	£8105	£2409	£3924	£10,071	£12,445	£21,098

3. Results

3.1. Fleet level analysis

Following the vessel level analysis, which can be undertaken for each of the vessels[3] represented in each interview, the data from the 31 static gear vessels provided an average figure for vessels above and below 10 m in length and whether they used pots, static nets or both. These headline figures, which are used for the sensitivity analysis, are presented below.

Basic descriptive statistics are presented in Table 2 (mix, max and standard deviation) to show variability in the data set. Results presented in Tables 3 to 17 do not include any descriptive statistics as they are all calculated from the figures in Table 2 (i.e. the average vessel per fleet type).

[3] The vessel number is higher than the number of interviews conducted as some interviewees owned multiple vessels.

3.2. Fleet level analysis by variable

3.2.1. Ghost fishing

The cost of ghost fishing comes from the cost of lost gear, time lost searching for and retrieving gear plus the potential lost value added (profits plus crew earnings) from reduced catch in the fishery.

3.2.2. Fishing efficiency

Any reduction in fishing efficiency of biodegradable gear versus current gear will reduce the revenue associated with fishing activity. The assumption made for this analysis is that there would be no additional fishing effort applied in order to return revenue to its former level and that all other costs remain fixed. Ghost fishing activity is assumed to remain at the original level for this analysis.

3.2.3. BFG cost

Any increase in the cost of gear on a per unit basis over current gear will reduce net profit assuming that fishing activity remains consistent with revenue and other costs unchanged. Ghost fishing activity is assumed to remain at the original level for this analysis.

Table 3
Fleet level analysis aggregated by vessel size.

	All static gear u10 (n = 23)	All static gear o10 (n = 8)	All static gear (n = 31)
Pots used/net length used (m)			
Total cost of pots/nets and markers/floats	£51,559	£178,576	£56,207
Ave. lifespan pots (months)	72	88	74
Ave. lifespan nets (months)	15	13	14
Revenue	£136,033	£385,313	£200,363
Total expenses	£91,333	£335,760	£154,411
Crew earnings	£40,248	£122,373	£61,441
Net profit	£44,699	£49,553	£45,952
Value-added (crew earnings + profit)	£84,947	£171,925	£107,393
Value-added per hour	£56	£110	£70
Cost of gear lost	£3238	£1711	£2844
Cost of lost value added from fishing time lost	£675	£185	£549
Ghost fishing catch as % of total active catch	5 %	5 %	5 %
Value added lost from fish caught in ghost nets rather than by active gear	£4247	£8596	£5370
Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen)	£8160	£10,492	£8762

Table 4
Cost of ghost fishing (vessel level).

Ghost fishing		Pots u10 m (n = 7)	Pots o10 m (n = 1)	Nets u10 m (n = 8)	Nets o10 m (n = 6)	Net and Pot u10 m (n = 8)	Net and Pot o10 m (n = 1)
2.5 %	Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen)	£5945	£1544	£2347	£5044	£9806	£17,753
5 %		£8105	£2421	£3924	£10,071	£12,445	£21,098
7.5 %		£10,265	£3298	£5500	£15,098	£15,084	£24,443
10 %		£12,425	£4175	£7076	£20,125	£17,723	£27,788

Table 5
Cost of ghost fishing (aggregated by vessel size).

Ghost fishing		All static gear u10 (n = 23)	All static gear o10 (n = 8)	All static gear (n = 31)
2.5 %	Total cost of ghost fishing (lost nets, fish ghost caught and time spent by fishermen)	£6036	£6195	£6077
5 %		£8160	£10,493	£8762
7.5 %		£10,284	£14,791	£11,447
10 %		£12,407	£19,089	£14,132

Table 6
Impact of fishing efficiency (vessel level).

Fishing efficiency		Pots u10 m (n = 7)	Pots o10 m (n = 1)	Nets u10 m (n = 8)	Nets o10 m (n = 6)	Net and Pot u10 m (n = 8)	Net and Pot o10 m (n = 1)
0 %	Revenue	£147,917	£60,000	£91,667	£456,250	£170,000	£285,000
−5 %		£140,521	£57,000	£87,083	£433,438	£161,500	£270,750
−10 %		£133,125	£54,000	£82,500	£410,625	£153,000	£256,500
−20 %		£118,333	£48,000	£73,333	£365,000	£136,000	£228,000
0 %	Net profit	£42,757	£23,730	£35,823	£53,877	£55,275	£49,431
−5 %		£35,361	£20,730	£31,240	£31,064	£46,775	£35,181
−10 %		£27,966	£17,730	£26,656	£8252	£38,275	£20,931
−20 %		£13,174	£11,730	£17,490	−£37,373	£21,275	−£7569
0 %	Total cost of GF	£8105	£2409	£3924	£10,071	£12,445	£21,098
−5 %		£7667	£2244	£3676	£8930	£11,940	£20,247
−10 %		£7229	£2079	£3428	£7790	£11,436	£19,395
−20 %		£6354	£1749	£2932	£5509	£10,426	£17,693

3.2.4. Sales price increase

The final sensitivity analysis relates to any potential improvement in the market price of fish landed due to any positive consumer response to fish products marketed as landed using biodegradable gear.

The scenarios show that even at low impact, the loss of profit is large and only in the 10 m and under vessel would this be offset by eliminating ghost fishing entirely. As this would be unlikely from the start, as already lost gear would continue to ghost fish for a period of time, the costs form the basis of the impact on the fleet from day one of biodegradable gear adoption.

3.3. Fleet size estimate

Achieving an accurate figure for the number of vessels operating in the Channel area is not possible.[4] Therefore, the figure for static gear vessels in the UK is taken from the 2019 Seafish fleet report which shows 1391 10 m and under (excluding low activity) and 311 over 10 m static gear vessels. The Channel area has ~20 % of the UK's static gear vessels which gives a crude estimate of 274 10 m and under and 61 over 10 m vessels.

Using the figures from the scenarios to derive figures at a static gear

[4] Such data do not exist.

Table 7
Impact of fishing efficiency (aggregated by vessel size).

Fishing efficiency		All static gear u10 (n = 23)	All static gear o10 (n = 8)	All static gear (n = 31)
0 %	Revenue	£136,033	£385,313	£200,363
−5 %		£129,231	£366,047	£190,345
−10 %		£122,429	£346,781	£180,327
−20 %		£108,826	£308,250	£160,290
0 %	Net profit	£44,699	£49,553	£45,952
−5 %		£37,898	£30,287	£35,934
−10 %		£31,096	£11,021	£25,916
−20 %		£17,493	−£27,510	£5879
0 %	Total cost of GF	£8160	£10,492	£8762
−5 %		£7766	£9508	£8210
−10 %		£7372	£8524	£7658
−20 %		£6584	£6556	£6553

Table 8
Impact of BFG cost (vessel level).

Cost increase		Pots u10 m (n = 7)	Pots o10 m (n = 1)	Nets u10 m (n = 8)	Nets o10 m (n = 6)	Net and Pot u10 m (n = 8)	Net and Pot o10 m (n = 1)
0 %	Yearly gear cost	£10,475	£8426	£10,544	£40,212	£26,526	£26,272
5 %		£10,998	£8848	£11,071	£42,223	£27,852	£27,586
10 %		£11,522	£9269	£11,598	£44,234	£29,178	£28,899
20 %		£12,570	£10,112	£12,653	£48,255	£31,831	£31,526
0 %	Net profit	£42,757	£23,730	£35,823	£53,877	£55,275	£49,431
5 %		£42,234	£23,308	£35,296	£51,866	£53,949	£48,117
10 %		£41,710	£22,887	£34,768	£49,856	£52,623	£46,803
20 %		£40,662	£22,044	£33,714	£45,834	£49,970	£44,176
0 %	Total cost of GF	£8105	£2409	£3924	£10,071	£12,445	£21,098
5 %		£8223	£2410	£3921	£9971	£12,675	£21,675
10 %		£8342	£2411	£3918	£9872	£12,905	£22,252
20 %		£8579	£2413	£3912	£9672	£13,366	£23,405

Table 9
Impact of BFG cost (aggregated by vessel size).

Cost increase		All static gear u10 (n = 23)	All static gear o10 (n = 8)	All static gear (n = 31)
0 %	Yearly gear cost	£16,082	£34,497	£20,834
5 %		£16,886	£36,221	£21,876
10 %		£17,690	£37,946	£22,917
20 %		£19,298	£41,396	£25,001
0 %	Net profit	£44,699	£49,553	£45,952
5 %		£43,895	£47,828	£44,910
10 %		£43,091	£46,103	£43,868
20 %		£41,483	£42,653	£41,785
0 %	Total cost of GF	£8120	£10,441	£8762
5 %		£8275	£10,489	£8847
10 %		£8391	£10,487	£8931
20 %		£8621	£10,481	£9101

Table 10
Impact of sales price increase (vessel level).

Price increase		Pots u10 m (n = 7)	Pots o10 m (n = 1)	Nets u10 m (n = 8)	Nets o10 m (n = 6)	Net and Pot u10 m (n = 8)	Net and Pot o10 m (n = 1)
0 %	Revenue	£147,917	£60,000	£91,667	£456,250	£170,000	£285,000
1 %		£149,396	£60,600	£92,583	£460,813	£171,700	£287,850
2 %		£150,875	£61,200	£93,500	£465,375	£173,400	£290,700
5 %		£155,313	£63,000	£96,250	£479,063	£178,500	£299,250
0 %	Net profit	£42,757	£23,730	£35,823	£53,877	£55,275	£49,431
1 %		£44,236	£24,330	£36,740	£58,439	£56,975	£52,281
2 %		£45,716	£24,930	£37,656	£63,002	£58,675	£55,131
5 %		£50,153	£26,730	£40,406	£76,689	£63,775	£63,681
0 %	Total cost of GF	£8105	£2409	£3924	£10,071	£12,445	£21,098
1 %		£8192	£2442	£3973	£10,299	£12,546	£21,269
2 %		£8280	£2475	£4023	£10,527	£12,647	£21,439
5 %		£8542	£2574	£4171	£11,212	£12,950	£21,950

Table 11
Impact of sales price increase (aggregated by vessel size).

Price increase		All static gear u10 (n = 23)	All static gear o10 (n = 8)	All static gear (n = 31)
0 %	Revenue	£136,033	£385,313	£200,363
1 %		£137,393	£389,166	£202,367
2 %		£138,753	£393,019	£204,370
5 %		£142,834	£404,578	£210,381
0 %	Net profit	£44,699	£49,553	£45,952
1 %		£46,060	£53,406	£47,955
2 %		£47,420	£57,259	£49,959
5 %		£51,501	£68,818	£55,970
0 %	Total cost of GF	£8160	£10,492	£8762
1 %		£8239	£10,689	£8872
2 %		£8318	£10,885	£8983
5 %		£8554	£11,476	£9314

Table 12
Scenario 1A: low impact with no price increase.

		All static gear u10 (n = 23)	All static gear o10 (n = 8)
Ghost fishing	5 %	£8067	£10,163
Fishing efficiency	−5 %	−£6802	−£19,266
Cost increase	5 %	−£804	−£1725
Price increase	0 %	£0	£0
Costs		−£7606	−£20,990
Benefits		£8067	£10,163
Total		£461	−£10,828

Table 13
Scenario 1B: low impact with 1 % price increase.

		All static gear u10 (n = 23)	All static gear o10 (n = 8)
Ghost fishing	5 %	£8093	£10,228
Fishing efficiency	−5 %	−£6802	−£19,266
Cost increase	5 %	−£804	−£1725
Price increase	1 %	£1360	£3853
Costs		−£7606	−£20,990
Benefits		£9454	£14,082
Total		£1848	−£6909

Table 14
Scenario 2A: high impact with no market price increase.

		All static gear u10 (n = 23)	All static gear o10 (n = 8)
Ghost fishing	5 %	£7788	£9176
Fishing efficiency	−20 %	−£27,207	−£77,063
Cost increase	20 %	−£3216	−£6899
Price increase	0 %	£0	£0
Costs		−£30,423	−£83,962
Benefits		£7788	£9176
Total		−£22,635	−£74,786

Table 15
Scenario 2B: high impact with 1 % market price increase.

		All static gear u10 (n = 23)	All static gear o10 (n = 8)
Ghost fishing	5 %	£7815	£9242
Fishing efficiency	−20 %	−£27,207	−£77,063
Cost increase	20 %	−£3216	−£6899
Price increase	1 %	£1360	£3853
Costs		−£30,423	−£83,962
Benefits		£9175	£13,095
Total		−£21,248	−£70,867

fleet Channel area and UK level shows that, assuming that ghost fishing cannot be eliminated from the start, the sums involved for individual vessels and the fleet are substantial. The Channel area range for 10 m and under vessels of £1.7 m to £8 m and over 10 m of £400 k to £5 m in these scenarios suggests a significant investment would be required to keep the fleet profitable during any transition.

Declines in fishing efficiency appear to be the most significant potential issue. For instance, in the scenarios if fishing efficiency declines

Table 16
10 m and under.

	All static gear u10 (n = 23)	Channel area	UK
Vessel numbers	Single vessel	274	1391
Scenario 1a			
No ghost fishing	£461	£126,466	£641,763
Ghost fishing	−£7606	−£2,084,815	−£10,579,549
Scenario 1b			
No ghost fishing	£1848	£506,550	£2,570,526
Ghost fishing	−£6245	−£1711,934	−£8,687,336
Scenario 2a			
No ghost fishing	−£22,635	−£6,204,413	−£31,484,754
Ghost fishing	−£30,423	−£8,339,261	−£42,318,198
Scenario 2b			
No ghost fishing	−£21,248	−£5,824,329	−£29,555,991
Ghost fishing	−£29,063	−£7,966,380	−£40,425,984

Table 17
Over 10 m.

	All static gear o10 (n = 8)	Channel area	UK
Vessel numbers	Single vessel	61	311
Scenario 1a			
No ghost fishing	−£10,828	−£663,577	−£3,367,373
Ghost fishing	−£20,990	−£1,286,420	−£6,528,032
Scenario 1b			
No ghost fishing	−£6909	−£423,415	−£2,148,649
Ghost fishing	−£17,137	−£1,050,277	−£5,329,710
Scenario 2a			
No ghost fishing	−£74,786	−£4,583,300	−£23,258,297
Ghost fishing	−£83,962	−£5,145,679	−£26,112,128
Scenario 2b			
No ghost fishing	−£70,867	−£4,343,138	−£22,039,573
Ghost fishing	−£80,109	−£4,909,537	−£24,913,807

are removed for the 10 m and under Channel area fleet the impact estimate drops from £1.7 m to £8 m down to −£150 k (i.e. a positive benefit) to £880 k.

4. Discussion

4.1. Incentives required for BFG uptake in the Channel static gear fishery

The results of our analysis show that one (or a combination of) of three scenarios is required for fishermen to invest in BFG. (1). A regulation mandating its use; (2). Consumer awareness of sustainable fishing methods, coupled with a willingness to pay for sustainably caught fish; (3). Demand from fishermen.

Notably, there is no regulation (or anticipation of a regulation in the short term) to mandate the use of BFG (1). A large-scale willingness to pay study to understand the publics' willingness to pay more for fish caught using BFG (2) would maybe cause confusion between lower impact fishing methods (e.g. the pot type/gill type gears that are addressed in our study) and these types of fishing methods being unsustainable. While we consider that there is potential for BFG to improve the sustainability of fisheries (coupled with the potential to attract higher market prices), the focus of our study is demand from fishermen (3). The objective is thus to provide a resource base to justify the potential role of BFG to address ALDFG – focussing on an economic impact of ALDFG – ghost fishing.

Given the decline in fishing efficiency impact on revenue, we focus on the use of financial incentives to stimulate demand from fishermen for BFG. There are limited examples in the literature of the type/amount of incentive that would be required for fishermen to engage with BFG. There are several references to the use of government financial incentives to mitigate impacts of ALDFG (including the role of BFG to address ghost fishing). For example, Cho (2009) discusses incentive schemes for ALDFG removal with different rates paid for the type and volume of gear retrieved. Kim et al. (2014b) discuss the need for financial incentives to stimulate BFG use (and the importance of public education to emphasise the need to address gear discarding at sea). Kim et al. (2016) report on the use of government financial incentives for biodegradable gillnet use as compensation for lower catch efficiency and higher gear costs. Standal et al. (2020) discuss the options for the type and level of incentives required for BFG use in the Norwegian cod gillnet fishery. Standal et al. (2020) report on a 10.9 M gillnetter working a fleet of six nets (120 panels in total). Replacing all gear with biodegradable gillnets would result in a 21 % decline in catch (approx. 20 t) resulting in almost £40,000 of lost revenue. Given biodegradable gillnets are twice as expensive in Norway as traditional gear the investment cost would be almost £3000. Therefore, a total cost (lost catch and gear investment) of £43,000. In the lack of government assistance, e.g. financial incentive, the gillnetter would either have to set more gear (higher investment cost) or spend more time fishing (higher variable costs e.g. fuel, as well as increased chance of bycatch etc.). Therefore, everything else remaining constant, the gillnetter would need to be compensated for the reduced catch and extra gear investment cost. This study does not factor in higher market prices from BFG use (as we have presented in our analysis). However, this study shows that the use of BFG is a technical challenge and not an economic one. The majority of incentive (>90 %) is to compensate for reduced fishing efficiency and <10 % for the actual cost of BFG.

Our analysis highlights various scenarios where the use of financial incentives would be essential for BFG uptake. The incentives required for decreases in fishing efficiency (especially for >10 m gillnetters) are the greatest. We found that for these vessels a 20 % decline in fishing efficiency (as consistently reported in the literature (Cerbule et al., 2022a, 2022b; Grimaldo et al., 2019; Grimaldo et al., 2020; Wang et al., 2020)) would yield negative profits of more than £37,000. Therefore, if BFG was given to these fishermen free of cost a financial incentive of £37,000 would be needed in order for fishermen to breakeven. As the current profitability for this vessel is around £53,000, an incentive for a "no change" scenario to the fishermen would be £90,000. However, under the same scenario, an incentive of less than £30,000 would be required for an <10 m potter. Extrapolating to the Channel fishery,[5] the impact of fishing efficiency would require financial incentives as high as £8 million (the worst-case scenario as presented in our analysis) to maintain a profitable fleet. If the issue of fishing efficiency could be addressed, a positive benefit of £150,000 could be realised (In the best-case scenario, not accounting for the environmental benefits that would accrue through the reduction of ALDFG, for instance).

Our analysis demonstrates the importance of a vessel level analysis showing that the cost of using BFG is dependent on the fleet characteristics of the range of vessels operating in a fishery. However, it also supports the findings of Standal et al. (2020) in that most of the financial incentive is required to offset declines in fishing efficiency. It further demonstrates that integrating BFG into a circular economy for fishing gear is a technical challenge rather than an economic problem. While subsidising the cost of BFG, as well as assuming that fishermen may be able to attract higher prices for fish caught using BFG, it is not enough to address the impact on profitability from declines in fishing efficiency (which represent most of the cost of BFG implementation).

Along with the use of incentives for BFG, fishermen will continue to play an important role in retrieving lost gear. Perhaps more so if fishermen were using BFG. Drinkwin (2022) notes that "requiring" fishermen to retrieve gear if it is lost as a critical measure to avoid impacts from ALDFG. Most fishermen make a great deal of effort to retrieve gear (even illegal fishing activity) as the purchase and maintenance of fishing gear is a major expense and investment for fishermen. Incentivising fishermen to do so will be important, otherwise retrieval attempts that divert attention from lucrative fishing, costing time and fuel, may result in fishermen abandoning lost gear in order to carry on fishing. An incentive to ensure that vessels carry the necessary equipment to recover gear would be useful in this respect (Drinkwin, 2022). Finally, coupling this with policy to establish new regulations would likely yield the best chance of success.

4.2. Extended producer responsibility and biodegradable fishing gear

The majority of experimental work on developing and testing BFG has focussed on fixed gear - mainly gill (type) nets and traps/pots. Biodegradable gillnets are currently used in commercial fisheries in China, Norway, Japan and South Korea and trap type gear in the USA and South Korea. The majority of research (as represented in the academic literature) has been (and is currently) conducted in Norway, South Korea and the USA. Further, biodegradable ropes have been tested for use in aquaculture (Suarez et al., 2021) and with Fish Aggregating Devices (FADs) in tuna fisheries (Moreno et al., 2017). Rather than having a sole focus on the relative catch efficiency of different BFGs, most studies have now evolved to address the outputs of earlier studies on BFG that documented such shortcomings – most related to strength, flexibility and durability. For example, a study by Bae et al. (2012) found that biodegradable gillnets in the South Korean Flounder fishery were 45 % less effective (in terms of catching efficiency), but this was not correlated to soak time (issues relating to reduced strength) - rather it was correlated to wave height.

Norway dominates BFG research for fixed nets. Gillnet fisheries are particularly popular in Norway with >5500 vessels using them (Grimaldo et al., 2020). While some studies in South Korea have shown comparable fishing efficiency between conventional and experimental BFG, most studies in Norway have shown a consistently lower catch efficiency, which has been attributed to the weaker monofilaments used (11–16 % weaker monofilaments than nylon monofilaments of the same diameter (Grimaldo et al., 2020)). However, increasing the diameter of the monofilament did not have a significant impact in Grimaldo et al. (2020), who tested larger diameter monofilaments in the north Norwegian cod and saithe fishery. Therefore, Grimaldo et al. (2020) conclude that strength does not explain the difference in catch efficiency, but the elasticity and stiffness (that relate to monofilament strength) may be responsible for reduced catch efficiency. Further, larger diameters of monofilaments cause a decrease in fishing efficiency, as gear becomes more visible (and thus available) to fish.

Grimaldo et al. (2019) compared biodegradable gillnets to nylon gillnets and found the traditional gear caught 21 % more of the target catch (cod), with better catch rates for most size classes. The number of deployments resulted in lower catch rates. Although less efficient, the biodegradable nets offer considerable potential for the reduction of ghost fishing and plastic pollution caused at sea by the fishery. A study by Cerbule et al. (2022a, 2022b) found a similar decline in catch rate (25 %) in the Norwegian cod gillnet fishery, declining with each deployment. Grimaldo et al. (2020) noted that the long term use of biodegradable gillnets negatively affects catch performance, with an aging test showing signs of deterioration after just 200 h of exposure. Cerbule et al. (2022a) also conducted a study on the use of biodegradable materials in longline comparing nylon vs. biodegradable snoods finding no difference in either the loss of snoods (nylon vs. biodegradable) or catch efficiency.

While some studies report that implementing biodegradability as a design feature of trap-type gear is relatively inexpensive, others (see e.g. Kim et al., 2014a, 2014b) suggest that in fact the main disadvantage is that the biodegradable pots are more expensive, so it is unlikely they will be widely used by the fishing industry without financial incentives. Demonstrating both the technical and economic feasibility remains one of the main challenges for BFG implementation.

The establishment of an EPR policy for fishing gear represents a clear and actionable response to address one major vector of potential plastic pollution derived from fishing activities (IUCN, 2021). Under an EPR scheme for fishing gear, it is the responsibility of the producer to ensure safe disposal/recycling of end of life gear. As such, it is hoped that EPR schemes would internalise the environmental costs of marine litter, incentivise the development of fishing gear with more sustainable materials (e.g. BFG) and provide much needed stimulation for the development of commercial recycling supply chains. However, there are significant barriers to overcome to increase recycling rates of fishing gear (MRAG, 2020).

Similar to the voluntary nature of some gear retrieval efforts (Drinkwin, 2022), voluntary EPR schemes already exist for some forms of plastic use e.g. The Plastic Pact, Textile 2030 and the voluntary EPR pilot for fishing gear in France developed by the PECHPROPRE project (Powell et al., 2021). Similar to other fisheries regulations (e.g. the EU landing obligation), managing ALDFG by direct regulation of fishermen may prove unfeasible due to the expense and effort required in the large scale monitoring and enforcement required at sea. However, engaging fishermen in the design of sustainable fishing gear that meets their expectations e.g. BFG, would improve buy in for developing manageable EPR schemes. Financial incentives to support the implementation of EPR would be essential, particularly during the voluntary/experimental phase (IUCN, 2021). We consider the same for BFG use.

Defra committed to reviewing EPR for fishing gear in the 2018 Resources and Waste Strategy for England and in 2019 commissioned a study to address EPR and other policy measures regarding the sustainable management of end of life fishing gear. An EPR scheme focussing on a mandatory EPR with take back was proposed as offering the best benefit/cost measure. The EU Commission Directive on single use plastics and EPR for fishing gear dictates a harmonisation between the implementation of an EPR across all Member States (as well as Iceland, Norway and the UK). This is a particularly important consideration for the development of EPR in the UK fishing industry, as the EU is the main market for UK caught fish (Zych, 2020).

While an EPR scheme for fishing is not a "silver bullet" solution, in

[5] Defined as ICES areas 7d and 7e.

the same way that gear retrieval and BFG are not, there may be considerable potential to incorporate BFG within an EPR scheme – given that some level of gear loss is fisheries is inevitable (e.g. poor weather).

Biodegradability as a design feature for fishing gear is not a new idea (Grimaldo et al., 2020; Wilcox and Hardesty, 2016). BFG has not been considered a key 'circularity aspect' with studies reporting a lack of faith in the concept by fishermen, or reservations around BFG as it is not like-for-like in terms of functionality and cost (Brown et al., 2005; MRAG, 2020; OSPAR, 2020). The fishing industry, however, is one of the main contributors to marine litter through ALDFG, with the European Commission (2018) estimating that 27 % of all marine litter in the EU is fishing waste. As such, urgent action is required to develop a circular economy for fishing gear to address the myriad of environmental impacts.

5. Conclusion

In this paper, we have focused on the ghost fishing impact of ALDFG by developing an economic model to address the cost of ghost fishing to the fishing industry and assess BFG as a management response. For an innovation to be accepted by end users, it must be demonstrated to be technically feasible and economically viable. Our analysis indicates that integrating BFG into commercial fishing is a technical challenge and not necessarily an economic one. We assert this given the various scenarios modelled in our analysis demonstrate that the majority of incentive (to engage fishermen) is needed to offset the decline in fishing efficiency (i.e. technical issue). In other words, the cost of ghost fishing prevented by BFG is not sufficient to offset the economic cost of declined catches from fishermen using BFG.

Conducting a vessel level analysis, we show that in only one scenario could a vessel benefit economically from the use of BFG. In all other scenarios, some level of financial incentive would be required. In some cases, the level of incentive may be prohibitive – especially in the developmental phase of BFG. This is supported by Standal et al. (2020), who show that >90 % of the incentive required to assist fishermen in their decision to invest in BFG is needed to offset revenue from declining catches (and <10 % for investment in the new gear). Similar to Standal et al. (2020), we consider incentives such as increased fishing effort or the deployment of more gear to offset fishing efficiency decline incompatible with sustainable management objectives. For example, there are concerns regarding the increase in static gear use in recent years in the Channel fisheries.

For the most part, our analysis supports the role of BFG in mitigating ghost fishing. Our engagement of stakeholders found that fishermen were more receptive to the role of BFG in mitigating the environmental impacts of ALDFG than previous studies (e.g. Brown et al., 2005; MRAG, 2020; OSPAR, 2020). In some cases, fishermen would be prepared to pay a higher price for BFG given its potential role in sustainable fisheries (helping to offset some of the incentive required for larger vessels where the decline in revenue from BFG use would be higher). However, a common theme was the need for financial assistance to engage in the developmental stage of BFG.

Ultimately, commercial use of BFG in the development phase is essential, so that functionality issues can be identified and addressed. While some studies have identified reduced fishing efficiency (Cerbule et al., 2022a, 2022b; Grimaldo et al., 2019; Grimaldo et al., 2020; Wang et al., 2020), other studies show similar efficiency (Bilkovic et al., 2012; Kim et al., 2016). Nevertheless, issues around fishing efficiency need to be better understood in the Channel static gear fishery to facilitate the successful implementation of BFG and to improve the sustainable management of fishing gear.

CRediT authorship contribution statement

Benjamin M. Drakeford: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Andy Forse:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Pierre Failler:** Supervision, Funding acquisition, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Benjamin Drakeford reports financial support was provided by INTERREG FRANCE-CHANNEL PROGRAMME.

Data availability

The data that has been used is confidential.

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