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Fishers' views and experiences on abandoned, lost or otherwise discarded fishing gear and end-of-life gear in England and France

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1. Introduction

Marine litter is a critical and global transboundary pollution problem with significant impact on the marine environment and coastal communities (Forleo and Romagnoli, 2021; Löhr et al., 2017). There are two pathways through which plastics enter into our oceans: land-based and sea-based sources (Lebreton et al., 2017; Thushari and Senevirathna, 2020).

While most marine litter originates from land-based sources (Chassignet et al., 2021), abandoned, lost and otherwise discarded fishing gear (ALDFG) is internationally recognised as a major sea-based source of litter in marine and coastal areas and a challenge to marine resource management (Do and Armstrong, 2023; Gilman et al., 2021; Scheld et al., 2016; Bilkovic et al., 2016). ALDFG includes all fishing gear, including gear from recreational fishing (e.g. nets, longlines, pots, lines, sinkers, hooks and rods) (Gajanur and Jaafar, 2022; Perroca et al., 2022; Link et al., 2019). Although not classed as ALDFG, fishing may also generate non-gear marine debris from fishing such as fishing gloves, and bait boxes (Gilman et al., 2021). The amount, distribution and impacts of ALDFG have increased in recent decades due to rapid expansion of fishing effort and fishing grounds and the transition to long-lasting and less expensive synthetic materials used to manufacture fishing gear (Gilman et al., 2021; Link et al., 2019; Scheld et al., 2016). A global estimate of the annual input of ALDFG to the marine environment (Macfadyen et al., 2009) is often cited erroneously (Richardson et al., 2021b), but in reality, the amount of ALDFG entering the marine environment globally each year is unknown (Richardson et al., 2022; GESAMP, 2021). The global drivers for the prevalence of ALDFG are numerous; they include adverse weather, gear conflict,[1] poor organisation of waste management, inadequate waste collection facilities for damaged or worn fishing gear to be disposed of, vandalism, theft, lack of awareness of impacts of ALDFG, marine user conflict, insufficient vessel storage, expense of gear disposal, the cost of retrieving lost gear, and illegal, unreported and unregulated fishing (Gallagher et al., 2023; Gilman et al., 2022; Macfadyen et al., 2009).

A variety of measures are available to reduce ALDFG; these can be categorised as preventative (refrain from creating ALDFG), mitigative (reduce the impact of ALDFG) and curative/remediative measures (remove the impact of ALDFG) (Macfadyen et al., 2009; Richardson et al., 2021a). When possible, prevention should be the choice to ensure the problem is tackled at source (GGGI, 2021). Mitigative measures still suffer some impact and tend to be experimental in nature (e.g., biodegradable gear, deterrents to capture) (Murua et al., 2023). Curative measures tend to be expensive (e.g., recovery programs) and happen when the impact has already occurred (Large et al., 2008; GGGI, 2021).

Fishing gear that has become ineffective and is no longer fully operational due to damage or wear and tear is referred to as end-of life (EOL) fishing gear (Stolte et al., 2019). There are many challenges in the recycling and reuse of fishing gear at end-of-life, but mismanagement can result in EOL gear becoming abandoned, lost or discarded in the marine environment (Feary et al., 2020). Financial incentives for returning EOL gear and provision of gear recycling initiatives can motivate fishers on ALDFG prevention (Macfadyen et al., 2009). At present, in the OSPAR Maritime Area, only a small share of fishing gear is recycled at end-of-life due to the difficulty of manually dismantling the different types of plastics used in fishing gear (OSPAR Commission, 2020). Recovered ALDFG is considerably more labour-intensive than EOL fishing gear to be dismantled and cleaned for recycling, as it often becomes entangled with marine life, corals and marine waste (Feary et al., 2020; OSPAR Commission, 2020).

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[1] Gear conflict occurs when a fishing vessel come into contact with another fishing vessel resulting in conflict between different gears and their consequent thus loss or damage (Macfadyen et al., 2009)

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Increased awareness of the harm caused by ALDFG has led to international recognition of the need for concerted efforts to address its manifold transboundary adverse impacts, as well as of the need for greater collaboration and more cost-effective solutions to the management of EOL fishing gear (Gilman et al., 2021; OSPAR Commission, 2020; Feary et al., 2020; GESAMP, 2021; OECD, 2021; Drinkwin, 2022; Giskes et al., 2022). Addressing environmental impacts associated with fishing operations has been recognised as crucial in supporting the achievement of the goals of the 2030 Agenda for Sustainable Development and, in particular, in meeting the Sustainable Development Goals (SDGs) targets 14.1 - significant reduction of marine pollution of all kinds by 2025 - and 14.2 - protect marine and coastal ecosystems (Nino, 2015). More recently, in 2022, the United Nations Member states agreed to start the negotiations for a new global treaty intended to reduce plastic pollution which should include also specific strategies to reduce ALDFG impacts to aquatic ecosystems and wildlife (Vitorino et al., 2022). The European Union adopted, in January 2018, the European strategy for plastics in a circular economy; this recognizes that plastics represent a significant proportion of global marine litter and emphasises the need for investment and innovation in circular economy (CE) solutions (EC, 2018). The strategy contains a commitment to "develop targeted measures for reducing the loss or abandonment of fishing gear at sea" (EC, 2018, p.12).

There is scarce understanding of the total quantities of ALDFG in the ocean and on our coasts, and very little knowledge of fishers' views on and experience with ALDFG, or on fishers' awareness of end-of-life management of fishing gear composed of plastics. To understand the prevalence of ALDFG at a local level it is necessary to understand the local fisheries; what fishing gears are deployed, fishing gear characteristics, vessel characteristics, temporal factors and target species (Gallagher et al., 2023). Furthermore, it is essential to understand fishers' perspectives of the problem of ALDFG and their experience with management of pollution generated by gear, i.e., gear disposal infrastructures and existing recycling channels when attempting to promote behavioural changes, best practices and make recommendations for policymakers.

To the best of our knowledge, no research to date, within the European context, has jointly investigated the issues of ALDFG and management of end-of-life fishing gear. Furthermore, so far no empirical studies have compared the fishing sector views and perspectives on such issues across the Channel, from England to France.

Therefore, in this paper we present and compare new findings that emerged from the INdIGO (INnovative fIshing Gear for Ocean) project (2019–2023), related to: i) characterising the fishing sector in the targeted study areas in France and England along with the amounts of fishing gear plastics pollution on board and lost at sea; ii) exploring views and experiences of the fishing sector across the Channel Area regarding ALDFG; and iii) understanding fishers' knowledge and awareness of management for end-of-life fishing gear.

2. ALDFG and EOL fishing gear in the literature

Previous work has not captured, as far as we know, the perspectives of fishers or fisheries stakeholders both ALDFG and EOL fishing gear simultaneously. While the collection, monitoring, recycling, and reuse of end-of-life fishing gear have been overlooked in observational research (Feary et al., 2020), several observational studies contain information on ALDFG. A summarized table of this review is included in the Supplementary Material. Drivers of ALDFG and various mitigation measures were examined by Richardson et al. (2018 and 2021a) in Australia, Belize, Morocco, Iceland, Indonesia, New Zealand, Peru and the United States. They found that the main causes of gear losses identified by fishers included gear conflict, adverse weather conditions and gear snagging on a bottom obstruction. Adverse weather and gear conflict were raised also by Sri Lankan fishers (Gallagher et al., 2023) and fishers in the Persian Gulf (Haghighatjou et al., 2022) among the key factors determining ALDFG. Additional drivers for ALDFG in the Persian Gulf include strong currents and abandonment, loss and otherwise discarding of fishing pots at the end of the fishing season once they meet their end-of-life (Haghighatjou et al., 2022). Adverse weather was also reported as an ALDFG driver by fishers in South Bahia, Brazil (Barbosa-Filho et al., 2020) and in Kerala, India (Daniel and Thomas, 2023). Most fishers in South Bahia also stated that the most common type of ALDFG they found at sea were nets, and these were mainly nets used to catch lobsters. A study by Richardson et al. (2022) indicated that, on average, about 2 % of fishing gear are lost to the ocean annually, of which 0.8 % are gillnets (km^2), 1.5 % purse seine nets (km^2), 3.6 % trawl nets (km^2), 3.3 % longline mainlines (Km), and 0.7 % pots and traps (million). Haghighatjou et al. (2022) estimated that at the end of the fishing season in the Persian Gulf, no less than 96 % of pots used by fishers are abandoned, lost or otherwise discarded. An assessment of ALDFG in Sri Lanka (Gallagher et al., 2023) revealed that in 2021 over 22,000 kg of plastic fishing gear had been lost, these being mostly gillnets followed by hooks and lines.

In relation to end-of-life fishing gear, findings from informal conversations held during a pilot study in Sri Lanka (Gallagher et al., 2023) show that fishers have different ways of repurposing EOL gear, such as fencing around agricultural fields to protect crops from pest species, protection of television satellite antennas from monkeys, or keeping monkeys away from outdoor seating areas. Research providing insights into EOL fishing gear quantities and management practices is limited to very few publications. In Norway, around 4000 t of fishing gear waste is reportedly collected annually and disposed of, either at port reception facilities or at the nearest waste management facilities (Deshpande et al., 2020b). Over 50 % of the collected waste gear is then recycled, but outside Norway due to the lack of industrial recycling facilities (Deshpande et al., 2020a). Similarly in Taiwan, over 4000 t of fishing gear waste is collected annually (Su et al., 2023); however in spite of there being several companies that can collect and recycle used gear, capacity is nevertheless limited to treat fishing gear when it meet its end of life. Consequently, a considerable amount of fishing gear waste is stored in ports and recycling rates are low compared to Norway (only 36 %: Su et al., 2023). Basurko et al. (2023) estimated that over 1600 t of EOL fishing gear is discarded yearly in Spanish ports. However, a lack of clear and specific guidelines for EOL gears, the absence of facilities and infrastructures for their storage and deposit in port, and difficulties in transporting it from vessels to storing/deposit locations hinder the sustainable management of EOL fishing gear.

3. Materials and methods

Preliminary structured phone interviews were conducted between May and July 2020 among a small sample of commercial fishers in England and France to collect qualitative insights on fishing activity technical aspects and fishing gear management practices. Preliminary interviews were also used to gather feedback from the interviewers on the clarity of questions and terminology used to construct and fine tune the main survey. The main survey was hosted on the Survey Monkey platform and was administered between December 2020 and March 2021. English participants were recruited via telephone by Cefas fisheries observers through the purposive sampling method and responses recorded via the online survey platform. Participants were selected based on observers' network within the fishing industry and the subsequent availability or willingness of contacted fishers to take part in the study. French participants were recruited by the Regional Fisheries Committees (RFC, France) via e-mail, and via phone through the network of contacts with fish professionals of the French project partners. In the case of e-mail recruitment, fishers registered in the RFC fleet databases were sent an e-mail in which they were solicited to take part to the survey. In this instance, respondents answered questions by completing the survey themselves. Should respondents be recruited by phone and choose to take the survey, French partners recorded

participant responses via the online survey software. In addition, the online survey was also advertised through the INdIGO project official social media channels. The non-random nature of the sample selection through purposive sampling and non-probability web surveys is known to have limitations in terms of potential bias (Andrade, 2021; Lehdonvirta et al., 2021).

Consent to participate in the study was obtained from participants prior to completing the survey; all fishers were informed about the INdIGO project and the purpose of the survey as well as confidentiality of responses and voluntariness of their participation. Participants were also provided with an email address to contact in case they had further questions. The geographical area initially targeted for data collection included all regions within the Interreg (Channel/Manche) programme area, i.e. French fishers in the regions Brittany, Normandy and Haut-de-France, and English fishers from the South and East Coasts of England (Fig. 1). However, it was decided to open up the scope of the survey to the national level, in order to compensate for the low response rate in some regions (Fig. 2).

The main survey included both closed-ended and open-ended questions and consisted of four parts (for details about the questions see Supplementary Material). Part one comprised questions about respondents' fishing activity as well as fishing equipment on board and lost at sea. Part two of the survey aimed at increasing knowledge of ALDFG by exploring respondents' views on causes and drivers of ALDFG and investigating their experience and behaviours related to ALDFG. Part three aimed at collecting information regarding the management of end-of-life fishing gear and associated regulations. Finally, part four included sociodemographic questions (age group, gender and professional qualifications) to further characterize the fishers in our sample. The time to complete the survey was typically 25–30 min.

Differences between fishers' responses regarding the drivers of ALDFG were tested using the Wilcoxon-Mann-Whitney test to determine whether responses provided were statistically different between countries. The Chi-Squared ($\chi 2$) test of independence was instead used to compare the distribution of categorical variables across the two countries.

4. Results

4.1. Fishers activity profile

After tidying the raw dataset to remove observations with missing values and incorrect data, the final dataset consisted of 150 responses (Table 1): 103 collected from French fishers (68.7 %) and 47 collected from English fishers (31.3 %). All fishers interviewed were male. Respondents' largest age group was that of 45–54 (34 %), followed by the age group 35–44 (22.7 %). Conversely, the smallest age groups were those of 18–24 (6.7 %) and over-65 (5.3 %). At country level, the age percentages indicate that 30 % of French respondents were between 45 and 54 years old, while just over 40 % of English respondents belonged to the category 45–54. None of the French fishers interviewed were in the oldest age group and none of the English fishers were in the youngest age category.

The most common professional qualification reported by English fishers in the sample was the STCW -Standards of Training, Certification, and Watchkeeping - Basic Safety Training (27.6 % of all respondents), which is mandatory to work on any UK registered commercial fishing vessel; this was followed by respondents with a skipper qualification (21.3 %). One respondent stated to have both the Basic Safety Training and a skipper qualification. A low proportion of respondents (8.5 %) held a fishing deck officer certificate and even a smaller segment of fishers (4.2 %) held an MCA (Maritime and Coastguard Agency) Master 200 certificate.[2] The remaining respondents either stated to not want to answer this question or provided information only related to the highest educational attainment in school. The most common qualification of the French respondents was the qualification to be a fishing master. The majority of French fishers (62 %) held a Master 200 certificate, followed by respondents (26 %) who held a Master 500 certificate.[3] A small share of respondents (3 %) indicated that they had a "CAP Maritime" (Certificat d'Aptitude Professionnelle)[4] followed by holders of a fishing deck officer certificate (2 %).

More than half of respondents in France (62.1 %) and more than three quarters in England (78.7 %) were both owner and skipper of a fishing vessel. Responses concerning the length of the fishing vessel used for their fisheries operations indicated that small scale fisheries (SSF) are dominant in both countries. In England, where SSF refers to the activities of vessels 10 m and under in length (Davies et al., 2018), about 55 % of respondents reported that their fishing vessel is under 10 m. In France, where SSF refers to fishing activities carried out by fishing vessels of an overall length of less than 12 m,[5] 69 % of respondents fish on vessels which are less than 12 m in length. More than half of respondents in both countries - 65 % in France and nearly 62 % in England - are passive fishers (fixed nets, pots and lines). Results indicated that these vessels conduct day trips as opposed to multiday trips.

4.2. Gear owned and estimated to be lost at sea

As shown in Table 2, among 74 fishers in our sample owning passive fishing gear (49.3 %), 47 (31.3 %) provided information on quantities of gear lost at sea yearly. It was estimated that, on average, about 60 creels and pots are lost per year at sea (Column d), which correspond to 8.2 % of the total creels and pots owned by 12.6 % of fishers (Column c) in England and France. Within the net fisheries, an average of 1413 m of gillnets were estimated to be lost annually based upon figures provided by 14.6 % of French and English respondents (Column d). This amount is equal to nearly 10 % of the total amount of gillnet gears owned by 30.6 % (Column c) respondents in our sample. Only French respondents fishing with lines provided information related to quantity owned and lost. Based on responses given by 6 % (Column c) of line fishers, the total length of lines owned amounted to, on average, 2578 m of which an average of 1820 m are lost at sea per year according to the figures provided by 4.6 % (Column d) of respondents.

Based on information provided by 19.3 % of active gear users in the sample regarding the trawl fisheries (Column c), the average number of trawls owned was estimated to be 6.6. Contrary to fishers interviewed using passive gear, a high proportion of fishers using trawls, 89.6 %, did not report any gear loss. Finally, based on responses of one French fisher using only seine nets, we estimated an average 1500 m of seine nets owned (Column c); similarly to trawl fisheries, no annual loss was reported.

[2] A Master 200 certificate allows the holder to be taken on board a vessel of less than 200 gross tons, with a propulsive power of less than 250 kW and going not more than 100 miles from the coast.

[3] A Master 500 certificate allows the holder to be taken on board a ship of less than 500 gross tons and going no further than 200 miles from the coast.

[4] The certificat d'aptitude professionnelle (CAP) is a professional national diploma issued by the Ministry of Education. Holders of the CAP maritime are qualified and versatile seamen, capable of adapting to and participating in the various activities carried out on the deck (and possibly on the machinery) of a fishing or commercial vessel.

[5] Source: EC, 2018 REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the European Maritime and Fisheries Fund and repealing Regulation (EU) No 508/2014 of the European Parliament and of the Council. Available at: resource.html (europa.eu)

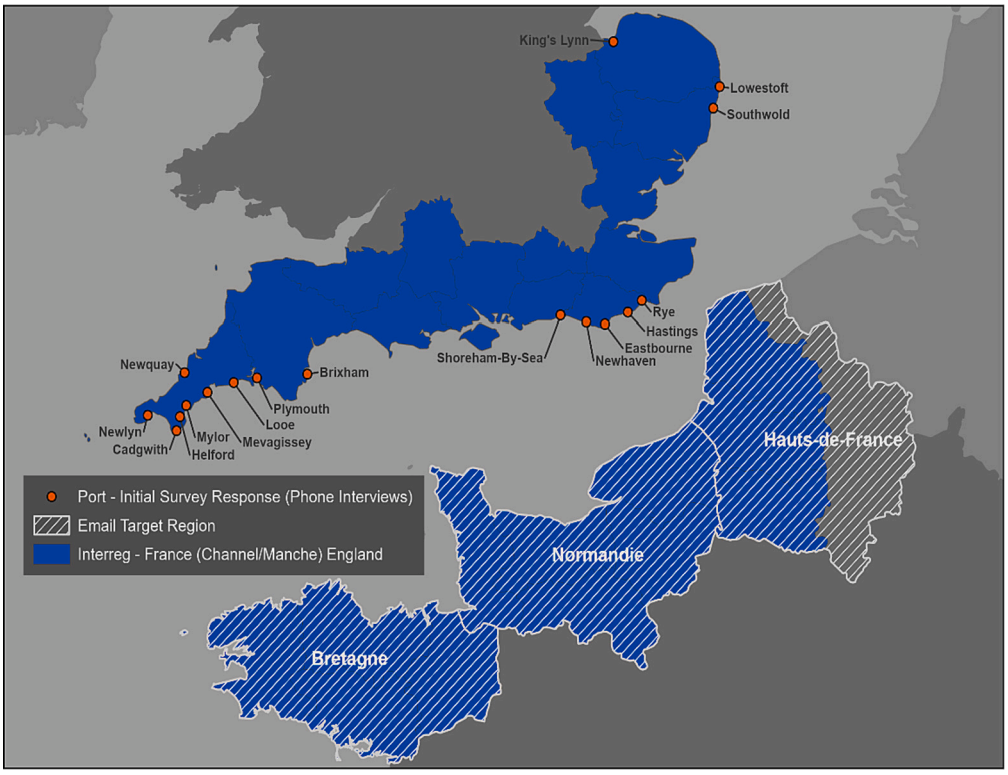

Fig. 1. Areas for the distribution of the survey within the regions covering Interreg programme area.

4.3. Drivers and awareness of ALDFG

Six ALDFG drivers which were identified through project researchers' expert knowledge and which are commonly reported in literature (see Gilman et al., 2022 and Richardson et al., 2021a) were presented to respondents to indicate their level of agreement or disagreement with each ALDFG cause using a 5-point Likert scale.

When examining what respondents in both countries combined perceived as the main causes for ALDFG, it was found that 42 % agreed that adverse weather is a driver of gear loss at sea, followed by 35 % who agreed that lack of awareness on the impacts of ALDFG and training on how this could be reduced are factors contributing to ALDFG. Thirty three percent of fishers agreed that inadequate collection facilities in fishing ports and harbours are a contributing factor, while almost 32 % of respondents viewed discarding as further cause of ALDFG. Conversely, 34.5 % of respondents did not consider the excessive cost of gear retrieval created by ALDFG, followed by 30 % of fishers who disagree about poor organisation of waste management by port services as factor contributing to the ALDFG problem.

At country level (Fig. 3), there were statistically significant differences in perspectives on causes of ALDFG in England and France for four of six items - *Poor organisation of waste management by port services* ($z = 2.025$, $p = 0.0428$, not perceived by both English and French respondents as an ALDFG determinant), *Lack of awareness and training* ($z = 3.007$, $p = 0.0026$, perceived as an ALDFG driver by French fishers), *Deliberate discarding* ($z = 4.338$, $p = 0.0000$, perceived by French fishers as important ALDFG driver) and *Poor weather conditions* ($z = 2.205$, $p = 0.0275$, perceived as important by both French and English respondents).

Specifically, when examining fishers' ratings of statements on these particular potential causes (Fig. 3), it was found that 49 % of English respondents and 31 % of French respondents indicated that they disagreed on attributing responsibilities for ALDFG to how waste is managed by ports and harbours services. About 43 % of English fishers stated their disagreement regarding limited awareness and training as cause of ALDFG as opposed to nearly 30 % of English respondents who think instead that lack of awareness and training are factors having an impact on ALDFG. Conversely, over 35 % of French fishers did agree in considering lack of both awareness and training a cause of ALDFG, followed by 25 % of French respondents who, on the contrary, disagreed on this. Also noticeable, a higher-level disagreement of English respondents, over 40 %, with regards to the item "*deliberate discarding*" in comparison to the nearly 25 % of French respondents who indicated disagreement on the same item as cause of ALDFG. On the contrary, the larger portion of French fishers, 31 %, agreed on intentional discard of fishing gear at sea as cause of ALDFG. There is agreement from both sides of the Channel - 42 % of French respondents and 42.5 % of English respondents, respectively - about poor weather conditions as a factor in gear loss.

The vast majority of French and English respondents, 86 % and 89.4 % respectively, indicated that they do encounter ALDFG at sea. Fishers were then asked what they do when they come across ALDFG at sea. Responses were similar on both the English and the French side of the Channel; seventy French fishers (88.6 %) and thirty-six English fishers (94.7 %) stated that they bring it ashore for disposal. Few English respondents who selected this option, however, provided additional comments clarifying that they bring the gear ashore only if it is safe to do, otherwise "*we throw it back*", or "(we) *will throw it back on the nearest wreck*". Alternatively, if the gear owners are known, fishers will directly inform them– "(I) *may report to the owner, if known*", "(I will) *notify the owner, if known*" – so that these can retrieve the lost gear. Similarly, French respondents who selected the option *"other"* added comments clarifying that ALDFG are removed from the sea whenever possible, meaning that gear retrieval is attempted if it does not jeopardise fishers' safety. On the contrary, some fishers indicated that when gear recovery cannot occur safely, they will *"record the location to communicate it to fellow fishermen"* in the area or *"give the position* (of the gear) *to the CROSS"* (Regional Rescue and Surveillance Centre).

With regards to the frequency of ALDFG encountered at sea by fishers (Fig. 4a), over 65 % of responses provided by English fishers were almost

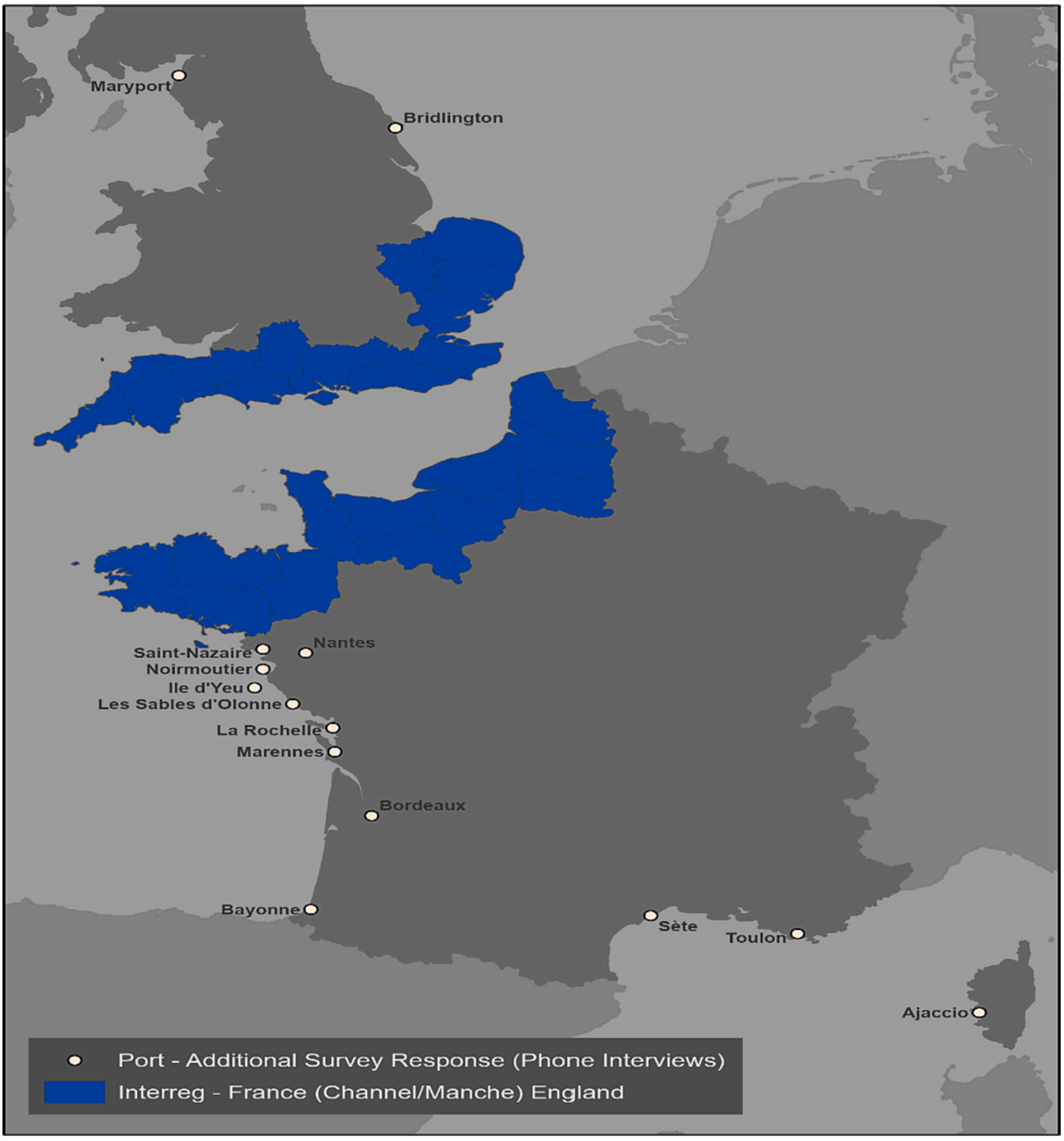

Fig. 2. Areas in France and England from where additional responses were collected.

equally distributed across two options: once a year (35.7 %), and several times per year (31 %). Responses to the same question provided by French fishers, conversely, were more spread out across the options offered. Twenty two percent of French respondents stated to come across ALDFG several times per year, followed closely by 19.8 % of respondents who, on the contrary, said to encounter ALDFG, several times per week and respondents who either reported coming across ALDFG once a month (15.1 %) or several times per month (12.8 %). Moreover, there is a statistically significant association between frequency of ALDFG encounter and respondents' country, χ^2 (6, $N = 128$) = 16.8, $p = 0.010$. In other words, the analysis did show evidence that there is a difference associated with coming across ALDFG and fishers' country.

The answers given to a follow up question (Fig. 4b) emphasised the variation in the types of ALDFG and associated equipment mostly encountered by fishers from both sides of the Channel, with the exception of nets which were the most selected ALDFG type selected by both English (59.6 %) and French (65.1 %). The second most selected ALDFG type by French fishers was ropes (51.5 %), this followed by fishing related waste (e.g., fish or bait boxes) (48.5 %), traps and pots (44.7 %), buoys (34 %), and trawls (32 %) and nets (32 %). On the English side, the second most selected ALDFG type instead was traps and pots (38.3 %) followed by trawls (31.9 %) and ropes (27.7). Contrary to French fishers, only a small percentage of English fishers (8.5 %) come across fishing related waste and buoys.

In response to the last question asking respondents whether they think ALDFG has an impact or costs to their business/activity, just over

Table 1
Fishing activity profile of respondents.

Fishers and activity profile		Total % (*N* = 150)	French % (*N* = 103)	English % (*N* = 47)
Profession	Owner & Skipper	67.3	62.1	78.7
	Owner	3.3	4.9	
	Skipper	14.7	13.6	17.0
	Crewman	9.3	12.6	2.1
	Other	5.3	6.8	2.1
Vessel Length	Less than 7 m	6.0	4.9	8.7
	over 7 m and under 10 m	38.3	35.0	45.7
	over 10 m and under 12 m	28.2	29.1	26.1
	over 12 m and under 15 m	9.4	7.8	13.0
	over 15 m and under 18 m	5.4	5.8	4.4
	over 18 m and under 24 m	4.7	5.8	2.2
	Greater than 24 m	8.1	11.7	0.0
Fishing Trip Length	Less than a day	53.7	57.8	44.7
	Between 1 and 3 days	33.6	26.5	48.9
	Between 3 and 5 days	1.3	1.0	2.1
	Between 5 and 7 days	4.0	3.9	4.3
	More than 7 days	7.4	10.8	0.0
Fishing Gear Type	Active	36.0	35.0	38.3
	Seine nets (SX)	3.3	5.0	0.0
	Scallop Dredge (DRB)	8.7	11.7	2.1
	Pelagic Trawling and purse seining (OTM, PS, RN)	4.0	4.9	2.1
	Otter trawl (OT)	10.0	0.0	31.9
	Bottom otter trawling and pair trawls (OTB, OTT, TB, TBN)	8.7	12.6	0.0
	Beam Trawling (TBB)	0.7	0.0	2.1
	Demersal seine netting (SDN)	0.7	1.0	0.0
	Passive	64.0	65.0	61.7
	Creeling and potting (FPO)	13.3	12.6	14.9
	Gillnets (GN, GNS, GTN, GTR)	36.7	35.0	40.4
	Line fishing (hand and mechanized line and longlining) (LHP, LL, LLS, LTL, LX)	14.0	17.5	6.4

Table 2
Estimates of fishing gear owned and lost by country.

	a. Gear type	b. Unit	c. Average owned (n. respondents)	d. Average lost per year (n. respondents)
	Creels and pots	Number	704 (19)	58 (18)
	Gillnets	m	14,229 (46)	1413 (22)
Passive	Lines*	m	2578 (9)	1820 (7)
Active	Trawls	Number	7 (29)	0
	Seines*	m	1500 (4)	0

* Indicates that responses were provided only by French fishers.

50 % of French respondents said yes, as opposed to the majority of English respondents, just under 60 %, who instead do not believe ALDFG has either negatively impacted their fishing activities or translates in additional costs and/or burdens. Examples provided by English respondents of why and how ALDFG have an impact on fisher's activity were "*Loss of time for fishing due to untangling whelk pots from trawls*", "*Lost time in clearing gear and impacts on fishing efficiency of the gear*", "*Trawl netting get stuck in propeller net at least once a year. If we can't remove them we lose a day or two of fishing and we need to get towed to get back to shore*", "*Reduced fish from local stocks due to ghost fishing*". Comments from French respondents were quite similar, with professionals citing "*loss of time*", "*loss of fishing*", "*loss of money*", "*breakage of equipment*", "*danger of accident*", risks to navigation", "*the additional physical impact of having to haul up an ALDFG*", "*the impact on the resource (ghost fishing), degradation and pollution of the seabed*".

4.4. End of life fishing gear

Fishers' awareness of EOL fishing gear management was investigated by asking them whether they know of any regulation or plan made specifically to manage EOL fishing gear. A great proportion of fishers, both in France (77.8 %) and England (78.7 %) stated that they are not aware of any regulations or plans related to the management of used fishing gear.

Fishers who took part in the survey were then asked to indicate what processes or facilities are available at the fishing landing sites to manage their used fishing gears when they reach end of life. Respondents were allowed to select from a list of multiple options presented. More than half of English (55.3 %) and French (56.3 %) fishers indicated that there are bins for general waste on site available for them to dispose of their used fishing gears (Fig. 3). The second most selected option by French fishers was "*Containers reserved for fishing gear*" (34 %), followed by "*Informal or Dedicated disposal area*" (27 %). The latter option was selected by almost 30 % of English respondents. Lifting equipment (cranes) was selected by just over 25 % of French respondents while, in contrast, almost twice as many English respondents (49 %) selected the same option (Fig. 5).

Based on additional information provided by fishers, the harbour of Newlyn (Cornwall) provides special sacks for fishers to dispose of their EOL nets and ropes (Fig. 6). These are then sent for recycling to the company Fishy Filaments[6] which turns old plastic fishing gear into filaments used for 3D-printing. Another popular initiative mentioned by English respondents is called Fishing For Litter (FFL),[7] developed by KIMO (Local Authorities International Environmental Organisation) in 2004 (Wyles et al., 2019). FFL is an example of a clean-up project aimed to remove ALDFG from the marine environment. The FFL scheme provides fishers volunteering to participate with bags to store any litter, including ALDFG, entangled in their nets while these are operating at sea (Fig. 6). Once the bags are full, they are moved to designated FFL skips and unloaded. Litter in the skips is either recycled or disposed of on land (Wyles et al., 2019). The FFL initiative has been endorsed by the Regional Seas Convention for the North-East Atlantic (OSPAR) and has been launched across multiple other countries (Belgium, Germany, Ireland, Netherlands, and Italy). In the UK, the project in the South West of England relevant to this study area was established in 2009 and currently, there are twelve participating ports and 150 vessels taking part to the scheme.[8] In France, initiatives aimed at promoting the management and valorisation of EOL fishing gear have been in place for several years at regional level (Fig. 7). In Brittany, for example, the company Fil&Fab[9] developed the first recycling network for old fishing nets which, once collected are sorted, cleaned and crushed into nylon granules ready for being reused and transformed into new plastic products. Drawing on additional information provided by some fishers in our sample it appears, however, that facilities dedicated to the collection of used fishing gear in their ports are not sufficient or not existent at all. One respondent, for example, stated to bring used fishing gear directly to the recycling center using his own vehicle; another one claimed that in Fécamp "*they are very poorly equipped for organising fishing gear collection*", which was backed up by another respondent who said "Nothing *is planned for used gear*".

[6] Source: Fishy Filaments® – Industrial Grade Printer Filament
[7] Source: https://fishingforlitter.org/
[8] Source: Fishing for Litter — South West England
[9] Source: https://www.fil-et-fab.fr/

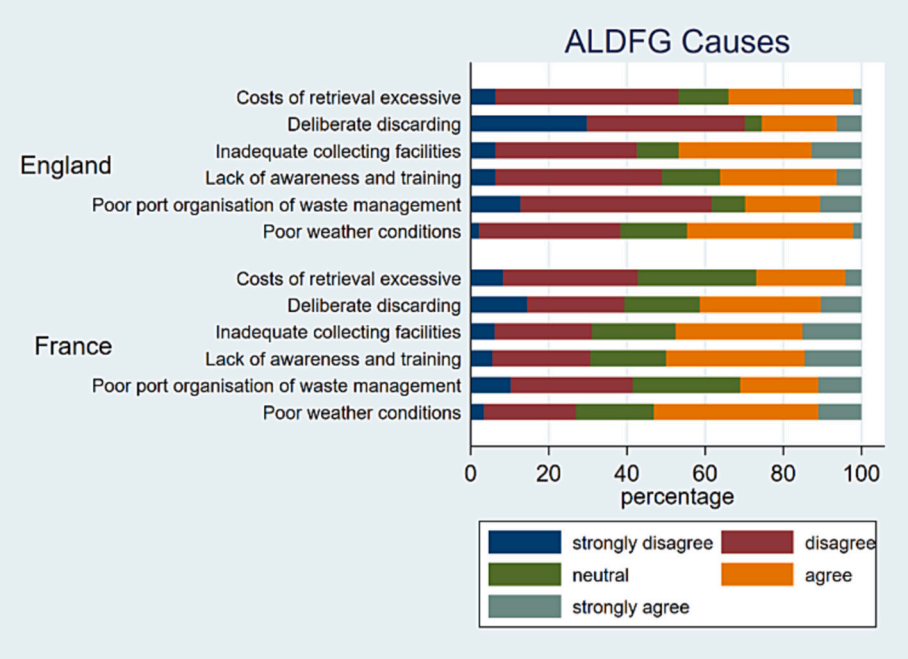

Fig. 3. Rating of different ALDFG causes by country.

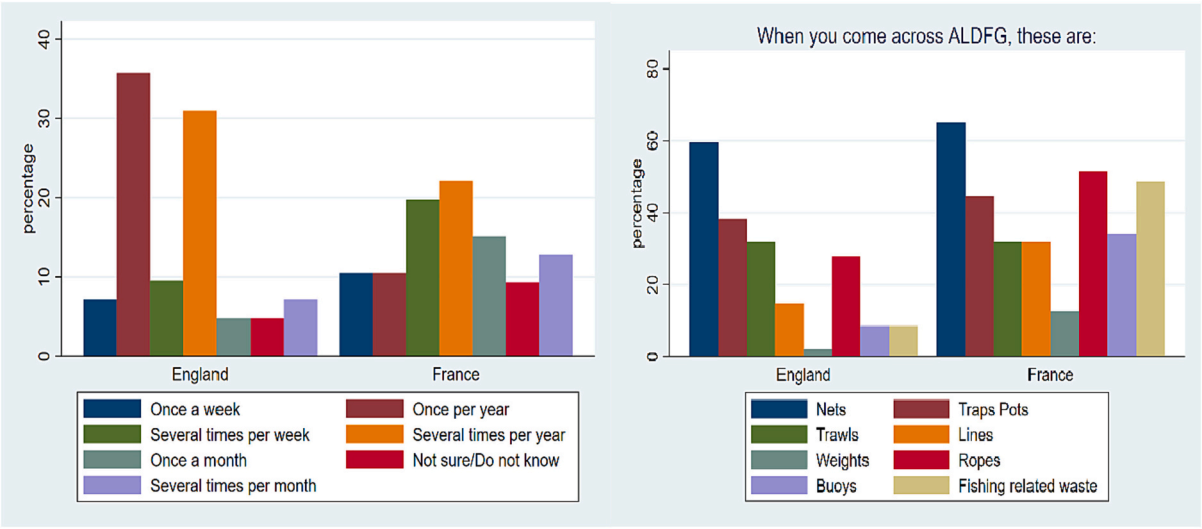

Fig. 4. a. ALDFG frequency of encounter by country.
b. ALDFG most encountered type by country.

5. Discussion

Recognition of the importance of addressing transboundary harmful impacts of ALDFG as well as the need for sustainable management of EOL fishing gear to prevent the generation of fishing-related marine litter have gained attention internationally (Basurko et al., 2023; Drinkwin, 2022; Gilman et al., 2021). There is limited understanding, however, of the contribution of ALDFG to marine and coastal pollution (Richardson et al., 2019; Drinkwin, 2022) and research tends to be conducted on a national or regional basis and, as such, it cannot be generalised to the global situation; however, does provide useful insight on the local level (Gallagher et al., 2023; GESAMP, 2021).

No study, to the best of our knowledge, has yet been conducted within the European context combining information regarding fishers' experience, views and awareness of issues surrounding fishing gear management at EOL, and also the gear which ends up abandoned, lost or otherwise discarded in the marine environment (as ALDFG). Therefore, with this work our objective was to broaden the current knowledge about the contribution of the commercial fishing sector to marine litter by capturing and incorporating fishers' perspectives and insights on ALDFG and EOL fishing gear management, looking specifically at the Channel area.

5.1. Fishing activity and gear losses

All respondents who agreed to take part in our survey were male fishers predominantly within the 45–54 age range. Absence of female respondents is not surprising; at European level (as well as globally), women's participation in the fisheries workforce is scarcely documented, despite they contribute to a wide range of roles and tasks, due to lack of

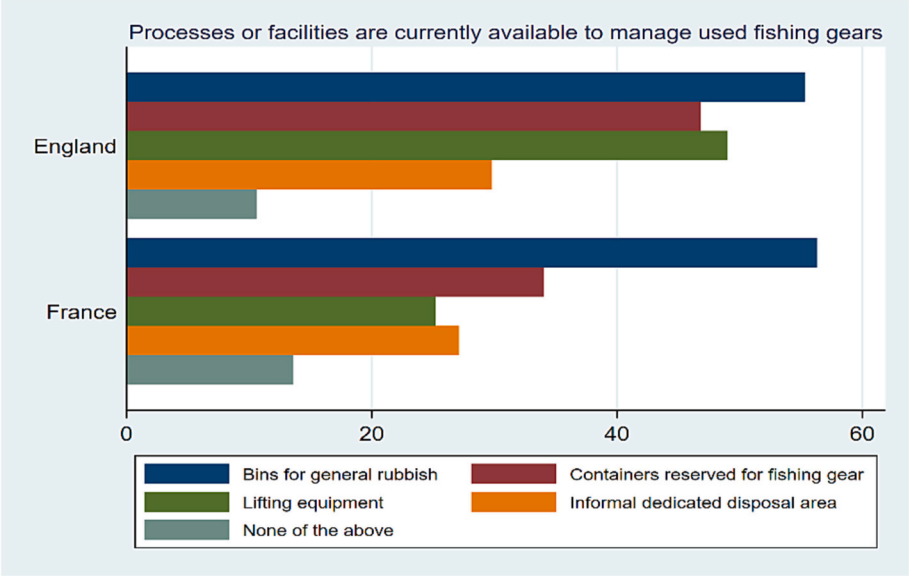

Fig. 5. EOL fishing gear management by country.

Fig. 6. Dumpy bags for collection of EOL fishing gear at Newlyn harbour (Cornwall) (A and B). Fishing for Litter (FFL) dumpy bag (C) and FFL bags containing waste caught at sea by fishers during fishing activities (D and E).

accurate statistics and the perception that the fisheries sector is a male-dominated industry (Frangoudes, 2013). Fishers primarily engaged in small-scale fisheries which is expected since small-scale fisheries in Europe play a crucial social and economic role (Natale et al., 2015). In the UK, small-scale enterprises make up nearly 80 % of the fishing fleet (Symes et al., 2020).

In our specific sample of fishers using active gear (e.g. towed gears such as trawls and seine nets), no gear was reported to be lost at sea. As suggested by Richardson et al. (2019) active gears are less likely to be lost than passive gears. Fishing gears attached to the vessel are constantly monitored; if an accidental loss occurs then the position of loss will be known, and a recovery can be attempted immediately. The considerable value of active gear will ensure that every effort will be made to attempt recovery. Moreover, improvements in navigation and gear marking technologies and requirements should facilitate the identification of the gear's owner (Macfadyen et al., 2009; GGGI, 2021). It must be noted, however, that our survey question on gear loss did not contain an explicit follow up question to establish whether loss concerned the whole gear, as opposed to partial gear loss or loss of gear fragments which may occur, for instance, when trawl nets contact the seafloor as reported in Richardson et al. (2021b). Due to the lack of consensus on specific metrics or units of measure to be used to quantify gear loss, it was decided at survey development stage to leave to the respondents - through the use of an open question - the choice of metrics/units to use to provide information on annual gear loss, according to the gear type used to catch fish. Based on the information given by respondents it can be assumed that fishers' interpretation of the question only referred to the loss of the whole gear. Therefore, a lesson learned for future research will be to 1) include in the survey a range of metrics or units of measure that respondents can select to report gear loss, and 2)

Fig. 7. Example of collection facilities for EOL fishing gear in Normandy fishing ports.

distinguish between whole and partial gear loss (including loss of fragments) in reference to active gears.

Similar to findings of other research (see Gallagher et al., 2023; Richardson et al., 2022), our study revealed that lost gears are mostly confined to passive gears such as gillnets, longlines, pots and traps. According to Drinkwin (2022) and Richardson et al. (2019), gear that is not actively managed or attended by fishers has higher potential to be lost. Passive gears moreover tend to be less expensive to replace than active gears, implying that there is less incentive for attempting recovery if lost.

5.2. ALDFG causes, frequency, types and impacts

Fisher interviews indicated that causes of ALDFG arise from poor weather, lack of awareness of the impact of ALDFG as well as a lack of training on how ALDFG could be retrieved/reduced. Our findings are consistent with evidence reported in literature (see for example Gallagher et al., 2023; Goodman et al., 2019; Richardson et al., 2018, 2019 and Santos et al., 2003). As pointed out by Wootton et al. (2022) limited awareness of the threat represented by plastic pollution may be overshadowed by other concerns such as declining fishing stocks. Awareness of the risks posed plastics to our oceans - or lack of - may be also influenced by media usage (e.g. newspapers, social media, television, internet) and targeted campaigns and projects (Abalansa et al., 2020; Henderson and Green, 2020). Conversely, neither the high cost of gear retrieval, nor lack of waste management facilities or services in ports and harbours for end-of-life gear were seen by fishers as determinants of ALDFG in this study.

There were significant differences in responses across the two countries regarding causes for ALDFG. While overall lack of awareness and training were identified as an ALDFG determinant, at country level most of English fishers did not perceive this as a major factor in ALDFG as opposed to the larger proportion of French fishers who instead did agree that scarce crew awareness of the issue and training to reduce, detect and remove ALDFG are factors influencing ALDFG incidences. Compared to French fishers, nearly twice as many English fishers disagreed that deliberate discarding of fishing gear is an ALDFG driver. Similarly, there is greater disagreement among English respondents compared to French respondents in attributing responsibilities for ALDFG to ports and harbours management given the lack of disposal facilities for fishing gear at end of life.

Most of the surveyed fishers stated that they had encountered ALDFG at sea. This contrasts with Savels et al. (2022) who found that only 20 % of fishers interviewed in their study had encountered and interacted with ALDFG at sea. Upon encountering ALDFG, both English and French fishers stated to retrieve it and bring it ashore for disposal, provided there are no safety risks. In case it is not possible to safely retrieve the gear, its location may be communicated to the competent authority or directly to fishing gear owners (if identified) so that they can retrieve their gear.

There is a relationship between frequency of ALDFG encounter and respondents' country which shows that English fishers infrequently come across ALDFG when they are at sea (once or few times per year), while French responses indicate they encounter ALDFG more frequently, ranging from several times per year to several times per week. Nets were the ALDFG type predominantly encountered at sea across the Channel, which mirrors the findings of a review on ALDFG in Brazil (Link et al., 2019) and also those of a beach litter survey carried out in Kerala (Daniel and Thomas, 2023). Trawl gear and traps and pots have been identified by English fishers as other fishing gear types also likely to be encountered, whereas on the French side of the Channel fishers mostly come across other ALDFG types which include ropes and fishing gear related waste. The latest OSPAR assessments for seafloor litter monitoring in the North-East Atlantic support this finding also. Fishing net was indeed the 7th most prevalent item collected during surveys in the North Sea, while synthetic rope, monofilament fishing line and fishline (tangled) were more frequently encountered (Barry et al., 2023). For the beach litter assessment, nets and tangled nets were the 11th most prevalent item, but string and cord and rope which also could be relating to fisheries were higher in number (Lacroix et al., 2023). It is recommended that definitions and types of ALDFG should be better defined and agreed to enable better comparison between data and wider understanding of types of fisheries related litter.

With regards to the economic consequences arising from encounters with ALDFG, fishers reported that there are a variety of costs and burdens they incur due to ALDFG, such as lost fishing time due to the time taken to clear nets and fouled propellers as well as time lost to clean or repair fishing equipment. Broader impacts beyond costs reported by fishers span from navigational safety to potential impacts on benthic environments. These results substantiate previous findings in the literature (see Macfadyen et al., 2009; Gilman et al., 2021; Richardson et al., 2021b; Gallagher et al., 2023 and Rodolfich et al., 2023).

5.3. EOL fishing gear management and disposal

It appears that fishers on both sides of the Channel have insufficient awareness about management measures or regulations for EOL fishing gear at ports and harbours, indicating that the creation or improvement of waste collection facilities is needed and, in general, the need to boost a circular management scheme of EOL fishing gear (Basurko et al., 2023). In both France and England, existing port facilities available to dispose of either used gear or gear retrieved at sea are mostly general waste bins; thus EOL fishing gear is likely to end up in landfill (Chambers et al., 2021) or is incinerated instead of being reused, repurposed or recycled. Our findings support similar research in this area carried out in Spain where a considerable fraction of the EOL fishing gears is landfilled (Basurko et al., 2023). On the contrary, half of the fishing gear waste collected in Norway is recycled (Deshpande et al., 2020a).

5.4. Limitations

It is plausible that a number of limitations may have influenced the results obtained here. The purposive sampling method used may have led to greater participation from individuals who were more aware and/or concerned about ALDFG and EOL fishing gear than were non-participants. In addition, some bias is pertinent to the selection of the survey participants which was guided by fisheries observers and researchers' direct knowledge of and closer links to the population (fishers) to be interviewed. As in Gallagher et al. (2023), the clarity of interviewers when asking the questions and recording the answers, as well as the understanding of respondents in providing truthful and unbiased answers may have impacted the results. Unfortunately, it was not always possible to make direct comparisons between fishing gear owned or lost since the information provided by fishers was in several different measurement units (e.g., number of pots, or metres of gillnets), often also concerning the same gear type (e.g., number of trawls versus metres of trawls). Lack of consistent measurement units in studies reporting on ALDFG was identified as a significant challenge by Gilman (2015) and Richardson et al. (2021b). These limitations require a refinement of the sampling strategy in order for results to be generalised as well as an improvement of some survey questions to enable the research to be fully replicable and comparable with other studies.

6. Conclusions and the way forward

Fishing gear comprises a considerable portion of the sea-based sources of marine litter polluting the world's seas and coastlines, thus being a threat to marine wildlife and habitats. The present study attempted to enhance understanding of the gear loss, discard and abandonment issue from the capture fisheries sector's perspective and experience in the Channel area by engaging and incorporating fishers' perspectives. Understanding why and how gear is lost, abandoned or discarded can inform our decisions on the best management solutions including those at end of life. It is imperative to investigate sustainable strategies to reduce and effectively manage waste generated from all fishing gear. Our findings add as well to a research topic which is gaining traction, that is ALDFG and end-of-life fishing gear management.

In our view, ALDFG could be reduced through more initiatives developed specifically for vessel owners and crews that include awareness raising on the issues of fishing gear as a source of marine pollution and the associated impacts on marine ecosystems. Capacity-building plans and activities for fishers focusing on EOL fishing gear sorting, separating different materials, appropriate disposal, recyclability and reuse of EOL fishing gear, would also be beneficial.

Furthermore, based on our research on collecting and recycling activities for fishing gear in fishing harbours in the Channel area, we also recommend some context specific measures, including:

i) anticipating peaks in EOL fishing gear flows and optimising the organisation of its collection through knowledge sharing between harbours staff and fishers on the fleets and their fishing calendar (fishing and gear renewal periods),
ii) having collection points as close as possible to the landing sites and/or in areas dedicated to the setting up and repair of fishing gear,
iii) providing simple visual instructions for more selective collection at source,
iv) having sufficient and trained staff in harbours to monitor and support collection on a daily basis and correct errors in dismantling or sorting, and
v) promoting or strengthening collaboration with neighbouring harbours to share facilities or co-ordinate collections.

This work has also emphasised the need for harmonised data collection guidelines for fishing gear monitoring, which include standardized units for ALDFG and EOL fishing gear rates which would facilitate cross-country comparisons. Finally, international coordination and collaboration will ensure a consistent approach to prevent pollution from fishing gears and approaches to the collection and recycling of fishing gear at the end of its life across regions and at the national level. The dedicated EU strategy on circular economy reinforces the need for collaboration between different stakeholders such as academia, the fishing industry and the wider public and private sector (e.g. waste collectors, gear manufacturers and recyclers) to tackle the marine plastic issue and create sustainable solutions for the management of end-of-life fishing gear.

Authors contribution

Elena Mengo, Peter Randall and Adil Bakir conceived this work. Elena Mengo Peter Randall and Solveig Larsonneur planned the data collection and compiled the data. Elena Mengo analysed the data with support from Gaetano Grilli. Elena Mengo drafted the initial manuscript, with edits and input from Peter Randall, Solveig Larsonneur, Gaetano Grilli, Josie Russell, Amanda Burton, Laurence Hegron and Adil Bakir.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2023.115372.

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