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NetTag - "Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries"		

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Table of Contents

Acronyms	3
Executive Summary	4
1. Introduction	5
2. Methodology	6
3. Results & Discussion.....	9
3.1. Fishing industry.....	10
3.3. Fishing gear collecting and recycling companies.....	17
3.4. Researchers.....	17
3.5. Governmental authorities	18
4. Conclusion.....	19
5. References	20
Acknowledgments	21
Appendices	22
Appendix I: Interview script for fishers	22
Appendix II: Interview script for fishing gears manufacturers	24
Appendix III: Interview script for a recycling company	26
Appendix IV: Interview script for researchers	27
Appendix V: Interview script for government authorities.....	29

Acronyms

ALDFG	Abandoned, lost or otherwise discarded fishing gears
EU	European Union
GPS	Global Position System
HDPE	High-density polyethylene
NM	Nautical Miles
PA	Polyamide/nylon
PE	Polyethylene
PLA	Polylactic acid
PP	Polypropylene
ROV	Remotely Operated Vehicle
WP	Work Package

Executive Summary

Marine litter poses a profound threat to the well-being of marine life. The aim of Work Package 2 (WP2) is to assess marine litter problems, as perceived by fishers and other stakeholders, possible mitigation measures and how to implement a detection and recovery systems. More specifically WP2 aims to identify and assess: (1) which fishing gears are lost, when, how and under what conditions, and the measures taken to prevent the loss of gear; (2) what type and how much garbage is produced by fishers during a normal fishing trip; (3) how does litter interfere with the on board fishing activity, and what is the economic loss due to lost gears and the time spent trying to recover lost gear; (4) fishers perception about marine litter, garbage produced on board, and the problems it causes to the fishing operation (time wasted, damage to gear, etc.); and (5) fishers' willingness to use a detection and recovery systems for fishing gears, to be developed as part of the project.

In order to identify the magnitude of the problem, semi-structured interviews were conducted with key players in the fishing industry, such as representatives of fishing associations, fishing gears producers, fishing nets waste collecting company, net monitoring system company, governmental authorities and researchers with expertise in the topic of Abandoned, lost or otherwise discarded fishing gears (ALDFG), in NW Portugal and Galicia. This report summarises findings from the interviews carried out as part of WP2 and addresses the most frequently lost gears and their hotspots off NW Iberian Peninsula.

Fishers usually lose part of the gear, and they try to retrieve it only when the process is operationally feasible and economically viable. Octopus plastic pots and small pieces of net seem to be the gear that is lost more frequently, and the main reasons to lose this gear are rocky bottoms and weather conditions. Fishers can lose up to three days looking for lost gear. Besides the financial costs of losing gear, there are also costs associated with retrieving lost gear, which includes: fishing time, rest time and fuel.

In Portugal and Galicia, hotspots for ALDFG are areas located near the coast, up to 5 nautical miles (NM). ALDFG has an impact on all fishing activities, damaging the gear and sometimes destroying the catch, especially the catches of trawlers. Another problem referred is the fact that lost gears can also affect the security and navigability of fishing vessels.

Fishers tend to throw old gear to the sea or to the garbage bin. Not all fishers seem to be aware that they could receive from 150€ to 400€ per tonne of net from recycling companies.

1. Introduction

The fishing industry is a major contributor to marine litter, with over 45% of plastic debris biomass found in the ocean being associated to abandoned, lost or otherwise discarded fishing gears (ALDFG) (Lebreton *et al.*, 2018). At least 20% of the European fishing gears are lost or discarded at sea which was estimated to represent 640 000 tonnes/year, around a decade ago (Macfadyen *et al.*, 2009).

ALDFG are one of the major issues for fisheries and marine conservation, its presence in marine ecosystems can have a significant impact on the commercial fishing and shellfish industry, leading to ghost fishing, stock depletion, the capture of non-target species, conservation concerns and hazards to other vessels (Lusher *et al.*, 2017). To add to this, the potential impact of microplastic fibres resulting from fishing ropes and nets (fragments of nylon, polyethylene, polypropylene, polyamide, and/or knotted polyester) on marine life is also a big concern (Murray & Cowie, 2011; Ramos *et al.*, 2012; Rodríguez *et al.*, 2012).

Fishing gears presents a growing waste management challenge and when managed poorly contributes to the accumulation of waste plastics in the marine environment and pollution (Charter *et al.*, 2018). As most fishing nets are manufactured with petroleum-based, non-biodegradable materials (Oxvig & Hansen, 2007; Bertelsen, 2016).

Different management measures are needed to address ALDFG. Lost or abandoned gear can continue fishing for years, the so-called “ghost fishing”, which can have disturbing effects on fish stocks. It is difficult to access the costs associated with this problematic, as it varies from fishery to fishery (NOAA, 2015). It’s been described that over 90% of the species caught with ALDFG are of commercial value, which represents a substantial loss of income for fishers (Al-Masroori *et al.*, 2004).

In the European Union (EU), Council Regulation (EC) No 1224/2009 stipulates the rules for the retrieval of lost gear, obliging the skipper of the vessel that has lost gear or part of it to attempt to retrieve it as soon as possible. The Regulation also stipulates what needs to be done in case the lost gear could not be retrieved; requiring the skipper of the vessel to inform the national competent authorities within 24 hours providing information about the type of lost gear, the time when the gear was lost, the position where the gear was lost, and the measures undertaken to retrieve the gear (EU, 2019).

Still, the extent and location of ALDFG around the world are unknown (Drinkwin, 2017). Experience shows that most countries have major problems with identifying hot spots for ALDFG and may need considerable resources for mapping these hotspots (CNO, 2019).

The main aim of this project is to reduce and prevent marine litter derived from fisheries, one way to do this is by raising awareness amongst fishers to the disposal of unwanted gear, measures to take to recover gear in case it gets lost, and measures to take when they find lost gear. This report aims to identify the most frequently lost gears and their hotspots off the NW Iberian Peninsula coast.

2. Methodology

A survey was developed to gauge fishers and other stakeholder opinions about lost gears, measures taken to recover lost gear, costs of losing and recovering lost, and hotspots for lost gear, as well as the problematics of marine litter, mitigation measures to avoid losing gear, domestic litter, etc. The survey consisted of semi-structured interviews to be carried out face-to-face (or skype interviews when face-to-face was not possible), from March to June 2019 in the northwest of Portugal and Galicia (Spain). Figure 1 shows the location of the study site.

The semi-structured interviews were carried out with stakeholders employed in (i) the fishing industry (fishers, representatives of fishing associations), (ii) fishing net producers, recycling company, fishing gears makers (net monitoring systems), (iii) researchers and (iv) governmental authorities.

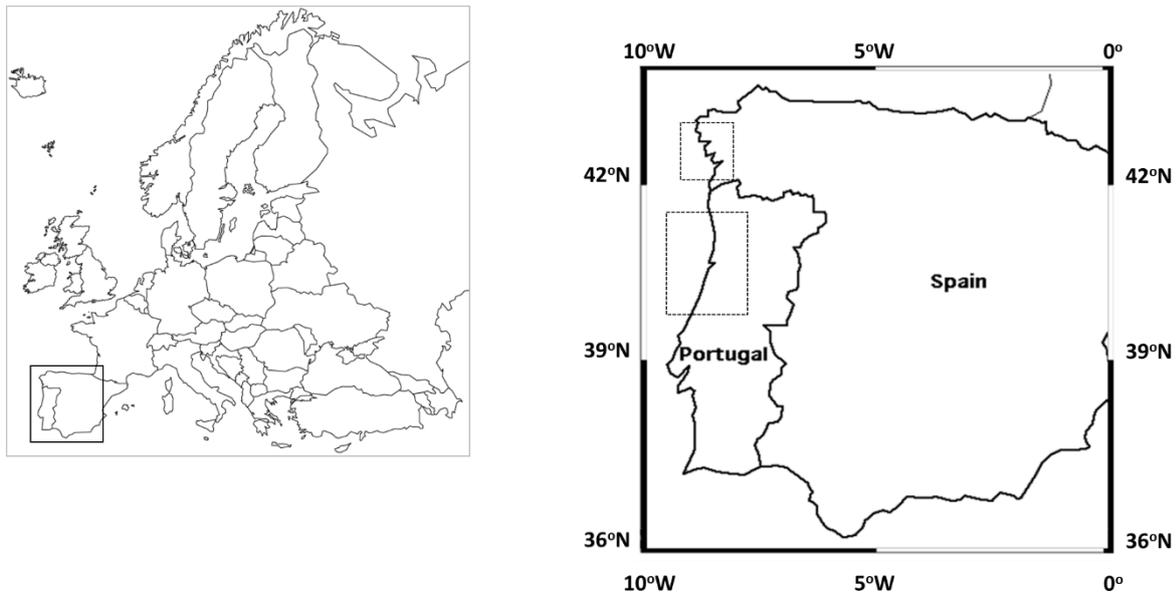


Figure 1. Location of the interview sites.

The list of questions in the interview was adjusted to each group of interviewees and, as such, slightly different for the diverse groups. The interviews with fishers were all carried out face-to-face (Figure 2) and consisted of a list of questions with the aim to collect information on fishers' personal experience. The questions were designed to address four main themes: identification of gear most frequently used and characteristics of such gear; identification of gear lost; measures to retrieve lost gear; waste produced on board; and, willingness to accept the use of acoustic tags for lost gear retrieval (appendix I). Respondents were also asked about their personal experience at sea, job characteristics, target species, and fishing grounds. The questions were developed based on relevant literature and information previously collected from meetings with key experts. The diversity of the fisheries sector was considered while designing the questions and deciding who to interview, and an effort was made to interview both owners of vessels, skippers and crew members of the fishing vessels.



Figure 2. Fishers interviews in Aveiro fishing port.

The interviews with fishing net producers, gear makers, and gear recycling companies were adapted and focused on their respective activities, as such the interviews were slightly different for each group. The interview with researchers focused on specialists in marine litter and microplastics, ecological and economic impacts of marine litter on beaches and coastal waters, floating debris in continental offshore waters and the impacts of marine litter on marine fauna. The interview with the government authorities focused on issues regarding the port management and how they deal with the issue of marine litter in the port. For the past 3 years, in some fishing ports along the Portuguese coast, a project called “Fisheries for a litter-free sea” (Free Translation of “*Pesca por um mar sem lixo*”) has been in place, that aims to improve waste management on board and at fishing ports. It also raises fishers’ awareness to the importance of using good environmental practices on board (Figure 3a and 3b), and some questions were asked about this project to governmental authorities and researchers involved in the project.

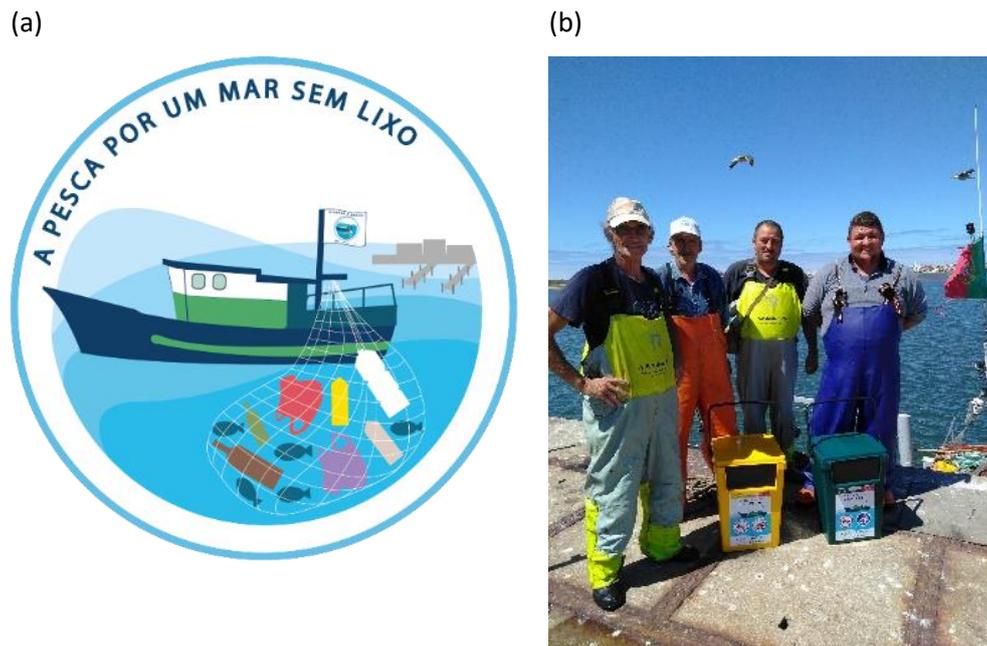


Figure 3. (a) “Fisheries for a litter-free sea” Project logo, and (b) fishers who take part in the project.

All questions were left open-ended in order to gather as much information as possible. The open-ended interview method was chosen as it contributes more information for an exploratory approach, by drawing from participants themselves, their perspectives on the topics in analysis, revealing causal factors that the researchers could not have elicited through a more closed data collection involving quantitative methods (Barclay *et al.*, 2017).

The list of questions used in all the interviews is available in appendices I to V.

3. Results & Discussion

A total of 46 stakeholders were interviewed, covering different expertise. The categories of stakeholders and the numbers of interviews are presented in Table 1. Most stakeholders’ interviews were directly engaged in fishing (37) as we wanted to collect first-hand knowledge on the most frequently lost gears and their hotspots.

The results will be shown separately for the fishing industry and other stakeholders.

Table 1. List of stakeholders interviewed.

	Number of interviews
Fishers	37
Fishing gears producer/makers	3
Fishing gears recycling companies	1
Government authorities	2
Researchers	3
Total	46

3.1. Fishing industry

The survey collected information from 17 individuals from the North of Portugal (from Peniche to Viana do Castelo) and 20 from Galicia (Spain). The length of the interviews ranged from 25 to 60 minutes. Table 2 provides information on the number of fishers interviewed per fishing gears category. Artisanal fishers included fishers with multi-gear or polyvalent fishing licenses (trammel nets, gill nets, longlines, dredges, and traps). Fishers interviewed include the owners of boats, skippers or crew members. Most fishers interviewed were boat owners (59% in Portugal, 70% in Spain).

Table 2. Number of fishers interviewed and their job at sea, per fishing gears.

		Gear Type					
	Country	Longline	Artisanal	Dredge	Trawler	Purse seiner	Total
No. interviews	Portugal	2	6	2	5	2	17
	Spain	1	8	1	7	3	20
Role of the interviewed	Portugal	1 Skipper	6 Owners	2 Owners	2 Skippers	2 Owners	17
		1 Crew	-	-	3 Crew	-	
	Spain	1 Owner	7 Owners	1 Owner	3 Owners	2 Owners	20
		-	1 crew	-	4 Crew	1 Crew	

Source: own elaboration from the results of the interviews.

Table 3 shows the main characteristics of the gear used by the interviewed fishers in the North West of Portugal and Galicia (Spain).

Table 3. Characterization of the gear used.

	Northwest of Portugal	Galicia - Spain
Gear prices & lifespan	Purse-seines cost 100,000€, last for 5 years.	Purse-seines cost 30,000€-100,000€, €, last from 2-5 years.
	Trawler nets & hardware cost 15,000€, last for 1 year. Trawler doors cost 6,000€.	Trawler nets cost 6,000€-50,000€, last for 6 years.
	Dredge “ <i>ganchorra</i> ” costs 1,000€ + 1,000€ for the hardware, lasts for 1 year.	Dredge “ <i>raño</i> ” cost 150€/7years.
	Surface Longlines cost 10,000€, last for 2 years.	-
	Aluminium Traps cost 30€, last for 15-20 years	-
	Iron traps cost less than 20€, lasts for 1 year.	Traps cost 20€.
	Trammel net cost 30€/net + 20€/cables, last for 6 months.	Trammel net cost 100€-75,000€, last for 2-4 months.
	Gillnet cost 20€ each panel (“ <i>pano</i> ”) + 20€ hardware, 1 set can have 50 panels, lasts for 6 months.	Gillnet cost 1,500€, last for 20 years.
Octopus plastic pot cost 1€, 1 set of pots has 100-300 pots, last for 10 years.	-	
Gear material	Fishing nets are made of polyethylene, nylon (polyamide) or polyester.	Fishing nets are made of polyethylene, nylon or polyester.
	Pots include iron, aluminium, and plastic.	Purse-seines, trawlers and artisanal nets have monofilaments.
	The dredge is made of iron and stainless steel.	
	Surface longlines have monofilaments.	
	Bottom longlines are made of polyethylene.	

Source: own elaboration from the results of the interviews.

The same gear has a wide range of prices in both countries possibly because the fisheries are slightly different. The most expensive gears are the trawling nets (up to 50,000€) and purse-seine nets in Spain (up to 100,000€). While artisanal gears are cheaper, for instance one octopus plastic pot costs 1€ in Portugal.

The lifespan of the gear depends on its material and locations of the fishing. A purse-seine net lasts on average 5 years, while trammel nets or gill-nets only last a few months (2-6 months). The hardware always lasts more than the nets or traps. The main materials used in fishing gears are polyethylene, nylon (also known as polyamide), polyester, iron, and aluminium. As identified in several publications, these fishing gears are made with materials that have a slow decomposition rate, lasting for decades at sea (MOTE, 1993, OSPAR, 2007; Iñiguez *et al.*, 2016; Lusher *et al.*, 2017).

3.1.1. Losing and recovering fishing gears

Table 4 presents the main results of fishing gear loss. Fishers can work for years without losing the entire fishing gears, they tend to lose pieces of it instead. Many fishers in Portugal complain about octopus plastic pots (“*alcatruzes*”), identifying this gear as a big problem, with lots of pots

lost at sea. Fishers say that “*Artisanal fishers have licences for up to 3000 pots depending on the size of the boat*” but admit to use many more, with one fisher saying “*they have 10 times more (than 3000 per vessel) at sea (...) when they lose a few pots, they won’t look for them, because they are cheap, only 1€ each*”.

Fishers found it hard to identify hotspots of ALDFG because as they report “*it’s everywhere*”, and many fishers interviewed ask authorities to carry out more inspections of illegal fishing gear. A problem referred by some Portuguese fishers is that artisanal fishers occupy many fishing grounds between 6NM and 12NM from the coast, that are now full of pots, traps, gillnets and trammel nets on purpose to deter trawling in these areas. They also refer that most artisanal fishers are not worried about losing pots, as they are very cheap, and according to some of them it is not a problem for octopuses, exactly the opposite, working as (like mentioned by one fisher) an “*octopus reserve*”, since octopuses use it for reproduction and protection. Trawl fishers complain that trawling vessels can’t work in these areas because they are full of deployed static gear.

The main reasons identified as the cause of losing fishing gear are the type of bottoms, specifically rocky bottom, shipwrecks, and conflicts with other gear in Portugal and bad weather conditions, entanglement in ALDFG/active gear and bad handling in Galicia. The ALDFG is mostly found near the coast, up to 5NM.

Table 4. Fishers’ self-reported perceptions about gear losses.

	Northwest of Portugal	Galicia - Spain
Main gear found	Mainly find lost octopus pots, small sections of nets and longlines.	Depending on the fishing activity, the main gear found lost are trawler nets, purse seine nets, traps and trammel nets.
What is lost	Not usual to lose the entire gear, but pieces of net, cables, and buoys: <ul style="list-style-type: none"> • up to 500kg of purse-seine nets lost/year; • up to 8 traps and 2 buoys in one day; • up to 12 trammel/gill nets per year; • up to 100kg of trawler net pieces, most of it is belly and wings; • only one dredge lost in 15 years 	Fishers can work for years without losing the entire net, it’s very rare to lose/abandon all the gear, but it happens sometimes to lose pieces of net: <ul style="list-style-type: none"> • In 5 years, fishers lose a maximum of 7 entire artisanal gears; • It can also happen to lose the entire longline (on average 4 per year); • Trawler boats lose in average 60m of net each time
Reasons to lose gear	Rocky bottoms and shipwrecks; conflicts between different gear-users in the same location	Weather conditions, ALDFG/active gear, rocky bottoms, and bad handling are the main reasons to lose gear; Old ropes from mussel rafts also affect fishing activities
Where it is mostly lost	Location of ALDFG: up to 5NM from the coasts, in Vila do Conde, Póvoa do Varzim, Aveiro, and Espinho;	Hotspots for ALDFG are mainly near the coast; Atlantic Northeast; south of Arousa Island (Pontevedra) and Ria de Arousa.

There are places where the seafloor is covered with ALDFG, so fishers are forced to work in the water column.

Source: own elaboration from the results of the interviews.

Fishers only try to recover lost fishing gears when it is economically worth it (Table 5), they can lose up to three days looking for lost gear. When trying to retrieve lost gear, fishers lose money by using fishing time, rest time and fuel. In Portugal, fishers estimate that the costs of retrieving lost gear can account for 400€ in a purse-seine vessel. In Spain trawler vessels spend 5,000€ to 12,000€ to retrieve their gear, while artisanal fishers can spend 105€ to 300€ to recover their nets, the longline boats can spend 25€ to retrieve their gear. Shell-fishers can lose 150€ looking for their fishing gear.

In Portugal gear mending costs between 5% (purse-seine & trawler vessels) and 50% (artisanal vessels) of the annual income. According to a Portuguese artisanal fisher to replace lost gear and mend damaged gear can sum up to 25,000 - 30,000€ per year. A longline boat owner referred values on the order of 5000€ per year to replace/mend gear. A strip of a purse-seine net can cost 120-240€. In Galicia, the costs for repairing gear can reach 9 000€ per year for trawlers vessels. One artisanal fisher can spend 60€ every three months on trammel nets or even 45,000€ per year. The cost of each shellfish gear is 150€, and the annual cost of repairing trap sets can reach 2000€. Each time a longline fisher needs to repair gear it will spend at least 10€.

Trawlers vessels usually have a global position system (GPS) mark on the position where the gear was lost and do transects on an area of 1sq nautical mile around the lost gear. The Portuguese trawlers vessels have a recovering tool, called “*ressega*” or “*garateia*”, on board to retrieve the lost fishing gear throughout transects (Figure 4).



Figure 4. “Ressega” or “garateia”, tool used by fishers to recover lost gear on trawler vessels.

Regarding the act of retrieving ALDFG, this is done differently depending on the type of boat, the location of the ALDFG (depth) and space on board. For instance, the loss of gear, or ALDFG, at a high depth makes it very difficult for some vessels to recover it. Some fishers report that they don't have a hauler to bring to board ALDFG found very deep. Table 5 gives detailed information about actions taken to retrieve lost gear.

Fishers using longlines report that their fishing grounds are full of ALDFG and that if it gets entangled in their longlines they bring it back to land. Other fishers admit that when they catch plastic pots on their nets, they throw it back into the sea, to avoid conflicts with the owner of these pots. Others report to bring it back to land, figure 5.

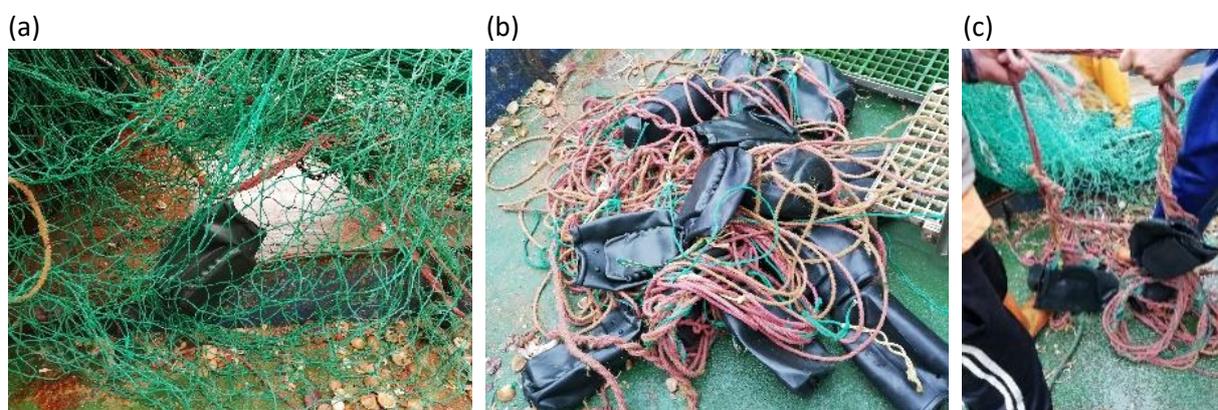
All fishers say that they repair and reuse the retrieved gear when possible. Portuguese fishers believe that it is not possible to recycle ALDFG, except for the old clean gear that they have on board of vessels or on warehouses. A few Portuguese artisanal fishers report to sell the clean old nets not in use to companies that collect them for recycling (e.g. Vila do Conde, Portugal). If the gear recovered in the nets is ALDFG or can't be mended, fishers try to bring it back to land and leave it waste bins. In Vigo port, Spain, waste companies collection retired nets not in use left in containers at the Port, these nets are not necessarily clean when they are collected.

Despite the fact that EC regulation 1224/2009 demands skippers to report lost gear and the location where it was lost, this tends not to happen. Portuguese skippers from trawler vessels admitted to only reporting lost gear when the loss results in damage to the vessels or mechanical problems, otherwise they tend to not report the loss of gear. Spanish fishers operating from the port of Vigo also admitted only reporting lost gear when it is required for security reasons.

Table 5. Fishers' opinion about retrieving lost gear.

	Northwest of Portugal	Galicia - Spain
Costs of recovering lost gear	Loss of fishing time, rest time, fuel, money; For a purse-seiner retrieving gear account for 400€.	One day lost looking for a trawler net can cost between 5000€ to 12000€; Artisanal fishers can spend 105€-300€ to recover their nets; Longliners spend 25€ looking for the gear; Shell fishers can lose 150€ looking for their gear.
Strategies to recover lost gear	Fishers try to retrieve the gear when the entire/complete or a significant part of the gear is lost; Fishers identify the location where they lost the gear with the GPS mark and look in the area up to 1sq mi from the position Trawlers use an anchor shape iron called "ressega" or "garateia"	Can take up to 3 days to recover the trawler nets, depending on the depth some are impossible to retrieve; For purse seine nets and dredges it can take up to 1 day to retrieve it; Artisanal fishers can lose up to 5hours recovering gear; Fishers identify the location where they lost the gear with the GPS mark and search within the area, up to 5 NM from the position
Use of recovered gear	Most of the times, recovered gear is reused	Most reuse the recovered gear.
Gear mending prices	Gear mending costs between 5% (purse seine and trawler boats) to 50% (artisanal fishers) of the annual income; 25,000€ to 30.000€ per year spent by artisanal fishers; 5000€ per year for a longline boat owner; The price of a trip of purse-seine costs 120€ to 240€.	9 000€ per year for trawlers vessels; 60€ every three months for trammel nets or even up to 45000€ per year; 150€ for each shellfish gear; Up to 2000€ annually for repairing traps; At least 10€ each time a longline fisher repairs the gear.
ALDFG	Most fishers bring back the ALDFG	Many fishers bring back to land the ALDFG found, up to 100Kg/trip; Depending on the fishing grounds they bring different types of ALDFG: "volanta", "pincho", purse seine, trawler nets or mussel rafts ropes

Source: own elaboration from the results of the interviews.

**Figure 5.** Octopus plastic pots entangled in a Portuguese trawler net.

3.2. Fishing net producers

Producers make nets that have strength, resistance, durability and light materials that can be coated. The products are created to last for years while working. For instance, 700m purse seine nets should last for 2-3years, bottom trawler nets for 1-3 years, pelagic trawler nets for 1-5 years. To achieve this durability, synthetic polymers are used such as polyethylene (PE), polyester and nylon (polyamide-PA). Some gear uses HDPE (high-density polyethylene) that consists of reinforced fibre.

One idea suggested by the manufactures was that the industry should make better, more resistant gear, if the nets were more expensive with better materials and last for a longer-time, fishers wouldn't abandon it at sea. It is well-known and recognized by the industry that they must find better solutions for all existent and new materials. The industry also pointed out that there are already some trials with polylactic acid (PLA), which show evidence that the material is degradable in soil but not in water. The manufactures also mentioned that there are already studies on natural fibres like sisal or cotton that can be eaten by fish, so it is not yet a viable option and could possibly be coated with polyethylene (PE) or polypropylene (PP). In the opinion of fishing net producers, it will be hard to find materials that can compete with plastics regarding price, strength, durability, lifespan, and cargo.

Retrieving lost gear

The net producing industry agrees with fishers with respect to the need to have incentives in place for fishers to collect ALDFG and marine litter. This topic is currently being addressed by the European Parliament where a legislative resolution was adopted on the 27th of March 2019 on the proposal for a directive of the European Parliament and the Council on the reduction of the impact of certain plastic products on the environment¹, stating that the existing legal requirements “do not provide sufficient incentives (for fishers) to bring fishing gears to shore for collection and treatment” and that the system should “be supplemented by further financial incentives for fishers to bring their waste fishing gears to shore”.

¹ European Parliament legislative resolution of 27 March 2019 on the proposal for a directive of the European Parliament and the Council on the reduction of the impact of certain plastic products on the environment, COM(2018) 0340 – C8-0218/2018 – 2018/0172(COD) (EU, 2019).

3.3. Fishing gear collecting and recycling companies

Unwanted fishing gear can end up in landfills or be recycled depending on its general condition. There are four different ways in which unwanted gear can reach recycling companies: (i) fishing companies work directly with companies that collect fishing gear for recycling, and call these companies to go to the port or warehouses to collect gear to be disposed; (ii) fishers take the gear to be disposed directly to the facilities of companies that collect fishing gear for recycling; (iii) local urban solid waste management companies collect old gear from the garbage bins at ports, subsequently separate it from the general waste and sell it to companies that collect fishing gear for recycling; (iv) illegal fishing gear confiscated by authorities is delivered to companies that collect fishing gear for recycling. Fishers can get paid for the unwanted gear on the two first cases, with values ranging from 150€ to 400€ per tonne of fishing net. However, according to a representative of a Portuguese recycling company, most fishers are not aware of the fact that they can be paid for unwanted gear.

3.4. Researchers

Researchers experienced with life onboard fishing vessels corroborated fishers' statements that they don't usually lose the entire gear, but only small pieces of gear. During oceanographic surveys, researchers tend to often find among floating marine debris cables and pieces of nets and point to the danger of this lost gear (parts of gear) for marine life. For instance, a researcher mentioned that when checking stranded animals, a lot of seagulls and northern gannets are entangled in fishing lines, which can lead to amputation or even the death of the animal.

Researchers point to the fact that more studies are needed to understand the current situation regarding marine litter in the Iberian coasts. They also mention that fishing gear is amongst the top 10 items when it comes to floating debris. For more information please see the report "Top Marine Beach Litter Items in Europe" (Addamo *et al.*, 2017). The scientist interviewed also referred that in beach clean-ups roughly 30% of the items of litter collected result from fishing activities. However, it is hard to point a precise number because this information depends on the location of the beach, the proximity of a city has high exposure to winds and currents, or in case of a recent storm then there is more debris on beaches.

Analysis of pictures taken by Remotely Operated Vehicle (ROV) in Portuguese fishing areas shows that fishing gear was the most common litter (Oliveira *et al.*, 2015; Vieira *et al.*, 2015).

Other researchers described that nearly 40% of the litter items collected with trawling nets comes from the fishing industry (Neves *et al.*, 2015). The researchers interviewed think that currently this figure is higher, and all agreed that more studies regarding this issue are needed.

When fishers lose or discard fishing net the abrasive environmental conditions cause nets to break up into progressively smaller fragments. The lighter plastic of the ALDFG floats and may be washed ashore or disintegrated due to the effects of sunlight, leading to the formation of microplastic particles but also fibers depending on the materials of the gear (Montarsolo *et al.*, 2018). The researchers interviewed state that the multifilament gear used in many nets contribute to the particles of microplastics. Researchers focused on octopus plastic traps, and the worry about these turning into microplastic, and pointed to the lack of studies and data on this topic as a major concern. According to one researcher, the dark colour of the plastic pots makes it hard to analyse its composition. Another problem researchers identified related to the fishing industry is the use of styrofoam boxes, and the high concentrations of fragments and polymeric foams found near fishing ports (Antunes *et al.*, 2018). Fishers use the styrofoam boxes at the ports, the light-weighted material can be dragged by the wind. Researchers interviewed are of the opinion that authorities should forbid the use of these boxes.

Regarding new materials for producing gear, researchers are concerned with the oxo-degradable plastic fibres, which they would not recommend because of it being highly pollutant and the fact that over time it will turn into smaller plastic particles, and finally into microplastics. When asked about biodegradable options, researchers point out that nothing viable exists at the moment, and that it is very hard to produce a synthetic product that can be decomposed in water.

3.5. Governmental authorities

Across the Iberian coast, there are several projects in place to manage marine litter in fishing ports. Most ports have general waste containers, some of these offer containers for plastic/packages and also offer containers or facilities for retired gear (see Figure 6 for an example). Representatives of governmental authorities are of the opinion that coastal vessels and trawlers are probably the ones that bring more litter to the port. The system of collection and recycling of marine litter and retired gears is available in many ports, it's free for all fishers. Waste management companies are responsible for the collection, separation and final destination of the marine litter including retired fishing gear.

In 2017 at Vigo fishing port a total of 16,18 tonnes of fishing nets were collected, in 2018 the numbers raised to 60,5 tonnes of gear collected and sent for recycling. The Matosinhos fishing port also has containers for fishing gears no longer being used (such as trammel nets, gill nets, and a few purse seine nets), that are sent for recycling; last year alone 8,14 tonnes were sent to be recycled (Docapesca, 2019).



Figure 6. Marine litter and fishing gears containers in a Portuguese fishing port.

4. Conclusion

Trawling and purse seine fishing gears cost thousands of euros, while artisanal fishing gears (namely trammel net, gill nets, and traps) are cheaper. Fishers don't usually lose the entire gear only parts of it, and they try to retrieve it, when economically viable. There are significant costs to retrieving lost gear; for example, to locate and retrieve a fishing net a trawler vessel can spend between 5000€ to 12000€.

Bad weather conditions and rocky bottoms are the main reasons for gear loss. It was not possible to define hotspots for ALDFG since it's everywhere up to 5nm from the coast. Octopus plastic pots and small pieces of nets are the gear (and parts of it) that is found more frequently. Fishers seem to bring back to land most of the ALDFG found, up to 100Kg/trip. Marine litter has an impact on all fishing activities, damaging fishing gears and sometimes destroying the catch, especially on the trawler vessels. Another problem referred is that lost gears also affect the security and navigability of fishing vessels.

While environmentally friendly fishing gear options are not available in the market, fishing gears produced must be recycled. It is possible to recycle end-of-life fishing nets made of polyethylene or nylon if clean and all types of ALDFG if economically viable to clean it.

Most fishers are still not aware that they can receive money for ALDFG/old fishing gear. However, according to the interviewee from a Portuguese company that collects fishing gear for recycling, fishers can be paid from 150€ to 400€ per tonne of net from recycling companies. Increasing fishers' awareness about these financial incentives could result in increased recycling.

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Appendices

Appendix I: Interview script for fishers



Interviews with professional fishers boat owners/skippers/crew

NetTag Project - “Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries”. NetTag is a European Project (Portugal, Spain, and United Kingdom) that focuses on reducing marine debris, aims to develop a new acoustic device that will help to locate lost fishing gears and carry’s the ambition of implementing best practices on board.

Questions

A. Fisheries

1. Years of experience
2. Method of fishing (gill nets trawling, seine, traps, others)
3. Regarding the nets – Size, material (e.g., polyamide or nylon), monofilament or multifilament, colour?
4. What is the cost (value) of fishing gears? How long can be used for fishing effectively, 5, 10 years?
5. Type of catch (fish, molluscs, crustaceans).
6. Area of fishing and type of grounds (smooth, moderate, hard)
7. Fishing period (daylight, night, both)

B. "Accidental marine debris" - Lost fishing gears

8. What types of fishing nets are lost more frequently?
9. Have you ever abandoned fishing gear?
10. Have you ever lost fishing gear? How many did you lose (number estimate)? How often did you lose it? (point one unit, i.e., per week/month/ year). Last year how many did you lost (2018)? How many did you lose in the last 5 years?
11. Does the vessel often lose the entire fishing net or parts of it? What is the average size of the pieces of fishing net that you’ve lost? (point one unit, i.e., m², fathoms)? Have you lost the all fishing net with or without the equipment?
12. What are the most common parts of the net that are lost (bottom, top, wings)?
13. What kind of material are the lost fishing nets (e.g., polyamide or nylon), monofilament or multifilament?
14. What’s the main reason for losing fishing gear? (accident, rope rupture, net rupture, weather hard conditions, too much catch, other)
15. What are the places where fishers lose more fishing gear? Which fishing spot?

C. "Accidental marine debris" - Retrieving and costs

16. Have you ever tried to retrieve fishing gear? How long did it take to retrieve it?
17. How did you retrieve the fishing gears (method)? Did you retrieve it during the day, night or both?
18. What can be the cost of repairing one fishing net? What is the percentage of your annual revenue related to fishing gear repairs?
19. What is the estimated area of search to locate one fishing net that was lost?
20. What do you do with the retrieved fishing gears? (repair, reuse, recycle, waste, other)

D. Litter produced on board (several)

21. What kind of objects do you take to the boat that can become marine debris? (Styrofoam boxes, cigarette butts, bottles, etc.).
22. How often do they lose/drop "litter" into the sea? And how many pieces or bags? (average per trip/day).
23. What is the quantity/volume of litter that goes to sea (estimation)? (record one unit)

24. What do you do with domestic waste? (bring it to land/throw it overboard) What kind of garbage to you throw overboard? Why do you do it?
25. Where do you keep the domestic waste on board? Do you have containers on board for the household waste? If not, would you be willing to receive one container for domestic waste?

E. Marine litter (collected by the fishing nets)

26. How much trash do you pick up in the nets (kg)? (average estimative; record one unit – per day/week/ year). How much did you catch last year? And on the last 5 Years?
27. What types of marine litter did you get? Have the type of marine debris change during the past years (10, 20 years)? Is there more marine litter nowadays?
28. Where did you collect more marine debris? In what areas?
29. What impact does the marine debris have? Does it destroy nets? Does it destroy the fish? Does it involve additional costs?
30. How much time do you spend to take care of the marine litter in the nets?
31. Regarding the lost fishing nets: At your fishing grounds what types of fishing gears are there in greater quantity? In 2018 how many Kg of lost fishing gears did you collect and brought to land?
32. What do you do with the marine litter that comes with the nets?

F. Acoustics Tags

33. Would you be willing to use acoustics tags on your fishing gear?
34. What is the maximum cost for an acoustic tag that would be viable for the average fisher? (Think in terms of what is a worthwhile investment when weighed against the cost of lost nets/gear. If this varies according to the type of net or gear, then please give examples.) how many tags would you buy?
35. What are the maximum dimensions for a tag device to avoid interfering with the normal deployment/recovery of nets?
36. Where and how would you suggest a tag device is attached to a net? If this varies according to the type of net or gear, then please give examples.
37. Can you estimate the minimum battery life required for acoustic tags? (The total time from entering the water that you would want the tags to be detectable for.)
38. What would be the preferred means of battery management in a tag? (a) single-use alkaline cells replaced while on net (b) rechargeable cells replaced while on net (c) tag removed from net and wirelessly charged (e.g. like electric toothbrush).
39. What form should the interface of a surface locator device take? (a) Self-contained device with built-in screen (b) mobile phone/tablet app with Bluetooth connection to locator unit (lower cost option).
40. How important is security? Would it be acceptable for other fisher to be able to find your nets or would you prefer that only can find them? What about the authorities?

Appendix II: Interview script for fishing gears manufacturers



Interviews with stakeholders involved in fishing gear manufacturing companies

NetTag Project - “Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries”. NetTag is a European Project (Portugal, Spain, and United Kingdom) that focuses on reducing marine debris, aims to develop a new acoustic device that will help to locate lost fishing gears and carry’s the ambition of implementing best practices on board.

Questions

1. What type of nets do you produce? What about artisanal?
2. What are the main materials of the fishing nets and ropes produced?
3. How long is the lifespan of a fishing net?
4. What do you do with the debris from fishing nets produced? Do you reuse them in the factory or recycle them? If so, do you have a contract with a recycling company?
5. Do you know anything about the new measure from the EU that demands that: *“Producers of fishing gears containing plastics will be required to cover the costs of waste collection from port reception facilities and its transport and treatment? (...) This will ensure that managing fishing gears plastic litter, once it has arrived on shore, is the responsibility of the producers.”* (European Union, 2018).
 - 5.1 What do you think about the new law that was recently approved (02-2019) in the EU about Extended Producer Responsibility (EPR)?
 - 5.2 *“The producers will carry the responsibility, and the cost, of managing old plastic-containing fishing gears once it is landed”* What do you think about this statement?
 - 5.3 Will your company also cover the costs of awareness-raising measures”? Do you already develop awareness societal campaigns? How?
 - 5.4 Is your company already finding solutions regarding the new law? New materials or make it biodegradable?
 - 5.5 Do you have an inter industrial cooperation? Did you find partners to recover and recycle fishing gears from the ports?
 - 5.6 What they are doing to avoid plastics and other contaminants in the seas?
- 6 Do you have any idea about how long does the ghost fishing nets last lost in the sea?
- 7 Does your company do anything related to old fishing gears? Do you recycle it or send it somewhere?

Monitoring systems

- 8 What do the sensors indicate? Dept, bottom, doors position, bag content, type of catch?
- 9 We only found this system in trawler boats. Are these sensors only used in trawlers in Portugal/Spain? Do you sell your purse seine or Dredge sensors for Portuguese/Spanish fishers? If so where are they from?
- 10 Does your system give the GPS position of the net while working?
- 11 What about the GPS position when the net is lost?
- 12 How does your system reduce waste? Is it because the system allows to know if the net is almost on the rocky bottom, so the fishers can control it?
- 13 Do you sell GPS buoys for the nets?
- 14 What’s the average price for one of your systems? How long does it last?
- 15 Do fishers get external financing to buy your systems? In Portugal, they cost around 40 000€.
- 16 Does marine litter/ghost gear interfere with the sensor’s operation?

A few extra questions:

- 17 Is it possible to recycle all types of nets?

- 18 Is the process difficult?
- 19 When a fishing net is lost, what's the maximum time that it can be lost and still be suitable for recycling.
- 20 Can you recycle fishing nets in poor conditions (not clean/with hooks...)?
- 21 What can be produced from a recycled fishing net?

NetTag acoustic tags

“The Guidelines are global in scope, but countries recognize that making them work for small-scale fisheries in developing countries will require additional support to meet the new standards. (...) Modern technologies such as satellite buoys or GPS receivers make it easier to detect the lost fishing gears, but it could be too expensive for the majority of small-scale fisheries ...” (FAO, 2018).

- 22 Would your company be interested in using an acoustic tag, like the one produced by the NetTag project?
- 23 Does this device compete you your system or complements it?
- 24 If they complement each other, do you think that it is possible to use pingers as sensors on the doors and the acoustics tags at the same time?
- 25 How much would your company be willing to pay for it?
- 26 What should be the size, shape, battery type, battery life, results output wise?
- 27 Where would you place it?
- 28 In your opinion, for what type of fisheries would this device be more suitable?
- 29 What is your opinion on these devices?
- 30 Is it possible to be implemented at your factory?
- 31 Is this device practical?
- 32 In your opinion, will fishers accepted it and use it?

Appendix III: Interview script for a recycling company



Interviews for stakeholders involved in recycling fishing nets
NetTag Project - “Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries”. NetTag is a European Project (Portugal, Spain, and United Kingdom) that focuses on reducing marine debris, aims to develop a new acoustic device that will help to locate lost fishing gears and carry’s the ambition of implementing best practices on board.

Questions

1. What type of fishing gear do you recycle?
2. Do you only get nets for recycling or do you also recycle plastic traps?
3. What type of nets/traps you get the most?
4. Where do the nets that you recycle come from? Do you have a contract with any company like the port authorities or a fisher’s association?
5. Do you collect the fishing gears at the ports? If you collect the gear do you provide any containers?
6. Where do you send it to?
7. What do you do with the gear that presents non-permitted material (hooks, Steel Ropes, Lead Ropes, floats, Nets with antifouling treatment, Nets mixed with debris)?
8. Why don’t you accept gear with hooks or entangled nets?
9. Is it possible to recycle those nets? Would it be more expensive to separate and clean these ones? Is it because of the machinery?
10. What are the main problems when recycling fishing gears? Is the process difficult?
11. Is it expensive to recycle all types of gear? Do we have the technology?
12. When a fishing net is lost, what’s the maximum time that it can be lost (in the water) and still be suitable for recycling?
13. Do you incinerate the nets that can’t be recycled? Who does it? Where do you send it to? Do you have any idea about the percentage that goes to land-fields or is burned?
14. Do you have any idea about the percentage of nets that are recycled? According to a recent EU report “Only 1.5% of gear gets effectively recycled (EU, 2018)”.
15. Do you have any idea about the quantity of ghost-nets lost in the sea?
16. Is it possible to recycle lost gear or only the retired gear?
17. Do you get payed by fishers, port authorities or fish auction company to collect the old fishing gears? Who covers the costs?
18. Do you have numbers (in tonnes) of gear received/recycled?
19. Do you know what is made from the recycled gear? Is it possible to make fishing gears from old fishing gears?
20. Do you get fishing nets collected from other companies that collect retired gear? Do you have an idea of other companies that collect fishing gear to recycle?
21. Do you know anything about the new measure from the EU that demands that: “Producers of fishing gears containing plastics will be required to cover the costs of waste collection from port reception facilities and its transport and treatment. They will also cover the costs of awareness-raising measures”?

Appendix IV: Interview script for researchers



Interviews with researchers

NetTag Project - “Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries”. NetTag is a European Project (Portugal, Spain, and United Kingdom) that focuses on reducing marine debris, aims to develop a new acoustic device that will help to locate lost fishing gears and carry’s the ambition of implementing best practices on board.

Questions

A. Personal experience – life on board

1. What types of fishing boats have you been on board?
2. What was the type or part of fishing gears that they lose more?
3. Do you think fishers throw everything to the sea? What kind of litter have you seen them throw? What about domestic litter (organic) and cigarette butts?
4. Do they have garbage bins on board?
5. What do they do with the retired gear?
6. What fishers do with marine litter that they get on the nets? What do they do with ALDFG on their nets?
7. What type of litter they bring back to land?
8. Do you think that there are enough containers on the ports for the litter fishers produce or encounter at sea?

B. Marine litter

9. What are the main impacts of Marine litter on marine fauna?
10. What are the main items in marine litter?
11. Did you find fishing gears when you were studying floating debris on our coast?
12. What are the main impacts of Marine litter on marine fauna?
13. What are the main items in marine litter?
14. Where are the underwater hotspots for marine litter on our coast?
Marine litter 15% on the beach, 15% floating in the ocean, 70% in the sea bottom. United Nations Environment Programme (UNEP, 2001)
15. What’s the percentage of fishing items in the marine litter that is collected on the beach clean-ups?
16. What happens with the litter collected on the beach, is it recycled?
17. Knowing that fishers throw all the cigarette butts on the sea and that this item the one that appears more at the beach, can we assume that fishers contribute for the beach marine litter?
18. Can we assume that 40% of the marine litter items at the sea bottom are fishing gears? How much of the marine litter on the fishing grounds are lost fishing gears and litter e.g. Gorringer Bank (NE Atlantic)?

C. Microplastics

19. Can the octopus plastic pots become microplastic?
20. From all sources of microplastic, what’s the contribution of fishing nets on the microplastic ingested by the fish we eat? Does a fishing net contribute to microplastics in particles or fibres?

D. Policymakers

21. “A combination of measures within stakeholders, namely industry and fishing sectors and share of good practices are needed to prevent marine anthropogenic litter.” What do you suggest that it should be improved? We are doing workshops with fishers, so we can do something.
22. “*High concentrations of fragments and polymeric foams were found near fishing ports (Antunes et al., 2018).*” All 18 fishers interviewed say that they don’t use those boxes while fishing. It is near

the ports that you found more foam. Should we ask the port authorities to investigate the Styrofoam boxes use in the ports?

E. Acoustic tags

23. What is your opinion on these devices?
24. Is this device practical?
25. In your opinion, will the fishers accept and use it?

Appendix V: Interview script for government authorities



Interview with governmental body

NetTag Project - “Tagging fishing gears and enhancing on board best-practices to promote waste free fisheries”. NetTag is a European Project (Portugal, Spain, and United Kingdom) that focuses on reducing marine debris, aims to develop a new acoustic device that will help to locate lost fishing gears and carry’s the ambition of implementing best practices on board.

A. Litter management and recycling

1. Is there a type of fishing boat that brings more litter?
2. What is the destination of the marine litter?
3. How does your institution manages the retired fishing gears?
4. What is the type of gear that is delivered at the port more frequently? Where is lost? Do you have an idea about amount?
5. What is the final destiny of the nets and traps?
6. If the abandoned/retrieved gear goes to the landfill, are there any associated costs? Who is the transportation?
7. How many recycling companies are there?
8. What are the main problems when recycling fishing gears?
9. Is it possible to recycle all types of lost gear?
10. Do you have any other marine litter project?
11. Do you know anything about the new measure from the EU that demands that: “Producers of fishing gears containing plastics will be required to cover the costs of waste collection from port reception facilities and its transport and treatment. They will also cover the costs of awareness-raising measures.” (*European Union, 2018*)?
12. Does your company provide separate collection facilities for retired fishing gears? If so, what are their dimensions (characteristics)?
13. Do you know if there are any contracts with waste management companies regarding the end of life/ALDFG? If so, where?
14. Is there a special fee-system in place or planned when it comes to retired fishing gears?
15. Do you have any idea of the quantity (Tons) of retired fishing gears?

B. Acoustic tags

16. What is your opinion on these devices?
17. Is this device practical?
18. In your opinion, will the fishers accept and use it?

Portuguese government authorities (only)

C. Project “Pesca por um mar sem lixo”

19. What projects are in place for reducing marine litter?
- 19.1. What is the purpose of the project? Where did the idea come from?
20. Is this a national project?
21. Where is it already being implemented?
22. Do you give containers to all fishers? Are there different types of containers?