BLUE MARINE
FOUNDATION

SAFEGEAR

PROJECT REPORT

February 2021

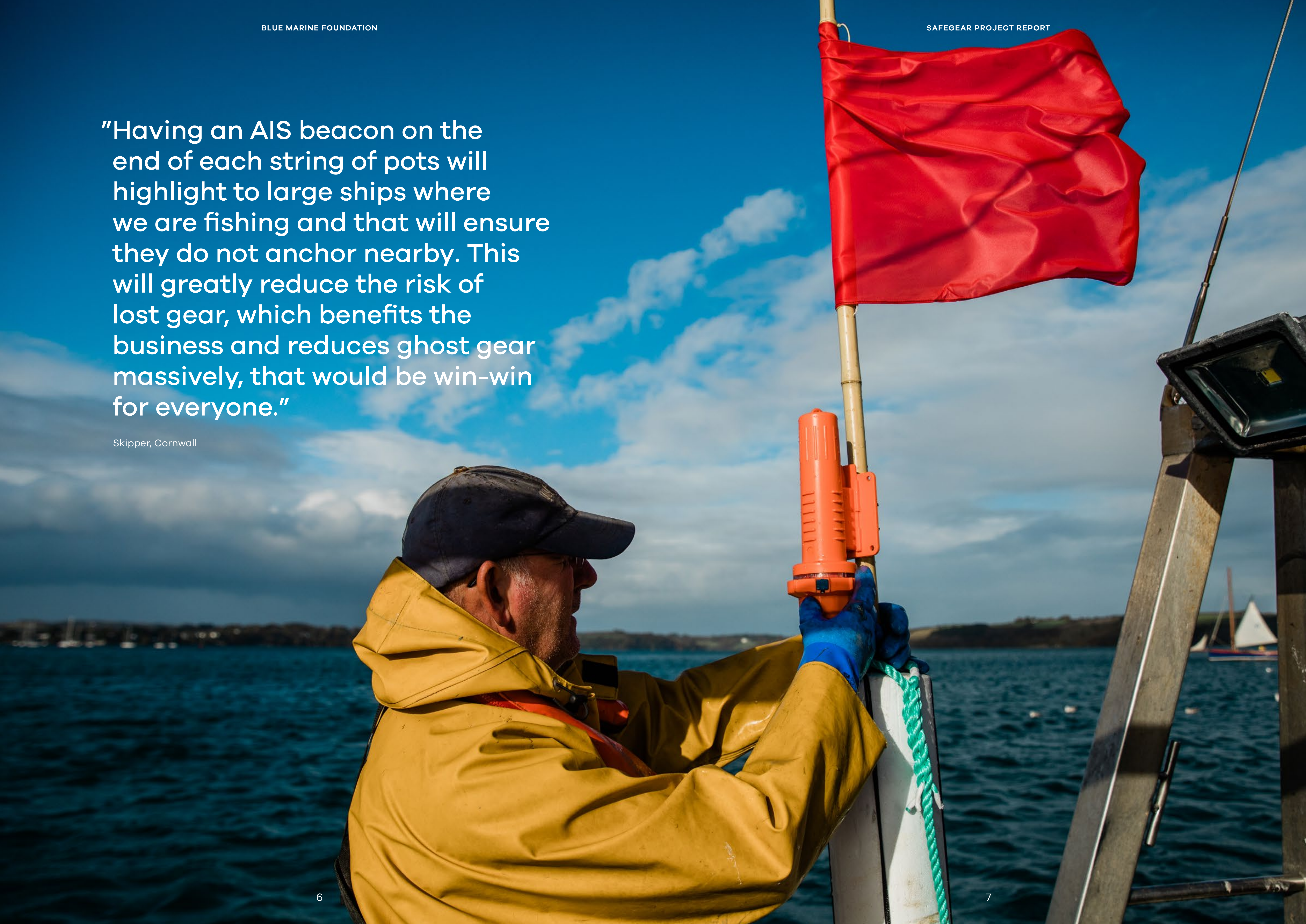
SAFE GEAR

"I lose on average 50 pots per year. As well as the pots I lose the ropes, buffs and ends. This all costs me time and money and is unwanted, as there is so much effort to get new pots made, long waiting lists, setting the gear, deploying it. Also, when I lose gear I then creep for it which takes a lot of time, effort and communications with other vessels. All this time spent is reducing my fishing effort, so it has a major impact."

Skipper, Cornwall

"Smaller pots cost anywhere from £40 a pot, big ones are £100 a pot. If you get a full string of 30 pots go, it's a lot of money. But the main problem for us, the way we look at it, it isn't just the money side of it, that gear is at the bottom of the seabed and it's not very good for the ecosystem."

Cameron Henry, Mylor fisherman, sea trial cohort



"Having an AIS beacon on the end of each string of pots will highlight to large ships where we are fishing and that will ensure they do not anchor nearby. This will greatly reduce the risk of lost gear, which benefits the business and reduces ghost gear massively, that would be win-win for everyone."

Skipper, Cornwall

"I lose most pots to scallopers who are dredging around my gear and tow them away. Secondly to tankers who are anchoring on top of my pots and pulling them up when they move away. I also lose to recreational vessels steaming over one end and losing gear, such as a 60ft motorboat, not aware of fishing grounds and steaming through buffs and towing gear. They would not know it's my gear, so there is no way of knowing for them where to notify."

Ivor Henry, Skipper, Cornwall, Mylor

"The small-scale fishing community needs good news stories this year more than ever before. SAFEGEAR could be a powerful and inspiring one."

Dan Crockett, Blue Marine Foundation

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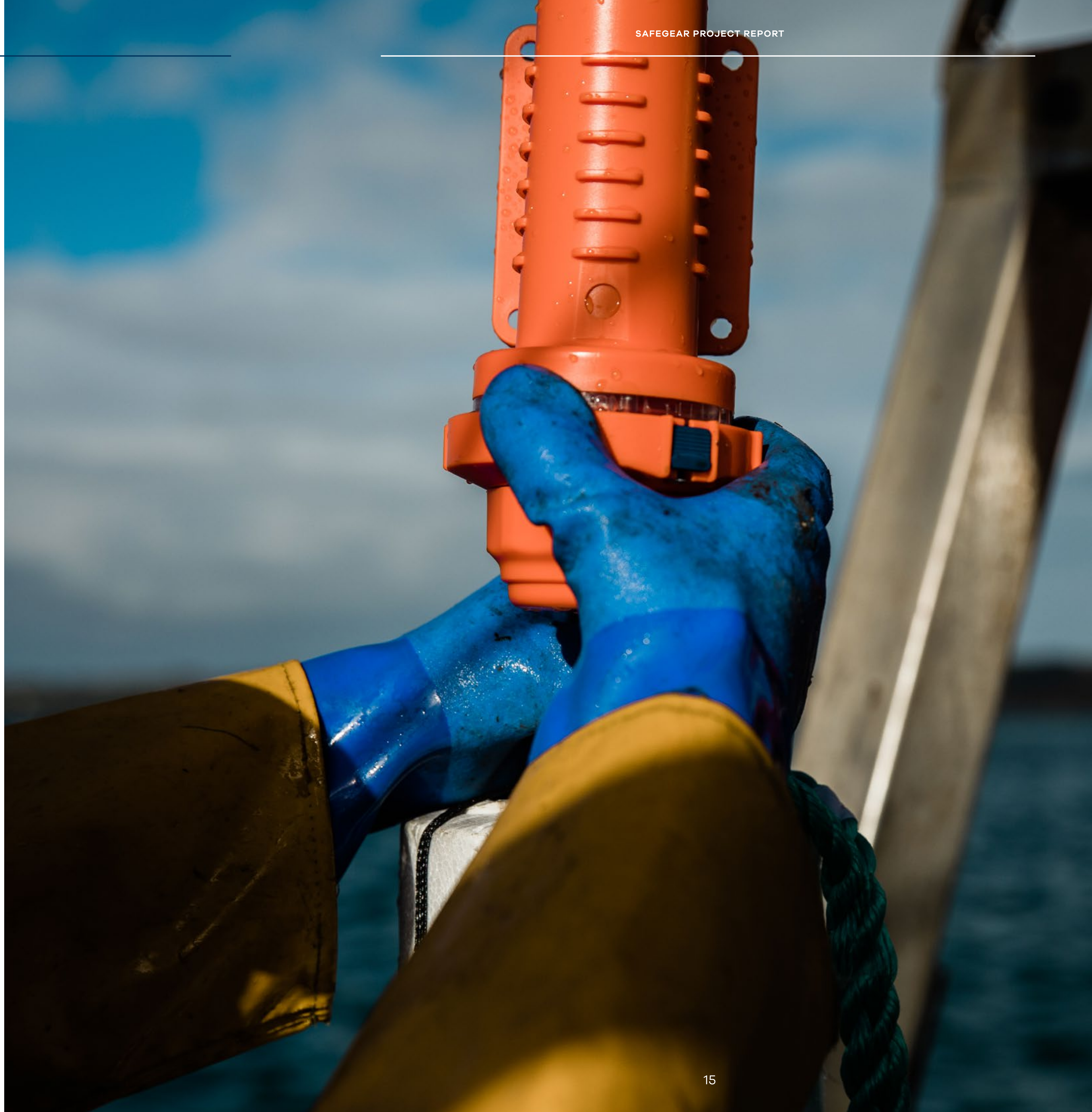
Foreword

Ghost fishing gear is becoming better understood as a major contributor to ocean plastic pollution. With the SAFEGEAR project, Blue Marine Foundation (BLUE) attempted to analyse the scale and severity of this problem and understand its root causes. Furthermore, SAFEGEAR created an innovative solution in the form of a cost-effective AIS beacon developed specifically for fishermen to use at sea to stop their gear entering the marine environment. Despite numerous complexities, not least the havoc in the fishing industry caused by the pandemic, the findings of the sea trials are truly exciting. The Fishing Animateurs engaged with dozens of fishermen and identified a genuine need for a solution to losing their gear through gear conflict, large vessels towing it away and bad weather. Fishermen in the south-west of England tested SAFEGEAR during a typically rough Cornish winter and found that it could stop the vast majority of static fishing gear entering the marine environment. They cited peace of mind, economic security and pleasure that gear would not be lost into the marine environment. This has huge ramifications, for fishermen to become an active part of stopping the issue of ghost gear at source. The next steps are for government to seriously consider how to support the fishing industry to ensure that fishing gear without this technology attached becomes a thing of the past. We look forward to that debate.

Charles Clover
Executive Director
Blue Marine Foundation



Executive Summary

The loss of fishing gear is economically, socially and environmentally significant. It is also, almost always, unintentional. The amount of abandoned, lost or otherwise discarded gear (ALDFG) is a significant source for marine plastic pollution.

The total volume is almost impossible to quantify, there is no recording system. Gear may be lost by being snagged, entangled by storm or tide, dislodged by bad weather, damaged by trawls or towed away by other vessels or anchors. This has a significant cost to fishermen each year, both economically and in the stress caused by losing gear and the effort required to find and retrieve it. SAFEGEAR, a project by the Blue Marine Foundation (BLUE) set out to solve these challenges.

We worked with the University of Plymouth Marine Biology and Ecology Research Centre (MBERC) to better understand the scale and cost of abandoned, lost or otherwise discarded fishing gear. We worked with marine specialists Tecmarine and Onwa to develop a cost-effective sea-hardened beacon that fishermen could easily deploy. The Fishing Animateur conducted a trial with a cohort of fishermen in the south west, attaching SAFEGEAR AtoN (Aid to Navigation) beacons secured to Dhan poles attached to fishing gear. The gear was fished over a number of months and in different locations.

Our work encountered several difficulties. Firstly, our initial sea trial was planned for early April 2020. There was no way to anticipate the havoc that COVID-19 would wreak on our domestic fishing industry, with the majority of their market closing down overnight. Secondly, and in some ways more critically, we encountered a major licensing complication with Ofcom. They would permit us to use the SAFEGEAR beacons in a limited capacity, restricting them to a closed AIS frequency.

BLUE and our partners worked extremely hard to overcome these complications. What we found was a fishing community entirely ready for an initiative of this nature. The vast majority of fishermen do not wish to lose gear, because it damages the ecology that provides them with a livelihood. Fishermen involved in the trial reported a sense of wellbeing, knowing that their gear was safe. They found SAFEGEAR easy to use. Its role in stopping fishing gear from being lost to the marine environment was proven through the sea trial – perhaps not at the scale that we had hoped, but irrefutably nevertheless.

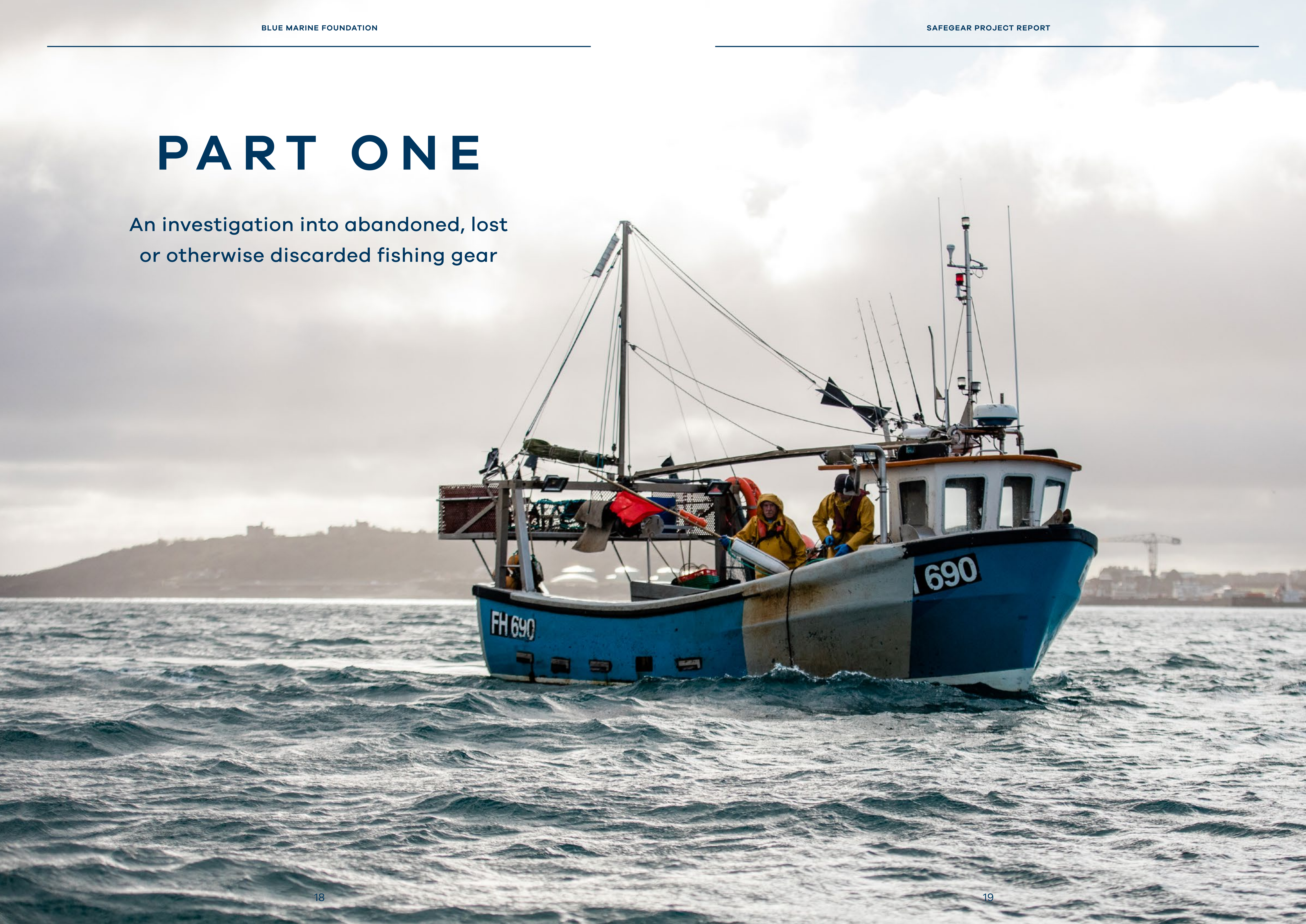
The next steps, how we use the positive momentum created by this trial, are incredibly important in the fight against ghost gear. Fishermen in this country want their gear to be marked. The Marine Management Organisation should support them in this, stopping gear loss and helping the sector. Furthermore, Ofcom should recognise the environmental possibilities of the AIS system, and consider how an Aid to Navigation with important safety at sea implications, like SAFEGEAR, could form part of the main system rather than being consigned to a bespoke frequency. BLUE will seek to facilitate this debate in the future.

BLUE would like to thank a number of people for their support throughout the SAFEGEAR project. These include Waitrose & Partners and Hubbub, and the Plan Plastic grant that made it all possible. Alison and the Fishmongers' Company's Fisheries Charitable Trust for their belief and funding at the very start of the project. The Fishing Animateurs, who worked incredibly patiently and closely with the fishing community to deliver the sea trial. Tecmarine, for providing technical assistance throughout and Onwa, for building the beacons. Professor Richard Thompson and Winnie Courtene-Jones at the University of Plymouth for researching the problem of ghost gear in our seas. Finally, we would like to thank Terri Portmann, whose insight into the lives of fishermen began the project.

Dan Crockett
Development Director
Blue Marine Foundation

PART ONE

An investigation into abandoned, lost or otherwise discarded fishing gear



An investigation into abandoned, lost or otherwise discarded fishing

Winnie Courtene-Jones & Richard C. Thompson
Marine Biology and Ecology Research Centre (MBERC), School of Biological and Marine Sciences, University of Plymouth

The commercial fisheries sector widely use synthetic plastics, largely due to the many benefits offered over natural counterparts, such as greater strength and durability, relative low cost and ease of handling (Lusher et al., 2017; UNEP, 2016). It is this durability which also supports the persistence of end of life plastics in the natural environment (Thompson et al., 2009). Plastics can originate from land-based (e.g. mismanaged waste, consumer products) and marine-based sources (e.g. fisheries, maritime sectors). While land-based sources are considered to contribute towards the majority of plastics found in the environment, marine-based sources still present a significant source of plastic waste.

The dumping of waste at sea is prohibited under the International Convention for the Prevention of Pollution at Sea (MARPOL), however unintentional losses may still occur, contributing towards the marine-based sources of plastic. Losses within the fisheries sector comprise of a) fishing gear, such as nets, ropes, pots, fishing line; b) ancillary items, including gloves, fish boxes, strapping/band, and c) the release of fibres and other fragments due to the wear and tear of ropes or other associated equipment. Fishing items might be lost at sea by accident, through abandonment or their deliberate disposal, and are termed as abandoned, lost or otherwise discarded fishing gear (ALDFG).

Fishing gears may become lost for a number of reasons including; if they come into contact with a passing vessel or become entangled and towed away by trawlers (Pawson, 2003; Santos et al., 2003), due to a malfunction of the vessel tracking system or if they become snagged on submerged features. Improper fishing methods or human error such as setting gears in areas with high seabed currents, irregular topography, or where there is a high probability of interaction with mobile gears can also result in loss (Gilman, 2015). Additionally, gear may be lost or abandoned if there are adverse weather conditions or if it is not safe to retrieve the equipment (Richardson et al., 2018; Santos et al., 2003).

While the quantities of ALDFG lost each year are not well known, it is estimated that globally ~640,000 tonnes are lost annually (Macfadyen et al., 2009; UNEP, 2016), which suggests ALDFG represents the largest category in terms of volume and potential impacts of ocean-based sources of marine litter (PEW charitable Trust, 2020; UNEP, 2016).

> “While the quantities of ALDFG lost each year are not well known, it is estimated that globally ~ 640,000 tonnes are lost annually”
>
> Macfadyen et al., 2009

1. Overview of fishing gears used in the UK

Fishing methods can broadly be categorised into either static or mobile. Mobile fishing gears are those which are towed from a fishing vessel or land based vehicle; while static gears are nets or traps that are deployed from a vessel or the shore but do not remain attached to the vessel (Kaiser, 2014). Some static gears can either be anchored to the seabed and remain in a fixed, permanent position with the catch emptied periodically (e.g. traps and pots), or they may drift passively in the instance of drift nets. Brief descriptions of the different fishing gears are provided below and are summarised in Table 1.

1.1 Mobile fishing gears

Mobile gears are often dragged along the seabed which can cause habitat destruction or degradation, as well as posing a risk that fishing gear may get snagged and result in it becoming lost or abandoned (Watling, 2005).

Beam trawls involve towing a net (typically composed of polyethylene (PE) or polypropylene (PP)) which is attached to a rigid beam and shoes along the seabed to target benthic species, such as flatfish and brown shrimp. The beam ensures the net is held open while the shoes enable it to glide across the seabed.

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- **Beam trawls** involve towing a net (typically composed of polyethylene (PE) or polypropylene (PP)) which is attached to a rigid beam and shoes along the seabed to target benthic species, such as flatfish and brown shrimp. The beam ensures the net is held open while the shoes enable it to glide across the seabed.

- **Otter trawls** derive their name from the two otter boards, or doors, which hold the outer wings of the net open. Otter trawls can be fished on the seabed for demersal species such as cod, whiting and Nephrops, or in the midwater for pelagic species such as herring and mackerel. As with beam trawls, the nets are typically made from PP or PE.

- **Seine nets** are primarily targeted towards midwater species, such as tunas, sardines and mackerel. Purse seine nets can be extremely large and take entire schools of fish. They often involve two vessels to deploy the nets and the term 'purse' come from the mechanism by which the net is closed, involving drawing in the lead line at the bottom of the net. Seine nets are usually made from polyamide (PA) or PE, with plastic surface floats (either PE, polyvinylchloride(PVC), polyethylene terephthalate (PET)).

- **Dredges** fall into two categories: mechanical or hydraulic. A typical dredge involves a robust bag attached to a rigid metal frame which has either cutting blades or toothed bars fitted (mechanical dredges) or water jets (hydraulic dredges), these are towed along the seabed where the teeth or water jets disturb shellfish in the sediment. Dredges are used to capture sedentary species, such as scallops, clams and gastropods, which live either on or within the seabed sediments.

1.2 Static fishing gears

Static gears operate passively to entangle or trap target species which move towards or into them (Kaiser, 2014). These gears are deployed and left in the sea for a period of time, this duration is known as the 'soak-time' and for most gears there is an optimum soak-time after which the catch rate decreases. Generally, static gear is considered to be selective for target species and there is less by-catch than in mobile fishing methods (Pawson, 2003), however there is a greater perceived risk of static fishing gear becoming lost due to the period of time they are left between deployment and retrieval (Werner et al., 2016).

- **Gillnets** are a series of mesh panels with a lead foot rope and a headline with floats, which hold the net vertically, from the seabed to the surface, in the water column, but their position depends on tidal conditions and whether nets are set from the surface or from the seabed. They derive their name from their method of capture, as fish attempt to swim through the net they become snagged by the spines on the gills or fins. Gillnets are typically made from monofilament or multifilament PA mesh, with a floating headline comprised of PE or PP and polystyrene floats.
- **Trammel nets** are similar to gill nets, but are mainly set on the seabed. These incorporate three layers of netting (typically made from PA) which entangle fish. Trammel nets are effective for catching flatfish, rays and crustaceans.
- **Tangle nets** use much larger PE or PP meshes than either trammel or gillnets. They are designed so that the mesh hangs loose between the headline and footrope. As fish or crustaceans move over the net they become snagged on the loose mesh and become rolled up in the netting. Tangle nets are particularly effective for spiny organisms such as monkfish, lobsters and spider crabs.
- **Traps and pots** act on the principles that a guiding mechanism directs fish or crustaceans into the entrance of the trap which has a series of non-return chambers or a maze of passageways which prevent the animal from escaping. Pots are typically comprised of wood, metal and plastics (PE and rubber) which are usually deployed in fleets anchored at both ends and marked by surface buoys. Pots are baited and set for several days to attract target species.

Table 1. The main types of fishing gears used in the marine environment in Europe. The broad category of target species are indicated in parentheses. Data taken from Kaiser, (2014).

MOBILE FISHING GEAR	STATIC FISHING GEAR
Beam trawl (flatfish, some roundfish and brown shrimp)	**Gillnet** (primarily roundfish)
Otter trawl (primarily roundfish, Nephrops norwegicus, queen scallop)	**Trammel net** (roundfish, flatfish, rays, certain crustaceans)
Pair trawl (Nephrops norwegicus, roundfish)	**Longlining** (all types of fish
Seine nets (roundfish, flatfish)	**Pots and traps** (crabs, lobsters, whelks, prawns and some fish
Dredges (surface dwelling and burrowing scallops and clams, worms)	**Barrier traps** (roundfish and flatfish)

2. Impacts of abandoned, lost or discarded fishing gear

The loss or abandonment of fishing gear can have wide ranging impacts, affects economic productivity and aesthetic values, as well as degrading the natural environment

2.1 Environmental impacts

2.1.1. 'Ghost fishing'

The ability for ALDFG to continue capturing and killing marine life is known as 'ghost fishing' (Brown and Macfadyen, 2007). Theoretically, this occurs once the contents of a lost pot/net (both target species and bycatch) die and attract more animals, which in turn become entrapped or entangled and die, attracting more. This cycle of mortality continues until the pot or net breaks down and can no longer fish.

Static gears such as gillnets and traps/pots are perceived as the two types of fishing gear with the greatest risk of ghost fishing (Werner et al., 2016). Indeed underwater surveys by Matsuoka et al., (2005) found many types of gear derelict on the seafloor of Kyushu Island, Japan, but ghost fishing of finfishes and other commercial species was only documented by static gears (traps/pots, gillnets, trammel nets) and some small seine nets.

The exact duration gears continue to fish for remains unquantified, but studies estimate that fishing gears can capture marine life for at least 2 – 3 years (Furevik and Fosseidengen, 2000), with pots located in shallow waters continuing to capture animals for over three years (Matsuoka et al., 2005). Depth, environmental conditions and gear characteristics are likely to affect the efficiency of ALDFGs to ghost fish (Pawson, 2003). Most gears show a steady increase in ghost fishing over time, reaching a maximum catch, before slowly decreasing their catching capacity (MacMullen et al., 2003; Revill and Dunlin, 2003), likely due to the fragmentation or fouling of the gear. Nonetheless, fishing rates may continue at not insignificant levels; one study found that gillnets lost on open ground continued to operate at around 90% catch efficiency after four weeks (MacMullen et al., 2003), while the majority of other studies report catches of up to 20% of their original capacity (Brown and Macfadyen, 2007; Humborstad et al., 2003; Werner et al., 2016). For lobster pots, the catch per unit effort reached a maximum level 125 – 270 days after initial deployment (Bullimore et al., 2001). Consequence, ALDFGs can cause mass mortality of numerous species over the duration that ghost fishing persists (Macfadyen et al., 2009; Werner et al., 2016).

> "One study found that gillnets lost on open ground continued to operate at around 90% catch efficiency after four weeks."
>
> MacMullen et al., 2003

2.1.2. Entanglement

Fishing nets, lines, pots and traps are some of the most commonly cited items associated with the entanglement marine life (Gall and Thompson, 2015; Kühn et al., 2015; Macfadyen et al., 2009). The risk of entanglement varies according to the size and structure of the lost gears as well as their location (Sancho et al., 2003). Entanglement may compromise an animal's mobility and in turn its ability to feed and grow, cause tissue damage and ulceration, or cause direct mortality through entrapment, starvation or asphyxiation (Kühn et al., 2015; Werner et al., 2016).

Entanglement cases are often reported anecdotally and relate differently to individual species, but the majority of entanglements reported (80%) document mortality of organisms (Sherrington et al., 2014). Analysis of a long-term ALDFG retrieval program in Puget Sound, USA estimated that the 5000 nets removed were responsible for entangling more than 3.5 million animals per year, which included 25,000 birds, 100,000 fish and 3 million invertebrates (CBD, 2016). In the UK, the incidence of entanglement is estimated to range between 2 – 9 % for some populations of seabirds and marine mammals (Allen et al., 2012; Werner et al., 2016). The Hebridean Whale and Dolphin Trust report that of all the minke whales stranded in Scotland between 1992 – 2000, 21% died due to entanglement (OSPAR Commission, 2009). During surveys conducted between 2014-2015 around Cornwall, 12 different species including seals, seabirds, catsharks, and invertebrates: crabs, mussels and the protected pink sea fan (CBD, 2010; JNCC and Defra, 2012) were found entangled in fishing gear (Sayer and Williams, 2015), indicating the diversity of species impacted.

Many seabirds incorporate marine debris, and in particular fragments of rope and net, into their nests, which present a further route of entanglement. A study found that 75% of gannet nests in three sites in North America contained fishing debris which was linked to the level of gillnet fishing effort in the waters around the colonies (Bond et al., 2012). At one of the largest gannet colonies in the UK, Grassholm island, nests were found to contain on average 470 g of plastics, mostly comprising of rope (Votier et al., 2011). At this colony between 37 - 89 birds were entangled in their nests each year, with the majority of these being nestlings; and a total of 525 individuals were recorded over the eight year study (Votier et al., 2011), such numbers could lead to population decline.

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>
> CBD, 2016

2.1.3. Ingestion

Large animals, such as marine mammal have been found with fishing related debris in their stomachs. A beached sperm whale was documented to have ingested 200kg of fishing gear (Ocean Conservancy,

"A beached sperm whale was documented to have ingested 200kg of fishing gear ... and post-mortem of a grey seal indicated ingestion of fishing line which had caused internal lacerations"

OSPAR Commission, 2009

2009), and post-mortem of a grey seal indicated ingestion of fishing line which had caused internal lacerations (OSPAR Commission, 2009), however such isolated reports make it difficult to quantify the ingestion of fishing related debris. Furthermore, the consumption of items are limited by the size of an organisms their mouths or feeding appendages. This means for the majority of animal's plastic items must fragment into smaller pieces for them to be ingested, which in turn makes attributing the sources of these plastics challenging, as the fragments do not resemble the items from which they originated.

While in use, ropes and nets can shed fibres and in the environment fishing gears can slowly break apart releasing synthetic fibres (Lusher et al., 2017). The ingestion of microplastic fibres are documented in a number of species including of commercial importance, such as cod, john dory and whiting (Foekema et al., 2013; Lusher et al., 2013) along with oysters, mussels and lobsters (Murray and Cowie, 2011; Renzi et al., 2018; Van Cauwenberghe and Janssen, 2014). While it is certainly not the case that fishing-related activities are the sole source of microplastics, some studies have linked the presence of ingested fibres in organisms to local fisheries sources (Dantas et al., 2012; De Witte et al., 2014; Mathalon and Hill, 2014).

2.1.4. Habitat destruction

Regardless of the type of fishing gear or where it was deployed within the water column, ALDFGs will ultimately sink to the seabed where they can impact seafloor communities. ALDFG can detrimentally affect benthic environments through smothering, abrasion, "plucking" of organisms and the translocation of seabed features (Macfadyen et al., 2009). The smothering of the seabed can reduce oxygen within the sediments and affect the biogeochemical properties of the underlying seafloor itself (Kühn et al., 2015). The implications of this on the habitat are greater in sensitive or more dynamic environments such as those in shallow water with strong tidal flows. Seagrass beds have been shown to decrease shoot densities in areas were fish traps were located (Uhrin and Fonseca, 2005), partly due to the weight of the traps abrading the seagrass fronds and pushing them into the oxygen-depleted sediment below. Lewis et al., (2009) tracked unbuoyed lobster pots, which simulate lost pots from the fishery, and measured that each pot damaged areas of 1 – 4.6 m2 of reef and reduced the cover of organisms from 6 – 15%.

2.1.5. Transport of species including non-natives

A total of 387 taxa, including microorganisms, seaweeds and invertebrates, have been found rafting on floating litter in all of the major oceanic regions (Kiessling et al., 2015). This type of species dispersal is not a new phenomenon as natural debris act as transport media that have promoted sea-based colonisation for millions of years. Natural materials, such as wood and seaweeds tend to degrade and sink within months. Conversely, plastics persist over much longer time scales (decades or longer), and so offer a mechanism for species to be transported over much greater distances (Barnes and Milner, 2005) and time-scales. Additionally their surface properties may favour the attachment and thus possibility for transport to new areas by both mobile and sessile species (Werner et al., 2016). Non-native species have been identified on fishing debris collected in northern Spain (Miralles et al., 2018) and on the Pacific Island of Rapa Nui (Easter Island) (Rech et al., 2018). Overall few studies have assessed the potential for ALDFG to transport non-native species and it is likely that their contribution is lower than other forms of marine plastics, such as packaging (GEF, 2012).

2.2. Socio-economic impacts

2.2.1. Impacts to fisheries

ALDFG poses economic harm to the fishing sector in a number of ways. Assuming gear was lost, as opposed to purposely abandoned, this represents considerable cost to the fisherman in gear which they must replace (Werner et al., 2016) and reduced fishing time. Gear once lost, represents an additional snagging danger to bottom contact fishing gears, potentially leading to further losses or the damage of fishing gear/ vessels (Macfadyen et al., 2009). A trap-fisher in the Scottish Clyde reported losses of up to US$21,000 in lost gears and a further US$38,000 in lost fishing time (SEAFISH, 2003).

ALDFGs which continue to fish ('ghost fishing') waste fishery resources in turn reducing fisheries' economic efficiency. Ghost fishing has been estimated to remove between 0.5% - 30% of landed catches of market species in various European and North American fisheries (Brown and Macfadyen, 2007; Gilman, 2015; Laist, 1997). Sancho et al., (2003) considered lost tangle nets to catch an equivalent of around 5% of the total commercial catch in northern Spain, while in the USA an estimated $250 million of marketable lobster is lost to ghost fishing annually (Allsopp et al., 2006). Bycatch and animal mortality caused by derelict crab pots in Chesapeake Bay, USA, was estimated to represent an annual economic loss of US$300,000 (Bilkovic et al., 2014). Factoring in the cost of lost nets plus the loss of available fish stock arising from ghost fishing, Brown and Macfadyen, (2007) estimated a not insignificant total loss of €26,400 to European gillnet fisherman per year.

As well as effects on overall fish populations there are concerns about the contamination of fish stocks from the ingestion of microplastics. Over 100 commercially important fish species such as hake, herring, whiting and sardines are reported to ingest microplastics (Kühn et al., 2015; Lusher et al., 2017), as well as shellfish, such as mussels, clams, oysters and crustaceans (Devriese et al., 2015; Kühn et al., 2015; Welden and Cowie, 2016). It is not known whether the levels of microplastics contained within fish and shellfish have impacts on human health, however there is concern in the fishing and aquaculture industry that even small quantities of microplastics may be preserved negatively by consumers and affect marketability (Beaumont et al., 2019).

2.2.2. Damage to vessels

Marine debris and ALDFG can have a number of impacts on the maritime sector. Key concerns are the safety risks associated with propellers becoming entangled, collisions with marine litter and blockages of vessel water intake valves (Mouat et al., 2010). Over 71% of harbours and marinas surveyed in the UK reported that their users had experienced incidents, the most common of which was fouled propellers (69%), blocked intake valves and pipes (28%), fouled rudders (13%) and fouled anchors (8%) (Mouat et al., 2010). As a result, these incidents can cause financial impacts or in extremely serious circumstances even injury or loss of life (Macfadyen et al., 2009). For example, The Korean Maritime Accident Investigation Agency report that a 110 gross tonnage ferry became entangled in fishing ropes resulting in its capsize and causing 292 deaths (Cho, 2005).

> "Bycatch and animal mortality caused by derelict crab pots in Chesapeake Bay, USA, was estimated to represent an annual economic loss of US$300,000"
>
> Bilkovic et al., 2014

2.2.3. Impact to tourism

Tourism is an important part of the economy of the United Kingdom; in 2019, it was valued at £145.9 billion (Tourism Alliance, 2019). While it is not possible to assess the impacts of ALDFGs, marine litter as a whole can negatively affect not only coastal recreational activities but also the aesthetic value of landscapes and scenery (Cheshire et al., 2009). Research indicated that observing litter when visiting the coasts evoked responses of concern in people (Hartley et al., 2018) and was often listed as a key reason why visitors avoided or spent less time in these environments (Beaumont et al., 2019). The presence of marine litter can impact the quality, cleanliness and safety of beaches and bathing waters, which can affect whether a beach is awarded a 'Blue Flag' or other such status (Mouat et al., 2010). Moreover, marine litter is considered a public health issue (Galloway, 2015). Beach-goers may injure themselves on debris and entanglement poses a serious threat to swimmers and SCUBA divers (Cheshire et al., 2009; Mouat et al., 2010). Indeed, each year several incidents of SCUBA divers becoming entangled are reported which could have life-threatening consequences (Fanshawe and Everard, 2002).

2.2.4. Cost of removal

Due to the safety and economic reasons listed above, clean ups are undertaken to remove litter from coastal areas. Direct costs include the collection, transportation and disposal of the litter collected, as well as associated administrative costs. Coastal municipalities in the UK spend approximately €18 million each year removing beach litter, with an average coast of €139,000 per municipality (Mouat et al., 2010). In addition, voluntary organisations play a key role in litter removal. The amount of time volunteers from 9 different organisations spent collecting litter equated to a monetary value of €84,579.35 in labour to pay manual workers to do the equivalent job (Mouat et al., 2010). Based on the number of Marine Conservation Society volunteer hours spent cleaning UK beaches in 2018 (Marine Conservation Society, 2020) this equates to a value of £350,590 of labour cost (based on current UK minimum wage (UK government, 2020)). While it is not possible to assess the proportion of the cost relating to removal of fishing debris alone, Nelms et al., (2020) found that fishing-related litter accounted for 12% of all the items on UK beaches, indicating that this a not insignificant source.

Harbour Authorities pay to keep navigational channels clear of litter and the estimated annual cost from 34 harbours was approximately £236,000; based on this, it was estimated that marine litter costs the ports and harbour industry in the UK approximately £2.1 million each year (Mouat et al., 2010). Additionally some ports in the UK spend up to €55,000 per year to clear fouled propellers (Hall, 2001). These figures serve to highlight the economic burden posed by marine debris including ALDFGs.

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>
> Mouat et al., 2010

3. Overview of the UK fishing fleet

In 2018, there were 4512 active fishing vessels registered in the UK (Quintana et al., 2019) which were responsible for landing 692,000 tonnes of fish, valued at close to £1 billion (Marine Management Organisation, 2019). More recent figures show that the number of fishing vessels has slightly decreased to 3252 vessels in 2020 (as of 17th June 2020) (Marine Management Organisation, 2020a). The majority of these vessels (78% in 2018, now 69% in 2020) are under 10m in size and operate mostly in inshore areas around the UK (Marine Management Organisation, 2020a; Quintana et al., 2019). Within the UK, the pelagic fishery accounts for the greatest number of landings, with shellfish constituting the lowest; however in terms of the value of these, shellfish are the highest value fishery brining in £362 million in 2018 (Marine Management Organisation, 2019).

> "In 2018, UK static fishing gear vessels landed 15,7000 tonnes of demersal species, 5000 tonnes pelagic species and 59,000 tonnes of shellfish, equating to £210.2 million"
>
> Marine Management Organisation, 2019

The three largest ports, accounting for 52% by quantity and 35% by value of all UK landings (Marine Management Organisation, 2019) are located in Scotland: Peterhead, Lerwick and Fraserburgh. The highest contributing ports within England are all situated on the South coast: Brixham, Newlyn and Shoreham (Marine Management Organisation, 2019), with the former two ports located in Devon and Cornwall respectively.

While UK fishing vessels vary in the types of gear they use, the majority employ static fishing methods: approximately 64% of vessels used static fishing gears in 2018 (Quintana et al., 2019), which increased to 72% in 2020 (data as of June) (Marine Management Organisation, 2020a). In 2018, UK static fishing gear vessels landed 15,7000 tonnes of demersal species, 5000 tonnes pelagic species and 59,000 tonnes of shellfish, equating to £210.2 million (Marine Management Organisation, 2019). The number of pots/nets fishers deploy varies based on the seabed character, the fishing ground and the size and design of the vessel. Lobster creels are either shot individually, or more commonly in strings, known as fleets, where a number of pots are attached to one long rope which is laid on the seabed. Typically the fleet numbers in most lobster fisheries can be anything up to 50 creels and will largely depend upon the number the boat can comfortably accommodate on deck at any one time, while for Nephrops fisheries, fleets can number around 100 creels. Static nets vary in length from 50 m to 200 m and the length of fleets from 300 m to 2000 m. Therefore the amount of netting being fished (set on the seabed) at any one time can range between 2 kilometres and 30 kilometres and the soak time (the time a fleet is left on the seabed to fish) can range from a 6 hour tidal soak to 72 hours (SEAFISH, 2011).

3.1. Overview of fishing activity in the South West of England

Three main administration ports within the South west of England, based on numbers of vessels

Table 2. The number of fishing vessels under and over 10m in length registered to the three largest administration ports in the South West of England in 2019.

ADMIN. PORT	NO. OF REGISTERED VESSELS			NO. OF VESSELS USING STATIC FISHING METHODS[a]		NO. OF VESSELS USING MOBILE FISHING METHODS[b]	
	< 10 m	10 m +	Total	< 10 m	10 m +	< 10 m	10 m +
Brixham	160 (67%)	78 (33%)	238	172	29	128	79
Plymouth	142 (68%)	68 (32%)	210	136	25	103	62
Newlyn	393 (84%)	77 (16%)	470	401	64	292	44

Data (Marine Management Organisation, 2020a).
[a] static fishing methods are defined as: driftnets, gillnets, pots, set longlines and trammel nets
[b] mobile gears are defined as: trawls (beam, otter, pair trawls), seines, dredges, longlines, **N.B.** Vessels where 'miscellaneous gear' was recorded are not included as they could not be assigned to a category: static/mobile.

registered are Brixham, Newlyn and Plymouth. Data from 2019 identified Newlyn to have the largest fleet of vessels within its administration (470), of which 84% were under 10m in length. (Table 2). The majority of the vessels using static methods are under 10 m in length, however this is confounded as a vessel may be registered as using multiple fishing gears. Indeed a single vessel in Brixham was recorded as using five gear types; therefore in Table 2, the sum of the vessels using mobile and static gear methods exceeds the total number of vessels within the administration port. It was noted that the use of multiple gear types is particularly common in smaller vessels (pers. comm).

Within Devon and Cornwall, a total of 558 vessels hold shellfish licences (Marine Management Organisation, 2020b, 2020c). Under the permit system quotas on the numbers of different species which can be landed each day are imposed, however there is no restriction on the number of pots per vessel (Cornwall IFCA, 2016; Devon & Severn IFCA, 2020). There are however, restrictions for the number of pots which can be used in the live wrasse fishery (Devon and Severn IFCA, 2018), which states that permit holders cannot exceed 120 pots per vessel and there is an annual closure of the fishery between 1st April – 30th June. The live wrasse fishery has only been operating in the South West of England since 2015, with Plymouth being one of the main operational ports (Davies and West, 2017).

“Static nets vary in length from 50 m to 200 m and the length of fleets from 300 m to 2000 m.”

SEAFISH, 2011

4. The magnitude and composition of ALDFG

Since the initial assessment of Macfadyen et al., (2009), performed now over a decade ago, which estimated that 6.4 million tons of fishing gear enters the oceans annually, there have been few attempts to update this figure. This may be due in part to the lack of requirements to report such information and partly to the commercial sensitivity surrounding this. Consequently, assessing the magnitude of ALDFG have great challenges associated.

The likelihood of different gear types becoming lost varies widely. An evaluation by the Global Ghost Gear Initiative rated gillnets to have the greatest risk, in terms of the likelihood of becoming lost and causing detrimental impact due continued ghost fishing; pots and traps were rated to have the next highest risk (Global Ghost Gear Initiative, 2016). when considering nets, fixed nets like gillnets were found to have the highest risk of being lost, while bottom trawl nets and were considered ow risk and midwater trawls like purse seins had the lowest risk of loss associated (PEW charitable Trust, 2020). This is supported by studies which quantified ALDFG over regional scales and indicated that static gear may be more likely to be lost that mobile gears. Globally it is estimated that 8.7 % of all traps and pots and 5.7 % of nets are lost annually.

On a regional scale the scale of loss also varies, often based on spatial and operational pressures. Early work by Breen, (1987) used fishers' responses to estimate the annual rate of 11% trap loss in the Fraser River Estuary of British Columbia. The commercial crab fishery in Queensland, Australia report annual pot losses of 35 pots/fisher, equating to in excess of 6000 pots for the entire fishery, of which only half are recovered (Sumpton et al., 2003). In Norway, interviews with fishers identified that repair of large expensive nets such as those used in seines and trawls are frequent, with 50% and >80% of gears respectively undergoing major repairs annually; while only a third of inexpensive fishing gears, such as gillnets, pots/traps and longlines undergo major repairs (Deshpande et al., 2020). This indicates that static gears likely have a greater turn-over than larger mobile gears, at least within the Norwegian fleets. The study also found significant differences in the probability of loss rates for different fishing gears. Longlines and pots/traps were identified to have the highest chances of loss, with around 4 - 7% of the total longlines and traps/pots owned by the Norwegian fishing fleet ending up in the ocean every year (Deshpande et al., 2020).

At selected sites in Spain, 89 vessel captains were interviewed, the data indicated annual gear losses for net fisheries (gill, trammel and tangle) were 1,186 nets, represents an average loss of 13.3 nets per vessel (MacMullen et al., 2003). This loss was higher for vessels of over 10 gross tonnes (16.2 nets/vessel), than for those of a smaller tonnage (10.4 nets/vessel).

> "Interviews with UK fishers using tangle nets in selected locations identified that on average 24 km of nets are lost per year, of this around 35% (13 km) is recovered."
>
> MacMullen et al., 2003

If this data is extrapolated to the entire Spanish fishing fleet, it's estimated that 2065 nets/year are lost in monkfish fisheries, 774 nets/year are lost in 'other net' fisheries, 600 nets/year are lost in red mullet fisheries and 100 – 500 nets/year are lost in shallow water fisheries (MacMullen et al., 2003). The losses by the Spanish fleet were much larger than those recorded in France where net losses varied between 2 – 10 nets/boat/year depending upon target fishery and area of fishing operation (MacMullen et al., 2003). Whereas in the Baltic Sea an estimated 5000 – 10,000 gill nets were lost in one year (2011) alone (Werner et al., 2016). More recently in the Netherlands, it was estimated that fisheries related waste makes up around 20% of the items and around 50% of the weight collected through Fishing for Litter schemes (OSPAR Commission, 2020).

As indicated in the figures above, across European (EU) fisheries estimates of ALDFG vary widely. Reports have suggested that around 25,000 nets may be lost or deliberately discarded annually within the EU, accounting for 1,250 km of net (Browne et al., 2015), while another source estimates that between 2000 – 12,000 tonnes of fishing gear are lost annually from the active EU fishing fleet (Eunomia, 2016).

While data on the quantities of fishing gears lost, abandoned or discarded is sparse and highly variable between locations and gear types, what is clear is that over a global scale ALDFGs represents a large source of debris entering the oceans

4.1. The magnitude and composition of ALDFG in the UK

Within the UK, there is no requirement for fishers to declare ALDFGs, this lack of empirical data poses challenges when trying to quantify ADLFG within the UK fishing fleet. However some sources of data where identified and utilised to facilitate assessments.

Interviews with UK fishers using tangle nets in selected locations identified that on average 24 km of nets are lost per year, of this around 35% (13 km) is recovered (MacMullen et al., 2003). All losses were attributed to conflict with mobile gear fishers such as scallop dredgers or trawlers. Within UK coastal fisheries it is estimated that 263 tangle nets and 62 hake nets (a gillnet which targets hake) are lost annually (Macfadyen et al., 2009).

> "Globally it is estimated that 8.7 % of all traps and pots and 5.7 % of nets are lost annually."

The Marine Conservation Society (MCS) beach clean have run beach litter surveys ad clean-ups since the mid-1990s. These surveys can provide useful insights into the abundance of different litter items over spatial and temporal scales. Utilising a MCS dataset spanning the last 25 years, Nelms et al., (2020) found that 13% of litter items surveyed along English coastlines were attributed to fishing activities.

For the purpose of this report, the MCS provided 'fishing related litter' data from the years 2007-2018 (Marine Conservation Society, 2020). Of the twenty-two categories monitored which could be attributed to the fishing sector, 12 were identified as 'gear', while the remaining 10 were ancillary items (such as fish boxes, buoys, strapping, gloves) which were not considered in the analysis below (Marine Conservation Society, 2020) (Appendix 1). Of note, three of these categories (Plastic: tangled nets/cord/string; Plastic: oyster pots; Plastic: oyster nets/mussel bags) were only introduced in 2016, hence no data for these categories are available prior to this. Data were normalised by the number of volunteer hours to compare the prevalence of different items between years.

Plastic string/cord/rope was the most abundant item found each year around the UK (Figure 1) however several of the categories showed a decreasing trend in their abundance over the years. Items associated with pot fisheries were found infrequently, with one item recorded every 100 - 500 volunteer hours, depending on the year. (Figure 2).

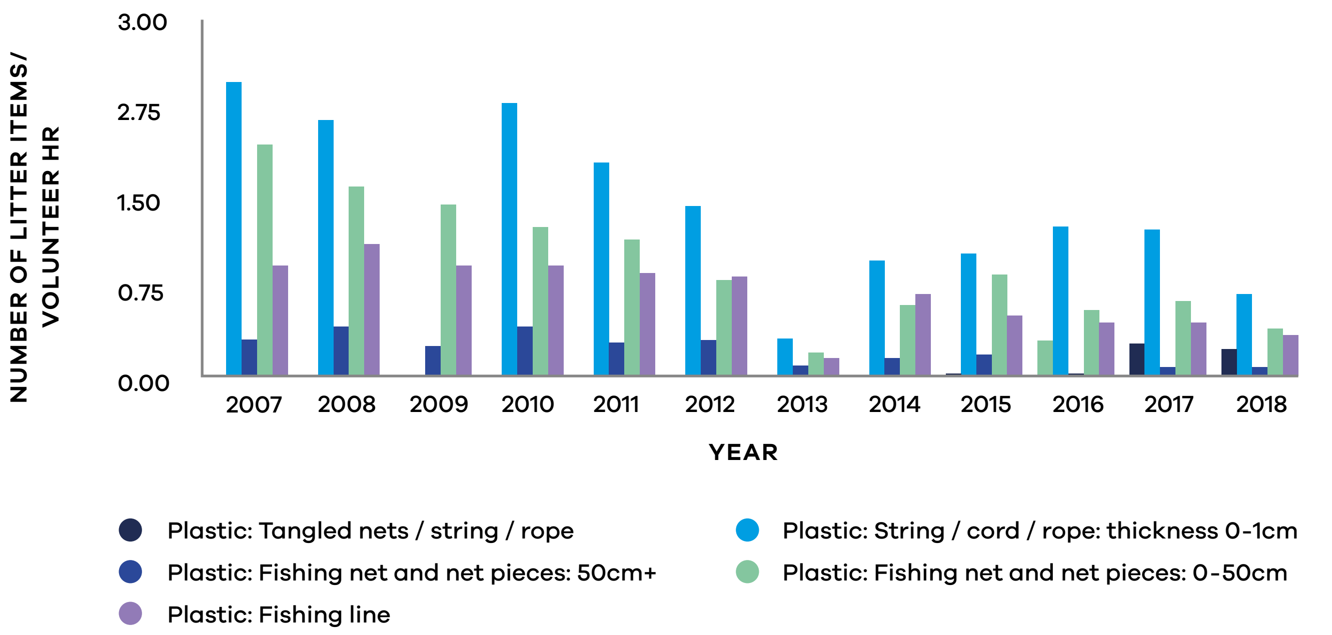


Figure 1. The number of fishing litter items normalised by volunteer hours, recorded by Marine Conservation Society volunteers on beaches around the United Kingdom during the years 2007 - 2018. Note difference in axis-scale between the figure below.

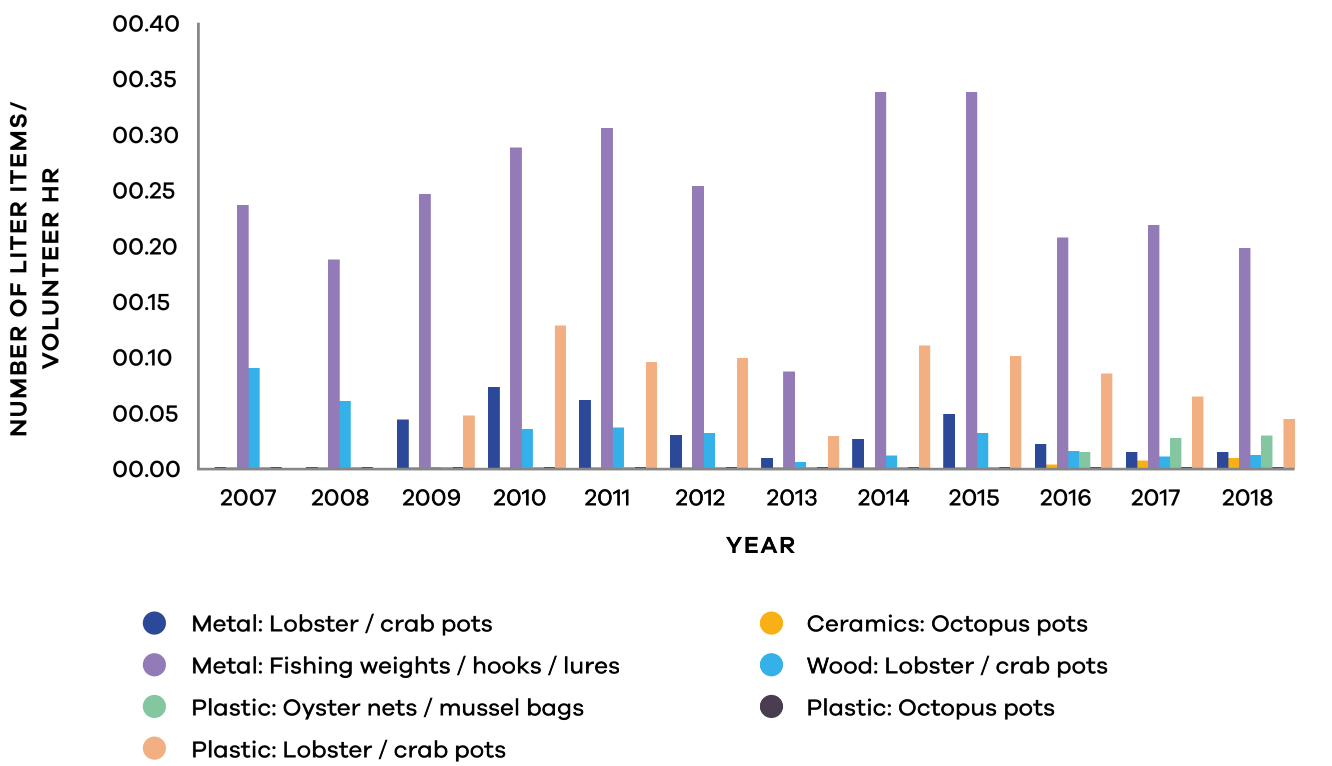


Figure 2. The number of fishing litter items normalised by volunteer hours, recorded by Marine Conservation Society volunteers on beaches around the United Kingdom during the years 2007 –2018. Note difference in axis-scale between the figures above.

4.2. The magnitude and composition of ALDFG in the South West of England

In the absence of empirical data, several other indirect sources were considered to assess fishing gear losses within the South West of England. These can broadly be divided into three categories, each of which are discussed below.

4.2.1. Assessing ALDFGs in beached debris

The MCS beachwatch initiative surveyed a total of 231 unique locations in Devon and Cornwall during the years 2007 - 2018, amounting to a total of over 31,000 volunteer hours (Marine Conservation Society, 2020). As in section 4.1, the 12 fishing gear categories recorded within the MCS dataset (Marine Conservation Society, 2020) were included in the regional analysis below.

Items of net, rope/string were the most commonly found debris across all years, with typically between 0.5 – 3 items recorded by volunteers per hour (Figure 3). Pots were less frequently recorded, with an items attributed to pot fisheries only logged once every 15 volunteer hours (Figure 4), however this rate is much higher than when considering the entire UK, where only one pot fishery item was found every 100 - 500 volunteer hours. Overall fishing related debris was more commonly found per volunteer hour in the South West of England (Devon and Cornwall) than in the UK as a whole (Figure 1 - Figure 4).

> "The MCS beachwatch initiative surveyed a total of 231 unique locations in Devon and Cornwall during the years 2007 - 2018, amounting to a total of over 31,000 volunteer hours"
>
> Marine Conservation Society, (2020)

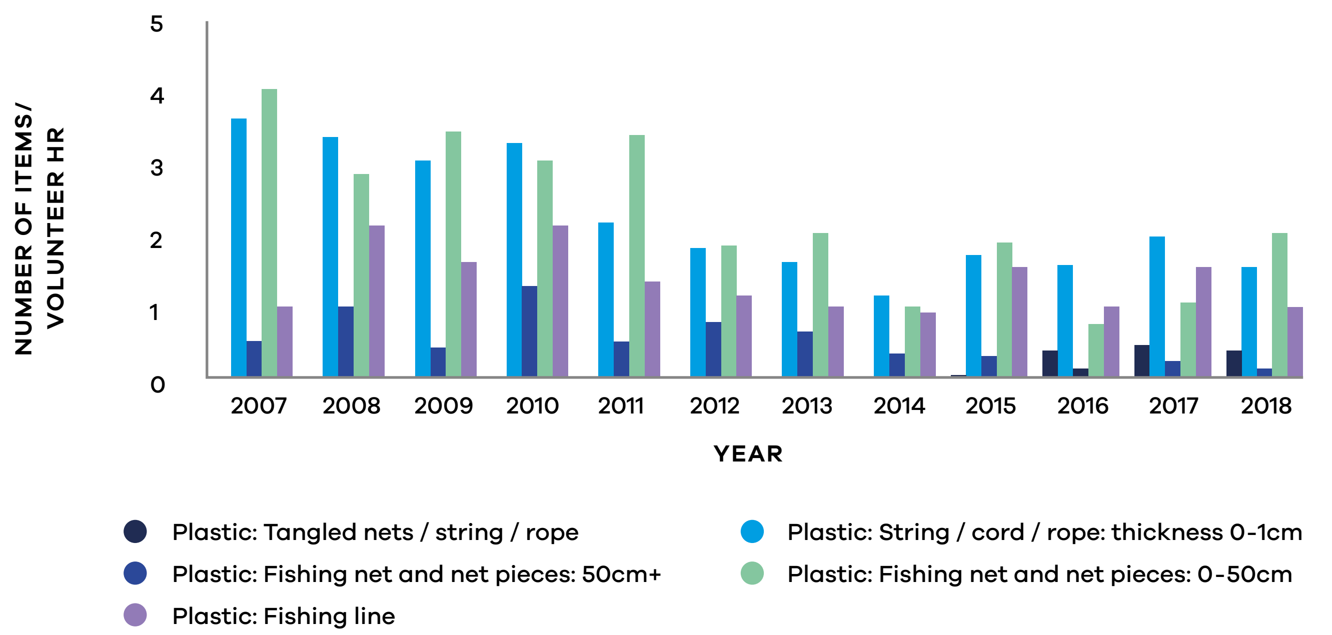


Figure 3. The number of net/string fishing litter items recorded normalised by volunteer hours on beaches in Cornwall and Devon during the years 2007 – 2018. Note difference in axis-scale between the figure below.

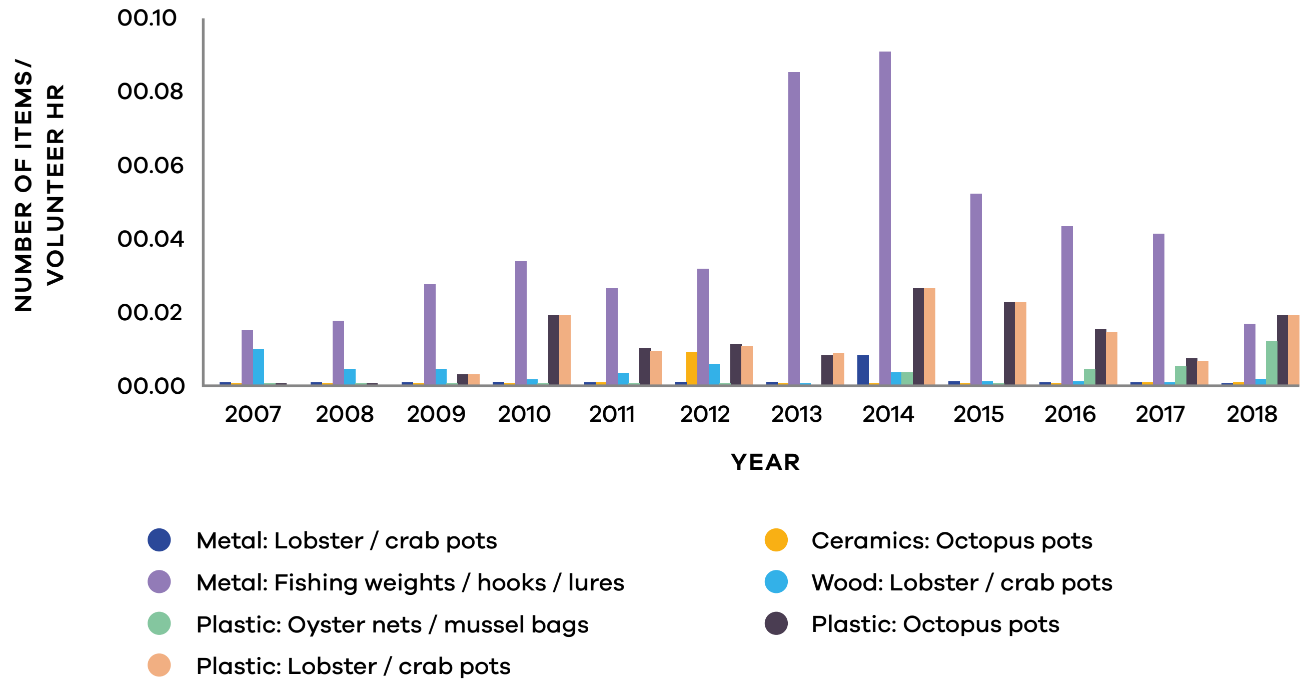


Figure 4. The number of fishing litter items recorded normalised by volunteer hours on beaches in Cornwall and Devon during the years 2007 – 2018. Note difference in axis-scale between the figure above.

Additionally, the Cornwall Seal Research Trust conducted fishing litter surveys during the years 2014 and 2015. Monthly boat-based surveys along the north Cornish coast indicated floats/buoys were most prevalent debris, followed by trawl nets, monofilament nets and rope, which were found to be widespread across the survey area, while pots were only identified at three of the sites surveyed (Sayer and Williams, 2015). Systematic land-based surveys were carried out which identified rope and monofilament line as the most prevalent debris, followed by trawl nets and pots/rubber strips (Sayer and Williams, 2015). Hotspots of litter were identified in several locations on the north and south coasts including at Polzeath, Hayle, Marazion and around Plymouth and Plymouth sound. These locations are in close proximity to some of the busiest administration ports where a large fleet of vessels operate from (Marine Management Organisation, 2020a, 2019), and could indicate point source pollution of fishing items into the marine environment.

4.2.2. Assessing ALDFG in underwater debris

Schemes working with the fishing industry, such as Fishing for Litter (FFL; https://fishingforlitter.org/), have been successful in increasing knowledge about marine debris along with raising awareness and investigating the attitudes and behaviours of fishers to marine litter. The FFL scheme was established in the South West of England in 2008 and incentivises the removal of marine litter by funding the disposal of marine litter brought up in the hauls of participating fishers. During its initial three years, 100 vessels in Devon and Cornwall removed 40 tonnes of litter which was mostly comprised of lightweight plastics, rather than heavy industrial materials, as had been found in the FFL scheme in Scotland (DEFRA, 2014). the number of participating vessels has subsequently increased to 213 from 12 harbours in the South West of England, who in 2016-17 removed 42 tonnes of litter (Kimo International, 2020). While the debris recovered by FFL is not sub-categorised into different types, and so estimates regarding the quantities of fishing debris recovered is not possible, is does still provide some indication of marine litter as a whole.

Extensive interviews with fishers participating in the FFL scheme in the South West of England reported that since signing up they had noticed reductions in the amount of marine litter being brought up in hauls at certain fishing sites (DEFRA, 2014; Wyles et al., 2019). Conversely, a South Devon harbour master (SD1 in the interviews below) remarked that while the "amount of gear being lost is less than in previous years, the amount of fishing gear brought back to shore is steadily increasing" (pers. comm.). He noted that it is "impossible to discern whether the gear being brought back is genuinely recovered from the sea", or if this is gear which has reached the end of its life and is falsely being declared as 'recovered from the sea', as in this instance disposal costs are covered, which they are not for end-of-life fishing gear.

4.2.3. Surveys with harbour officers

A series of questions were sent to harbour masters located in the South West of England to collect qualitative data on abandoned, lost and discarded fishing gears. Five harbour masters provided responses which are detailed below, however not all respondent replied to every question. Respondents are kept anonymous and answers are coded according to geographic location

Question 1:

How frequently do fishers replace gear due to general wear and tear?

North Devon 1 (ND1): New pots arrive every year approx. 3-400, I can't say if this is due to loss or just upgrade, as for nets I am not privy to this information they mostly try to repair but on average I would say at least once per season.

South Devon 1 (SD1): The frequency with which fishers replace their gear varies but in general those which are the most 'industrial' (i.e. the largest vessels) might change it 2ce pa whereas a small day boat might nurse their equipment through several years. By gear I refer to the nets and wires which are consumable; their beams etc. might last much long.

North Cornwall 1 (NC1): as and when needed.

North Cornwall 2 (NC2): [it's] difficult to estimate, but pots probably last 2-3 years, and nets 2-3 yeas.

South Cornwall (SC1): Fishing gear is replaced sometimes on a seasonal basis especially the nylon inners of gill nets which are cut out and bagged up for re-cycling by the fisherman. Crab pots would only be replaced when they become worn out or damaged and would last ten seasons or more.

Question 2:

How much gear do you think is lost per year?

ND1: hard to say but looking at the deliveries about 30%

SD1: The amount lost is unquantifiable because there is no requirement to declare lost gear to harbour authorities

NC1: 50 to 100 pots and 1 to 3 nets

NC2: 5% of both pots and nets. Question 3:

Question 3:

Do you think the amount of lost gear has increased over the last 5 years, or over the duration you have been in your position?

ND1: I have been here for 2 years and it seems to be about the same amount being delivered

SD1: In general, much less is lost than in previous years, but the amount recovered and brought ashore is steadily increasing. It is however impossible to discern which is genuinely recovered and that which is being landed by responsible fishers who know that if they declare it as 'recovered' its disposal costs will be covered and thus they are incentivised to declare all end-of-life gear as 'recovered having been previously lost'

NC1: Increased due to a particular fisherman

NC2: about the same

SC1: Difficult to say if lost gear is increasing but I would imagine less gear [is] being lost in recent times as said before it is expensive to replace, and with modern navigational equipment being used more widely ie, GPS, SONAR, Ground mapping technology etc, fishing gear and the grounds that are fished are more precisely known which would lead to less fishing gear lost.

4.3. Quantifying the economic cost of ALDFG to fisher

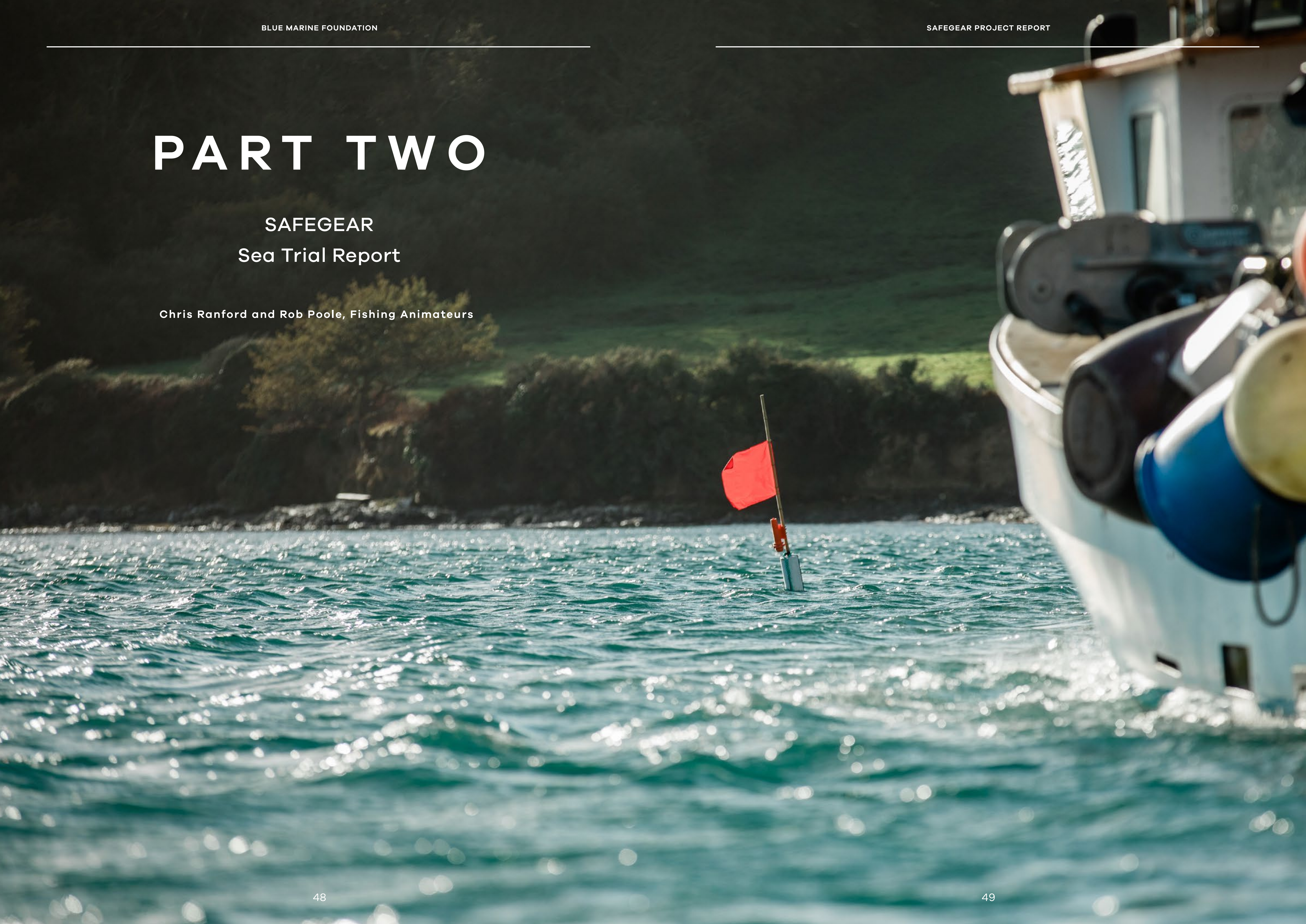
It was recently estimated that a vessel captain may typically invest between £2000 – £20,000 per annum on fishing gear components (The Scottish Government, 2019). The cost of fishing gear varies between gear types and the target species. The costs of fishing gears were obtained from widely used distributers in the South West of England: Coastal Nets and Gael Force Marine Equipment.

Lobster creels, depending on their size, vary in cost between £56.50 to £93.00 purchased new (Coastal Nets, 2020a; Gael Force Marine Equipment, 2020a) and for crab pots this is around £59 per creel (Coastal Nets, 2020a). The most commercially active vessels typically purchase between 50 – 300 creels per year (equating to £13,081 ± £11,702) and individual creels are deployed on strings of 10 – 30 which can last up to 5 years in use (The Scottish Government, 2019). Based on the global estimate of 8.7% of traps/pots are lost annually (Macfadyen et al., 2009), this equates to a value of between £246 – £2427 spent on replacing lost gear each year. This figure does not take into account other components, such as shackles, clips, line, floats etc, attached to the gear which may also become lost. It is also important to note this estimate does not take into account the monetary loses associated with the not landing the catch in the pot, the economic impact this has to the fishery through potential ghost fishing, and the time wasted in lost fishing activity while replacing the gear. Therefore the true economic value of lost gear is likely to be much greater than the estimate provided above.

The South Devon and Channel Shellfishermen association remark that with "the average cost of £100 per pot, significant efforts are made to recover any lost pots" (South Devon & Channel Shellfishermen, 2019). Personal communication with a harbour master in Devon, indicated that fishers on small vessels were likely to "nurse their equipment through several years" while large industrial fishing vessels were likely to change their gear (nets and wires) around twice per year due to general wear and tear.

For static nets, costs vary depending on target species and net mesh size. Tangle nets may cost anything from £10.50 - £80.00 per net (Gael Force Marine Equipment, 2020b), or £58 - £93 per net for those ready rigged with lead line (Coastal Nets, 2020b), and trammel nets between £138 - £187 (Coastal Nets, 2020c). Based on figures of the 263 tangle nets and 62 hake nets lost per year (Macfadyen et al., 2009) and the average cost of static nets taken as £60.38 (ranging from £10-93 per net) (Coastal Nets, 2020c, 2020b; Gael Force Marine Equipment, 2020b), lost nets could represent an average cost of £19,623.50 to the UK coastal fleet. Again, this estimate is not considering the cost with other associated components such as shackles, lead lines, floats etc.

"Personal communication with a harbour master in Devon, indicated that fishers on small vessels were likely to "nurse their equipment through several years" while large industrial fishing vessels were likely to change their gear (nets and wires) around twice per year due to general wear and tear. "



PART TWO

SAFEGEAR
Sea Trial Report

Chris Ranford and Rob Poole, Fishing Animateurs

"Applying SAFEGEAR to manage and reduce the risk of gear conflict is a realistic way to reduce ghost gear, that fishermen demonstrably want. The benefits are far reaching, from the obvious reduced impact on the marine environment and fish stocks, the financial savings to the fishermen of having to replace lost gear, improving safety to fishermen by reducing the need to recover lost gear which can be very dangerous, as well as the safety benefits of not having ghost gear floating freely, potentially damaging other vessels."

Skipper, Cornwall

"I'm a fisherman from Mylor. I've been doing it for forty years. We've had a ot of gear gone missing in the last few years. There are many ways of losing your gear, we get gear towed away by trawlers and scallopers that come from different places so they don't know where all the gear is, and it gets moved half a mile or a mile away – the gear is lost. It's very costly, on average we lose at least about thirty pots a year and that's just one boat. All the fleet have the same issue. Smaller pots cost anywhere from £40 a pot, big ones are £100 a pot. If you get a full string of 30 pots go, it's a lot of money. But the main problem for us, the way we look at it, it isn't just the money side of it, that gear is at the bottom of the seabed and it's not very good for the ecosystem."

Cameron Henry, Mylor fisherman, sea trial cohort

"You go out in the morning, you don't know what you are going to face with your gear, you don't know if it's going to be there or not. It's a constant worry all the time. Since the last month, I've been using SAFEGEAR, I can just check to see where my gear is positioned, it's peace of mind. I can see this all day when I'm working. I can be five miles away and fishing another area and see that my gear is behind me and safe."

Ivor Henry, Mylor fisherman, sea trial cohort

"We have 300 pots at one time in the water as an average. 10 strings of 30, right through the whole year. We lose 60 pots a year (£80 per pot), a total of £4500 including ropes. We are trying to avoid this happening, but it's not possible with ships in our fishing grounds, we have no relationship with them. When large ships tow gear away, as we have no communications with them, we won't get it back. Having an AIS beacon on the end of each string of pots will highlight to large ships where we are fishing and that will ensure they do not anchor nearby. This will greatly reduce the risk of lost gear, which benefits the business and reduces ghost gear massively, that would be win-win for everyone. Obviously others will see my fishing grounds, but today's technology will show where I have been fishing anyway. We have fished together for 30 years, so we know where we all are."

Skipper, Cornwall of Tanegan, Looe

"Lost gear is expensive. £80 per lobster pot = £800 per year. £11 per whelk pot inc back ropes , so £600 per year including ropes etc The cost is significant , but the length of time without the gear, ordering , making it up, deploying it again is a major impact on our business, the crew then have a loss of earnings, so it's hard to retain them when we lost large amounts of gear."

Skipper, Cornwall, Silver Queen

"We encounter large amounts of gear conflict with other maritime craft, primarily large cargo ships that anchor in the fishing grounds and tow away gear when moving on. There is no way of them knowing where our gear is, so we are relying on them seeing our marker buoys, which are not going to be visible to 50m + vessels. It's cost me £3000 in the last year."

Skipper, Cornwall of Scorpio, Cadgwith

The Fishing Animateur held a number of quayside conversations to start the trial. This engagement was with fisherman's associations, producer organisations and fishing gear technology experts.

This built a knowledge base of gear loss, as well as the perceptions of the application of SAFEGEAR. Following this, fishermen in the south west of England were surveyed about how gear is lost, what it means to them and how something like SAFEGEAR could help. From the responses, a cohort of willing participants to engage in the sea trial were identified. The Fishing Animateur had a number of recommendations for how SAFEGEAR could develop further.

Geographic focus of trial

There is an increased congestion of marine traffic in the Falmouth Bay area. This consists of all types of marine traffic, including large ships anchoring and navigating in and out of Falmouth Bay. There are many active fishing vessels using various catching methods in the Bay and some of the small-scale coastal fishing vessels setting out static gears, such as nets and pots, within this busy marine space. Falmouth Bay is a known area for gear conflict. This focused the pilot communities and led to engaging with fishermen based in Cadgwith, Mylor and St Mawes, as well as further afield in Looe and Eastbourne, which were also deemed as areas where gear loss was an issue. From initial contact with these communities the fishermen were willing to engage with the project and saw a genuine benefit to reducing impact on the marine environment, as well as reducing the economic impact on their business through regular loss of fishing gear. The Fishing Animateur therefore spoke to fishermen in the following areas:

Cadgwith (some fishing in Falmouth Bay)

On the South Eastern tip of the Lizard Peninsula in Cornwall, Cadgwith is a beach fleet of u10m vessels. They primarily target shell fish using pots, but also diversify to static netting to target prime species, such as Red Mullet and Turbot. Cadgwith vessels are day boats, and known for high quality fresh fish and shellfish. The Cove is iconic in the artisanal small scale fishing world as operates in a very traditional way. The fleet is active on the East side of Lizard and Falmouth Bay, which is a busy marine area and many of the vessel owners in Cadgwith have encountered gear conflict with other maritime craft. They also suffer from Easterly winds and storms that pass through in the winter months, most notable recent storm would be the Beast from the East, which caused damage to gear and some gear loss. However, from interviews with local fishermen it is evident that the main reason for gear loss is due to conflict with other large vessels towing their gear away.

Mylor and St Mawes (Falmouth Bay)

Both fishing communities have a diverse range of small scale fishing vessels, using towed and static gears, operating from them, the majority of which will be inside of the 0-12 mile limit. Due to this they are at risk to gear conflict with large vessels steaming in and out of Falmouth Bay, who anchor in their fishing grounds, as well as large foreign trawlers inside of the 12m limit. There is significant increased marine traffic and large vessel activity within the 6mile limit , which is an area fished by the fleet here. The vessels are also susceptible to Easterly storm events, which can also have an impact on gear loss.

Looe

Further East on the Cornish coast, Looe is a strong fishing community with a focus on u10m day boat fishing vessels who use a diverse range of fishing gears. The fishing grounds from Looe are a good place to start a project testing AIS beacons on static nets to monitor and reduce potential gear conflict, as the area they fish is populated with trawlers and scallopers, so the risk to lost nets is high.

Eastbourne

In the South-East of England, there is a strong u10m fishing community, which is known as the Eastbourne u10m Fishermans CIC. The use of Eastbourne as part of the trial was based on the fact that this is a very busy marine traffic area, as well as a condensed space to fish from given the close proximity to France. This would put fixed gear vessels at high risk from conflict with other vessels, so was an obvious location to engage with.

Survey Responses

The Fishing Animateur surveyed over twenty fishermen to draw the following conclusions:

– The amount of gear set and used varied significantly with the size of vessel and target species. Those targeting with nets for sole, pollack or tangle had nets from a single sheet, with 30% setting under 1000m net, 30% setting 1000 to 5000m net and 40% setting over 5,000m of nets.

43.75%

of fishermen had lost gear due to poor weather or winter storms.

– With static gear around 45% of the sample has 100 to 300 pots set usually in strings from 10 to 50 pots. 22% had 300 to 500 pots set, with 22% 500 to 1000 pots and 11% over 1000 pots.

– The majority of these vessels were thought to be leisure vessels or large vessels anchoring. However, 56.25% of fishermen had experienced a fishing vessels towing gear such as a trawler, beamer or scalloper.

– Although most vessels incurred some loss of gear due to storms and poor sea and weather conditions, this was not the primary cause of gear loss. Most vessel owners stated that under extreme and/or unforeseen weather conditions they risk losing gear, but most attempt and are successful at recovering it. This is carried out by a method known as 'creeping' where they tow and anchor along the bottom of the sea in the estimated area where the gear might be, based on sea conditions. They are then able to haul it back on to the vessel and repair it, or bring it into port to dispose of it is is no l onger usable.

– 19 Vessel owners stated they would always attempt to creep and find any lost gear from storm damage for the two obvious reasons; not wanting to leave ghost gear fishing and the financial cost of the gear is so significant to them as a small business they could not afford to lose it.

– The costs of lost gear varied depending on the size of operation and location. This can be significant. A single gill net £290, a tangle net £160, a trawl £3500 and a beam trawl £6000. There is also the associated markers, rope, clip work etc and the time elements to make new gear alongside the time of reduced fishing.

"19 Vessel owners stated they would always attempt to creep and find any lost gear from storm damage for the two obvious reasons; not wanting to leave ghost gear fishing and the financial cost of the gear is so significant to them as a small business they could not afford to lose it."

6.25%

Lost under £100

37.5%

Lost £101-500

18.75%

Lost £501-1000

12.5%

Lost £1001-5000

12.5%

Lost £5000+

The Sea Trial

Based on survey data there was a clear need to set up the trial with fishing vessels operating in the Falmouth Bay area. With regular gear conflict encounters leading to gear loss, as well as challenges with Easterly wind and storms causing occasional gear loss, there were a number of willing vessels ready to take part in a 30-day trial. Prior to starting the trial, a number of modifications had to be made to the hardware and software technology in the wheelhouses. This was also accompanied by creating shore-based charging stations to recharge beacons. A number of small-scale coastal fishing vessels were then issued with 20 SAFEGEAR beacons each, ready made up on to dahns and buffs, which the fishermen then took to sea attached to either end of a series of nets and pots. These were deployed in December 2020 and all gear was set in the Falmouth Bay area. The official trial period lasted 30 days, which allowed a number of vessels to thoroughly test the SAFEGEAR technology. A number of findings came from the trial period, as stated below.

Reducing gear loss - initial feedback from all vessels has demonstrated the opportunity to monitor fishing gear from up to 25 miles away. This has proven beneficial to the trial vessels, who were able to view their marked fishing gear from the plotter in the wheelhouse of their vessel whilst tied up on the quayside without having to go to sea. This proved especially beneficial over the Christmas and New Year period where markets were shut, which reduced the need to go to sea and fish. Allowing a simple way to check that fishing gear was safe and in its expected position, the participating trial vessels stated this gave a lot of assurance and reduced the need to go to sea and check on gear.

Battery life of beacons - trial vessel owners highlighted the length of time the batteries lasted was approximately 16 days, which was deemed a positive. Trial vessels suggested this was an acceptable amount of effort and time required to change beacons over on the gear they wished to mark. Trial vessel owners stated the need and importance of having a shore-based space to re-charge the beacons, as smaller

"Visibility of beacons - as well as having the beacons showing on AIS channel 2006 the beacons have lights which act as a supplementary deterrent to warn other passing vessels of their position."

vessels (u10m) lacked the deck, or wheelhouse, space to safely and effectively re-charge the beacons while at sea, it was deemed necessary to develop a shore based charging space and enough beacons to swap over when out fishing. Larger vessels may not see this as a challenge.

Robustness of beacons - the trial took place between December and January 2020-21, which included categorised storms. No SAFEGEAR beacons were lost due to storm events and were attached to the dahn poles using stainless steel clips. However, one beacon was damaged by adverse weather and the spring became detached, which then turned it off, making it useless until human intervention. This would need to be monitored for a longer period of time, as maintaining long term function in a harsh environment would be important for value for money and the effectiveness of the technology.

Visibility of beacons - as well as having the beacons showing on AIS channel 2006 the beacons have lights which act as a supplementary deterrent to warn other passing vessels of their position. This raised conversation and interest with Harbour Authorities and other vessels, but was deemed safe and permissible to continue with the trial. This could be seen as an added benefit as typically fishing gear markers would not include lights.

Investment - costs of the SAFEGEAR beacons themselves were deemed acceptable to participating vessels. However, due to Ofcom licensing requiring the bespoke frequency, there was also a requirement for significant wheelhouse technology upgrades, which were in the region of £2000 per vessel. This is an important consideration, as it may well be that many other small-scale vessels would require additional wheelhouse hardware and software to make use of the beacons.

Interest from other vessels - during the trial period time there was increased interest from other local vessels seeking to understand more about the SAFEGEAR technology. Upon release of this report and acting on the recommendations there is scope to scale up the trial to more vessels to amplify the benefits of the use of SAFEGEAR.

Exit strategy - with a limited trial and innovation licence in place at present, participating vessels suggested the importance of having a sensible and workable exit strategy for the ongoing use of the SAFEGEAR technology. Support from Blue Marine Foundation to supply an increased number of beacons with necessary supporting dahns, floats and buoys along with an extended licence to continue using the technology was suggested. Ongoing monitoring and evaluation of the project would be possible with quarterly meetings with the vessel owners to ensure long term impacts are recorded.

RECOMMENDATIONS & CONCLUSION

Based on the delivery and outcomes of the trial a number of recommendations have come forward to evolve the project.

1. Make SAFEGEAR fisheries grant eligible to reduce industry impact on the marine environment

The purchase of the SAFEGEAR beacons, wheelhouse technology upgrades and shore based recharging set up come with a significant cost, especially to the small scale fleet. Given the high upfront investment to purchase necessary equipment to mark and monitor gear, it would be advisable that this becomes eligible for grant funding through any future government fisheries funding programmes. Typically, DEFRA and The MMO have awarded up to 80% grants for the small-scale coastal fishing vessels, and 50% for those over 12m, or using towed gears, which would certainly encourage take up of the SAFEGEAR technology and reduce gear loss. The previous funding programmes have contained themes that focus on reducing impact on the marine environment, climate change, as well as improving vessel safety, all of which would be relevant for the SAFEGEAR technology.

2. Ofcom Licence within 0 -12 miles of UK coastline to reduce gear conflict with foreign trawlers and large ships

Based on the survey data and trial results, it is clear that there is benefit to the use of SAFEGEAR beacons to support fishermen in reducing gear loss. However, there are limitations to the current trial and innovation licence with Ofcom, which has restricted it to channel 2006. Although the participating vessels can track their gear on this channel, it is not visible to other vessels, so would not reduce the risk of gear conflict in the first place. In order to make this of full benefit to reducing gear loss from gear conflict, then an obvious recommendation would be to offer a licence on the main channel and present the Safegear beacons as visible marks on the AIS channel. In order to manage this in a way that would not over clutter plotters, a limited number of Safegear beacons per vessel would be advised, to allow vessels owners to mark each end of a net, or string of pots, in areas where there is a higher risk of gear conflict. Vessels wishing to use the Safegear beacons would be required to make their own application to Ofcom for this, to give coordinates for the area they wish to mark. This would ensure professional and safe application of the technology and the ability to manage sensibly.

Conclusions

The most striking moment in the SAFEGEAR project arrived at the very end, when Cameron Henry, a Mylor fisherman who had participated in the sea trial of SAFEGEAR, said: "the main problem for us, the way we look at it, it isn't just the money side of it, that gear is at the bottom of the seabed and it's not very good for the ecosystem." SAFEGEAR is interesting in that it unites conservationists and fishermen with a common purpose, while also saving fishermen money. For BLUE, whose flagship project in Lyme Bay is built on this premise, SAFEGEAR feels like a solution with huge potential.

Blue Marine Foundation (BLUE) seeks to convene a roundtable discussion to share the outputs from the SAFEGEAR project with government agencies, to make the case for fishermen to become eligible to receive grant funding for beacons and therefore encourage the marking of static pots and nets. The event would open with an overview of the problem of fishing gear entering the marine environment. The audience and participants should include fishermen who participated in the trial, Ofcom, Defra, the MMO, the Cruising Association, the coastal POs, fish buyers, the Global Ghost Gear Initiative and fishermen's associations. We look forward to making this a reality in 2021 and to the future resonance that SAFEGEAR could have for elements of the fishing industry and the health of the marine environment.

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