Glaukos

Circular solution for the textile industry

Report on Market Studies

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ABBREVIATIONS AND ACRONYMS

Abbreviation / Acronym	Description
ABS	Acrylonitrile butadiene styrene
ALDFG	abandoned, lost or otherwise discarded fishing gear
EOL	End-Of-Life
GRFD	Glass fibre reinforced plastic
HDPE	High Density Polyethylene
HMPE	short for UHMWPE
NGO	Non-governmental organisation
PA/PA6	Polyamide (nylon)
PE	Polyethylene
PET	Polyethylene terephthalate (Dacron/Polyester)
PP	Polypropylene
PS	Polystyrene
PU	Polyurethane
PVC	Polyvinylchloride
PVDF	Polyvinylidene fluoride
SMEs	Small and Medium Sized Enterprises
UHMWPE	Ultra-High Molecular Weight Polyethylene (e.g. Dyneema®)
UK	United Kingdom
PRF	Port Reception Facilities
SUP	Single Use Plastic

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1. INTRODUCTION

In the framework of the Glaukos project, Eurocord has been responsible to provide the group with a market study in the frame of WP2 (Task 2.2) on the use of some synthetic fibres in some main applications, generating a considerable “plastic waste” for the environment. The EU Directive “Single Use Plastics” from June 2019 clearly aims at reducing this waste stream throughout Europe, both on land and in the seas. For the consequent development of a bio-based or bio-degradable fibre, which should on term replace the synthetic ones, a preliminary examination of the use and the virtues of these man-made fibres is thus necessary.

Eurocord is a European Association, taking care of the lobby activities and harmonization interests of the European manufacturing companies, active in the production of synthetic fibre-based ropes and nets which are used in a variety of applications. The Association not only counts rope- and net manufacturers in its members, it also welcomes companies and research institutions developing very close ties with the maritime and agricultural rope & netting production , as there are e.g. suppliers of (braiding) machines, (synthetic fibre) raw materials, all types of coatings, specific usage of the ropes (slings), academic institutions cooperating in research (universities), other Associations linked to this business, either by the industry (e.g. textiles, fibres, …) or by the political aspect (European lobby Alliances, …).

“Ropes and nets” industry is typically a family-owned, medium-size companies type of cluster, with only a hand-few multinational-types of corporations. As such a certain ”reserve & confidentiality” is observed by its members in terms of sharing quantified information. Experience and frequent contacts with the members nevertheless allow a decent understanding of what the business stands for, and which its aims and challenges are.

The synthetic “Ropes and nets” sector is characterized, as far as Eurocord is concerned, by 2 major industry streams: the maritime & leisure sector for the ropes and nets, and the agriplastics sector regrouping the major EU companies manufacturing nets, twines and films. Altogether Eurocord only counts 70 members, however those ones will represent roughly 75% of the total output of the manufacturing activities throughout Europe. The number of companies active in these 2 manufacturing sectors are estimated 300 to 350 in Europe. Globally an estimate of the annual volumes of new finished products brought into the EU market levels at 40 to 45.000 Tons for the maritime ropes and nets (with a capacity usage of all the production assets not exceeding 75%), and at 730.000 Tons for the agriplastics (full capacity usage). In the maritime world, roughly 45% of the ropes and nets used in Europe are imported from mainly China, India and the Far-East. This leaves the EU production performance with an estimated 22 to 25.000 Tons output.

In the framework of the Glaukos project, a preliminary market study on the use of synthetic fibres in different sectors seems an absolute prerequisite, in order to understand the needs of those sectors and consequently the specifics a newly developed material would need to serve. Basically, considering

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Glaukos will focus on developing a new, bio-based material for making a yarn, we can target the sectors of use as follows:

- Maritime use for ropes and nets (in the fishing and mooring activities)
- Agricultural use : crop protection, bailer-twine, mulching & greenhouse films.

Both sectors have a lot in common in terms of suppliers' approach (they source the same type of polymers, with frequently the same suppliers, and on top, many EU companies are active both in the maritime as in the agricultural sector. Quite some synergies can thus be obtained.

- Clothing sector (apparel, sportswear, confection fabrics, etc…)

The present study focuses on the first 2 application activities in Europe, but a separated market study on the clothing sector will be also made by BSI in the beginning of 2021. The coverage is expected to expand to the clothing sector in the coming months. The market analysis will be reviewed during Glaukos life-time, as alterations, modifications, completions and additions might be needed.

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2. POLYMER PRODUCTION RESULTS

Plastics are synthetic organic polymers that can be easily moulded into different shapes and products for a large variety of uses. Invented only 110 years ago, plastics are now the most widely used man-made material and have become omnipresent in every aspect of our lives. From medical supplies and water bottles to food packaging, clothing, and construction materials, every person in the world now disposes an average of 52 kg of plastic waste every year (main polluter being China) (Worm et al., 2017). Geologists are now considering a plastic horizon in the world's soils and sediments as one of the key indicators marking the current geological epoch, the Anthropocene.

Concerns about plastic release into the environment were at first non-existent. The material was seen as benign, due to its inertness and perceived lack of toxicity. As a result, an estimated sum total of 5 Bio tonnes of plastic has been discarded into landfills and the environment since 1950. This led to increasing concerns about pollution, particularly in the oceans, with some actions by governments to stem the growing tide of plastic debris. The International Convention for the Prevention of Pollution from Ships (MARPOL) was signed in 1973, although a complete ban on the disposal of plastics at sea was not enacted until the end of 1988. (Xanthos and Walker, 2017) At the same time, waste disposal practices and recycling capacities improved, particularly in highly industrialized countries, leading to better waste management and lower release of plastic waste into the environment. Next to that other initiatives on EU level have been taken and are in the course of their execution. The "Circular Plastics Alliance", is an initiative under the European Strategy for Plastics (2018), in particular under one of its Annexes related to voluntary pledges by the industry. The European Commission launched the Circular Plastics Alliance in December 2018 (https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6728) to help plastics value chains boost the EU market for recycled plastics to 10 million tons by 2025. Eurocord and other major plastic-related companies and institutions are part of this Alliance.

Plastic pollution has now become widely recognized as a major global environmental burden, particularly in the oceans where the biophysical breakdown of plastics is prolonged, effects on wildlife are severe and options for removal are very limited (Maritime use). Also on land, where the agricultural sector uses a vast amount of plastics for its greenhouses, crop protection, bailer twines and other applications, the plastics breakdown forms a significant challenge for a "green" approach (Agricultural use). Both areas will be treated in this document.

There has been a recent shift in strategy within the EU regarding plastics, with the development of initiatives within the European industry towards a more circular plastics economy. In support of this, in 2019 the European Parliament and Council adopted two Directives that will make a significant contribution to the reduction of marine litter from sea-based sources. First, the revised Port Reception Facilities (PRF) Directive (2000/59/*EC*). Up until now, ports have been able to charge fishermen for bringing retrieved abandoned, lost or otherwise discarded fishing gear (ALDFG) ashore over and above their normal fee. The revised PRF Directive introduces indirect fee and consequently removes this disincentive. Second is the Single Use Plastics (SUP) Directive

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(https://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf), which addresses 10 most common single use plastic items found on European beaches as well as end-of-life fishing gear and ALDFG, foresee introduction of the Extended Producer Responsibility (EPR) for fishing gear as from 31/12/2024. Within this Directive producers of fishing gear containing plastic will have to take on the responsibility (and costs) for separate collection, transport, treatment and awareness raising measures of fishing gear. This has been brought in to reduce port costs for fishers, particularly in small fishing ports, and potentially accelerate the development of a dedicated waste stream for fishing gear waste.

In support of the PRF and SUP Directives, there are several challenges that need to be examined. The majority of producers of ropes and netting for the fishing industry are dominated by Small and Medium Sized Enterprises (SMEs), with a small number of large producers of fishing gear. In addition, there are substantial logistic issues across the entire value chain of fishing gear, from collection and retrieval at sea by fishermen (or other groups), to bringing and unloading in ports, collecting in ports, transporting to recycling facilities, performing mechanical and chemical recycling, and producing new products from recycled fishing gear. To date, all of the available work that has examined the issues surrounding logistics have focused solely on End-Of-Life (EOL) fishing gears - there are no successful efforts globally to recycle ALDFG, with all material incinerated or dumped in landfills. Lastly, there are substantial problems with the current design of fishing gear in terms of environmental impact at end-of-life.

At present, six raw polymer types are utilized to manufacture the majority of nets within Europe:

1. Polyamide (PA),
2. Polyester (PES),
3. Polyethylene (PET),
4. Polypropylene (PP),
5. Aramid, and
6. High-density polyethylene (HDPE).

However, within the current design of fishing nets within Europe, there is said to be up to 700 different combinations of these polymers and other materials (Figure compiled by Bernard Merkx, plastics specialist, member of the Board of Plastix, co-founder of Waste Free Oceans and member of the Board of Plastic Recyclers Europe). Such mixing of different raw materials, although potentially important for the use of the fishing gear, makes it nearly impossible to recycle as a single unit. Furthermore, there is a range of other factors that reduce the likelihood of fishing gear being recycled, including the use of materials within nets that are toxic or unrecyclable (i.e., lead shot in sink lines), the likelihood that collected gear may have been contaminated (i.e. sand, salt) or other man-made material mixed, the small number of recyclers within Europe (two predominate; Plastix and Aquafil) and the need to provide to these recyclers cleaned and sorted gears, as well as the lack of agreed standards for circular design of fishing gear.

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2.1. Volumes

According to interviews led with several major players in the rope- and net manufacturing community, the use of raw materials in the 2 domains looked after by Eurocord (maritime ropes & nets and agricultural nets & bailer twine) reach the following levels (Table 1).

Table 1: Volumes (tonnes) in synthetic fibres, used in the European Manufacturing in 2018 (own data of Eurocord)

Volumes (tonnes) in synthetic fibers, used in the European Manufacturing of Ropes and	
	Total Year 2018
Ropes & Nets	
Polypropylene - Polyethylene	10.199
Polyester - Polyamide (Nylon)	8.734
Other synthetics	7.927
(UHMPE like Dyneema, Kevlar, Spectra, ...)	
	27.110
Twines	
Agricultural	568.077
Packaging	122.346
	723.533

3. MARITIME USE OF SYNTHETIC FIBRE ROPES AND NETS

3.1. Types of commercial fishing gear

Various types of fishing gear are used throughout the North Atlantic Maritime Area, depending on the target species and the specific area (Table 2). Bottom trawls, pelagic trawls and nets (including gillnets) are the main types of gear used, followed by seines and traps. Independent of gear type, the main plastic materials used are polypropylene (PP), polyethylene (PE) and polyamide (nylon/PA6). However, fishing gear can also include single and mixed materials containing metals, PVC, polystyrene, PVDF, Dacron (PET, Polyester), HMPE (e.g. Dyneema®), rubber, foams and various hazardous materials (e.g., lead weights, copper coatings).

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Table 2: Summary of the main plastics used in different types of commercial fishing and aquaculture gear.

Material	Use
Polyamide/Nylon (PA)	Nets (mostly gillnet and seine), lobster and crab
Polypropylene (PP)	Nets (mostly gillnet and trawl net), rope
Polyethylene (PE)	Nets (mostly trawl net, purse seine net); longlines; aquaculture: rope, cage, floats, tubes, disks
High-density Polyethylene (HDPE)	Trawl doors, dredges, small parts and cladding
Expanded Polystyrene (EPS, foam)	Insulation, floats and buoys
Polyurethane (PU)	Fish aggregation devices (FADs)
Polyvinylchloride (PVC)	Aquaculture: cages, tubing and piping
Acrylonitrile butadiene styrene (ABS),	Aquaculture: valves
Polyvinyl difluoride (PVDF)	Rope, net (newer technology)
Aramids, Ultra High MW Polyethylene (UHMWPE, e.g. Dyneema®)	Rope, net (newer technology)
Aromatic polyester	Rope, net (newer technology)
Glass fibre reinforced plastic (GFRD)	Aquaculture (newer technology)

3.2. Marine litter from fishing gear

Both unintentional and intentional loss of fishing gear at sea result in marine litter and negative environmental impacts. Inadequate waste management on-board vessels during repairs, snagging of fishing gear beneath the surface and severe weather are reported as the most substantial reasons for loss of fishing gear. Conflicts with other gear or vessels are also commonly reported as a reason for loss, especially for gillnets. Discarded or lost fishing gear containing plastic materials will degrade very slowly, remaining in the marine environment for decades if uncollected. Gradual shedding of microplastic fibres leads to ingestion by filter feeding organisms and fish. Netting made from low-density plastics continues to float on the surface and remains hazardous for marine animals (ghost fishing) as well as posing security risks to vessels. Furthermore, loss of fibres or materials through abrasion during normal use (e.g. dolly rope) contributes to the presence of plastics in the ocean.

3.3. Fishing gear usage and supply chain

Raw materials for fishing gear production, as well as final fishing gear products (i.e., ropes or nets) are predominantly sourced from overseas, with final assembly undertaken locally. Such assembly is often tailormade and performed by specialized facilities (e.g. fisheries cooperative). Sometimes, fishers carry out assembly or repairs themselves. Overall, the supply chain for fishing gear is complex and country-specific, with many different parties involved at various stages. There is at the time of writing this report little information known about this supply chain.

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3.4. Recycling of fishing gear

At present in the North Atlantic Maritime Area, a small proportion of fishing gear is recycled at end-of-life and various barriers are identified. In Europe, dedicated fishing gear plastic recycling is predominantly done by two companies (Plastix Denmark & Aquafil Italy) both being highly specialized in the material they can process and with high standards and requirements on accepted end-of-life fishing gear. Facilities available for collection and recycling are limited, requiring high effort and costs to pre-process and transport material to the recyclers, which results in a high ecological footprint for recycling. Some regions (Mediterranean countries and the northern countries of Scandinavia (Sweden, Finland, Iceland) and majority of the UK coastal area) still lack facilities for fishing gear collection in ports, including lack of available space to store old gear for collection, contamination of disposal facilities by fly-tippers, and poor portside coordination on the cleaning and separation process. Lastly, recyclates originating from fishing gear generally have a lower quality and / or a perception of lower quality, therefore lower market value than comparable virgin polymers. Fishing gear can contain multiple types of (mixed) polymers, which require a high level of pre-processing (sorting & dismantling) in order to be recycled, with high costs and time involved. This is because fishing gear needs to be sorted into individual polymer type components before shipping to the recycling facility, and all contaminants such as lead from sink lines need to be removed. Fishing gear must also be relatively clean, without sediment, sand or organic materials. However, gear experts (e.g. Lankhorst Euronete, Badinotti, Cotesi, Cittadini, Mörenotsay) say that the technology to recycle fishing gear is available, that contaminated fishing gear can be recycled, and that the market for such products is growing. Further understanding is needed of feasible solutions to pre-processing materials at scale and the available technology to undertake this.

3.5. Design of fishing gear

Design of fishing gear is predominately driven by functionality and cost. It is accepted that these two factors will always be key considerations for fishermen, however it is also hoped that environmental impact and waste management will increasingly become drivers in their own right for the design of fishing gear. Three options for design modifications to reduce marine litter from fishing gear have been investigated recently in the framework of the several working groups gathered by the EC in order work out solutions for reducing and avoiding further waste disposal. Both fishermen- and rope manufacturing communities came up with following (cumulative) requirements:

- design to reduce impact on the marine environment when fishing gear is lost;
- design for better recyclability; and
- design for better traceability.

Regarding environmental impacts, hazardous materials are still used in fishing gear (i.e., copper coating, lead), which may negatively impact marine life. For these, alternative materials might be viable, subject to the appropriate analysis of erosion rates and biota interaction. On top, there is increasing discussion and research on marine biodegradable fishing gear or its components, but little evidence is available to demonstrate the feasibility of these materials for use in fishing gear on a large-scale. Concerns remain about how long these materials take to degrade, what they degrade to, and

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whether they create perverse incentives to dispose of gear irresponsibly. Therefore, with this in mind, first and foremost, one should aim at preventing loss of gear (or parts thereof) in the first place. In situations where this is not deemed possible, then design solutions to reduce environmental impact should be implemented. With respect to design for recyclability, there is still a range of materials and mixtures of materials used in fishing gear design that reduces or negates its ability to be recycled (ex. HMPE, copper coatings, PES buoys, etc.) . End-of-life materials are often difficult to dismantle into individual material fractions. Little research has been done into the potential for reducing the number of materials used in fishing gear, design for better disassemble, or marking materials for identification purposes to aid dismantling at end-of-life. There is also a lack of technology to extract hazardous materials from fishing gear, e.g. for nets that have been treated with copper or other antifouling agents. Lastly, various new technologies have been developed to mark fishing gear, which could disincentive the intentional loss of fishing gear, incentivize lost fishing gear to be reported, and aid the retrieval of lost fishing gear (e.g. through location and identification). However, there is still a lack of standardized approaches, and gear marking may only be effective to trace larger parts / sections of gear, or specific gear items such as traps and pots.

3.6. Where do fishers buy their gear?

It is a common practice that local net manufacturers assemble their gear (Table 3), while the manufacturing of raw materials is typically done overseas. Companies in Spain (Redes Salinas) and Portugal (Euronete) are considered important producers of fishing gear. Important international netting companies include a.o. Euronete and Hampiðjan.

Table 3: Main fishing gear suppliers per country and, where mentioned, type of gear supplied.

Contracting Party	Type of gear	Manufacturers / assemblers
Belgium		Main companies in Portugal, Italy, Greece, Iceland, Norway and to a lesser extent Central European countries. VVC equipment : https://www.vvcequipment.be (VVC Zeebrugge, VVC Oostende)
Denmark	trawls	Tor-MoTrawl: http://www.tormotrawl.dk/dk/profil.html Cosmos Trawl: http://www.cosmostrawl.dk/ Comet Trawl: https://comet-trawl.dk/erhvervsfiskeri/ StrandbyNet: http://www.strandbynet.dk/forside.aspx Egersund Danmark: https://www.hmsn.dk/da/medlemmer/egersund
	aquaculture	Hvalpsund net
France	trawls	Le Drezen (Finistère) / Nabera (Spain but an office in Finistère) and DEMK (Morbihan)

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	nets	Mondiet (Gironde) / le Drezen (Finistère) / Alprech (Pas de Calais) / Kerfil (Finistère) / Atelier du Filet (Vendée)
Germany	trawled gear netting	Gruchow Norddeich, Cux-Trawl, Dutch auctions
	gill nets	Frydendahl/Haugesund in Denmark. Also online trade, presumably focus on Asian production sites
	angling equipment	Presumably from regular global market sources in the shops l
	lines	Likely from the Asian line market bottom and pelagic trawls Rostock-Warnemünde Kloska Group Net manufacturer Engel Netze https://engelnetze.com/
	gill nets for lake fisheries	Kremmin Netze https://www.kremmin.net Vogt Netze https://shop.vogtnetze.de/
	gill nets, small nets, traps, crab pots etc.	Herberle Netze https://www.heberle-netze.de/ rod & line lines and others a large number of monofilament-nylon producers
Iceland		Hampidjan, Ísfell, Egersund and Morenot
Ireland	all types of gear	Swan Net Gundrys, Castletownbere, Union Hall & Killybegs; Jackson Trawls, Peterhead,
Scotland	pelagic	KT nets Killybegs
	trawls and seine nets	Donegal, Stuart nets & Castletownbere Frankie Griffin, Schull; Ger Dougal, Greencastle; Cavanagh Nets, Greencastle (but nationwide); Mc Carry nets, Greencastle (but nationwide); Stuartnets, West Cork; Carrymccarry, Donegal, North West; Pepe Trawls and Marine Suppliers, Howth, East coast. Also producers in Scotland, Cornwall and Iceland.
Norway	seine	Only some manufacturers of purse seine and Danish seine
	other gear	Production of components abroad, mainly in Asia
Portugal	Ropes	Exporplas, Sicor, Cordex
	Ropes/cables	Lankhorst
	Nets	Sicornete, Euronete, Mustad & son
Spain		Spanish manufacturers; Mörenot
Sweden		FF Norden, Smögen; Hönö trawl, Hönö, (Gothenburg); Träslövsläge trawl, Träslövsläge
The Netherlands	pelagics	H. Maritiem BV and Nettenfabriek van Duijn
	bottom trawls	VCU Maritime BV, JV Visserijconsultant and Cooperatie Westvoorn IJmuiden stores Holland BV (Ijmuiden), Van Beelen Group (Ijmuiden)

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		Euronete (Portugal), Redes Salinas (Spain) Alibaba/China
UK	trawl gear	NE Scotland - Jackson trawls, Faithlie trawls, Strachan trawls. England - Boris nets, Fleetwood, Coastal nets Bridport, Caedmon Nets in Whitby. Shetland LHD Net store and Swan nets both in Lerwick. Also several smaller operators.
	pelagics	nylon gear produced in Ireland, Scotland, Iceland & Norway
	pots & static gear	Gaelforce in Inverness, Caithness creels & numerous smallscale
	nets	Some netting is supplied by overseas companies (e.g. Euronete and Hampiðjan) Bridport Net Gundry, Tyson's Ship Riggers

Manufacturers and assemblers or netting companies are most often the places where fishers buy their gear. Often, fishing gear is assembled locally from raw materials. Various companies (Denmark, Germany, Ireland, Sweden, Netherlands, UK) indicate that part of the gear consists of tailor-made fishing equipment, made according to specific demands depending, for example, on the ship and the target species. Trawl gear especially is mentioned as often being custom-made, according to individual preferences of fishers. This results in a high diversity of especially trawling gear design. To some extent, fishers also self-assemble their gear, as fishers may build their own nets using raw material from netting companies or from older pieces of gear (e.g. for Germany, Ireland, Sweden). For the UK, pots and traps are also reputed as sometimes being self-assembled. A UK member indicates that in general, larger offshore operating vessels are less likely to assemble their own gear, while those that assemble their own gear are often smaller scale, inshore operations.

In some countries (especially the Netherlands and Belgium), fishers buy part of their gear through fisheries cooperatives. For example, In the Netherlands, several of the raw materials are bought via the Fisheries Cooperative Buyers (CIV). In Belgium, the main cooperative is called VVC Equipment. Online ordering doesn’t seem to be an important source for most commercial gear. Most companies consider online ordering as a source for cheaper gill nets, static gear and rods & lines. Several producers of fishing gear express concerns that if the price of gear increases due to EPR, more gear might be ordered online (read in China or India) to avoid the additional EPR fee imposed in the EU. Concerning recreational fishing, main players often indicate that gear (angling gear, rods & lines) is bought in specialized shops or through online ordering. Since cheap gear such as gill nets are especially prone to be discarded or left behind it is of high importance to provide solutions on how to implement EPR for gear ordered online / overseas.

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4. AGRICULTURE: SPECIFIC NEEDS AND CHARACTERISTICS

4.1. Method of data collection

There are no special tools for gathering statistics for plastics used in agriculture at a European level. The data provided in this report have been gathered through multiple interviews with Eurocord members (market experts, suppliers) and organisations taking responsibility for the end of life management of agricultural plastics and therefore having a clear knowledge of what is put onto the market (these interviews and data collection were done in the framework of the close cooperation with the European Plastics Alliance, set up end of 2018) . It is considered that the data provided here are sufficiently accurate for an efficient state of play analysis of the market at this stage. The establishment of a reliable tool for gathering statistics is a recommendation within the Agri community and is also part of a global recommendation on national statistics for the establishment of collection schemes.

4.2. Products range

Whilst there are many different plastic products used in agriculture, the focus is only put on the non-packaging plastic products used directly by farmers in their production activities. Considered in this category:

- Films for vegetable production (fruit and vegetables, horticulture):
- greenhouses and large tunnels, small tunnels, mulching, protective coverings…
- Films for animal production (meat, milk…): silage and stretch…
- Nets for round bales and protectives nets (anti-hail net, insect and bird protection nets, sun and wind screens…)
- Twines for horticulture and bales
- Irrigation pipes

4.3. Polymers

The polymer most used in agriculture are

- Low Density Polyethylene (LDPE), accounting for 81% (for films and pipes), followed by
- Polypropylene (PP - 11% for films and twines) and
- High Density Polyethylene (HDPE - 8% for nets) Ø

These polymers are fully recyclable but their recyclability depends upon several factors, such as the variance in soilage content.

4.4. Waste characteristics

The polymer most used in agriculture are

- Low Density Polyethylene (LDPE), accounting for 81% (for films and pipes), followed by
- Polypropylene (PP - 11% for films and twines) and

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- High Density Polyethylene (HDPE - 8% for nets) Ø

These polymers are fully recyclable but their recyclability depends upon several factors, such as the variance in soilage content.

4.5. Global statistics

The volume of new products put onto the market are considered by industry expects to account for 721 KT of agri-plastics, of which 8 KT are oxo degradable mulching films. These oxo degradable plastics are presently banned from most markets but will eventually be replaced by another type of mulching film, whether conventional or biodegradable, that in turn will need to be collected. All these quantities generate a global estimated volume of agriplastics waste of approximately 1,175KT to be sorted, collected, and recycled (Table 4).

Table 4: European Market for Agricultural Plastics: New vs Used (data from Bernard Le Moine from Agriculture Plastic Europe (APE)).

Table 4: European Market for Agricultural Plastics: New vs Used (data from Bernard Le Moine from Agriculture Plastic Europe (APE)).

European Market Survey	Tons New	%	Tons Used	%
Films	547.000	76%	927.500	79%
Pipe	40.000	6%	48.000	4%
Net	54.500	8%	79.950	7%
Twines	80.000	11%	120.000	10%
LDPE	587.000	81%	975.500	83%
HDPE	54.500	8%	79.950	7%
PP	80.000	11%	120.000	10%
Grand Total	721.500	100%	1.175.450	100%

LDPE : mulching & sileage film

HDPE : net-wraps

PP: twines

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4.6. Data per country

National statistics are not wholly available, unfortunately. While the quantities for films are well understood, further investigations are still required for gathering statistics on other categories of products. Nevertheless, agri-plastic films represent 79% of the overall agri-plastics market, hence, the analysis on films is nonetheless extremely valuable. 10 countries collectively account for 80% of the whole agri-plastics market, when 18 countries account for just for 20% of the whole market (Table 5).

Table 5: Market volumes ranges per country.

Films Market	Volume Range	Countries
80% of total volume in Europe	> 50KT	Spain, Italy, Germany, France
	20 KT - 50 KT	UK, Poland, Holland
	10 KT - 20 KT	Ireland, Sweden, Belgium, Finland
20% of total volume in Europe	5 KT - 10 KT	Bulgaria, Greece, Austria, Norway, Denmark, Hungary, Czech Republic
	1 KT - 5 KT	Switzerland, Portugal, Estonia, Lithuania, Latvia, Slovakia
	< 1 KT	Slovenia, Romania, Cyprus, Malta, Luxembourg

Even with over 720KT of agri-plastics put onto the market each year, the market is still relatively small when compared to the market for all plastics. Agri-plastics are almost all produced with the most used polymers (PE, PP…) which are all recyclable. Nevertheless, recyclability depends on various factors, not least being the soilage content and the organisation for collection and sorting.

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5. RELEVANT EUROPEAN UNION LEGISLATION

The Marine Strategy Framework Directive (MSFD) (2008/56/EC) aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine related economic and social activities depend. With respect to marine litter, the MSFD requires EU Member States to ensure that, by 2020, "properties and quantities of marine litter do not cause harm to the coastal and marine environment". The Waste Framework Directive (2008/98/EC) was adopted in 2008 and provides a general framework for waste management requirements in the EU, setting out definitions related to waste, recycling and recovery. The governing principle of the Directive is the waste management hierarchy; prevention, preparing for re-use, recycling, recovery, and finally disposal.

Amongst other things, the directive works on the basis of the ‘polluter pays principle’ and ‘extended producer responsibility’. The revised Port Reception Facilities Directive (EU/2019/883, revision of EC/2000/59) was adopted in 2019 and aims to reduce pollution from the waste produced by ships. The EU directive aligns with the International Maritime Organization’s MARPOL Convention 73/78 and obliges Member States to provide adequate facilities for the reception of waste from ships with a cost recovery system which requires the application of a 100% Indirect fee (i.e. independent of how much waste a ship delivers to port). Ports must ensure separate collection, waste reception and handling plans, also with respect to fishing gear and passively fished waste.

The European Strategy for Plastics in a Circular Economy was adopted in January 2018 as an official communication by the European Commission. The Strategy is linked to the EU’s wider plan to develop a circular economy and originated from the 2015 Circular Economy Action Plan, which identified plastics as a priority area. The Single Use Plastics Directive (EU/2019/904) introduces a set of ambitious measures to reduce plastic litter and increase collection and recycling, with a focus on preventing and reducing the impact of certain plastic products on the environment. Included within the Directive is the requirement for Member States to implement Extended Producer Responsibility (EPR) for fishing gear and components of fishing gear containing plastic. Under the EPR schemes, producers of fishing gear containing plastic should cover the cost for the separate collection of waste fishing gear containing plastic and its subsequent transport and treatment. The producers shall also cover the costs of the awareness raising measures regarding fishing gear containing plastic. EU Member States are required to set up the EPR Schemes for fishing gear by 31st December 2024. The Directive also envisages the European Commission to request European standardization organization to develop harmonized standards for circular design of fishing gear.

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6. STANDARDS

6.1. CEN/CENELEC TC 466

TC 466 (in course of establishment) will develop standards for sustainability and circularity regarding sustainable fishing, aquaculture and fish products. This includes: fishing gear and its components, freshness of products and marketing. Included in the scope are environmental, social and economic sustainability of fishing products and freshness categories. With regards to fishing gear the scope includes technical requirements for circular gear, material use and design – both for circularity and environmentally conscious design – and also processes and systems in terms of management and implementation – collecting, monitoring, traceability, repairing and recycling, environmental monitoring and data reporting.

Excluded from the scope are machinery for fish processing, CEN/TC 249 Plastics, CEN/TC 248 Textiles and Textile Products.

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7. BIODEGRADABLE GEAR

7.1. Ongoing developments

There has been growing interest in plastics that are biodegradable in seawater, where polymers disintegrate in either industrial composting installations or the natural environment into smaller molecules and eventually minerals (CO2, H2O, CH4, etc.). The rate of biodegradability depends on the 'aggressiveness' of the environment; seawater is considered less 'aggressive' than freshwater, soil or composting facilities and therefore materials will be slower to degrade (CE Delft, 2017).

At present, only a small number of plastics that are biodegradable in seawater are available on the market. These are available in low quantities and with different characteristics and properties than the currently used types of plastics used in fishing gear, and, as such, are not feasible to replace conventional plastics on a large scale. Since 2015, an official certificate has been available for plastics that are biodegradable in seawater called OK biodegradable MARINE issued by TÜV AUSTRIA. For this certification scheme, plastic is considered to be marine biodegradable if, under laboratory conditions, the disintegration of a slim film of the material being tested happens within 2.5 months and biodegradation (mineralization) within six months. However, for the test, the water temperature is maintained at 30 ± 2°C and the test item is put in a shaking unit during the entire duration (TÜV AUSTRIA, 2019). In field conditions, however, the biodegradation of materials in the marine environment is difficult to predict and can vary depending on the properties of the material and the environmental conditions including nutrients, abundance of microorganisms, climatic variations (including temperature), and fouling by micro- and macro-organisms.

A research project in Norway, involving SINTEF Ocean, Arctic University of Norway and S-ENPOL, is at this stage trialing biodegradable gillnets made from polybutylene succinate co-adipate-coterephthalate (PBSAT). After 25 months in the marine environment, PBSAT gillnets exhibited a 35% reduction of tensile strength due to degradation. While this is attractive from the perspective of reducing the lifespan of gear if it becomes lost, there is an important trade-off with functionality. Two studies by Grimaldo (2018a, 2018b), comparing these biodegradable PBSAT gillnets with conventional gillnets, concluded that biodegradable nets have a lower fishing efficiency than conventional nets. The catch of Greenland halibut with biodegradable nets was 16% lower than with nylon nets; for saithe this was 22-40% lower, and for cod 21% lower. This is because marine biodegradable nets are both weaker (10-12% lower tensile strength) and more elastic (about 5%) than nylon nets.

At present, there are serious constraints on marine biodegradable plastics being used for fishing gear on a large scale. In addition to trade-offs with design for functionality, durability and recyclability, there are concerns that marine biodegradable materials could create a perverse incentive to intentionally discard more gear into the marine environment, ultimately doing more harm. Besides, there are concerns about the degradation process leading to the emission of microplastics into the marine environment. Differences between gear types and related risk of (un)intentional discards should also be considered. For example, the best strategy for expensive trawl gear might be to improve durability and increase life span. However, for gill nets, that are less expensive and more likely to end up in the marine environment, and biodegradable netting could be looked into further. When asked about the success of biodegradable materials for fishing gear, most companies give inconsistent

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responses. Some see the trials as promising, while others raise concerns about the functionality of alternative materials and the time it takes to biodegrade in the marine environment. More research is clearly needed to understand the balance of benefits and risks of marine biodegradable materials in different circumstances, in order to define clear standards on marine biodegradability. However, there are some specific instances where use of marine biodegradable materials seems promising. For example, studies have shown that the ghost fishing by lost pots causes significant economic losses (Scheld et al., 2016). Simple design modifications have the potential to reduce this. In Norway, ResQunit has developed a floatation device that can be attached to lobster traps and pots with cotton twine that disintegrates in 90 days, revealing an escape hatch and releasing the floatation device. This enables wildlife to escape and alerts fishers to the location of the lost gear. Such small design modifications can easily be embedded in regulations. For example, in Puget Sound/Washington and Alaska, a biodegradable cord on shellfish trap escape hatches is compulsory. These cords are generally made of cotton. A similar regulation is in place in Canada, California and Oregon.

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8. RECOMMENDATIONS FROM STAKEHOLDERS

There has been growing interest in plastics that are biodegradable in seawater, where polymers disintegrate in either industrial composting installations or the natural environment into smaller molecules and eventually minerals (CO2, H2O, CH4, etc.). The rate of biodegradability depends on the ‘aggressiveness’ of the environment; seawater is considered less ‘aggressive’ than freshwater, soil or composting facilities and therefore materials will be slower to degrade (CE Delft, 2017).

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8.1. Some quotations by EUROCORD members

a. *The industry inherently strives for cost-effective solutions, including materials with lower embodied energy and/or water. For example, development of standards for manufacturing (under ISO 5000135) is the result of the industry working with suppliers (e.g., Dow, Repsol) committed to addressing their impact, conserving resources and improving the bottom line through efficient energy management.*
b. *Reduction of process waste is also part of the normal manufacturing process. For example, within production of raw materials (typically some form of extruding), the waste is recycled in-line, while during assembly of fishing equipment there are typically implemented gathering and recycling of cut-offs.*
c. *The use of internally recovered or recycled materials from process waste is already being undertaken by producers of filaments during the extrusion phase. The percentage of such materials is defined according the desired output for the final application, with lower performance products containing higher percentage, while materials that have a higher performance containing lower percentage of internally recovered or recycled materials.*

8.2. Environmental recommendation

Reducing environmental impact of the product lifecycle across the supply chain is needed considering not only the usage of the material but also transportation and distribution. Extension strategy is also required to enhance life of product and to manage recycling at end of life.

8.3. Technical requirements

Below are the main patterns in the needed specifications for fishing gear and then if relevant, there is provided any further comments from manufacturers.

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8.3.1. Most important technical requirements for fishing gear (and its components)

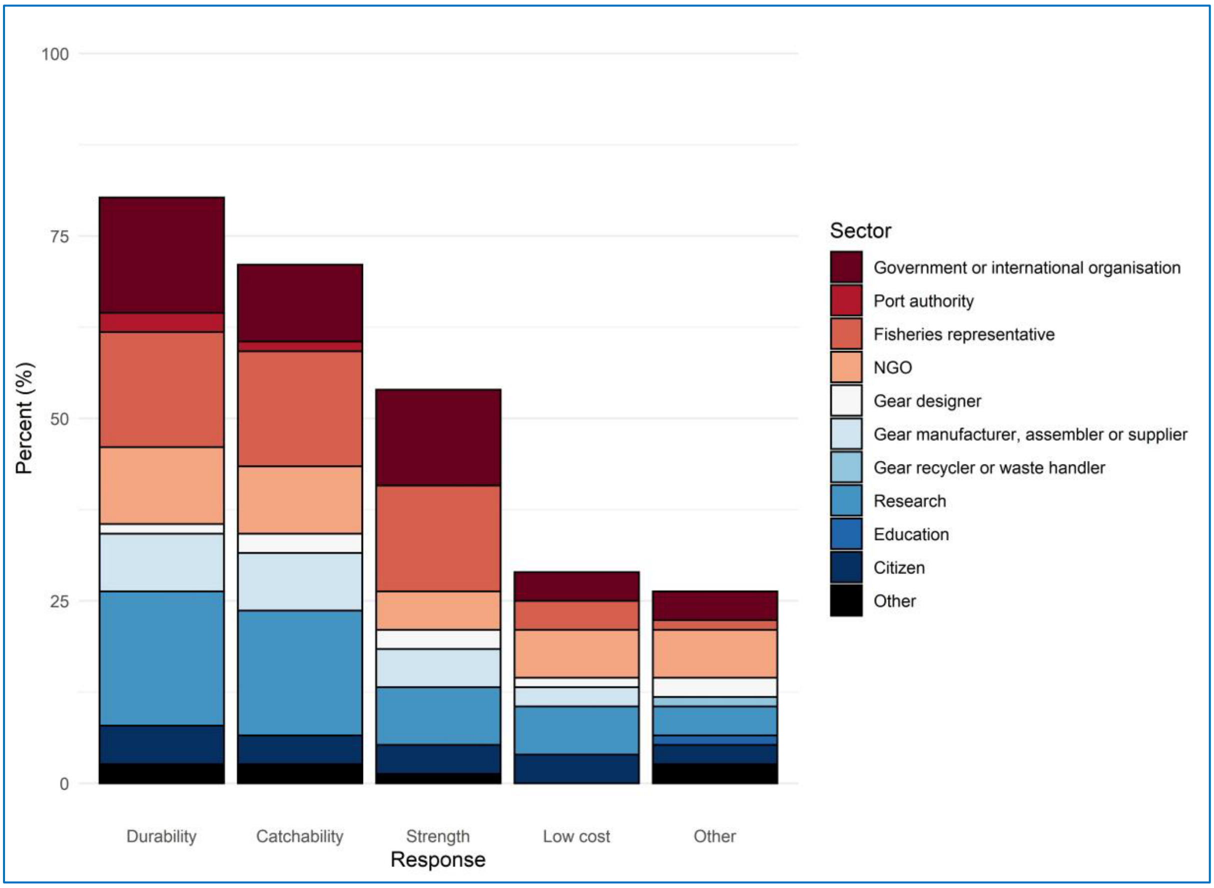

Figure 1: Technical requirements for fishing gears (based on stakeholders inputs, own data of Eurocord).

8.3.2. Importance of technical properties for fishing gear

There is a range of other factors that manufacturers state are important in terms of technical requirements. Of these, ease of repair and recyclability (Citizen, NGO, Government or international organization), biodegradability (Fishing Gear designer/eco-designer, Government or international organization), efficiency and selectivity (Government or international organization, NGO, Research), and low environmental impact (Government or international organization, NGO) are stated across the community of stakeholders (fishermen, gear manufacturers, recyclers, collecting authorities). The ability to track the vessel origin in case of loss is stated as important by NGOs, while simplicity in material used is stated by a fishing gear designer/eco-designer.

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9. CONCLUSIONS AND POTENTIAL NEXT STEPS

Several options were identified for next steps to reduce the amount of fishing gear that ends up as marine litter within the North Atlantic Maritime Area (in terms of design and recycling of fishing gear):

- Knowledge gaps need to be addressed and further research is needed to understand the fishing gear supply chain and life cycle. Interested parties could undertake national mapping exercises for the 'life cycle of fishing gear'.
- Analysis of existing national legal frameworks, related to end-of-life fishing gear as waste, is needed. The establishment of a harmonized waste categorization scheme throughout Europe would remove barriers for recycling. To increase efficiency of recycling schemes, interested parties could develop measures to better organize end-of-life management of fishing gear (through separate collection), including straightforward return logistics, centralized sorting and dismantling facilities, harmonized waste reception facilities (tailored to specific harbour requirements), monitoring of fishing gear placed on the market and collected at end-of-life, and providing both market and non-market incentives (i.e., financial or positive branding benefits) to encourage recycling.
- Awareness raising is also needed, both on the issues of fishing gear as a source of marine litter, and on the practical considerations when preparing gear to be recycled.
- Recyclability of fishing gear could be improved at the design stage by reducing the number of materials in gear, making materials easier to identify, make them bio-degradable or bio-friendly, ensuring higher purity of materials and making gear easier to dismantle. Any adaptations should follow the waste hierarchy, favouring re-use and repair, over recycling.

EUROCORD could play a role in further awareness raising on this topic, and further steps for interested parties could be to explore the role of legislative or voluntary measures to improve fishing gear design or recycling. EUROCORD and / or interested parties could share their experiences on how to apply EPR-schemes along the production chain and support pilot studies that consider alternative, more environmentally friendly materials or aiming at better gear protection. Design to reduce environmental impact should include considerations to make gear less prone to wear and tear and less prone to getting lost, as well as reducing environmental impact in the event that gear is lost at sea.

Glaukos will demonstrate the complete life cycle of eco-designed fishing gear, all the way from virgin biobased feedstock to prototype, and ending with two EOL solutions: triggerable biodegradation and bio-recycling. In order to ensure that Glaukos will respond appropriately to the different needs and requirements, taking into account the specific challenges, barriers and bottlenecks of the targeted sector, Glaukos will set up a Stakeholder Labs consisting of the Quadruple Helix (Academia, Industry, Policy Makers and Civil Society) focusing on fishing gear sector. The ultimate ambition is to offer policymakers, the industry and other stakeholders advanced methods and tools for the reliable assessment of the textile value chain and its impact on the environment and society.

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