ADVANCING TOWARDS LITTER-FREE ATLANTIC COASTAL COMMUNITIES BY PREVENTING AND REDUCING MACRO AND MICRO LITTER

Life cycle study of fishing nets in Galicia
(File no. 113-25-CG)

WORK PACKAGE 1.

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Activity and task	MANAGEMENT AND RECYCLING OF WASTE FISHING GEAR - STUDIES ON FISHING GEAR LIFE CYCLE
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GLOSSARY OF ACRONYMS

ALDFG: Abandoned, lost or discarded fishing gear
ASTM: American Society for Testing and Materials
EN: European Standards
EOLFG: End-of-life fishing gear
EPR: Extended producer responsibility
EPS: Expanded polystyrene
GRT: Gross registered tonnage
HDPE: High-density polyethylene
HMWPE: High molecular weight polyethylene
ISO: International Organisation for Standardisation
LDPE: Low-density polyethylene
MAPA: Spanish Ministry of Agriculture, Fisheries and Food
MITECO: Spanish Ministry for Ecological Transition and Demographic Challenge
PA: Polyamide
PA 6: Polyamide 6
PA 66: Polyamide 66
PE: Polyethylene
PES: Polyester
PET: Polyethylene terephthalate
PP: Polypropylene
PUR: Polyurethane
PVA: Polyvinyl alcohol
SPA: Spanish Port Authority (state or regional)
SUP: Single-use plastics
t: Unit of measurement for tonne
UHMWPE: Ultra-high molecular weight polyethylene
UNE: Spanish Association for Standardisation

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1. INTRODUCTION

This study is part of the Free LitterAT Project, funded under the Interreg Atlantic Area Programme, whose overall objective is to protect and preserve biodiversity and reduce pollution through the development and implementation of innovative approaches to prevent and reduce marine litter, with a special emphasis on 'Abandoned, Lost or Discarded Fishing Gear' (ALDFG) and microplastics, with the aim of understanding their distribution, abundance and sources of pollution. The project combines the development of knowledge, tools and technology with the implementation of pilot actions, with the participation of stakeholders.

In the context of this project, studies are being carried out on the life cycle of fishing gears in the participating countries, either at the national level (Ireland and Portugal) or at the regional level (Spain and France). In Spain, the study analyses the life cycle of fishing gears in Galicia. The aim is to gain an in-depth understanding of their use, management and treatment at the end of their useful life, in order to identify opportunities for improvement and design strategies that promote proper management, prevent possible losses or abandonment that contribute to marine litter, and explore options for reuse or recycling.

The study focuses on the *Comunidad Autónoma de Galicia*, a region heavily dependent on fishing located in north-western Spain and aims to provide an overview of the current legal framework, the characteristics of the port system and fishing activity. It also analyses the materials used in the manufacture of nets and other fishing gear, as well as their production and consumption, end-of-life management through collection, sorting and subsequent destination or treatment, including recycling. The objective is to provide information that will facilitate the implementation of an Extended Producer Responsibility (EPR) scheme for fishing gear and obtain new raw materials that can be incorporated into a circular economy model.

2. METHODOLOGY

This study was conducted in two phases. In the first phase, based on secondary sources of information, a review and analysis of the regulatory framework, studies, reports and publications was carried out, which allowed key information on the life cycle of fishing gear to be compiled. In the second phase, based on primary sources, information was obtained directly from key stakeholders in the fishing gear value chain, using questionnaires designed specifically for each of the six groups of stakeholders identified and conducting personal interviews. The main results of this process of gathering information and analysis are presented in different sections of this document on the life cycle study of fishing gears in Galicia.

3. LEGAL AND REGULATORY FRAMEWORK

International regulations, through the MARPOL 73/78 Convention, prohibit the discharge of fishing gear into the sea and require fishing vessel owners to notify the competent authorities and record discharges and losses of their fishing gear.
Furthermore, within the framework of the *European Strategy for Plastics in a Circular Economy*, Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment, also known as the Single-Use Plastics Directive (SUP), was adopted. This directive establishes actions to combat marine pollution caused by plastics, including fishing gear containing plastic, and has been transposed into Spanish law through Law 7/2022, of April 8, on waste and contaminated soil for a circular economy. In parallel, Directive (EU) 2019/883 on port reception facilities for the delivery of waste generated by ships contributes to ensuring the proper management of fishing gear containing plastic. This directive has been transposed into Spanish law by Royal Decree 128/2022 on port reception facilities for ship-generated waste.
The main contents of these regulations, which form the regulatory framework for the management of fishing gear and its waste, are set out below, including the establishment of an EPR scheme and its corresponding regulatory development through the draft Royal Decree on the management of waste fishing gear containing plastic.

3.1. International convention for the prevention of pollution from ships MARPOL 73/78

In Annex V, the Convention sets out rules to prevent pollution by garbage from ships, prohibiting *the disposal into the sea of all plastics, including but not limited to synthetic ropes, synthetic fishing nets* (Regulation 3). As an exception to Regulation 3, Regulation 7 states that *it shall not apply to the accidental loss of fishing gear from a ship, provided that all reasonable precautions have been taken to prevent such loss, nor to the discharge of fishing gear from a ship to protect the marine environment or the safety of the ship or its crew*. Regulation 10.6 states that the discharge or accidental loss of fishing gear that poses a significant threat to the marine environment or navigation shall be reported to the State whose flag the vessel is entitled to fly and, in cases where the discharge or loss occurs within the waters under the jurisdiction of a coastal State, also to that coastal State. In addition, fishing gear is recorded in Part I, category H of the Garbage Logbook, considering fishing gear, among other objects, to be included in the definition of "garbage".

3.2. Law 7/2022 on waste and contaminated soil for a circular economy

Law 7/2022 introduces the SUP Directive in Title V: Reduction of the impact of certain plastic products on the environment. With regard to fishing gear containing plastic, it

includes a definition of fishing gear waste: *any fishing gear that meets the definition of waste, including all separate components, substances or materials that were part of the fishing gear or were attached to it when it was discarded. This also includes abandoned or lost fishing gear and its components.*

The law establishes that producers of products, or their authorised representative established in another Member State that markets these products in Spain, must comply with their obligations under the EPR framework (article 40). To this end, article 60.5 establishes that, before 1 January 2025, the Government must develop an EPR scheme specifically for fishing gear, which includes:

- establishing a minimum national collection rate for this waste for recycling.
- monitoring fishing gear placed on the market, as well as the waste collected.
- ensuring that fishing gear waste collected at authorised facilities in ports through selective collection is managed at the expense of producers, including transport, treatment and awareness-raising measures as set out in article 61.

Among the annual reporting obligations to the European Commission, the Ministry of Ecological Transition and Demographic Challenge (MITECO) must submit data on fishing gear for marine use containing plastics placed on the market, as well as on the waste collected each year (article 65.5.g).

3.3. Law 5/2023 on sustainable fishing and fisheries research

Law 5/2023 introduces in article 17.3 on fishing gear containing plastic the obligations already discussed and set out in Law 7/2022 on waste and contaminated soil, relating to the management of this waste and the regulatory development of the EPR scheme for fishing gear.

3.4. Royal Decree 128/2022 on port reception facilities for waste from ships

The purpose of this Royal Decree 128/2022 is to protect the marine environment from the negative effects of waste discharges by ships using Spanish ports, while ensuring the smooth operation of maritime traffic, improving the availability and use of adequate port reception facilities and the delivery of waste to such facilities. Article 6 establishes that port reception facility operators must ensure the separate collection of ship-generated waste (including end-of-life fishing gear) in ports to facilitate its reuse and recycling. Article 18 establishes a **system of indirect fees** to **remove the incentive** for ships to discharge their waste at sea and guarantees the right to deliver it.

Fishing gear is listed under category H of Annex V to MARPOL (see section 3.1. of the International Convention MARPOL 73/78).

3.5. Commission Implementing Decision (EU) 2021/958

It sets out how data on fishing gear containing plastic, both that placed on the market and fishing gear waste collected in Member States, will be reported, based on article 13.1.d of Directive (EU) 2019/904, or in its transposition into Spanish law, which is set out in article 65.5.g of Law 7/2022 on waste and contaminated soil for a circular economy.
This Decision includes Annex 1, which sets out the format for reporting data on plastic-containing fishing gear placed on the market and on the waste from such gear collected, and Annex 2, which sets out the format for the quality control report, the purpose of which is to gather information on data collection methods and the quality of the data submitted.

3.6. Prior public consultation on the draft Royal Decree on the management of waste from fishing gear containing plastic

During 2024, the MITECO submitted for prior public consultation an information document on the drafting of a new Royal Decree on the management of fishing gear containing plastic, in accordance with the provisions of Law 7/2022 on waste and contaminated soil for a circular economy, with the aim of gathering the opinions of interested parties.
This draft Royal Decree will develop the management of waste from fishing gear containing plastic, applying an EPR scheme for this purpose. It will establish waste prevention targets and measures, set a minimum annual national collection rate for fishing gear containing plastic and define the responsibilities of the different stakeholders involved in the management of this waste. It will also develop the obligations of producers, including the scope of their financial contribution and EPR, as well as the obligations of other economic agents involved. Finally, it will include the awareness-raising and sensitisation-building measures provided for in Law 7/2022.

3.7. Development of the EPR scheme and end-of-life fishing gear (EOLFG)

Law 7/2022 defines the EPR scheme as: *the set of measures adopted to ensure that producers of products assume financial responsibility or financial and organisational responsibility for the management of the waste phase of a product's life cycle.* The draft Royal Decree on the management of fishing gear waste provides for the development of the EPR scheme applicable to this type of waste. As indicated in section 2.1.2 of Law 7/2022 on waste, producers of fishing gear containing plastic must bear the costs of the selective collection of this waste at the receiving port facilities, in accordance with Royal Decree 128/2022, as well as its subsequent transport and treatment, including the corresponding awareness-raising measures.

3.8. Standard EN 17988. Circular design of fishing gear and aquaculture equipment series (CEN-CENELEC, 2025)

This European standard 17988 establishes the general requirements and guidelines for the circular design of fishing gear and aquaculture equipment and is broken down into six parts:

- Part 1: Requirements, recommendations and guidelines for the transition from a linear to a circular economy, incorporating the general principles of circular design applicable to fishing gear and aquaculture equipment.
- Part 2: User manuals and labelling systems, which accompany the circular design of fishing gear and aquaculture equipment, facilitating traceability and ensuring proper management throughout their useful life.
- Part 3: Recommendations and guidelines to be applied throughout the entire life cycle of fishing gear and aquaculture equipment, including repair, remanufacturing and reconditioning, as well as storage and transport; and, finally, end of use, including recycling.
- Part 4: Aims to optimise the use of materials and resources, reducing the amount of plastics that end up as waste.
- Part 5: Develops circular business models that aim to keep products in their original use for as long as possible and includes guidelines to support EPR scheme for fishing gear and aquaculture equipment.
- Part 6: Requirements and guidelines for the digitisation of information on fishing gear and aquaculture equipment components.

4. SPANISH PORT SYSTEM. CHARACTERISTICS OF THE GALICIAN PORT SYSTEM

The Spanish port system consists of 46 state-owned ports managed by 28 Port Authorities (Figure 1) dependent on *Puertos del Estado*, the public body responsible for implementing port policy (Puertos del Estado, n.d.) and regional ports managed by the different Autonomous Communities (regions).

Figure 1. State-owned port system (Port Authorities and State Ports, Public Body State Ports, 2024)

There is a total of 127 ports located in the Autonomous Community of Galicia, of which 5 are state-owned ports, managed by the Port Authorities of Vigo, Marín and Ría de Pontevedra, Vilagarcía de Arousa, A Coruña and Ferrol-San Cibrao. The remaining 122 ports (Figure 2) are managed by the Regional Government of Galicia (Xunta de Galicia) through *Portos de Galicia*, a public body attached to the Regional Ministry of the Sea (Conselleria do Mar), whose structure has a territorial organisation divided into four work centres:

- Central Services (Santiago de Compostela).
- Northern Zone: manages 21 ports from Ribadeo to Redes.
- Central Zone: manages 58 ports from Pontedeume to Rañó.
- Southern Zone: manages 43 ports from Pontecesures to Tui.

Among these, 83 ports are authorised for the unloading of fishery, shellfish and aquaculture products (Portos de Galicia, n.d.).

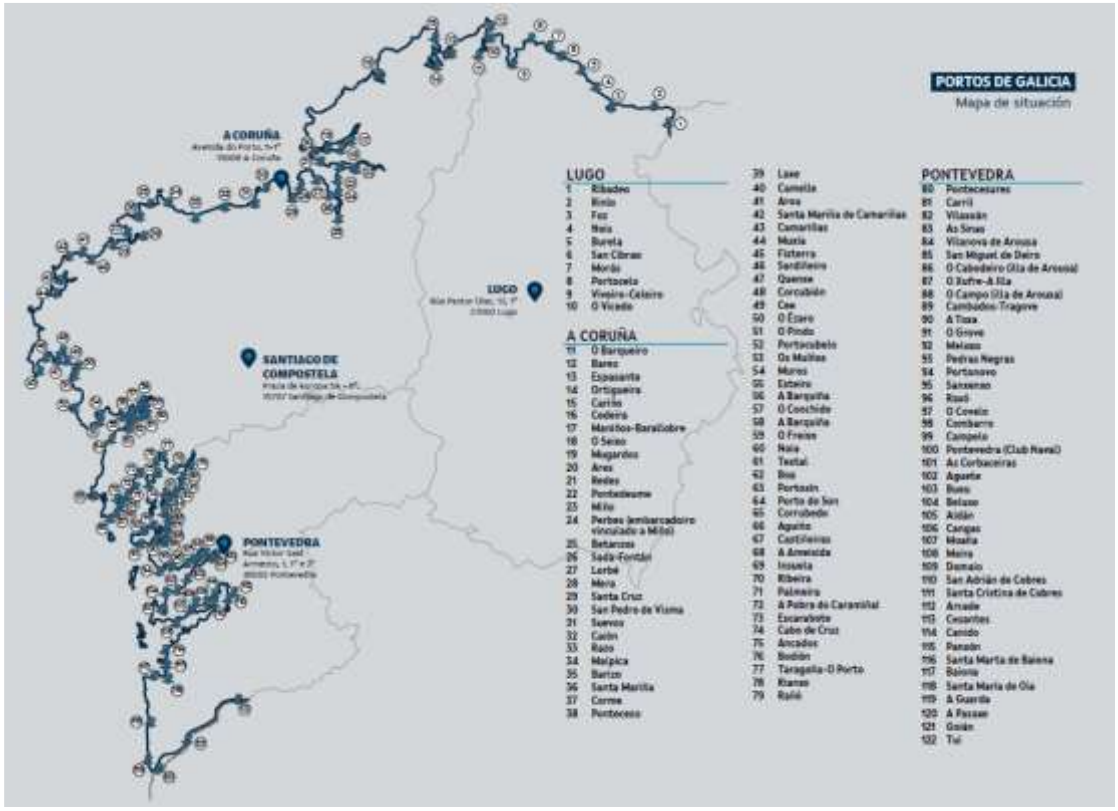

Figure 2. Port system of Galicia. Location map (Portos de Galicia, 2022)

According to the Economic Survey of Sea Fishing 2023 income from fishing activities reached **€1,806.92 million**. In the same survey, **total expenditure by the sector on fishing gear** amounted to **€45.39 million**, **with €15.21 million corresponding to national waters** and **€30.18 million to non-national waters** (MAPA, 2025).
Meanwhile, data from the **2024** management report of the ***Portos de Galicia*** entity recorded 60,000 t of fresh fish unloaded, representing a **turnover of €232 million in fish markets**.

5. SPANISH FISHING FLEET. CHARACTERISTICS OF THE GALICIAN FISHING FLEET

5.1. Spanish fishing fleet

Data from the Operational Fishing Fleet Census as of 31 December 2024 indicate that the Spanish fishing fleet consists of 8,432 vessels, of which 8,102 operate in national fishing grounds, 93 in European Union fishing grounds and 237 in international fishing grounds (MAPA, 2025).
According to data collected in the 2024 report by the Spanish Economic and Social Council, the Spanish fishing fleet has an average age of 35 years. It is mainly structured

as artisanal (78 % of vessels are less than 12 m in length, 19 % are between 12 and 24 m, and 2.8 % are over 24 m), with small-scale fishing techniques being the most widely used (78 %), followed by trawling (10.2 %) and purse seining (6.3 %).

5.2. Galician fishing fleet

The **Galician fishing fleet** consists of **5,428 vessels**, of which 1,281 are auxiliary vessels, according to the Galician Fishing Register in June 2025 (Table and Table 2), classified according to vessel specifications (tonnage, power, length, etc.), type and method of fishing, or the fishing grounds where they operate (Xunta de Galicia - Consellería Do Mar, n.d.):

- **Coastal fleet**
- **Deep-sea fleet**
- **Distant water fleet**

The **coastal fleet** consists of small vessels with highly variable tonnage and very heterogeneous characteristics depending on the fishing gear used:

- **The small-scale or artisanal fleet** includes shellfish gathering from boat and is the largest in terms of number of vessels, with 3,699 units operating mainly in inland waters, especially in estuaries.
- **The coastal fleet** consists of vessels between 10 and 150 Gross Registered Tonnage (GRT) operating near the Galician, Cantabrian and Portuguese coasts. The **purse seine fleet is the second largest in the inshore fleet**, with some 143 vessels.
- **The coastal trawl fleet** operates in the waters of the Cantabrian Sea, from Portugal to France, and consists of some 48 vessels based in the ports of Burela, Celeiro, A Coruña, Ribeira, Muros, Marín and Vigo.
- The coastal fleet is completed by other less numerous types of vessels, such as **bottom longliners, fishing boats with `rascos´ and `volanta´, and the surface longline fleet**, with around 90 vessels.

The **deep-sea fleet** comprises vessels that exploit internal fishing resources within the European Union. Sixty-four fishing vessels based in Galicia operate in these non-Spanish Community waters. Noteworthy are the Gran Sol units of the North-East Atlantic Fisheries Commission, with refrigerated vessels operating mainly in the waters south and west of Ireland; vessels fishing off the coast of France using trawls and bottom longlines; and fishing vessels from Portuguese fishing grounds operating trawlers and purse seiners.
This deep-sea fleet also includes purse seiners that fish for anchovies in the Bay of Biscay, with some of these vessels subsequently joining the seasonal albacore fishery.

The **distant water fleet** operates in international waters in the Atlantic, Indian and Pacific Oceans, using surface longliners in the North and South Atlantic, freezer trawlers

in these same waters and other types of fishing vessels in other areas of the Atlantic, off the African coast and in countries bordering the Pacific. (Xunta de Galicia - Consellería Do Mar, n.d.).

Table 1. Galician fleet vessels by fishing ground (June 2025)

Main fishing ground	No. of vessels
NATIONAL	3980
EU	64
INTERNATIONAL	103
SUBTOTAL	**4147**
AUXILIARY	1281
TOTAL	**5428**

Galician fishing fleet vessels by main fishing ground (Galician Fisheries, 2025)

Table 2. Vessels in the Galician fleet by type of fishing and fishing ground (June 2025)

Type of fishing	Main fishing ground	Fishing method	Tonnage range (Gross Registered Tonnage-GRT)	No. of vessels	Total fishing type
TRAWLING	NATIONAL			48	
TRAWLING	EU			20	
TRAWLING	INTERNATIONAL			26	**94 (2.3%)**
PURSE SEINE	NATIONAL			143	
PURSE SEINE	INTERNATIONAL			2	**145 (3.5%)**
GILLNET	NATIONAL	RASCOS		3	
GILLNET	NATIONAL	VOLANTAS		20	**23 (0.50%)**
BOTTOM LONGLINE	NATIONAL			18	
BOTTOM LONGLINE	EU			44	
BOTTOM LONGLINE	INTERNATIONAL			1	**63 (1.5%)**
SURFACE LONGLINE	NATIONAL			49	
SURFACE LONGLINE	INTERNATIONAL			74	**123 (3%)**
SMALL SCALES	NATIONAL		Less than 2.5 GRT	2,748	
	NATIONAL		From 2.5 to 25 GRT	905	
	NATIONAL		From 25 to 50 GRT	5	
	NATIONAL		From 50 to 100 GRT	1	
	NATIONAL		N/R	40	**3,699 (89.2%)**
SUBTOTAL				**4147**	**4147**
AUXILIARY				1281	**1281**
TOTAL				**5428**	**5428**

Galician fishing fleet broken down by type of fishing, fishing grounds, fishing method, tonnage range and number of vessels (Galician Fisheries, 2025)

6. FISHING GEAR. TYPES AND MATERIALS USED. MANUFACTURERS AND DISTRIBUTORS

6.1. Types of fishing gear used in Galicia

The main types of fishing gear used in the Autonomous Community of Galicia are listed below.

Small scale fishing gear

- Small scale gillnets and/or entangling nets:
  - fixed gillnets: *betas*, *volantillas*, *volantines*, trammel nets, *miños*, *raeiras*
  - drift gillnet fishing: *xeito*
- Small scale hook fishing gear:
  - *línea*
  - jigging
  - trolling
  - *palangrillo*
- Small scale trap gear:
  - traps for professional fishing
  - traps for professional shellfish gathering

Purse seine

- Purse seine with purse line net
- Purse seiners for tuna fishing

Longline

- Surface longline (or pelagic)
- Bottom longline (or demersal)

Bottom trawling

Gillnets

- *Volanta*
- *Rasco*

6.2. Materials used in fishing gear

The introduction of synthetic fibre materials in the manufacture of fishing gear represented a significant improvement compared to plant fibres, which were gradually replaced in the manufacture of ropes and nets during the 1950s and 1960s, leading to a reduction in prices (He et al., 2021). Compared to plant fibres, synthetic fibres are more

uniform and continuous, more resistant to breakage and more resistant to degradation (Ramos, 1999).
Table 3 lists the main chemical groups or classes of synthetic fibres used in fishing gear.

Table 3. Chemical groups or classes of synthetic fibres

Group	Symbol	Trade names
Polyamide	PA	Nylon, Amilan, Anzalon, Enkalon, Kapron, Perlon
Polyester	PES	Terylene, Dacron, Diolen, Tergal, Terital, Terlenka, Tetoron
Polyethylene	PE	Corfiplaste, Courlene, Drylene, Etylon, Kanelight, Nymplex, Polythene
Polypropylene	PP	Meraclon, Courlene PY, Danaflex, Hostalen P, Nufil, Ulstron
Polyvinyl alcohol	PVA	Cremona, Kuralon, Kuremona, Manryo, Vinylon

(Ramos, 1999)

Polyamide (PA)

The most important types of synthetic fibres are PA 66 and PA 6. PA 66 is manufactured from two components, hexamethylenediamine and adipic acid, each of which contains six carbon atoms. PA 6 or polycaprolactam is obtained by polymerising the monomer caprolactam, which also contains six carbon atoms (Radhalekshmy and Nayar, 1973; Meenakumari, 2009).
In terms of fishing gear, there is no difference between PA 66 and PA 6 (Ramos, 1999). In general, it can be said that PA 66 may be more resistant, while PA 6 is more economical (Radhalekshmy and Nayar, 1973).

Polyester (PES)

The main PES fibres are made of polyethylene terephthalate (PET) and are manufactured by polycondensation of terephthalic acid with ethylene glycol alcohol (Meenakumari, 2009).

Polyethylene (PE)

Polyethylene is an additive polymer derived from the ethylene monomer, which is generally obtained by cracking petroleum (Meenakumari, 2009).

Polypropylene (PP)

Polypropylene is the additive polymer of propylene obtained in the same way as PE (Meenakumari, 2009).

Polyvinyl alcohol (PVA)

Polyvinyl alcohol is commercially produced from polyvinyl acetate, usually by a continuous process. The acetate groups are hydrolysed by ester exchange with methanol in the presence of anhydrous sodium methylate or aqueous sodium hydroxide (Saxena, 2003).

High-strength PVA fibre stands out for its excellent tensile strength and durability, maintaining its strength even when wet, making it ideal for applications involving exposure to moisture or water, such as fishing nets. This strength is essential in textile products that require superior performance and longevity. A notable feature of this type of fibre is its water solubility, which allows products made from PVA to be easily recycled, facilitating their management (Elephchem, 2023).

Table 4 lists the properties by type of material used in fishing gear.

Table 4. Properties of materials used in fishing gear

Name of chemical group	Polyamide (PA)	Polyester (PES)	Polypropylene (PP)	High-density polyethylene (HDPE)
Ease of use	Good	Excellent	Good	Excellent
Durability	Good	Excellent	Good	Excellent
Resistance to decomposition, fungal deterioration and moisture	Good	Excellent	Excellent	Excellent
Resistance to UV radiation	Acceptable	Excellent	Poor	Acceptable
Acid resistance	Good	Excellent	Excellent	Excellent
Alkali resistance	Excellent	Excellent	Excellent	Excellent
Wear resistance	Excellent	Excellent	Acceptable	Excellent
Buoyancy (density)	Submerges (1.14)	Submerges (1.38)	Floats (0.91)	Floats (0.97)
Melting point	Approx. 250º C	Approx. 245º C	Approx. 150º C	Approx. 147º C

(Adapted from Oxvig and Jansen, 2007 in Hunt and Charter, 2016)

In recent years, manufacturers (Eurored, n.d.; Duracordix, 2025) have introduced new synthetic fibres for use in trawl and purse seine nets (Table 5), such as HMWPE (high molecular weight polyethylene) and UHMWPE (ultra-high molecular weight polyethylene) fibres. UHMWPE fibres are notable for their lightness, high tensile strength, resistance to abrasion, seawater, chemicals and UV rays, as well as their flexibility and low density (Duracordix, 2025).

Purse seine nets use mesh materials with densities higher than that of seawater, such as polyamide or polyester, in order to increase the sinking speed of the net and prevent fish from escaping horizontally (He et al., 2021; Table 5).

In gillnets, the most common material is monofilament nylon (PA), although in some fisheries multifilament or multi-monofilament nets are also used (He et al., 2021; Table 5).

Twine is a type of thread or cord used to make trawl nets. It is usually made from synthetic materials such as nylon, PE or PES (Table 5), which offer strength and durability. Twine for fishing nets is available in various thicknesses and can be single braided, using a single thread, or double braided, using two threads (Sea Fisheries Protection Authority, 2023; Figure 3). Trawl cables are usually made of strong and durable materials, such as steel, to withstand the tension and stress involved in towing these fishing gears (Sea Fisheries Protection Authority, 2023).

Figure 3. Simple twine braids

Double twine braids

(Sea Fisheries Protection Authority, 2023)

As part of the 2012 Eco-Redes II project, a study was conducted on the business and employment potential of recycling fishing gear in the ports of Galicia and Asturias. As part of the study, data was collected on the materials used (Table 5) in some reference gear, also known as "standard gear", for the following types of fishing:

- bottom trawling for coastal, deep-sea and high-sea fishing, where PE represents between 39-48 % by weight of the total trawl gear;
- gillnets *(volanta, rasco, trasmallo, miño, beta, xeito*), predominantly made of monofilament or multifilament nylon or PA;
- purse seine and longline gear, where nylon or PA are again used as the material, either as multifilament (purse seine) or monofilament (longline).

The study conducted by Basurko et al. (2023) on EOLFG in Spain analysed 37 samples to determine the composition of their materials (8 from purse seine nets, 11 from gillnets, 4 from longlines, 9 from trawl nets and 5 from pots), collected in 8 ports, 7 of which were located in the Atlantic coastal area and 5 in the Autonomous Community of Galicia (Burela, Ribeira, A Coruña, Celeiro and Vigo).

Among the materials present in the nets, it was observed that PA 6 and PA 66 are used in purse seine gear, while gillnets are mainly made of PA 6 and, occasionally, PA 66; longlines use PA 6, and HDPE is the predominant material in trawl nets and pots (Table 5).

The trawl nets analysed contain polyolefins, particularly HDPE, which show signs of degradation due to use and exposure to the marine environment. Two types of polymers are identified in pots: HDPE in the ropes and accessories, and PA 6 in the body of the basket (Basurko et al., 2023).

The following is a summary of previous studies describing the materials used in fishing gear or nets, as well as the results of the specific study on materials analysed in the laboratory in EOLFG in Spain, which can be found at Table 5.

Table 5. Review of studies indicating the materials used by type of fishing gear or net, specifically those analysed for EOLFG

Type of fishing gear or net	Materials
Purse seine	Polyamide (PA) [1; 2]and Polyester (PES)[1; 2] Polyvinyl alcohol (PVA) [2] HMWPE [6] UHMWPE [7]
Purse seine with purse line	multifilament Polyamide (PA); Polyamide (PA); Polyethylene (PE); steel [5]
Purse seine (EOLFG)	Polyamide (PA): PA 6 and PA 66 [4]
Gillnet	Polyamide (PA) [1;2] Polypropylene (PP) [2]
Gillnet gear (*Volanta, Rasco, Trasmallo, Miño, Beta*)	Polyamide (PA) monofilament; Polyethylene (PE); Polyamide (PA) multifilament; steel (rope)[5]
Gillnet gear (*Xeito*)	multifilament Polyamide (PA); Polyethylene (PE); steel[5]
Gillnet (EOLFG)	Polyamide (PA): PA 6 and PA 66 [4]
Buoys (different gear types)	Polyethylene (PE); Polyurethane (PUR); Expanded Polystyrene (EPS) as filler [8]
Trawl gear or net	Polyethylene (PE) [2;3, 5] Polyamide (PA) [3] (lower mesh or rail) [5] Polyester (PES) [3] Polysteel (mesh) [5] coated steel cable [5] Polypropylene (lower rail) [5] HMWPE [6] UHMWPE [7]
Trawl net (EOLFG)	High-Density Polyethylene (HDPE) [4]
Surface longline	plastic-rubber material (buoys); Polyamide (PA) monofilament; Polyamide (PA); stainless steel; galvanised steel or iron (hook) [5] UHMWPE [7]
Longline (EOLFG)	Polyamide (PA): PA 6 [4]
Pot (EOLFG)	High-Density Polyethylene (HDPE): ropes and accessories[4] Polyamide (PA): PA 6 in the body of the net [4]

([1] He et al., 2021; [2] Radhalekshmy and Nayar, 1973; [3] Sea Fisheries Protection Authority, 2023; [4] Basurko et al., 2023; [5] Eco-Redes II Project, 2012; [6] Eurored, n.d.; [7] Duracordix, 2025; [8] Direção Regional do Ambiente e Alterações Climaticas (DRAAC), 2023)

6.3. Recyclability of EOLFG materials

The study by Basurko et al. (2023) assigns three degrees of recyclability based on the melting temperature and composition of EOLFG materials:

- Type 1: high thermomechanical recyclability potential as it is composed of monomaterials;
- Type 2: thermomechanically recyclable, but requires prior separation as it is composed of two or more materials;
- Type 3: difficult to recycle due to degradation.

Of the total fishing gears analysed, 56 % were classified as highly recyclable by thermomechanical means (Type 1-2); of this group, 8 % first required a polymer separation process, while the remaining 44 % presented difficulties for mechanical recycling (Type 3).

By type of gear, Basurko et al. establish that purse seine nets are the most suitable for mechanical recycling, followed by gillnets and longlines, which require prior separation before recycling. On the other hand, trawl nets and pots, being multi-material, are more difficult to recycle mechanically. In general, it is concluded that PA nets are more suitable for thermomechanical recycling than HDPE gear (Basurko et al., 2023).

Furthermore, the application and promotion of eco-design in fishing gear involves integrating environmental considerations from the outset, including improving the recyclability of plastic materials. In this regard, it is essential to take into account the compatibility between different plastics for subsequent recycling, so that designers use mutually compatible materials, reducing the need for disassembly and sorting (
Figure 4).

In order to optimise recycling, it is recommended that designers:

- ✓ give preference to thermoplastics over thermosetting plastics
- ✓ select versatile materials with a wide range of applications over materials with limited use
- ✓ redesign components with materials that improve the intercompatibility of the finished product (Maier, 2021;
- ✓ Figure 4).

When assembling fishing gear, the use of parts made of different materials should be minimised, as the presence of multiple materials hinders the recyclability of the product (Maier, 2021). In cases where it is necessary to use different materials, these should be easily separable according to the assembly system (
Figure 4), without compromising the technical specifications of the gear or reducing its useful life.

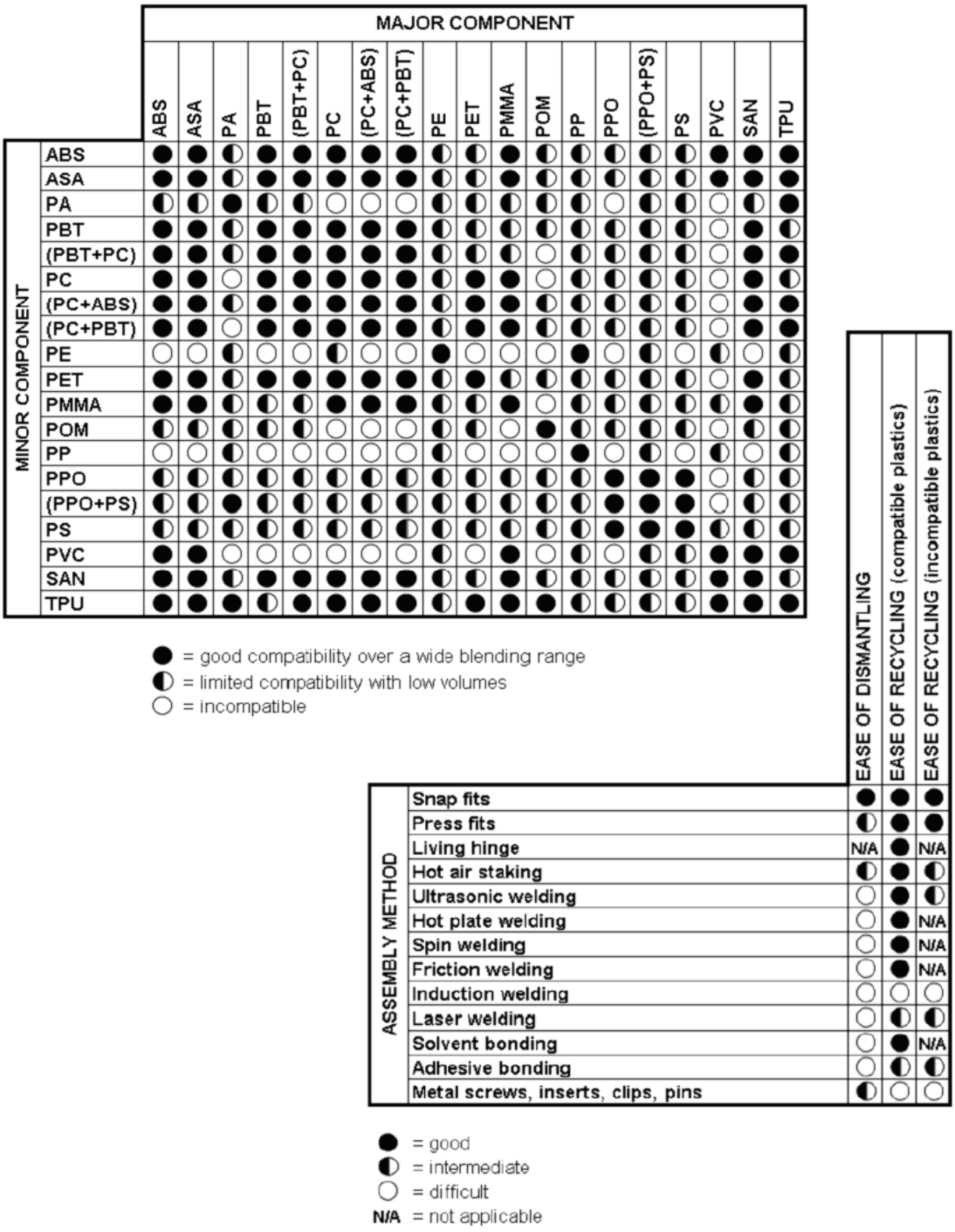

Figure 4. Compatibility of two plastic components and plastic assembly methods to improve recyclability (Maier, 2021)

6.4. Biodegradable materials and their application in fishing gear

As an alternative to fossil-based plastic materials, there are new plastic materials from renewable sources, differentiating between non-biodegradable and biodegradable materials, and within these, compostable plastic materials that can be treated in **domestic or industrial** composting facilities, according to the requirements and conditions demanded by each type of material (Figure 5).

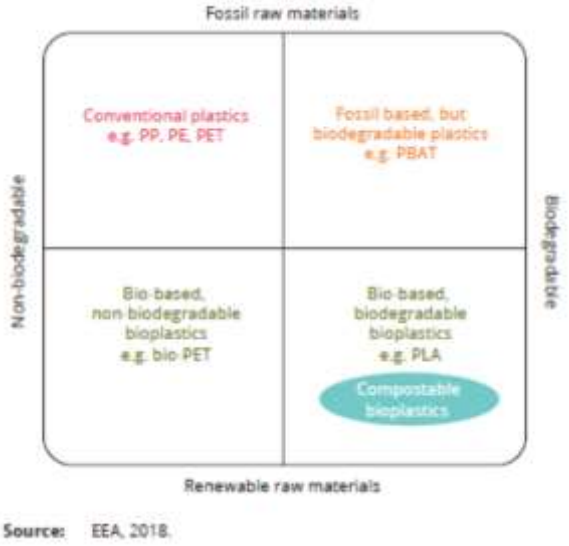

Figure 5. Classification of materials according to their fossil or renewable origin and biodegradability (European Environment Agency, 2018)

Biodegradable polymers can be classified into three different families according to their origin and production (Giménez et al., 2008, Figure 6):

- Category 1: polymers directly extracted from biomass. Examples of this type of polymer are polysaccharides such as starch, cellulose or chitosan, and proteins such as gluten or zein.
- Category 2: biodegradable polymers from renewable sources or monomers derived from petroleum chemistry. An example of the former is polylactic acid and an example of the latter is polycaprolactones.
- Category 3: polymers produced by genetically modified microorganisms or bacteria. The main group of this type of polymer consists of polyhydroxyalkanoates and some polypeptides.

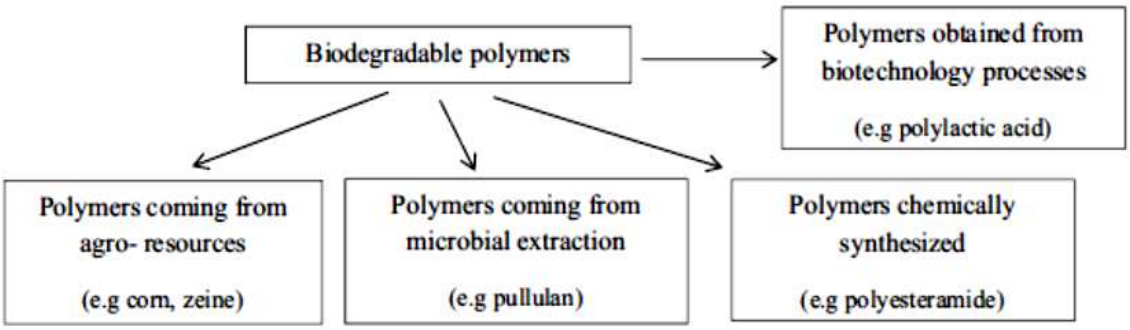

Figure 6. Origin and synthesis of biodegradable polymers (Trinetta, 2016)

When using biodegradable or compostable materials for the manufacture of fishing gear, these must comply with the technical specifications for each type of fishing gear and the new standards developed (Table 6), which guarantee their biodegradability in the marine environment.

Marine environmental conditions have a significant influence on the kinetics of biodegradation, so factors such as salinity, depth, temperature and the diversity of marine habitats must be taken into account. It is also necessary to consider the properties of polymers, including their physical, chemical and mechanical characteristics (Mozo, 2022).

Table 6. List of standards for the assessment of biodegradability in the marine environment (Mozo, 2022).

ISO 18830:2016	Plastics - Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sandy sediment interface - Method by measuring the oxygen demand in closed respirometer.
ISO 19679:2020	Plastics - Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sediment interface - Method by analysis of evolved carbon dioxide.
ISO 23977-1:2020	Plastics - Determination of the aerobic biodegradation of plastic materials exposed to seawater - Part 1: Method by analysis of evolved carbon dioxide.
ISO 23977-2:2020	Plastics - Determination of the aerobic biodegradation of plastic materials exposed to seawater - Part 2: Method by measuring the oxygen demand in closed respirometer.
ASTM D7991-15	Standard Test Method for Determining Aerobic Biodegradation of Plastics Buried in Sandy Marine Sediment under Controlled Laboratory Conditions.
ISO 22404:2019	Plastics - Determination of the aerobic biodegradation of non-floating materials exposed to marine sediment - Method by analysis of evolved carbon dioxide.
ASTM D6691-17	Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium or Natural Sea Water Inoculum.

ISO 16221:2001	Water quality - Guidance for determination of biodegradability in the marine environment

The characteristics and properties of these biodegradable materials used in fishing gear, as well as their behaviour under normal use by the fishing industry, have been studied in various research projects. In general terms, biodegradable polymers with strength and durability comparable to materials currently in use, such as nylon, have been observed, but other bioplastics have been found to have a reduced useful life and greater rigidity.
The main barrier for the sector is the higher cost of these materials at present, requiring greater financial support for their use.

6.5. Manufacturers and distributors of fishing gear in the autonomous community of Galicia

Manufacturers and distributors of fishing and aquaculture gear in the autonomous community of Galicia have been identified, although at the time of this study, there is no association that brings together manufacturers or distributors.

7. CONSUMPTION AND WASTE GENERATION (EOLFG AND ALDFG)

Several projects and studies (Eco-Redes, 2012, Basurko et al., 2023; Asociación Paisaje Limpio, 2022; MITECO, 2025) have been identified that have analysed the consumption of nets and the generation of net waste in Spain, specifically in the Galician region. Furthermore, the questionnaires and interviews conducted have also provided relevant information. The results obtained from secondary sources and from the surveys conducted in this study are presented below:

7.1. Fishing nets consumption

Data from the Eco-Redes I and II Projects (Galicia)

Based on vessel records, the degree of net use and the type of gear employed, it was estimated, based on the GRT of the vessels, that the number of nets used by Galician coastal vessels reached a figure of 441,253 nets per year, broken down by type of gear as follows (Eco-Nets Project I, 2012):

- ✓ 216,704 small scale gear units/year
- ✓ 21,131 units of gillnets, *rascos y volantas*/year
- ✓ 203,418 units of purse seine gear/year

With the development of the Eco-Redes II project, data was presented (Table 7) on the potential annual consumption of nets, by weight (t), by the Galician trawl, gillnet and purse seine fleet, considering the material used in each fishing gear. This potential consumption value for the fleet was calculated by estimating the weight of material consumed per year per vessel and type of gear, multiplied by the number of vessels of each type of gear that make up the Galician fleet.

Table 7. Potential annual consumption of nets by the Galician trawl, gillnet and purse seine fleet (t)	
Trawl nets (PE)	361.5
Trawl nets (PA)	72.1
Gillnets (PA)	154.6
Purse seine nets (PA)	33.0
TOTAL	**621.2**

(Eco-Redes II Project, 2012)

Data from the MITECO survey of fishing gear manufacturers (Spain)

Through surveys conducted among fishing gear manufacturers, MITECO compiled this information in 2025, presented in the Free LitterAT project webinar in November 2025, on fishing gear introduced and marketed in the Spanish market, obtaining the following figures: **7,107 t (2022)** and **6,732 t (2023).**

Data from the study surveys of fishing groups and associations (Galicia)

As a result of the surveys carried out in this study of fishing groups regarding the annual consumption of different fishing gear by the Galician fishing fleet, the data obtained are as follows:

- ✓ **Longline**: an average value of 2.1 t/year of PA per vessel: **391 t/year of PA** for all vessels.
- ✓ **Trawling**: approximately 1 tonne/year per vessel: 94 t/year for all vessels, of material intended for repairs. Approximately 3 t/year of cables and nets are replaced: **282 t/year** for all vessels.
  New gear is not purchased systematically, but rather materials are acquired as needed.
- ✓ **Purse seine**: annual replacement of the purse line weighing 0.9 t/year per vessel: **130 t/year** for all vessels.
  In addition to damaged sections or panels of the net.

Total of 803 t considering all fishing gear.

In some cases, there is no clear estimate of the annual quantity of nets incorporated by the fishing fleet.

7.2. EOLFG generation

Eco-Redes Project

As part of the Eco-Redes II project in 2012, information was presented on the weights of fishing gear materials removed from ports in Galicia, data provided by port authorities and port service companies:

- ✓ PE: 275.1 t
- ✓ PA: 143.1 t
- ✓ **TOTAL: 418.2 t**

BAJUREC Project

The BAJUREC project analyses the waste generated by the fishing sector and shows a clear difference between state and regional ports (Table 8). Although state ports have a greater amount of fishing gear and net waste, they also show greater variability compared to regional ports (Asociación Paisaje Limpio, 2022).

Table 8. Generation of waste from fishing nets and gear (tonnes) in regional and state-owned ports in Galicia

Port ownership	2016	2017	2018	2019	2020	2021
State		214.5	290.4	304.6	69.2	34.2
Regional	74.2	79.6	51.4	77.7	-	54.0
Total	**74.2**	**294.1**	**341.8**	**382.3**	**69.2**	**88.2**

(Clean Landscape Association, 2022)

Study by Basurko et al. 2023

The Basurko study estimates that **1,643 t of EOLFG** (97.5 % HDPE and 2.5 % PA) are discarded in Spanish ports each year. Among the gear studied (trawl, gillnet or purse seine), nets are the most commonly discarded component, except in trawlers, where the contribution is more diverse and includes both nets and ropes.

MITECO survey

Data obtained by MITECO through surveys conducted in State Ports, regional ports, projects, aquaculture companies and waste managers show that **635 t of fishing gear waste** were collected in Spain **in 2022 and 921 t in 2023** (MITECO, 2025).

Data from the study surveys (Galicia)

- *Information from ports*

  Figure 7 shows the quantities of EOLFG managed in the ports of Galicia, estimated on the basis of the responses obtained in the questionnaires and interviews conducted in this study at these ports. The data include both state-owned ports and those managed by the regional entity *Portos de Galicia*.

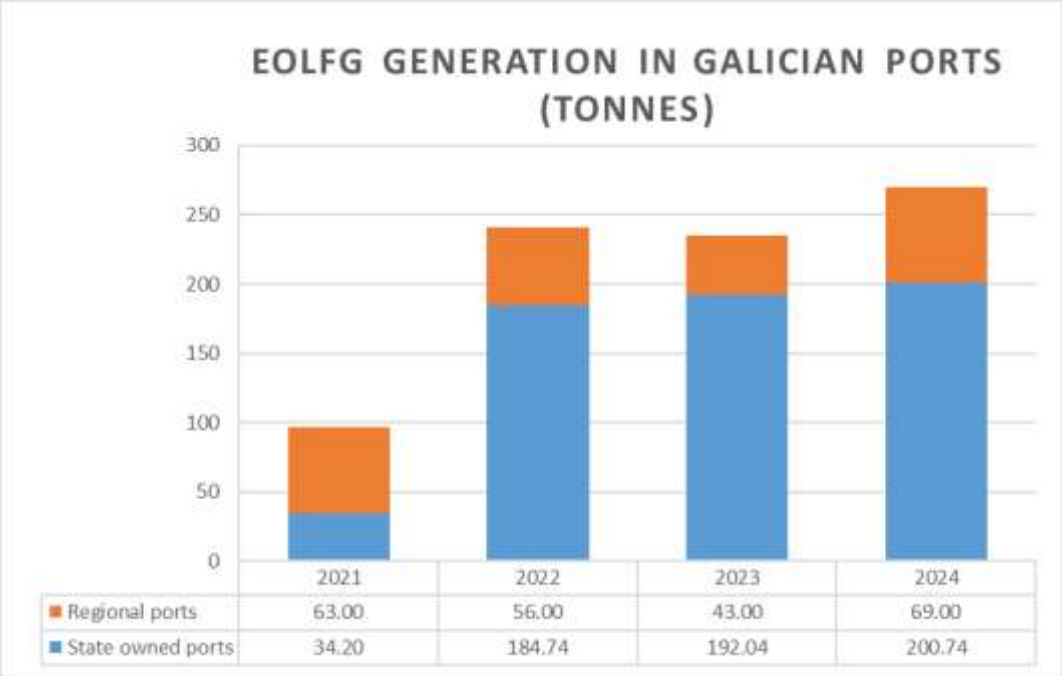

Figure 7. Quantities of EOLFG managed in the ports of Galicia based on the responses to the interviews and questionnaires in this study.

- *Information from waste managers*

  The quantities of EOLFG managed per year by waste managers, with plants at both national and regional level, vary significantly between the participating companies. According to the data provided in the questionnaires, the figures range from 5 to 750 t.

  - ✓ 5t
  - ✓ between 7-8 t
  - ✓ 60 t
  - ✓ 100 t
  - ✓ between 200 and 300 t
  - ✓ a total of 750 t (gillnets: 300 t; purse seines: 300 t; trawls: 150 t); and 250 t from aquaculture

The total value of fishing gear to be managed by waste managers, after deducting the amounts corresponding to aquaculture, is estimated at between 1,122 and 1,223 t/year (**average value of 1,172 t/year**).

- *Information from fishing gear repairers ("redeiras")*

  Based on the results of the surveys conducted in this study among fishing gear repairers, *redeiras*, and in relation to the quantities managed, although it is difficult to quantify precisely, it is estimated that *redeiras* repair between 150 and 200 t per year of EOLFG (**average of 175 t**). The fishing gear items handled include thread cloths, nets, hooks and fishing lines. PE ropes are reused.

7.3. Overview: Sankey diagram

To illustrate net consumption, waste generation and waste managed, a Sankey diagram has been elaborated based on the data collected in the questionnaires and interviews conducted. This diagram visually represents the quantities of fishing gear renewed annually by fishing groups, the quantities of EOLFG deposited in ports and the quantities of gear managed by waste managers together with those repaired by net makers (Figure 8).

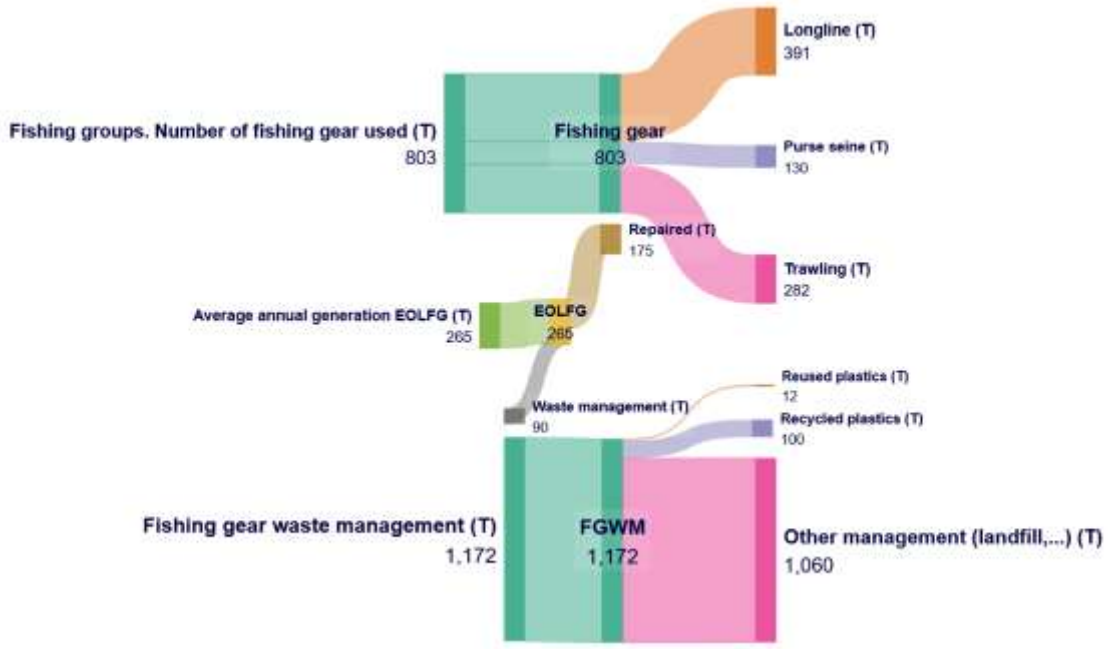

Figure 8. Diagram showing the quantities of nets renewed annually by Galician fishing groups, the EOLFG deposited in Galician ports, and the fishing gear waste managed by waste managers (based on data collected from questionnaires and interviews).

The upper left-hand corner of Figure 8 shows the quantity of fishing gear, in tonnes, that needs to be renewed annually, according to information from the fishing groups. The upper right-hand corner shows the quantities of gear renewed by these groups, broken down by different types of fishing gear (longline, purse seine and trawl).
The centre-left of Figure 8 shows the average annual amount of EOLFG generated in Galician ports (265 t), according to information provided by the SPAs. Based on the information provided by the fishing gear repairers (*redeiras*), an average amount of 175 t/year is repaired, which is redirected to the top as part of the amount that can be renewed by the fishing groups (ship-owners).
The rest of the EOLFG is managed by waste managers, representing a flow of 90 t, which forms part of the total average value of fishing gear waste managed by waste managers (1,172 t), as shown in the lower left part ofFigure 8 .
Of these 1,172 t managed, the percentages indicated by the companies reflect: 1 % destined for reuse, 100 t recycled, and the rest (90-98 %) subjected to other treatments, mainly landfill, information that is represented in the lower right part of the figure.

7.4. Data on ALDFG removed and deposited in ports

The data obtained for the Autonomous Community of Galicia using the Lost or Abandoned Fishing Gear (ALDFG) tool of the LIFE IP INTEMARES project, which collects a record of ALDFG found, located and removed in the five Spanish marine demarcations or outside them, show 59 ALDFG findings. Of these, 41 were identified as trawl fishing gear, located mainly in the North Atlantic Marine Demarcation (88 %). Of the 59 ALDFG, 14 were removed, with this data being validated by the managing body.

The fishing entities consulted in this study indicate that they only manage ALDFG when they participate in fishing for litter projects. The amount of ALDFG managed by these entities is estimated at between 2 and 15 t/year, considered within the total marine litter removed and deposited in the port. With regard to ALDFG, all SPA receive this type of waste in their ports, although it is generally mixed with other waste from marine litter removal. They indicate that the quantities received are included in the total marine litter removed, with an estimated average value of 10 t/year.

The experience gained in projects that have differentiated ALDFG from other marine litter, such as Mares Circulares by the Vertidos Cero Association, indicates an average value of 0.48 t/year of ALDFG in the ports of Galicia where the project is involved (Bueu, Ribeira and Muros). When considering these data together with those obtained in previous projects that also differentiated ALDFG - such as “Nada pola Borda” (2009-2010), PESCAL (2012-2014) and ML-STYLE (2018-2020) - a joint analysis is carried out to estimate an average annual value of 5.20 t of ALDFG removed from ports in the Autonomous Community of Galicia (Figure 9).

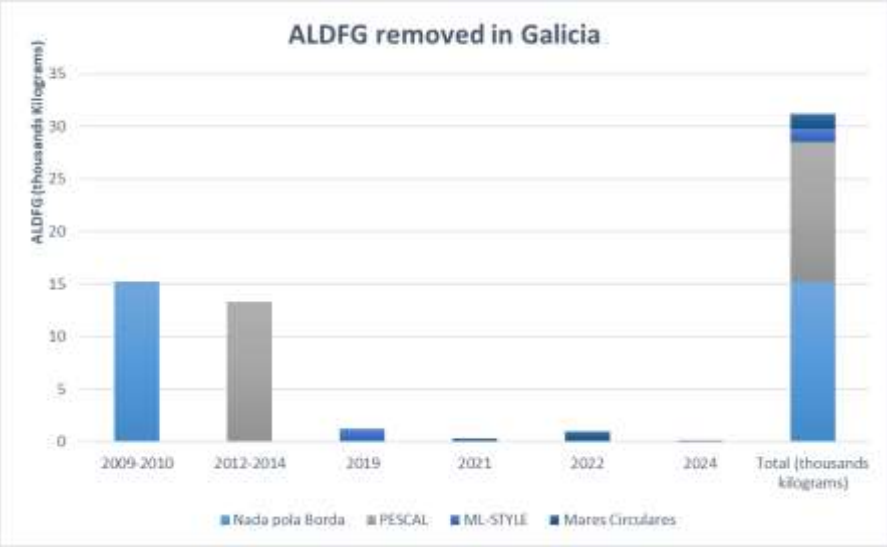

Figure 9. Quantities of ALDFG removed (thousands kg) by fishing for litter projects that discharge and deposit this waste in different ports in Galicia

ALDFG is deposited in containers (Port Authority of Vigo and *Portos de Galicia* ports) or at a collection point equipped with a compactor (Port Authority of Marín). The source of this waste is identified in relation to the marine litter removal projects mentioned above, together with the **Upcycling the Oceans** project, fishing groups and the direct management of the Port Authority.
Management consists of temporary storage in the port before delivery to waste managers. Valuable materials are recycled, while those that are worthless are sent to landfill.

8. MANAGEMENT OF FISHING GEAR WASTE (EOLFG and ALDFG) IN PORTS

The management of EOLFG in Spain, and in particular in the Autonomous Community of Galicia, varies between ports and depends both on their ownership - state or regional - and on the agreements in place between the fishermen's associations and the management companies. As an example of this variability, there are ports that manage EOLFG as MARPOL solid waste, while in certain regional ports, EOLFG has been incorporated into their waste management plans, with specific spaces and containers, such as cages or bins, being provided (Basurko et al., 2023). Basurko's study illustrates the management of fishing gear and net waste among the stakeholders consulted in Spanish ports (Figure 10 ; Table 9):

- 31 % used containers located in an area designated for the storage of EOLFG;
- 12 % disposed of EOLFG in big bags; of these, half had an assigned area in the port and the other half dumped them directly;

- 25 % used cages or containers (Autonomous Communities of Galicia and Catalonia);
- 6 % left EOLFG directly on the port floor (procedure agreed with waste managers);
- 12 % treated EOLFG as MARPOL waste, collecting it together with other waste;
- 14 % did not specify the management method used.

Figure 10. Management of EOLFG in Spanish ports. (a) Assigned storage in cages; (b-e) in metal containers; (f-h) storage on the ground; (i-k) assigned storage in big bags (Basurko et al., 2023)

Table 9. Management of EOLFG in the ports of Galicia

Port	Quantity (t/year)	Storage location	Final treatment of EOLFG
Burela	N/A	Allocated area (containers and cages)[1]	Reuse and recycling[1]
Celeiro	N/A	Allocated area (containers and cages)[1]	Reuse and recycling[1]
A Coruña	60.0[1]	Allocated area (warehouse floor)[1,2]	Reuse, recycling and landfill[1]

Vigo	N/A	Allocated area (containers)[1,2]	Reuse, recycling and landfill[1]
Ribeira	N/A	Allocated area (land)[1]	Reuse and recycling[1]
Muxía	N/A	Allocated area (cages)[1]	Reuse and recycling[1]

([1] Basurko et al., 2023; [2] Asociación Paisaje Limpio; 2022)

The BAJUREC project carried out an analysis of waste management in Spanish ports, both state and regional. The results for the Autonomous Community of Galicia and the specific management of EOLFG are presented below:

State-owned ports

- In the five ports administered by the state in Galicia, fishing gear and nets are collected at collection points with a total capacity of 2.9 m^3 (Figure 11).
- In the port of A Coruña, the collection point is located directly on the ground, while in the other ports open boxes or cages are used (see Table 9 ;Figure 11). Collection by the waste manager is carried out on demand.
- At two of the port recycling points, fishing nets and gear are stacked directly on the ground, except at the port of Marín, where they are sorted and compacted.
- One shortcoming that has been identified is the absence of signage or screen printing clearly indicating the type of waste that should be deposited in the containers or cages.

Regional ports

- 19 ports have warehouses for the storage of fishing nets.
- 32 ports have self-service collection of fishing nets and gear, with a total of 47 collection points with an average volume of 1.7 m^3.
- 96 % of ports have open-top containers.
- Deficiencies include the absence of signage or screen printing on 57 % of containers, the presence of waste outside containers in 19 % of cases, damaged containers in 11 % of cases, dirty containers in 6 % of cases, graffiti in 2 % of cases, and the use of inappropriate containers in 9 % of cases.
- Only the port of Sada-Fontán stores fishing nets and gear at its recycling centre.

Figure 11. Net collection cages in the port of Ferrol (Asociación Paisaje Limpio, 2022)

The lack of eco-design for fishing gear, the combination of different polymers and materials in its composition, the difficulty in dismantling it, the presence of adhered organic matter, together with logistical problems throughout the value chain, constitute an obstacle to the recycling or recovery of EOLFG (Basurko et al., 2023).
Until now, only Galicia and Catalonia had known EOLFG management services, through companies that collected fishing gear directly from ports for recycling (*TEXMA* in Catalonia and *JJ Chicolino* in Galicia), charging in all cases for the recovery of the gear. In other Spanish coastal regions, waste managers reported that EOLFG is recycled, but no company specialising in this activity was identified, so it is likely that some of this waste ends up in landfills (Basurko et al., 2023).
The BAJUREC project identified the waste managers for fishing nets and gear in the three areas into which the ports of Galicia were divided: in the north, *Ascán S.A.*; in the centre, *Misturas S.A.*; and in the south, *Tragsa S.A*. The final treatment of the collected fishing net and gear waste varies according to the area: in the northern area, it is carried out at the *Terra Recicla21* plant; in the central area, at the *Grupo Couceiro* and *Terra Recicla* plants; and in the southern area, at the *Grupo Couceiro* plants and the *Gestán* - Arteixo plant (Asociación Paisaje Limpio, 2022).

As a result of this study on the life cycle of fishing nets in Galicia, after reviewing and analysing primary and secondary sources, the following information on the general development of the EOLFG and ALDFG management process is included below.

Management of EOLFG

The management of EOLFG initially falls to the ship-owner, who is responsible for equipping and maintaining the fishing gear in optimal condition for use, in accordance with current regulations and applicable safety requirements.

Once the gear reaches the end of its useful life, it is deposited in spaces provided by the SPA, which provide temporary storage, custody and subsequent delivery to a waste manager.

The waste manager is responsible for their removal and transport to their facilities and, depending on the type of fishing gear and their operational capabilities, carries out a dismantling process, making use of reusable parts and preparing the rest for delivery to the appropriate recycler. During this process, the manager sorts the materials by type and colour, following the recycler's specifications. Parts of the EOLFG that are not suitable for material recovery by the recycler are sent for energy recovery or to a controlled landfill, following the waste management hierarchy established by current regulations.

In mechanical recycling of plastics, the recycler carries out a pre-treatment process that includes size reduction by shredding or grinding, followed by washing and drying of the materials. Subsequently, separation by polymer type is carried out, which is then subjected to a thermal melting and extrusion process to obtain pellets or spun recycled material.

In the case of chemical recycling, various thermal, chemical or biological technologies are used to break down the polymer into its monomer, which can be reintroduced into the production process to manufacture new material.

Currently, mechanical recycling is the predominant method, compared to chemical recycling. In particular, mechanical recycling is mainly applied to polymers such as PA, although it should be noted that processes such as depolymerisation are also applied to PA. Chemical recycling, on the other hand, is particularly suitable for polymers such as PE and PP.

Onshore management of ALDFG

ALDFG removed by fishing groups, fishermen´s guilds, professional teams and even volunteers participating in marine litter clean-up projects, as well as those delivered as ship waste (MARPOL Annex V), are received at ports, where the SPAs set up temporary storage areas (containers or storage areas for big bags) until they are collected by the authorised waste manager.

If the ALDFG arrives at the port and is of a manageable size and weight, it is best to deposit it in the waste collection systems available at the port as indicated by the SPA. If, on the other hand, the ALDFG is large or heavy and cannot be managed with the means available at the port, it is recommended that the SPA be notified so that the appropriate management procedure can be established.

The process of managing ALDFG by the manager and recycler is similar to that of EOLFG, with the exception that these nets and gear are less likely to be treated. This is because they are often mixed with other marine litter removed during clean-up projects, contaminated with organic matter, high concentrations of salt or the

presence of sand. The recycling of ALDFG requires a more complex and costly process, which includes sorting by polymer type and more thorough cleaning of the aforementioned contaminants.

9. FISHING GEAR VALUE CHAIN

In order to achieve a circular and sustainable value chain, a circularity model has been established in which fishing gear, once it has reached the end of its useful life, is recycled to obtain secondary or recycled raw materials, which are then reincorporated at the beginning of the value chain (Figure 12).

In the case of fishing gear, four distinct chain links have been identified in its value chain: production, distribution or marketing, use and end-of-life management.

- Production: this chain link includes fishing gear manufacturers, those who resell fishing gear manufactured by third parties, and those who introduce or import fishing gear from other Member States or third countries. These actors are key to knowing the quantities of fishing gear that are placed on the market.
- Distribution or marketing: marketers are responsible for the distribution of fishing gear and play a key role in monitoring and traceability to end users.
- Use: users, mainly ship-owners, are responsible for maintaining fishing gear in a condition suitable for use. Once the fishing gear has reached the end of its useful life, the ship-owner must ensure that it is deposited in the areas designated by the relevant SPA.
- End-of-life management:
    - SPAs manage fishing gear within the port domain, providing spaces for repair, temporary storage of EOLFG and separate storage for ALDFG removed from the sea by fishing groups. They also monitor the quantities of both EOLFG and ALDFG generated, take custody of this waste and facilitate access to the port for the authorised waste manager responsible for removing these fractions.
    - The waste manager is a key chain link in determining the quantities of fishing gear waste generated (EOLFG and ALDFG) and ensuring the traceability of the waste. They are responsible for collection and transport to their facilities and, depending on the type of fishing gear and their operational capacities, they carry out dismantling processes, reuse reusable components and prepare the materials for delivery to the appropriate recycler. The manager sorts the material by type and colour, following the specifications of the recycler or processor. Those parts of the fishing gear that are not suitable for material recovery by the recycler are sent for energy recovery or to a controlled landfill, following the waste management hierarchy established in current regulations.

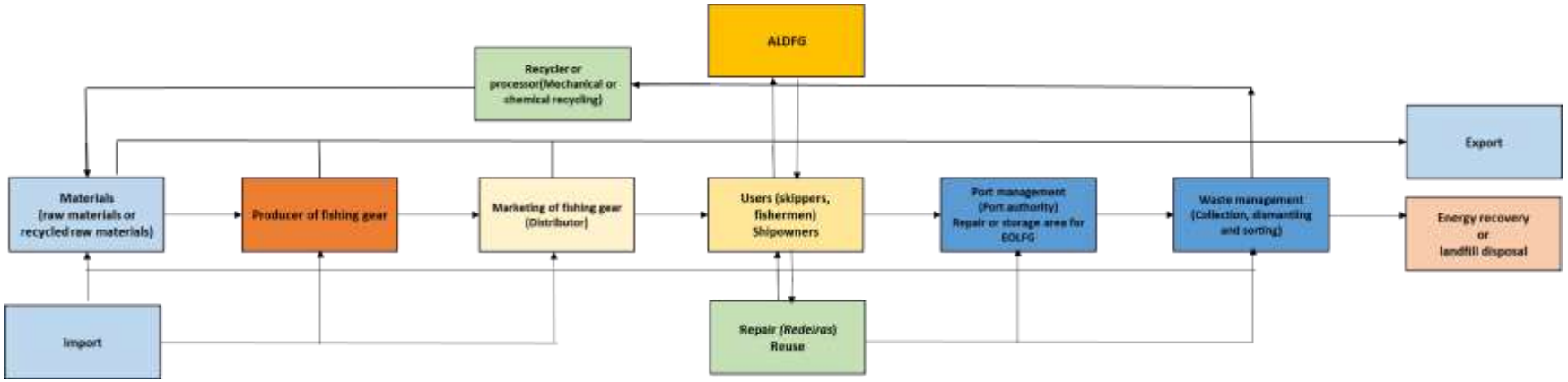

Figure 12. The fishing gear value chain.

The main stakeholders and their activities through repair, management, and end-of-life treatment within the fishing gear life cycle are shown in Figure 13.

Within this circular economy model, two key players take on a particularly important role in the Autonomous Community of Galicia: the *redeiras*, through the repair and reuse of fishing gear that prolongs its useful life, and the recyclers or processors, responsible for converting fishing gear waste into new raw materials that can be reintroduced into the production system.

- The *redeiras*: as professionals specialising in the repair of fishing gear in the Galician port areas, they play a key role in extending the useful life of the gear by repairing those components that can be reused. Whenever possible, they should prioritise the reuse of existing materials and, if new materials are incorporated, encourage the use of materials containing recycled raw materials. They can also contribute to the control and traceability of repaired fishing gear by recording the quantities and types of repairs carried out, as well as the materials reused. Waste generated as a result of repair activities must be managed by an authorised waste manager.

- The recycler or processor: responsible for the recycling processes of fishing gear waste, either through mechanical or chemical recycling. This stakeholder is key to the control and traceability of the quantities of waste received by the waste manager, as well as the volumes of material actually recycled at their facilities, thus enabling the quantification of secondary raw material obtained and its potential reincorporation into the value chain.

The recycled raw material obtained by recyclers can be reintroduced into the value chain through material manufacturers, who supply these raw materials to fishing gear manufacturers, thus closing the cycle and promoting a more circular and sustainable production system (see Figure 12).

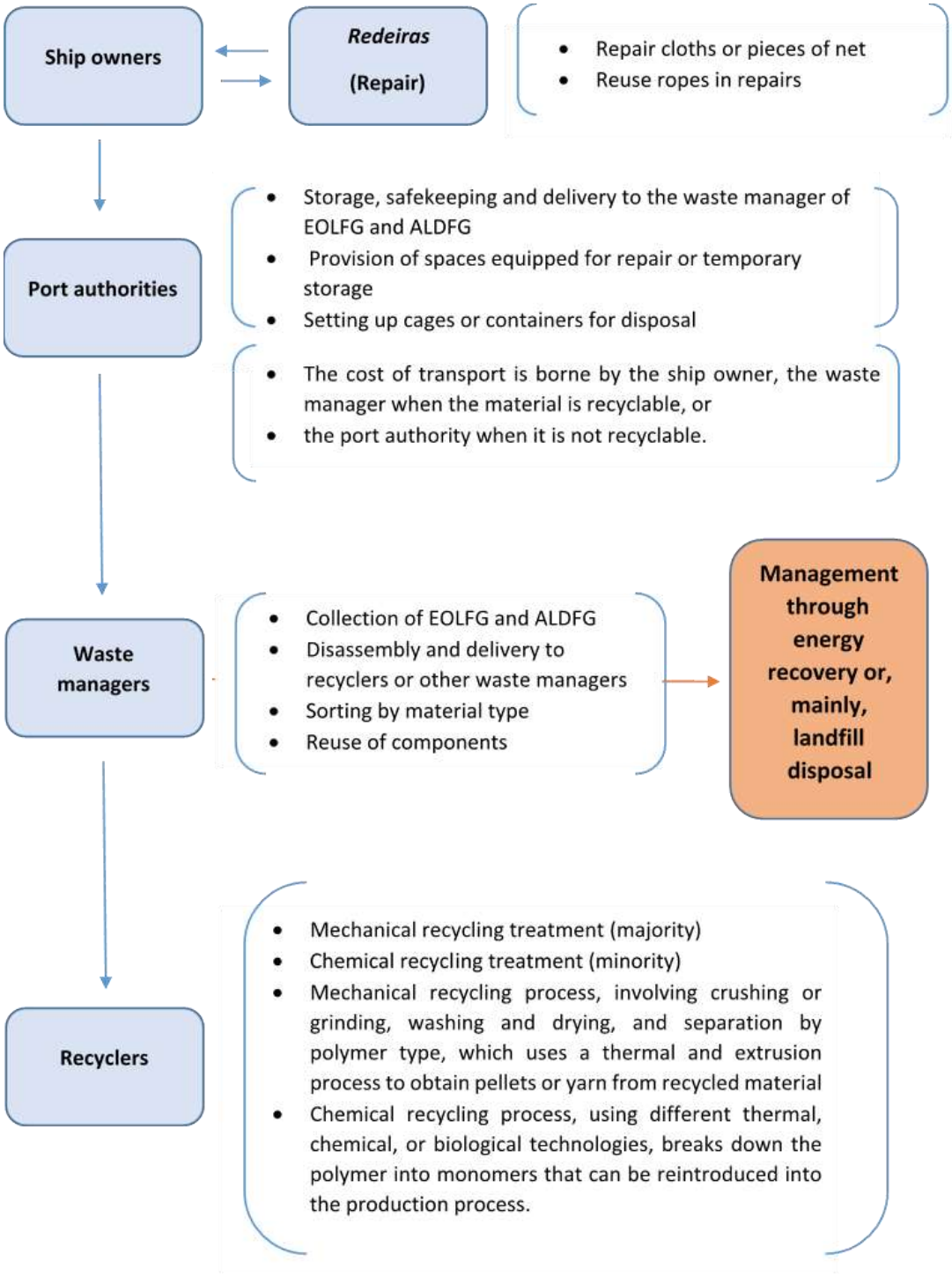

Figure 13. Main stakeholders and their activities in the end cycle of fishing gear

10. CONCLUSIONS

The Autonomous Community of Galicia is closely linked and dependent on fishing activity. It has **83 ports authorised for the unloading of fishery products**, out of a total of 127 ports in the region, as well as a coastal, deep-sea and high-sea fleet comprising **5,428 vessels**, whose main fishing gear is **trawls, gillnets, purse seines, longlines and various minor gear**.

The following are the main materials used in the fishing gears employed by the Galician fleet:

- **PA, mainly PA 6**, used in gillnets, purse seines and longlines, as well as in certain sections of trawl nets.
- **HDPE,** mainly used in trawl nets and pots.
- **PP**, used in trawl nets.
- **Polysteel**, consisting of a combination of PE and PP, used in ropes for purse seine and trawl gear.
- New materials, such as **HMWPE and UHMWPE**, used in trawl and purse seine gear.

With regard to data on **fishing gear consumption**, information has been obtained from some of the stakeholders consulted through questionnaires and interviews, in particular fishing groups, which has made it possible to estimate **an incorporation of 803 t/year of fishing gear into the fleet**. However, the lack of participation by manufacturers and producers means that precise figures are not available on the total incorporation of fishing gear into the Spanish market or, specifically, into the Autonomous Community of Galicia.

Something similar occurs with the values obtained for **EOLFG**, as the different sources consulted offer disparate figures on the generation of this waste at the national level. In the case of Galicia, data on the evolution and temporal variation in the generation of EOLFG could be analysed from primary and secondary sources. However, there are significant differences between the figures provided by the **SPA (265 t/year)**, both state and regional, and those provided by **waste managers (1,172 t/year)**. This discrepancy could be due to the fact that waste managers treat EOLFG from other regions of Spain and even fishing gear imported from other countries for management and treatment.

In the case of ALDFG, data is available from marine litter removal projects that segregate and weigh this waste during their operations. Although SPAs facilitate the reception of this waste, they only record the total figures for marine litter received at their ports. Waste managers do not provide detailed information on these fractions. As a result, there are no accurate or well-differentiated values for ALDFG compared to other waste removed from the sea.

The management of this waste (EOLFG and ALDFG) in relation to its deposit and temporary storage in ports by the SPAs varies greatly, depending on the size and

availability of space in each port, the type of containerisation and the place of deposit. This waste is difficult to manage due to the degradation of its materials, especially in the case of ALDFG, and the complexity of its dismantling, which is mainly manual. In addition, it requires different pre-treatment processes compared to other plastic waste, which significantly limits mechanical recycling. This is more feasible when separate materials (PA, PE or PP) can be obtained, and becomes more complicated when the gear contains additives that hinder recycling, such as anti-fouling treatments in aquaculture nets.

Recyclers have developed specific processes for PA, due to its high market value, but there are still significant limitations to the recycling of PE and PP from nets and ropes, as the prices of virgin materials are much lower than those of recycled materials. The possibilities for treating EOLFG and ALDFG would improve with chemical recycling, although this technology is currently under development on an industrial scale and has higher processing costs than mechanical recycling. For the time being, the main treatment flow for this waste is disposal in controlled landfills.

It is essential to support and introduce eco-design in fishing gear, considering the use of compatible mono-materials or bi-materials, as well as the incorporation of biodegradable materials. In addition, the dismantling of the different sections of fishing gear should be facilitated, which improves the pre-treatment and transformation processes in the mechanical recycling of plastic materials, as well as the development of chemical recycling processes. Likewise, promoting the incorporation of recycled or secondary materials instead of virgin raw materials will contribute to enhancing the management and treatment of plastic materials through recycling.

The development and application of the regulatory framework, including the reception of waste from ships in port facilities and the incorporation of the regulatory requirements on the management of waste fishing gear containing plastic, should generate significant improvements through the implementation of EPR and its obligations. This establishes a new operating context for the fishing gear value chain, facilitating the transition to a circular economy model in this sector.

11. RECOMMENDATIONS FOR A CIRCULAR VALUE CHAIN

Based on the study and surveys conducted, the following recommendations and opportunities for improvement have been identified:

Information management

- Record and monitor information in a harmonised manner so that data is compatible and comparable.
- Improve the collection of information on fishing gear manufactured and placed on the market or the consumption of gear by the fishing sector, as well as the collection of data to optimise the management of EOLFG and ALDFG, considering the quantities of fishing gear waste generated, collected and treated, broken down by type of gear, material and treatment carried out.

- Collect information on the quantities of repaired fishing gear and reused materials, identifying the type of material and the type of gear.
  Improve the understanding of the costs associated with managing this waste in order to facilitate decision-making and the implementation of EPR.
- Establish a register of fishing gear associated with each vessel, including its registration for use, repaired or replaced parts, and the decommissioning of irreparable components or sections, as well as permanent decommissioning as EOLFG.

Manufacturing

- Promote the incorporation of secondary raw materials from recycling, with the aim of reducing the use of virgin raw materials in the production of the synthetic fibres that make up fishing gear.
- Explore the feasibility of introducing biodegradable materials into fishing gear, taking into account that the technical specifications of these materials meet the quality, environmental and durability requirements demanded for these products by the fishing sector.
- Improve the traceability of fishing gear by implementing labelling and sensor systems to prevent the loss of nets.
- Adopt measures aimed at preventing the environmental impact of fishing gear, including reducing its weight, eco-design, reuse, recycling and improving the sustainability of the materials used.
- Introduce redesign, eco-design or circular design criteria for fishing gear, incorporating improvements that facilitate reuse and recycling, such as:
  - prioritising the use of thermoplastics over thermosetting plastics.
  - using single materials instead of multi-material combinations.
  - using compatible materials when it is necessary to combine two or more materials.
  - facilitating the separation and disassembly of components, without compromising technical specifications or reducing the useful life of fishing gear.
  - Apply the requirements, recommendations and guidelines of the UNE-EN 17988:2024 set of standards, aimed at circular design and the life cycle management of fishing gear.
- Consider an eco-modulation model that adjusts tariffs based on factors such as the incorporation of recycled material, eco-design, and the elimination of hazardous substances, adjusting the costs assumed by manufacturers within the framework of EPR, in order to ensure the sustainability of EOLFG and ALDFG management, reducing their environmental impact and promoting a circular economy.

Repair and reuse

- Promote the reuse of materials and the repair of fishing gear components in order to extend their useful life.
- Repair fishing gear by reusing parts or sections from other gear, or by using new components that incorporate recycled material.

- Implement labelling systems that ensure the traceability of repaired parts, as well as geolocation systems that facilitate the recovery of ALDFG.

Fishing sector

- Train and inform stakeholders about the obligations arising from the proper management of fishing gear, highlighting the benefits of promoting reuse, the use of recycled or biodegradable materials, and the proper separation and disposal of waste in accordance with the instructions of the port authorities.
- Support the use of spaces provided by the SPAs that allow for the repair of gear in order to extend its useful life, and areas designated for the temporary disposal of fishing gear, always in accordance with the separation and disposal rules established by the SPAs, enabling them to fulfil their duties as holders of fishing gear waste.
- Promote the application of established protocols for the recovery of ALDFG.
- Raise awareness of the economic and environmental impact of ALDFG, as well as their destination and treatment.
- Apply for government grants for the replacement of fishing gear with new gear that improves durability, incorporates recycled materials and contributes to the reduction of ALDFG.

Port authorities

- Facilitate the repair of fishing gear by providing space to fishing groups for this purpose, as well as establishing designated areas for temporary storage, safekeeping and delivery to authorised managers to improve the management of EOLFG.
- Improve storage areas by standardising signage, container types and colours to differentiate between the types of gear to be separated, as well as assessing the establishment of identification systems for users accessing these spaces. Facilitate measures to improve information, as well as awareness-raising actions aimed at users to promote their use.
- Receive and manage retrieved ALDFG, separating it from other marine waste collected in fishing waste projects.
- Ensure the traceability of EOLFG, collecting and providing data on the origin and generation of this waste.
- Facilitate the removal and transport of this waste by authorised managers to their sorting and dismantling plants.
- Include these waste streams, EOLFG and ALDFG, in their waste management plans.

Waste managers/recyclers

- Make authorised sorting plants available near ports, facilitating the logistics of this waste, ensuring its removal, transport, sorting and dismantling or disassembly for recycling.
- Support the development of measures to reduce the high costs associated with the logistics, collection and transport of fishing gear.

- Promote the correct separation of the different types of EOLFG in ports, facilitating subsequent sorting and dismantling by the managers themselves, as well as the processes to be carried out by recyclers.
- Promote new material recovery processes that make the most of ALDFG and reduce its environmental impact.
- Assist in the implementation of the eco-design measures indicated above, in order to increase the amount of recycled materials obtained.
- Promote and develop new processes for the transformation or recycling of EOLFG, such as chemical recycling, which allow the recycling of the main materials that make up fishing gear.

Material recovery

- Improve the percentage of recycled material, currently around 2 %, and reduce landfill disposal, which stands at 98%.
- Strengthen the market for recycled materials by promoting the incorporation of higher percentages of recycled material through regulations.
- Promote the reuse of materials, currently limited to 1 %, to extend the useful life of fishing gear components.
- Encourage the use of recycled materials in the fishing industry, giving them greater value compared to other sectors such as textiles or automobiles.

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