SEARCULAR
Circular Solutions for Fishing Gears

Executive Summary: Guidelines on Good Management Practices for End-Of-Life fishing gear

SEARCULAR's 'Blue Point' is designed to be scalable and replicable across coastal regions. This report explores the practical requirements for implementing collection and sorting facilities for end-of-life (EOL) fishing gear at ports, supporting the reduction of marine pollution from fisheries and contributing to the objectives of the EU Plastics Strategy.

Sustainable management of fishing gear at the end of its life is compulsory in the EU. However, issues relating to sorting, logistics, and traceability mean that a lot of fishing gear still ends up in landfill or incinerators. To address this, SEARCULAR is trialling replicable port-based solutions for EOL fishing gear.

SEARCULAR has developed a 'Blue Point', a centralized collection and sorting concept for EOL fishing gear. An experimental facility, developed in the Basque Country, will showcase these guidelines for best practice. The Blue Point will serve as an operational hub for the collection, dismantling, and conditioning of discarded fishing gear, supported by a network of satellite collection points at smaller ports, all connected through a coordinated reverse logistics system.

The Blue Point is designed to handle various material streams, including plastic and metal components. Once processed, the materials are directed towards established recycling routes, such as mechanical and thermochemical recycling, supporting the development of a 'Plastic2Plastic strategy'. Non-recyclable residues are sent to energy recovery or, where necessary, to safe disposal.

To enhance the system's viability at scale, we explore alternative supply chain models, including:

- Integration of fish farming equipment waste
- Integration of Abandoned, Lost or Discarded Fishing Gear
- Establishment of an Extended Producer Responsibility system
- Promotion of Design-for-Recycling principles in manufacturing

In addition to technical planning, we address regulatory, social, and economic aspects such as port logistics, workforce training, stakeholder involvement, and financing mechanisms.

SEARCULAR aims to reduce marine litter and microplastic pollution originating from European fisheries. This report presents the work and outcomes of Work Package 4 (Deliverable D4.1). More information about our work on port-based solutions can be found on our website.

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Guidelines on Good Management Practices for EOL fishing gear

SEARCULAR Deliverable 4.1

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1. Introduction

SEARCULAR project core objective is the reduction of marine litter and microplastic generated by European fisheries (demersal trawlers, demersal seiners, tropical tuna purse seiners) at source and, in support of this, the introduction of circular economy practices within the fishing sector value chain, including at ports. It seeks to do this by building acceptance of the tried and tested solutions offered by the project and fostering behavioural change. SEARCULAR involves the collaboration of 13 organisations, including 11 partner organisations. SEARCULAR is funded by the European Union under the EU Mission 'Restore our Ocean and Waters' and UK Research and Innovation (UKRI).

Sustainable management of fishing gear at the end of its life is compulsory in the EU[1]. However, issues relating to end-of-life (later EOL) fishing gear sorting, logistics, and traceability mean that a lot of fishing gear still ends up in landfill or incinerators. SEARCULAR will trial a port-based approach that can facilitate collection, characterization, sorting and conditioning of EOL fishing gear via a Plastic2Plastic strategy. In the first phase, the materials will be characterized to determine their chemical composition, which will allow for more efficient and appropriate classification. Subsequently, as part of the Plastic2Plastic strategy, pyrolysis will be applied to certain selected materials, with the aim of recovering those that are of greatest interest.

Under European policy directives and to improve the sustainability of fisheries, ports are seeking to improve the management of EOL fishing gears. The available facilities, and capacity for processing is often a limiting factor in the ability of ports to process and successfully recycle old and discarded gears. Challenges remain around sorting, logistics, traceability and governance, and, as a result, thousands of tonnes of fishing gear still end up in landfill or incinerators. To address this and generate opportunities in this space, this solution will trial replicable port-based solutions for EOL fishing gear. This will be implemented via the design, development and testing of Blue Points – which collect, sort and condition the gears as part of a Plastic2Plastic strategy. These Blue Points will be designed around a ‘point and reverse’ logistics model which helps optimise and simplify collection process and guide waste managers on the best local practice for the handling and treatment of fishing gear waste. A ‘point and reverse logistics model’ refers to a hub-and-spoke collection approach, where materials are gathered at satellite points and transported to a central facility for processing. This will ensure the efficient handling of waste to break it down and recycle it into new plastics, facilitating a circular economy for fishing gear.[2]

[1] https://eur-lex.europa.eu/eli/dir/2019/904/oj/eng

[2] https://searcular.eu/

2. Commercial EOL fishing gear recycling

2.1 Plastic waste recycling motives and basics

Plastic waste refers to any discarded plastic material, including packaging, containers, and single-use items like bags and straws. These materials pose significant environmental threats due to their non-biodegradable nature, often degrading in the environment slowly[3].

Plastic recycling is the process of recovering waste plastic and converting it into new products. This process helps mitigate the environmental impact of plastic waste by reducing the need for virgin plastic production. Plastic waste recycling contributes to mitigating the environmental impact of plastic waste in many ways. Recycling plastic reduces the demand for virgin plastic resin, which is derived from fossil fuels. By using recycled plastic materials, **we conserve natural resources** and decrease our reliance on non-renewable sources of energy that harm the planet. Producing plastic from recycled materials typically requires less energy compared to manufacturing plastic from scratch. This results in **significant energy savings** and a reduced carbon footprint, contributing to overall energy efficiency. Plastic waste is a major contributor to **overflowing landfills**, posing environmental hazards, and leaching harmful chemicals into the soil and water. By diverting plastic from landfills through recycling, we alleviate the burden on waste management infrastructure and minimise environmental pollution. Plastic pollution in the world's oceans is a growing concern, with devastating impacts on marine life and ecosystems.

Recycling plastic helps prevent the disposal of plastic waste in water bodies, thereby reducing the **risk of marine pollution and safeguarding aquatic habitats**. The recycling industry creates employment opportunities in various sectors, including collection, sorting, processing, and manufacturing. By supporting recycling initiatives, we encourage the growth of green economies and **promote job creation in sustainable industries**. Embracing plastic recycling encourages the principles of a **circular economy**, where resources are kept in use for as long as possible, maximising their value and minimising waste generation.

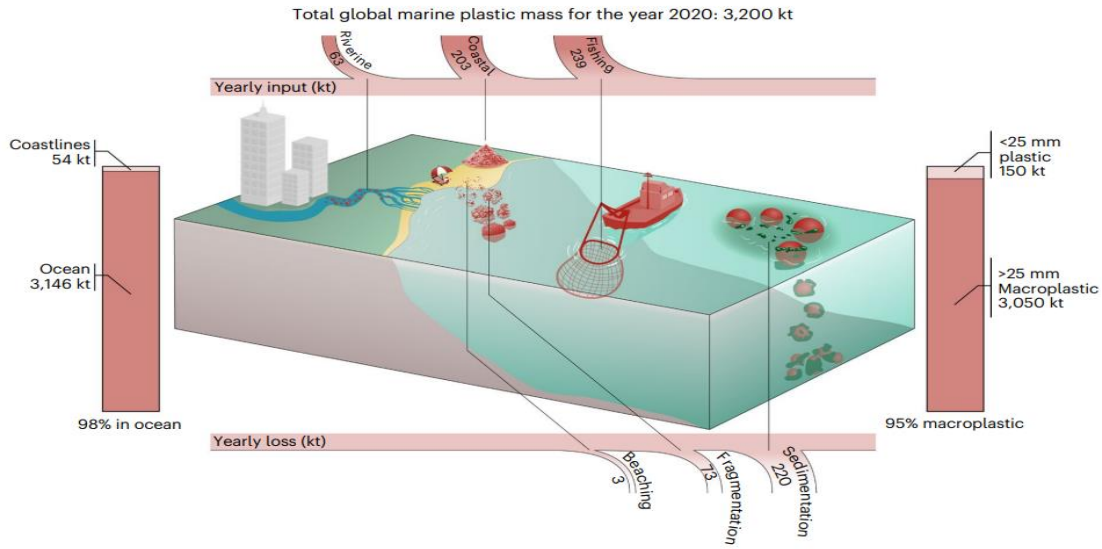
By closing the loop on plastic production and consumption, we move towards a more regenerative and sustainable economic model. Plastic pollution not only harms the environment but also poses risks to human health, particularly through the ingestion of microplastics and exposure to toxic chemicals. By reducing plastic waste through recycling, we mitigate these health hazards and promote **safer living environments for communities**. Plastic recycling is a critical component of sustainable waste management practices, offering a multitude of environmental, economic, and social benefits. Typically, plastic recycling works – as in fishing gear domain also - by five step simple process illustrated in the figure 1.

[3] https://www.sciencedirect.com/science/article/pii/S2405844024168697#bib29

Figure 1. Basic steps in plastics recycling.[4]

2.2 Commercial EOL fishing plastic waste generation and management

Kaandorp et al[5] have calculated that the total marine plastic input of 500 kilotons per year, originating from coastlines (39–42%), from fishing activity (45–48%) and from rivers (12–13%). The estimated input of 220–260 kilotons from fishing activity is somewhat lower than previous estimates of 640 kilotons per year.



[4] https://www.wastemanaged.co.uk/our-news/recycling/plastic-waste-recycling-guide/#what-is-plastic-waste

[5] https://www.nature.com/articles/s41561-023-01216-0

Figure 2. Schematic overview of the estimated marine plastic fluxes and standing stocks. Fluxes (top and bottom) are given in kilotons per year; standing stocks (left and right) are given in kilotons. Sizes of objects are not to scale. Fragmentation loss is defined as particles becoming smaller than 0.1 mm[3]

Currently recycling technology exists for four main polymers PE, PP, PA and PET, which means that, in principle, even up to 80% of EOL fishing gear could currently be recycled. As with all plastics, the prerequisite for recycling is that different polymer types are separated, implying that fishing gear made of different components needs to be dismantled to facilitate recycling. At this moment in time, disposal and EOL treatment of fishing gear is hardly circular; the level of recycling of fishing gear in the EU is 1 to 5 %. To run an efficient waste management system within a lot of small ports divided over a large area is not cost effective[6].

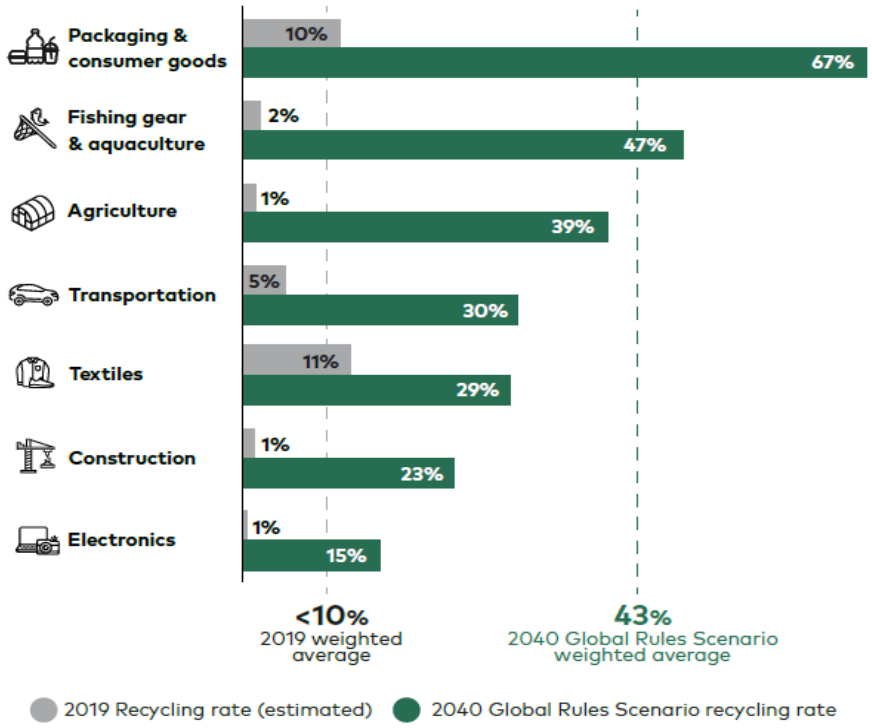


Figure 2. Plastic recycling rates by sector in 2019 and under the Global Rules Scenario in 2040[7]

The Global Rules Scenario would mandate a shift from multi-material packaging to mono-material packaging; impose bans on materials and additives that impede safe recycling; and introduce sector-specific design requirements. These design rules would ensure that plastic products in all sectors of the economy are designed to reduce volumes, to promote safe reuse and to allow for cost effective recycling in local contexts. Achieving high rates of circularity would require global rules on design standards, to facilitate industry adoption and enable governments to develop the right infrastructure.

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6 https://repository.oceanbestpractices.org/bitstream/handle/11329/1399/p00757_fishing_gear_scoping.pdf?sequence=1&isAllowed=y

7 https://www.systemiq.earth/downloads/Systemiq_Towards_Ending_Plastic_Pollution_by_2040-Technical_Annex.pdf

According to IMO[8] guidelines garbage, as defined in MARPOL Annex V, means all kind of food wastes, domestic wastes and operational wastes, all plastics, cargo residues, incinerator ashes, cooking oil*, fishing gear* and animal carcasses generated during the normal operation of a ship and liable to be disposed of continuously or periodically. In a port the place for delivering waste is called waste reception facility. According to IMO reception facility refers to any fixed, floating, or mobile facility capable of receiving MARPOL waste/residues from ships and fit for that purpose.

2.3 Prerequisites for EOL fishing gear recycling in fishing industry

Various types of fishing gear are used throughout the North Atlantic Maritime Area, depending on the target species and fishing areas. Bottom trawls, pelagic trawls, nets and gillnets are the main types of gear used, followed by seines and traps. The main plastic materials used are polypropylene (PP), polyethylene (PE) and polyamide (PA/nylon, predominately PA6). However, fishing gear can also include single and mixed materials containing metals, PVC, polystyrene (PS), PVDF, Dacron (PET, Polyester), HMPE (e.g. Dyneema®), other polyamide types like PA6.6, rubber, foams and various hazardous materials (e.g., lead weights, copper coatings). Used fishing gears also contain organic material (algae, bacterial films, insulating tape and cellophane, the latter commonly used to repair or extend the useful life of the gear). In addition, it is common to find textile materials used for the same purpose, generally composed of synthetic fibers of organic origin. Added to this is the presence of inorganic materials such as sand, which also accumulates on the gear during use. This combination of organic and inorganic waste makes it technically difficult to treat in existing waste sorting and management facilities and processes.

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)

Figure 3. The main plastics used in different types of commercial fishing and aquaculture gear[9].

[8] https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/MEPC.1-Circ.834-Rev.1.pdf

[9] https://drive.google.com/file/d/1b7E55yzw1s6cBvt48-NbECyDaybifL-z/view

The recycling process for plastic varies depending on the product and the plastic types, which means specific polymers. After pretreatment certain polymers follow the mechanical recycling route, whereas some others follow the thermochemical route. **The SEARCULAR project approach is to propose recycling polyamides mechanically and polyolefins (PP and PE) chemically**.

Recycling EOL fishing gear is feasible and even viable if specific conditions are met. First, a **sufficient volume of plastic material** must be available to ensure **economic viability**. Second, a **nearby plastic recycling industry** is essential for efficient processing. This reduces logistics costs and the carbon footprint of the process. Optionally, fishing gear-based **feedstock can be combined** with similar plastics collected from other sources, such as agriculture, aquaculture, industry, and municipal waste. Third, the **feedstock must meet certain quality standards**, requiring cleaning, washing, and polymer-specific sorting, particularly for mechanical recycling. In this sense, waste with high organic contamination or a mixture of polymers can be diverted to thermochemical routes, such as pyrolysis. If mixed plastics are used, maintaining a balance between different plastic types is crucial. When plastic waste volumes are insufficient for recycling, EOL fishing gear can be incinerated for electricity generation, provided the necessary facilities are in place.

Fishing gears include hazardous materials - like lead - from weights embedded in sink lines or in the form of copper coatings. This means that for recycling purposes fishing gear should be **treated separately through dedicated processes**. On the other hand, fish farming infra related nets and other plastics components could be processed together FG ones.

When **fishing gear is collected at ports** it needs to be transported to a **facility where the gear can be recycled**. In this stage a new obstacle for good EOL management of fishing gear arises, since the absence of recycling facilities is an obstacle for a more circular system for fishing gear.

2.4 EOL fishing gear plastics recycling status in Spain

In whole Spain yearly according to SEARCULAR partner AZTI, **1643 tonnes of EOL fishing gear** (mainly nets) are discarded in ports from trawling (97.5%), gillnet/trammel nets (2.3%) and purse seine (0.2%) fisheries. High-density polyethylene (from trawling nets) is the most common discarded polymer, followed by polyamide 6 (from gillnets/trammel net and purse seine nets). EOL fishing gear management is diverse in Spain as it depends on the nature of the port (who governs it, either regional or national authorities), special agreements between local fishers' guilds and waste managing companies, the waste managers in port, etc. Polyamide nets in good condition can be recycled mechanically; but for trawl nets chemical recycling is more suited due to their degraded state. Currently, few recycling companies exists in Spain that are engaged on [10]mechanical recycling of EOL fishing gears, none in chemical recycling.[11]

[10] https://www.sciencedirect.com/science/article/pii/S0269749122017596?via%3Dihub

[11] https://doi.org/10.1016/j.envpol.2022.120545

Figure 4. EOL fishing quantity and recyclability in Spain

Presently, three companies in the EU, Italian yarn producer Aquafil, Danish cleantech company Plastix, and Norwegian company Nofir have the technology and resources to recycle fishing gear on a large scale. All of them were created in response to the ghost gear problem, and they are expanding to serve harbours and aquaculture in Europe and around the world.

Aquafil recycles fishing net-based nylon (polyamide, PA6). Aquafil has already recycled hundreds of tons of fishing gear since it began operation in 2013. Much of this gear has come from the Healthy Seas initiative, a collaboration between Aquafil and other businesses and nonprofits. Activities needed include stripping away non-recyclable components of seines and gillnets to get the nylon nets ready for shipping. This work is carried out by fishermen, who are paid for their work out of a lump sum. The pure nylon nets are then packed into bags, which will weigh 400 to 500 kilograms when full. The bags are ready to be shipped when 20 tonnes of nylon have been packed. Transportation costs is a challenge, since smaller harbours need to pay to move the nets to the larger ports from which recyclers are willing to pay shipping. Smaller fishing ports could join forces with their counter partners and set up a joint EOL port reception facility to tempt recyclers[12][13].

All in all, though there are some recycling cases up and running, there is room for development in many European countries.

3 EOL Fishing gear related regulation and references for arranging waste management

3.1 Waste Framework Directive

[13] https://ensia.com/features/fishing-gear-recycling/

The Waste Framework Directive (WFD) (2008/98/EC) creates the basis for waste legislation in EU Member States and countries of the European Economic Area. The Directive stipulates that the management of waste must be conducted in a manner that avoids causing harm or endangering both the environment and human health. The directive specifies that waste management encompasses various stages of the waste managing process, encompassing activities such as transportation, disposal, collection, and recovery, emphasizing that it extends beyond the act of users simply discarding waste. Member countries must operate according to the regulations and the waste management plan. This plan should include at least specific information on the generated waste, current state of waste management, waste management policies, assessment of new collection options and information about used locations and capacity for disposal of waste. (Directive 2008/98/EC)

An important goal of the WFD is also to improve waste treatment by reducing the amount of waste through re-use and recycling. The directive describes that once products reach the end of their usable life, they should be managed to enable the continued use of their material. Final disposal of waste in landfills is the last option if the material cannot be recycled and typically this involves the polluter pay principle (PPP). That principle dictates that those who hold the waste, did hold the waste, or originally caused it are responsible for handling it appropriately and pay the costs for waste treatment. It is the responsibility of the member states to ensure adherence to the Polluter Pays Principle. (Directive 2008/98/EC)

In addition, the Waste Framework Directive introduces Extended Producer Responsibility (EPR) schemes as one form of PPP. It means that producers bear responsibility for their products beyond the usage phase, encompassing the proper collection and treatment of waste. (European Commission, 2023). Extended Producer Responsibility (EPR) pertains to a range of stakeholders including manufacturers, developers, importers, sellers, treaters, and processers. Applied to various product types, if a product falls under EPR regulations, the responsibility for organizing and financing its waste management rests with the entities covered by EPR. The idea of EPR is included in scenario options giving full responsibility for producers to renew FG design and materials towards circular economy and, for example from the perspective of the fishing sector, to look for materials for fishing equipment that are best suited to material recycling. The Circular Economy package has amended the Waste Framework Directive (WFD) through Directive 2018/851, emphasizing a sustainability-focused approach. Directive 2018/851 also focuses on marine litter and says that the member states must jointly participate in the prevention of pollution and the reduction of marine litter. (Directive 2008/98/EC)

3.2 SUP Directive and Extended Producer Responsibility

The main aim of the EU Single-Use Plastics (SUP, (2019/904) Directive is to prevent and reduce the environmental impact of certain plastic products, particularly in marine environments, and to promote a circular economy for plastics. It includes regulations for plastic containing fishing gear because a large part of the marine litter found in the EU area is caused by them and they have high recycling potential. In the EU waters, the predominant marine litter consists of plastic, with single-use plastics accounting for 50%, and fishing gear comprising 27% of the cumulative total. The aim of the directive is to reduce marine litter and to support collection of EOL fishing gear, which will make it possible to include them in the circular economy. (Directive 2019/904)

The directive initiates collection efforts within EU member states with marine waters and the countries concerned should set an annual minimum collection rate for plastic containing fishing gear waste. Regarding waste collection itself, the directive does not give specific guidance on how it should be organized. EPR means that the producers are responsible for collection, transport, handling, and treatment of EOL products after the user has brought plastic-containing fishing gear waste to the port reception facilities. For the producers responsible, their costs will rise because of

the EPR. Users should be informed about this, and other issues related to producer responsibility. The focus should be on spreading information about good and harmful waste management practices and about the environmental effects of fishing equipment. Producers' responsibility involves providing annual reports on products introduced to the market and the collection of fishing gear waste, contributing to the generation of accurate statistical data for the EU. (Directive2019/904)

3.3 Directive of waste reception facilities at port

The EU Directive on port reception facilities for the delivery of waste from ships (2019/883) aims to protect the marine environment from negative impacts from the ships and ensure appropriate waste reception facilities in ports. Waste reception facilities at ports must be easily accessible to visiting ships, ensuring they also manage the waste generated by these vessels. Effective preparation enhances the likelihood of successful separate waste collection and recycling while simultaneously mitigating marine pollution. According to the directive, smaller ports with lower levels of traffic do not have to have as complete waste reception facilities as larger ports managed by municipalities or governmental organizations must provide. The MARPOL convention and its Annexes (International Maritime Organization, 2019) have been used as a norm in the formulation of this legislation. (Directive (EU) 2019/883)

Based on the MARPOL Convention and Directive (2019/883), EU Member States must have waste reception and handling plans that are in use in ports. This must include information about the location of the facilities, how they work and for what waste fractions reception facilities are provided at the port. The plan must be available and easily accessible and in the spoken language of the Member State. The plan must also provide information on how waste is to be delivered at the port and how the port charges for the delivered waste. The port authority must fill out a form about the delivered waste, but this does not apply to smaller ports that are remote or unmanned. Passively fished waste should also be collected and reported to the EU. (Directive (EU) 2019/883)

There is also a report: Study to support the implementation of obligations set out in the Single Use Plastics and Port Reception Facilities Directives.[14]

3.4 Commission regulation on passively fished waste

Based on the Commission Implementing regulation on data collection of passively fished waste (2022/92), member countries must provide information about passively fished waste annually from 2022 onwards. Passively fished waste means marine litter that is recovered while fishing and can also contain **abandoned, lost or discarded fishing gear (later shortly ALDFG)**. The collection of passively fished waste improves the marine environment and must be reported. The reported data must contain the total weight of the collected marine waste, but more detailed information can also be collected. This can include information about the material of the passively fished waste, which can be plastic, metal, rubber, wood, textiles, etc., but using this reporting category is optional. (Commission implementing regulation (EU) 2022/92)

[14] https://cinea.ec.europa.eu/document/download/0f5aebf6-7d2f-48aa-9e7c-24ecf3935efb_en?filename=StudySingleUsePlastic.pdf

3.5 References for Blue Point and EPR

References for Blue Points to be conceptualised in SEARCULAR include arrangements in selected nations where commercial fishing and aquaculture are lively industries including Norway, UK, Sweden, France, Island and Ireland. All the references are located in Europe.

In **Norway,** both fisheries and aquaculture firms have started to recognise the importance of moving towards a more circular plastic system. Research and pilots are already taking place both upstream and downstream but a robust EPR policy, constructed in collaboration with all actors in the value chain, will be key to accelerating the transition to a more circular system[15]. In Norway the **current system is still highly linear**, **with 42% of total waste is incinerated, 21% landfilled, and 2% leaks into nature**. **33% of total waste is currently recycled**, though this has been increasing over the last years, 60,847 tons collected, 219,000 tons CO_2 saved. Most of this recycled material flows to other sectors, but a small proportion of components are reused after gear has been discarded (~2%). It is important to note that in Norway there is a strong culture of fishing gear repair, and a significant amount of repair and reuse takes place before the gear is discarded, especially for nets, which are very expensive. Over 60% of nets get repaired at least once a year. More ambitious policies are on the horizon, specifically a **new EPR regulation which could make a significant difference if designed and implemented well**. Convenient access to zero-cost disposal is key. **Collection facilities are already being put in place i**n ports, and a direct fee for handing in waste is being changed to an indirect fee (i.e. the **waste handling fee will apply to ships regardless of whether they deliver waste or not**), thus removing an incentive for littering. However, it will be a challenge to implement this across all ports and aquaculture farms considering the sheer number of eligible locations in Norway. Other key enablers for circularity include design for both longer lifetimes and recycling, research and awareness building on how to better use equipment, making it economically viable to scale up infrastructure and ensure the latest technologies are available (from local sorting, to cleaning and recycling), and making the price of recycled plastic more competitive compared to virgin plastic. **An EPR** for fishing gear will be introduced by the 31st of December 2024 and could be a **game changer if implemented correctly**, influencing everything from fishing gear design to EOL infrastructure, and delivering the financial resources for the transition.

With the aim to combine deployment of upstream and downstream levers, circularity could increase to 81% by 2040 (figure 5), and the reliance on virgin plastics could be reduced to 55%, down from 100% in 2020, although having access to enough recycled material could be a barrier. To achieve higher levels of circularity, reuse and recycling should be maximised through better design and scaling up of local sorting, cleaning and recycling infrastructure.

15 https://www.systemiq.earth/reports/downloads/Systemiq_Achieving_Circularity_for_Durable_Plastics.pdf

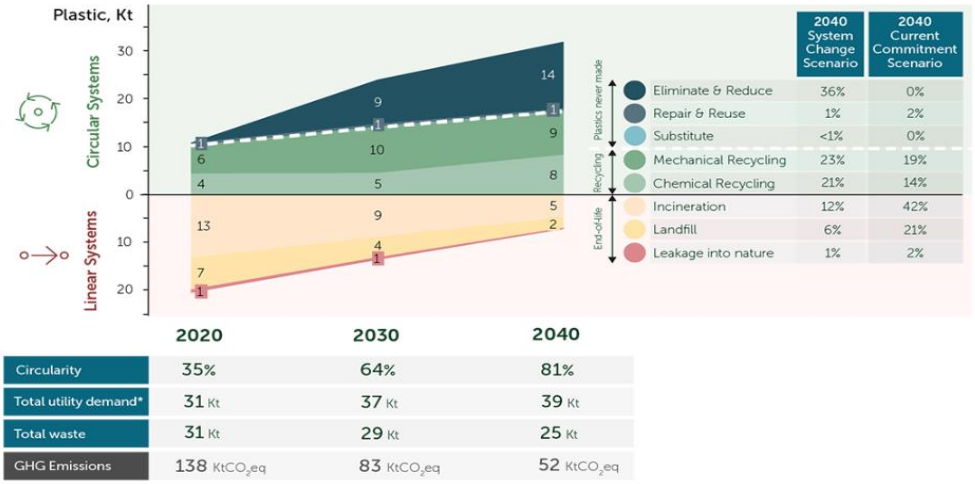


Figure 5. Through the application of circularity levers, the Fisheries & Aquaculture sector can reach 81% circularity by 2040 in Norway[16]

Also, the downstream levers should be developed. Firstly, maximising collection, cleaning, and **pre-sorting facilities in ports or near aquaculture farms** could enable up to 90% of waste to flow to formal sorting facilities. Almost 50% of collected waste ends up in residual waste without being checked for recyclable materials, often due to a lack of cleaning and pre-sorting capacity at the port or near the aquaculture farm. **Financing through the EPR scheme** will be key to enabling the scale up of these facilities and creating a viable business model. A good example of improving local infrastructure are **the local collection and recycling hubs** currently being planned by Marine Recycling Cluster. Local mechanical recycling in Norway could be expanded to recycle ~36% of total waste volumes domestically by 2040. The main local mechanical route recyclers include companies **Noprec/Oceanize, Brontes and Quantafuel Kristiansund**. In Norway the recycling capacity is ~6,000-10,000 tonnes and this is expected to double over the next couple of years.

Figure 6. Quantafuel Kristiansund recycling plant – existing and planned[17]

[16] https://www.systemiq.earth/reports/achieving-circularity/for-durable-plastics/chapter-2/fanda/

[17] https://www.helse-vest.no/499f72/siteassets/documents/om-oss/miljo-og-samfunnsansvar/presentasjonar-klimakonferansen-2023/15.-brede-mordal---quantafuel.pdf

In Norway, **chemical recycling will remain a key solution** for nets and capacity should be expanded. Hard to recycle nets make up >70% of the total plastic waste in fisheries[18]. Even though improvements can be made in terms of design for recycling, the mixed polymer design combined with unrecyclable materials and the condition of the nets at EOL will keep this a particularity difficult type of gear to recycle. Aquafil has a patented technology to process nets into Econyl yarn via a depolymerisation process and has created a positive market value. It is likely that chemical recycling of nets will continue to take place outside of Norway considering the investment required.

Norway has also arranged ALDFG collection. Fishing for Litter was implemented as a pilot scheme in 2016/17 and has been continued since 2018 via the Norwegian Environment Agency's grant scheme for measures against marine litter. The scheme is one of the largest clean-up measures for marine litter in Norway. The reception areas for fished waste are spread out along the Norwegian coast, and participating vessels can register for delivery in several ports. The participating vessels are given **big bags** for storing and delivering the fished waste, and recyclable and non-recyclable waste are separated upon delivery. The scheme contributes to increased material recycling, with a lower climate footprint in the disposal phase of the waste.

Figure 7. The world's first wheelbarrow made from 98% recycled marine plastics in Norway[19], Norwegian ALDFG collection points and big bag collection system.[20]

In **UK** there is a fresh reference how to arrange discarded EOL FG recycling in a networked fishing port environment where so called **The Net Regeneration Scheme (NRS)** offers free recycling facilities for EOL fishing gear and marine plastics in a traceable and sustainable manner. By removing cost barriers, this scheme tries to support fisherman to collect lost fishing gear and marine plastic waste whilst out at sea further supporting sustainability and clean ups within the fishing industry. The concept was created in INdiGO-project which is a European funded project part of the Interreg France England programme, which has been working with NRS to help apply circular economy solutions for EOL fishing gear, aiming to reduce plastic pollution in the channel region. The NRS works within a growing number of over 40 fishing communities making regular collections of sorted gear. NRS collects from harbour authorities around our coastlines, including the Southwest, South, East and Wales, who are all committed to converting their waste plastic into a recycled resource. The NRS is the first of its kind and has seen fishermen in the UK's Southwest region recycle a wide array of fishing gear for free over the past 6 years. So far, the scheme has recovered and recycled over 200 tonnes of fishing gear. NRS - offered by Odyssey Innovation - is aimed at harbours, fishermen, fisheries, and net makers across the UK and aims to promote

[18] https://www.systemiq.earth/reports/achieving-circularity/for-durable-plastics/chapter-2/fanda/
[19] https://www.interreg-npa.eu/media/jjyf2r1a/oceanize-presentation-emd-webinar.pdf

[20] https://salt.nu/fishing-for-litter

behavioural change by supporting stakeholders through offering preventative measures for them to be part of the solution to cleaner and safer seas.

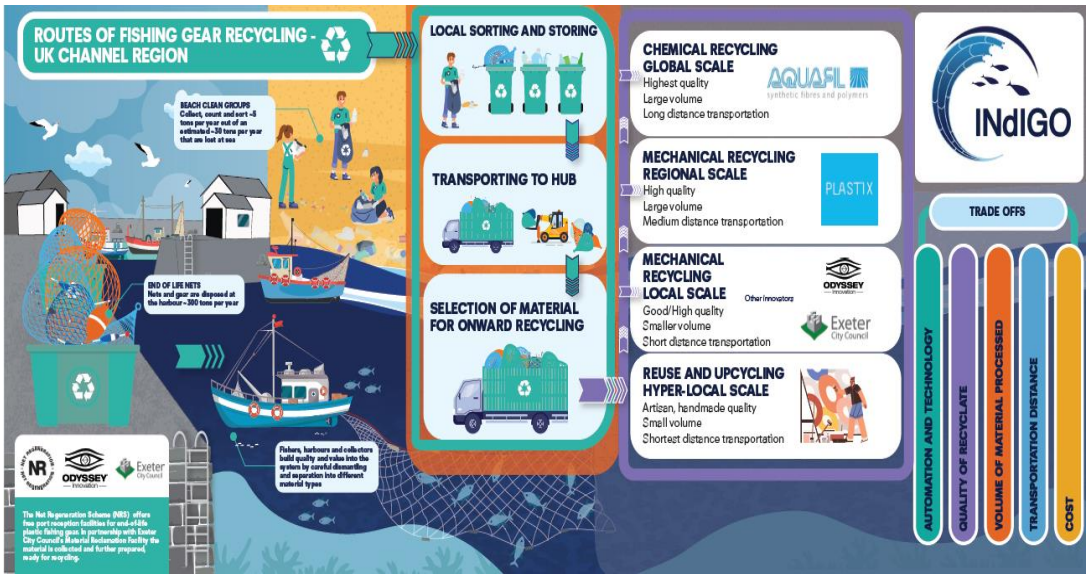


Figure 8. Net Regeneration Scheme (NRS) in UK with EOL FG Recycling Hub and IndiGO project-based routes of fishing gear recycling.[21]

In **Sweden,** Sotenäs marine recycling centre SMRC, established 2020, has processed more than 170 tonnes of waste and EOL fishing gear that was collected locally and from elsewhere through a series of recycling hubs located in the different regions of Sweden. 10 decentralized hubs are in fishing villages and ports, from where EOL FG is transported by truck to SMRC. Hubs are located close fishers FG repairing but also FG producers are involved. **The producers and fishers repair and adjust gear for best performance and to extend product life of the fishing gear** whilst adhering to the appropriate technical regulations. Fishers who do not plan to repair nets themselves drop their gear off at the hubs. In some cases, gear is collected from the fishers by Fiskereturen ('Return of Fishing Gear' project) and taken to a hub, at no cost to the fishers. SMRC is run by Sotenäs municipality, provided financial support also from involved maritime municipalities.

Figure 9. Sotenäs marine recycling center SMRC yard and facilities in Sweden

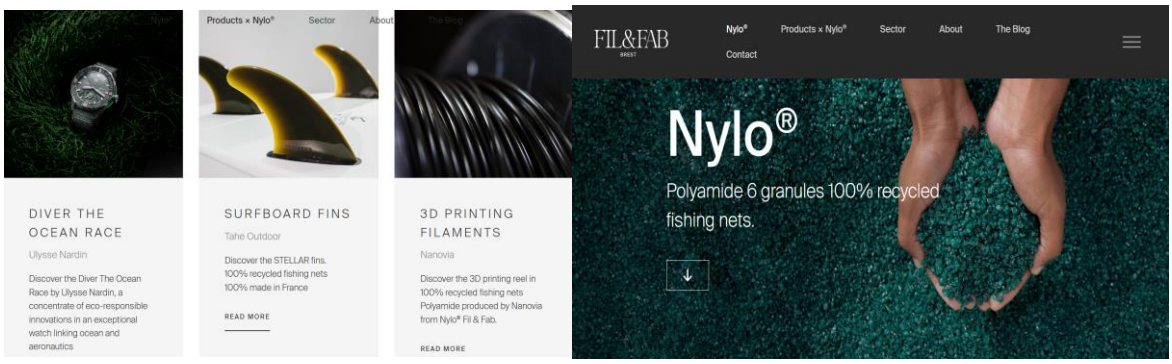
[21] https://indigo-interregproject.eu/en/best-practices-for-harbours/

SMRC receives annually approximately **200 tonnes of EOL fishing gear.** The type of plastics sorted are PP, PE, PET and PA. The metals sorted are lead, aluminium, copper, lead ropes, and stainless steel. Rubber and floats are also sorted. Some percentages of the floats collected are reused in the production of new trawls. PP and PE are recycled at Plastix in Denmark. PA and PET do not have recyclers yet, but the fractions are sorted at the SMRC for future recycling. Metals are recycled at Stena Metal in Sweden. **Sotenäs marine recycling center sorting process is very labour-intensive for the small number of SMRC employees including 4 sorters and 1 facility manager**. In addition, materials going to incineration have increased costs to approximately 3,000 SEK/tonne (=261 Euro). In Sweden there is already established fishing producer responsibility organization (PRO) called Fiskekretsen, taking care of arranging EOL fishing gears.[22]

Of 176 tonnes of sorted EOL fishing gear in 2023	
Materials	**%**
Plastic	56
Metal	33
Other materials (wood, stone and electronics)	10
Of 99 tonnes of sorted plastic	
Materials	**%**
PP	19
PE	15
PA	10
PET	3
Floats (PP, PE, PA)	5
Incineration	50 (including rubber = 30)

Figure 10. Swedish Sotenäs marine recycling center, SMRC, EOL fishing gear and other plastic materials collected and sorted in 2023[23]

In **France** company Fil & Fab[24] recycles nylon (PA 6) based nets. First, nets are sorted by colour, then separated from their floats and ropes, to guarantee a 100% regenerated PA 6 plastic. Then nets are shredded to fibers of a few centimetres. They pass the extrusion line where they are melted and then mixed with additives.



[22] https://fiskekretsen.se/en/collection-reuse-recycling/
[23] https://www.interreg-npa.eu/media/2wwn2gvl/circnets_report_d211.pdf

[24] https://www.fil-et-fab.fr/

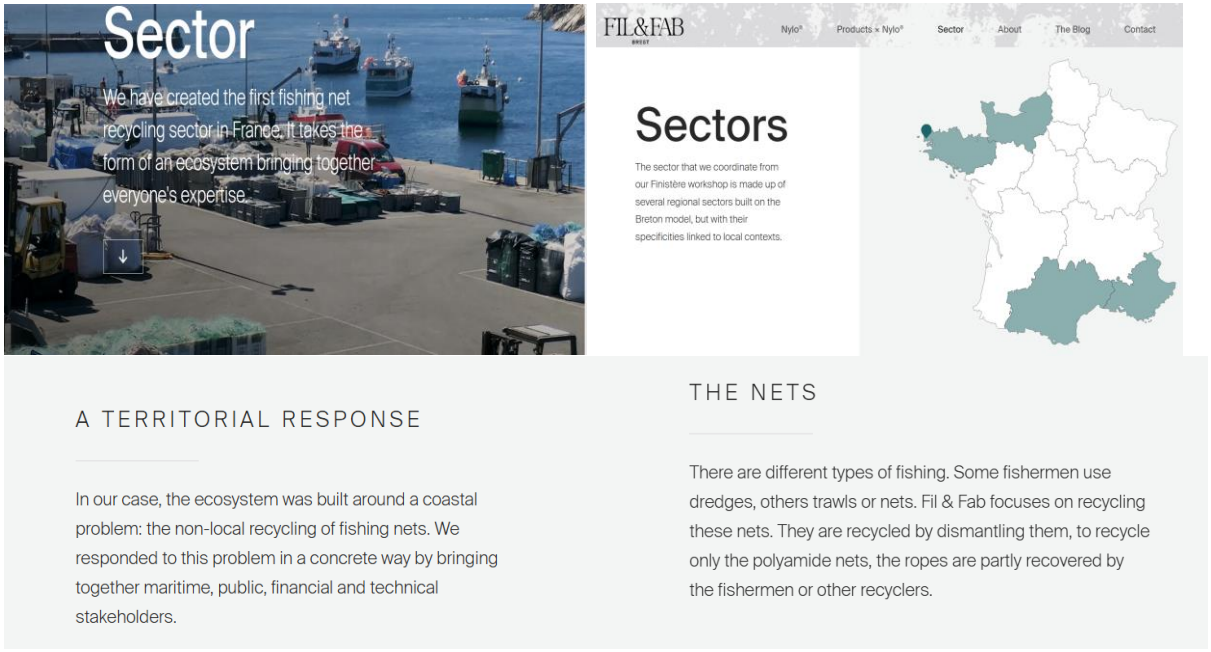


Figure 11. Fil &Fab France Prest EOL PA 6 FG based recycled product references, recycled polyamide granules, overview of Prest fishing port area and infra, aerial coverage in France and concept basics[25]

In **Iceland** there is a tradition with local FG manufacturers taking back EOL fishing gears. There is one collection station for fishing gear waste located at Skipaþjónustan (Vessel Services) at Grandinn in Reykjavík. The fishing gear manufacturers Hampiðjan, Ísfell, Egersund Iceland and Skinney-Þinganes accept fishing gear waste at all their operating units throughout Iceland. Also, fishing gear made of synthetic materials refers to fishing gear specified in Annex XVII to Act No. 162/2002 in Icelandic law, as subsequently amended. Fishing gear waste must be dry (6% maximum moisture content) and sorted according to type. The fishing gear waste must be free of all foreign items, foreign materials, and impurities such as sand, oils, fish and marine vegetation. The fishing gear waste must be free of all accessories such as floats, lead, rubber, chains and wires.[26]

In **Ireland** there is a fresh Eunomia and Poseidon report available including identification of **most suitable EPR model** for compliance with the single-use plastics directive.

[25] https://www.fil-et-fab.fr/filiere/

[26] https://csr.sfs.is/fishing-gear/#content

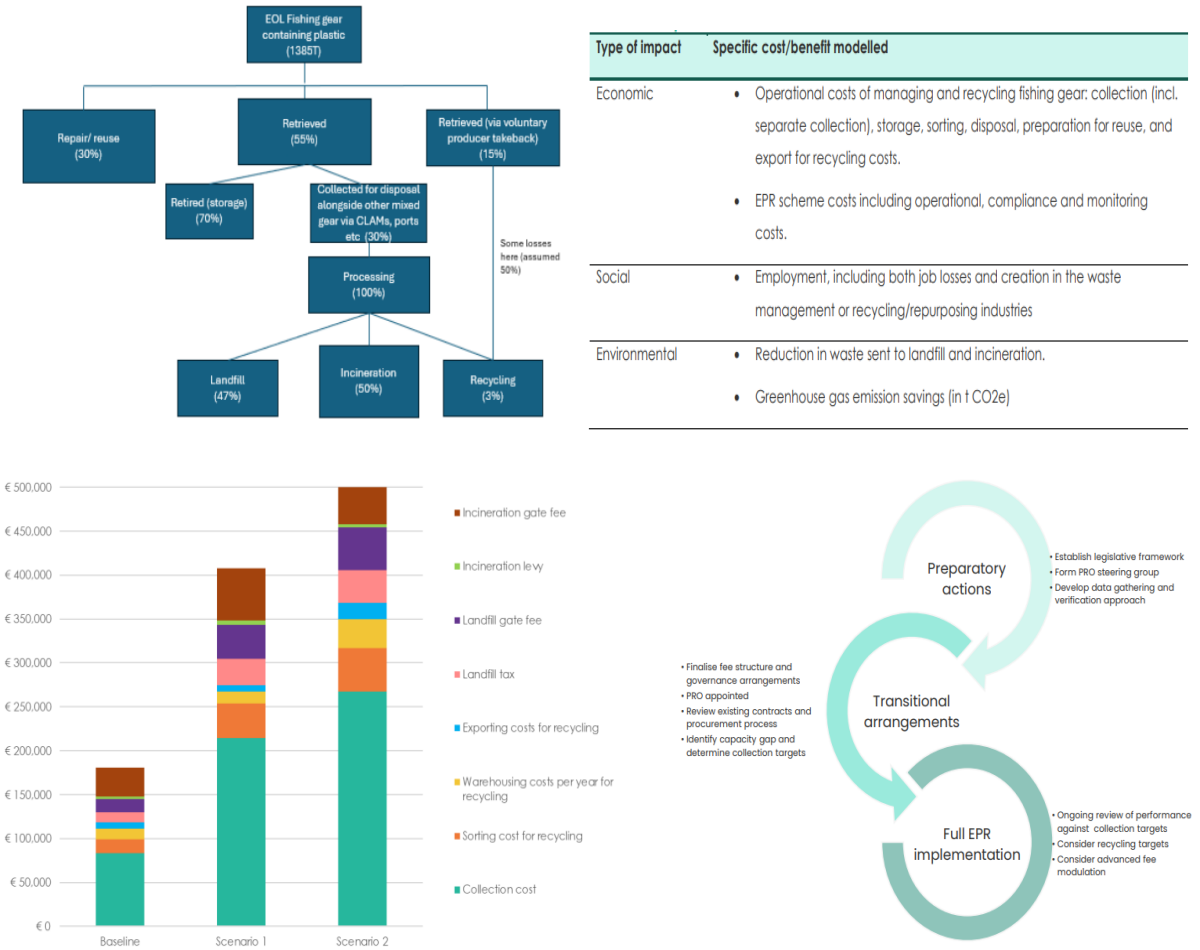


Figure 12. Eunomia & Poseidon based research of the most suitable EPR model for compliance with the single-use plastics directive.[27]

In Ireland fishing gear company SNG provides also fishing gear repair services. Examples are illustrated in figure below.

[27] https://eunomia.eco/wp-content/uploads/2024/12/DECC-Full-Final-Report-v3.pdf

Figure 11. SNG fishing services in Ireland.[28]

4. Blue Point concept planning for arranging FG recycling

4.1 SEARCULAR goals for Blue Point

The main objective of SEARCULAR is to reduce the amount of marine litter and microplastic from among the most relevant European fishery contributors (demersal trawlers, demersal seiners, tropical tuna purse seiners), to introduce good management practices for EOL fishing gears within the fishing sector and involved value chain partners including ports, by fostering behavioural change. SEARCULAR will do this by developing, testing and validating four close-to-market sustainable and circular solutions. Therefore, SEARCULAR solutions are aimed to eliminate waste generated from fishing gears, circulate materials and regenerate nature.

Fishing gear is not yet designed for recyclability through material and eco-design choices and modularity to enable better upgradability, repair or smooth disassembly. As a result, it is costly to disassemble fishing gear due to the time involved in manual dismantling processes. A potential solution is for fishing gear to be “designed for disassembly” to reduce costs and ease the separation of materials (as needed) at the end of (each) life of the fishing gear. Such a design strategy would support the culture of product life extension through repair that already exists amongst fishers. Additionally, fishers often upgrade their gear to enhance catches in specific situations. This underscores the need to view fishing gear as "product as a service," where gear manufacturers and fishers share common interests.

Together with technological solutions there is also need for EOL fishing gear port solutions. WP4 aim was to develop and evaluate port-based solution models facilitating the recycling of EOL fishing gears by 3 specific objectives:

(1) Ensuring the correct functioning of a port-based Blue Point that accommodates the collection, sorting, and conditioning of EOL fishing gears and waste streams,
(2) Defining a reverse logistic model that advice on the most sustainable (environmental and cost-effective alternative) supply chain scenarios for conditioned EOL fishing gear waste streams considering existing or potential EOL recycling plants, and
(3) Pyrolyzing EOL fishing gears by Plastic2Plastic strategy, to obtain high quality oil (TACOIL).

The solution model should include three objectives that are interlinked but can work independently, and as an outcome best practice and replication guidelines will be produced.

Financial instruments for Blue Point further development can be related to EPR, and are as an example FG repairs vouchers.

4.2 State of the Art in Basque area fisheries

[28] https://sng.ie/fishing/

In Basque Country there are altogether around 20 fishing harbours. Four biggest ones are in Bermeo, Ondarroa, Hondarribia (Fuenterrabia) and Guetaria. Figure 13 gives detailed information about the share of vessels, tonnage, power and other relevant figures. There is legacy information based on 2010 figures available. These have been updated with new information collected through SEARCULAR, with Bermeo identified as the largest harbour in terms of number of vessels, tonnage, engine power, and fishing catch.

PORT	No Vessels	Tonnage (TRB)	Power (kW)	Average tonnage (TRB/vessel)	Average power (kW/vessel)
BERMEO	28 %	71 %	65 %	794	1 225
ONDARROA	13 %	12 %	9 %	291	380
PASAJES	9 %	5 %	4 %	179	256
FUENTERRABIA	12 %	4 %	8 %	118	365
GUETARIA	11 %	4 %	6 %	122	285
ORIO	3 %	2 %	3 %	191	562
LEQUEITIO	5 %	1 %	1 %	47	160
SAN SEBASTIAN	5 %	0 %	1 %	29	115
MOTRICO	1 %	0 %	0 %	81	195
SANTURCE	4 %	0 %	1 %	22	102
CIERVANA	3 %	0 %	1 %	30	108
Other ports	7 %	0 %	1 %	8	46
TOTAL	**100 %**	**100 %**	**100 %**	**317**	**534**

Figure 13. Distribution of the registered fishing fleet by ports in Basque County in 2010[29]

Up to date information about the Basque area's fishing fleet, types of fishing gear used, annual volume of EOL fishing gear generated, and opinions regarding necessary actions for fishing gear collection was collected. A total of 106 fishing vessels operates in the target cities of the Basque Country, managed by 102 fishing companies, indicating that nearly all companies operate a single vessel and coordinated some of them by the Basque Government and others by the Spanish Government.

4.3 Requirements for Blue Point

According to FAO and IMO[30] Port reception facilities (**PRFs**) are **dedicated facilities at ports designed to receive waste(s) from ships visiting the ports**. They are extensively supported as part of the International Convention for the Prevention of Pollution from Ships (**MARPOL**), PRFs serve as important **infrastructure to allow for the dedicated collection of EOLFG and recovered ALDFG which can subsequently be prepared for recycling**. (IMO, 2016).

Recovered ALDFG and fishing gear no longer in use should be **recycled or disposed of responsibly on land. ALDFG and EOL FG´s must be collected separately due to their different degrees of purity and contamination. States should ensure the provision of adequate port reception facilities for the disposal of such fishing gear in accordance with MARPOL Annex V** (FAO, 2019a; emphasis added). Port reception facility refers to any **fixed, floating, or mobile facility** capable of receiving MARPOL residues/wastes from ships and fit for that purpose.

[29] https://www.europarl.europa.eu/RegData/etudes/STUD/2010/431583/IPOL-PECH_NT(2010)431583_EN.pdf

[30] https://openknowledge.fao.org/server/api/core/bitstreams/f126ddd0-b423-430d-89c8-488667a9add9/content

Dedicated EOL FG reception facilities at fishing ports are necessary to provide fishers with **sites where they can deliver their EOL fishing gears, dismantled gear components and collected scraps from gear repairs for recycling**. Following the collection of EOL fishing gears at port reception facilities, gears can be prepared for recycling at **centralized or decentralized waste treatment facilities**, **depending upon the volume of unwanted gears and location of local ports and recycling facilities.**

For practical and organisational reasons, **neighbouring ports in the same geographical region might want to develop a joint plan**, covering the availability of port reception facilities in each of the ports covered by that plan while providing a common administrative framework (EU directive 2019/883)[31]. In the focus region of the SEARCULAR project, the Basque coast in Spain, there are 4-5 neighbouring ports. Special emphasis was given to support the joint planning for arranging a Blue Point regarding the alternative fishing port free space availability, environmental risks and economic circumstances.

According to available references the requirements for good **EOL fishing gear management, handling and recycling** include technical, operational, environmental, and logistical requirements. Breakdown of these identified key requirements include:

1. Location

- **Selection of the location**
  - Prioritizing the avoidance of litter and other harmful sources in natural environments and vulnerable marine ecosystems.
  - Optimal position for managing entire coastal area EOL FG collection and recycling.
  - Selection is based on a risk and benefit assessment.

2. Infrastructure and operational equipment

- **Collection, dismantling and storage facility (=Blue Point)**
  - Sufficient size and working areas.
  - Dedicated facility and infrastructure for washing, dismantling, separating and storage for EOL FG recyclable components and fractions (nets, lines, traps, ropes, metals etc.) and wastes.
  - Appropriate wastewater and litter management system.
  - Dedicated collection containers/big bag systems separately for different collected recyclable fractions and ALDFG.
- **Handling equipment at Blue Point**
  - Safe handling and moving equipment for heavy or bulky gear (e.g., forklifts, cranes, backhoe loaders, pallets).
  - Dismantling tables/areas and separate containers for different materials: plastics, metals and biobased materials.
  - Equipment and hand tools for handling and dismantling heavy and large FG`s.
- **Markings and symbols**
  - Clear marking system for placing different types of fishing gear (e.g., nets, buoys, dolly ropes, different metallic materials, rubber…).
- **Material identification support systems (together with markings)**
  - Systems, analytics, tools and information for identifying types of plastics (e.g., PP, PE, PA, PET…) and metals to ensure high quality material streams.

[31] https://eur-lex.europa.eu/eli/dir/2019/883/oj

3. Logistics and transport

- **On-Site transport systems**
  - Trucks, tractors, backhoe loaders and trolleys for moving large quantities of collected gear.
  - Weighing system; integrated possibly to handling.
- **External transport partnership(s)**
  - Agreements with external waste management company and transporting companies.
  - Appropriate transport and load handling capacity.

4. Recycling and disposal systems

- **Partnerships with recycling operators**
  - Collaboration with companies that specialize in recycling metals and plastic materials from fishing gear.

- **Disposal of non-recyclable materials**
  - Safe disposal routes and mechanisms for non-recyclable waste (e.g., energy recovery through incineration or landfill).

5. Environmental and safety considerations

- **Pollution prevention measures**
  - Drainage systems to prevent leachate from contaminating the marine environment.
  - Spill control equipment and pollution response plans.
- **Health and safety standards**
  - Personal protective equipment for staff handling EOL gear.
  - Training in safe handling, sorting, and recycling procedures.

6. Administrative and legal framework

- **Permits and Compliance**
  - Compliance with local, national, and international regulations (e.g., MARPOL Annex V, EU Port Reception Facility Directive).

- **Documentation and record keeping**
  - Systems to track (weighing ...) collected, recycled, and disposed fishing gear.
  - Providing certificates for participating companies depositing EOL gear.

7. Stakeholder engagement and communication

- **Established producer responsibility organization, PRO**
- **Involvement of fishermen**
  - Awareness programs for all area fishing companies on proper disposal and recycling options.
- **Coordination with authorities**
  - Engagement with port authorities, waste management companies, and environmental agencies.

8. Financial mechanisms

- **PRO and cost recovery systems**
  - PRO financial model arranging EOL fishing gear collection.

- Fee structures or incentive programs for fishermen to encourage proper disposal (e.g. fees need to be paid whether EOL fishing gears are collected and treated properly).

- **Subsidies**
  - Access to funding from governmental or non-governmental sources to support Blue Point operations.

Figure 14. EOL FG heavy duty truck loading, sorting infrastructure and backhoe loader used for handling

4.4 Blue Point concept planning

4.4.1 Data and information collection

Basque Country EOL fishing gear recycling facility - Blue Point - is a shared facility with needed resources but also an operational concept for sustainable FG collection and recycling. Blue Point is networked FG recycling Hub also for the smaller fishing ports in Basque area.

Together with SEARCULAR project partner Gaiker support, information gathering was arranged to collect data about the number of operating fishing companies, number of operating fishing vessels, types of fishing-generated wastes, waste plastics and metals quantities and existing local recycling companies, changes expected in waste volumes, existence of FG repair and storing facilities and ideas where the so-called Blue Point should be located. Shortly, total number of fishing vessels operate in the target cities of the Basque Country is 106, managed by 102 fishing companies. This reveals that nearly all companies operate a single vessel. Main used fishing gears are stern trawler, pair trawler, longline, purse seine, small scale gillnet, small scale longline. Secondary used fishing gears are gillnet, trolling, pole and line and pots.

Quantities of EOL FG plastics waste produced annually:

- Ondarroa 104,730 kg (average amount 2010-2019), 94,257 kg from trawling, 10,473 kg from other fisheries
- Bermeo 6,492 kg
- Guetaria 410 kg
- Hondarribia 255 kg; purse seine nets are directly taken by farmers, not included in the calculations

Data collection full results are in Annex 1.

4.4.2 Blue Point location

Based on the data collected, insights were also requested regarding the location of the Blue Point. Initially, Bermeo was ranked first as a potential location for the Blue Point. However, based on the data, Bermeo was excluded. The primary reason is the limited space available to accommodate the Blue Point facility. Additionally, Bermeo is located within the Urdaibai Biosphere Reserve, a protected area in the province of Biscay, Basque Country, Spain. This coastal wetland at the mouth of the Oka River is renowned for its ecological value and has been designated as a UNESCO Biosphere Reserve since 1984, imposing additional environmental constraints.

Instead, among the evaluated options, **Hondarribia emerged as the most promising candidate for the Blue Point location**. Hondarribia, situated near the French border, offers strategic advantages in terms of both Basque area fisheries accessibility and potential synergies with southeastern French fisheries.

Hondarribia Blue Point – Collection, dismantling and recycling hub for EOL fishing gear

- **Blue Point is a centralized collection and sorting hub** in Hondarribia, targeted for operational hub for EOL fishing gear management of coastal area taking care of collection all EOL fishing gear-based plastics wastes, metallic and other recyclable materials
- Blue Point will deliver feedstock for recyclers including metals (e.g. lead, copper, steel) for metals recyclers, plastics (at least polymers PE, PP, PA) through chemical recycling route, pretreatment rejects and ALDFG based fractions for energy use, and not recyclable waste for landfill
- Blue Point can deliver also dismantled EOL fishing components for sustainable secondary use e.g. as protective netting or fencing material in agriculture, provided the materials are non-toxic and structurally sound. However, it is unclear whether the secondary use of EOL fishing gear aligns with the extended EPR policy for gear manufacturing
- Bermeo, Ondarroa and Pasajes are **EOL FG local collection hubs** equipped with collection bins/containers/big bag system to allow separate collection and prevent environmental contamination, e.g. containers are weather-resistant bins with permanent lid
- Collection and transportation from the smaller ports is arranged during and after the fishing seasons
- Specific collection route along the coast could connect all other smaller harbours mitigating the logistics challenges and increasing the waste stream
- Figure 15 illustrates the collection and logistics flow between Blue Point and included ports

Figure 15. Blue Point EOL FG recycling concept including Hondarribia collection hub and local collection points in Bermeo, Ondarroa and Guetaria.

4.4.3 Blue Point handling and sorting basic infrastructure

Blue Point basic infrastructure in Hondarribia requires a well-built building with sufficient space for handling, dismantling, separating, storing and conditioning (shredding and washing) of recyclable fractions. Main recycling infrastructure needed includes lifting, moving and handling machinery, handling tables, washing infrastructure, placing area for containers, water and wastewater treatment systems to avoid marine litter, runoff waters or other contaminations from dismantled fractions.

- **Indicative details about the Blue Point facility**
  - Needed land area 1500-2000 m²
  - Rental/Ownership based plot
  - Building floor area 300-400 m² (estimation)
  - New or renovated existing facility, e.g. EOL fishing gear storage and repair facility
  - Practical collection, dismantling and storage areas for EOL fishing gear to prevent environmental contamination
  - EOL FG treatment capacity annually
    - 150-300 tonnes/a, includes future growth capacity, including also ALDFG treatment
    - staff 1-2 persons, reference Sotenäs SMRC recycling center in Sweden is operated with 1+4 persons with wider operational focus
  - Capex, no references available
  - Opex, no references available
- **Handling equipment**
  - Sufficient capacity and safe handling equipment for heavy and bulky gear, lifting equipment from ships and from trucks (e.g., machinery, crane, forklift, pallets).

  - Infra and tools for washing (e.g. high pressure washing), compacting of fishing gear (e.g., trawls, nets and ropes) and dismantling (e.g. cutting tools).
- **Signage and markings**
  - Clear signage/markings for depositing different types of fishing gear (e.g., trawls, nets, buoys, ropes) and recyclable material streams.

Waste segregation and sorting

- **Sorting infrastructure and mechanisms**
  - Separate containers of different plastic polymers (PP, PE, PA6, PET etc.)
  - Separate containers for other recyclable materials: different metals, wooden components, other components and biobased materials; according to Swedish Sotenäs reference 20 different containers/bins are needed for placing trawl dismantled recyclable materials
- **Material identification**
  - Systems, analytics, tools and good lighting conditions for identification of polymer types to ensure proper recycling pathways
  - Hand-held analysers are needed if visual identification is not enough for identification

Figure 16. Sorting infrastructure and visual EOL FG plastic fraction identification signboard in Sweden SMRC, ref. CircNet workshop presentation material.[32]

Logistics and transport

- **On-Site transport systems**
  - Trucks and trolleys for moving large quantities of collected gear
- **External transport partnerships**
  - Agreements with external waste management companies and transporting companies

[32] https://www.interreg-npa.eu/media/oycnzzmo/circnets-sotenaes-webinar.pdf

- Waste trucks

Figure 17. EOL fishing gear waste transportation trucks

Recycling and disposal systems

- **Partnerships with recycling operators**
  - Collaboration with companies that specialize in recycling marine plastics and fishing gear

- **Disposal of non-recyclable materials**
  - Safe disposal mechanisms for non-recyclable waste (e.g., energy recovery through incineration or landfill)

Environmental and safety considerations

- **Pollution prevention measures**
  - Drainage systems to prevent leachate from contaminating the marine environment
  - Spill control equipment and pollution response plans
- **Health and safety standards**
  - Personal protective equipment for staff handling EOL gear
  - Training in safe handling, sorting, and recycling procedures

5. Defining alternative supply chain scenarios

5.1 Reference scenarios

EU funded foresight study on fishers of the future was commissioned by the European Climate, Infrastructure, and Environment Executive Agency (CINEA) and the Directorate-General for Maritime Affairs and Fisheries (DG MARE). This strategic foresight study explored the future of fishers in the European Union (EU) up to 2050. The study was conducted by Tetra Tech International Development, in collaboration with Poseidon Aquatic Resource Management Europe, Ipsos, F&S, Trinomics, and supported by additional expertise and a network of country experts

covering 22 coastal Member States and outermost regions. Results of the study and final report was published 14.1.2025.

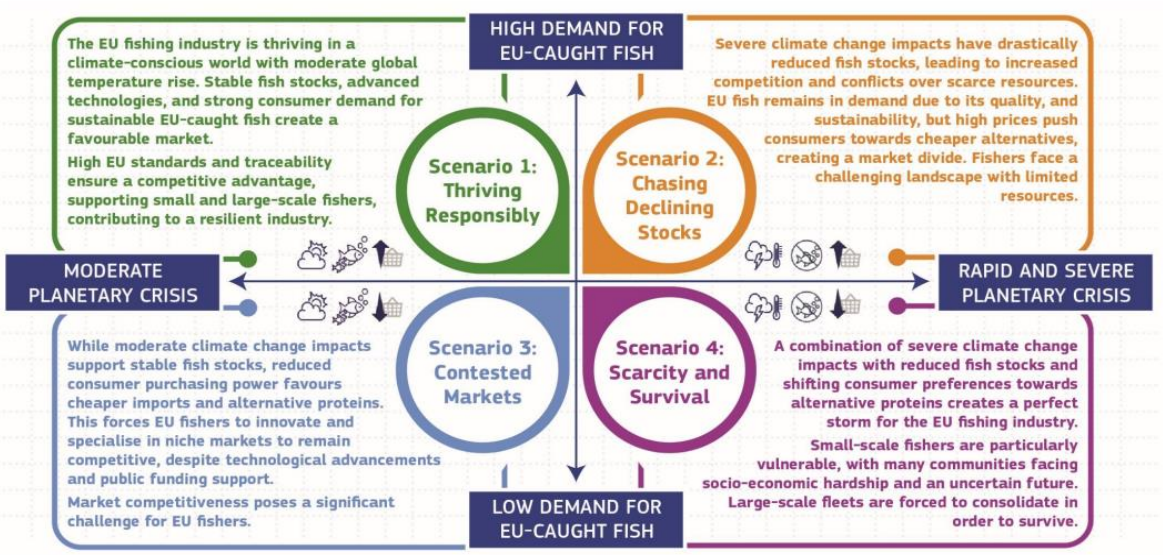


Figure 18. Four European Fishing scenarios[33]

Plastics industry provides foresight studies for the future of recycling technologies for industrial multi-material plastics products for the next five to ten years. The scenario matrix in figure 10 shows the key drivers as main assumptions and comprises a range of possible future scenarios for the recycling of multi-material plastics.

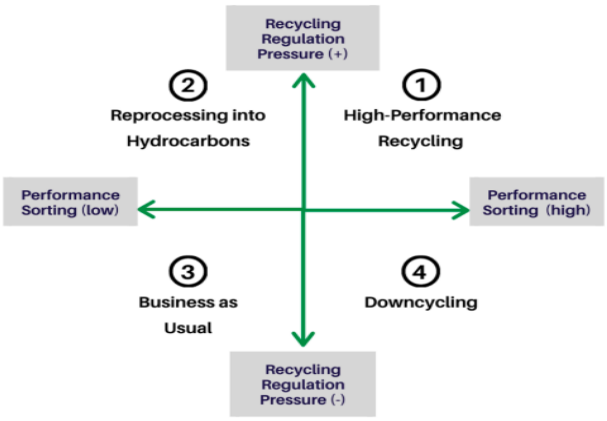


Figure 19. Scenario matrix for the future of multi-material plastics recycling, considering sorting technologies performance and recycling regulation pressure on the axes (x/y). Scenario 1 represents the foreseen future when both factors are existent in a (+/+) scenario; scenario 2 shows the future for a (-/+) case, scenario 3 a (-/-) situation and scenario 4 a (+/-) situation [34]

Lau et al[35] have proposed a scenario-based approach with multiple intervention classes aimed at reducing plastics in the system. This approach enables the management of interventions of varying

[33] https://op.europa.eu/en/publication-detail/-/publication/d1fde0a2-cf0f-11ef-be2a-01aa75ed71a1

[34] https://doi.org/10.1016/j.resconrec.2021.105905

[35] https://ikhapp.org/stories-and-research-brief/evaluating-scenarios-toward-zero-plastic-pollution/

scales and timescales, while also considering potential synergies between some of these interventions. In the context of the fishing gear system, this raises the question of how near- and mid-term interventions can be properly aligned with long-term goals, specifically progressing toward an Extended Producer Responsibility (EPR) scenario. Full implementation of EPR includes different entities of system interventions:

1. Reducing FG plastic quantity in the system
2. Substituting fossil FG plastics with alternative materials and delivery systems
3. Implementing design for recycling
4. Establishing and increasing EOL FG collection capacity
5. Scaling up sorting and mechanical recycling capacity
6. Scaling up chemical conversion capacity
7. Reducing post-collection environmental leakage
8. Reducing trade in FG plastic waste

5.2 Alternative EOL fishing gear supply chain scenarios

EOL fishing gear recycling alternative supply chain scenarios refer to different evolving pathways, routes or management practices that EOL FG can follow once they are collected. References and scenario work done in SEARCULAR aimed to identify sustainable scenarios how especially the Basque Country FG should be recycled and managed following more sustainable approaches. Alternative scenario options cover FG components and net fractions upcycling as such, how different trawl and net materials (polymers like PP, PE, PA) are recycled using available technological routes (mechanical, thermochemical) together with involved collection and logistical approaches. In addition, future scenario work covers also so-called ghost fishing gear collection and sustainable treatment, and fishing gear extended producer responsibility EPR.

Basque Country potential EOL fishing gear recycling future scenario options were innovated, drafted, evaluated, and described together with project partners. Business as usual and Future scenarios are:

Scenario 1 - Business As Usual Scenario - EOL fishing gear landfill

Long-term goal Scenario - EOL fishing gear EPR and Circular Management

Fishing gear Extended Producer Responsibility (EPR) and Circular Management entails that fishing gear are designed by producers to include more durable materials, allowing easy replacement of components, and repairing, dismantling, and recycling. This far-reaching goal scenario includes fishing gear producers' full commitment and financial participation in fishing gear life cycle support and collection system involvement. Secondary use of EOL fishing gear components is excluded since secondary use of fishing gear components is out of full control of original producers' ownership and sustainable EOL management.

EOL fishing gears consist of several parts (e.g., net, float line, floats, wires) made of polymers, metals, wood, or a combination of them. Often, a component such as a netting or a buoy includes a combination of several polymers. In these cases, the disassembly of the materials is too complex, and this complexity ends up affecting the recycling possibilities[36]. To reach the long-term goal scenario - EOL fishing gears EPR and Circular Management - more detailed sub-scenarios are needed

[36] https://www.sciencedirect.com/science/article/pii/S0269749122017596

to break down the transformation into manageable components. To reach this goal, we have identified totally eight sub-scenarios, which are explained briefly. Fishing gear producer responsibility organization (PRO) is included in the long-term scenario. For example, in Finland, The Finnish SUP Producer Group Ltd is the designated Producer Responsibility Organization (PRO) responsible for implementing the Extended Producer Responsibility (EPR) scheme for fishing gear containing plastic. This scheme makes producers responsible for the entire lifecycle of their fishing gear products, including collection and recycling of EOL fishing gear.

Sub scenario 2: EOL fishing gear metallic components recycling

EOL fishing gear includes metallic components like weights, wires, rings, and cables. The metals involved are lead, steel, copper, and aluminium. Motive for metals recovery is large volume (metals even 10% by weight) of the total amount. If metals are not managed and recycled properly, at least lead can have severe ecotoxicity impacts if entering incineration. Also, FG may include integrated sensors in ropes, and these may end up as WEEE. Metals and possible WEEE's should be disassembled and separated in the Blue Point. The most promising recycling route for metals and WEEE is to integrate them with the nearest existing EOL metals/WEEE collection route.

Sub scenario 3: EOL fishing gear components thermochemical recycling (pyrolysis)

Currently, EOL PP, PE and PA fishing gear components potential recycling route is thermochemical recycling by pyrolysis. Major requirement for the feedstock is larger volumes and allowance of some impurities compared to the mechanical route.

Sub scenario 4: EOL fishing gear energy use

EOL FG components and rejects that are not possible to recycle thermochemically are collected separately and incinerated for energy use. Optionally, for energy use sustainable synergies are available through integrating additional available waste streams closely related to commercial fishing. These are EOL fish farming infrastructure components and ALDFG.

Sub scenario 5: EOL fish farming components recovery, sustainable treatment and recycling

Optionally, if there are nearby fish-farming based EOL plastics components available, and if there are collection, logistics and volume-based synergies available, cooperation between fish-farming operators is an option for the Basque area fishing companies.

Sub scenario 6: ALDFG Recovery, sustainable treatment and recycling

According to Marelitt Baltic project[37] ALDFG are usually heavily contaminated after long residence times in the sea and might contain metals, salt, sand, stones, wood, textiles, biological residues (algae, mussels, barnacles) and waste. These contaminants can account for more than 20% of the total weight. The mix of

37 https://static1.squarespace.com/static/58525fe86a4963931b99a5d1/t/5dd3de440fb697248c2d53eb/1574166112449/11+Study+on+Logistics.pdf

materials, impurities and pollution makes it difficult to recycles these nets, as the necessary treatment is technically demanding and cost intensive. ALDFG based material is mostly incinerated or dumped in landfills. ALDFG collection is often incentivized through campaigns together with local fishing companies. Also, random catches of ghost FG's need to be treated in a responsible manner. Anyway, plastic recycling is not easy since these streams are heavily contaminated, adding biomass and biominerals to the fishing gear polymers.

Sub scenario 7: Biobased and biodegradable fishing gear

EPR and eco-design principles bring additional environmental protection criteria for the products lifecycle, design principles and emerging material choices. There has been a growing interest in bringing biobased and biodegradable new fishing gear materials.

Existing possible technological recycling routes and their processes are explained in Figure 19.

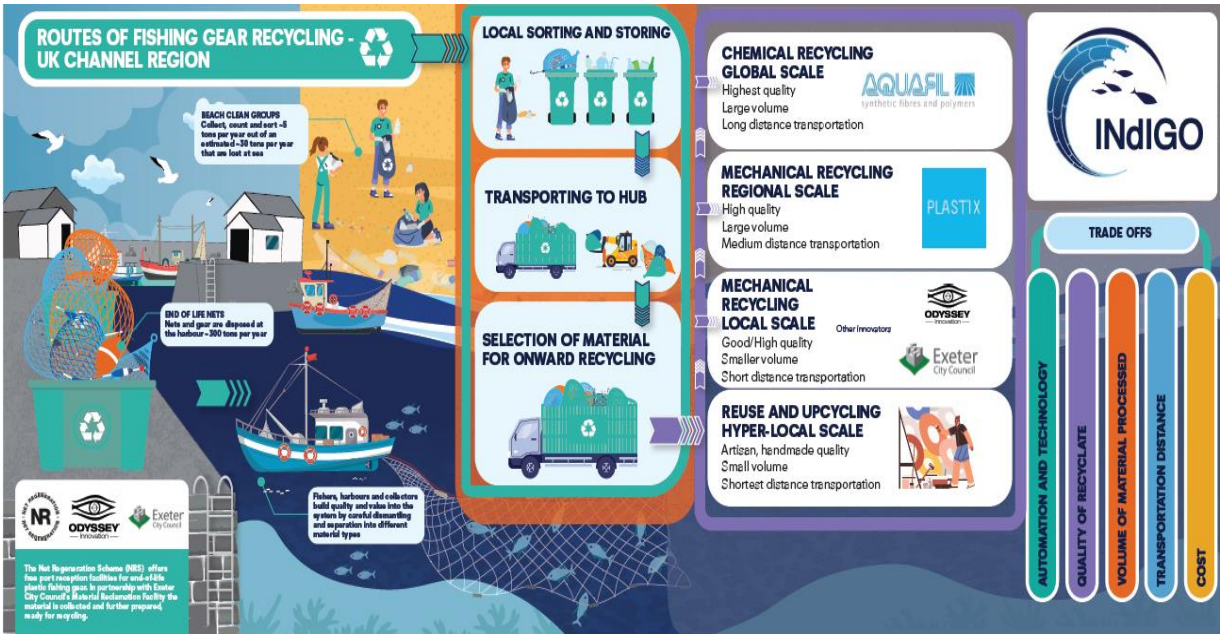


Figure 20. Current key recycling methods and their benefits and challenges for EOL FG`s.[38]

Scenario work related ideation, and refining was a cooperative action together with all SEARCULAR partners. Alternative scenarios scheme was refined by different options including reduction, substitution, recycling and disposal of fishing gear. The future scenario options are illustrated in figure 20.

[38] https://indigo-interregproject.eu/en/best-practices-for-harbours/

Figure 21. SEARCULAR goal scenario and six sub scenarios for implementing full extended producer responsibility (EPR) of fishing gears.

The execution of future long-term scenario work is planned to be rolled out in phases, constructed and defined in detail by all participating stakeholders. FG producers and fishing companies play a crucial role among the other needed key stakeholders. Full adoption of EPR schemes and policies promote changes towards more recyclable fishing gear designs, as well as improved functionality, by giving fishing gear producers and manufacturers full physical and financial responsibility for the products – full gear items and gear components – they produce.[39]

5.3 Comparison of alternative scenarios

The planned comparison of alternative scenarios - illustrated in Figure 21 - raises at least two key questions:

- Which alternative scenarios should be selected for comparison?
- Is relevant data available to enable the comparisons?

Extended Producer Responsibility (EPR) scenario - can be meaningful by assessing the economic, social, and environmental impacts. The main challenge lies in data availability, particularly regarding collection and processing costs, yields, the quantity of material recovered and recycled, and the environmental impacts of the technologies used. One approach to conducting such a scenario comparison is by drawing on the references identified earlier in this deliverable. Reference number 22 outlines regulations and guidance related to EOL fishing gear and waste management. It illustrates how phased implementation and national plans are embedded in broader policy frameworks and systemic changes. The Blue Point-based collection system, with

39 https://wwwcdn.imo.org/localresources/en/OurWork/PartnershipsProjects/Documents/GloLitter/Fishing%20Gear%20Recycling%20Technologies%20and%20Practices.pdf

its dedicated reception facilities, represents a local practical arrangement that supports broader development goals.

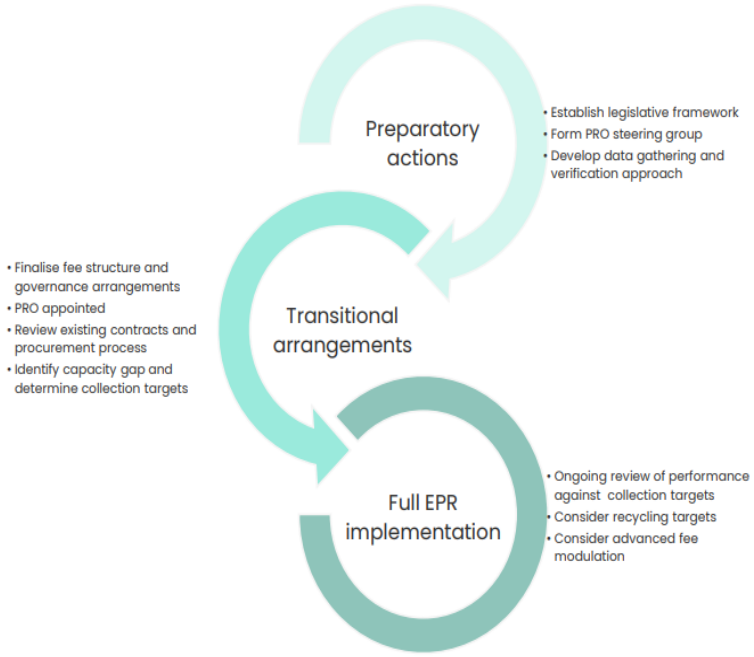


Figure 22. Phased implementation of EPR.[40]

What comes to the options to compare technological scenarios between each other?
When comparing technological recycling scenarios, the key question is not which is better, but how they complement each other in a full system approach. Comparison as such is possible, but on the contrary when we aim to utilize all the EOL FG-based plastics fractions, we most probably need to have all these technological routes in place, the ones which are more suited for recycling PA6-based fractions, which could be recycled more preferably through mechanical recycling or depolymerisation. Some other polymers (PP, PE and especially blends thereof) should follow a thermochemical recycling route where pyrolysis is the most potential option. Currently, all main available technological routes will be needed. There is no need to find the best solutions between recycling technologies.
Emerging fishing gear producer responsibilities and following eco design principles most probably affect fishing raw material base, choices and new more sustainable raw materials (e.g., biobased materials). Some existing not sustainable, harmful and challenging materials for recycling purposes will be abandoned. A lot of further research, development and cooperation activities will be needed to assess material substitution trends and boost the transition process. Currently, we must prepare for the future with evolving technological recycling routes for fishing gears recycling.

5.4 Critical factors for EOL reverse supply chain

Identified critical factors for EOL reverse supply chain providing feedstock for recycling are the following:

- Small available feedstock volumes
- Mixed feedstock stream challenges
- Dirty streams with different challenging contaminants

[40] https://eunomia.eco/wp-content/uploads/2024/12/DECC-Full-Final-Report-v3.pdf

- Recycling technological portfolio readiness
- Recycling capability development takes time
- An industrial-scale pyrolysis plant requires a substantial volume of feedstock
- High investment costs for industrial scale pyrolysis plants
- Lack of specialized EOL fishing gear recyclers
- Excessive logistics costs
- Remarkable regulatory changes

According to executed information gathering, the total annual volume of available EOL fishing gear in Basque Area is small (112 tons), enabling economic challenges for collection and recycling. Main planned route by thermochemical recycling through pyrolysis requires larger volumes.

Secondly, integrating different plastic waste fractions for recycling often presents challenges due to the incompatibility of various plastic types and the presence of contaminants. Efficient sorting and separation are essential to isolate specific plastic types, enabling effective recycling and preventing contamination of the final product. Additionally, EOL fishing gear often contains contaminants (biofilms from bacteria and algae, minerals like sand and silt from seabed), which increase treatment costs and negatively impact the quality of the recycled material and final products.

Fishing companies are frequently encouraged to bring ashore accidental catches of abandoned, lost, or discarded fishing gear (ALDFG), and numerous campaigns are organized to clean the seas of such debris. However, ALDFG is typically even more contaminated (e.g. with mussels or barnacles growing on the FG), posing significant challenges for further processing. Nevertheless, from an environmental perspective, the collection of ALDFG by fishing companies should be allowed – if it does not compromise recycling procedures.

Capability development in EOL fishing gear recycling also requires time. This is evident from the broader plastics recycling sector, where **mechanical recycling currently dominates**. A widely accepted principle in plastics recycling is that any plastic that can be mechanically recycled should be processed that way.

However, based on current knowledge, the **most promising route for many EOL fishing gear plastic fractions is chemical recycling**, particularly via pyrolysis. Some polymers—such as polypropylene (PP), and in certain cases polyethylene terephthalate (PET) or polyethylene (PE)can still be mechanically recycled. Polyamide 6 (PA6) is typically not sent to pyrolysis because its high nitrogen content is undesirable in that process. Instead, PA6 is often recycled through **depolymerisation**, as in the Aquafil process. Ultra-high-molecular-weight polyethylene (UHMWPE), on the other hand, cannot be mechanically recycled but, because it contains no heteroatoms, is a good feedstock for pyrolysis. PE/PP blends used in fishing gear are also challenging for mechanical recycling and may likewise be better suited to pyrolysis[41].

Overall, the **technological readiness for these recycling routes is still evolving**, and further development is needed before large-scale application becomes viable.

Economically viable pyrolysis requires large volumes of input material and relies on expensive processing technologies. Within the GloLitter[42] project, there is ongoing work on small-scale, container-based pyrolysis solutions. Since these approaches operate at lower volumes, plastics recyclers should monitor such developments closely, as they may prove beneficial for EOL fishing

[41] https://www.mdpi.com/2073-4360/13/18/3155?utm_source=chatgpt.com

[42] https://glolitter.imo.org/

gear recycling. In addition, bio-based plastics present a promising alternative for future fishing gear solutions.

Lack of local potential recyclers is a major challenge. For example, the distance from Basque Country to the project partner Plastic Energy recycling company plant, located is Sevilla, is nearly 800 kilometres. Positively, for metals recycling there is a local company available.[43] Possibilities to integrate with some other potential waste streams, like EOL equipment from fish farming (aquaculture) should be considered to increase recycling volumes.

From the Basque Country port of Hondarribia, the planned Blue Point opens partnership opportunities with French fishing and recycling operators who share similar aspirations.

5.5 Alternative options for EOL fishing gear collection and logistics in different circumstances

Alternative options for EOL fishing gear collection and logistics under different circumstances refer to the various strategies or systems that can be implemented depending on specific local or operational conditions, as well as evolving factors and opportunities within the fishing sector, ports, and regional context.

As stated clearly earlier, running an efficient waste management system within a lot of small ports divided over a large area is not cost effective. Logical question to ask is: Is there additional feedstock beyond EOL fishing gear available? The first thinkable supplementary waste stream is ALDFG, offering additional volume and logistical advantages. However, ALDFG often contains significant contamination, requiring costly sorting and treatment processes.

A second additional source is discarded nets and cages from fish farming (aquaculture), which might provide similar materials and quality to those collected from commercial fishing activities. Critical factors to consider here include the availability of this waste stream and the proximity of fish farming sea-based operations. While this stream can enhance both volume and logistical efficiency, it may also raise handling costs if the material is heavily contaminated.

Another key circumstance to consider is the proximity to downstream recyclers. In particular, the presence of a local mechanical recycler could offer a valuable opportunity — especially when combined with Extended Producer Responsibility (EPR**),** which has driven changes in material selection and improved recyclability.

Finally, the geographic and operational link between the Basque Country fisheries and French fisheries operating also in the Bay of Biscay presents an opportunity for cross-border synergies. Given that waste streams are often exported within the EU when domestic recycling capacity is lacking, regional collaboration could help retain valuable materials within a local or transnational circular economy framework.

[43] https://reciclajesondarroa.com/eu/

6. Summary

The SEARCULAR project, funded by the European Union under *the EU Mission "Restore our Ocean and Waters" and by UK Research and Innovation (UKRI)*, aims to reduce marine litter and microplastic pollution originating from European fisheries. This report presents the work and outcomes of Work Package 4.1 (Deliverable D4.1).

The focus lies on the requirements and development of a centralized collection and sorting concept for End-of-Life Fishing Gear (EOL FG), referred to as the "Blue Point". This facility will be located in the port of Hondarribia (Basque Country, Spain) and will serve as an operational hub for the collection, dismantling, and conditioning of discarded fishing gear. It will be supported by a network of satellite collection points at smaller ports, connected through a coordinated reverse logistics system.

The Blue Point is designed to handle various material streams, including plastic, metal, and other recyclable components. The processed outputs will be directed towards established recycling routes, such as mechanical and thermochemical recycling (e.g. pyrolysis). Non-recyclable residues will be sent to energy recovery or, where necessary, to safe disposal.

To enhance the system's viability and sustainability, the report also explores alternative supply chain models to reach economy of scale, including:

- Integration of fish farming equipment waste
- Collection and treatment of Abandoned, Lost or Discarded Fishing Gear (ALDFG)
- Establishment of an Extended Producer Responsibility (EPR) system with a Producer Responsibility Organisation (PRO)
- Promotion of Design-for-Recycling principles in gear manufacturing

In addition to technical planning, the report addresses regulatory, social, and economic aspects such as port logistics, workforce training, stakeholder involvement, and financing mechanisms. The developed concept is designed to be scalable and replicable across other coastal regions.
This deliverable offers practical requirements and blueprint for implementing circular economy practices in the fisheries sector, supporting the reduction of marine pollution and contributing to the objectives of the EU Plastics Strategy in marine contexts.

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Annex 1

Basque area survey results	**Ondarroa**	**Bermeo**	**Getaria**	**Hondarribia**
What data and information sources were used	Number of vessels: Data Collection Framework (DCF) and are owned by the Fisheries Secretariat of the Spanish Government (Secretaría General de Pesca, Gobierno de España) (confidential) Quantities of EOL FG: AZTI (confidential reports), and also https://doi.org/10.1016/j.envpol.2022.120545, and Serbitzu (ports of Gipuzkoa (Hondarribia, Donostia, Orio, Getaria, Mutriku)			
Number of operating fishing companies?	21	31	27	23
Number of operating fishing ships?	25	31	27	23
What type of FG's are used mainly?	Main: Stern trawler, pair trawler, longline, purse seine, small scale gillnet, small scale longline Secondary: Combination with gillnet or trolling, pole and line, trolling	Main: Small scale longline, small-scale gillnet, purse seine, longline, gillnet Secondary: trolling, longline, pole and line	Main: Small scale gillnet, small scale longline, purse seine Secondary: Trolling or trammel nets, longlines, pots, pole and line	Main: Small scale gillnet, small scale longline, purse seine Secondary: Trolling or longline, pole and line
Quantity of EOL FG plastics waste produced annually (tn)?	104,730 kg (average 2010-2019) (94,257kg from trawling; 10,473 kg other fisheries)	6492 kg (average 2010-2019)	410 kg (including the EOL gear of the neighbouring port of Orio)	255 kg Hondarribia purse seine nets are directly taken by farmers, not included in the calculations
Type of EOL FG plastic waste; trawls, nets, traps, ropes, parts of them etc.?	Metal, ropes and net parts	Metal, ropes and net parts	Metal, ropes and net parts	Metal, ropes and net parts
Quantity of passively catched ALDFG waste annually (tn)? Are these included in Blue Point streams?	Some trawlers bring the fished waste to port, but the amount is not registered. These wastes are included or managed by the port waste managers, not reported.	0	0	0
Type of EOLFG metallic wastes; copper, lead etc?	NA	-	-	-

Quantities of metallic wastes?	NA (we have the total amount)	In the tables below.	In the tables below.	In the tables below.
How seasonal variation in fishing activities affect the EOL FG generation	NA	NA	NA	NA
How the transport of EOL FG is arranged? Truck capacity etc.	NA	NA	NA	NA
How the EOL FG quantities will change in future and why (+\-)?	We don't expect large changes			
Annual amount of waste disposal fees currently paid for the waste fractions collected, in euros?	0 €. It is part of the port service fee paid by the shipowner to take care of the vessels IMO wastes….	0 €. It is part of the port service fee paid by the shipowner to take care of the vessels IMO wastes….	0 €. It is part of the port service fee paid by the shipowner to take care of the vessels IMO wastes….	0 €. It is part of the port service fee paid by the shipowner to take care of the vessels IMO wastes….
Are there facilities for repairing and storing fishing gear? Are there facilities suitable for Blue Point after renovation?	Trawlers do not combine different gears during a year. They only trawl. The net is repaired by local companies. Nets are stored in the company's warehouses	The nets are repaired by the "women" of shipowner family. It is a quite traditional industry, and the nets are mended by these ladies. But in the case some parts of the gears must be changed, there are companies at each port providing supplies and this service. The fishing gear is stored in the premises of the shipowner. These premises are small sites, like a garage where they store the gear. Please bear in mind that a vessel can use 2 or 3 different fishing gears during 1 year. Depending on the species they are fishing in, the gear is changed.		
Ideas or opinions where Blue Point should locate? Why?	Bermeo it is not very recommendable for limited space in the town and the fact that it is surrounded and located within the Biosphere reserve (called "Urdaibai"). Hondarribia is in the border with France. On one hand, it can be a good place because of the access and the link with southeaster fisheries			
Can some of fishermen work part-time at Blue Point?	Trawler: not likely. They work all year around; they stop in August only. Small scale fishers maybe yes.	Small scale fishers maybe yes. Purse seine/pole and line vessels are engaged all year along. So, we don't think they would be interested.		

FLEET CENSUS	First metier	Secondary metier	Nº vessels	Vessel length (m) (average)
Ondarroa	Stern trawler	-	6	39
Ondarroa	Pair trawler	-	6 (3 pairs)	31
Ondarroa	Longline	Some combine it with gillnet or trawling, others NA	9	25
Ondarroa	Purse seine	Pole and line	1	33
Ondarroa	Small scale (gillnet)	Trolling	1	15
Ondarroa	Small scale (longline)	Pole and line	2	11
Bermeo	Small scale (longline)	Trolling	7	13
Bermeo	Small scale (gillnet)	Trolling, longline or pole and line,	7	16
Bermeo	Purse seine	Trolling or pole and line	6	26
Bermeo	Longline	Trolling	6	24
Bermeo	Gillnets	Trolling	5	26
Getaria	Small scale (gillnet)	Trolling or trammel nets	7	12
Getaria	Small scale (longline)	Longlines or Pots	4	9
Getaria	Purse seine	Pole and line	16	34
Hondarribia	Small scale (gillnet)	Trolling or longline	4	14
Hondarribia	Small scale (longline)	Trolling	2	16
Hondarribia	Purse seine	Pole and line	15	31
Hondarribia	Longline	Pole and line or trolling	2	22

DATA OF EOL FISHING GEAR COLLECTED IN SOME PORTS

Month	Hondarribia		Donostia		Orio		Getaria		Mutriku	
	Metal (kg)	Net (polymer) (kg)	Metal (kg)	Net (polymer) (kg)	Metal (kg)	Net (polymer) (kg)	Metal (kg)	Net (polymer) (kg)	Metal (kg)	Net (polymer) (kg)
Jan.	15.00	25.00	20.00	0.00	60.00	0.00	0.00	10.00	0	0
Febr.	20.00	10.00	30.00	0.00	50.00	15.00	0.00	30.00	0	0
Mar.	20.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0	0
Apr.	10.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	10	0
May	20.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	10	0
Jun.	0.00	10.00	0.00	0.00	0.00	0.00	0.00	15.00	0	0
Jul.	10.00	20.00	10.00	0.00	0.00	0.00	20.00	30.00	15	0
Aug.	20	0	20	0	0	0	30	20	10	0
Sept.	10	0	20	0	0	0	20	0	10	10
Oct.	20	0	0	0	0	0	10	10	10	0
Nov.	10	15	0	0	0	0	20	0	10	0
Dec.	20	0	0	0	0	0	10	20	10	20

Management: landfill

Year	ONDARROA EOL Fishing gear collected (kg)	BERMEO EOL Fishing gear collected (kg)	Management
2010	84,840	0	The nets are collected in port and are sent to Reciclajes Ondarroa (recycling company). They send the material to another recycled (Urdaibai Rezikleta) in Mungia, where the steel and lead are removed. The rest are taken to the CESPA landfill in Zalla.
2011	164,080	2,500	
2012	131,200	1,680	
2013	93,280	0	
2014	74,200	4,500	
2015	49,360	8,180	
2016	103,760	9,260	
2017	161,240	4,040	
2018	136,700	23,280	
2019	48,640	11,480	

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SEARCULAR
Circular Solutions for Fishing Gears

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