circnets

WP2 REPORT

D.2.1.2: Review and analysis of Life Cycle Assessments in fishing gear waste management methods

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CIRCNETS

Northern Periphery and Arctic

Table list

Figure list

GLOSSARY

Derelict fishing gear. Derelict fishing gear, sometimes referred to as "ghost gear," is any discarded, lost, or abandoned fishing gear in the marine environment. This gear continues to fish and trap animals, entangle and potentially kill marine life, smothering habitat, and act as a hazard to navigation (National Ocean Service, 2024).

End-of-life fishing gear: Fishing gear and gear accessories (e.g. ropes, floats, sink weights and other attachments) that are no longer actively used by fishers. These gears can be old, redundant, retired, disused, damaged or discarded (Stolte et al., 2019).

Environmental impact categories: Environmental impact categories represent different ways we affect the environment around us, i.e., global warming, ozone depletion, and resource depletion. These categories help assess the environmental performance of products throughout their life cycle.

Fishing port. A port that is mainly used by fishing vessels, i.e., vessels that are used to catch fish or other living natural resources mainly commercially.

Life cycle assessment: systematic methodology for evaluating the environmental impacts associated with a product, process, or activity from raw material extraction to its final disposal.

Plastic containing fishing gear; “means any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface and is deployed with the objective of attracting and capturing or of rearing such marine biological resources”. (Directive (EU) 2019/904)

Pre-treatment methods: methods employed to end of life fishing gear before the treatment process (e.g., sorting, washing, drying, etc).

ACRONYMS AND ABBREVIATIONS

ALDFG	Abandoned, lost or discarded fishing gear
AP	Acidification potential
CIRCNETS	Blue Circular Nets project
EOL	End-of-life
EPD	Environmental product declaration
EPfw	Freshwater eutrophication potential
EPm	Marine eutrophication potential
EPt	Terrestrial eutrophication potential
EPR	Extended producer responsibility
ETfw	Freshwater ecotoxicity

ETm	Marine ecotoxicity
ETt	Terrestrial ecotoxicity
EU	European Union
FD	Depletion of abiotic resources – fossil fuels depletion
FFL	Fishing for Litter campaign
FU	Functional unit
GWP	Global warming potential
HT	Human toxicity
LCA	Life Cycle Assessment
MD	Depletion of abiotic resources – minerals/metals depletion
NPA	Northern Periphery and Arctic
PA	Polyamide/nylon
PE	Polyethylene
POF	Photochemical ozone formation
PP	Polypropylene
SUP	Single-use plastics
WD	Water depletion

Table of contents

1

INTRODUCTION

1. Introduction

1.1. Blue Circular Nets (CIRCNETS) project

The Blue Circular Nets (CIRCNETS) is an INTERREG project funded under the Northern Periphery and Arctic (NPA) 2021–2027 program, aimed at addressing the problem of marine litter, specifically end of life (EOL) fishing gear waste in the NPA region (https://www.interreg-npa.eu/projects/circnets/home/). The project involves partners from Finland (University of Oulu -UO), Iceland (Marine Ecological Solutions-MarEco), Ireland (Western Development Commission-WDC and University of Galway-GALWAY), Norway (Norwegian University of Science and Technology-NTNU), and Sweden (Municipality of Sotenäs-SYMBIOS).

In Europe and other parts of the world, single-use plastics and fishing gear are major contributors to marine plastic pollution (Kasznik & Łapniewska, 2023). In response, the European Union has taken significant action to protect aquatic ecosystems, including banning many single-use plastic (SUP) items and promoting alternatives made from more sustainable materials. However, applying the same strategy to plastic-based fishing gear is currently not feasible. Instead, the focus has shifted to managing EOL fishing gear by collecting and recycling these materials before they reach the ocean and add to marine pollution. The EU SUP directive (2019/904/EC) requires producers and importers of plastic-containing fishing and aquaculture gear in all EU member states to organise the collection of EOL fishing gear based on the Extended Producer Responsibility (EPR) principle.

Based on this premise, the specific aim of CIRCNETS is to support the establishment of a collection system for EOL fishing gear in the NPA region, addressing all barriers to the proper management of this waste stream.

1.2. Challenges with plastic-based fishing gear waste streams

In recent years, plastic pollution has become a serious anthropogenic concern and a global environmental burden, especially in the oceans. The increasing accumulation of plastic pollutants in water bodies and the prolonged biophysical properties of plastics in this environment cause direct and/or indirect effects on aquatic ecosystems, disrupting their structure, functions, services, and values (Feary, 2020; Thushari & Senevirathna, 2020). Biological effects of plastic pollution include entanglement, toxicological effects from the ingestion of plastics, suffocation, starvation, dispersal and entrainment of organisms, the creation of new habitats, and the introduction of invasive species. Additionally, the presence of plastic pollutants in the sea can have adverse socio-economic effects, including negative impacts on tourism, fisheries, shipping, and human health (Thushari & Senevirathna, 2020). Fishing gear, together with the other 10 most commonly found single-use plastic items on European beaches, accounts for 70% of all marine litter in the European Union (EU) (European Commission, 2025b).

The EU is developing new strategies and initiatives to reduce the negative impacts of marine litter and promote a more circular plastics economy in Europe. In 2019, the European Parliament and Council adopted two Directives with significant contributions to reducing marine litter from sea-based sources: the revised Port Reception Facilities (PRF) directive (EU Directive 2019/883) and the SUP Directive (EU Directive 2019/904). The revised PRF directive has introduced indirect fees to fishermen for retrieving abandoned, lost, or otherwise discarded fishing gear (EOLFG). The SUP directive addresses the ten most common single-use plastic products found on European beaches (e.g., cotton bud sticks, plastic cutlery and plates, straws, food and beverage containers) and aims to reduce their volume and environmental impact. This directive also includes measures on abandoned, lost or discarded fishing gear (ALDFG) containing plastics. Although these materials do not fall within the definition of single-use plastics, they are found on European beaches and have a significant impact on marine environments. The SUP directive foresees the implementation of the EPR scheme for fishing gear by the end of December 2024. With the implementation of this EPR scheme, producers of fishing gear containing plastic will take on the responsibility (and costs) for separate collection, transport, treatment, and awareness-raising measures for fishing gear (European Commission, 2025b; Feary, 2020).

Considering the recent introduction of the EPR directive for EOL fishing gear in both European and associated countries, waste management practices for these materials need to be adapted accordingly to accelerate and facilitate the implementation of this directive. Within the CIRCNETS project, two studies have analysed the fishing/aquaculture industry and current EOL fishing gear waste management practices in fishing ports and aquaculture facilities in the partner countries (D.1.1.1. report and D.2.1.1. report). The main results from these studies showed how the fishing/aquaculture industry plays an important role in the waste management practices for EOL fishing gear. For instance, Iceland presents one of the largest fishing industries, which has led to a well-established collection and recycling scheme for waste materials from fishing gear. While in Finland, the local fisheries are small-scale and lack well-established waste management practices for their fishing gear waste streams. In comparison, other NPA countries (i.e., Ireland, Norway, and Sweden) can be placed between these two spectrums in terms of industry and waste management practices. Despite its small fishing industry, Sweden is unique because the government established and funded a national collection and recycling scheme for EOL and historical fishing gear. This scheme was developed through the Fiskereturen project, funded by the Swedish government and the Marine and Water Management Agency. Since 2019, the project has collected fishing gear along the east, west, and south coasts. The gear is then transported to the Marice recycling Centre in Sotenäs, Sweden, for sorting and pre-treatment, after which the materials are sent to specialised recycling facilities within and outside the country.

Overall, these previous reports have assessed the current status, key gaps, and opportunities in the systems and practices in place for the collection and treatment of EOL fishing gear waste in each partner country. These analyses have been conducted within an economic and administrative framework. However, to achieve maximum sustainability within the fishing industry, it is important to understand the potential environmental impacts of these collection and recycling practices. In this way, countries will be able to implement environmentally sustainable waste management systems for EOL fishing gear.

1.3. Fishing gear types and materials

Traditionally, and until the 1960s, fishing gear was mostly made of biodegradable materials, including metals (e.g., alloys, iron, copper, and lead), wood, and natural fibres (e.g., linen, hemp, cotton) (Andrady, 2015). However, since the invention of plastic, it has become dominant in fishing gear design due to its superior versatility, durability, and longevity (Feary, 2020). Different types of plastic polymers are used in the design of fishing gear, including the following ones:

- **Nylon or polyamide (PA):** including aromatic polyamide or aramid.
- **Polyethylene (PE)**
- **Low-density and high-density polyethylene (LDPE and HDPE)**
- **Polyethylene terephthalate (PET):** often in the form of polyester (PES)

- **Polypropylene (PP)**

Fishing gear can also be composed of a mixture of different plastic polymers and other materials (e.g., metals, rubber, wood and natural fibres), typically done to enhance the strength and durability of the equipment. Additionally, key gear components such as nets and ropes are occasionally treated with copper-based and other biotoxin antifouling coatings, which can prevent recycling and other sustainable disposal or repurposing methods (Basurko et al., 2023).

EOL fishing gear has a high recycling potential as it is made of valuable raw materials. With proper cleaning and separation procedures, materials can be reintroduced into the manufacturing process. Synthetic polymers such as PP, PE, and nylon, commonly found in fishing gear, have a high value in the recycling market. For instance, nylon can be recycled into textile fibres and carpets, while PP and PE can be recycled into new products, such as buckets and trays (Wong, 2022). However, the mix of materials and polymers in fishing gear often makes recycling processes challenging due to the need to separate the different types of material comprising a single gear component. This issue affects both mechanical and some chemical recycling methods and may require more advanced and costly processes, such as chemical recovery, thermal conversion, and incineration (Salla & Richardson, 2023).

In addition to the use and mixing of various materials for the manufacture of fishing gear, formalised product design and development are less frequent in the fishing gear industry compared to other manufacturing sectors (Charter et al., 2020). Fishing gear producers usually rely on individual expertise and experience to create designs that are not formalised or made publicly available due to intellectual property protections. This results in large knowledge gaps regarding the material composition of fishing gears, including the choice and combination of polymers and additives, further complicating efforts to efficiently recycle these gears (Salla & Richardson, 2023). Another aspect that can hinder the recyclability of fishing gear is the high presence of chemical additives in the plastic materials. Chemical additives can interact with plastic polymers during the recycling process, diminishing their structural integrity and quality. In addition, they can also generate hazardous byproducts, which can subsequently leach into the environment and contribute to marine pollution (Carney Almroth et al., 2025; Iftikhar et al., 2024; Jang et al., 2024). Therefore, fishing gear design is a crucial step in the recyclability of the materials used, which can facilitate or hinder the entire process.

1.4. Waste management of EOL fishing gear.

This section outlines the most used waste management methods for EOL fishing gear waste containing plastic (**Figure 1**). These methods include: 1) pre-treatment methods; 2) four recycling processes, including primary and secondary (mechanical), tertiary (chemical), and quaternary (energy recovery) recycling; 3) incineration without energy recovery; and 4) landfilling.

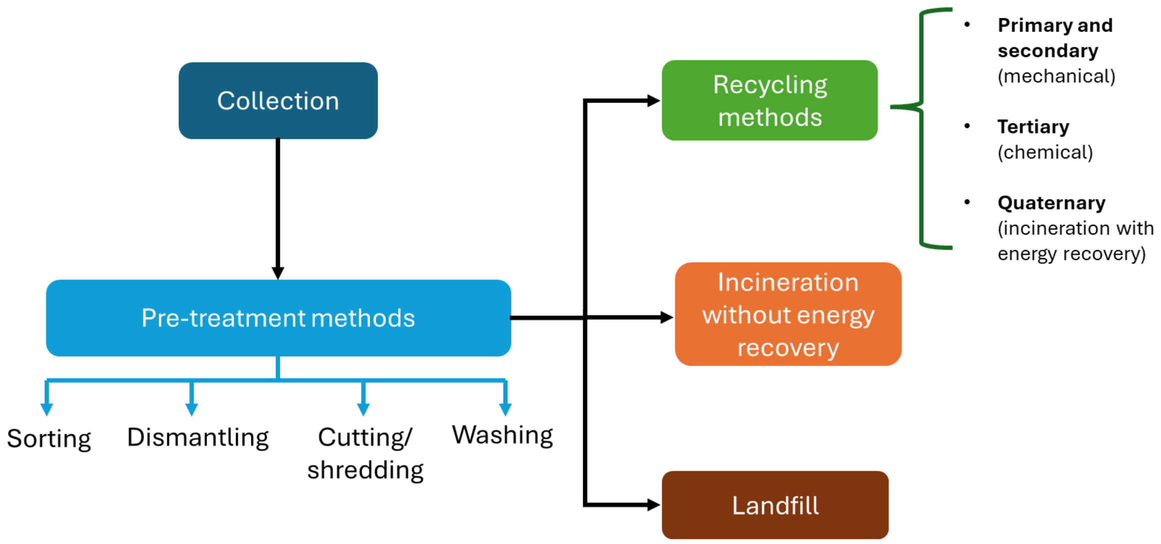


Figure 1: Common waste management methods for end-of-life fishing gear containing plastics. Black arrows show the material flow.

1.4.1. Pre-treatment methods

Materials from ALDFG and EOL fishing gear need to be sorted and manually pre-processed prior to recycling. This is especially important for nets, ropes and traps, which often have a complex design with multiple parts and materials (**Figure 2**).

Figure 2: Discarded and collected fishing gear waste (inc. nets, ropes, floats, and lobster pots) at the Sotenäs Marine Recycling Centre facilities (Sotenäs, Sweden).

Pre-treatment methods vary based on the type of fishing gear, the recycling method used, available resources (e.g., personnel, tools, and infrastructure), and the condition of the fishing gear. According to Schneider et al., (2019), pre-treatment methods generally include:

1. **Sorting, disassembling, and cleaning gear items** to separate polymer types and remove sediments, biofouling, and other contaminants.

2. **Removal of lead lines (if needed)** to avoid harmful contamination.

3. **Cutting and/or shredding of nets** into manageable sizes for further processing.

4. **Washing** to reduce the salt content and any residual/accumulated sediments prior to the processing steps required for recycling.

Recovered ALDFG is typically heavily contaminated with salts, sediments, organic matter, and marine biota due to prolonged seawater exposure, requiring extensive pre-treatment (Van Meel, 2023). In comparison, EOL fishing gear is disposed of at the end of its service life, resulting in lower levels of contaminants and requiring less intensive pre-treatment steps (Salla & Richardson, 2023).

Joint or separate collection of EOL fishing gear and ALDFG is based not only on the quantity of material but also on the recycling technique being used. For mechanical and chemical recycling, separate collection is recommended to reduce contamination, prevent tangling, and simplify processing. However, if the total volume of collected ALDFG is smaller than EOL fishing gear, and the materials used in ALDFG are properly cleaned and sorted, both waste streams can potentially be recycled together using mechanical methods (Salla & Richardson, 2023).

As mentioned above, the type of fishing gear can influence the recycling method employed and the required pre-treatment steps. For instance, traps must be compressed using a hydraulic press to reduce their volume for transport, and any plastic netting in traps must be melted to recover the metal for recycling. Separating the different materials before compaction can facilitate the recyclability of different gear materials. Gillnets are particularly challenging to recycle mechanically. They require lead lines and sink weights to be removed, materials to be separated manually, and to separate higher and lower-density polymers (Stolte et al., 2018). During the cleaning process, the fine polyamide fibres in woven gillnet often fluff up and form clumps with other substances, such as PP and PE fragments, and residual organic waste materials that were not removed in earlier pre-treatment stages. Trawl nets are often made from various materials to give them function and increase durability and strength. The materials are often woven and bonded, allowing them to be easily disassembled into their constituent components. Netting should be cut into smaller sections/pieces to facilitate transport and processing. Attached components such as floats, wires, ropes, sink lines, and weights can often be retrieved and reused.

Proper storage and transport of EOL fishing gear are also essential to facilitate their recycling (**Figure 3**). This can prevent fibre contamination from sand and dirt during onshore handling and fibre degradation from UV exposure (Salla & Richardson, 2023).

Figure 3: Sorted end-of-life fishing gear at the Sotenäs Marine Recycling Centre facilities (Sotenäs , Sweden).

1.4.2. Recycling methods

Plastic products are categorised into four levels: primary, secondary, tertiary, and quaternary based on the plastic's complexity status prior to processing. Recycling methods can be classified using the same categories. Therefore, the recycling methods described in this section will cover:

- **Primary and secondary recycling (Mechanical recycling),** where primary plastic products do not lose their original complexity and can be recycled for the same purpose (e.g., recycling PET bottles into new PET bottles). Secondary products have lost some of their complexity and cannot be reused for the same application (e.g., recycling PET bottles into PET fibre).

- **Tertiary recycling (Chemical recycling)** involves the chemical transformation of plastic into new products.

- **Quaternary recycling (energy recovery)**, where plastic products are burned to release energy.

Primary, secondary, and tertiary plastic products can support the plastics circular economy, as plastic is kept in the use cycle and does not leave the system. In contrast, quaternary recycling results in the loss of materials and, therefore, does not align with the circular economy principle. Additionally, incineration without energy recovery and landfills are not classified as recycling methods because these processes do not produce new end products. However, it is important to note that primary to tertiary recycling is not perfectly circular, as some material could be lost during processing (Davidson et al., 2021).

Primary and secondary recycling (Mechanical recycling)

Mechanical recycling processes can be divided into primary and secondary recycling:

- **Primary recycling ("closed-loop recycling")** involves mechanically reintroducing clean, single-polymer plastics into the extrusion cycle to generate new products with identical properties to the original product (Al-Salem et al., 2009). It requires uncontaminated input materials, typically waste materials produced during the manufacturing process (e.g., unused scrap, pure and sufficiently washed PA6 extracted from gillnet netting, unwanted fishing gear, and new material used in net mending) (James, 2022). These materials are ground up and reintroduced into the extruder, in a process known as re-extrusion.

- **Secondary recycling (downgrading or down-recycling)** involves the mechanical introduction of solid plastic waste to the extrusion cycle to produce plastic pellets, flakes, or powders, depending on the input material quality and polymer composition. The resulting products are of lower quality compared to the original material due to impurities resulting from the multi-material structure and/or the use phase of the end product. These processes are often referred to as “downgrading” or “downcycling” (Dorigato, 2021; Ragaert et al., 2017).

Mechanical recycling starts by melting plastic components, which are then shaped into secondary raw materials, such as plastic pellets or re-granulates. The melted polymer must be of sufficiently high purity to produce a secondary raw material with qualities comparable to those of virgin plastic. Contamination with organic matter (e.g., biofouling and sand) or a mixture of polymers with different melting points and properties can lead to material weakness and fractures in the final recycled product. When multiple types of plastic polymers are combined, secondary recycling results in downgraded materials of lower quality. Therefore, identifying and properly separating polymers from fishing gear can facilitate and improve the quality of recycled products.

Tertiary recycling (chemical recycling, recovery, and thermal conversion)

Chemical recovery can be employed for those fractions of fishing gear that cannot be recycled mechanically, or to produce a higher-quality end-product if desired (e.g., depolymerisation). This process can also act as an alternative to incineration or landfilling of unwanted fishing gear and components that are not suitable for mechanical recycling (Salla & Richardson, 2023). Chemicals and heat are used to break down plastic polymers into their constituent polymers or monomers and convert them into secondary raw materials. Therefore, the chemical structure of the polymer changes through these processes. A wide variety of technologies are employed within chemical recycling processes, resulting in equally diverse range of terminology used when discussing these processes (Manžuch et al., 2021).

Based on Davidson et al., (2021), the most common chemical recycling technologies used are as follows:

- **Pyrolysis:** plastic waste is heated in an oxygen-deficient environment, breaking hydrocarbon bonds and converting the material into a range of solid, liquid, and gaseous hydrocarbon products.

- **Gasification:** Heat and controlled steam, oxygen, and/or air content are used to break down plastic waste and produce syngas, a gaseous mixture rich in hydrogen and carbon monoxide.

- **Hydrocracking:** Carbon-to-carbon bonds in plastic waste are broken using heat and pressure in a hydrogen-rich, inert atmosphere. Hydrogen is then introduced to produce solid, liquid and gaseous hydrocarbons.

- **Depolymerisation:** This process reverses the polymerisation using polymer chemistry, breaking down plastics into their original monomers and oligomers, which can be reused for further polymerisation reactions.

The polymer composition of unwanted fishing gear and the degree of contamination will largely determine which tertiary technology is most suitable for recycling fishing gear. Chemical recycling processes can produce high-quality outputs that are ideal for multiple recurring material circulations. This process also requires less pre-processing input (e.g., basic pre-sorting and cutting/shredding, depending upon the gear type and process) than mechanical recycling. However, chemical recycling often comes with high operational costs, substantial energy demands, and the need for larger quantities of waste inputs (excluding depolymerisation). Additionally, many technologies are still in the development and pilot phases (European Commission, 2020).

Quaternary recycling (energy recovery)

For plastic-fishing gear waste fractions that cannot be recycled using primary, secondary or tertiary processes, quaternary technologies provide an alternative by converting these remaining materials into energy sources. Energy recovery involves burning (via combustion or incineration) waste to produce heat, steam, and electricity (Al-Salem et al., 2009). This method reduces the volume of non-recyclable fishing gear sent to landfills while recovering valuable energy sources (Salla & Richardson, 2023). As noted earlier, combustion or incineration processes that produce fuel or recover energy are not always classified as recycling methods, as the outputs produced are not substances that can be used in the manufacture of new products (i.e., new plastic products). Nevertheless, the high-energy content of plastic waste and its potential to serve as a solid fuel are the main arguments for considering it a resource (Salla & Richardson, 2023).

1.5. Introduction to Life Cycle Assessment (LCA)

One way to determine and assess the environmental impact of the collection and recycling practices of EOL fishing gear is through Life Cycle Assessment (LCA). LCA is an internationally standardised modelling tool (ISO 14040/44) that has been applied for 50 years to assess potential environmental impacts in value chains (Davidson et al., 2021). LCAs include the following steps (**Figure 4**): 1) goal and scope definition; 2) inventory analysis; 3) impact assessment; and 4) results interpretation (ISO, 2018; ISO 2006). Each step is explained in detail in the following sections based on Widheden & Ringström, (2007).

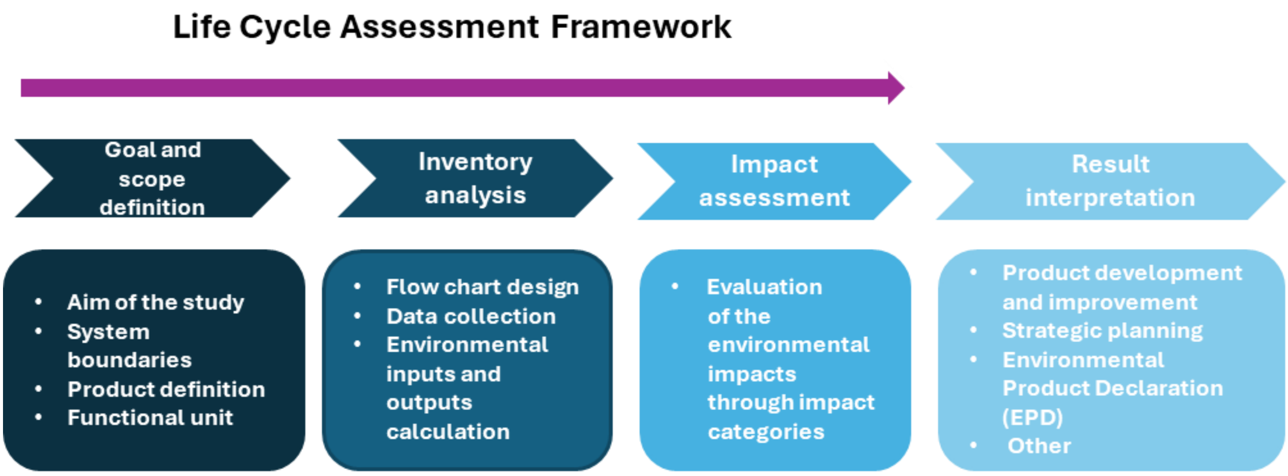


Figure 4: Flowchart of the different steps of a Life Cycle Assessment. Adapted from Golsteijn, (2025).

1.5.1. Goal and scope definition

The Goal and scope definition is the first step of an LCA study and consists of the planning step. It includes a definition of the study's purpose and scope to facilitate inventory analysis, impact assessment, and interpretation. Within this step, several definitions must be made:

- **Goal:** according to the ISO standards (ISO, 2018; ISO 2006), the goal definition “shall unambiguously state the intended application, the reason for carrying out the study, and the intended audience”. It is also important to consider if the study will be used externally (e.g., for marketing purposes) or internally (e.g., to make internal decisions within the process chain).

- **Scope:** The scope of the study defines the system boundaries (i.e., which processes will be included in the study and which will not), the unit processes for which data will be collected, the technological level of these processes, and the geographical location of the study. This stage also includes decisions on the preferred environmental parameters to be assessed and the methodology for impact assessment and interpretation.

- **Product definition and functional unit:** The product under study should be described as a physical product (e.g., plastic polymer) or a service (e.g., a plastic factory). In both cases, the minimum requirements that the product must meet should be specified. For example, the primary function of a plastic factory is to produce plastic polymers. However, the required properties of these polymers must be specified to enable a fair comparison of different plastic production alternatives. The functional unit, on the other hand, serves as the basis for calculations and measures the performance offered by the system. It should be defined in a way that considers all aspects of the product under study. An example of a functional unit is 1 kg of plastic polymers.

1.5.2. Inventory analysis

In the Inventory Analysis or Life Cycle Inventory (LCI), a mass and energy balance is performed considering only the environmentally relevant flows. Specific flows, such as diffuse heat and water vapour emissions from combustion, are typically excluded from the model.

An LCI analysis generally involves the following steps:

- **Develop a flow chart** to represent the product system based on the defined system boundaries.
- **Collect data** for all activities within the product system, followed by data quality assessment and documentation of collected data.
- **Calculate the environmental inputs and outputs of the system** (i.e., resource consumption, pollutant emissions and waste) relative to the functional unit.

1.5.3. Impact Assessment

The Impact Assessment evaluates the environmental impacts associated with the environmental loads quantified in the inventory analysis. This process involves categorising the inputs and outputs from the LCI results into specific environmental impact metrics, using commonly employed environmental impact categories such as global warming, acidification, and effects on biodiversity (**Table 1**).

Table 1: Impact categories commonly assessed on waste treatment Life Cycle Assessments. Adapted from Hillege, (2025).

Impact category	Unit	Definition
Climate Change (CC) or Global warming Potential (GWP)- total, fossil, biogenic and land use	kg CO_2-eq	Indicator of the global warming potential from airborne greenhouse gas emissions. This indicator is divided into three subcategories: 1) fossil resources 2) bio-based resources 3) land use climate change
Acidification potential (AP)	kg SO_2 -eq	Indicator of the potential acidification of soil and water through the release of gases such as nitrogen oxides and sulphur oxides.
Freshwater eutrophication potential (EPfw)	kg PO_4-eq	Indicator of the enrichment of the freshwater ecosystem with nutritional elements through the emission of compounds containing nitrogen or phosphorus.
Marine eutrophication potential (EPm)	Kg N-eq	Indicator of the enrichment of the marine ecosystem with nutrients through the emission of nitrogenous compounds.
Terrestrial eutrophication potential (EPt)	mol N-eq	Indicator of the enrichment of the terrestrial ecosystem with nutrients through the emission of nitrogen-containing compounds.
Photochemical ozone formation (POF)	kg NMVOC-eq	Indicators of gas emissions that contribute to the creation of photochemical ozone in the lower atmosphere (smog) are catalysed by sunlight.

Human toxicity (HT)	1,4-DB-eq	Indicator of the impact on humans of toxic substances emitted to the environment. Divided into non-cancer and cancer-related toxic substances.
Terrestrial ecotoxicity (ETt)	1,4-DB-eq	Impact on terrestrial organisms of toxic substances emitted to the environment.
Freshwater ecotoxicity (ETfw)	1,4-DB-eq	Impact on freshwater organisms of toxic substances emitted to the environment.
Marine ecotoxicity (ETm)	1,4-DB-eq	Impact on marine organisms of toxic substances emitted to the environment.
Water depletion (WD)	m^3	Indicator of the relative amount of water used based on regionalised water scarcity factors.
Depletion of abiotic resources – minerals/metals depletion (MD)	kg Sb-eq	Indicator of the depletion of natural non-fossil resources.
Depletion of abiotic resources – fossil fuels depletion (FD)	MJ, net calorific value	Indicator of the depletion of natural fossil fuel resources.

1.5.4. Interpretation of results

Results are processed into more useful and presentable metrics to facilitate comparisons and conclusions. This process includes reviewing the initial results, identifying key data points and evaluating the impact of missing information. Conducting an LCA study requires gathering extensive and appropriate data, which can be challenging. Sometimes, specific data is unavailable, requiring alternative sources such as published data or estimates (Widheden & Ringström, 2007).

Overall, the results of an LCA can be used to compare processes, identify environmental hotspots within the value chain, track shifts in burden, and guide process improvements (Finnveden et al., 2009). LCA results can be translated into different outputs, including material declarations and certified Environmental Product Declarations (EPD). These outputs provide customers and the market with quantitative and qualitative data about the environmental performance of products and services. Additionally, LCA can support eco-efficiency analysis by integrating environmental data from an LCA with economic aspects, enabling a comparison of products from a sustainability perspective (Widheden & Ringström, 2007).

Although LCAs have some methodological limitations and challenges, the assessment tool is robust and widely accepted for assessing the environmental performance of systems (McManus et al., 2015). LCA modelling has been widely applied in the waste treatment industry, with several studies being conducted in the treatment of plastic waste (Faraca et al., 2019; Gu et al., 2017; Shen et al., 2010; Shonfield, 2007). A few studies have also been conducted in recent years on the treatment of EOL fishing gear (**Table 8, Annex 1**). However, there are still knowledge gaps and limitations in the analysis of these processes.

Overall, LCAs allow the understanding of the environmental impacts of collection and treatment processes for EOL fishing gear waste. However, there is ongoing progress to reduce and prevent the impacts of these waste streams on the natural environment.

1.6. Objectives of the report

The present report aims to understand and analyse the environmental impacts of different waste management practices for EOL fishing gear. To achieve this, the current report conducted a literature review of LCA studies on the collection, waste treatment practices, and recycling of EOL fishing gear. The main objectives of this literature review are as follows:

1. Identify environmental hotspots within the value chain for the treatment of EOL fishing gear waste material.

2. Compare the environmental performance of different waste treatment practices and alternatives.

3. Set up recommendations to establish collection and recycling schemes for EOL fishing gear with a sustainable focus.

By addressing these objectives, this report aims to assess which practices are preferred for the establishment of sustainable collection and recycling schemes for EOL fishing gear in the partner countries and beyond.

2

MATERIALS AND METHODS

2. Materials and methods

For the development of the literature review on LCA studies of the treatment and recycling of fishing gear waste, including lost, abandoned, discarded, or end-of-life fishing gear, a database screening was conducted using Google Scholar and Scopus. The search string used was repeatedly tested and refined to ensure it was both synthetic and comprehensive. The final search string included the following key terms: "end of life fishing gear" OR "EOL fishing gear" " fishing gear waste" OR "discarded fishing gear" OR “derelict fishing gear” OR "marine plastic waste"; “waste treatment” OR “recycling” OR “mechanical recycling” OR “chemical recycling” OR “energy recovery”; AND "life cycle assessment " OR "life cycle analysis" OR "LCA" OR "impact analysis" OR "environmental impacts" OR "material flow analysis" OR "sustainability assessment". To be suitable for inclusion in the review, the document had to meet the following criteria: (1) be a scientific article, book or book chapter, or report; (2) be a study conducting a systematic LCA of the treatment and recycling of fishing gear waste; and (3) the materials studied should include plastic waste. Documents that did not meet these criteria were rejected. The final selection of case studies included eight documents.

3

LITERATURE REVIEW OF LCAS ON WASTE MANAGEMENT OF END-OF-LIFE FISHING GEAR

3. Literature review of LCAs on waste management of end-of-life fishing gear

3.1. Statistical analysis

Based on the reviewed documents, a statistical analysis was conducted on the following categories: 1) Document type; 2) Geographical distribution; 3) Year of publication; 4) Materials studied; 5) Processes studied; 6) Methodology used; and 7) Software used.

In terms of document type, half of the gathered documents were articles, followed by three reports and one PhD thesis (**Figure 5A**).

Regarding geographical distribution, the majority of studies (88%) were conducted in Europe, encompassing a wide variety of countries, including Germany, Norway, Denmark, Lithuania, Slovenia, Croatia, Italy, and Spain. The only study outside Europe was conducted in Turkey (**Figure 5B**).

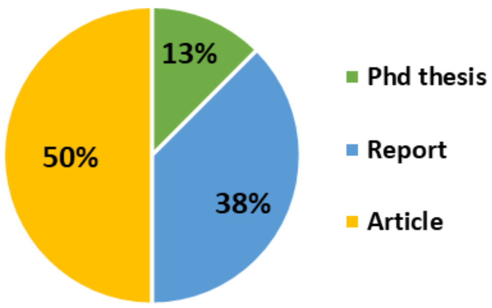
The years of publication presented a high variety, with 38% of the sample (3 studies) published in 2023 and 25% (2 studies) in 2024. The remaining studies were published in 2017, 2022 and 2025 (**Table 8, Annex 1**).

With regard to the type of materials studied (**Figure 5C**), polyamides (i.e., nylon) were the most common, appearing in 88% of the studies, followed by polyethylene and polypropylene (63% each). Two studies also examined the environmental impact of using and/or recycling other materials, such as Polylactic acid (PLA), Polyhydroxybutyrate (PHB), and carbon fibres (Cañado et al., 2022; Pasciucco et al., 2025).

The studies analysed the sustainability of various processes within the fishing gear waste recycling and processing value chain (**Figure 5D**). Mechanical recycling was the most studied waste management process (75%, six studies), followed by chemical recycling (38%, three studies), energy recovery, incineration and landfill (25% each, two studies). Composting was the least studied process, with only one study (Cañado et al., 2022) addressing this area. Other processes, including waste collection (38%), material transport (88%) and dismantling and sorting (50%) were commonly analysed within the recycling value chain. However, only one study included packaging and storage in the LCA analysis (Tippet, 2023). Additionally, 38% of the studies compared the environmental impacts of recycling plastic from EOL fishing gear versus virgin plastic production. Two studies also examined the manufacturing of the final product from recycled materials or virgin materials (Cañado et al., 2022; Pasciucco et al., 2025). It is also important to note that the Karadurmuş & Bilgili, (2024) study covered the environmental impacts of the fishing gear value chain, from manufacture to their end of life, comparing two EOL treatment methods: mechanical recycling and incineration. Schneider, (2020) study also examined the impacts of steel and lead recycling within derelict fishing gear.

The most used impact assessment method is ReciPe (38%, three studies), followed by the CML method, where one study used CML 2001 and another used CML i.a. 9.6 version (**Table 8, Annex 1**). Only one study employed the EF 3.1 methodology (Aquafil, 2024b), while two studies did not specify the methodology used (NOFIR, 2023; Storm, 2017). Finally, the most widely used LCA software is SimaPro, utilised in 63% of the studies.

A)



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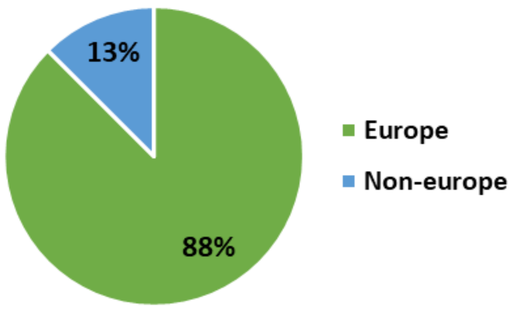

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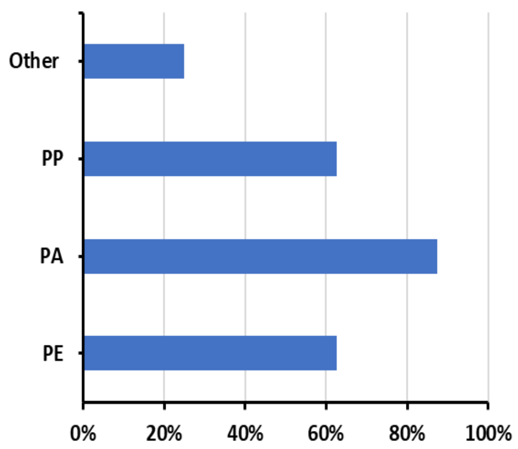


D)

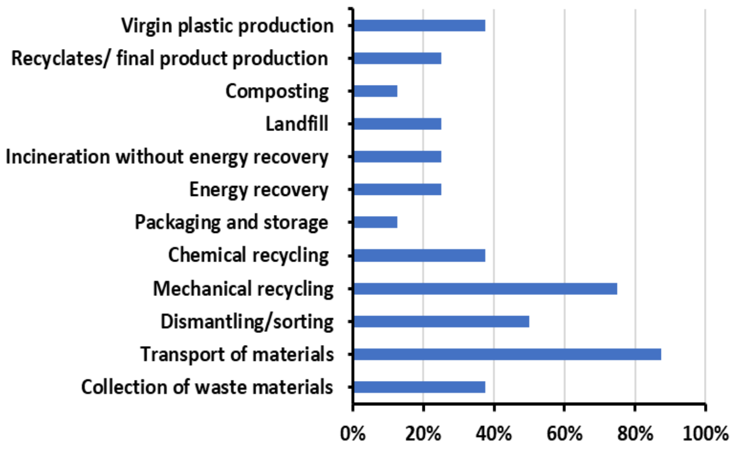


Figure 5: Statistical analysis of the literature review on Life Cycle Assessment studies on the waste management of EOL fishing gear: A) Document type; B) Geographical distribution; C) Materials studied; D) Processes studied. PE: polyethylene; PP: polypropylene; PA, polyamide (nylon).

Summary box: half of the reviewed documents were journal articles, with most studies (88%) conducted in Europe. Publications spanned from 2017 to 2025. Polyamides were the most studied material (88%), followed by polyethylene and polypropylene (63% each). Mechanical recycling was the most analyzed recycling process (75%), with others including chemical recycling, incineration, landfill, and energy recovery. Commonly assessed stages included transport (88%), dismantling/sorting (50%), and collection (38%), while packaging was rarely included. About 38% of studies compared recycled vs. virgin plastics. Key methodologies included ReCiPe (38%) and CML, with SimaPro as the most used LCA software (63%).

3.2. Functional unit (FU)

The most common FU used by the reviewed studies is one weight unit (tonne or kg) of the material studied, which may refer to fishing gear, recycled output or final product (**Table 8, Annex 1**). Karadurmuş & Bilgil (2024), NOFIR (2023), and Schneider(2020) defined the FU as one weight unit of fishing gear or similar variants. In contrast, Storm (2017) and Tippet (2023) defined the FU based on recycled output (e.g., 1 tonne of plastic granules). Aquafil, (2024b), Cañado et al., (2022) and Pasciucco et al., (2025) defined the FU based on the final manufactured product (e.g., 1kg of 3D-printed material, 1 kg of ECONYL® NTF or 1 tonne of Carbon Fibres Reinforced Polymers composites). Notably, those studies that compared the environmental impacts of virgin plastic production with recycling processes used the same FU but applied to virgin plastic products (**Table 8, Annex 1**).

3.3. System boundary

The system boundaries of the sampled studies encompass a high degree of variability in processes, depending on the study's focus. When developing an LCA, it is essential to understand the various life cycle stages encompassed in the study. In the European markets, the life cycle stages that can be included in LCAs are defined by EN 15978 and EN 15804 standards. These stages are defined in **Figure 6** and further described (Circular ecology, 2025; Shaun, 2025):

- **Product stage (A1-A3):** These stages include the provision of all raw materials, products, and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the product stage. LCA studies including only these stages are classified under “Cradle-to-Gate” models.

- **Construction and installation stage (A4-A5):** includes all impacts and aspects related to any losses during this construction process stage (i.e., production, transport, waste processing, and disposal of the lost products and materials). LCA studies, including up to these stages, are classified under “Cradle-to-Practical Completion” models.

- **Use stage (B1-B7):** comprises all impacts related to the use of the product over the entire life cycle of the project that should be captured. This incorporates provisions for the transportation of all materials, as well as the energy and water impacts associated with building use.

- **End-of-life stage (C1-C4):** The end-of-life stage encompasses the deconstruction and demolition of the product, including the impacts of transportation to waste processing sites and the disposal of the resulting waste. This encourages design teams to consider the environmental impact at the end of the life cycle early in the design process, and to use recyclable or reusable materials to minimise this stage. LCA studies, which cover these stages, are classified under “Cradle-to-Grave” models.

- **Beyond stage (D):** It encompasses the net benefits and loads arising from the reuse of products, as well as the recycling or recovery of energy from waste materials generated during the construction stage, the use stage, and the end-of-life stage. LCA studies containing Module D are classified as “Cradle-to-Cradle” models.

Therefore, to understand which processes are included, these stages were identified for each study.

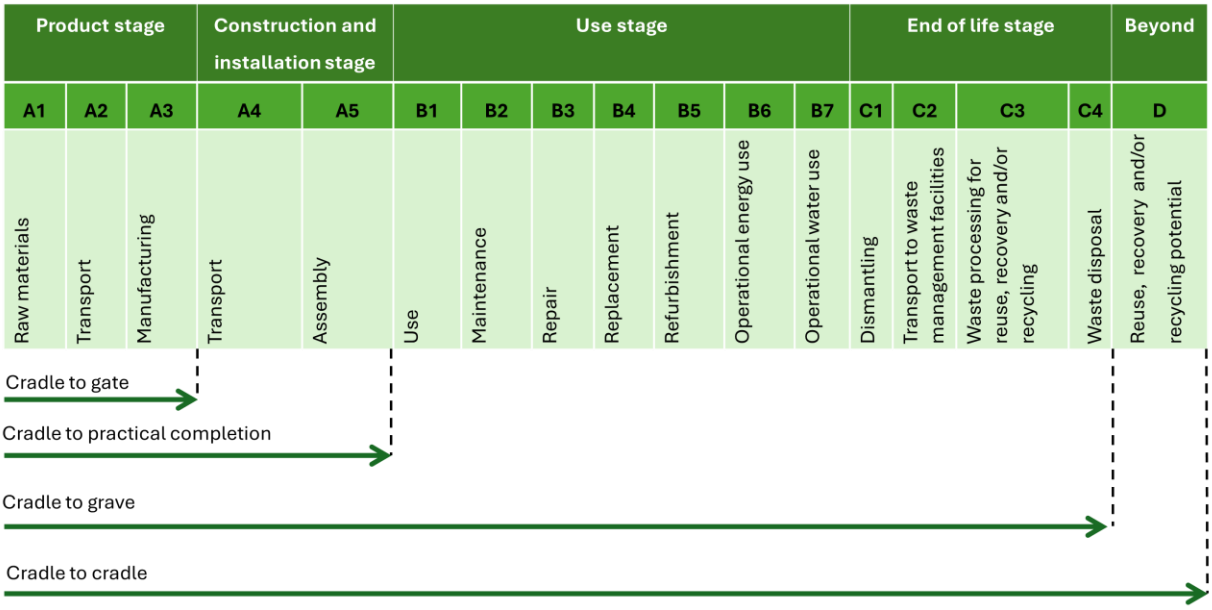


Figure 6: Life Cycle stages diagram based on Environmental Product Declaration (EN 15804 and A2 annex). Adapted from Circular ecology, (2025).

Case study 1: "Life Cycle Assessment applied to fishing gear scrap. A system for collecting and recycling discarded equipment from the fishing and fish farming industry".

The NOFIR, (2023) study estimated the environmental impacts of the Nofir system, specifically focusing on the collection and processing of discarded equipment from the fishing and aquaculture industries. Nofir is a Norwegian-based company that collects waste gear from fishing and fish farming operations worldwide. The company converts the waste into raw materials for further recycling into a wide variety of products (NOFIR, 2025). Nofir's main suppliers are net washing facilities, net lofts, and waste facilities from Norway, the United Kingdom, and Denmark. At the Lithuanian plant, workers manually sort and cut ropes and nets, organising them by size and material before further processing. The Italian company Aquafil acquired a 32% ownership stake in Nofir in 2021, following over 10 years of collaboration with them.

The system boundaries of the study include C1- C3 stages, covering: 1) collection of discarded fishing equipment; 2) transportation of materials to Nofir's facilities in Lithuania; and 3) dismantling at Nofir's facilities. The process stops at Nofir's gate, before the processed waste materials (i.e, secondary materials) are shipped to other recyclers (**Figure 7**).

To assess the impact of Nofir's work, the study compares the recycling potential of secondary materials with a virgin material production scenario, where, in addition to assessing the impacts of virgin plastic production, discarded fishing gear is not recycled. Instead, it follows a traditional waste management route (i.e., incineration with energy recovery). To do so, more processes were added to complete the picture of Nofir's work impacts. C1-C4 stages were included for the recycling potential of fishing gear, covering the following processes: 1) Energy recovery (electricity and thermal energy), 2) transport to recyclers and 3) Recyclers activity (Recycling by Aquafil). Alternatively, the virgin material production scenario focuses on creating 1 kg of virgin materials with the same mass share as the Nofir output (**Table 8, Annex 1**). This scenario considers the burden associated with transporting EOL fishing gear to incineration. Therefore, the virgin material production scenario includes A1-A3 stages for virgin plastic production and C1-C4 stages for EOL fishing gear waste management, thus covering the following processes: 1) Incineration with energy recovery of the discarded fishing nets; 2) Virgin materials production; and 3) Energy recovery (electricity and thermal energy).

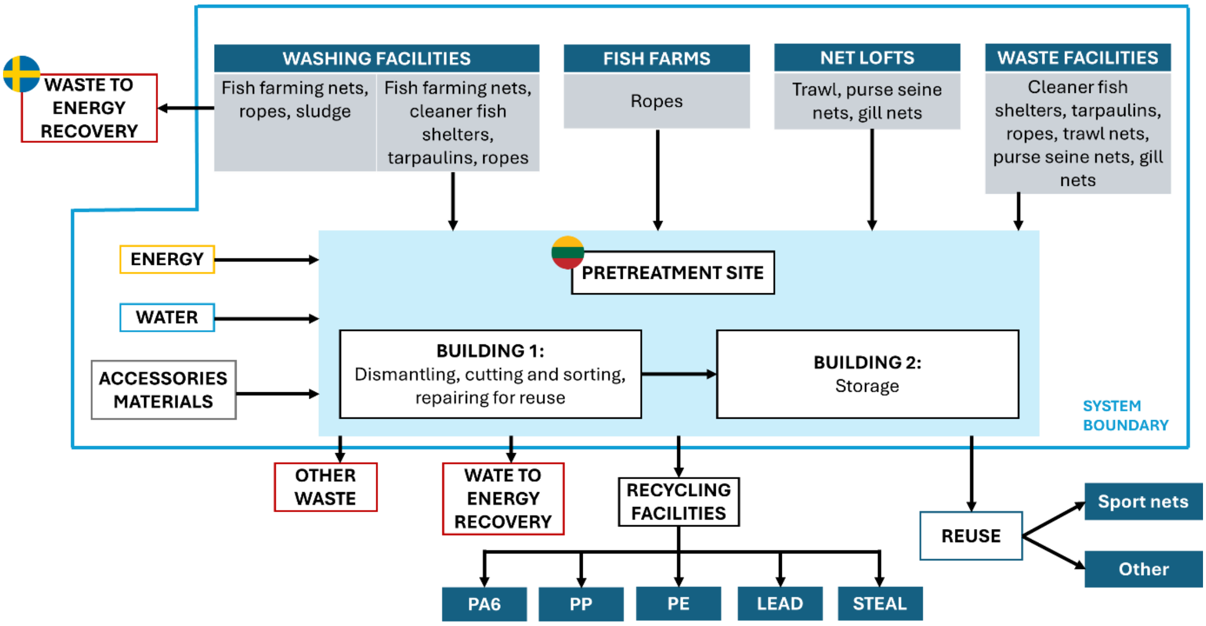


Figure 7: System boundaries and material flow diagram of the life cycle assessment of NOFIR collection and recycling practices of fishing gear waste in Norway(NOFIR, 2023). PA: polyamide; PP: polypropylene; PE: polyethylene.

Case study 2: "A Life Cycle Assessment (LCA) on the retrieval and waste management of derelict fishing gear."

Schneider (2020) aimed to assess the environmental impacts of retrieving and waste management of derelict fishing gear (i.e., fishing gear found at sea) retrieved from the Baltic Sea. Four different scenarios for treating derelict fishing gear were assessed in the study:

- **Scenario 1:** mechanical recycling to produce nylon.
- **Scenario 2:** chemical recycling to produce syngas.
- **Scenario 3:** energy recovery to produce heat and electricity.
- **Scenario 4:** landfill disposal.

The system boundaries (**Figure 8**) encompass stages C1-C4 and D. In addition, the whole system includes primary processes (i.e., main processes to treat DFG and obtain the final products), secondary processes (i.e., treatment of other residual fractions), avoided processes (i.e., avoided primary production processes) and excluded processes (i.e., landfilling of residues and repeated processes in all scenarios).

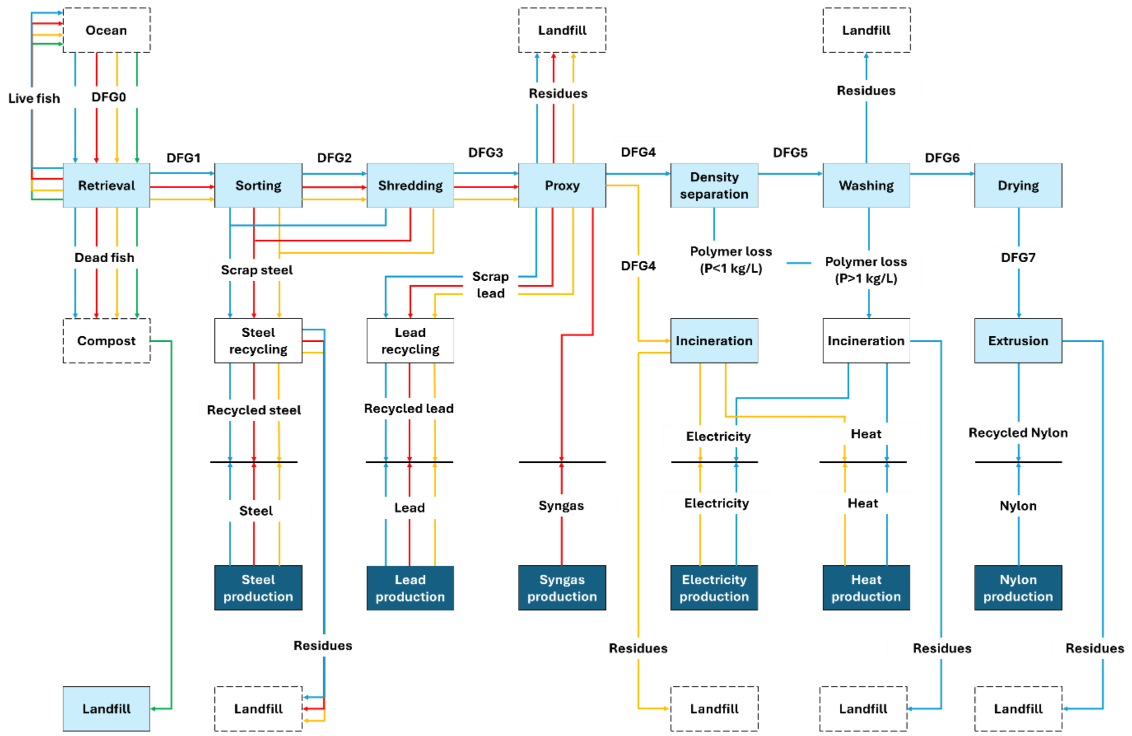


Figure 8: System boundaries of the life cycle assessment of processing derelict fishing gear (DFG) from its ocean retrieval (Baltic Sea) to its recycling or disposal (Schneider, 2020). Scenario 1 (blue): mechanical recycling; scenario 2 (red): chemical recycling/gasification; scenario 3 (yellow): energy recovery; scenario 4 (green): disposal; dashed boxes: excluded process; light blue boxes: primary processes; white boxes: secondary processes; dark blue boxes: avoided processes.

Case study 3: "Life Cycle Assessment of Fishing and Aquaculture Rope Recycling"

Tippet, (2023) estimated the environmental impact of recycling waste PP/PE fishing and aquaculture ropes into PP/PE granulates, based on the operations of a recycling company in Norway. The system boundaries include C1-C4 stages, starting with the collection of fishing/aquaculture ropes waste (i.e., upstream processes: transport of materials) and covering all processes related to the mechanical recycling into new plastic granulates (i.e., core processes: sorting, forklift, granulation, wastewater treatment, waste production, storage and packaging) and the delivery to the customers (i.e., downstream processes: transport of materials to customers). The study does not extend to the use of the plastic granulates by customers (**Figure 9**). To evaluate the environmental impacts of PP and PE recycling processes, the study compares them to the emissions of virgin plastic production. Therefore, the boundaries are designed to facilitate this comparison.

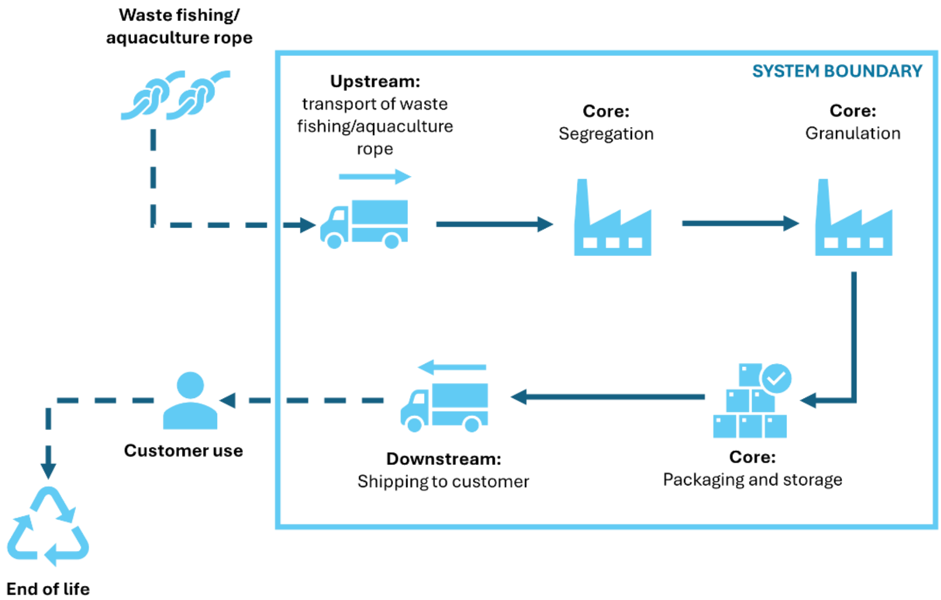


Figure 9: *System boundaries of the life cycle assessment of fishing and aquaculture rope recycling in Norway* (Tippet, 2023). Dashed arrows represent material flows not included in the system boundaries.

Case study 4: "Production of recyclates – compared with virgin Plastics – a LCA Study".

Storm, 2017 examined the environmental impact of Plastix A/S recycling facilities (Lemvig, Denmark). Plastix is a recycling plant that processes discarded fishing gear materials into recycled plastic pellets through mechanical recycling.

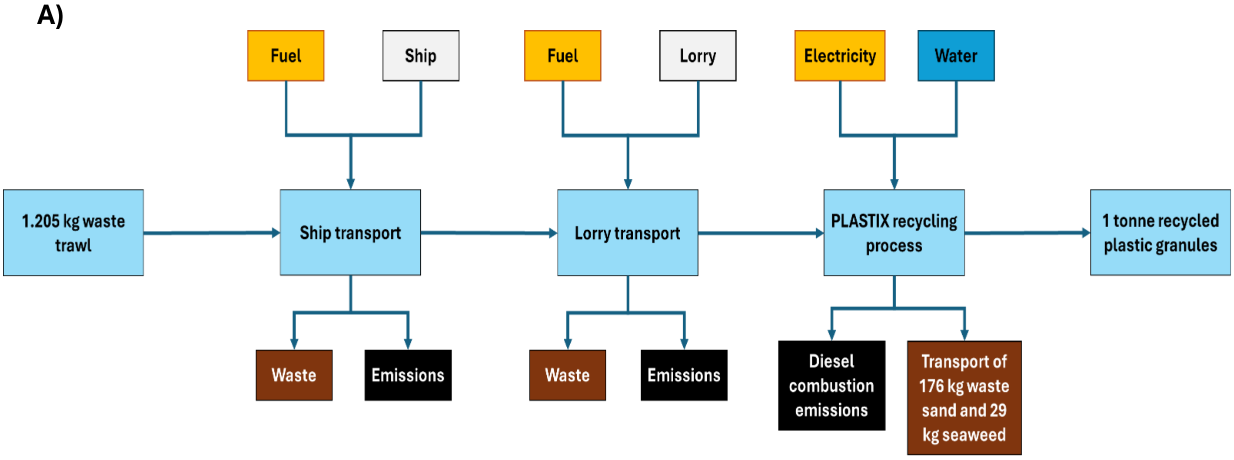
The system boundaries of this study covered C1-C4 and D stages for the recycling scenario of PA6, PE and PP at Plastix facilities (**Figure 10A**):

1. Transport of discarded fishing gear to the Plastix A/S facilities
2. Mechanical recycling at Plastix A/S, including gate control, storage, cutting, cleaning, final separation, and extrusion.

This study also compared the emissions from Plastix's recycling process with those from virgin material production (**Figure 10B**). The production of virgin plastic involves A1- A4 stages, including:

1. Mining/production of raw materials
2. Refining of raw materials to produce monomers and other components
3. Additional processing
4. Polymerisation
5. Transport.

A)



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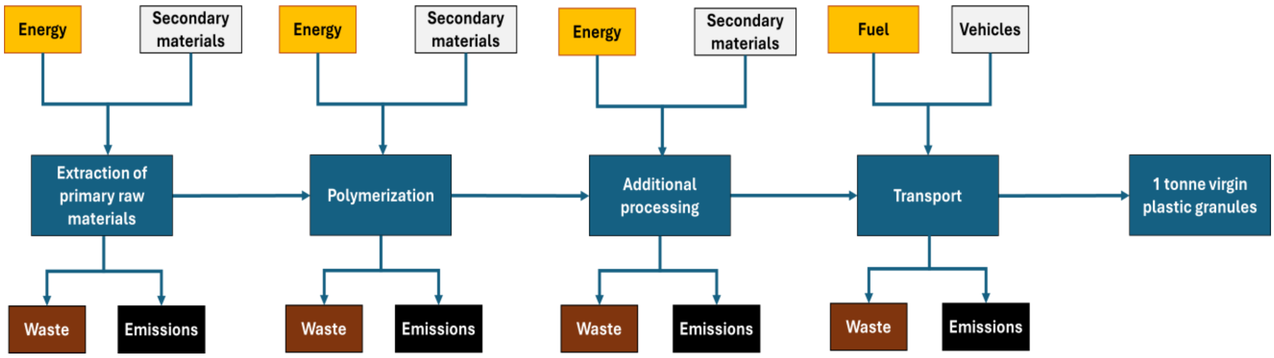

Figure 10: A) System boundary of the life cycle assessment of the PLASTIX recycling practices for EOL fishing gear; B) System boundaries of the life cycle assessment for the production of virgin plastic (Storm, 2017).

Case study 5: "Recycling polyamide 6 fishing nets and carbon fibres for the development of novel sustainable composites: Properties and LCA process analysis"

Pasciucco et al., (2025) investigated the production of carbon fibre reinforced polymer (CFRP) composites in Italy under three different scenarios:

- **Scenario 0:** CFRP composites made from virgin PA6 (vPA6) and virgin carbon fibres (vCF).
- **Secnario 1:** CFRP composites made from recycled PA6 (rPA6) from discarded fishing nets and vCF.
- **Scenario 2:** CFRP composites made from rPA6 from discarded fishing nets and recycled carbon fibres (rCF).

The system boundaries of the study included A1-A5 stages for the manufacture of CFRP in all scenarios, C2-C4 and D stages when recycled materials were used (Scenarios 1 and 2). The system covers the consumption of materials, energy, chemicals, and transportation during the operational phases. The environmental impact of the construction and dismantling stages was excluded, as it was considered negligible compared to the manufacturing phases. Additionally, system boundaries were expanded to account for avoided processing from recovered products, which could replace primary products (**Figure 11**).

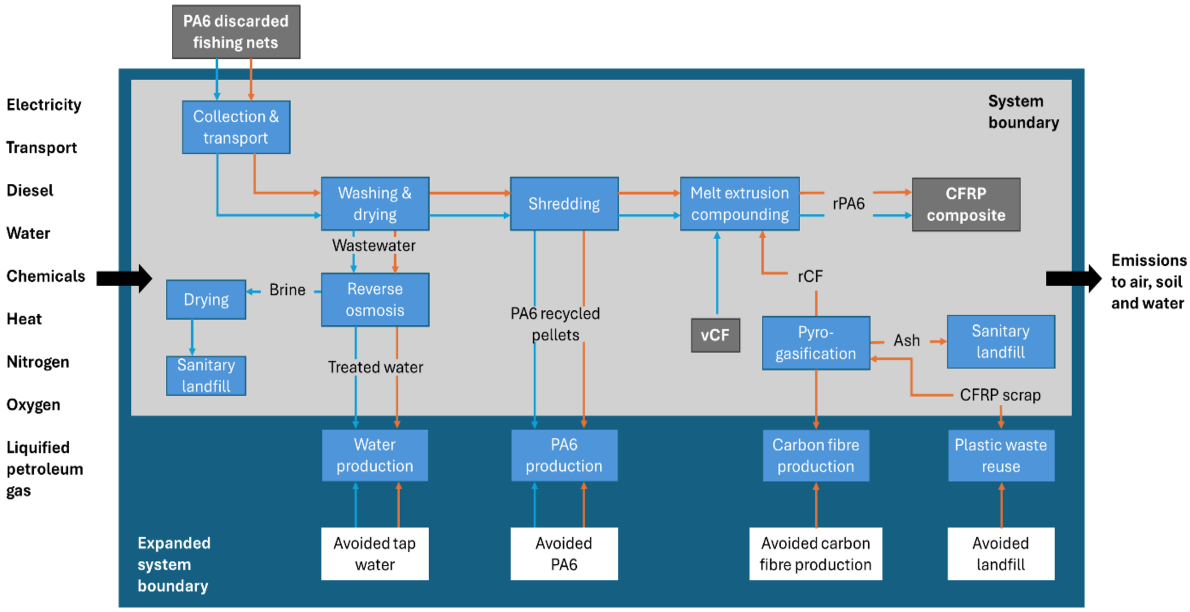

Figure 11: System boundaries of the life cycle assessment for producing carbon fibre reinforced polymer (CFRP) from two different scenarios: scenario 1 (orange arrows): recycled PA6 fishing nets (rPA6) and recycled carbon fibre (rCF); scenario 2 (blue arrows): rPA6 and virgin carbon fibre (vCF) (Pasciucco et al., 2025).

Case study 6: "3D printing to enable the reuse of marine plastic waste with reduced environmental impacts".

Cañado et al., (2022) aimed to compare the environmental impacts of the production and EOL of a 3D printed product used in the marine industry (i.e., a needle for mending nets) in Spain. The primary objective was to compare the impacts of utilising various plastic components and different end-of-life pathways. To that end, five scenarios were studied:

- **Scenario 1 (PA-Petrol):** petroleum-based polyamide (PA-66) as the raw material. Landfill and incineration as EOL scenarios.

- **Scenario 2 (PA-NETS):** marine plastic waste composed of PA-66 as the raw material. Landfill and incineration as EOL scenarios.

- **Scenario 3 (PA-Bio):** bio-based polyamide (PA-66) derived from castor oil as raw material. Landfill deposition as EOL scenario.

- **Scenario 4 (PLA):** polylactic acid (PLA) as raw material. Landfill deposition and composting as EOL, since this plastic material is biocompatible and biodegradable.

- **Scenario 5 (PHB):** polyhydroxybutyrate (PHB) as raw material. Composting as EOL scenario, since PHB can be readily degraded in marine environments.

The processes and materials flow for each scenario are described in **Figure 12.** In scenario 2 (PA-NETS), C2-C4 and D stages are included for the waste treatment and recycling of fishing nets. Then, A1-A5 stages cover the 3D printing of the new product, and C1-C4 stages cover the end of life of the 3D printed product. It is essential to note that, of all the plastic waste collected, only fishing nets are utilised. For scenarios 1 and 3 to 5, only A1-A5 and C1-C4 stages are covered for the production and end of life of the 3D printed product, respectively.

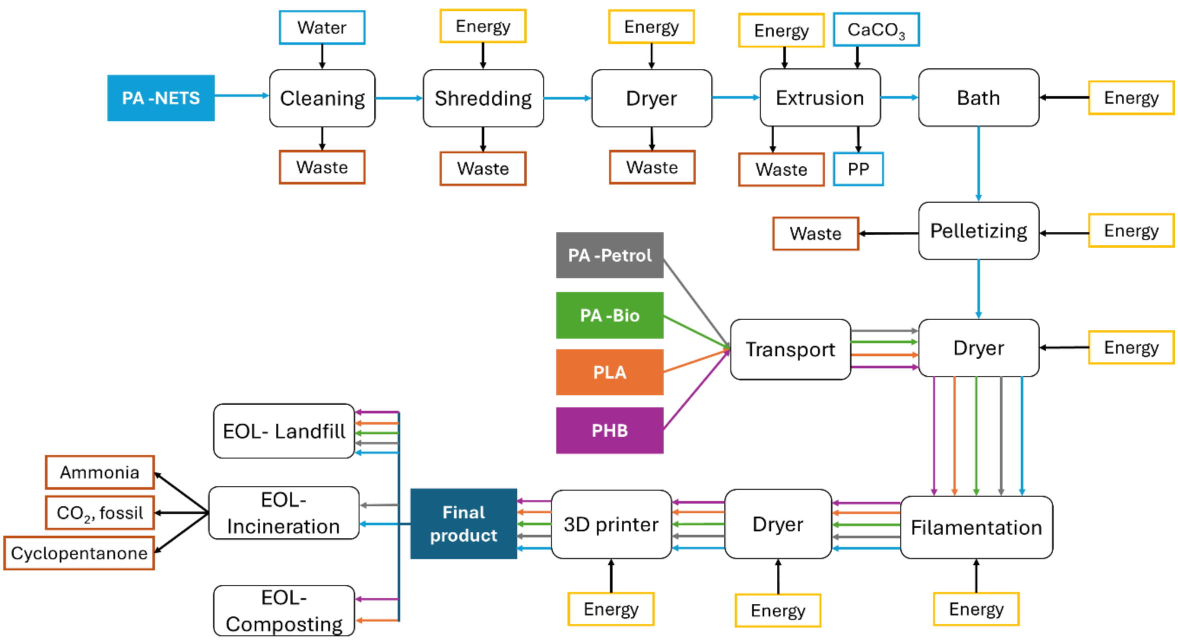

Figure 12: System boundaries of the life cycle assessment of the production and EOL of 3D printed needles for mending nets in Spain using different raw materials (Cañado et al., 2022). Scenario 1 (blue arrows): uses marine plastic waste polyamide ; scenario 2 (grey arrows): uses petroleum-based polyamide; scenario 3 (green arrows): uses bio-based polyamide; scenario 4 (orange arrows): uses polylactic acid; scenario 5 (purple arrows): uses polyhydroxybutyrate; PA: polyamide; PLA: polylactic acid; PHB: polyhydroxybutyrate; PP: polypropylene; EOL: end of life. Rounded boxes are processes, and squared boxes are materials.

Case study 7: “Environmental product declaration for EOCNYL ® NTF texturized yarns and cones”

Another case study assessed is the EPD of the ECONYL® raw white or black texturized nylon yarns and cones produced by Aquafil (Aquafil, 2024b).

The Aquafil Group is the world leader in the manufacture of carpet yarns and one of the leading suppliers of yarns, synthetic fibres, and polymers to Europe’s top clothing and design brands. They manufacture Nylon 6 fibres, Nylon 6.6 fibres, polymers and yarn. Their flagship product is ECONYL®, which is a chemical recycled textile yarn produced from EOL nylon fishing nets, old carpets and pre-consumer nylon six waste (Aquafil, 2024a).

The system boundaries of this EPD study cover C2-C4 and D stages for the recycling of waste nylon to PA6 granulates. Then, A1-A5 stages are covered to produce the ECONYL ® product. And finally, C1-C4 stages are fully covered for the end of life of ECONYL (**Figure 13**). The system includes upstream processes (i.e., waste pre-treatment, depolymerisation, and polymerisation processes), core processes (i.e., spinning and texturizing), and downstream processes (delivery and end of life). End-of-life disposal consists of 8% reuse, 10% recycling, 24.9% incineration, and 57.1% landfill. The use phase of the product is not included in the study.

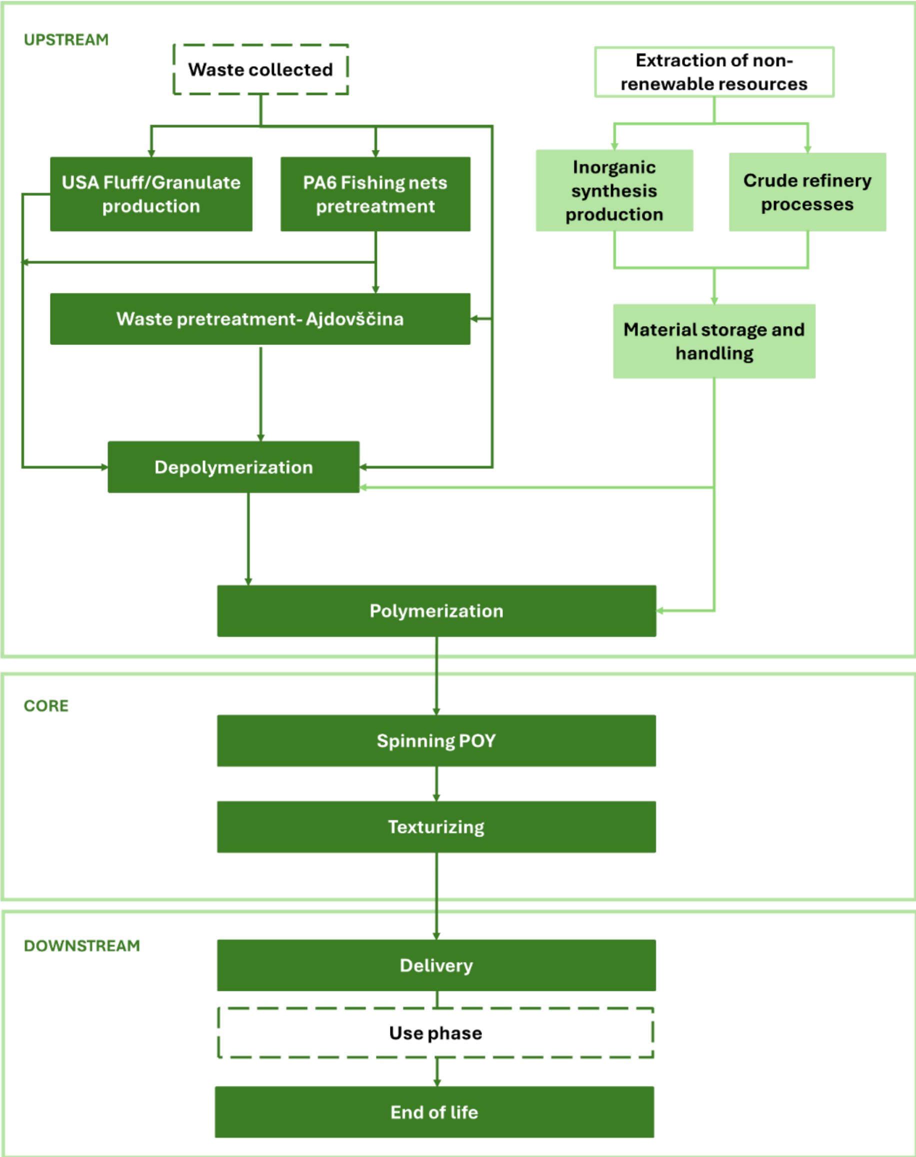

Figure 13: System boundaries of the Environmental Product Declaration (EPD) for the production of EOCNYL ® (Aquafil, 2024b). Dashed boxes: processes not included in EPD; dark green boxes: processes included in EPD; light green boxes: processes related to the production of auxiliary chemicals.

Case study 8: "Environmental impacts of synthetic fishing nets from manufacturing to disposal: A case study of Türkiye in life cycle perspective"

Karadurmuş & Bilgili, (2024) focused on evaluating the environmental impacts of fishing nets in Turkey from manufacturing to disposal. The system boundaries encompass stages A1-A5 for the manufacturing of the fishing nets, and C1-C4 stages, covering the EOL processes (**Figure 14**). Once fishing nets have reached the end of their economic life (i.e., maintenance/repair costs exceed the cost of manufacturing a new net). The study assessed two EOL scenarios: incineration (scenario 1) and recycling (scenario 2). Recycling refers to replacing virgin plastics (i.e., the raw materials of the nets) with recycled plastics. The use phase of the product is not included in the system.

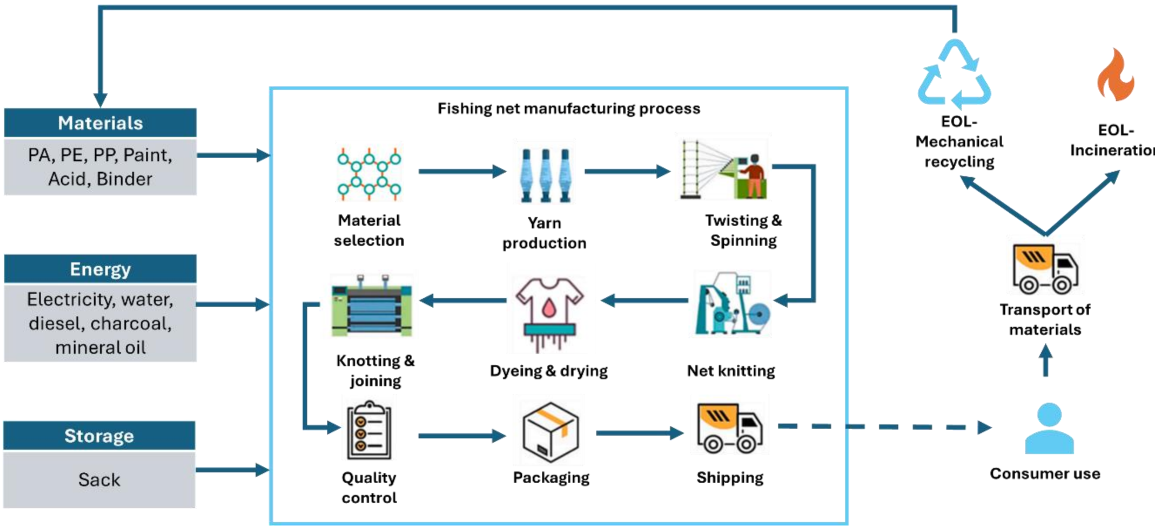

Figure 14: Material flow of fishing net manufacturing process and disposal (Karadurmuş & Bilgili, 2024). PA: polyamide; PP: polypropylene; PE: polyethylene; EOL: end of life. The Fishing net manufacturing process may vary depending on the raw material, net type, or the intended use of the product.

Summary box: all studies exclude the use phase of the product. Multiple scenarios are considered in nearly all cases to compare recycling to virgin material or disposal options. End-of-life treatment (recycling, incineration, landfill) is consistently included. Most studies cover at least stages C1–C4, with several expanding to A1–A5 or D where relevant Cañado et al.,(2022) for PA-NETS and Schneider, (2020) uniquely include D-stage for avoided burdens via system expansion. (Aquafil, (2024b), Karadurmuş & Bilgili, (2024), Pasciucco et al., (2025) and Storm, (2017) include A1–A5 stages, extending boundaries to raw material production. Canado and Pasciucco explore bioplastics and alternative materials, not just recycled vs. virgin.

3.4. Data quantity and quality

The quantity and quality of data in LCA models depend on the amount of primary data available and secondary data used. In all the studies gathered, primary data are used to model foreground processes, collected through interviews, questionnaires, or experimental trials. On the other hand, background data were modelled using database sources, where 63% of the studies used Ecoinvent databases, 38% used Gabi databases, and one study didn't specify the database used (Karadurmuş & Bilgili, 2024).

In the NOFIR, (2023) study, foreground processes are based on data from NOFIR's operational activities. This primary data was gathered through customised questionnaires throughout 2021 (1st of January 2021 - 31st of December 2021). In contrast, the alternative scenario (i.e., Virgin material scenario) was modelled using secondary data from the Ecoinvent database.

Schneider, (2020) used a combination of industrial experiments, company data and literature sources to model primary and secondary processes. The industrial experiments assessed the technical feasibility of recycling options for derelict fishing gear, focusing on pre-treatment, mechanical recycling and gasification. These experiments primarily collected data on material flow, process-specific energy consumption, and modelled the fate of chemical elements throughout the processes. Although no incineration or landfilling experiments were conducted, these processes were modelled theoretically to represent standard disposal techniques. Since some experimental processes were performed manually, adjustments were made to fairly compare them with large-scale industrial technologies. Company and literature data were used to fill gaps for ancillary materials and process emissions. Additionally, avoided production processes (i.e., steel, lead, electricity, heat and nylon production) and background processes (e.g., electricity generation) were modelled using the Ecoinvent 3.5 database.

Storm, (2017) did not give detailed information on the source of data used for foreground processes. The study only mentions that LCA calculations were conducted by Tomas Sander Poulsen as part of an EU co-funded project, Retrawl, under the Eco-Innovation Initiative of the European Union. However, all data for the virgin plastic production scenario were based on the Ecoinvent database, without any site-specific additions.

In Tippet, (2023), foreground data on upstream, core, and downstream processes was collected directly from the case company in 2020, using data collection sheets, meetings and interviews**.** Background data was sourced from the Gabi Sphera database.

Pasciucco et al., (2025) gathered foreground data using literature, experimental tests and commercial catalogues (for industrial machinery). Background data was retrieved from the Ecoinvent database version 3.10. Electricity consumption for industrial machinery, sourced from commercial catalogues, was estimated based on power requirement and operating hours.

In Cañado et al., (2022) study, primary data were directly collected from the Leartiker Company (production plant in Markina-Xemein, Biscay, Basque Country). All processes, inputs, and output measurements were taken in the laboratory and then used as a reference for defining the processes in the other scenarios. EOL scenarios were modelled using data from the Ecoinvent 3.7 and Gabi bioplastics 2019 databases.

Aquafil, (2024b) collected primary data from Aquafil Group's processes between January and December 2022. All the background data was sourced from Gabi database v. 2023.2.

Karadurmuş & Bilgili, (2024) data collection focused on raw material inputs, energy consumption, emissions, and waste generation at each stage of the production process. The study site for data collection was a major fishing net manufacturing factory in Türkiye. Field visits to the factory were done to obtain detailed documentation, including notes, photographs, and sketches, to accurately record the factory's production processes, equipment layouts, and operational flows. Additionally, official company records, such as accounting books, were utilised to gather historical data on raw material consumption, energy usage, and other relevant production metrics over a one-year period.

Summary box: All reviewed LCA studies gathered primary data for foreground processes via interviews, experiments, questionnaires, or company records. Secondary data for background processes was obtained from databases. Ecoinvent was the most used database (63%), followed by GaBi (38%). Overall, studies combined primary operational data with standard databases to model LCA processes, with varying levels of detail and transparency.

3.5. Allocation methods

Most of the reviewed studies (75%) do not apply allocation methods. This is likely because they focus on processes with one single input or output, where the functional unit is expressed as 1 unit weight of the product produced (e.g., plastic granules, new plastic product).

Karadurmuş & Bilgili, (2024) stated that, although fishing nets were the primary product analysed, it was not possible to operate allocation procedures due to data limitations. On the other hand, Schneider (2020) performed an attributional LCA with system expansion. This approach was applied due to the small quantities of retrieved derelict fishing gear, which do not significantly impact energy production or other background systems on a large scale. Allocation methods distribute environmental impacts across multiple inputs or outputs, often based on mass or economic value; however, avoiding allocation is generally recommended (ISO, 2018). An alternative approach to divide the unit process into sub-processes is by conducting a system expansion, which subtracts an alternative single in- or output process from the multi-functional system.

Among studies that applied allocation methods, NOFIR, (2023) used economic allocation for plant consumption processes (i.e., water and energy consumption, and waste management), based on each product's economic value and share in revenue in the reference year. However, allocation was not applied to data specific to each of the output flows (e.g., specific material or energy consumption, packaging materials, distribution scenarios), since these were already product-specific.

In the Aquafil, (2024b) study, the Life Cycle Analysis represents a broad range of similar products, by averaging primary data from products within the same group (i.e., ECONYL® NTF Texturized Yarns on cones), location, and time frame (i.e., 2022). In this study, the environmental impact of waste recycling processes is attributed to the product system that generates the waste. Therefore, they are not included in this LCA study. However, processes after the end-of-waste state are attributed to the product system using the recycled material flow (recycled materials are thereafter considered secondary materials).

3.6. Environmental impact assessment method

Regarding the environmental impact categories, many of the reviewed studies covered the most common impact categories (**Table 1**), as well as less commonly used ones.

All the reviewed studies included the Global Warming potential. Acidification potential was examined in seven studies, with four specifically referring to it as terrestrial acidification potential (APt) (Cañado et al., 2022; Karadurmuş & Bilgili, 2024; Schneider, 2020; Storm, 2017).

Eutrophication potential was included in 7 studies, with five analysing both freshwater and marine water eutrophication potential (Aquafil, 2024b; Cañado et al., 2022; Karadurmuş & Bilgili, 2024; Schneider, 2020; Storm, 2017).

Fossil depletion was another frequently studied impact category, appearing in 88% of the studies reviewed.

Regarding ecotoxicity impact categories, four studies included all subcategories, i.e., terrestrial, freshwater, and marine ecotoxicity (Cañado et al., 2022; Karadurmuş & Bilgili, 2024; Pasciucco et al., 2025; Schneider, 2020). However, Storm (2017) only included ETmw.

Photochemical ozone formation was included in 6 studies, where Cañado et al., (2022) and Karadurmuş & Bilgili, (2024) divided this impact category into ozone formation-terrestrial ecosystems (OF-te) and ozone formation-human health (OF-hh) impact categories.

Water depletion was present in 63% of the studies, while mineral depletion and stratospheric ozone depletion were included in 50% of them.

Human toxicity was examined in four studies, with Cañado et al. (2022) and Karadurmuş & Bilgili (2024) distinguishing between human cancerogenic toxicity (HCT) and human non-cancerogenic toxicity (HNCT).

Particulate matter formation (PMF), ionising radiation (IR), and land use (LU) had a lower representation, only present in 38% and 25% of the studies, respectively. Tippe (2023) included some of the less common impact categories, such as hazardous waste disposed (HWD), non-hazardous waste disposed (NHWD), total use of non-renewable primary energy resources (PENRT), and total use of renewable primary energy resources (PERT).

Summary box: Many of the reviewed studies covered common environmental impact categories, with all including GWP. Acidification and eutrophication potentials were addressed in seven studies, often distinguishing between subcategories. Fossil depletion appeared in 88% of studies. Water depletion, mineral depletion, and stratospheric ozone depletion were also frequently included. Ecotoxicity and human toxicity were analyzed in fewer studies, with some differentiating between cancer and non-cancer impacts. Less common categories, such as waste disposal and energy use, were included in one study.

3.7. Result interpretation

3.7.1. Impact contribution analysis

When it comes to interpreting the results, 63% of the reviewed studies performed a contribution analysis. **Error! Reference source not found.** presents, for each study, the r esults of the LCA analysis for the most relevant impact categories (i.e., GWP, APt, EP, POF, HT, ET, WD, MD, and FD), as well as the processes that contribute higher or lower impacts. Overall, comparing the reviewed studies is challenging due to the diversity of processes included and materials studied in each case study. However, to understand the environmental impacts of waste management practices for EOL fishing gear, this section will describe the main environmental hotspots from the reviewed studies, categorized under the following process categories: 1) Collection; 2) Pre-treatment; 3) Transport; 4) Mechanical recycling; 5)

Chemical recycling; 6) Incineration or Landfill; and 8) Other processes. A summary of this section can be found in **Table 2**.

Collection

Schneider, (2020) includes collection processes under the LCA analysis, referred to as the retrieval process. The retrieval scored the same relative impact contributions in all scenarios because it was carried out independently of the waste treatment pathway. It contributed most to GWP, APt, EPm, POF, and FD, mainly due to its preceding diesel production and process emissions.

Pre-treatment

In Schneider, (2020), the processes of sorting, shredding, washing and drying contributed less than 5% to any of the impact categories. The impact contributions from these processes were mostly related to electricity production. This study also included a density separation process to extract the desired nylon fraction from derelict fishing gear for mechanical recycling. This involved a two-stage manual sink-float separation, first removing higher-density materials, and then the lower-density ones. In the study, density separation was modelled as a two-stage process in scenario 1 and a one-stage process in scenario 3. In both scenarios, the density separation process contributed to the impact categories of HT, ETfw, and ETm. While for scenario 1, additional contributions were noted in the EPfw and ETt categories. The primary environmental burden associated with this process was linked to electricity production. While the sink-float separation method was effective, the manual process was highly inefficient, requiring 8-10 person-hours to separate 100 kg of material. Despite testing different sieves, efficiency improvements were not achieved, highlighting the need for automation in future density separation processes.

On the other hand, NOFIR, (2023) assessed the sustainability of the waste management activities for EOL fishing gear, focusing on sorting and pre-treatment activities performed at Nofir facilities. Nofir's system resulted in 2.51 kg CO_2 eq. kg^{-1}. Meanwhile, the alternative scenario (i.e., incineration of EOL fishing gear + virgin materials production) resulted in 8.10 kg CO_2 eq. kg^{-1}. It is estimated that 5.6 kg CO_2 eq. can be saved per kg of produced material in comparison to burning all the waste and generating new polymers out of fossil sources.

Pasciucco et al., (2025) examined the impact of sorting and pre-treating EOL fishing nets to produce 1 tonne of CFRP, a combination of recycled and virgin raw materials. When recycled PA6 was used, wastewater treatment from net washing was a major source of emissions, responsible for 48% and 77% of CO_2 emissions in scenarios 1 and 2, respectively. This process also had significant effects on the FD impact category, representing 42% and 84% of direct emissions in Scenario 1 and Scenario 2. Under the EP category, wastewater treatment from washing fishing nets resulted in 2.76 kg of PO_4 eq. Overall, wastewater treatment made a significant contribution to direct emissions in ecotoxicity impact categories. It made a greater contribution to photochemical oxidation potential than to acidification potential, although its impact was not as predominant as that of other environmental indicators.

Transport

The environmental impact of transport activities varies across studies, with some reporting high contributions from transport, while others show minimal emissions.

NOFIR, (2023) reported very low emissions from transport activities (0.09 kg CO_2 eq., 4% of the total).

In the Schneider, (2020) study, transport impacts mostly derive from direct emissions and diesel production and represent a significant contribution to GWP potential in scenarios 1 to 3 (209 kg CO_2-eq).

In Cañado et al (2022), transport primarily refers to the route from polymer production to the processing plant. When comparing PA-nets, PA-petrol and PA-bio scenarios to produce 3D printed net-mending needles, PA-nets showed the highest transport-related impacts across several categories (i.e., GWP, SOD, AP and EPm). For instance, in the GWP category, transport activities in PA-nets contributed 36% of the total impact, followed by PA-petrol (22.8%) and PA-bio (14.5%). A similar tendency was observed for terrestrial acidification, where PA-nets transport activities contributed 32.1%, followed by PA-petrol (17.3%) and PA-bio (12.7%). On the other hand, under the SOD and EPm categories, PA-nets had the highest transport impacts, followed by PA-bio and PA-petrol scenarios. PA-nets require additional waste processing steps (i.e., cleaning and shredding of the nets) before the conditioning processes (i.e., drying, filament formation, additional drying, and 3D printing). As a result, PA-nets materials must be transported to a processing plant prior to the conditioning, which could result in higher transport emissions.

Other studies also highlighted the importance of transport activities. Storm, (2017) claimed that the environmental impacts at Plastix A/S are mainly related to electricity and water use, landfill avoidance and transport activities. Internal transport was noted as an energy-consuming process. In Tippet, (2023), transport is also a key activity within a recycling company's production system. Upstream and downstream transport processes contributed about 30% to the GWP, with 55 and 57 kg CO_2-eq emissions, respectively.

In both Aquafil, (2024b) and Pasciucco et al., (2025) studies, transport processes were included within the system boundaries. However, emissions were not specified in the results. In comparison, Karadurmuş & Bilgili, (2024) excluded transport from the LCA analysis since it is a variable process.

Mechanical recycling

In Schneider (2020), the extrusion process significantly contributes to all impact categories except for mineral depletion, where emissions are mainly dominated by steel and lead recycling processes. For categories such as GWP, APt, EPm, POF, WD, and FD, avoided nylon production dominates the impact contribution, resulting in avoided emissions. On the other hand, within EPfw, ETfw, and ETm, the avoided benefits of nylon production are offset by emissions from electricity production.

Storm, (2017) analysed Plastix A/S activities, a recycling plant treating discarded fishing nets and trawls through separation, cutting, washing and extrusion to produce recycled plastics granulates. The LCA results showed that energy use, especially from non-renewable coal energy sources (23%), was the largest input in the recycling process. However, the recycling activities at Plastix A/S presented lower impacts compared to virgin plastic production, mainly due to lower electricity demand.

In the Tippet, (2023) study, core activities (i.e., segregation, granulation, packaging and storage) account for most of the environmental impacts. The upstream (i.e., transport of waste fishing/aquaculture rope) and downstream (i.e., shipping to customers) processes contributed a similar proportion to one another. On the other hand, core processes dominate impacts related to freshwater use, non-hazardous waste disposal, and renewable energy use. Overall, diesel production and consumption are key contributors across the life cycle of the entire product system, where 31 kg of diesel is required to produce 1,000 kg of PP/PE granulate, accounting for 74% of CO_2 emissions.

In Scenario 1 of the Pasciucco et al., (2025) study, the use of rPA6 from discarded fishing nets resulted in lower environmental impacts in 6 out of 11 impact categories, including GWP. Scenario 2 was the most sustainable option due to the use of both rPA6 and rCF to produce CFRP composites. Avoided impacts significantly exceeded the direct impacts generated by the system, notably reducing the total emissions across all environmental indicators. Overall, scenario comparison reveals how the introduction of recycled materials into the CFRP composite production chain has led to a progressive reduction in total emissions, highlighting the importance of a sustainable recovery of waste products.

In Cañado et al (2022), mechanical recycling processes are studied for the production of PA-nets (i.e., PA granulates from marine plastic waste as a feed material). The LCA results indicate that the use of PA-nets is environmentally preferable to virgin bioplastics, such as bio-based polyamide (bio-PA), PLA, or PHB. Specifically, GWP emissions were reduced by factors of 3.7 and 1.8-fold when compared to bio-based and virgin petroleum-based polyamides, respectively. Beyond the reduction in CO_2 eq. emission, using marine plastic waste as raw material, showed lower impacts in 11 of the 18 assessed categories. However, increases were observed in the categories of water depletion, urban land occupation, ionising radiation, and ozone depletion. In addition, for PA-NETs, electricity use was the primary driver of emissions in the GWP, APt, EPm, and SOD impact categories, accounting for 64% to 96% of the impacts. Overall, the findings suggest that using polyamide derived from marine plastic waste to produce 3D printed net-mending needles is the most sustainable option among the three evaluated alternatives.

Karadurmuş & Bilgil (2024) assessed the environmental impact of manufacturing fishing gear, along with two EOL methods: mechanical recycling and incineration. In this section, the manufacturing and mechanical recycling results will be presented. The net manufacturing process generates 8,309.8 kg CO_2 eq to global warming. This amount drops to 7,130.7 kg CO_2 eq when the recycling method is preferred, resulting in a 14% reduction. When it comes to other impact categories, the recycling scenario also reduced its emissions up to 49%. This demonstrates that recycling fishing nets provides significant environmental benefits, reducing not only CO_2 emissions but also all assessed categories. However, it is important to note that recycling has only a minor positive effect on human health and the ecosystem, as the manufacturing of nets remains the most significant contributor to overall impacts. The study reveals that fishing net manufacturing has a significant environmental footprint, primarily due to its reliance on plastic-based materials and fossil fuels in the production process. The primary material of the fishing net accounts for 87.23% of the total environmental impact, followed by electricity consumption (6.68%) and coal use (3.96%).

Chemical recycling

Chemical recycling was evaluated in two studies. Schneide (2020) assessed the environmental impact of gasification processes for recycling derelict fishing gear. The results showed that gasification contributed to nearly all impact categories, except for POF and APt. Most of the impacts derive from electricity production, although in the water depletion category, both electricity and nitrogen production contributed equally.

Aquafil (2024b) assessed the environmental performance of a chemical recycling process that involves depolymerisation to recycle nylon waste into new nylon products. Upstream processes (i.e., materials and energy input, transportation, depolymerisation and polymerisation) were the main contributors in 7 out of 10 impact categories, primarily due to the use of non-renewable energy sources and raw materials. These processes also had the highest net freshwater consumption and disposal of non-hazardous waste. In contrast, the GWP category was dominated by downstream processes (i.e., transportation to the average retailer and the End of Life of the product), resulting in 1,34 kg CO_2 eq, primarily due to the use of renewable energy sources. When it comes to ODP and MD categories, the core processes (i.e., manufacturing processes and the transportation of materials into these processes) contributed the most.

Incineration and Landfill

Three studies assessed the impact of incineration (with or without energy recovery) and landfill as EOL alternatives for fishing gear waste. Schneider, (2020) evaluated the impacts of incineration in two scenarios: a) scenario 1: Mechanical recycling to produce nylon; and b) scenario 3: Energy recovery to produce heat and electricity. In scenario 1, polymer residues from sorting and pre-treatment processes were incinerated with energy recovery. This resulted in avoided emissions for the EPfw, HT, ETt, ETfw, and ETm impact categories, due to the benefits of heat and energy production. In scenario 3, all derelict fishing gear was incinerated with energy recovery. Both direct and avoided emissions were observed for GWP and HT categories. While only avoided emissions are present in APt, EPfw, EPm, ETt, ETfw, Etm and FD categories. In GWP and FD, avoided heat production dominates the emissions, while avoided electricity production was the primary contributor in the other impact categories. Conversely, in scenario 3, process emissions and electricity production contribute notably to GWP and HT, respectively. Regarding the landfill process, apart from EPfw, it contributes to all impact categories. For EPm and HT the main contributions derive from landfill emissions, whereas the diesel production dominates emissions in the remaining impact categories.

Cañado et al., (2022)assessed the impacts of producing 3D printed net-mending needles from marine plastic waste with two EOL scenarios: landfill and incineration. The LCA results showed that incineration increased emissions in the GWP, APt, and EPm impact categories compared to landfilling. The other categories remained equal or experienced a slight increase when landfill was chosen as the end-of-life alternative.

Karadurmuş & Bilgili, (2024) assessed the effect of manufacturing of fishing gear nets with two EOL scenarios: incineration and mechanical recycling. The results showed that the GWP increases to 10,405.3 kg CO_2-eq in the case of incineration compared to the production emissions. Therefore, incineration caused a sharp increase, especially in the terrestrial ecotoxicity category.

Other processes

Schneider, (2020) evaluated the impacts of recycling the metal fraction (i.e., steel and lead) from the collected derelict fishing gear. Impacts from steel and lead recycling were the same in scenarios 1 to 3. Steel recycling notably benefited the MD category, while lead recycling reduced impacts in EPfw, HT, ETfw and ETm by avoiding primary production. However, steel recycling contributed to MD due to the use of pig iron, and the combined oxygen demand from steel and lead recycling affected the WD category.

Table 2: Summary table of key environmental hot spots per process category from the reviewed LCA studies.

Process	Impact hot spots*	Avoided impact hot spots**	Main impact categories affected
Collection	Diesel use, process emissions	n.r.	GWP, APt, EPm, POF, FD
Sorting & Pre-treatment	Wastewater treatment, electricity production	n.r.	GWP, FD, SOD, ET
Transport	Process emissions, diesel production, distances	n.r.	GWP, SOD, EPm, APt
Mechanical recycling	Electricity production, energy use	Avoided primary production	GWP, APt, EPm, FD, WD
Chemical recycling	Electricity production, process emissions, raw materials	n.r.	GWP, MD, WD, HT
Incineration	Process emissions, electricity production	Avoided energy/heat production from energy recovery	GWP, ET, EPm
Landfill	Process emissions, diesel production	n.r.	EPm, HT, GWP
Metal recycling	Pig iron use (steel), oxygen demand	Avoided primary production	MD, EPfw, HT, ETfw, ETm

Abbreviations: **GWP,** Global warming potential**; APt,** Acidification potential**; EPm,** Marine eutrophication potential**; POF,** Photochemical ozone formation**; SOD,** Stratospheric Ozone depletion**; ET,** Ecotoxicity**; ETfw,** Freshwater ecotoxicity**; ETm,** Marine ecotoxicity**; HT,** Human toxicity**; FD,** Fossil depletion**; WD,** Water depletion**; n.r.;** not relevant.

Notes: * Impact hot spots: processes resulting in positive value emissions; ** Avoided impact hot spots: processes resulting in negative value emissions.

3.7.2. Sensitivity analysis

Sensitivity analysis was performed in 75% of the reviewed studies (**Error! Reference source not found.**). This analysis is used to determine how changes in selected input parameters affect the overall results. In this section, the sensitivity analysis results of the reviewed studies are described:

Schneider, (2020) performed a sensitivity analysis to examine how variations in waste composition, energy mix, transport distances, and avoided production processes affect the environmental impacts of different waste treatment scenarios for DFG (**Figure 15, Annex 2**).

- **Waste composition:** the mixed DFG in the baseline scenario (i.e., 50% gillnets and 50% trawl nets) was adjusted to 100% trawl net or 100% gillnet streams to assess if both waste streams result in the same optimal waste treatment approach. The use of lead and the amount used (13.5% in gillnets, 0% in trawl nets) had a significant influence on the outcomes. Gillnets performed better in recycling due to avoiding lead production, while trawl nets lost credits. However, in the landfill scenario, gill nets had higher toxicity impacts (i.e., human toxicity), while trawl nets outperformed mechanical recycling in categories like EPfw and toxicity-related impact categories.

- **Energy mix:** To evaluate the impact of a greener energy mix, the 2017 German energy mix was updated to a 2030 version with more wind (19.3% → 43%) and less lignite (24.5% → 10.3%). This shift is notable in the syngas production scenario, which has a high electricity demand, resulting in significant fluctuations over the EPfw and the toxicity-related impact categories. In this scenario, increased wind power led to higher metal depletion, freshwater and marine ecotoxicity impacts, but reduced burdens in the other impact categories. Energy recovery, as a net electricity producer, experienced reduced environmental credits. While syngas performed better relative to energy recovery, the overall scenario rankings remained unchanged.

- **Transport distances:** Transport distances were modelled for best- and worst-case scenarios. The best-case scenario involved local pre-treatment and shorter transport (20–250 km), while the worst-case scenario involved transporting untreated, wet DFG to a sorting facility in Eastern Europe, 1,300 km away from the harbour, compared to 500 km in the baseline scenario. Overall, transport changes had a minimal impact. Shorter distances slightly improved outcomes without altering rankings, while longer distances increased impacts for recycling and energy recovery, allowing landfills to move up to second-best in terms of terrestrial ecotoxicity and climate change, due to narrow performance margins.

- **Avoided production processes:** to assess the impact of avoided production assumptions, best- and worst-case scenarios were modelled using varying substitution rates for syngas (100–312%), nylon (81–100%), electricity (33–233%), and heat (0–72%). These variations significantly impacted climate change, eutrophication, and toxicity. While best-case assumptions did not change the scenario rankings, worst-case modelling allowed landfill to move from third to second-best in terms of climate change and terrestrial ecotoxicity. However, the differences were minor and not significant overall.

In the Tippet, (2023) study, transport was a major contributor to emissions in both upstream and downstream activities within a recycling company's operations. The sensitivity analysis examined how adjusting the % of load utilisation of a Euro 6 truck trailer (27 tonne payload) affected CO_2 emissions. Results showed that CO_2 emissions were highly sensitive at low utilisation rates but stabilised at around 55% utilisation (**Figure 16, Annex 2**).

Cañado et al (2022) identified electricity as a significant impact driver in the PA-NET life cycle, particularly in the EOL landfill scenario. Therefore, a sensitivity analysis was developed by varying the origin of the energy source: a) high to medium voltage electricity (Spain) and b) photovoltaic electricity from certified rooftop panels (global), both for producing 1 kg of processed material by 3D printing. Results reveal that the selection of the energy source has a significant impact on environmental outcomes, with variations of 50% or more, highlighting the critical role of energy origin in impact assessments (**Table 9, Annex 2**).

Karadurmuş & Bilgil (2024) applied a sensitivity analysis using the 20-year results of the ReCiPe 2016 method to assess short-term impacts, as the standard calculations use a 100-year timeframe. The results showed an increase in global warming potential, while categories such as ionising radiation, stratospheric ozone depletion, and ozone formation remained constant. Additionally, toxicity impacts dropped sharply. The increase in the global warming effect can be linked to the persistence of greenhouse gases, such as nitrous oxide, which have a higher GWP impact and do not dissipate quickly in the atmosphere. On the other hand, a drop in toxicity reflects the gradual disappearance of toxic substances over time.

In Pasciucco et al. (2025), wastewater treatment from PA6 fishing net washing was considered a key aspect, as it is associated with high environmental emissions and is affected by many uncertainties. Therefore, a sensitivity analysis was conducted to assess how transport distances (i.e., 50 km, 100 km, 150 km, 200 km, and 250 km) and wastewater treatment at an industrial wastewater treatment plant (WWTP) could alter the environmental impacts. The results (**Figure 17, Annex 2**) showed that at 100 km, Scenario 2 was always the best option, while Scenario 1 outperformed Scenario 0 in the same impact categories. However, changes made in the sensitivity analysis generally led to an increase in the environmental impacts. Compared to the default LCA scenario using reverse osmosis treatment, the use of industrial WWTP disposal increased environmental impacts in 8 out of 11 indicators (**Table 10, Annex 2**), primarily due to transport emissions, which accounted for over 50% of the total emissions. Nonetheless, using WWTP led to environmental benefits in important categories, such as FD, GWP, and OLDP, which are mainly affected by energy and chemical consumption. The quantity of wastewater to be treated and WWTP distances were found to be critical decision planning aspects. In view of this, further distances of the WWTP were considered to investigate how the results change with different transport distances (**Table 10, Annex 2**). At 50 km, WWTP disposal improved 9 out of 11 impact categories, whereas, beyond 150 km, on-site reverse osmosis was preferred in all impact categories. When examining the percentage differences in environmental impacts generated by the alternative scenarios, although polluting emissions increased with higher distances, scenario 2 remained the best solution in 9 out of 11 categories. This highlights how recycling activities improve the environmental sustainability of the entire process.

Summary box: a sensitivity analysis was conducted in 75% of the reviewed studies. Scheneider, (2020) evaluated the effects of waste composition, energy mix, transport distances, and avoided production. Results showed significant impacts from lead content, energy sources, and substitution rates, with minimal influence from transport.

Tippet, (2023) found CO_2 emissions highly sensitive to truck utilization, with emissions dropping significantly at > 55% load efficiency.

Cañado et al., (2022) demonstrated that energy source choice could alter impacts by over 50%, emphasizing electricity's role in 3D printing processes.

Karadurmuş & Bilgili, (2024) used a shorter 20-year ReCiPe timeframe, which increased GWP but decreased toxicity due to time-dependent pollutant behaviour.

Pasciucco et al., (2025) analysed wastewater treatment options, revealing WWTP disposal outperformed reverse osmosis at short distances (<150 km), though transport emissions became dominant at longer ranges.

Overall, energy source, transport, and treatment method were key drivers of variability.

Table 3: Life Cycle Assessment results from the reviewed studies.

Study	**Treatment**	**LCA results[1]**												**High impact processes**	**Low impact processes**	**Sensitivity analysis**
		GWP	AP	EPfw	EPm	POF	HT	ETt	ETfw	Etm	WD	MD	FD			
Fishing gear manufacture + end of life																
(Karadurmuş & Bilgil, 2024)	Production fishing nets	8,310.8	24.1	1.7	1.6	**OF-hh:** 14.5 **OF-te:** 15.0	**HCT:** 238.2 **HNCT:** 2,135.7	3,935	79.4	107.4	181.7	17.3	2,392	Fishing net production	Mineral oil and PP	Yes
	Production fishing nets + incineration	10,405.3	24.4	1.9	1.6	**OF-hh:** 14.9 **OF-te:** 15.5	**HCT:** 251.7 **HNCT:** 3,350.7	10,498	225.9	318.6	181.9	17.7	2,414			
	Production fishing nets + recycling	7130.7	21.7	1.6	1.6	**OF-hh:** 12.7 **OF-te:** 13.0	**HCT:** 205.0 **HNCT:** 1,796.9	2,445	54.1	74.8	167.4	14.8	1,210			
Fishing gear waste management (collection/pre-treatment/ recycling)																
(NOFIR, 2023)	Dismantling and sorting of fishing gear waste	2.51	--	--	--	--	--	--	--	--	--	--	--	Packaging and recycling	Electricity and heat production	No
	Virgin material production + Incineration	8.1	--	--	--	--	--	--	--	--	--	--	--	Virgin input and waste treatment	Electricity and heat production	
(Scheneider et al., 2023)[2]	Mechanical recycling	-559	14.6	0.008	-1.46	33.4	-216	0.11	-9.23	-7.8	-66.8	-130	-209	Retrieval	Extrusion	Yes
	Chemical recycling	2,714	24.7	1.15	1.91	40.9	394	0.45	18.0	17.0	16.5	-118	874	Retrieval and gasification	rest <5%	
	Incineration with energy recovery	2,140	22.8	-0.292	1.46	40.0	-456	-0.04	-17.6	-15.9	5.91	-134	526	Retrieval and rest <5%	Incineration	
	Landfill	2,274	28.9	0.110	2.52	44.0	510	0.11	5.35	4.66	8.77	28.10	1,730	landfill	rest <5%	

(Storm, 2017)[3]	Mechanical recycling PE nets	(0.354) 0.032	0.037	0.268	0.007	0.02	--	--	--	0.30	--	--	0.06	Electricity and water use, landfill avoidance and transport activities	n.s.	No
	Mechanical recycling PP nets	(0.376) 0.034	0.04	0.284	0.008	0.02	--	--	--	0.32	--	--	0.07			
	Mechanical recycling PA nets	(0.456) 0.041	0.045	0.359	0.009	0.02	--	--	--	0.38	--	--	0.08			
	PE virgin production	(2.008) 0.179	0.18	0.092	0.015	0.16	--	--	--	0.25	--	--	1.041	n.s.	n.s.	
	PP virgin production	(2.052) 0.183	0.18	0.181	0.018	0.15	--	--	--	0.24	--	--	1.028			
	PA virgin production	(9.352) 0.834	0.82	0.540	0.345	0.51	--	--	--	0.77	--	--	1.624			
Tippet, 2023)	Mechanical recycling PP/PE fishing gear	184	2.17	2.27	--	--	--	--	--	--	2.69	2 E-05	2,249	Core processes	Upstream and downstream processes	Yes
Manufacture of recycled products																
(Pasciucco et al., 2025)[2]	Production of CFRP composites (vPA6 + vCF)	13,700	44.9	17.5	n.r	2.26	17,800	130.0	3,680	1.05 E+07	--	0.07	2.03 E+05	vPA6 and vCF production	Melt extrusion and compounding	Yes
	Production of CFRP composites (rPA6 + vCF)	4,230	1.5	10.5	n.r	0.53	28,300	186	5,970	1.67 E+07	--	-0.03	1.10 E+05	vCF production	Avoided vPA6 production	
	Production of CFRP composites (rPA6 +rCF)	-5,740	-32.1	-13.6	n.r	-0.89	-3,180	-33.6	-355	-9.43 E+05	--	-0.06	-9.77 E+04	Wastewater treatment	avoided vPA6 and vCF production	
Cañado, 2022)	Production of PA-Petrol + Landfill	28.2	0.11	0.004	0.001	**OF-hh:** 0.04 **OF-te:** 0.04	**HCT:** 0.48 **HNCT:** 3.75	15.5	0.16	0.22	0.29	0.01	2.39	Polymer production	n.s.	Yes
	Production of PA-Petrol	30.8	2.05	0.004	0.001	**OF-hh:** 0.03 **OF-te:** 0.03	**HCT:** 0.48 **HNCT:** 3.40	13.7	0.16	0.22	0.28	0.01	2.39	n.s.	n.s.	

	+ Incineration															
	Production of PA-NETS +Landfill	14.7	0.08	0.004	4.45 E-04	**OF-hh:** 0.04 **OF-te:** 0.04	**HCT:** 0.52 **HNCT:** 4.00	10.4	0.18	0.24	0.07	0.01	2.52	Electricity	n.s.	
	Production of PA-NETS +Incineration	17.0	2.02	0.004	3.49 E-04	**OF-hh:** 0.03 **OF-te:** 0.03	**HCT:** 0.52 **HNCT:** 3.65	8.61	0.18	0.24	0.07	0.01	2.52	n.s.	n.s.	
	Production of PLA + Landfill	24.0	0.12	0.003	7.15 E-04	**OF-hh:** 0.06 **OF-te:** 0.06	**HCT:** 0.49 **HNCT:** 4.44	18.3	0.16	0.23	0.08	0.02	2.40	Polymer production	n.s.	
	Production of PLA + Compost	18.2	0.09	0.003	4.94 E-04	**OF-hh:** 0.05 **OF-te:** 0.05	**HCT:** 0.49 **HNCT:** 4.08	15.5	0.16	0.23	0.07	0.01	2.40	n.s.	n.s.	
	Production of PHB + Compost	71.2	0.19	0.013	0.001	**OF-hh:** 0.11 **OF-te:** 0.11	**HCT:** 1.97 **HNCT:** 14.5	35.1	0.74	1.00	-0.93	0.05	10.0	n.s.	n.s.	
(Aquafil, 2024b)	Upstream processes	0.749	0.007	3,16 E-05	0.003	0.005	--	--	--	--	0.86	2,66 E-07	7,17	Upstream processes	Downstream processes	Yes
	Core processes	0.245	0.002	2,54 E-05	1,20 E-03	0.001	--	--	--	--	0.43	2,85 E-07	3,08			
	Downstream processes	1.34	0.001	7,87 E-06	1,02 E-03	0.002	--	--	--	--	0.06	3,65 E-09	1,28			
	Total	2.34	0.01	6.49 E-05	0.005	0.008	--	--	--	--	1.35	5.55 E-07	11.5			

Abbreviations: **GWP**, Global Warming Potential; **AP**, Acidification Potential; **EPfw**, Freshwater Eutrophication Potential; **EPm**, Marine Eutrophication Potential; **POF**, Photochemical ozone formation; **OF -hh**, Ozone formation-human health; **OF-te**, Ozone formation-terrestrial; **HT**, Human toxicity; **HCT**, Human carcinogenic toxicity; **HNCT,** Human non-carcinogenic toxicity; **ETt**, Terrestrial ecotoxicity; **ETfw**, Freshwater ecotoxicity; **Etm**, Marine ecotoxicity; **WD**, Water depletion; **MD**, Depletion of abiotic resources – minerals/metals depletion; **FD**, Depletion of abiotic resources – fossil fuels depletion; **PA**, Polyamide/nylon; **PE**, Polyethylene; **PP**, Polypropylene; **PLA**, Polylactic acid; **PHB**, Polyhydroxybutyrate; **CFRP**, Carbon fibre reinforced polymer ;**vPA6**, Virgin polyamide 6 ;**rPA6**, Recycled polyamide 6; **vCF**, Virgin carbon fibres; **rCF**, Recycled carbon fibres; **n.s.**, not specified.

Notes:

1) Impact categories units: GWP, kg CO_2-eqkg; AP, SO_2 -eq; EPfw, kg PO_4-eq; EPm, Kg N-eq; POF, kg NMVOC-eq; HT, 1,4-DB-eq; ETt, 1,4-DB-eq; ETfw, 1,4-DB-eq; ETm, 1,4-DB-eq; WD, m^3; MD, kg Sb-eq; FD, MJ or net calorific value
2) Negative values refer to avoided emissions.
3) Impact categories' values are normalised to a European citizen person equivalent. GWP is also expressed as kg CO_2-eq (value in brackets)

4

ANALYSIS: ENVIRONMENTAL IMPACTS OF END-OF-LIFE FISHING GEAR WASTE MANAGEMENT

4. Analysis: environmental impacts of end-of-life fishing gear waste management

4.1. Environmental impact analysis

4.1.1. Collection and transport

When assessing the environmental impact of EOL fishing gear treatment, the impacts from collection and transport activities were primarily driven by diesel use, which is directly attributable to the distances covered. Longer distances result in higher fuel consumption, thus increasing the associated environmental impacts. In most of the reviewed studies(Aquafil, 2024b; Cañado et al., 2022; Karadurmuş & Bilgili, 2024; Pasciucco et al., 2025; Storm, 2017; Tippet, 2023), collection activities had relatively low impacts. However, Schneide (2020) reported substantial environmental impacts associated with DFG retrieval campaigns conducted at sea. Although such retrievals offer significant benefits to the marine ecosystem, they also generate high emissions because recovering DFG form the sea often involves single-purpose trips with low recovery volumes. Schneider (2020) suggested that to decrease the retrieval impact and improve recovery efficiency, single journeys could be combined into multi-destination trips by using side-scan sonars. This technology has already been tested in several EU countries (e.g., Germany, Poland, France and Mediterranean states) through initiatives led by the Worldwide Fund and Keep the Estonian Seas Tidy.

Under EU law, member state authorities are responsible for maintaining healthy marine ecosystems. One notable initiative aiding ALDFG recovery from the oceans is the Fishing for Litter project, launched by KIMO International in 2004. This project aims to reduce marine litter by engaging with the fishing industry. Volunteer fishers are provided with bags to collect debris caught in their nets during regular fishing activities, which is then brought to ports for recycling and disposal. The initiative cleans the ocean, raises awareness of marine litter and promotes better waste practices among fishers (KIMO, 2025). Recognised as a best practice by the European Commission, UNEP, and OSPAR, it has been successfully implemented in 15 European countries, including partner countries Ireland and Norway.

On the other hand, transports impacts presented high variability between the studies reviewed, with low and high impact contribution. This could be attributed to case-specific peculiarities, such as the distances covered from the collection points to the treatment plants or other transport activities along the value chain. The sensitivity analysis performed by Schneider, (2020) showed minimal impacts when transport distances to the recycling facilities varied. However, Tippet, (2023) results from the sensitivity analysis suggested that increasing load truck utilisation from 10% to 70% could reduce greenhouse gas emissions by nearly five times, highlighting the importance of maximising load efficiency in transport-focused operations.

4.1.2. Sorting and pre-treatment

Sorting and pre-treatment impact mainly stem from wastewater treatment and electricity use. These activities generally had a low impact contribution in the reviewed studies (NOFIR, 2023; Schneider, 2020). However, Pasciucco et al (2025) found that when recycled PA6 from fishing nets is used to produce new recycled products, wastewater treatment makes a significant contribution across impact categories. Effective sorting and cleaning of waste plastic is essential to avoid contamination in the final product. Therefore, the waste composition and quality of EOL fishing gear materials play an important role in this step, since the higher the quality, the lower the pre-treatment effort required.

Pasciucco et al (2025) evaluated the potential of reverse osmosis for wastewater treatment, which showed notable environmental impacts, particularly due to the use of chemicals. To enhance the sustainability of on-site water recovery, natural coagulants like chitosan have been proposed as an eco-friendly alternative to conventional coagulants in wastewater treatment. While promising, their effectiveness depends on several factors, such as the working pH value and the type of contaminants. Therefore, they should be tested accordingly before their application (Ang et al., 2016).

Overall, collection, transport, sorting, and pre-treatment processes contributed minimally in most studies, a trend also observed in broader plastic recycling research (Biganzoli et al., 2015; Faraca et al., 2019; Wäger & Hischier, 2015). These findings may support the exclusion of these processes in future LCAs. However, such decisions should be made cautiously, as LCAs are highly case-specific.

4.1.3. Waste treatment techniques.

After the sorting and pre-treatment processes, EOL fishing gear waste can be processed under different waste management methods, including mechanical recycling, chemical recycling, incineration (with or without energy recovery) and landfill.

Mechanical recycling

Mechanical recycling is the most common and sustainable method for processing plastic waste. All the reviewed studies agree that mechanical recycling of fishing gear and marine plastic waste offers notable environmental benefits, reducing GWP emissions among other categories, and potentially replaces the use of virgin plastic. However, despite its advantages, mechanical recycling does not eliminate all environmental impacts. Energy use and recycled products manufacturing remain significant impact contributors and are areas for improvement.

In addition, mechanical recycling presents low effectiveness and recovery rates. Challenges in sorting plastics into pure, single-polymer streams, combined with a lack of adequate collection and sorting infrastructure, result in many plastic waste streams remaining mixed. Consequently, the final recycled product has compromised physical properties, such as reduced tensile strength, which limits its application and leads to a process known as downcycling. For instance, recycled PET bottles are often turned into polymer fibres instead of new plastic bottles due to concerns about food safety and material quality (Davidson et al., 2021). These limitations are also evident when recycling EOL fishing gear. In Schneide (2020), the recovered DFG pellets contained rubber and heavy metals, including a lead content of 358 ppm in washed gillnet fibres, which exceeded the EU limit of 100 ppm for packaging materials (Directive 94/62/EC). Compared to virgin B35 nylon, recycled DFG pellets showed reduced strength, ductility, stiffness and toughness, with only tensile strength remaining competitive.

Even with improved sorting, full recovery of virgin-like properties is unlikely. Although the material recovery rate was high (98.2%), Schneider (2020) recommends using a more realistic substitution factor of 81% to account for quality loss. In addition, not all plastics are suitable for mechanical recycling. Thermoset plastics cannot be recycled, as their chemical structure prevents melting, and complex materials like plastic films or laminated composites are difficult to sort and process (Hopewell et al., 2009).

Chemical recycling

Chemical recycling is currently the least used method for plastic waste management due to its early development stage, limited infrastructure, and high costs compared to virgin plastic production. However, it is gaining attention as a promising solution for handling plastics that cannot be mechanically recycled and would otherwise end up in landfills or incinerated (Plastics Europe, 2020).

Also known as *feedstock recycling*, chemical recycling produces outputs similar to those from virgin fossil fuels, making them suitable replacements in industrial applications. This could help reduce dependence on non-renewable resources while offering a recovery route for difficult-to-recycle plastics (Davidson et al., 2021).

Assessments of the environmental performance of chemical recycling indicate that these processes are generally energy-intensive, with electricity consumption, particularly from non-renewable sources, being a major contributor to several environmental burdens (Aquafil, 2024b; Schneider, 2020). However, the magnitude and nature of these impacts differ across technologies and life cycle stages.

On the other hand, chemical recycling also faces criticism due to several environmental and technical concerns. One major issue is the need to add chemical or mineral substances to recovered monomers and polymers to meet reuse performance standards. On the other hand, thermal conversion processes can generate hazardous pollutants and toxic waste, which pose serious risks if not properly managed (NRDC, 2022; Ocean Conservancy, 2022). However, this can be influenced by product design and by introducing certain restrictions on the use of materials (e.g., banning the inclusion of brominated or chlorinated components in additives/fillers).

Klotz et al., (2024) examined the potential of chemical and solvent-based recycling to improve plastic waste management within a circular economy, using LCA approaches to quantify environmental impacts. As mentioned before, chemical recycling processes work by breaking down polymer chains, either through thermal methods or with the help of chemical catalysts. In contrast, solvent-based (dissolution) processes largely preserve the structure of polymer chains but share some features with mechanical recycling. These solvent-based methods can remove additives from the polymer matrix or separate individual plastic types from multilayer structures, thereby changing the chemical composition of the plastic feedstock. The study found that combining these methods with mechanical recycling can reduce the impacts of climate change by up to 40% compared to thermal treatment with energy recovery. Depolymerisation and dissolution exhibit the greatest environmental benefits due to their high output quality and effective contaminant removal, whereas gasification and pyrolysis perform less well due to higher energy demands.

Overall, mechanical recycling is preferred due to its lower energy demand. However, it is limited by the need for clean and homogeneous plastic waste. Chemical recycling, on the other hand, can process mixed or contaminated plastics that are unsuitable for mechanical recycling, thereby complementing existing recycling efforts (Klotz et al., 2024). Expanding both recycling approaches while reducing landfill and incineration can reduce reliance on virgin fossil fuels and provide valuable petrochemical feedstocks for the chemical industry (Davidson et al., 2021). Increasing research into practical and robust plastic waste management systems, particularly chemical recycling methods, is essential for future solutions and the implementation of EOL fishing gear recycling schemes.

Incineration

Based on the literature review, incineration has both positive and negative environmental impacts. Three of the reviewed studies indicate that incinerating EOL fishing gear increases emissions in key impact categories such as GWP, AP and EP (Cañado et al., 2022; Karadurmuş & Bilgili, 2024; Schneider, 2020). However, Schneider, (2020) also found that energy recovery from incineration can reduce carbon emissions by replacing fossil fuels used for heat and electricity production. Nevertheless, its benefit depends on the type of energy displaced. If the displaced energy derives from renewable, carbon-neutral sources, incineration may lead to higher emissions (Eriksson & Finnveden, 2009).

In addition, co-incinerating unwanted fishing gear can release toxic pollutants (e.g., dioxins, furans and metal compounds). In particular, some fishing gear containing high levels of polyvinyl chloride can generate substantial chlorine gas emissions. As such, it poses serious environmental and health risks (Frosch & Gallopoulos, 1989; UN Environment, 2019; Verma et al., 2016). As a result, strict emissions control, such as that under the EU Waste Incineration Directive (2000/76/EC), is necessary. From a circular economy perspective, incineration cannot be considered a circular technology, as it destroys plastic waste, removing it from the value chain and requiring virgin plastic to replace it (Davidson et al., 2021).

Landfill

Landfilling is the most widely used method for plastic waste disposal and has traditionally been applied to EOL fishing gear waste due to its material complexity (Davidson et al., 2021; Schneider, 2020).

When adequately sealed, landfills can have positive impacts by acting as a ‘carbon sink’ for plastic waste, trapping carbon in plastics that would otherwise be released as CO_2 through incineration. However, storing plastic in landfills removes it from the production cycle, which conflicts with the circular economy principles that promote reuse and recycling (Davidson et al., 2021). In contrast, poorly managed landfills contribute significantly to environmental pollution. At least 14 million tonnes of plastic are dumped into the ocean annually, accounting for approximately 80% of all marine debris (IUCN 2024). Additionally, large plastic debris can damage infrastructure, for instance, by blocking drainage systems. In comparison, smaller fragments break down into microplastics and nanoplastics, which in turn lead to further impacts on ecosystems (Davidson et al., 2021).

The reviewed studies identify landfilling as one of the most polluting waste management methods, primarily due to process emissions and the use of diesel. For instance, in Schneider's study, landfilling showed the highest impacts across categories, including APt, EPm, HT, POF, MD, and FD, compared to other waste management processes (i.e., mechanical recycling, chemical recycling, and incineration).

4.1.4. Other processes

Besides the waste treatment methods previously discussed, processes like metal recycling of fishing gear components can significantly influence the overall environmental performance of EOL fishing gear waste management.

Among the studies reviewed, only Schneider, (2020) evaluated the environmental impact of metal recycling. In this study, lead and steel recycling were identified as major contributors to mineral resource depletion, alongside other processes such as gasification, landfill and retrieval. However, the recycling of steel and lead resulted in substantial avoided impacts, primarily due to the environmental benefits of avoiding primary steel and lead production. These results indicate that, beyond plastics, recycling the metal fractions in EOL fishing gear can also enhance the environmental sustainability of waste management strategies.

4.2. Recommendations for the establishment of sustainable collection and recycling schemes

4.2.1. Fishing gear design

Fishing gear is designed to withstand marine and aquatic conditions, ensure durability, functionality, and a long service life. To comply with these design considerations, fishing gear is typically manufactured with high-strength materials, including a wide variety of plastic polymers, often braided or twisted to enhance the strength of nets and ropes. Metals, wood and natural fibres are also present in many fishing gear equipment (Salla & Richardson, 2023). The material complexity of this equipment composition can pose difficulties for its recycling, resulting in most EOL fishing gear ending up in landfills or being incinerated. The information gaps and limited publicly available design information can significantly hinder the recyclability of fishing gear, as recyclers are unable to identify the materials present in it. To promote more sustainable and transparent fishing gear designs, several recommendations can be made (**Table 4**).

Table 4: Fishing gear design recommendations.

Recommendation	Description
Standardise material use	Minimising the number of mixed polymers used and labelling single polymers with identification tags, digital product passports, QR codes, etc, to document the type and mix of materials used in each product
Incorporate design-for-recycling principles	Fishing gear designers and manufacturers should, wherever possible, exclude the use of non-recyclable materials and components that are frequently lost at sea. They can also avoid the use of hazardous polymers or other components (e.g., additives, fillers, etc) that hinder recycling or pose environmental and health risks. Furthermore, efforts should be made to simplify gear design, manufacture and assembly to make disassembly and recycling more efficient.
Build industry-wide databases	Develop centralised databases with anonymised or aggregated information about commonly used fishing gear materials and their recycling requirements. Support collaboration among manufacturers, recyclers, and researchers to regularly update these databases.
Promote the inclusion of biodegradable materials and	Designs that combine recyclable synthetics (e.g., PE, PP, PA) with biodegradable materials (e.g., PLA, PHA) can strike a balance between performance and sustainability if the components are separable. The inclusion of PLA in fishing gear design has been

easy-to-recycle materials	explored by the PE.S.PLA project for the development of sustainable artisanal gear (Blue Life Hub, 2025). On the other hand, the Virginia Institute of Marine Science (VIMS) has developed escape panels for crab, lobster, and fish traps made from PHA to reduce the long-term impact of lost gear (Virginia Institute of Marine Science, n.d.).
Encourage training and capacity Building	Provide training on eco-design and sustainable materials for fishing gear manufacturers and designers. Develop toolkits and design guides tailored for the fishing gear sector, including case studies and best practices.
Increased research and innovation	Invest in R&D for the development of recyclable materials suitable for marine use with properties comparable to those of virgin materials, thereby encouraging their adoption by the fishing industry.
National and regional policies	Regulatory frameworks can promote recyclable fishing gear design. Under the SUP Directive, the EU has requested the European Committee for Standardisation (CEN) to develop circular design standards, resulting in the EN 17988 series (Nov 2024), which provides guidelines to facilitate the repair, reuse, and recycling of EOL fishing gear. This aims to support more sustainable industry practices (European Commission, 2025a).

4.2.2. Collection and transport

To prevent the mismanagement of EOL fishing gear and ALDFG and avoid marine pollution, the collection of this waste stream and its transport to waste treatment facilities are crucial. Overall, how these activities are approached is specific to each region's peculiarities, influenced by the collection campaigns in place, available collection points, transport routes to treatment facilities, and other factors. However, these aspects also influence the environmental performance of such activities. For instance, the location of the waste management infrastructure is a crucial technical consideration in fishing gear recycling, as it influences logistics and resources for delivering unwanted gear to the recycling facility, and can impact the environmental emissions associated with transport activities. To promote effective and sustainable collection and transport practices for EOL fishing gear waste management, the following recommendations are set (**Table 5**).

Table 5: Collection and transport activities recommendations

Recommendation	Description
Expand and support port-	Scale up "Fishing for Litter" type initiatives to encourage voluntary collection by fishers during regular operations.

based collection programmes	
Standardise port facilities	Ensure that ports are equipped to receive, sort, and store retrieved gear for proper recycling or disposal.
Separate collection of EOL fishing gear and ALDFG	Recyclable, clean fishing gear made from a single type of plastic should be collected and transported separately from mixed or lower-quality gear. The latter often requires additional processing and may need different recycling methods.
Improve transport efficiency	This can be done through different strategies: **1.** Maximising the truck utilisation (e.g., from 10% to 70%) to significantly cut emissions per unit of gear transported. **2.** Transport routes can be consolidated by developing group shipments to reduce the number of trips between ports and recycling plants. **3.** Other transport modes should be considered, such as rail or sea transport for longer distances, to reduce carbon emissions.
Promote cross-sector collaboration	Coordinate logistics with other sectors (e.g., aquaculture, shipping, domestic plastic waste management facilities) to share infrastructure and reduce redundancy. Develop public-private partnerships that support the engagement of municipalities, NGOs, fishing cooperatives, and recyclers to streamline the collection and recycling of fishing gear.
Monitor and adapt	Track emissions and volumes by implementing reporting systems to monitor the environmental impact and gear recovery rates. Apply GIS and fleet management tools to optimise dynamic collection and transport scheduling.
Policy and funding support	Encourage EU Member States to develop action plans in line with their responsibilities under the EU marine ecosystem. Access EU funding mechanisms (e.g., EMFAF, Horizon Europe) to support innovation in sustainable retrieval and transport.

4.2.3. Sorting and pre-treatment

Sorting and pre-treatment are crucial steps in the recycling of EOL fishing gear, as they can affect the quality of recycled products and the overall efficiency of the process. Although their environmental impact is generally low, mainly attributed to electricity use and wastewater treatment, some cases reveal notable concerns. For instance, when recycling PA6 from fishing nets, wastewater treatment emerged as a significant environmental burden, especially when energy and chemical-intensive methods are used. Additionally, the quality and composition of the collected gear significantly impact the level of pre-treatment required. Cleaner, single-polymer materials reduce contamination risk and need less intensive processing. Exploring more sustainable options, such as natural coagulants for wastewater treatment, looks promising. However, their effectiveness depends on specific conditions and must be carefully tested before use. Therefore, addressing these concerns is key to improving he environmental sustainability and scalability of fishing gear recycling. The following recommendations aim to support more efficient and eco-friendly sorting and pre-treatment practices (**Table 6**).

Table 6: Sorting and pre-treatment activities recommendations.

Recommendation	Description
Prioritise high-quality input materials	Promote the sorting of clean, single-polymer gear (e.g., PA6) from mixed or contaminated waste to reduce the need for intensive pre-treatment. Train fishers, port staff and collection centres to identify and separate high-quality gear for recycling.
Improve sorting and cleaning efficiency	Invest in the development and application of automated sorting tools and technologies, such as optical systems, which can detect and identify different types of plastic polymers and their colours. Additionally, promote dry-cleaning or low-water-use methods to reduce water and chemical consumption.
Minimise the environmental impact of wastewater treatment	This can be achieved by optimising water recovery systems, such as closed-loop water systems, to reduce wastewater generation during cleaning and avoid high-impact treatment options (e.g., reverse osmosis). Pilot the use of chitosan or other biodegradable coagulants to reduce the environmental impact of wastewater treatment.
Adopt tailored and sustainable strategies	Choose cleaning and sorting methods based on the gear's composition and contaminant load, ensuring optimal performance.
Mix of centralised and decentralised sorting	A combination of centralised and decentralised waste management is recommended for managing unwanted fishing gear to ensure efficient and cost-effective processing. To minimise transport activities and emissions, gear could be collected at the port's facilities, where fishermen and port staff can perform early separation, ensuring that single-polymer gear is kept apart from mixed or low-quality material, which may require more complex recycling methods. Basic pre-processing, including removing metal components and rocks, should be done near the harbour. Afterwards, pre-sorted materials can be transported to centralised sorting facilities, which can handle large volumes more efficiently and consistently.
Promote research and standardisation	Support R&D on low-impact sorting and pre-treatment technologies designed explicitly for plastics from fishing gear. Develop best practice guidelines for pre-treatment activities that strike a balance between effectiveness and environmental performance.
Integrate sorting and pre-	Encourage manufacturers to use materials and designs that simplify separation and reduce contamination. Align sorting and pre-treatment

treatment with upstream practices	needs with how gear is collected and stored to streamline the recycling chain.

4.2.4. Waste management techniques.

Waste management of EOL fishing gear poses significant environmental and operational challenges. Traditionally reliant on landfilling and incineration due to the complex composition of fishing gear materials, these practices conflict with the goals of a circular economy. Landfilling, although sometimes viewed as a carbon sink, removes plastics from the value chain and often results in pollution. In comparison, the use of incineration, even with energy recovery, produces harmful emissions (e.g., greenhouse gases, persistent organic pollutants, and heavy metals) and destroys reusable materials. Mechanical recycling is widely recognised as the most sustainable option, but is limited by issues such as material contamination, material degradation, and sorting inefficiencies. Chemical recycling offers potential for treating non-recyclable plastics but remains energy-intensive, costly, and has notable environmental impacts. These concerns highlight the urgent need for more efficient, cleaner, and scalable waste management solutions that prioritise material recovery, pollution prevention, and long-term circularity. Although the EPR directive does not address the recycling of EOL fishing gear materials, advancing a circular blue economy requires understanding how to efficiently treat these waste streams and the environmental impacts of the different waste management methods. Therefore, a set of recommendations is presented to improve the sustainability performance of waste management techniques (**Table 7**).

Table 7: Waste management techniques recommendations

Recommendation	Description
Prioritise mechanical recycling where feasible	Support infrastructure and sorting technologies to improve the separation of clean, single-polymer materials, increasing the quality and yield of recycled products. Downcycling risks can also be addressed by investing in techniques that preserve mechanical properties and minimise contamination (e.g., pre-treatment, metal removal). Establish realistic substitution factors (e.g., 81%) in policy and reporting to reflect actual material quality and ensure transparency accurately.
Limit landfilling and improve controls	Discourage landfill use through policy disincentives and economic instruments, especially for recyclable gear. Landfilling should remain a last resort for non-recyclable, contaminated waste only. If landfilling

	can be avoided, enhance landfill management to mitigate leaching, microplastic release, and methane emissions associated with diesel-powered operations.
Limit incineration and improve controls	Limit incineration to non-recyclable residues and only under strict emissions control measures (e.g., the EU Waste Incineration Directive). Prioritise incineration with energy recovery. Avoid co-incineration of materials with high chlorine content or heavy metals, as this poses risks of dioxin formation and toxic emissions.
Expand and improve chemical recycling capacity	Invest in pilot projects and infrastructure for chemical recycling (e.g., depolymerisation, dissolution) of plastics that are unsuitable for mechanical recycling. Prioritise innovative and sustainable technologies, such as solvent-based methods. Ensure adherence to strict environmental and safety regulations for handling toxic by-products and meeting high energy demands. Promote hybrid recycling strategies (mechanical + chemical) to expand circularity and reduce climate impacts.
Support innovation in recycling technologies	Fund further research into innovative recycling and treatment technologies for complex gear materials. Promote pilot programs to test recycling solutions for specific gear types and use the results to inform better design standards.
Support policy involvement	Align waste treatment policies with EU circular economy goals, discouraging destructive disposal methods.

5

CONCLUSIONS

5. Conclusions

The management of EOL fishing gear waste presents complex environmental, logistical, and technological challenges. However, strategic improvements across the collection, transport, sorting, pre-treatment, and treatment stages can enhance sustainability outcomes and align with the goals of a blue circular economy. The conclusions obtained from analysing the environmental impact of EOL fishing gear waste treatment are as follows:

1. **Collection and Transport**
   a) The main environmental drivers for collection and transport activities are related to process emissions, diesel production, and the distances covered.
   b) Collection and transport activities have a low environmental impact, but these can vary widely depending on trip distances and vehicle utilisation.
   c) Optimising transport routes, load efficiency, and integrating with other sectors (e.g., aquaculture or shipping) can significantly reduce greenhouse gas emissions.
   d) Initiatives such as "Fishing for Litter" demonstrate effective, low-impact recovery practices and should be expanded and supported through policy and funding mechanisms.

2. **Sorting and Pre-Treatment**
   a) While typically low in environmental burden, the impacts of sorting and pre-treatment rely on electricity production and wastewater treatment processes for the pre-treatment of EOL fishing gear material.
   b) Emissions of these processes can increase significantly with contaminated or complex waste inputs.
   c) Clean, single-polymer gear should be prioritised to minimise the need for intensive processing.
   d) The adoption of eco-friendly wastewater treatment methods, such as natural coagulants, and investment in automated sorting technologies can further enhance environmental outcomes.

3. **Waste Management Techniques**
   a) **Mechanical recycling** appears to be the most sustainable option, offering significant environmental benefits by reducing emissions and minimising the use of virgin plastic. Despite presenting environmental benefits, mechanical recycling also generates

environmental emissions associated with electricity production and energy use. In addition, this recycling treatment is limited by the complexity and contamination of materials, often resulting in downcycling.

b) **Chemical recycling** offers a complementary pathway for handling non-recyclable or contaminated plastics, although it remains energy-intensive, costly, and infrastructure-limited. Hybrid systems that integrate mechanical and chemical recycling can substantially reduce climate impacts. Emissions from this process are primarily attributed to electricity production, process emissions, and the raw materials used.

c) **Incineration** and **landfilling**, although still in use, should be minimised due to their high environmental impacts from process emissions and energy use, as well as their conflict with circular economy principles. Incineration should be used only with energy recovery and stringent emissions standards, while landfilling should be the last resort.

4. **Material and Design Considerations**

a) The complex material composition of fishing gear significantly hinders recycling efforts. Standardisation of materials, adoption of eco-design principles, and transparency through labelling or digital passports are critical to improving recyclability.

b) Biodegradable and easily recyclable materials should be explored and incorporated where feasible, supported by regulatory standards and industry-wide databases.

5. **Policy and Innovation Needs**

a) Strong policy frameworks, aligned with EU circular economy goals, are essential to discourage destructive disposal methods and support the development of sustainable alternatives.

b) Continuous investment in research, pilot projects, and infrastructure development, particularly for chemical recycling and advanced sorting, is necessary to close knowledge gaps and scale solutions.

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Annex 1: Literature review results

Table 8: Reviewed Life cycle assessment studies on fishing gear waste treatment.

Study	Location	Material	Processes studied	LCA stages	Functional unit	Methodology	Impact categories	Software	Document
(NOFIR, 2023)	Norway and Lithuania	Secondary EOL fishing gear (PA6, PA66, PE, PP)	Collection, transport, dismantling, recycling	C1- C3	1 kg of secondary material ready to be delivered to the next user	n.s.	GWP	SimaPro 9.4.0.2	Report
		Virgin material production (PA6, PA66, PE, PP)	Virgin material production , incineration (with energy recovery)	A1-A3 and C1-C4	1kg of virgin material production	n.s.	GWP	SimaPro 9.4.0.2	
(Schneider, 2020)	Germany	Derelict fishing gear (gill nets and trawl nets including PP, PE and PA)	Retrieval, sorting, mechanical recycling, gasification, incineration, landfill	C1-C4 and D	1 tonne of derelict fishing gear	ReCiPe 2008 1.12	GWP, APt, EPfw, EPm,POF,HT,ETt, ETfw,ETmw, WD, MD, FD	SimaPro 8.3.0.0	PhD thesis

(Storm, 2017)	Denmark	HDPE-waste trawl nets PP-waste trawl nets PA6- waste trawl nets	Collection, sorting, mechanical recycling, transport to customer	C1-C4 and D	1 tonne of produced plastic granulates output of the three materials	n.s.	GWP, APt, EPfw, EPm, POF,PMF, ETmw, FD	SimaPro 8.2	Report
		HDPE-virgin plastic PP- virgin plastic PA6- virgin plastic	Virgin plastic production, transport to customer	A1- A4	1 tonne of produced plastic granulates output of the three materials	n.s.	GWP, APt, EPfw, EPm, POF,PMF, ETmw, FD	SimaPro 8.2	
(Tippet, 2023)	Norway	Waste PP/PE fishing and aquaculture ropes	Transport, Dismantling, sorting, mechanical recycling, packaging and storage	C1-C4	1 tonne of recycled PP/PE granulate from waste fishing/aquaculture rope	CML 2001	GWP, AP, EP, MD, FD, WD, HWD, NHWD, PENRT, PERT	Gabi ts	Article
(Pasciucco et al., 2025)	Italy	Virgin PA6 and virgin carbon fibres	Virgin plastic production, virgin carbon fibre production, carbon Fibers Reinforced	A1-A5	1 tonne of CFRP composites (consisting of 85 wt% PA6 and 15 wt% carbon fibre)	CML-IA 9.6.	GWP, AP, EP, HT, ETt, ETfw, ETmw, POF, MD, FD, SOD	Simapro	Article

			Polymers (CFRP) manufacture						
		Recycled PA6 from fishing nets and virgin carbon fibres	Collection, transport, PA6 mechanical recycling, virgin carbon fibre production , CFRP manufacturing	A1-A5, C2-C4 and D	1 tonne of CFRP composites (consisting of 85 wt% PA6 and 15 wt% carbon fibre)	CML-IA 9.6.	GWP, AP, EP, HT, ETt, ETfw, ETmw, POF, MD, FD, SOD	Simapro	
		Recycled PA6 from fishing nets and recycled carbon fibres	Collection, transport, PA6 mechanical recycling, carbon fibre chemical recycling, CFRP manufacturing	A1-A5, C2-C4 and D	1 tonne of CFRP composites (consisting of 85 wt% PA6 and 15 wt% carbon fibre)	CML-IA 9.6.	GWP, AP, EP, HT, ETt, ETfw, ETmw, POF, MD, FD, SOD	Simapro	
(Cañado et al., 2022)	Spain	PA- 66-petrol	Transport, final product manufacturing, landfill, incineration	A1-A5, C1-C4	1kg of 3D printed material	ReCiPe	GWP, APt, EPfw, EPmw, PMF, HCT, HNCT, IR, LU, ETfw,ETmw, ETt, MD, OF-hh, OF-te, WD, SOD, FD	OpenLCA 1.10.3	Article

		PA-66-nets	Transport, mechanical recycling, product manufacturing, landfill, incineration	A1-A5, C1-C4	1kg of 3D printed material	ReCiPe	GWP, APt,EPfw, EPmw, PMF, HCT, HNCT, IR, LU, ETfw,ETmw, ETt, MD, OF-hh, OF-te, WD, SOD, FD	OpenLCA 1.10.3	
		PA-66-bio	Transport, product manufacturing, landfill	A1-A5, C1-C4	1kg of 3D printed material	ReCiPe	GWP, APt, EPfw, EPmw,PMF, HCT, HNCT, IR, LU, ETfw,ETmw, ETt, MD, OF-hh, OF-te, WD, SOD, FD	OpenLCA 1.10.3	
		PLA	Transport, product manufacturing, landfill, compost	A1-A5, C1-C4	1kg of 3D printed material	ReCiPe	GWP, APt, EPfw, EPmw,PMF, HCT, HNCT, IR, LU, ETfw,ETmw, ETt, MD, OF-hh, OF-te, WD, SOD, FD	OpenLCA 1.10.3	
		PHB	Transport, product	A1-A5, C1-C4	1kg of 3D printed material	ReCiPe	GWP, APt, EPfw, EPm,PMF, HCT, HNCT, IR, LU,	OpenLCA 1.10.3	

			manufacturing, landfill, compost				ETfw,ETmw, ETt, MD, OF-hh, OF-te, WD, SOD, FD		
(Aquafil, 2024b)	Slovenia and Croatia	ECONYL® Nylon Textile Filament yarns(100 % recycled PA6 Polymer from fishnets, carpet, oligomers and other waste)	Collection, transport, chemical recycling, product manufacture	A1-A5, C1-C4 and D	1 kg of ECONYL® NTF Texturized yarn on cones.	EF 3.1	GWP, AP, EPfw, EPmw, Ept, POF, SOD,MD, FD, WD	n.s.	Report
(Karadurmuş & Bilgili, 2024)	Turkey	Fishing net	Fishing nets manufacture, mechanical recycling, transport	A1-A5, C1-C4	1 tonne of fishing nets (89 % of PA, 0.06 % of PE, and 0.05 % of PP)	ReCiPe 2016	GWP, APt, EPfw, EPmw, PMF, HCT, HNCT, IR, LU, ETfw, ETmw, ETt, MD, OF-hh,OF-te, FD, WD, SOD	SimaPro 9.3.0.2	Article
		Fishing net	Fishing nets manufacture, incineration, transport	A1-A5, C1-C4	1 tonne of fishing nets (89 % of PA, 0.06 % of PE, and 0.05 % of PP)	ReCiPe 2016	GWP, APt, EPfw, EPmw, PMF, HCT, HNCT, IR, LU, ETfw, ETmw, ETt, MD, OF-	SimaPro 9.3.0.2	

							hh,OF-te, FD, WD, SOD		

Abbreviations:

GWP, Global Warming Potential; **AP**, Acidification Potential; **EPfw**, Freshwater Eutrophication Potential; **EPm**, Marine Eutrophication Potential; **POF**, Photochemical ozone formation; **HT**, Human toxicity; **ETt**, Terrestrial ecotoxicity; **ETfw**, Freshwater ecotoxicity; **Etm**, Marine ecotoxicity; **WD**, Water depletion; **MD**, Depletion of abiotic resources – minerals/metals depletion; **FD**, Depletion of abiotic resources – fossil fuels depletion; **SOD,** Stratospheric ozone depletion**; PMF,** Particulate matter formation**; HCT,** Human carcinogenic toxicity**; HNCT,** Human non-carcinogenic toxicity**; IR,** Ionising radiation **; LU,** Land use**; OF-hh,** Ozone formation-human health**; OF-te,** Ozone formation-terrestrial ecosystems**; HWD,** Hazardous waste disposal**; NHWD,** Non-hazardous waste disposal**; PENRT,** Total use of non-renewable primary energy resources **; PERT,** Total use of renewable

primary energy resources; **PA**, Nylon or polyamide; **PE**, Polyethylene; **PP**, Polypropylene; **HDPE,** High Density Poly Ethylene**; PLA**, Polylactic acid; **PHB**, Polyhydroxybutyrate; **CFRP**, carbon fibre reinforced polymer ;**vPA6**, virgin polyamide 6 ;**rPA6**, recycled polyamide 6; **vCF**, virgin carbon fibres; **rCF**, recycled carbon fibres; **n.r.**, not relevant; **n.s.**, not specified.

Annex 2: Sensitivity analysis results

Table 9: Sensitivity analysis results of Cañado et al., (2022) study for the scenario PA-NET with landfill as end-of-life treatment, varying the origin of energy used.

Indicator	a	b	Unit	Variation (%)
Fine particulate matter formation	2.88E-02	1.18E-02	kg PM2.5 eq	58.82
Fossil resource scarcity	2.52E+00	5.42E-01	kg oil eq	78.51
Freshwater ecotoxicity	1.77E-01	9.94E-01	kg 1.4-DCB	462.82
Freshwater eutrophication	3.62E-03	1.44E-03	kg P eq	60.38
Global warming	1.47E+01	7.45E+00	kg CO2 eq	49.27
Human carcinogenic toxicity	5.18E-01	4.07E-01	kg 1.4-DCB	21.37
Human non-carcinogenic toxicity	4.00E+00	6.63E+00	kg 1.4-DCB	65.76
Ionizing radiation	5.36E+00	3.63E-01	kBq Co-60 eq	93.23
Land use	1.91E-01	6.24E-02	m2a crop eq	67.36
Marine ecotoxicity	2.43E-01	1.25E+00	kg 1.4-DCB	416.66
Marine eutrophication	4.45E-04	2.59E-04	kg N eq	41.89
Mineral resource scarcity	1.37E-02	4.76E-02	kg Cu eq	246.87
Ozone formation. Human health	4.09E-02	1.70E-02	kg NOx eq	58.45
Ozone formation. Terrestrial ecosystems	4.11E-02	1.73E-02	kg NOx eq	57.94
Stratospheric ozone depletion	4.93E-06	1.69E-06	kg CFC11 eq	65.61
Terrestrial acidification	8.02E-02	3.42E-02	kg SO2 eq	57.40

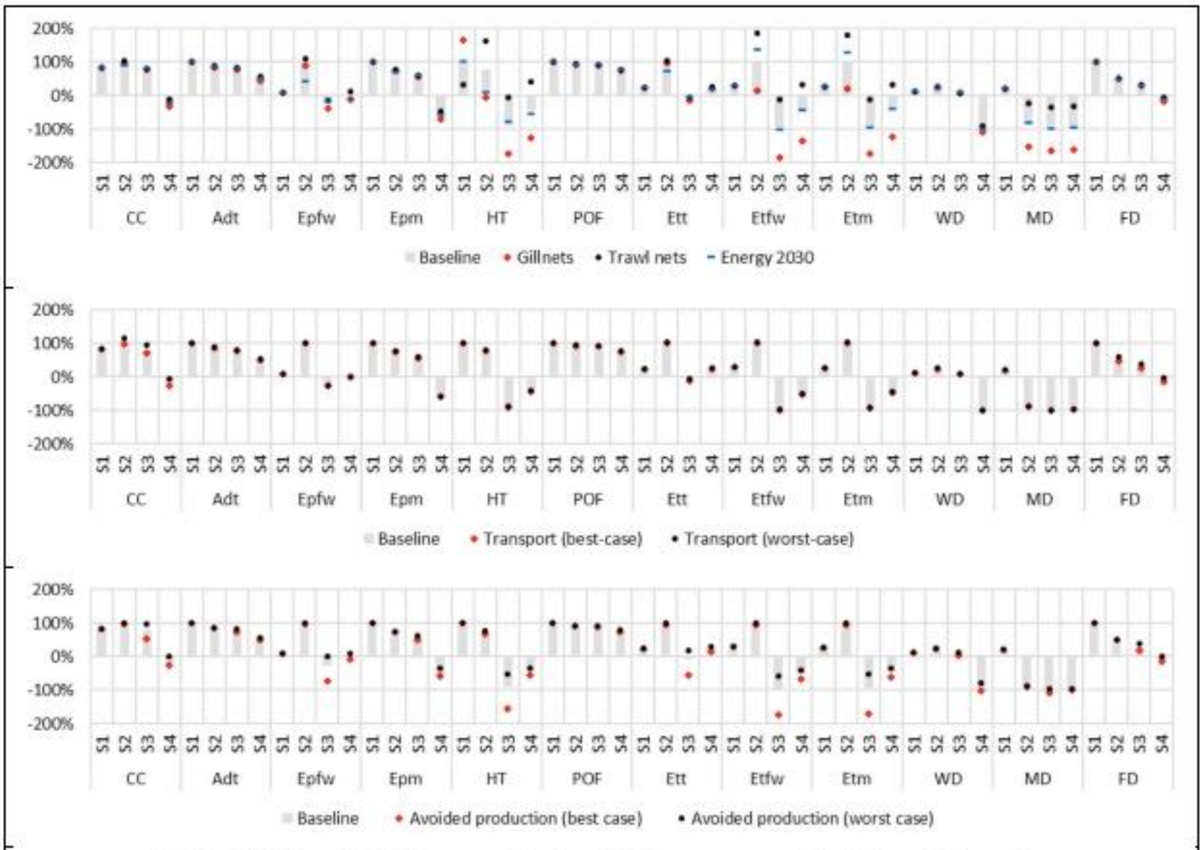
Terrestrial ecotoxicity	1.04E+01	4.36E+01	kg 1.4-DCB	319.28
Water consumption	7.22E-02	7.62E-02	m3	5.58

Notes: **a:** electricity voltage transformation from high to medium voltage | electricity, medium voltage | Cut-off, U – ES and **b:** electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted, label-certified | electricity, low voltage, label-certified | Cut-off, U – GLO, for 1 kg of processed material by 3D printing.

Table 10: Sensitivity analysis results of Pasciucco et al., (2025) study showing the percentage differences in the environmental impacts generated by the alternative scenarios (i.e., wastewater treatment plant disposal at different distances) compared to reverse osmosis treatment.

Impact category	50 km		100 km		150 km		200 km		250 km	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Abiotic depletion [kg Sb eq.]	7%	4%	31%	17%	56%	30%	81%	44%	106%	57%
Abiotic depletion (fossil fuels) [MJ]	-51%	-58%	-27%	-30%	-2%	-3%	22%	25%	47%	53%
Global warming [kg CO_2 eq.]	-83%	-62%	-36%	-27%	12%	9%	59%	44%	106%	79%
Ozone layer depletion [kg CFC-11 eq.]	-17%	-96%	-3%	-17%	11%	62%	24%	141%	38%	220%
Human toxicity [kg 1,4-DB eq.]	-4%	-38%	24%	210%	51%	457%	79%	705%	107%	952%
Freshwater aquatic ecotoxicity [kg 1,4-DB eq.]	-11%	-192%	5%	92%	22%	377%	39%	662%	56%	946%
Marine aquatic ecotoxicity [kg 1,4-DB eq.]	-15%	-271%	3%	47%	21%	366%	39%	684%	57%	1003%
Terrestrial ecotoxicity [kg 1,4-DB eq.]	46%	253%	73%	405%	101%	556%	128%	708%	155%	860%
Photochemical oxidation [kg C_2H_4 eq.]	-43%	-26%	9%	5%	61%	37%	114%	69%	166%	100%
Acidification [kg SO_2 eq.]	-126%	-6%	94%	4%	315%	15%	536%	25%	756%	35%
Eutrophication [kg PO_4 eq.]	43%	33%	52%	40%	61%	47%	71%	54%	80%	62%

Notes: **S1:** scenario 1- CFRP composites made from recycled PA6 (rPA6) from discarded fishing nets and vCF; **S2:** scenario 2- CFRP composites made from rPA6 from discarded fishing nets and recycled carbon fibres (rCF).



S1- Landfill disposal; S2- Syngas production; S3- Energy recovery; S4- Mechanical recycling

CC- Climate change, AP_t - Terrestrial acidification, EP_{fw} - Freshwater eutrophication, EP_m - Marine eutrophication, HT - Human toxicity, POF - Photochemical oxidant formation, ET_t - Terrestrial ecotoxicity, ET_{fw} - Freshwater ecotoxicity, ET_m - Marine ecotoxicity, WD - Water depletion, MD - Metal depletion, FD - Fossil depletion

Figure 15: Sensitivity analysis results for the waste composition, energy mix, transport distances and avoided production processes compared to the baseline scenario results. From Schneider, (2020).

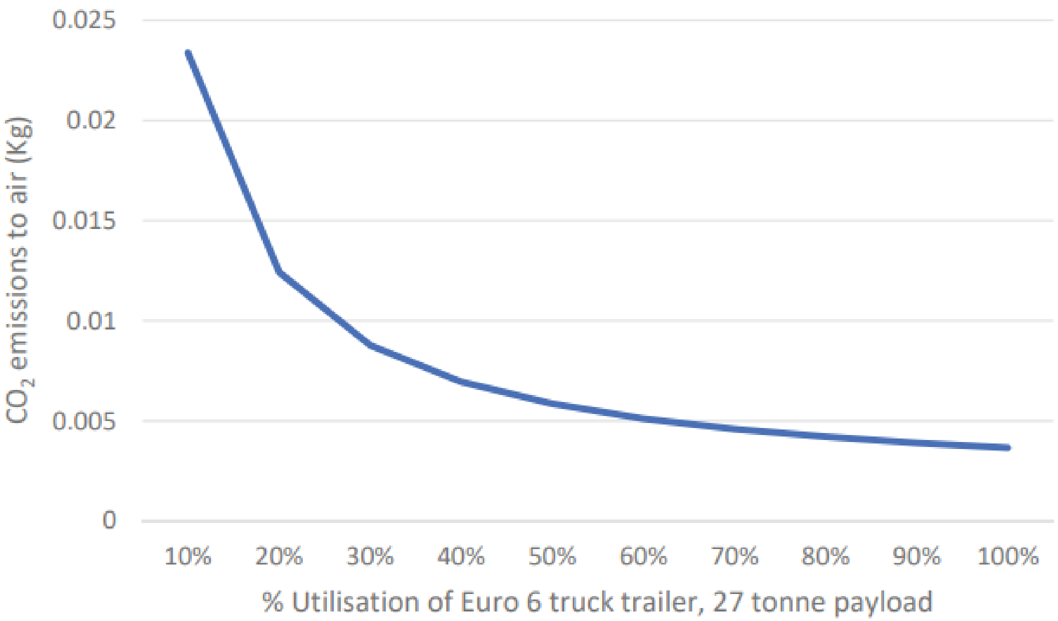


Figure 16: Effects of variation in % utilisation of Euro 6 truck trailer (27 tonne payload) data set on CO_2 emissions to air (kg). From Tippet, (2023)

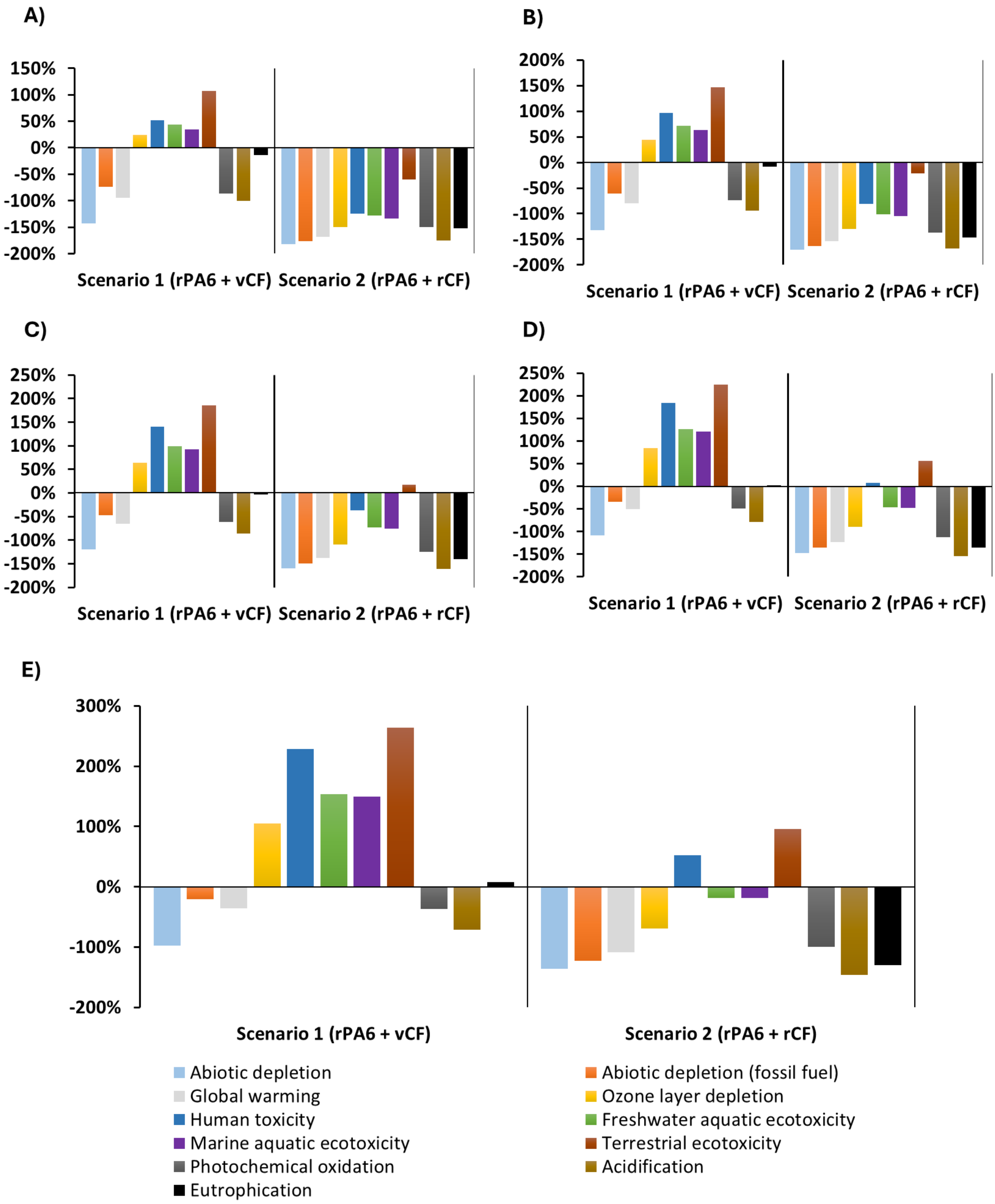


Figure 17 : Percentage differences in the environmental impacts compared to the reference (Scenario 0). A) WWTP 50 km away; B) WWTP 100 km away; C) WWTP 150 km away; D) WWTP 200 km away; E) WWTP 250 km away. WWTP: Wastewater treatment plant; rPA6: Recycled PA6 from fishing nets; vCF: virgin carbon fibre ; rCF: recycled carbon fibre. Adapted from Pasciucco et al., (2025).

circnets

Improving the management of end-of-life fishing gear

Blue Circular Nets (CIRCNETS) supports collection, treatment and recycling of fishing gear, so that these end-of-life nets are disposed appropriately, and they will not end up in seas and degrade the marine environment.

interreg-npa.eu/projects/circnets/

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