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Deliverable 2.2 Litter management plans and facilities at ports

Report, including a policy brief about regulations, norms, and plans on marine litter management at European fishing ports. Assessment of port authorities' and port managers' perceptions about current waste management policies, processes and infrastructure in each country; the economic and social implications, major obstacles and challenges faced, and capacity and willingness to improve policies and facilities to properly manage and monitor fishing litter, including recycling and circular economy activities.

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Summary NETTAG+ Project
NETTAG+ aims to provide a portfolio of three innovative smart and sustainable solutions to address the negative impacts of abandoned, lost or otherwise discarded fishing gear (ALDFG) on marine life and habitats. NETTAG+ will be based on synergistic activities between the fisheries industry, scientists and NGOs to develop three solutions to PREVENT, AVOID and MITIGATE the harmful impacts of ALDFG. NETTAG+ will PREVENT marine litter derived from fisheries activities, AVOID loss of fishing gears, and MITIGATE harmful impact by removing existing ALDFG. These three solutions will jointly contribute to reduce ALDFG and marine pollution, namely by: reducing the introduction of hazardous chemicals and microplastics originating from ALDFG; reducing ghost fishing, bycatch and entanglements of sensitive or endangered species on ALDFG; and improving mapping, tracking and recovery technologies to retrieve ALDFG. NETTAG+ aims to upgrade and upscale the integrative preventive approach that started in the previous NetTag project, and aims to replicate it in Mediterranean regions, providing the fisheries industry with three smart and environmentally-friendly solutions to reduce ALDFG and prevent the environmental impacts of fishing gears. The three solutions will be developed to maturity (TRL 7-8) by the end of the project, and will be tested, validated and demonstrated in real conditions in Atlantic and Mediterranean countries, namely Portugal (PT), United Kingdom (UK), Spain (ES), Italy (IT), Croatia (HR) and Malta (MT). NETTAG+'s ambition is to change the paradigm of the fisheries industry, aspiring to transform the societal perspectives about the role of fishers as Guardians and Cleaners of the Ocean. NETTAG+ will empower the sector to take effective actions to address marine pollution, promoting their role as key actors to tackle marine pollution.

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List of Acronyms

ALDFG	Abandoned, lost or discarded fishing gear
CE	Circular Economy
EOL	End-of-life
ES	Spain
HR	Croatia
IMO	International Maritime Organization
IT	Italy
MARPOL	International Convention for the Prevention of Pollution from Ships
MT	Malta
PRF	Port Reception Facilities
UNCLOS	The United Nations Convention on the Law of the Sea
UK	United Kingdom
WMP	Waste Management Plan

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Executive Summary

This assessment (D2.2) examines fishing litter management in ports across Croatia (HR), Italy (IT), Malta (MT), Portugal (PT) and Spain (ES), focusing on port authorities' and port managers' perceptions of waste management policies, practices, infrastructure, and the economic and social implications of these systems. It also explores key obstacles and the capacity and willingness of stakeholders to enhance management, including recycling and circular economy (CE) activities. Marine litter—particularly from land-based sources (e.g. plastic production), as well as from maritime transport, and fishing activities—poses serious navigational risks and environmental threats. These risks are exacerbated by inadequate litter management and recycling systems. Abandoned, lost or discarded gear (ALDFG) constitutes a portion of the marine litter found. Port reception facilities (PRFs) are central to preventing marine litter pollution and supporting both sustainable fisheries and CE transitions.

Our research identifies that the legal context governing PRFs includes international conventions such as UNCLOS (United Nations Convention on the Law of the Sea) and MARPOL (International Convention for the Prevention of Pollution from Ships), and EU legislation (particularly Directive 2019/883/EU on port reception facilities for the delivery of waste from ships). This directive was adopted in 2019 and was intended to be implemented by 2021. It requires that Member States provide PRFs that meet users' needs and implement indirect fee systems to avoid disincentivising waste delivery. However, practical implementation is inconsistent across and within Member States, particularly between larger and smaller ports. Larger ports typically exhibit more structured waste management systems and align more closely with MARPOL requirements. In contrast, smaller ports often face limited administrative capacity, unclear mandates, and fragmented responsibility for compliance.

PRF effectiveness depends on accessibility, awareness, and stakeholder collaboration. Most ports subcontract waste collection activities, with commercial shipping terminals showing the most developed MARPOL-aligned practices. The fee structure for waste delivery by fishers varies significantly across the different study countries, according to the interviewees. Fishing vessels using MARPOL services pay direct variable fees based on the amount and type of waste collected, while some ports do not charge fees under certain conditions. PRFs across the study countries manage a range of waste types, including end-of-life (EOL) gear, passively fished waste, and hazardous or recyclable materials. Nonetheless, infrastructure and services vary considerably by country and port.

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Key challenges include insufficient infrastructure for waste separation and recycling, low levels of fisher engagement and awareness, financial constraints, regulatory ambiguities, and inconsistent monitoring. In smaller ports especially, limited enforcement and inadequate coordination with municipal systems further weaken compliance. Port authorities interviews identified various obstacles including personnel shortages, resistance to regulatory changes, and the absence of clear incentives for sustainable practices.

Proposed solutions derived from the interviews include improved waste management systems tailored to fisheries, enhanced on-site collection and sorting infrastructure, education and training campaigns, and the development of regulatory and financial incentives. Investments in recycling technology and port partnerships were also cited as potential enablers. Increased collaboration among authorities, waste management providers and fishers is critical to overcoming these barriers.

Marine litter policies remain insufficiently harmonised across EU countries, due to administrative complexity, economic disparities, and logistical differences between ports. Gaps in coordination and standardisation hinder broader compliance and the efficient scaling of best practices. Interviewees recommended initiatives such as stakeholder networks (e.g. port authorities, fishers' associations, waste managers, recycling companies and government bodies) to support coordination and standardisation issues, improved monitoring frameworks, infrastructure upgrades, and targeted CE interventions to close these gaps.

CE principles are increasingly incorporated at port level within the study countries. Activities vary by port and include waste prevention, collection and separation, infrastructure development, the use of indirect fees, stakeholder education, recycling, and participation in EU-funded projects. Some ports (e.g. in Spain) have established dedicated CE departments, though uptake and effectiveness vary widely. Despite the ambitions of Directive 2019/883/EU, major challenges persist in aligning PRF policies, processes, and infrastructure across the EU.

Ultimately, while efforts to manage fisheries-related waste are evident, especially in larger ports, significant improvements are needed. These include streamlining regulatory frameworks, enhancing economic support, investing in monitoring systems, incentivising sustainable practices, and deepening cross-sector partnerships. The transition to harmonised, efficient, and CE-oriented fishing waste management systems remains ongoing but necessary.

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The report recommends several policy actions for waste management in ports based on the findings:

- Streamline the regulatory framework across EU countries
- Enhance economic viability
- Support adequate infrastructure development
- Improve monitoring and data collection
- Provide incentives and support for fishers
- Promote partnerships and knowledge sharing

By implementing these recommendations, ports can effectively harmonise their approaches, leading to improved management of waste generated, reduced marine litter and greater sustainability in fishing practices.

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1 Introduction

The proliferation of marine waste over the last half-century is closely tied to the dramatic rise in plastic production, maritime transport, and extractive activities at sea. In 2019 alone, global annual plastic production reached 460 million tonnes, with an estimated 6 million tonnes of used plastic leaking into rivers or coastlines and 1.7 million tonnes entering the oceans, equivalent to 0.5% of the world's plastic waste (OECD, 2022; Ritchie, 2023). Plastics constitute up to 80% of marine waste (Morales-Caselles et al., 2021). Cumulatively, between 86 and 150 million tonnes of plastic are estimated to be present in marine environments (Jang et al., 2015), with most ending up on the seafloor (UNEP 2005; Madricardo et al., 2020; Morales-Caselles et al., 2021). At least 22% of all marine litter is estimated to come from sea-based sources such as fishing, aquaculture or shipping (e.g. fishing gear, clothes, consumer and household items), contributing significantly to marine litter pollution (Morales-Caselles et al., 2021). Most (61%) plastic items found in the open ocean consist of synthetic ropes, strings, threads, buoys and nets from lost or discarded fishing gear (Morales-Caselles et al., 2021).

The impacts of marine waste are extensive and varied. Entanglement and ingestion in nets by marine wildlife, introduction of invasive species, degradation of habitats, and hazards to navigation are well-documented outcomes (Richardson et al., 2017; Scheld et al., 2016). The economic consequences are equally severe. In Europe, marine waste costs the fishing sector an estimated €60 million annually, or 5% of total revenue (European Commission et al. 2024). In the Pacific Rim, damages attributed to marine debris reach around 316 million euros (McIlgorm et al., 2011). Derelict fishing gear has been shown to cause significant losses to target fisheries, such as the 18.5 million euros in annual loss in Chesapeake Bay due to derelict crab pots (Scheld et al., 2016).

Fishing vessels significantly contribute to marine waste, particularly the loss or discarding of fishing gear and used plastics (Richardson et al., 2017, 2021). Observer data from the Western and Central Pacific Ocean recorded over 10,000 pollution incidents from purse-seine and longline vessels between 2003 and 2015, with the majority involving the dumping of plastic waste and abandoned gear (Richardson et al., 2017). Although quantifying the precise contribution of fishing vessels is challenging due to methodological limitations, underreporting, and a lack of empirical data from at-sea operations (CE Delft, 2017; Deshpande et al., 2023; IMO, 2021), the fishing sector is identified as playing a critical role in effectively manage marine plastics globally Morales-Caselles et al., 2021).

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Globally, only about 27% of ship-generated waste is delivered to port reception facilities (PRFs), with the remainder often dumped or incinerated at sea (Øhlenschlæger et al., 2013). This situation is exacerbated in regions where PRFs for managing litter collected and ship-generated at sea are inadequate or absent, incentivising illegal disposal and further complicating efforts to monitor and manage marine waste (Richardson et al., 2017).

PRFs are critical port infrastructures designed to receive ship-generated waste at ports, helping prevent the direct discharge of pollutants into the marine environment (IMO, 2021; IMO, (1978/2017: MARPOL Annex V). They also play a pivotal role in the collection of passively fished waste, including litter and derelict gear retrieved during fishing operations, contributing to the circular economy (CE) and reducing fisheries' environmental footprint (Directive 2019/883/EU).

Effective management of PRFs is therefore vital to international and European maritime environmental policy, directly supporting efforts to reduce marine waste and promote sustainable fisheries and ocean health (Directive 2019/883/EU; MARPOL Annex V). The adequacy, accessibility, and management of PRFs (implemented through waste management processes described at a high level in ports' Waste Management Plans (WMPs) are especially significant for the fisheries sector, where operational constraints and economic pressures can challenge compliance with best environmental practices.

Well-managed PRFs can achieve recycling rates exceeding 50% of ship-generated waste (Vaneeckhaute & Fazli, 2020). However, their effectiveness depends on several complementary factors: capacity, accessibility, convenience, and the absence of economic or administrative barriers (Richardson et al., 2021; Verdesoto et al., 2025). Incentive structures, such as indirect fee systems and cost recovery mechanisms, are widely recommended to encourage waste delivery without penalising responsible behaviour (Directive 2019/883/EU; Verdesoto et al., 2025).

An important strategy for managing fisheries waste comes from CE principles. These principles focus on transforming waste streams into valuable resources through various processes and technologies with the aim of reducing environmental impact while creating economic opportunities. Some examples of CE activities include waste stream utilisation, such as converting processing by-products, by-catch, aquaculture sludge, and fishing gear plastics into useful products (Caruso et al., 2020; Deshpande et al., 2020); or producing alternative fertilisers and feeds from fishery waste (Zhang et al., 2023); resource recovery methods such as developing local recycling capabilities, particularly for plastic materials (Deshpande et al., 2020); value

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creation, for example creating new value chains around marine debris recycling (Ruiz-Salmón et al., 2020) and establishing new business models based on waste valorisation (Cooney et al., 2023); as well as sustainable management, including using life cycle assessment and material flow accounting to optimise resource use (Ruiz-Salmón et al., 2021), implementing stepwise valorisation frameworks for systematic waste management (Cooney et al., 2023), and focusing on stakeholder collaboration across the supply chain (Ruiz-Salmón et al., 2020).

1.1 Purpose and scope

The purpose of Deliverable "D2.2 Litter management plans and facilities at ports" is to provide a comprehensive assessment and evaluation of litter management in selected ports across Croatia (HR), Italy (IT), Malta (MT, Portugal (PT) and Spain (ES), under current legal frameworks. This includes an assessment of port authorities' and port managers' perceptions about current waste management policies, processes and infrastructure in each country; the economic and social implications of waste management, major obstacles and challenges faced, and capacity and willingness to improve policies and facilities to properly manage and monitor fishing litter, including recycling and CE activities.

1.2 Relevant work package

This deliverable falls under Work Package 2 (WP2) PREVENT: Fishers as Guardians and Cleaners of the Ocean. Task 2.3 specifically addresses the evaluation of current port practices and infrastructure for litter management, contributing to WP2's broader goal of supporting sustainable and harmonised waste management solutions in line with EU and international conventions.

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2 Methodology

2.1 Data collection

The aim of this research was twofold: 1) to understand the legal framework governing PRFs and waste management in European ports and 2) to gather the perceptions, experiences and practices of those responsible for the reception and treatment of waste delivered to ports by fishers. We therefore conducted a desktop review of relevant institutional reports, followed by a stage of qualitative fieldwork in the five study countries.

Qualitative interview methods enable a flexible investigation of topics through open-ended questions and follow-up inquiries, while maintaining a consistent framework. Such methods also allow the exploration of unexpected issues and deeper insights, capturing both complexity and context (Rubin & Rubin, 2011). We employed in-person, semi-structured interviews with 15 port authorities and managers from selected fishing ports in Portugal (five interviews), Spain (five), Croatia (two), Italy (two) and Malta (one) (Figure 1).

Interviewees were selected based on their active involvement in environmental or overall port management, and to represent a diversity of port sizes and infrastructures ensuring a grounded perspective on the handling and reception of fishing-related waste under different practical and institutional circumstances. All interviewees mainly discussed activities within the ports under their direct management except the interviewee from Malta who reported on five ports, since they were the sole appropriate representative with adequate knowledge and experience to discuss the topic. In Portugal, we interviewed five key stakeholders from three ports who represented different roles in charge of managing fisheries waste (Table 1).

Interviews were conducted between November 2024 and April 2025 in the interviewees' native language and audio recorded to capture their full content and nuances. The audio recordings were subsequently transcribed and translated into English, following the original script structure to support direct comparison.

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Table 1. Summary of key characteristics of ports included in the study

Country	Port size	Sectors (Fishing / Tourism / Commercial Shipping)	Fishing Infrastructure & Port Reception Facilities (PRF)	Interview reference code
Croatia	Small	High / Medium / Low	Very basic PRFs; co-use with tourism facilities	HR01
	Small	High / Low / Low	Basic PRFs; recent investments in circular practices	HR02
Italy	Small	High / High / High	Basic infrastructure; limited CE; PRF under Directive 2019/883	IT01
	Small	Medium / High / High	Mixed-use port	IT02
Malta	Large	Low / High / High	Port waste systems in place; PRFs under national implementation	MT01
	Medium	High / Medium / High	Advanced PRFs; key fishing infrastructure hub	
	Small	Low / High / Low	Basic facilities; limited fishing-specific infrastructure	
	Small	Medium / High / Low	Limited infrastructure; emerging waste initiatives	
	Small	Medium / High / Low	Basic PRFs; some investment in circular waste management	
Portugal	Large	Medium / Low / Medium	Fishing quay managed by Docapesca	PT01, PT03, PT04
	Large	High / High / High	Active PRFs; advanced fish processing facilities	PT02
	Large	Medium / Low / High	Fishing quay operated by Docapesca	PT04, PT05

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Country	Port size	Sectors (Fishing / Tourism / Commercial Shipping)	Fishing Infrastructure & Port Reception Facilities (PRF)	Interview reference code
Spain	Large	High / Medium / High	Advanced PRFs, recycling systems, fish market infrastructure	ES01
	Large	High / Medium / High	Advanced PRFs, CE initiatives	ES02
	Large	Medium / Medium / Medium	Some PRFs, moderate infrastructure	ES03
	Small	High / Medium / High	Waste reception facilities; integrated with national systems	ES04
	Large	Medium / Medium / High	PRFs for multiple sectors	ES05

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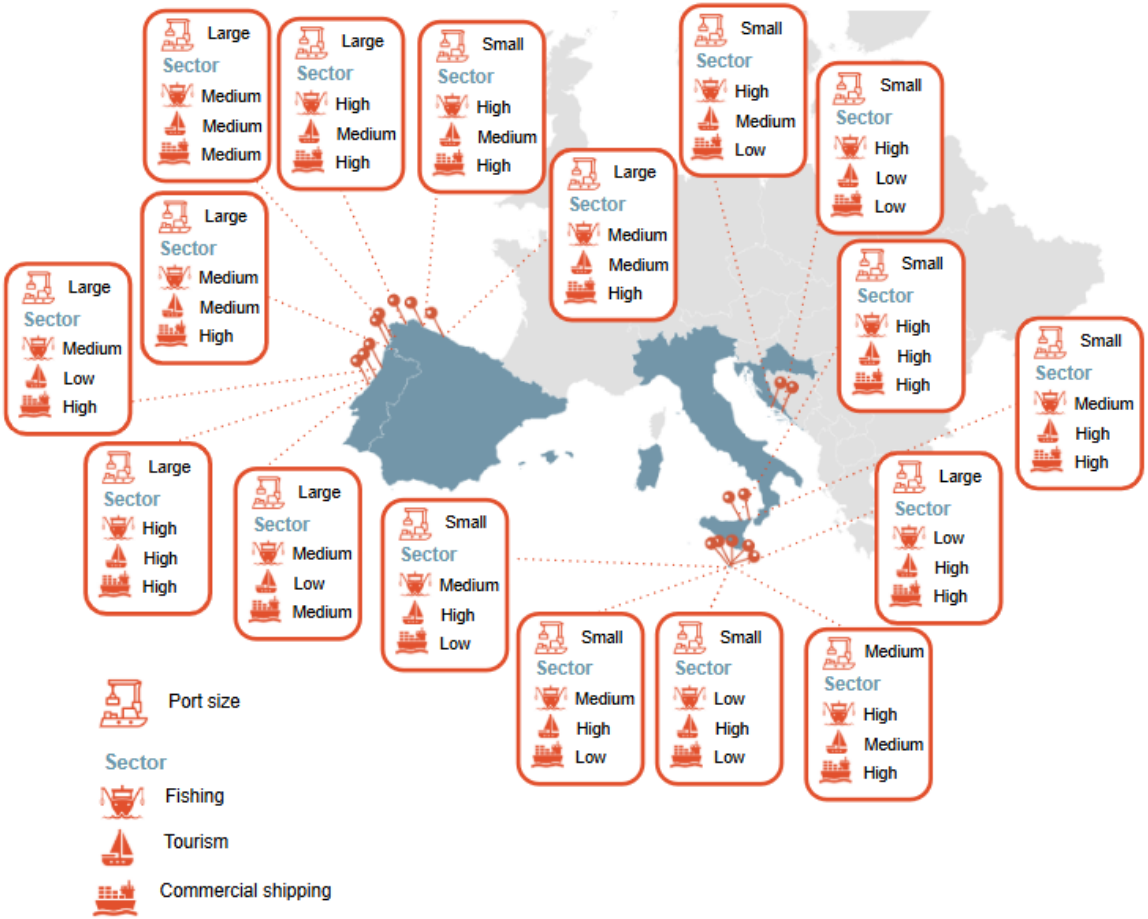

Figure 1. European map showing location of our case studies

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2.2 Data analysis

The interview content was analysed using qualitative coding. Each response was divided into its various meanings, relevant to the objectives of D2.2. The first coding cycle was based on process coding, which is particularly appropriate for denoting processes, observable activity, actions, and consequences perceived by respondents, as well as sequences. Descriptive coding was also applied to passages or references of a more general or abstract nature. The deliverable objectives constituted, in themselves, a priori categories. The codes from the initial phase were later distributed across each subcategory for categorical analysis through pattern coding, bringing together related codes to elicit emerging patterns. Magnitude coding (descriptive coding that identifies frequency or presence of a given characteristic, allowing quantitative analysis of qualitative data) was then applied to the identified sub-categories, allowing comparative quantitative data derived from the responses to be compared between the different ports. Magnitude coding is the origin of the tables presented in this report. All coding phases were carried out in Excel format, with all coding and categorisation being carried out manually (Miles et al., 2014; Saldaña, 2016).

To maintain anonymity of participants and ports, we use coded abbreviations to represent the source of interview data or interviewee quotations in this report. For example, “PT 01” refers to the first interview conducted in Portugal, while “HR 02” refers to the second interview conducted in Croatia, and so on.

2.3 Ethical considerations

Ethical approval to implement the social science interviews was obtained from the University of Santiago de Compostela Bioethics Committee in December 2023 (Code USC Nº 77/2023). All participants provided signed Consent Forms, explained before the start of the interview. To ensure that all information shared is treated in strict confidence, all data resulting from the interviews is anonymised and where possible, responses are reported cumulatively.

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3 Results

3.1 Current waste management policies, processes and infrastructure

This section begins by summarising our findings from our review on the legal framework governing PRFs and waste management in European ports. It then provides an overview of management priorities amongst the port authorities and managing entities interviewed in Croatia, Italy, Malta, Portugal and Spain regarding their waste management policies, processes, providers, fee structures and port reception infrastructure.

3.1.1 Waste management policies

The legal framework governing PRFs and waste management in ports is multi-layered, reflecting the complexity of maritime governance, stemming from global treaties with varying levels of acceptance to regional regulations for local implementation. The United Nations Convention on the Law of the Sea (UNCLOS; United Nations 1982) establishes the general obligation of states to preserve and protect the marine environment, including the duty to prevent intentional discharge of wastes from ships (UNCLOS, Art. 194). The International Convention for the Prevention of Pollution from Ships (MARPOL), particularly Annex V, affirms that PRFs are a key element in mitigating pollution from ships. MARPOL further substantiates these obligations by prohibiting the discharge of most waste at sea and mandating the provision of adequate PRFs in ports (MARPOL Annex V, Rules 3, 4, 7, 8, 10).

MARPOL Annex V states that all discharge of waste at sea is prohibited, with limited exceptions for food waste and unavoidable losses for safety reasons. Ports and terminals must provide adequate PRFs for marine waste originating from ships, tailored to the needs of vessels calling at those ports, and must not cause undue delays (MARPOL Annex V, Rule 8). Vessels of 100 Gross Tons or more must maintain WMPs and record books, recording all discharges, including those to PRFs, with supporting documentation retained on board for inspection (MARPOL Annex V, Rule 10). Before 2024, this requirement applied to vessels above 400 Gross Tonnes (MEPC.360(79))

The International Maritime Organization (IMO) has developed comprehensive guidelines to support the implementation of adequate PRFs (IMO Resolution A.896(21); IMO, 2021). These guidelines define adequacy as the ability to incentivise waste delivery, ensure convenience, avoid delays, and guarantee environmentally responsible disposal. The guidelines recommend advanced notification procedures, regular assessment of PRF effectiveness, and integration of

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stakeholder input in facility management. They also emphasise the importance of separating waste types, providing up-to-date information on available PRFs, and encouraging best practices such as on-board waste minimisation and recycling (IMO, 2021).

At the European level, Directive 2019/883/EU transposes international obligations into EU law. It was adopted in 2019 and intended to be implemented by 2021. The Directive requires Member States to ensure that PRFs meet the operational needs of port users, are adapted to local circumstances, and employ indirect fee systems that cover the full cost of waste reception without discouraging use (Directive 2019/883/EU; Verdesoto et al., 2025). The Directive also mandates that PRFs must be capable of receiving all waste types specified under MARPOL, with processes that are simple, quick, and environmentally sound. Safety measures must be in place to protect workers, crew, and the environment, and the fees applied must not discourage PRF use.

A key innovation of Directive 2019/883/EU is the mandatory use of indirect fee systems covering 100% of the cost of reception for Annex V wastes, with direct fees permitted only for quantities exceeding declared storage capacity. The Directive also encourages incentive schemes for the delivery of passively caught waste and end-of-life (EOL) fishing gear, with cost recovery limited to indirect fees. Member states are required to collect and report data on the volume and weight of passively fished waste, using a combination of advanced waste notifications, surveys, and municipal waste processing data (Directive 2019/883/EU).

Transparency and fairness are key principles to the Directive's fee provisions. Fee structures and rationales must be publicly available, easily accessible, and provided in widely used languages. Lower fees may be charged to vessels demonstrating reduced waste production or sustainable management practices, such as certification under ISO 21070 (Directive 2019/883/EU). Importantly, the Directive recognises that the cost of PRF use should not be borne solely by fishers and encourages the use of EU funding and other financing mechanisms to support sustainable waste management (e.g. extended producer responsibility or EPR). For example, according to the EU directive on single use plastics, 'Member States shall ensure that the producers of fishing gear containing plastic cover the costs of the separate collection of waste fishing gear containing plastic that has been delivered to adequate port reception facilities in accordance with Directive (EU) 2019/883 or to other equivalent collection systems that fall outside the scope of that Directive and the costs of its subsequent transport and treatment. The producers shall also cover the costs of the awareness raising measures referred to in Article 10 regarding fishing gear containing plastic' (Article 8, EU Directive 2019/904 on the reduction of

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the impact of certain plastic products on the environment). Critical success criteria for an EPR system include identifying the producer (e.g. retailer/distributor, manufacturer), implementation of robust collection and recovery infrastructure, effective and transparent management of financial flows, and strong monitoring and enforcement of the system (cyclos GmbH, WWF Mediterranean Marine Initiative 2024).

According to the port authorities interviewed, current responsibility for the implementation and monitoring of port environmental policy varies by the size of the port and the national framework in each country (Figure 2). Larger ports, managed directly by port authorities and experienced in MARPOL processes, demonstrate more comprehensive waste management policies. Larger ports with multiple sectors, notably commercial ports, tend to apply environmental policy directly or as a unified application. In these cases, the port authority applies the waste management policy and respective plan. They engage directly with relevant stakeholders, managing the entire waste collection and treatment stream either directly or through waste managers, to implement improvement strategies and the development of PRFs, as well as waste segregation and treatment.

Smaller ports present a greater diversity in implementation responsibilities, a lack of capacity for adequate waste reception and treatment, lower participation in European waste management initiatives, as well as a wider variety of management policies and entities. For example, in smaller ports, there are cases where waste management policy is implemented by local fishers' and shipowners' associations (e.g., Spain) or by municipal authorities (e.g., Italy and Malta), while in other small ports, concessionaires are responsible (e.g., Italy and Malta). Hence, processes such as waste monitoring and engagement with fishers tend to be more complicated than in larger ports.

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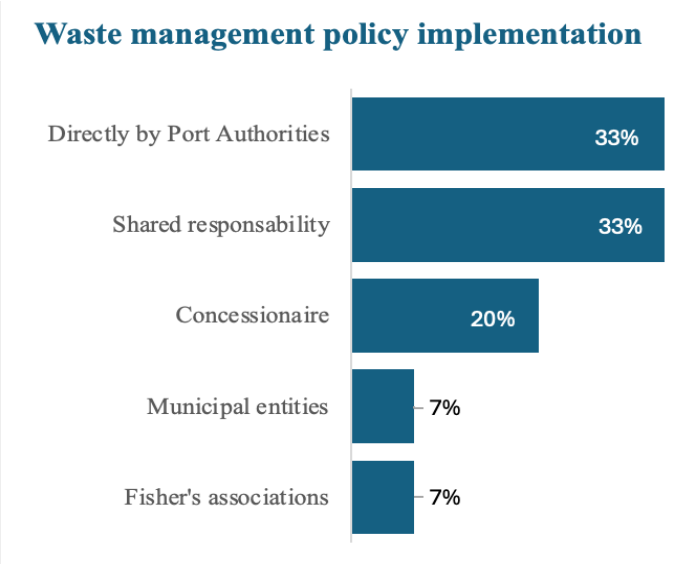

Figure 2. Entities responsible for waste management policy implementation. Indicating the percentage of interviewees mentioning each entity

For example, in Portugal where fishing ports are managed by the auction management entity, the application of waste management policies is either fully concessioned or under shared responsibility, as one interviewee (PT01) notes:

> *"The waste in the fishing port is collected by Docapesca in their concessioned area, which includes the area of Docapesca, the ice factory, merchants' warehouses, fish auction site, etc, and the water surface. The port administration collects the waste in the remaining area."*

The EU Directive on PRFs (2019/883) mandates ports to collect abandoned, lost or otherwise discarded fishing gear (ALDFG) through an indirect fee system for waste disposal, stating that no additional fees should apply for delivering passively caught marine litter, including ALDFG (ES01; IT02; PT02). In Spain, the Directive has recently been incorporated into national law, impacting how ports manage ALDFG and EOL gear, although the legislation remains "*very new and not yet well-defined*" (ES01). Italy's "Salvamare" Law (Legislative Decree 197/2021) makes the disposal of special waste, such as ALDFG, free of charge for fishers (IT02).

Local policies in ports often lead to the creation of designated areas for fishers to drop off EOL fishing gear at no cost. In Spain, designated "green points" are established for this purpose (ES01, ES02; HR01; PT03). In Croatia, fishers can leave EOL gear in front of their boats along with bags of marine litter, simplifying waste disposal (HR01). Portugal's "Mar sem Lixo" program incentivised participation by providing waste bags and fee exemptions (PT02, PT03, PT05). In

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Malta, however, there are currently no specific policies or facilities for managing ALDFG and EOL gear, highlighting the need for improvements in waste management for fishing vessels (MT01).

Despite various initiatives, there is a noticeable lack of harmonisation across ports in implementing policies for managing ALDFG and EOL gear, with challenges in enforcement persisting (PT02, PT03). This discrepancy reflects differences in infrastructure, fishing fleet structure, and local circumstances across regions (ES01).

3.1.2 Waste management processes

Interviews revealed that effective promotion of PRFs among fishers relies heavily on awareness-raising and collaboration. Ten of the fifteen interviewees cited awareness campaigns or direct engagement with individual fishers, while eight emphasised partnerships with fishers' and shipowners' associations. These efforts were seen as essential to foster adherence to waste management policies, as one interviewee (ES01) noted,

> "(...) *without the altruistic collaboration of the fishers, it wouldn't be possible* (…)".

Another interviewee highlighted ongoing dialogue to align practices with fishers' needs (ES04). Additional strategies to promote the use of PRFs among fishers included responding to user requests, implementing incentive programmes (PT01, PT03, PT04, PT05), and ensuring continuous PRF availability (PT01, PT03, PT04, PT05). Some interviewees mentioned constant availability as a feature, and one (PT02) stressed its importance for operational flexibility. One interviewee (PT02), in particular, elaborated on the importance of continuous PRF availability and operational flexibility. Another practice frequently reported was investments in infrastructure and capacity. Six interviewees described plans to expand PRF capacity or differentiate waste types. Examples included investment in compactors for the treatment of specific waste (ES04) and new collection points (ES05):

> *"…we are trying to develop a waste collection point that is closed and assigned individually to shipowners and fishers so that we can identify who deposited the waste.".*

Personnel limitations were also flagged, with an interviewee from Croatia noting:

> *"We currently do not lack capacity in terms of space, but we certainly lack human resources to separate the waste".* (HR01)

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The majority of ports (11 out of 15) subcontracted waste management and used contractual mechanisms to enforce waste hierarchy principles (Directive 2008/98/EC). In Spain, for instance, service providers were financially incentivised to recover waste rather than send it to landfill, with the interviewee noting:

> *"In the contract we have with this company, we have a fixed price. We do not pay them for the amount of waste they collect, we demand that they have to recover everything that can be recovered (…)."* (ES01)

This model aligns provider interests with environmental goals.

Another frequently mentioned policy option was to increase the pre-processing capacity of collected waste, cited by seven interviewees. This includes initiatives such as the *Fish No Waste* project in Croatia (HR01) and the installation of recycling infrastructure in Spain (ES04). Two interviewees also mentioned initiatives to reduce waste management costs, seen as essential for competitiveness.

Support for on-site waste processors and MARPOL adaptations also featured prominently. MARPOL-based waste management approaches were consistently cited as effective, particularly where port authorities also oversaw commercial shipping terminals. All interviewees emphasised that fishing waste should be integrated into MARPOL systems for traceability and service efficiency, for example. As two interviewees from Spain noted:

> *"More can be done because the regulations already exist (…) in the end the nets and gear are MARPOL waste (…)"* (ES02).

> *"Reception plans are called MARPOL plans. Plans for the collection of waste from ships (...) we give licences to waste managers and transporters so that fishing vessels or ships can call them to collect waste"* (ES05).

One Portuguese interviewee (PT01) described a lack of simple and clear MARPOL practices for the fishing sector:

> *"On ships, it is simple. Someone goes there and brings the waste separated. On fishing vessels, that system does not exist. The rules are different, the ships have IMO rules, which have clear rules. They have port rules, which are also very clear. And the fishing vessels, I don't know if they even have rules."*

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Finally, interviewees identified three key approaches to increasing port capacity for waste recovery: participation in EU-funded projects, establishment of local/national partnerships, and pursuit of certifications. While five ports mentioned EU projects as central, local partnerships were highlighted by four others, particularly among smaller ports.

Waste management providers

Waste management providers vary with port size and governance structure (Figure 3). Larger ports typically contract certified waste management companies through public tenders, allowing authorities to enforce requirements for waste separation, destination, and valorisation. In ports with shared responsibility between port authorities and concessionaires, management is often mixed. Depending on waste type, collection may be handled by (usually certified) contractors or local councils. In larger ports, authorities also license MARPOL waste management providers, giving vessels a choice of certified companies and enabling better oversight of waste flows. For example, shipowners' associations may directly contract logistics services for their fleets (ES04). Licensing and fixed-cost service models incentivise recovery, as noted by one interviewee from Spain (ES 01):

> *"The more waste the company can recover, the more it benefits".*

In contrast, smaller harbours, that mainly serve small-scale fisheries, rely primarily on municipal waste collection systems. These ports often lack contracts that enable oversight or innovation. One interviewee from Italy (IT02) described how waste management is delegated to municipalities, which provide basic infrastructure and awareness, but with limited enforcement or data collection.

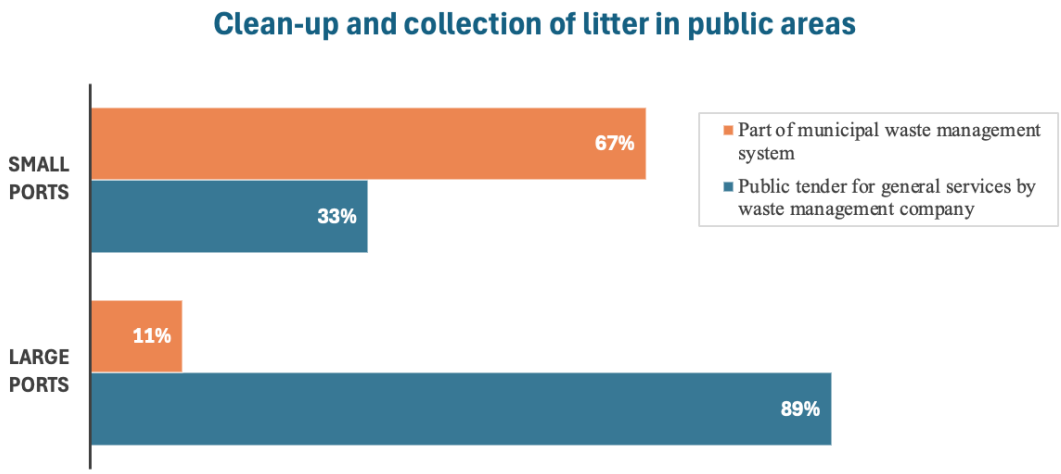

Figure 3. Clean-up and collection of litter in public areas in small and large ports. Indicating the percentage of interviewees mentioning each entity

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There is a big difference in waste management capacity and the consequent ability to reuse waste between smaller and larger harbours. In both large and small ports, contracted service providers are typically responsible for collecting and sorting waste in shared areas. In larger ports with MARPOL services, companies must provide certified waste transport and recovery documentation. These companies are also required to perform individualised collections, unlike general cleaning services in smaller ports. The diversity and specialisation of providers in larger ports—including those handling fishing gear pre-treatment—enables more effective waste valorisation. In contrast, smaller ports mirror urban waste systems with fewer controls and reduced capacity for recovery.

Service quality directly impacts the adequacy of PRFs and waste systems. Poor contractor performance, particularly during peak periods, can result in waste accumulation and pollution, as noted by one interviewee from Portugal (PT05):

> *"We used to work with a company, part of a big waste management group, and they had means to do it (...) We changed companies, and we can see that during busy weeks, the new company fails badly."*

Monitoring of waste reception and management

Monitoring of waste reception and management in fishing ports varies significantly, influenced by port size, governance model, and applicable legislation.

Larger ports, particularly those serving commercial shipping or deep-sea fleets, implement more developed systems aligned with MARPOL Convention and Directive 2008/98/EC requirements. These systems enable individual tracking of waste deliveries, including volume, type, and associated costs.

Some ports track coastal vessels' delivery of marine litter using uniquely tagged bags or logs of daily marine litter returns (HR01). In contrast, small-scale fisheries are rarely subject to individual tracking; monitoring relies instead on general waste management provider reports.

Ports dedicated exclusively to fishing, regardless of size, tend to have a waste management provider, with monitoring based largely on transport documentation required by Directive 2008/98/EC. For instance, in Portugal, individual vessel monitoring is applied only to vessels participating in the "Mar sem Lixo" (Sea *Without Waste*) program; outside of it, there are no individual monitoring procedures for waste delivered by fishing vessels.

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Smaller ports, particularly those integrated into municipal waste systems, often seem to lack systematic monitoring. Interviewees provided limited or no information on tracking processes, suggesting minimal oversight.

Alternative monitoring methods mentioned include direct observation by port workers (including one case in Spain for waste delivered under MARPOL procedures), the use of CCTV or electronic systems to access green points, and direct reports from fishers or staff, especially for detecting illegal discharges (PT02).

In larger ports, monitoring data is used for contract management, performance evaluation, and troubleshooting. As one interviewee (PT02) explained:

> "*If the waste volume exceeds the contracted amount, the company reports it with documentation, and we renegotiate the contract*."

However, monitoring frequency varies. Individual tracking provides near real-time data, while broader waste management reports may be annual (ES04). Though larger ports can request data on demand, such performance control procedures were not mentioned for small ports, where inspections—if conducted—are infrequent.

Overall, interviewees viewed monitoring as essential for evaluating waste management policies and ensuring responsive interventions, yet implementation remains uneven across port types.

The assessment of the effectiveness of PRF and fishing waste management systems is closely tied to monitoring data and feedback from fishers. Of the 15 interviewees, seven reported using feedback from fishers and complaints received as indicators of the effectiveness. However, no port reported a formal evaluation system with defined metrics.

In addition to fishers' feedback, data obtained from cleaning activities, waste collection volumes, and on-site observation are also used to gauge performance. Quantitative indicators, such as volumes collected at designated points, were also mentioned. For example, one respondent (ES01) shared:

> *"Since we have installed the green point, at least 15 years ago, we have seen, for example, 11 tonnes of batteries collected over the years. So that tells us it works."*

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Direct feedback from fishers was often considered the most practical and reliable indicator. As expressed by several interviewees:

> "*The direct feedback from those involved (...) is what tells us if things are going well or not*" (PT02)
>
> "*If there are no protests, it is because it is going better*" (ES04)
>
> "*People are happy with the way it works. That's our feeling*" (ES05)

In smaller ports, the lack of monitoring systems appears to result in an absence of effectiveness assessments altogether. Two interviewees explicitly stated that no such evaluations are carried out.

Overall, assessment practices remain informal, subjective, and inconsistently applied, particularly in smaller or less resourced ports.

Fee structures

The fee structure for waste delivery by fishers varies significantly across the different study countries, according to the interviewees. Fishing vessels using MARPOL services pay direct variable fees based on the amount and type of waste collected. For instance, in Italy (IT02), both large and small fishing vessels can face these fees, particularly for MARPOL Annex I waste, while some small fishers may deliver EOL gear waste at no charge.

In Portugal, compliant vessels are exempt from waste fees, whereas non-compliant vessels face a small daily charge of €0.74, which partially funds cleaning services. Spanish fishing ports employ a yearly waste fee in smaller locations but not in larger ones. In Croatia, Italy, and Malta, waste delivery is largely free unless directly collected by waste management companies. An Italian interviewee mentioned plans for implementing an indirect flat fee in line with EU Directive 883/2019, similar to Spain's approach.

Many interviewees displayed limited understanding of fee structures, perceiving them as centrally set or as attempts to meet legal requirements. In Spain, two interviewees noted that formal cost-benefit analyses for waste fees exist, but they only apply to merchant vessels not fishing vessels. In Portugal, such analyses are done centrally, so individual ports lack regular data sharing.

Some informal assessment methods included feedback from fishers, direct cleanliness observations of common areas, and waste collection volume monitoring. Most participants

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viewed the fees as ineffective, while a minority considered them moderately or quite effective. Key points of view were divided between advocating for increased indirect flat fees to enhance waste delivery or eliminating fees altogether.

Half of the interviewees believed that raising fees might encourage responsible waste disposal, while others warned against excessive fees driving fishers to seek alternative waste disposal methods (PT02). Lack of fees was seen as a viable motivator for waste delivery in some countries (IT02). Suggestions for improving fee structures included formal assessment methods (PT03), indirect flat fee systems (ES02), aligning fees with MARPOL structures (IT02), and implementing incentive programs (HR01) to differentiate between vessels that properly dispose of waste and those that do not, potentially using mobile apps for monitoring (ES02).

3.1.3 Waste management infrastructure

Port reception facilities differed by country and type of waste. Interviewees mentioned the main types of waste delivered to PRFs as including:

- Fishing gear (e.g. trawl nets, gillnets, pieces of net), fishing equipment (e.g. octopus traps), and abandoned or EOL fishing gear (ES03, ES04; HR01; IT02; PT01, PT04, PT05). Some fishing gear waste contains metal components (PT02),
- Hazardous waste (e.g. used oils, lubricants, oil filters and batteries) (ES01, ES02; HR02; MT01; PT01, PT03),
- Passively fished waste (HR01; MT01) including: plastics (e.g. plastic bags, bottles and packaging) (ES03; PT01, PT05); styrofoam (HR02; PT01, PT03, PT05); household-type waste (e.g. juice cartons, yogurt containers) (PT05); large pieces of wood (ES02; HR01; PT01); electronic waste (e.g. refrigerators, freezers, washing machines) (HR01; PT01),
- Organic fish waste (e.g. from fish gutting) (ES01; IT02),
- Plastic waste from fishing activities (e.g. plastic film used to cover fish, hard plastics, and polystyrene boxes) (ES02, ES03),
- Mixed municipal waste (HR01),
- Recyclable materials (e.g. glass, paper, cardboard, plastic) (HR01),
- Other types of waste (e.g. EU-labelled containers, trawler doors) (HR01; PT01).

Interviewees described the types of infrastructure they use to manage the different types of waste delivered to their ports (Table 2).

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Table 2. Port infrastructure mentioned interviews for managing different types of waste delivered by fishing vessels

Types of waste delivered to ports	Infrastructure for waste management
Fishing gear	• Net collection: nylon nets collected in separate containers for recycling (ES 04); non-recoverable nets and net pieces go to ordinary waste containers (ES 04); dedicated areas in warehouses are provided for collecting and storing gear before disposal (ES 02) • Dedicated containers (HR 01; PT 05) • Storage space for oversized EOL gear next to the container (HR 01)
Hazardous (MARPOL) waste	• Clean points (puntos limpios) (ES 01, 04) • Specific areas or structures for oil collection including retention basins (PT 04) • Receptacles for waste oils/filters (HR 01; MT 01)
Passively fished waste	• Specific projects and facilities help to segregate and characterise litter (ES 04) • Same facilities are used as for normal waste (MT 01) • Dedicated containers (HR 01) • The port provides blue bags which can be left alongside boats in the harbour (HR 01)
Organic fish waste	• No specific information provided
Plastic waste from fishing activities	• Clean points ("puntos limpios") (ES 04) • Large containers for styrofoam (HR 01)
Mixed municipal waste	• General waste containers (ES 04; HR 01) • Skips (MT 01)
Recyclable materials	• Recycling bins (HR 01; PT 05)
Other types of waste	• No specific information provided
Litter management projects	• Dedicated containers (PT 04)

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Different facilities, management challenges and future plans to improve waste management systems were identified for each country.

Croatian interviewees found PRFs convenient due to their proximity to docking areas, allowing fishers to dispose of waste immediately upon arrival (HR02). These facilities were described as always open, enabling waste disposal at any time, and offer comprehensive services for marine litter, municipal waste, recyclables, and EOL fishing gear. For EOL fishing gear, cost-free disposal was said to be available, eliminating financial barriers to proper waste disposal:

> *"As for EOL gear… we collect it and contact a company that takes it for recycling. There are no costs for the fishers, as opposed to when they previously had to dispose of it as bulky waste where they were chared per kilogram. This is a much better solution." (HR01).*

In Italy, PRFs for marine litter and ALDFG vary by port, with one port included in our study offering well-used facilities, allowing small-scale and purse seine fishers to deposit waste directly into containers or request reliable on-call collection services (IT02).

> *"Currently, fishermen appear to use port facilities effectively for the disposal of marine waste and ALDFG without difficulty. This is evident from the absence of abandoned waste piles in port areas." (IT02).*

However, not all ports have dedicated fishing waste facilities, leading some fishers to use general waste bins (IT01).

Maltese interviewees identified two types of PRFs: fixed facilities provided by terminal operators and mobile facilities managed by licensed waste carriers (MT01). The availability of fixed facilities varies; for instance, some are located near hard stands while others are offered by marina operators. Challenges include limited availability of facilities and the absence of dedicated options for passively fished waste, currently handled with municipal waste. Plans are underway to improve disposal mechanisms for this type of waste.

In Portugal, PRFs typically feature containers and collection points situated conveniently near unloading docks to facilitate waste disposal (PT03, PT05). Dedicated areas exist for MARPOL waste, such as used oil (PT04).

Spanish ports also prioritise convenient waste delivery by locating facilities close to docking areas (ES01). The specific arrangements differ significantly between ports, influenced by factors like port size and fishing fleet composition. For instance, containers for large ships are placed

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directly on the quay, while smaller boats can deposit waste within 15 meters of their docking area (ES01, ES03).

While some ports manage fisher-delivered waste, others lack specific treatments due to insufficient regulations (IT02) or being non-fishing ports (IT01). Waste recovery and utilisation depend on local authorities (IT02) or municipal services (IT01). The extent of recycling and reuse is inconsistent and hampered by practical and economic issues. Some ports promote waste separation using facilities like waste parks (PT02), dedicated clean points ("punto limpios") for fishing waste (ES03), and ecological islands (IT02). Sorting practices differ widely among countries and ports. For instance, common containers are used for solid urban waste (ES03), while separate bins exist for recyclables (HR01; ES03) and fishing waste types like oils and gear (PT03, PT04).

Recyclable materials such as styrofoam and plastics are sometimes collected separately (PT 02, 03, PT04), with some ports achieving 60-65% recycling rates for fishing waste (ES01). For EOL fishing gear, ports may have systems for notifying disposal needs, with designated containers for recycling (HR01). However, marine litter is frequently classified as municipal waste (HR01), though some ports are improving management strategies, like the 'Fish No Waste' project, which equips fishers with waste separation tools (HR01).

Challenges persist in establishing advanced recycling systems due to limited storage space and economic constraints (IT01). Much waste remains unsorted and classified as urban waste. For example, recycling fishing nets is complex and costly due to mixed materials (ES01), with non-recoverable nets often ending up in landfills (ES03; PT04). Contaminated materials, such as dirty styrofoam, may also be unrecyclable (PT05). Moreover, some ports lack sufficient recyclable materials to make recycling economically viable (PT01).

Monitoring of waste volumes and recycling rates is ongoing in some ports, with records submitted to environmental authorities; however, full implementation of CE practices faces significant hurdles (ES01). In Malta, no specific recycling system exists for litter from fishers, with available facilities typically addressing general waste. Efforts are underway to encourage berthing facilities to adopt better waste management practices, including receptacles for recyclables (MT01). Challenges include reluctance to provide food waste bins due to pest concerns and variability in waste management effectiveness across port areas. There is also a lack of publicly available documentation on waste management tailored for fishing vessels.

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Ports focus on waste collection and sometimes sorting. After delivery to the ports, waste is typically managed by contracted waste management companies that handle collection, disposal and recycling. These companies are responsible for collecting both recoverable and non-recoverable waste from collection points (e.g. clean points, containers or designated waste areas), and contracts sometimes incentivise companies to maximise recycling and valorisation (ES01). This process can be beneficial for all parties involved, when it incurs no costs for the fishers or the port and creates new raw materials through recycling (HR01).

Therefore, coordination between port and territorial planning is essential to ensure smooth integration with municipal WMPs and processes (e.g. provision of specific bins for fishing waste and information for fishers) (IT02). The responsibility for ensuring that local regulations are followed regarding final disposal typically falls on the waste carrier collecting the waste (MT01).

3.2 Challenges, solutions and economic impacts of managing waste from fisheries

This section provides an overview of interviewees' perceptions regarding the challenges, solutions and economic costs and benefits of managing waste from fisheries within the individual port(s) they represent.

Our analysis identified several key categories of challenges encountered by port authorities when managing the collection of marine litter and fishing gear, many of which were common in different locations. This highlights the complexity of marine litter management in ports and the need for comprehensive, tailored solutions that address both logistical and economic concerns.

Figure 4 shows the major challenges, potential solutions and the cost and benefits of implementing proposed solutions according to study countries.

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	Major challenges	Potential solutions	Costs & benefits of implementation
Spain	• **Awareness** and **participation** by fishers • Inadequate waste **separation and recycling** • **Financial** constraints • **Infrastructure** and capacity • **Regulatory** challenges and **harmonization**	• **Education** and **awareness** • **Collaboration** • **Infrastructure** and facilities • **Regulatory** and **financial** measures • Improved waste **processing**	**Economic costs:** • **Infrastructure** and **equipment** • **Personnel** • Waste management **Economic benefits:** • Long-term **cost savings** • **New revenue** streams • Indirect benefits
Portugal	• **Awareness** and **participation** by fishers • Fishers' **resistance to change** • **Inadequate** waste separation, recycling and management • Insufficient **infrastructure** and **resources** • Limited **monitoring and enforcement**	• **Education** and **awareness** • Improved waste **processing** • Increased **supervison and enforcement** • **Incentives and rewards** • **Infrastructure** improvements • **Collaboration** and standardization	**Economic costs:** • Higher **running costs** • Investment in **infrastructure** **Economic benefits:** • Improved port **cleaningness** and **operations** • Enhanced **fish quality and value** • Long term sustainability • Long-term **cost savings**
Malta	• Lack of **ownership** and **responsibility** • **Financial** constraints • Day-to-day **management** • Insufficient **infrastructure** • Inadequate **waste handling** • Lack of **harmonization** and misalignment with international conventions	• Agreement and **collaboration** amongst stakeholders • Dedicated **facilities** for passively fished waste • Effective **monitoring** system • Free disposal of waste • **Rewards programs** • **Harmonization** of policies • **Simplification** of procedures and **clearer policies**	**Economic costs:** • Significant costs of **implementing** and **running** **Economic benefits:** • Long-term **cost savings** • Lowering risk of incidents • Improved environmental accreditation
Italy	• Problem with **management** of ALDFG • Lack of **space** and dedicated **facilities** • **Financial** constraints • **Lack of interest** by companies	• Promoting a **circular economy**	**Economic costs:** • **Space** requirements • Invesment in **infrastructure** **Economic benefits:** • **New revenue** streams • Local economic growth
Croatia	• **Awareness** and **participation** by fishers • Fishers' **resistance to change** • **Human resources** and capacity • **Financial** constraints • Inadequate **infrastructure** • **Regulatory** constraints	• **Education** and **awareness** • **Incentive programs** • **Infrastructure** improvements • **Collaboration** and partnerships • Technology and innovations • **Financial** support	**Economic costs:** • **Infrastructure** investments • **Human resources** **Economic benefits:** • Long-term **cost savings** • Recognition and reputation • Potential for **co-financing** • Recycling opportunities

Figure 4. Main challenges ports face regarding the collection of ALDFG and marine litter, proposed solutions and estimated economic costs and benefits of addressing these challenges

The main challenges included:

- **Lack of clear regulation and regulatory harmonisation:** There is perceived lack of harmonisation in marine litter implementation and policies, with inconsistent implementation of EU regulations across different ports, even within the same country (ES04, MT01, HR02). Plus, national and EU policies on waste management are sometimes not aligned with international maritime conventions like MARPOL, which govern waste management on vessels (MT01). To add to this, in some locations there is a lack of clarity regarding the distribution of responsibilities among various stakeholders and ministries (HR01). The unclear division of duties creates obstacles in implementing

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programs or regulations effectively (HR01). The absence of harmonised regulations and standardised practices across ports creates inconsistencies in marine litter management (ES04). Policies also often fail to distinguish between different types of vessels and their specific waste management needs (MT01). Furthermore, recent legislation is still in the early stages of implementation (ES01).

- **Lack of ownership and responsibility:** The primary challenge is the absence of clear delegation of responsibility for providing and managing PRFs, especially in areas where fishers don't pay berthing fees. This creates uncertainty about who should bear the costs and manage the facilities (MT01).
- **Financial constraints:** The costs of implementation, maintenance, managing and processing marine waste, especially EOL fishing gear, require significant funding, which often outweigh the economic value of the recovered materials (ES01, MT01, IT02, HR01). Ports and local councils often face budget constraints, lacking sustainable, long-term financing mechanisms to cover these costs long-term (ES01, MT01, HR01). The economic costs are also prohibitive for companies due to high collection fees (resulting from the widespread distribution of ports, often with few fishing vessels) resulting in a lack of interested companies to engage in waste management (IT02).
- **Inadequate infrastructure, insufficient capacity, and day-to-day management challenges:** Some ports lack the necessary facilities, infrastructure and human resources to effectively collect, sort and manage waste (ES04, PT04, IT01, HR01, HR02). Smaller ports lack infrastructure or may struggle to implement comprehensive systems, leading to improper waste disposal (ES04, MT01). For instance, when fishers collect litter in a single bag, port workers must empty the bag and separate the waste into categories: a labour-intensive process that may require additional staff (HR02). Many ports face storage problems due to limited space, making it difficult to set up equipped areas within the port or to build treatment plants for waste management (IT01). In some other cases, public procurement policies result in inadequate capacity. As one interviewee said: "*Companies that win the tender are the ones offering the lowest prices, and some don't have the necessary means to fulfil everything that's required*" (PT04). Ongoing management of facilities (including security, CCTV, personnel for monitoring, and coordination with waste contractors) is challenging (MT01, PT04), while there are also challenges with companies that provide collection services (IT02).

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- **Inadequate waste separation, handling and recycling:** Ports struggle with effective separation and recovery of different types of waste, particularly discarded fishing gear (ES01, ES02, PT01, PT03, PT04). The complex mix of materials in fishing nets and degraded condition of marine plastics complicate sorting and increase processing costs (ES01, ES02). Also, in some ports most of the waste isn't sorted correctly and is all classified as “urban waste" (PT04). In some other locations, problems with inadequate handling of hazardous waste (e.g., oil) was mentioned; while, this is not the typical waste from fishing vessels, managing this hazardous waste presents additional challenges, with the risks of overfilling, spillage or damage to facilities, potentially leading to environmental contamination (MT01).
- **Limited monitoring and enforcement:** There is a lack of effective supervision and enforcement, both at sea and in ports. One interviewee stated that "*More supervision and intervention by the authorities*" is needed and that "...*sometimes they don't have the means*" or personnel to carry out proper monitoring and supervision (PT03, MT01).
- **Fishers’ resistance to change:** A certain resistance to changing established practices amongst fishers was also identified in some locations (PT03, HR02). One interviewee noted that "*The imposition of anything in fishing is always negative*", indicating that attempts to impose harmonised practices without proper engagement could face pushback from the fishing community (PT03). It often takes time and persistence to change established behaviours and ensure compliance with proper waste disposal methods (HR02).
- **Limited awareness and participation of fishers:** Several interviewees highlighted that one of the primary challenges is raising and maintaining awareness among fishers about proper waste management practices. This requires better and continued education and awareness campaigns, as well as daily engagement with fishers, to ensure consistent participation in litter collection (ES04, PT03, PT04, HR02). One interviewee described how generational shifts are contributing to increased environmental consciousness, but that continued efforts in education, outreach, and engagement are still needed to secure consistent involvement in litter collection initiatives (ES04).

Interviewees also identified several potential solutions to address the challenges of marine litter and ALDFG management, by improving coordination, making waste collection convenient for

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fishers, financing the system, providing incentives, establishing clear systems and policies and finding ways to recycle and reuse the collected materials. The solutions included:

- **Improve regulatory measures and financial support:** Changes to regulations and financial incentives could be adopted, including: establishing a stable financing system for waste management (ES01), seeking co-funding or co-financing through projects (HR02); harmonising waste management policies and practices across European ports (ES01, ES04, PT02, MT01); and implementing clear policies that address the common interests of all stakeholders (MT01).
- **Increase collaboration and partnerships:** Increased collaboration between different stakeholders and ports would help to harmonise processes, including: coordinating efforts between ports authorities, fishing associations, waste managers, environmental authorities, recycling companies, and relevant ministries (ES01, ES04, MT01, HR02); enhancing cooperation and exchanging experiences and information between ports (PT02, HR02); and participating in research projects to develop new solutions (ES01).
- **Improve waste management systems:** Reorganizing waste management responsibilities, including transferring all management of fishing areas to those responsible for first sale locations (e.g., Docapesca in Portugal) as they already handle daily operations and communication with fishers (PT01); Increase monitoring (e.g., CCTV), supervision and enforcement by maritime authorities to prevent irregular and illegal dumping, or unauthorised use of facilities (PT03, MT01), and improving tracking systems (e.g., GPS tracking systems on all fishing vessels to better monitor fishing activities and waste disposal) (PT02); promote a CE transforming waste into resources (IT02).
- **Enhance in-situ waste collection and sorting:** Ports could invest in better infrastructure and facilities to make waste collection easier, by: implementing a more comprehensive waste collection system with dedicated collection and sorting facilities (PT02, MT01); providing more containers and collection points close to where fishing vessels dock (ES01, ES05); installing compactors and other equipment to reduce waste volumes (ES02); creating dedicated "*clean points*" for collecting different types of waste (ES01, ES04); implementing innovative technologies (e.g., automatic collection systems for certain types of waste, creating an App to record waste generated by each vessel) (PT04; HR02); or providing controlled, locked containers to monitor and measure waste disposal by specific vessels (HR02).

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- **Improve waste processing:** Better methods to process and recycle collected waste could be implemented, including: investing in technology to separate and recycle different types of plastics from fishing gear (ES01, ES02) and exploring partnerships with companies interested in recycling marine plastics (ES01, ES04).
- **Increase education and awareness:** Ports could implement a system of continued education and awareness-raising among fishers, including: continuous awareness campaigns (ES04, PT03, PT04, HR02), holding frequent talks and information sessions for fishers (ES01, ES04, HR02), and involving local communities (PT05).
- **Setting incentives and rewards:** Ports could provide tangible benefits to fishers involved in collecting marine litter, including: improving existing incentive programs (e.g., Sea without Waste) (PT02); exploring new incentives (e.g., reductions in port fees, auction fees, fuel subsidies, providing equipment, or other incentives) for fishers who bring back marine litter from sea (ES01, ES02, PT03, MT01, HR02); and recognizing fishers' efforts in collecting marine litter (ES01, MT01).

Interviewees also identified the potential economic costs and benefits for ports of implementing the proposed solutions for marine litter and ALDFG management. These varied across ports and countries. It's important to note that the full economic impact is difficult to quantify and would likely vary depending on the specific port and solutions implemented.

Potential economic costs included:

- **Infrastructure and equipment costs** of investing in additional containers, compactors, weighing equipment, and other facilities to improve waste collection and segregation (ES04, ES05, PT02, IT01, IT02, HR2). Interviewees estimated costs of around 200,000 euros to set up collection facilities (E05), and around 30,000-50,000 euros a year for additional containers, trucks, and personnel to monitor waste collection (ES04).
- **Waste management.** Ports would require significant initial investment and an increase in budget allocation to face increased operational costs for waste management services, especially if they take on the responsibility for managing waste that was previously handled by fishers or other entities (ES01, MT01). One interviewee noted that implementing better waste management would require increasing the budget by "*a few million*" (PT05). Some specific costs were also mentioned, such as waste transfer costs in Malta: since Malta lacks on-site waste handling facilities, there would be additional costs to transfer waste from the port to other facilities on the island (MT01).

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- **Space requirements.** A major challenge in smaller harbours would be the need for more space to unload waste with a subsequent economic investment for the port expansion, when feasible (IT02).
- **Higher service costs.** Contracting more capable waste management companies would likely increase costs (PT04).
- **Personnel.** There might be a need for additional human resources to establish effective port surveillance, provide education/training, and manage new waste management processes (ES04, HR01)
- **Incentives and rewards.** reward programs for fishers who properly dispose of waste could represent an additional cost for the port or relevant authorities if implemented (MT01).

Potential economic benefits included:

- **Long-term cost savings.** Improved waste segregation and recycling could reduce disposal costs over time (ES02, PT01, PT02, PT03, HR01, HR02). One interviewee noted that in 2024, the port paid approximately 6,000 euros for waste removal and implementing more efficient practices could help lower costs (HR01). Another interviewee highlighted that compacting certain materials like EPS (polystyrene) could increase its value from 50 to 700 euros per ton (ES02).
- **Additional revenue and new revenue streams.** Some ports see potential for generating revenue from recycled materials (ES02, IT02, RH01), depending on market conditions as current recycling efforts are often not profitable due to high labor costs for separating materials (ES01).
- **Reduced illegal dumping.** Implementing a proper waste management system would decrease illegal dumping, which is expensive to clean up (MT01).
- **Lower risks of accidents.** A better waste management system would reduce the risk of incidents, potentially saving money on mitigation efforts (MT01).
- **Reduced pest issues.** Proper waste management could help minimise problems with pests (e.g., seagulls and rats) potentially reducing associated control costs (PT04).
- **Indirect benefits.** Several interviewees emphasised long-term environmental benefits that could have long-term economic impacts, such as reduced pollution and improved sustainability of fishing grounds (ES05, PT03), local economic growth related to new activities and operators (IT02), improved port cleanliness and overall port functioning (PT01, PT04), improved environmental accreditation scores potentially leading to ISO

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certifications for quality protection and environmental management (avoiding penalties and reducing costs) (MT01, HR02), increased recognition and reputation potentially attract more business or funding opportunities (HR02).

3.3 Capacity and willingness to improve policies and facilities

In this section, we present interviewees' insights about their capacity and willingness to improve policies and facilities to properly manage and monitor fishing litter, including recycling and CE activities. This includes perspectives on the harmonisation of policies and facilities across ports and across countries, willingness to implement the required improvements previously identified in managing and monitoring fishing litter, and views on their current roles and challenges regarding contributing to a CE.

3.3.1 Improving policies and facilities through harmonisation

Overall, the port authorities interviewed described a low degree or lack of harmonisation of marine litter management policies and practices in their respective countries. While there are common European directives and regulations on ship and fishing vessel waste (e.g. MARPOL), these must be harmonised with varied national laws (IT01, MT01). One consequence is that implementation of European directives and regulations is unevenly applied across ports (HR02). In Malta, for example, vessels of all types, from large commercial ships to small fishing boats, are often treated the same way as land-based waste sources, such as households or commercial entities (HR01). Furthermore, there are regional disparities in the policies and incentives between different parts of Europe: while northern European countries (e.g. Belgium, the Netherlands, Germany) were said to have various policies and incentives in place, southern countries were said to be unaligned with their northern counterparts (MT01).

Challenges to harmonisation

Several common challenges to harmonisation were identified:

Regulatory and administrative challenges are prevalent in the management of fishing waste. Often, national and EU policies are not aligned with international conventions, such as MARPOL (MT01). This discord makes it difficult to find common solutions within the European network, given the varying legislation across member states (IT02). Additionally, the legislation concerning accidental fishing waste is relatively new and poorly defined (ES01). Current

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regulations are criticised for being too general and failing to consider the specific needs of many port facilities (ES04).

There is also a significant lack of personnel to monitor and enforce regulations at sea (PT03). Furthermore, port authorities are not entirely autonomous; they depend on government and state ports for decision-making (ES01). Regulations are frequently imposed without consulting the actual needs on the ground, leading to new waste separation requirements that are perceived as unrealistic and challenging to implement in practice (HR01). Also, the absence of adequate adaptation periods for the implementation of new regulations forces some ports into non-compliance (ES04).

Economic and logistical factors pose significant challenges to waste management in the fishing industry. A major concern is the need for stable and sustainable financing for waste management programs (ES01, HR01). Additionally, small-scale economics in waste management often lack profitability, making it difficult for operators to remain viable (IT02). The recovery of marine litter, particularly fishing nets, is complex and costly due to the labor-intensive process of separating different materials (ES01). Furthermore, many ports face a lack of space for establishing equipped areas or building treatment plants, complicating waste management efforts (IT01). Implementing potential operational changes is also not straightforward (MT01). There is a limited presence of economically interested operators, especially in smaller localities, which exacerbates the challenges (IT02). At the national level, there is no established practice for marine waste management, resulting in many landing ports having reception facilities that are either non-existent, locked, or insufficient in capacity and human resources (HR01). Additionally, state bureaucracy and institutional inertia regarding public tender processes further complicate effective waste management (PT05).

Differences between ports significantly impact waste management practices. Ports vary greatly in size, infrastructure, and levels of fishing activity, which complicates the implementation of uniform practices (ES04, PT03, PT05). This discrepancy influences the amounts and types of waste they handle (ES01). Additionally, each port has a distinct fishing fleet composition, such as the presence of trawlers versus purse seiners, resulting in variations in the types and quantities of waste generated (ES01). Moreover, the levels of experience among ports differ; some have been addressing marine litter issues for many years, whereas others are just beginning to tackle these challenges, leading to disparities in knowledge and capabilities (ES01).

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Coordination and standardisation issues present significant challenges in waste management across ports. There is a lack of uniformity, as each port and region manages waste differently, which complicates efforts for harmonisation (ES04). Additionally, ports are at various stages of implementing regulations, further contributing to inconsistencies (IT01). There is a pressing need for stakeholder involvement to address these challenges effectively (ES04, PT03, PT04). Furthermore, there is often a lack of understanding regarding the needs and expectations at institutional levels (HR01). This situation is compounded by an unclear distribution of responsibilities among different stakeholders and ministries (HR01, MT01).

Other issues affecting waste management in the fishing industry include the need for improved education and awareness among fishers (HR01, HR02). There are also challenges related to mixing different types of waste (PT02) and the difficulty of separating waste from various sources (PT03). Additionally, there is resistance to change among fishers, particularly concerning potential fees (MT01).

Solutions to harmonisation

The port authorities suggested potential solutions to the harmonisation challenges they had identified that could be applied across ports and across countries:

Regulatory and administrative solutions are essential for improving waste management practices across ports. To harmonise different national legislations with common European directives and regulations, a concerted effort is needed to identify common solutions within the European network that can be effectively implemented across various legal frameworks (IT02). An improved European regulatory framework is necessary; regulations should be more specific and easier to implement in all ports, along with a common system for sustainability and financing of waste management (ES01). Additionally, there should be adaptation periods in new regulations to give ports adequate time to comply (ES01).

Establishing clear policies is also crucial (MT01). More uniform criteria and clearer guidelines from national authorities could help standardise practices across different ports (ES01). Furthermore, ports need greater authority to enforce regulations effectively (PT04). Agencies such as the national navy, coastal control units, and maritime authorities could play a significant role in supervising and enforcing these regulations (PT03).

Economic and logistical solutions are vital for enhancing waste management practices. Expanding the scale of waste management is one approach; by creating larger-scale economies,

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it becomes more economically attractive for operators to participate (IT02). This shift could help alleviate the current lack of profitability in small-scale waste management operations (IT01). Additionally, ports could collaborate on joint waste management contracts—particularly among nearby ports—to reduce costs and improve efficiency (ES01). Increasing budgets for waste management contracts (PT04) and reducing bureaucracy and paperwork (PT02) are also important steps. There is a clear need for a stable, long-term financing system for marine litter management programs, rather than reliance on short-term project funding (ES01). Furthermore, hiring additional personnel is necessary to manage the increased workload effectively (HR02).

Addressing port differences is crucial for effective waste management strategies. A flexible implementation approach is necessary; while general guidelines are important, interviewees acknowledge that the practical application may need to differ between ports due to their unique characteristics. Solutions should consider the variations in port size, infrastructure, and types of fishing fleets (ES01). Additionally, tailored support is essential for addressing these differences. Some ports may require more assistance, such as dedicated coordinators for waste management, while others with established systems may not need this level of support (ES01).

Coordination and standardisation solutions are essential for improving waste management across ports. Effective coordination among multiple stakeholders, including port authorities, fishers' associations, waste managers, and government bodies, is crucial (ES04, HR02, PT03, PT04). This coordination must also include a clearer distribution of responsibilities (HR02).

Increased collaboration between ports is necessary, particularly for sharing best practices and experiences. Advanced ports could guide those just starting out (ES01, HR02). Being part of a network or partnership focused on waste management can help overcome institutional obstacles in general (HR02, IT02). Identifying and emphasizing shared goals and benefits is vital for overcoming potential resistance and building consensus among different entities (MT01).

Additionally, coordinating and standardizing fee structures across ports could help prevent ships from selecting waste disposal sites based solely on cost (ES01). It is important that waste management procedures are similar, well-defined, and clear in each port (IT01).

Other issues include the need for continuous education and awareness-raising among fishers (e.g. daily conversations, discussions, workshops, leaflets, visits to ports that manage waste well) to improve fishers' awareness and adherence to proper waste management practices (HR02, PT01, PT02).

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3.3.2 Suggested improvements in managing and monitoring fishing litter including recycling

Interviewees identified the need for improvement in the current approach to marine litter management and recycling. It was suggested that there is room for more efficient and effective systems, and that a more harmonised approach across European ports could be beneficial in addressing these challenges (MT01). Some ports indicated their willingness to make significant improvements, particularly with the implementation of new WMPs and systems:

- **Develop recovery systems**: Implement more efficient and accessible waste management systems within the port (IT02, MT01) and explore innovative solutions, such as developing applications to monitor waste generation and management (HR01).
- **Collaborate with companies and stakeholders**: Work with waste recovery companies to handle special waste and develop economically viable collection systems (IT02); develop agreements between major entities and fishers to develop effective waste management systems (MT01).
- **Join networks**: Become part of networks or partnerships focused on marine litter management to overcome institutional obstacles and create larger scale economies (IT02).
- **Infrastructure renovation**: Better organisation of harbours to enhance waste management facilities (PT02).
- **Standardisation**: Some ports are working towards obtaining ISO certifications for quality protection and environmental management (HR02; PT04). By implementing these standards, ports aim to set an example for other ports and demonstrate their commitment to sustainable practices (HR02).
- **Fishers' rewards programs**: Implementing environmentally friendly practices, such as reward programs for collecting marine litter, could incentivise fishers to collect and properly dispose of marine litter (HR02) and help the port achieve higher environmental accreditation scores (MT01).
- **Encourage CE**: Promote the transformation of waste into resources, such as using fish waste for animal feed production or cosmetics (IT02).
- **Participation in EU-level discussions**: While not specifically focused on CE, participation in relevant working groups and subgroups at the EU level could potentially include discussions on CE principles (MT01).

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3.3.3 Fostering a circular economy

In Malta, ports currently have a limited role in promoting CE principles for marine litter from fishers since they do not have a specific legal responsibility in this matter (MT01). Nevertheless, the interviewee acknowledged that promoting a CE would be beneficial for all port users, and that other entities such as the Environmental and Resources Authority are currently implementing policies related to CE principles, in collaboration with stakeholders (MT01).

Interviewees in the Croatian, Italian, Portuguese and Spanish ports described playing several key roles in promoting CE principles for marine litter from fishers:

- **Facilitator and supporter:** Ports act as facilitators and supporters for companies operating in the port area to implement CE practices. They provide infrastructure, facilities, and incentives to enable more sustainable waste management (ES02, IT01).
- **Waste prevention and collection:** A primary objective is to prevent pollution by encouraging the disposal of accidentally caught waste on land rather than discarding it at sea (IT02). For example, mitigating the environmental impact of marine litter through proper collection and disposal methods (IT02).
- **Waste management and separation:** The ports in Croatia were described as being actively engaged in proper waste management practices. They provide facilities for fishers to dispose of various types of waste, including marine litter, EOL gear, and other waste generated on fishing vessels (HR01). The ports ensure that waste is separated and handled according to regulations, which is a crucial step in promoting CE principles (HR02).
- **Infrastructure provider:** Ports provide the necessary infrastructure for waste collection, segregation, and management (IT02). This includes installing facilities like:
    - Green points for MARPOL waste and battery collection (ES01);
    - Ensuring easy access to waste collection points for fishers (ES01);
    - Facilities for fishers to deliver marine litter and EOL fishing gear (PT05);
    - Specific containers for the Sea without Waste program (PT05);
    - Contracting waste management companies to collect and process the waste delivered by fishers (PT04).
- **Indirect fee system:** A new indirect fee system in Italy, established by Legislative Decree 197/2021, is being implemented to discourage waste discarding and promote collection from all naval units, including fishing vessels (IT02). This system involves paying a fee for

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access to waste disposal services, which is expected to act as an incentive for proper waste management (IT02). Some ports elsewhere offer tax rebates and reduced port fees to companies that demonstrate good environmental practices (ES01).

- **Promoter and educator:** Ports take on a leadership role in promoting CE principles through awareness campaigns, educational initiatives, and recognition of fishers' efforts (ES01, PT03). They organise talks, share data on waste collection, and highlight the positive impact of fishers' actions on social media and other platforms (HR02, ES01, PT03).
- **Recycling and reuse efforts:** There are some attempts at recycling and reusing materials:
    - Styrofoam recycling: The port separates styrofoam for recycling, which seems to be one of the few materials consistently sorted (PT04);
    - Nylon nets: When possible, nylon nets are sent to a company for recycling (PT01); Recycling of fishing gear is a key CE practice implemented by the Croatian ports. They collaborate with companies to recycle EOL fishing gear, turning it into new raw materials (HR01). This process not only reduces waste but also creates value from what would otherwise be discarded.
    - Metal and plastic separation: EOL fishing gear is sometimes separated into metal (frames) and plastic (netting) components for recycling, though this is not always done consistently (PT02);
- **Participating in projects:** Many ports actively participate in research projects and initiatives focused on improving waste management and promoting CE principles (ES01). They collaborate with technology centres, private companies, and other stakeholders to explore innovative solutions for waste recovery and valorisation. Ports also participate in various projects aimed at reducing marine litter and promoting CE practices, for example:
    - The 'Fish No Waste' project, which includes equipping a recycling facility and providing fishers with equipment for waste collection (HR01);
    - The Fishing for Litter project, where fishers were provided with protective gear and bags for waste collection (HR02);
    - The Sea without Waste program (PT05).

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- **Policy implementer:** Ports work to implement and enforce regulations related to waste management and CE practices. They establish specifications for waste collection services that prioritise recycling and proper waste management (ES02).
- **Circular economy department:** Some ports have dedicated departments or offices focused on promoting CE principles. For example, one port has a blue economy department specifically tasked with participating in projects to achieve CE goals (ES01).

While ports play these important roles, it's worth noting that they currently face multiple types of challenges in implementing CE principles:

- **Limited space**: The lack of space within the port makes it difficult to set up equipped areas or build treatment plants for waste (IT01).
- **Economic viability**: The management of fishing waste, particularly on a small scale, and of recycling some materials is often not economically profitable (ES01, IT02).
- **Lack of specialised facilities**: There is a current absence of facilities specifically dedicated to receiving and processing fishing waste (IT01).
- **Lack of recovery and valorisation** of certain types of marine litter like fishing nets (ES01).
- **Limited sorting**: Most waste is not properly sorted and is often classified as general urban waste (PT04).
- **Lack of control**: The port often has difficulty controlling what waste is brought in and how it's disposed of (PT01).
- **Budget constraints**: Decreasing budgets make it difficult to implement more comprehensive waste management systems (PT04).

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4 Discussion and Conclusions

Despite the existence of a unified legal framework through EU Directive 2019/883/EU, significant challenges persist in achieving effective harmonisation of PRFs and waste management processes across EU Member States. One of the main obstacles is the variation in how Member States transpose and implement the Directive's requirements, resulting in inconsistencies in the adequacy, accessibility, and efficiency of PRFs from port to port (Directive 2019/883/EU, Art. 4).

While the Directive mandates that PRFs must be adapted to the operational needs of port users, capable of receiving all MARPOL-designated waste categories, and employ processes that are simple and quick, the practical application of these standards often diverges due to differences in national legislation, port size, available infrastructure, and administrative capacity. In many regions, facilities are either insufficient in capacity or poorly adapted to the operational needs of fishing vessels, especially small-scale or artisanal fleets (Richardson et al., 2017, 2021). This leads to disparities in the quality of waste reception services, the level of fees charged, and the implementation of indirect fee systems and incentive schemes for the delivery of passively fished waste and EOL fishing gear (Directive 2019/883/EU, Art. 8; Verdesoto et al., 2025).

Inadequate PRFs can result in long waiting times, inconvenient locations, or limited opening hours, all of which discourage use and increase the likelihood of illegal disposal at sea. The lack of harmonised standards at EU level and inconsistent enforcement at Member State levels further complicate efforts to ensure compliance and monitor effectiveness (IMO, 2021).

Our research demonstrates that port environmental policy implementation varies by port size and national frameworks. Larger ports show comprehensive waste management, while smaller ones face diverse responsibilities and capacity issues. The PRFs described in our research vary significantly by country and waste type, with some areas lacking adequate infrastructure. The Croatian ports were said to offer convenient, always-open PRFs for immediate waste disposal. In Italy the ports had varied facilities, with some lacking direct waste collection options. The Maltese ports featured fixed and mobile PRFs but faced limited availability. The Portuguese ports provide easy access to containers near docks, while the Spanish arrangements depend on port size, highlighting disparities in infrastructure. Many ports face challenges in managing fisher-delivered waste due to insufficient regulations and infrastructure. Recycling rates are inconsistent, hindered by economic constraints, limited storage capacity, and contamination with other litter items. Some ports lack dedicated recycling systems or effective waste

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separation methods. Coordination between port planning and municipal services is crucial for improving waste management and recycling practices.

Fee structures are a critical determinant of PRF use. While the IMO does not prescribe a specific charging system, it emphasises that cost recovery mechanisms must not discourage use (IMO, 2021). The European approach, as articulated in Directive 2019/883/EU, mandates indirect fee systems to cover the full cost of waste reception, thereby removing direct financial disincentives for waste delivery. However, the implementation of these systems remains uneven across Member States, with some ports continuing to apply direct fees or failing to provide sufficient transparency regarding fee structures (Verdesoto et al., 2025). Some ports fail to provide clear information in accessible languages or to adapt fees for vessels demonstrating sustainable waste management practices (Directive 2019/883/EU, Art. 8).

Although EU directives mandate free disposal of marine litter for fishers, lack of harmonisation and challenges in enforcement persist across regions, affecting waste management effectiveness. Our research identified inconsistent application of fee structures for waste delivery across the study countries. Some ports charge direct variable fees; others use flat fees or exemptions. Many lack clarity on fees, leading to mixed effectiveness perceptions and suggestions for improvements, including incentive programs and better alignment with MARPOL regulations.

The challenge of fisheries waste management is further compounded by the need to balance economic sustainability for ports with the goal of maximising waste delivery. Small surpluses may be necessary to cover indirect costs and investments in PRF improvements, but excessive fees or poorly designed systems can undermine compliance and drive illegal dumping (Verdesoto et al., 2025). The Directive encourages the use of differentiated fees to reward vessels that minimise waste or adopt sustainable practices, but the practical application of such incentives is still evolving. It was evident from this report that fees levied to fishers represent an ongoing struggle for port authorities, requiring careful and rigorous analysis and regulation. One source of financial support could come from the requirement for producers of single use plastics ('extended producer responsibility'), including fishing gear containing plastic, to cover the costs for setting up and operation of specific infrastructure and collection and treatment of waste regarding single use plastic products (Article 8, Directive 2019/904).

Fishers face unique challenges in complying with PRF requirements. Long periods at sea, limited storage capacity on small vessels, and the absence of on-board incinerators can make it difficult

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to retain waste until reaching port (Gnip & Velkavrh, 2022; Mantoju, 2021). In regions with low inspection rates or limited enforcement, the only proof of disposal may be entries in the waste record book, which are susceptible to falsification (Gnip & Velkavrh, 2022). Furthermore, administrative burdens, lack of awareness, and insufficient incentives can discourage fishers from using PRFs, particularly when facilities are not tailored to their specific needs (Richardson et al., 2021).

The port authorities interviewed highlighted a critical need for continuous dialogue and engagement with fishers about the use of PRFs. They said that effective promotion of PRFs for fishers relies on awareness campaigns, partnerships, user engagement, continuous availability, and investments in capacity. Interviewees emphasised collaboration and adapting practices to meet fishers' needs, while highlighting challenges like personnel limitations and the importance of integrating fishing waste into MARPOL systems.

This research illustrates the importance of education, training, and stakeholder engagement in promoting compliance and improving waste management practices. Fishers are more likely to use PRFs when they are involved in the design and operation of facilities, receive clear information about available services, and perceive tangible benefits from compliance. Conversely, high administrative burdens, complex procedures, or a lack of trust in the system can drive non-compliance and perpetuate the problem of marine waste. The perceptions elicited from the interviews conducted highlight that these challenges are significant.

Waste management processes for ship-generated waste face significant limitations, particularly concerning the sorting, collection, and proper treatment of waste. One persistent issue is the insufficient separation of waste streams both on board and at PRFs, which undermines recycling efforts and environmentally sound disposal (MARPOL Annex V; Vaneeckhaute & Fazli, 2020). Although MARPOL Annex V and related IMO guidelines require vessels to sort waste according to defined categories and encourage ports to provide facilities for separate collection, in practice, the infrastructure for sorting and segregating waste is often lacking or inconsistently applied (IMO, 2021; Vaneeckhaute & Fazli, 2020).

Collection processes are further hindered by the limited capacity or inconvenient location of PRFs, which may not be available around the clock or may not be adapted to the operational realities of fishing vessels and small ports (Directive 2019/883/EU, Art. 4; IMO, 2021). Also, ensuring proper treatment is not always guaranteed. In many cases, ship-generated waste is either inadequately treated or simply transferred to landfill, rather than being recycled or

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valorised, due to a lack of suitable onshore treatment facilities, insufficient integration with municipal waste systems, or the absence of incentives for recycling (Directive 2019/883/EU; Vaneeckhaute & Fazli, 2020).

Financial constraints, lack of ownership and responsibility for providing PRFs and fishers' resistance to change also hinder processes for waste collection and management in the ports studied. Additionally, monitoring of waste reception in fishing ports varies by size and governance. Larger ports aligned with MARPOL have robust tracking systems, while smaller ports lack effective monitoring, relying on general reports. Feedback from fishers was identified as crucial for assessing effectiveness, but formal evaluations and consistent monitoring practices remain inadequate across smaller ports.

These limitations collectively undermine the effectiveness of international and European legal frameworks and highlight the need for improved infrastructure, harmonised procedures, and stakeholder engagement to ensure that waste is not only collected, but also properly sorted and treated in an environmentally responsible manner. The constraints mentioned in relation to waste management and the market impediments to products resulting from recycling processes were emphasised by the interviewees linked to port authorities in large ports in this study.

Interviewees indicated a willingness and capacity to implement improvements to properly manage and monitor fishing litter, including recycling and CE activities. Indeed, they proposed several solutions to improve marine litter and ALDFG management, including enhancing coordination and convenience for fishers. Although the interviewees recognised that these solutions would require economic investment, they identified several long-term benefits such as cost savings, additional revenue and new revenue streams, and reduced illegal dumping.

Another example of port authorities' willingness to manage waste more effectively is the extent and diversity of CE activities they claim to be already practicing. Nevertheless, they noted many obstacles to implementation such as limited space, economic viability and lack of recovery and valorisation of waste.

There are several additional important considerations regarding implementation of CE approaches in European fisheries operations. Technological issues include a lack of mature recycling infrastructure and processing capacity (Deshpande et al., 2020), alongside a need for standardisation and optimisation of extraction procedures (Caruso et al., 2020). Regulatory constraints involve complex compliance with evolving EU regulations (Zhang et al., 2023), legal obstacles impacting new product development (Caruso et al., 2020), and the EU Common

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Fisheries Policy's slow adaptation to climate change (Ruiz-Salmón et al., 2020). Economic barriers include lost local value due to waste export (Deshpande et al., 2020) and feasibility challenges in implementing new processes (Caruso et al., 2020). Environmental and operational issues involve managing micropollutants and microplastics (Zhang et al., 2023), necessary changes in governance and consumer behavior (Ruiz-Salmón et al., 2021), territorial limitations (Ruiz-Salmón et al., 2021), stakeholder engagement challenges (Cooney et al., 2023), and quality control in extraction (Caruso et al., 2020). Addressing these challenges requires technological innovation, policy development, and stakeholder collaboration across the supply chain.

Potential solutions include enhancing local recycling capabilities (Deshpande et al., 2020) and implementing CE strategies to close the loop for fishing plastics (Deshpande et al., 2020). Ultimately, successful implementation of CE principles requires overcoming challenges such as infrastructure limitations, regulatory barriers, and the need for cost-effective technologies (Caruso et al., 2020; Deshpande et al., 2020).

Our report also underscores the need for harmonising marine litter management policies across European ports to ensure more consistent and effective waste management practices and effective contribution to CE strategies. The lack of harmonised procedures for data collection and reporting on waste volumes further complicates monitoring and enforcement, making it difficult to assess compliance or to compare performance across ports and Member States (Directive 2019/883/EU, Art. 13).

Interviewees suggested that harmonisation can lead to improved compliance with regulations, better resource allocation, and enhanced collaboration among ports. This could be achieved through regulatory alignment, clear policies and standards, economic collaboration, coordination among stakeholders and education and awareness. In this way, ports could effectively harmonise their approaches, leading to improved management of marine litter and greater sustainability in fishing practices.

To conclude, although ports are attempting to comply with the EU and national regulations on fisheries waste management and have many successful strategies in place, there is significant room for improvement in terms of PRFs infrastructure, stakeholder education, and implementation of more standardised, aligned and advanced CE principles and processes.

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5 Recommendations for Policy and Practice

Streamline regulatory framework

- **Harmonise and clarify regulations:** A more unified regulatory framework at EU level with clear guidelines that harmonises with national legislation could help standardise practices and make implementation easier across ports in different Member States and ensure consistency and ease of compliance for fishers who operate in multiple locations. This harmonisation could extend to the European level to create a more unified approach. But also recognise that different ports may have different needs and challenges and allow for some flexibility in implementing waste management strategies while maintaining overall consistency.
- **Establish clearer guidelines on roles and responsibilities:** National policies, programs and plans need to define clear roles and responsibilities for various stakeholders and ministries.
- **Implement the indirect fee system**: Policies should support the implementation of the indirect fee system introduced by European legislation, which includes waste disposal costs in a fixed fee paid by vessels to incentivise proper waste disposal without additional charges.
- **Recognise the unique needs of fishing vessels:** Develop specific policies that address the unique waste management needs of different types of vessels (e.g. shipping versus fishing) as well as different types of fishing vessels (e.g. purse seine, trawler). Current policies often treat vessel waste the same as waste generated on land, which is not always appropriate.
- **Support collaborative/co-management systems for waste management:** Ensure that new regulations and measures are developed in consultation with local stakeholders to address practical challenges.

Enhance economic viability

- **Establish sustainable funding mechanisms** Policy should focus on 1) addressing budget constraints by reviewing and potentially increasing budgets for waste management, and 2) establishing sustainable funding mechanisms, potentially through a combination of government support, industry contributions, port fees and extended producer responsibility schemes, to ensure continuity of these programs.

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- **Promote CE principles**: Policies should support research and innovation into more effective methods of reuse, recycling and valorising marine litter, especially fishing gear to mitigate current challenges in recycling certain types of waste and to encourage the transformation of fishing waste into valuable resources. This could involve supporting initiatives that promote the recycling and reuse of fishing gear and other marine litter or use fish waste for animal feed production or other purposes, creating economic incentives for proper waste management.
- **Create port operations networks**: To make waste management economically viable, policies should promote larger-scale operations across multiple ports. This approach could attract more companies to participate in waste recovery and processing.
- **Improve tender processes for waste management companies**: Revise the criteria for selecting waste management companies, focusing on quality of service rather than just the lowest price.

Support adequate infrastructure development

- **Improve infrastructure and facilities:** Policies should support the development and improvement of PRFs to ensure they are adequate, easily accessible, and properly maintained to make it as convenient as possible for fishers to deliver marine litter.
- **Develop dedicated facilities for fishing waste**: Currently, some ports lack specific facilities for receiving and managing fishing-related waste. Implementing dedicated reception facilities for marine litter and abandoned, lost, or discarded fishing gear (ALDFG) would make it easier for fishers to dispose of waste properly.
- **Optimise space utilisation**: Given the limited space in many ports, policies should focus on efficient use of available areas for waste management. This could include creating designated areas for waste collection and temporary storage.

Improve monitoring and data collection

- **Establish effective monitoring systems**: Policies should focus on developing adequate methods to track and measure the effectiveness of waste management practices, particularly for fishing-related waste, as well as proper enforcement and compliance checks to prevent abuse.
- **Strengthen monitoring and enforcement**: Increase the presence and effectiveness of maritime authorities to ensure compliance with fishing and waste management regulations at sea. This may require allocating more resources to relevant authorities.

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- **Improve waste traceability**: Implement systems to better track and quantify waste from fishing vessels and ALDFG, distinguishing them from other port waste. This could involve digital tracking systems such as an application for recording waste generated by each vessel or tracking the implementation of WMPs for more detailed reporting requirements.

Provide incentives and support for fishers

- **Ensure free disposal for special waste**: Policies should guarantee that the disposal of special waste, including EOL and ALDFG, remains free of charge for fishers to remove financial barriers to proper waste disposal. Waste management systems should have simple and effective procedures to ensure fishers' participation.
- **Invest in education and awareness for fishers:** Policies should prioritise comprehensive and ongoing education and awareness programs for the fishing sector, focusing on environmental protection and proper waste management and targeting both local and foreign workers in the fishing sector.

Promote partnerships and knowledge sharing

- **Involve multiple stakeholders:** Policies should encourage closer collaboration between various stakeholders in marine litter management, including port authorities, environmental authorities, fishing associations, producers' organisations, waste recycling companies and local authorities to develop and implement effective waste management strategies.
- **Promote partnerships and networks**: Policies should encourage ports to participate in networks or partnerships focused on marine litter and ALDFG management. This collaboration could facilitate knowledge sharing and the implementation of best practices.
- **Promote collaboration between ports:** Policies should encourage and facilitate collaboration between ports, especially those in close proximity, to share best practices, coordinate efforts, and potentially reduce costs through joint initiatives. This could involve creating formal networks or partnerships focused on marine litter management.

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7 Appendix – Policy Brief

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PREVENT WP2 Fishers as Guardians and Cleaners of the Ocean

Litter management plans and facilities at ports

July 2025

An assessment of challenges and recommendations for marine waste management in European fishing ports

Context

"NETTAG+ AIMS TO EMPOWER THE FISHERIES SECTOR TO TAKE EFFECTIVE ACTIONS TO ADDRESS MARINE POLLUTION, PROMOTING THEIR ROLE AS KEY ACTORS TO TACKLE MARINE POLLUTION"

Fishing port reception facilities (PRFs) are central to preventing marine litter pollution and supporting both sustainable fisheries and circular economy transitions. However, in many European regions PRF infrastructure to manage fishing-related waste is deficient, incentivising illegal disposal and further complicating efforts to monitor and manage marine waste.

NETTAG+ aims to provide a portfolio of three innovative smart and sustainable solutions to address the negative impacts of abandoned, lost or otherwise discarded fishing gear (ALDFG) on marine life and habitats. NETTAG+ is based on synergistic activities between the fisheries industry, scientists and NGOs to develop three solutions to PREVENT, AVOID and MITIGATE the harmful impacts of ALDFG.

Pertaining to the PREVENT solution, this research aimed to:

1) understand the legal framework governing port reception facilities (PRFs) and waste management in European ports and
2) gather the perceptions, experiences and practices of those responsible for the reception and treatment of waste delivered to ports by fishers.

Our assessment examined fishing litter management in ports across Croatia, Italy, Malta, Portugal and Spain, focusing on fisheries waste management policies, practices, infrastructure, and the economic and social implications of these systems. We also investigated key obstacles and the capacity and willingness of port authorities to enhance management, including recycling and circular economy activities.

In this policy brief, we identify key challenges, and policy recommendations for waste management in European fishing ports.

Challenges

Our analysis identified several key categories of challenges encountered by port authorities when managing the collection of fisheries-related marine litter and fishing gear, many of which were common in different locations. This highlights the complexity of marine litter management in ports and the need for comprehensive, tailored solutions that address both logistical and economic concerns.

Lack of clear regulation and harmonization
- Unclear division of responsibilities between ministries and stakeholders
- Policies not targeted to fishing vessels or aligned with MARPOL
- Inconsistent implementation of EU regulations across ports

Lack of ownership and responsibility
- Uncertainty about who bears the costs of managing PRFs

Financial constraints
- Long-term funding mechanisms required to manage marine waste, especially end-of-life fishing gear;
- Costs outweigh the economic value of recovered materials

Inadequate capacity in ports
- Ports lack infrastructure, facilities and human resources to effectively collect, sort and manage waste

Inadequate waste separation, handling and recycling
- Ports struggle to manage different types of waste

Limited monitoring and enforcement
- Lack of effective supervision at sea and in ports

Fishers' resistance to change
- Attempts to impose practices without engagements risks pushbacks

Limited awareness and participation of fishers
- Low participation in proper waste management practices

Recommendations

Although ports are attempting to comply with the EU and national regulations on fisheries waste management and have many successful strategies in place, there is significant room for improvement in terms of streamlining policies and processes - especially those relating to the circular economy, modernising PRF infrastructure and investing in end-user education.

Streamline regulatory framework
- Harmonize and clarify regulations
- Establish clearer guidelines on roles and responsibilities
- Implement the indirect fee system
- Recognize the unique need of fishing vessels
- Adapt regulations to local realities

Enhance economic viability
- Establish sustainable funding mechanisms
- Promote circular economy principles
- Scale up waste management operations
- Improve tender processes for waste management companies

Promote partnerships and knowledge sharing
- Involve multiple stakeholders
- Promote partnerships and networks
- Promote collaborations between ports

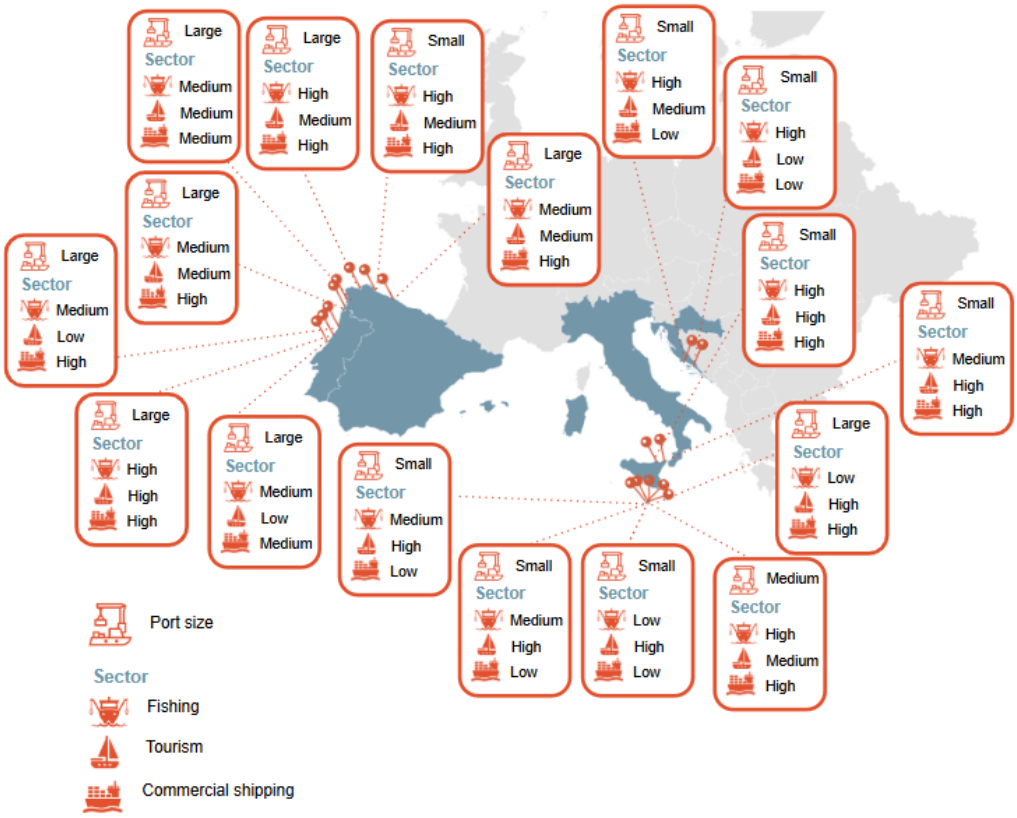
Support adequate infrastructure development
- Improve infrastructure and facilities
- Develop dedicated facilities for fishing waste
- Optimize space utilization

Improve monitoring and data collection
- Establish effective monitoring systems
- Strengthen monitoring and enforcement
- Improve waste traceability

Provide incentives and support for fishers
- Ensure free disposal for special waste
- Invest in education and awareness for fishers
- Reward waste management

Methodological Approach

In-person, semi-structured interviews with 15 port authorities and managers from selected fishing ports in Croatia, Italy, Malta, Portugal and Spain were conducted between November 2024 and April 2025. Interviewees were selected based on their active involvement in environmental or overall port management, and to represent a diversity of port sizes and infrastructures ensuring a grounded perspective on the handling and reception of fishing-related waste under different practical and institutional circumstances.



Locations and characteristics of ports studied

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