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Agenda Item 4: Progress report on the implementation of SPA/RAC activities under the UNEP/MAP Programme of Work for the biennium 2024-2025

Guidelines for reducing discharge of solid waste from fishing boats

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Note by the Secretariat

1. This present document has been developed within the context of the GEF FishEBM MED project[1] "Fisheries and ecosystem-based management for the blue economy of the Mediterranean" under output 3.3 " Measures identified to cope with the negative effects of non- indigenous species on biodiversity as well as those of other potential stressors" that focus potential stressors such as marine litter and how they are reportedly impacting Mediterranean fisheries, biodiversity, human health, and ecosystem services. For further details on FishEBM project please refer to the document "Status of the implementation of The GEF FishEBM MED project "Fisheries and Ecosystem Based Management for the Blue Economy of the Mediterranean" (UNEP/MED WG.608/Inf.6).

2. The guidelines focus on identifying measures to mitigate the negative impacts of waste from fishing vessels. This report reviews existing waste management practices, identifies common sources of solid waste, assesses the effectiveness of current regulations and systems at fishing port facilities, and highlights existing gaps and areas for improvement. It provides practical recommendations to enhance the management of waste generated by fishing activities and vessels, in line with POST-2020 SAPBIO Action 7.

3. This document is hereby presented to the 17th Focal Points Meeting for information.

[1] funded by GEF through a partnership between the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP) with execution facilitated by the General Fisheries Commission for the Mediterranean (GFCM) and the Mediterranean Action Plan (MAP) under the Barcelona Convention, through the Specially Protected Areas Regional Activity Centre (SPA/RAC). The project is implemented in Albania, Algeria, Bosnia and Herzegovina, Lebanon, Libya, Montenegro, Morocco, Tunisia, and Türkiye to foster a sustainable future for Mediterranean fisheries while promoting the broader blue economy agenda.

UN environment programme

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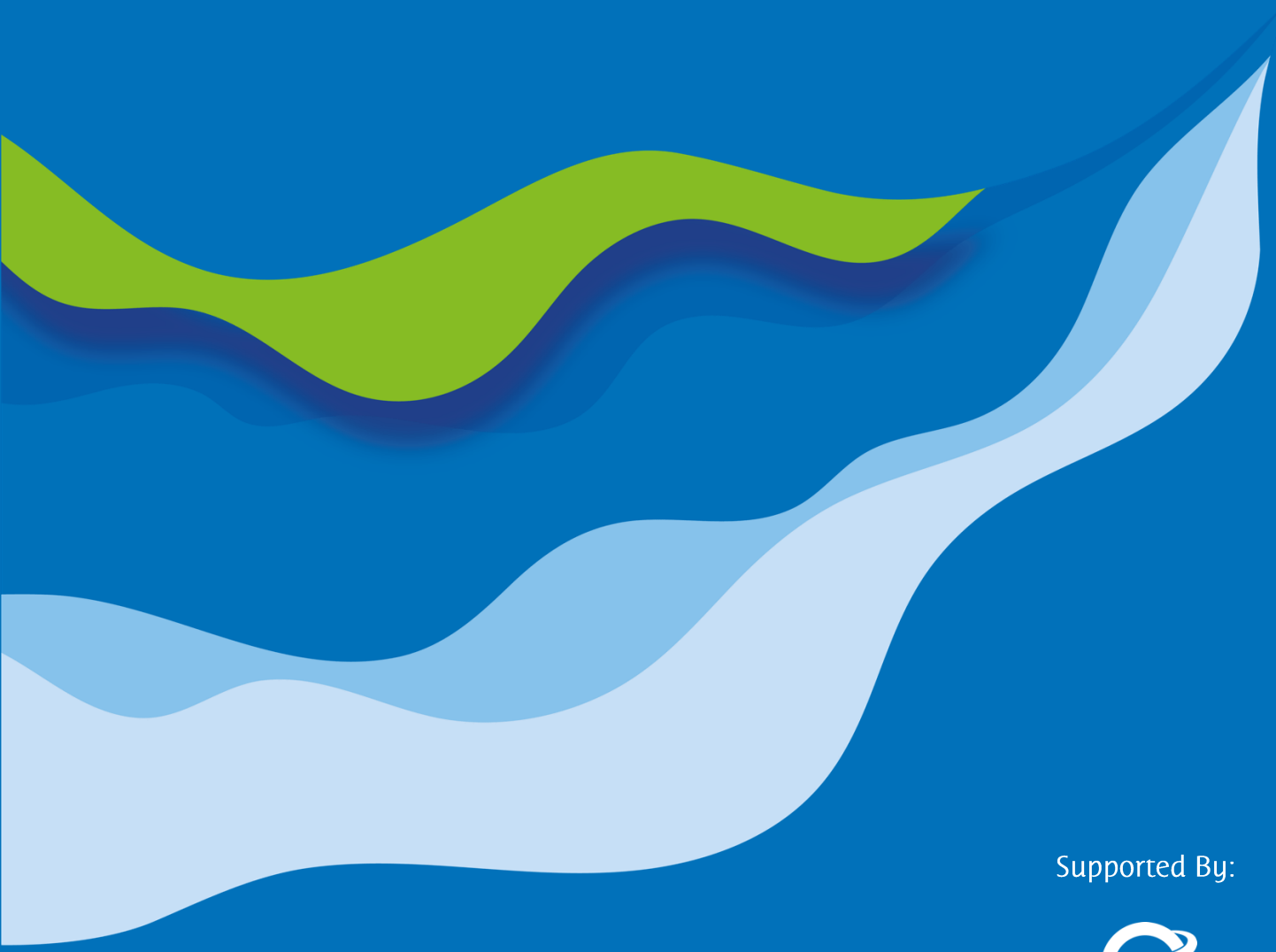
REDUCING SOLID WASTE FROM FISHING BOATS IN THE MEDITERRANEAN: GUIDELINES TO SUPPORT SAPBIO POST-2020 ACTION 7



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List of acronyms

ALDFG: Abandoned or Lost Derelict Fishing Gears
DFG: Derelict Fishing Gear
EPR: Extended Producer Responsibility
FAD: Fish Aggregation Device
FAO: Food and Agriculture Organisation
GEF: Global Environment Facility
GES: Good Environmental Status
GESAMP: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM: General Fisheries Commission for the Mediterranean
GIS: Geographic Information Systems
IMO: International Maritime Organization
LSF: Large-Scale Fisheries
MEDPOL: Programme for the Assessment and Control of Marine Pollution in the Mediterranean
NGO: Non Governmental Organization
NSF: No-Special-Fee
PRF: Port Reception Facilities
ROV: Remotely Operated Vehicle
REMPEC: Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
SSF: Small Scale fisheries
UNEP: United Nations Environment Programme
VMS: Vessel Monitoring Systems

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François Galgani is a senior scientist at Institut français de recherche pour l'exploitation de la mer (Ifremer, France), specializing in marine environmental sciences and pollution in the Mediterranean Sea. Over the course of his career, he has worked in several renowned

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Dr. Galgani has actively contributed to major global initiatives, including those led by the G7, G20, and the UNEA Science Advisory Committee on Plastic Pollution. From 2019 to 2021, he served on the Board of the EU Horizon Europe Mission "Restore our Oceans and Waters."

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Executive summary

The Mediterranean Sea, a critical marine ecosystem supporting diverse environmental pressures, including fisheries, faces significant threats from marine litter, particularly waste generated by fishing activities. This issue necessitates urgent action to ensure sustainable fisheries, biodiversity conservation, and economic stability for coastal communities. The FishEBM MED project, led by the FAO and UNEP with support from the Global Environment Facility (GEF), aims to strengthen ecosystem-based fisheries management while mitigating marine pollution.

One of the most pressing challenges in the region is the inadequate management of waste from fishing vessels, particularly abandoned, lost, or discarded fishing gear (ALDFG). The accumulation of such waste contributes to ghost fishing, habitat destruction, and microplastic pollution, severely impacting marine biodiversity. Additionally, the lack of effective waste disposal mechanisms and enforcement of regulations has led to illegal dumping and inefficient waste management at ports. Addressing these issues requires the development and implementation of well-equipped Port Reception Facilities (PRFs) to ensure proper waste handling and disposal.

Currently, existing PRFs are often insufficient in capacity, poorly regulated, and financially burdensome for fishers. To enhance their effectiveness, PRFs must be strategically located in key fishing hubs, ensuring accessibility and efficiency in waste collection. These facilities should be designed with adequate storage capacity and equipped with waste segregation and recycling technologies to process fishing gear, plastics, and other operational waste efficiently. Properly managed PRFs will help minimize marine litter and provide fishers with convenient and cost-effective waste disposal options.

Implementation of PRFs in the Mediterranean requires harmonized regulations and policies across regional and international frameworks. Aligning PRF management with MARPOL regulations, the Barcelona Convention, and EU Directive 2019/883 will establish uniform waste disposal standards. The introduction of a No-Special-Fee (NSF) system, where waste disposal costs are integrated into port fees, will encourage compliance among fishers and reduce illegal dumping. Additionally, financial incentives and funding from governments and international organizations should be allocated to improve PRF infrastructure and operations, ensuring their sustainability.

To further strengthen PRFs, guidelines are proposed to address the specific issue of waste from fishing vessels. A focus on Small Scale and artisanal Fisheries (SSF), in addition to Large-Scale Fisheries (LSF) has become critical. Regional cooperation among Mediterranean countries is also essential. Data sharing, standardized monitoring systems, and collaborative enforcement measures will enhance transparency and efficiency in waste management. Public-private partnerships can also play a significant role in developing and maintaining PRFs, ensuring cost-effectiveness and long-term sustainability. Furthermore, raising awareness among fishers through training programs and community engagement initiatives will foster responsible waste disposal practices and encourage the use of PRFs.

By prioritizing PRFs as a key solution to marine waste management, Mediterranean countries can significantly reduce pollution, protect marine ecosystems, and support sustainable fisheries, enhancing the resilience and economic well-being of coastal communities reliant on fishing industries.

1 INTRODUCTION

The Mediterranean Sea, a semi-enclosed basin with rich biodiversity and a long history of human interaction, faces increasing threats from marine litter, particularly waste generated by fishing activities. This region supports diverse industrial, semi-industrial, and small-scale fisheries, relying on a variety of benthic and pelagic stocks. Sustainable management is essential to balance marine biodiversity preservation with the needs of coastal communities dependent on fishing for employment, nutrition, and economic sustenance. Emerging sectors like tourism and oil exploration add to anthropogenic pressures, underscoring the urgent need for ecosystem-based management.

The FishEBM MED project, supported by the Global Environment Facility (GEF), is a collaborative effort led by the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP). It aims to reverse the over-exploitation of commercially significant marine resources by strengthening the capacity of Mediterranean countries to manage fisheries using ecosystem-based management tools. The project aligns with the Post-2020 Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean (SAPBIO) and the General Fisheries Commission for the Mediterranean (GFCM)'s 2030 strategy. Key objectives of the FishEBM MED project include developing ecosystem-based management tools to ensure long-term sustainability.

Under this component, the focus is on identifying measures to mitigate the negative effects waste from fishing vessels. This report reviews waste management practices, identifies common sources of solid waste, evaluates the effectiveness of current regulations and systems at fishing port facilities, and highlights gaps and areas for improvement. It provides guidelines to better manage waste generated by fishing activities and fishing vessels, in line with POST 2020 SAPBIO Action 7.

2 MEDITERRANEAN FISHERIES AND MARINE LITTER

2.1 Fishing, Fishing Vessels, Waste, and Litter in the Mediterranean Sea

Global fisheries production has increased dramatically over the past decades, driven by the growing demand for seafood. Aquaculture now contributes a substantial portion of total production. The fishing industry's environmental impacts include overfishing, habitat destruction, bycatch, and pollution from waste. Discarded fishing gear, plastics, and other waste materials contribute to marine litter, posing risks to marine ecosystems and human health.

The global fishing fleet comprises millions of vessels, ranging from small artisanal boats to large industrial trawlers. The size and composition of the fleet vary significantly across regions. Unlike other regions with large mono-specific fisheries, the Mediterranean relies on a variety of benthic and pelagic stocks, including molluscs and crustaceans. The Mediterranean fishing fleet is predominantly small-scale and artisanal, consisting of over 73,000 vessels (FAO, 2023). These fisheries are vital for regional food security, livelihoods, and socio-economic stability.

Different fishing techniques are employed, each with specific impacts on the marine environment. Trawling, for example, can cause significant damage to the seabed, while longlining and gillnetting can result in bycatch and the entanglement of marine animals. The Mediterranean faces numerous challenges, including overfishing, habitat degradation, pollution, and climate change. These pressures threaten the sustainability of fisheries and the health of marine ecosystems.

Fishing activities are a significant source of marine litter, contributing to the degradation of Mediterranean ecosystems. Abandoned, Lost, or Derelict Fishing Gear (ALDFG) poses a persistent threat, with materials such as nets, ropes, and traps remaining in the marine environment for decades. In addition to litter from fishing operations, plastic from grey water, microplastics from paints and coatings, and abandoned shipping vessels exacerbate the problem. Plastic packaging used for storing and transporting fish, bait, and other supplies is another component of waste from fishing vessels, while operational waste includes general waste from fishing vessels, such as food containers, plastic bottles, and other debris.

Fishing-related litter constitutes a significant portion of marine debris, particularly plastic waste, accounting for over 95% of all recorded debris in some areas. Factors influencing litter generation include fishing operations (such as the type of fishing gear used, the intensity of fishing activities, and the operational practices of fishing vessels), waste management practices (including collection schemes, the availability of waste management facilities in ports, the cost of disposal, and fishers' awareness), and regulatory frameworks, particularly the enforcement of regulations governing waste management from fishing vessels.

Monitoring and assessing litter distribution and composition—specifically seafloor litter and abandoned, lost, or otherwise discarded fishing gear (ALDFG)—in the Mediterranean Sea is crucial for understanding the extent and impact of marine pollution, as the seafloor accumulates much of the marine litter, including ALDFG. Various methods are used to monitor and assess seabed litter, each with its own advantages and limitations.

Trawl surveys provide long-term data collection but may underestimate litter due to gear limitations, as they are only effective on soft sea beds. Visual surveys, conducted by divers or using underwater cameras, offer detailed observations but have limited spatial coverage. Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) enable detailed observation of complex seafloor terrains; however, their high costs and the complexity of data integration present significant barriers to widespread use.

Emerging technologies, such as Acoustic Imaging Systems, facilitate large-scale seafloor mapping, identifying areas with high concentrations of litter. Meanwhile, Hyperspectral Imaging and Machine Learning enhance litter detection and classification, but further development is needed for large-scale application.

2.2 ALDFG in the Mediterranean Sea

Data scarcity remains a significant obstacle to comprehensive assessments of fishing vessel waste, particularly in small-scale fisheries. Studies on abandoned, lost, or otherwise discarded fishing gear (ALDFG) have highlighted the localized and regional impacts of fishing gear waste. Areas such as the Tunisian-Sicilian Channel, the north-eastern part of the Levantine Basin, the Alboran Sea, the south-western coast of Spain, and the northern Adriatic exhibit some of the highest densities of fishing-related debris, reflecting the intensity of fishing activities. Specific gear types are used in certain regions, such as Fish Aggregating Devices (FADs) in the southern part of the Sicilian-Tunisian Channel, while ropes and lines, along with mussel and oyster socks, constitute up to 30% of fishing-related waste in the northern

Adriatic. Despite these challenges, initiatives such as Fishing for Litter have shown promise in promoting waste recovery and fostering regional collaboration. Programs that incentivize fishers to retrieve lost gear and bring marine litter ashore are gaining traction as practical and cost-effective solutions.

2.3 Impacts of Waste from Fishing Vessels: A Focus on the Mediterranean Sea

Waste from fishing vessels, especially abandoned, lost, or otherwise discarded fishing gear (ALDFG), significantly impacts marine ecosystems, biodiversity, and coastal economies. ALDFG contributes to ghost fishing—the continued trapping and killing of marine animals long after being discarded— causing harm to marine life, damaging habitats, and spreading invasive species.

A wide range of marine species are vulnerable to entanglement in ALDFG, including fish, seabirds, marine mammals, and sea turtles. Additionally, ALDFG can damage sensitive marine habitats such as coral reefs and seagrass beds. While ingesting plastic can cause various health problems, including digestive blockages, malnutrition, and exposure to toxic chemicals, it remains a minor impact of waste from fishing vessels. However, the breakdown of fishing materials introduces microplastics that may enter marine food webs. Waste from fishing vessels can also transport invasive species to new areas, including on the seafloor, disrupting local ecosystems. Furthermore, fishing gear can leach harmful chemicals into the marine environment, though this remains a minor source of contamination. Finally, marine litter undermines the socio-economic foundations of coastal communities reliant on fisheries and tourism, placing financial burdens on ecosystem services. Impacts include reduced catches due to ghost fishing and habitat degradation, decreased tourism revenue from polluted beaches and coastal areas, expenses associated with cleaning up marine litter from beaches and coastal waters, and repair costs resulting from damage caused by floating debris, which poses navigation hazards, particularly for smaller vessels.

3 MANAGEMENT OF WASTE FROM FISHING VESSELS

Strategies to mitigate waste from fishing vessels include research, prevention through improved gear design, awareness programs, gear marking, recovery initiatives, and recycling efforts.

Prevention, awareness, and technological measures focus on implementing regulations to reduce gear loss and improve waste management practices on fishing vessels, raising awareness among fishers about the impacts of marine litter and promoting responsible waste management practices, and utilizing technological approaches, such as durable, biodegradable materials and improved operational practices, to minimize gear loss.

Strategies to limit ALDFG rely on improved fishing practices that minimize the risk of gear loss, regular inspection and maintenance of fishing gear to prevent breakage and loss, and the responsible disposal of damaged or unwanted gear at designated waste facilities.

Localization and marking of fishing gear help identify and recover lost gear by applying unique identifiers to track ownership and facilitate recovery and establishing systems for reporting lost gear to enable timely retrieval efforts.

Recovery efforts include encouraging fishers to collect marine litter during fishing activities and bring it ashore for proper disposal, developing and deploying technologies for locating and retrieving ALDFG from the seafloor, and cleaning ALDFG before sending the material to a recycling facility or landfill. Programs such as *Fishing for Litter* and advanced retrieval technologies help mitigate environmental impacts.

Effective waste management in harbours is crucial, particularly in regions like the Mediterranean. Key strategies include ensuring that ports have sufficient capacity to handle waste from fishing vessels, providing Port Reception Facilities (PRFs) with convenient locations and operating hours to facilitate waste disposal, and offering financial or other incentives for fishers to use PRFs.

Port Reception Facilities (PRFs) play a critical role in preventing marine pollution by providing proper waste disposal services for ships, including fishing vessels. These facilities ensure compliance with MARPOL and other regulations aimed at reducing marine litter. However, the availability and effectiveness of PRFs vary across Mediterranean ports. Improving PRF operations requires addressing challenges such as inadequate capacity, high costs, and lack of coordination.

Establishing dedicated recycling programs for fishing gear and exploring alternative uses—such as repurposing discarded gear for construction materials—can promote sustainability. However, technical challenges and financial viability remain key concerns in scaling up these initiatives.

Global efforts to tackle waste from fishing vessels involve international agreements, regional frameworks, and collaborative projects. The International Maritime Organization (IMO), MARPOL, and the London Convention (MEPC.1/Circ.834/Rev.1), as well as the Barcelona Convention (MAP/REMPEC, 2019), and to a lesser extent, EU directives (e.g., EU 2019/883), are working to enhance Port Reception Facility (PRF) infrastructure, promote best practices in waste management, and support cooperation in addressing marine litter. Numerous international and regional projects and initiatives are also dedicated to improving waste management from fishing vessels. Global initiatives, such as the IMO-FAO/GLO LITTER (Glo- Litter), and Mediterranean-focused projects, such as MEDSEALITTER (MedSeaLitter), aim to promote sustainable fishing practices. Additionally, many Mediterranean countries have implemented national programs to address waste management from fishing vessels.

4 EXISTING GUIDELINES

Over the past decades, there has been increasing international recognition of the need for multilateral efforts to address transboundary problems resulting from waste generated by fishing vessels, including ALDFG and ghost fishing (MacFadyen, 2009; Richardson et al., 2018). Past performance assessments of governance frameworks within regional fisheries management organizations have identified substantial deficits, particularly in monitoring, surveillance, and enforcement (Gilman et al., 2023). It has become clear that stakeholders—including governments, regulatory bodies, fishers, and environmental organizations—must work collaboratively to implement effective measures and ensure the sustainability of marine ecosystems.

The development of guidelines is a long and complex process, often taking decades and evolving based on knowledge acquired over time. References to recommendations on fishing waste date back many years, initially based on scientific studies (review in Stelfox et al., 2016) and later integrating acquired knowledge into the development of management plans.

In the Mediterranean Sea, guidelines for Port Reception Facilities (PRFs) are shaped by international conventions, regional agreements, and EU directives. Mediterranean states ensure compliance with PRF regulations through a combination of governance frameworks, monitoring systems, and regional cooperation. These measures help ensure that PRFs in the Mediterranean operate efficiently, meet international environmental standards, and contribute to reducing marine pollution in this ecologically sensitive region.

4.1 The 2009 FAO/ UNEP guidelines

Not only in the Mediterranean Sea, but globally, UNEP has played a key role in assessing and analysing the situation from scientific, environmental, social, economic, and even political perspectives. The body of reference work in this field is substantial and deserves recognition. In its reports from 2009 (MacFayden et al., 2009), FAO and UNEP provide a comprehensive and action-oriented roadmap for tackling the problem of abandoned, lost, and discarded fishing gear (ALDFG). The combination of preventive, mitigating, and curative measures ensures a multi-faceted approach to reducing ALDFG and its impacts. The recommendations emphasize regulatory improvements, technological advancements, and economic incentives to drive change in the fishing industry.

The guidelines mention that the most effective approaches to mitigating ALDFG are:

a) Preventive Measures :

- Gear Marking for Ownership Identification (mandatory, harmonized tracking methods, integrating registration numbers).
- On-Board Technology for Gear Tracking (monitoring, locating, and recovering lost gear using acoustic technology).
- Port State Measures and Gear Disposal Facilities (implementation of PRFs, incentives, and regulatory frameworks).
- Reduction of Fishing Effort (limited deployment, restrictions on soak-time, fishing quotas, and licensing policies).
- Spatial Management and Zoning (regulations for high-risk areas, minimizing gear conflicts, and promoting sustainable fishing techniques).

b) Mitigation Measures

- Biodegradable and Alternative Gear Materials (use of biodegradable materials, reduced entanglement risks, incentives, and funding).
- Reducing Ghost Fishing Impacts (escape panels and degradable twine, acoustic deterrents, collaboration with scientists).
- Improved Gear Retrieval Programs (incentives for fishers to retrieve lost gear, organized and supported retrieval missions in high-risk areas, partnerships between fishers and environmental organizations).

c) Curative Measures

- Locating and Mapping Lost Gear (databases, sonar and remote sensing technology for retrieval, reporting of gear loss through mobile applications and logbooks).
- Gear Recovery and Clean-Up Initiatives (coordinated operations involving fishers, NGOs, and governments; targeted retrieval; public-private partnerships).

- Recycling and Waste Management (dedicated recycling facilities for fishing gear, economic incentives for recycling synthetic fishing materials, exploration of up cycling programs that repurpose old gear into usable products).

d) International and Policy-Level Recommendations

- Integration of ALDFG Concerns into Existing International Agreements (strengthening MARPOL Annex V regulations, greater enforcement of FAO's Code of Conduct, strengthening regional fisheries management organizations).
- Legislation and Regulation at the National Level (national governments should adopt clear legislation on gear marking, retrieval, and disposal, impose penalties for illegal gear discarding, and mandate the reporting of lost gear incidents).
- Economic and Incentive-Based Approaches (encouraging responsible fishing practices, supporting research on alternative materials and sustainable fishing practices, and introducing gear buyback programs to remove obsolete fishing equipment from circulation).
- Awareness and Capacity Building (public campaigns, training programs on responsible fishing practices, and conferences and workshops on best practices).

4.2 The Honolulu Strategy

The Honolulu Strategy is a global framework developed in 2011 by scientists, practitioners, managers, and the private sector from around the world to address marine debris, including solid waste, lost cargo, and ALDFG. It was developed with the support and assistance of the United Nations Environment Programme (UNEP) and the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program throughout the development process of the Fifth International Marine Debris Conference.

It aims to reduce ecological, economic, and human health impacts associated with marine litter through strategic planning and collaboration among international, national, and local stakeholders. The strategy does not impose specific targets but provides a structured approach to managing marine debris by reducing waste generation, enhancing monitoring and enforcement, and facilitating waste recovery and disposal.

One of the key areas addressed by the strategy is waste management from fishing vessels and ALDFG, which is critical to minimizing the adverse effects of marine litter. The strategy also emphasizes the role of Port Reception Facilities (PRFs) in preventing the improper disposal of waste at sea. This document outlines the monitoring, location, retrieval, and treatment of marine litter, particularly from fishing activities and vessels, as well as the significance of efficient port reception systems.

a) Monitoring of Marine Litter and ALDFG

Effective monitoring systems are essential to track marine litter sources, assess their impact, and evaluate the effectiveness of mitigation measures. The Honolulu Strategy proposes several key actions for enhancing the monitoring and location of ALDFG:

- Standardized Data Collection (uniform methodologies to monitor marine litter in coastal areas, sea beds, and pelagic waters).
- Integration of Reporting Mechanisms (requiring operators to report lost or abandoned gear through national databases).
- Utilization of Remote Sensing and Tracking Technologies (satellite monitoring, sonar detection, and electronic tagging of fishing gear to locate and recover lost equipment).

- Collaboration with Fisheries and Maritime Authorities (strengthening cooperation between environmental agencies and the fishing industry to ensure compliance with waste management regulations).
- Public Participation and Citizen Science (engaging local communities, non-governmental organizations (NGOs), and researchers in litter tracking initiatives).

b) Marine Litter and ALDFG Location and Retrieval

- Mapping Hotspots (using geospatial data to identify key locations such as fishing or convergence zones).
- Recovery Initiatives and Clean-ups Campaigns (targeted clean-ups missions involving government agencies, environmental organizations, and fishing communities).
- Ghost Net Retrieval Programs (incentive-based retrieval programs where fishers are compensated for recovering lost nets and gear).
- Innovative Removal Technologies (use of autonomous underwater drones for detecting and retrieving marine litter).
- Cross-Border Cooperation (regional collaboration in areas where trans-boundary marine litter is a significant concern).

c) Treatment and Disposal of Fishing Waste and ALDFG

To minimize environmental impact, the strategy highlights several approaches:

- Recycling and repurposing (recycling old fishing nets into new products, such as ropes, textiles, and construction materials).
- Biodegradable Fishing Gear (promoting the development and use of biodegradable materials to replace traditional plastic-based fishing gear).
- Responsible Waste Management Systems (establishing clear protocols for sorting and disposing of collected waste to prevent its re-entry into marine environments).
- Waste-to-Energy Solutions (alternative waste treatment options, such as incineration and energy recovery from non-recyclable materials).
- Legislative Frameworks and Incentives (measures mandating proper disposal and providing financial incentives for sustainable waste practices).

d) Port Reception Facilities and Their Role in Waste Management

Port Reception Facilities (PRFs) play a crucial role in providing designated areas for waste disposal and recycling. Key measures include:

1. Expansion and Modernization of Facilities (increasing the number and capacity of PRFs to accommodate waste from vessels).
2. Improved Waste Collection and Processing (enhancing waste sorting and treatment infrastructure to ensure efficient disposal and recycling of ship-generated waste).
3. Financial Incentives for Proper Disposal (introducing cost-reduction schemes and subsidies for vessels that utilize PRFs responsibly).
4. Strict Enforcement of MARPOL Annex V (ensuring compliance with MARPOL regulations to prevent illegal waste disposal at sea).
5. Awareness and Training Programs (educating ship operators, fishers, and port authorities on best practices for waste management and legal requirements).

4.3 The International Maritime Organization, MARPOL and its annexes

The global guidelines regarding Port Reception Facilities (PRFs, are based on international standards, particularly those set by the International Maritime Organization (IMO). Member States of the MARPOL Convention are required to provide adequate port reception facilities to handle waste from ships, including oil residues, sewage, garbage, and other hazardous substances. These facilities must enable efficient waste management without causing undue delays to ships.

The IMO has adopted a strict "zero tolerance" policy for illegal discharges at sea. This requires every port to have adequate facilities to prevent ships from dumping waste into the ocean.

In 2018, the IMO published a consolidated guide for providers and users of PRFs (MEPC.1/Circ.834/Rev.1), which compiles several circulars on best practices for these facilities. This document is a critical resource for maritime stakeholders, ensuring that ship waste is managed responsibly, reducing marine pollution, and improving port reception services globally. It provides:

a) Regulatory Framework and Responsibilities

- The document highlights the legal obligations of both ships and port operators under MARPOL. Ships are required to minimize waste generation and deliver waste to designated reception facilities, while ports must ensure the availability and adequacy of these facilities.
- Special emphasis is placed on special areas and emission control zones, where stricter waste disposal regulations apply.

b) Best Practices for Ship Operators

- Pre-arrival Notification: Ships should provide advance notice of their waste disposal needs to the port reception facilities to streamline operations.
- Efficient Waste Management: Ship-owners should implement waste minimization strategies, such as reducing packaging materials and segregating waste at the source.
- Record Keeping: Vessels must maintain accurate records of waste disposal through standardized forms, such as the Garbage Record Book.

c) Best Practices for Port Reception Facilities

- Adequate Infrastructure: Ports must ensure that reception facilities are accessible, well-maintained, and capable of handling various types of ship-generated waste, including hazardous materials.
- Standardized Procedures: PRFs should provide uniform documentation and receipts for waste delivered by ships.
- Cost Considerations: Ports must avoid excessive fees for waste disposal to encourage compliance and discourage illegal dumping at sea.

d) A Reporting and Compliance System

- A reporting mechanism is in place for ships to notify authorities about inadequacies in port reception facilities.
- A global database on PRFs has been integrated into the IMO Global Integrated Shipping Information System (GISIS) to provide stakeholders with access to relevant information.

- Regional arrangements may be established to meet MARPOL requirements when individual implementation is not feasible due to exceptional circumstances (e.g., for Small Island Developing States (SIDS)).

Environmental, health, and safety (EHS) guidelines for ports recommend implementing appropriate infrastructure to collect and treat waste generated by ships and the port itself, while conducting rigorous environmental assessments to ensure that waste management complies with both **human health** and **environmental protection** standards. Within **IMO**, the **Mediterranean Sea** has been designated as a **Special Area** under **MARPOL Annex I (oil pollution)** and **Annex V (solid wastes**), requiring stricter controls on waste discharge. Moreover, **PRFs** must be adequate to handle all **MARPOL** wastes, including oil residues, sewage, garbage, and cargo residues.

4.4 The Barcelona Convention

Article 14 of the "Prevention and Emergency" protocol requires Mediterranean countries to ensure adequate port reception facilities (PRFs) in ports and marinas, with these facilities operating efficiently without causing undue delays to ships.

Additionally, the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) has outlined key strategies and best practices to address waste management from fishing vessels in the Mediterranean (MAP/REMPEC, 2019; MAP/REMPEC/IMELS, 2020). These guidelines focus on PRFs, cost recovery systems, regulatory frameworks, and operational best practices to minimize the environmental impact of ship-generated waste and abandoned, lost, or otherwise discarded fishing gear (ALDFG). REMPEC's work aligns with international commitments under the Barcelona Convention, the MARPOL Convention, and EU Directives (2000/59/EC and EU 2019/883) on PRFs.

A major challenge identified by REMPEC is the lack of adequate PRFs in many Mediterranean ports, leading to improper disposal of fishing waste at sea. To mitigate this, REMPEC emphasizes the No-Special-Fee (NSF) system, which allows fishing vessels to offload waste at PRFs without direct financial charges. This system is essential in preventing illegal dumping, as it removes cost-related barriers that discourage waste delivery. The NSF system has been successfully implemented in several European ports, notably in the Baltic Sea and North Sea regions, demonstrating its effectiveness in reducing marine litter.

Additionally, REMPEC highlights the need for cost recovery systems that align with the "polluter pays" principle. These systems include a fixed fee model, where vessels contribute to PRF operations regardless of whether they discharge waste, and an incentive-based model, where reduced fees or financial benefits are provided to vessels that demonstrate environmentally responsible waste management practices. The inclusion of extended producer responsibility (EPR) programs is also recommended, requiring fishing gear manufacturers to take back end-of-life gear for proper disposal or recycling.

Operational best practices identified by REMPEC include enhanced waste segregation at the source, improved on board waste storage solutions, and regular waste collection programs at sea. Fishermen are encouraged to participate in Fishing-for-Litter (FFL) initiatives, where vessels voluntarily collect marine debris encountered during normal operations and bring it to designated reception facilities. Such initiatives have been successfully implemented in countries like Spain, Italy, and Greece, demonstrating the feasibility of cooperative approaches to marine waste management.

Regulatory enforcement plays a crucial role in ensuring compliance with waste management guidelines. REMPEC calls for harmonized regulations across Mediterranean states, enhanced monitoring of waste discharge activities, and strict penalties for non-compliance. National governments are encouraged to strengthen inspection protocols at ports and on board vessels to prevent illegal waste disposal. The use of digital reporting tools and real-time monitoring systems for tracking waste movements is also recommended to enhance transparency and accountability in waste management.

To improve the efficiency of PRFs, REMPEC advocates for investments in modern waste treatment infrastructure, including mechanical and chemical recycling systems tailored for fishing gear waste. The adoption of circular economy principles, where old nets and ropes are repurposed into new materials, is emphasized as a sustainable alternative to landfill disposal. Successful examples of gear recycling programs exist in Norway and the Netherlands, where fishing nets are transformed into plastic pellets for manufacturing new products.

International collaboration is fundamental in addressing marine litter from fishing vessels. REMPEC encourages regional partnerships between Mediterranean states, enhanced data sharing on ALDFG hotspots, and coordinated efforts in ghost gear retrieval operations. The establishment of a Mediterranean-wide gear collection and disposal network is proposed as a long-term solution to systematically address abandoned fishing gear.

By promoting efficient PRFs, cost recovery mechanisms, on-board waste segregation, Fishing-for-Litter initiatives, regulatory enforcement, investment in recycling technologies, and regional cooperation, these best practices create a comprehensive framework for sustainable marine waste management. Implementing these recommendations will significantly reduce the environmental footprint of fishing activities, contributing to cleaner and healthier Mediterranean waters.

4.5 GFCM and FAO guidelines

The strategy and guidelines on waste from fishing vessels, as outlined by the General Fisheries Commission for the Mediterranean (GFCM) and the Food and Agriculture Organization (FAO) (FAO, 2019, 2021, 2023b, 2024a & b), emphasize the need for a structured approach to managing marine litter and abandoned, lost, or otherwise discarded fishing gear (ALDFG). These strategies align with international commitments to sustainable fisheries and the reduction of environmental impacts caused by fishing activities.

The GFCM 2030 Strategy for Sustainable Fisheries and Aquaculture in the Mediterranean and Black Sea provides a broad framework aimed at ensuring responsible fishing practices and addressing marine pollution. The strategy integrates technical and policy measures to prevent and mitigate marine litter from fishing vessels, with a focus on gear management, retrieval efforts, and waste disposal at ports. In support of this, the FAO's Voluntary Guidelines on the Marking of Fishing Gear establish a global standard for gear identification, aiming to enhance the traceability of lost or abandoned fishing equipment. These guidelines recommend mandatory marking, electronic tracking systems, and the integration of Vessel Monitoring Systems (VMS) to minimize ghost fishing and improve recovery efforts.

a) Monitoring and Prevention Measures to Minimize Waste from Fishing Vessels

The FAO and GFCM stress the importance of standardized data collection systems, which involve:

- Mandatory reporting of lost gear by fishers through centralized databases.

- The use of remote sensing technologies, including satellite tracking and sonar systems, to detect ALDFG.
- Regular assessments of waste accumulation in key fishing areas, with targeted interventions in high-risk zones.

b) Waste Prevention Measures

- Encouraging the use of biodegradable fishing gear to reduce long-term environmental impacts.
- Promoting alternative materials and modifications in gear design, such as escape panels and weak links that minimize ghost fishing.
- Educating fishers on responsible waste disposal and gear retrieval obligations.

c) Location and Retrieval of ALDFG

This is a priority under FAO and GFCM guidelines and includes:

- Implementation of retrieval programs where vessels actively participate in recovering lost gear.
- Financial incentives for fishers who retrieve and return ALDFG.
- Designation of ALDFG hotspots where organized recovery missions, including the use of remotely operated vehicles (ROVs), are conducted.
- Encouraging cross-sector collaboration, particularly between fisheries, environmental agencies, and NGOs.

d) Waste Treatment and Port Reception Facilities

To ensure proper waste disposal at ports, the following measures are recommended:

- Well-equipped port reception facilities with clear regulations for the disposal and recycling of fishing waste.
- Efficient waste segregation and processing, including specialized systems for handling synthetic fishing gear.
- Regulatory enforcement to ensure compliance with MARPOL Annex V, which prohibits the disposal of plastics and fishing-related waste at sea.
- Extended Producer Responsibility (EPR) programs, requiring manufacturers to take back used fishing gear for recycling or proper disposal.

e) Enforcement and Capacity Building

To ensure adherence to these guidelines:

- Training programs for fishers on best practices in waste management.
- Strengthening enforcement mechanisms, such as port inspections and fines for illegal dumping.
- Regional cooperation among Mediterranean countries to harmonize policies and share best practices.

4.6 EU framework and the EU directive 2109/883

Highlighted by a study conducted by the European Maritime Safety Agency (EMSA), the directive applies to EU ports in the Mediterranean and mandates (i) Adequate PRFs for all ship-generated waste, (ii)

Advance waste notification by ships, and (iii) reduced fees for ships producing less waste or managing it sustainably. In addition, these guidelines aim to strengthen compliance with MARPOL while minimizing the environmental impact of maritime activities. Key operational guidelines include:

a) Planning and Capacity

PRFs should be established based on port-specific needs, considering ship traffic and waste types. Waste reception and handling plans should be developed in consultation with stakeholders.

b) Waste Management:

Efficient collection, treatment, and disposal of ship-generated waste should be prioritized, along with the promotion of waste segregation to incentivize proper waste delivery.

c) Monitoring and Compliance:

Port waste information and monitoring systems should track the collection, treatment, and disposal of ship-generated waste. Licensing should be used as a tool for monitoring waste management practices.

d) Harmonization of Efforts and Regional Cooperation:

Mediterranean states should collaborate through regional initiatives—such as REMPEC under the Barcelona Convention—to share best practices, improve PRF efficiency, and harmonize standards across the region.

e) Economic Incentives:

Cost recovery systems and fees should be structured to encourage sustainable waste management practices, such as reduced fees for waste segregation or minimal waste production.

f) Inspections and Enforcement:

A minimum number of ships should be inspected, with penalties or restrictions applied under both EU law and national regulations to ensure compliance.

g) Capacity Building and Training:

Regional programs should provide training for port authorities, operators, and inspectors to effectively manage PRFs and enforce compliance.

4.7 GLO Litter and Marelitt projects outputs

The Marelitt Baltic and GloLitter projects have been instrumental in addressing marine waste through practical interventions and policy recommendations. The Marelitt Baltic project (Stolte, 2019; Stolte et al., 2019) has focused on mapping and retrieving abandoned, lost, or otherwise discarded fishing gear (ALDFG) in the Baltic Sea, while the GloLitter initiative (IMO/FAO, 2023)—a collaboration between the International Maritime Organization (IMO) and the Food and Agriculture Organization (FAO)—assists developing countries in reducing plastic litter from the maritime and fisheries sectors.

The guidelines provided by these two projects offer a comprehensive, actionable, and sustainable approach that can help manage waste from fishing vessels in the Mediterranean. While the two projects propose detailed operational measures, their key strategies focus on prevention, retrieval, and management solutions derived from comprehensive research and pilot projects.

a) Prevention Measures: The Most Effective Way to Reduce Waste from Fishing Vessels

- Gear Marking and Tracking:
  - Mandatory gear marking using RFID technology to improve traceability of lost or abandoned gear.
  - Development of an electronic tracking system integrated with vessel monitoring systems (VMS).
- Improved Fishing Practices:
  - Promoting the use of biodegradable materials in fishing gear.
  - Introducing modified fishing techniques to reduce unintended catch.
  - Establishing seasonal fishing zones to prevent gear loss in high-risk areas.
- Industry Incentives and Regulations:
  - Financial incentives for fishers to retrieve and recycle their gear.
  - Enforcing regulations under MARPOL Annex V.

b) Retrieval and clean-up Operations: Mitigating Existing Marine Pollution

- Mapping and Identification of ALDFG:
  - Use of sonar technology and remote sensing for locating lost fishing gear.
  - Establishment of regional ALDFG databases, allowing fishers to report lost gear locations.
- Fishing Industry Involvement in clean-up Activities:
  - Community-led retrieval initiatives, involving fishers and divers.
  - Subsidies for retrieval efforts to encourage participation.
- International Collaboration:
  - Strengthened regional partnerships and cross-border agreements to manage trans-boundary waste issues.

c) Waste Treatment and Management

- Port Reception Facilities (PRFs):
  - Expansion and modernization of PRFs.
  - Implementation of cost-recovery systems to ensure sustainable waste management.
  - Efficient sorting and recycling of collected fishing waste.
- Recycling and Circular Economy Approaches:
  - Reuse of fishing gear components in new equipment.
  - Waste-to-energy solutions, such as pyrolysis, for non-recyclable materials.
  - Extended Producer Responsibility (EPR) programs, requiring manufacturers to take back end-of-life gear.

d) Policy Recommendations and Capacity Building: Ensuring Long-Term Effectiveness

- Legislation and Compliance:

    - Mandatory reporting of lost gear under national fisheries laws.
    - Penalties for illegal dumping to deter non-compliance.
    - Alignment of national policies with regional and international conventions on marine litter.
- Education and Training:
    - Training programs for fishers on best practices in waste management.
    - Public awareness campaigns to promote responsible waste disposal.
    - Knowledge-sharing initiatives between fishing communities and regulatory bodies

4.8 Expert recommendations

Several researchers and associated organizations have contributed to understanding the causes of and mitigation strategies for abandoned, lost, or otherwise discarded fishing gear (ALDFG) (Gilman, 2015; Gilman et al., 2023; Richardson et al., 2018; Basurko et al., 2023). Their findings provide key insights to international institutions, environmental and maritime agencies, and global initiatives, helping to develop recommendations and guidelines that address this issue from a comprehensive perspective.

As with many guidelines, prevention remains the most effective way to minimize fishing-related waste. A key recommendation is the implementation of mandatory gear marking, using internationally standardized systems to enhance traceability and prevent deliberate abandonment. Adopting biodegradable and high-durability materials is another essential measure, reducing long-term environmental impact while maintaining gear efficiency. Additionally, regulating fishing activities through spatial and temporal restrictions can help prevent gear conflicts and loss incidents. Education and awareness initiatives, including training programs for fishers, are crucial in promoting sustainable fishing methods and proper waste disposal practices.

Retrieval and clean-up measures must be strengthened. The use of sonar and GPS tracking, as explored by Stolte et al. (2022), has proven highly effective in locating lost fishing gear, allowing for more precise and efficient recovery operations. Incentivizing gear recovery by providing financial compensation for fishers who retrieve and return lost gear can also significantly reduce ghost fishing and marine litter. Collaborative retrieval efforts involving fishers, divers, and environmental organizations further enhance the efficiency of clean-up operations.

Once fishing gear is retrieved, efficient treatment and disposal methods are necessary to prevent further environmental harm. Basurko et al. (2023) highlight the need to expand and modernize Port Reception Facilities (PRFs) to ensure proper sorting and treatment of fishing gear waste. Recycling initiatives, particularly mechanical recycling, should be encouraged to repurpose materials, while alternative methods such as energy recovery can be explored for non-recyclable waste. The introduction of Extended Producer Responsibility (EPR) programs, requiring manufacturers to implement take-back systems for end-of-life fishing gear, can further support sustainable waste management. In cases where recycling is not feasible, waste-to-energy conversion through incineration or gasification presents a viable alternative for processing discarded fishing materials.

Effective implementation of these recommendations requires strong policy frameworks. Mandating the reporting of lost gear, as suggested by Richardson et al. (2018), and maintaining comprehensive records can improve accountability and tracking. Stricter penalties for illegal dumping should be enforced to deter non-compliant practices. International and regional collaboration among governments, regional fisheries management organizations, and conservation groups is essential to address trans-boundary waste issues and enhance regulatory enforcement. Funding and research support should be directed toward the development of innovative gear materials, improved monitoring techniques, and sustainable waste management solutions, ensuring continuous progress in marine conservation efforts.

Ultimately, reducing waste from fishing vessels requires an integrated approach that combines prevention, retrieval, waste management, and stringent policy enforcement. The recommendations outlined in scientific literature provide a clear pathway for governments, industry stakeholders, and environmental organizations to mitigate the impacts of ALDFG effectively.

4.9 Comparison of regulatory frameworks

The comparison of the different guidelines highlights specific features tailored to the desired objectives (Table 1). The FAO/UNEP (2009) and Honolulu Strategy remain the most comprehensive in structured ALDFG management, covering both preventive and remedial actions. However, region-specific initiatives like REMPEC under the Barcelona Convention, GFCM strategies, and the EU Directive provide stronger legislative backing and enforcement mechanisms for the Mediterranean. Additionally, pilot projects like GloLitter/Marelitt and recent scientific studies are introducing innovative tech-driven solutions for tracking and retrieving ALDFG.

The objectives of the guidelines differ in their global, regional, or national scope, as well as in their focus on scientific, environmental, or economic interests. They may also vary depending on economic development and the type of maritime activity. Nevertheless, numerous similarities and convergences exist, allowing for the definition of key elements essential to a harmonized management approach.

Prevention remains the primary focus across all guidelines, as the most effective way to manage ALDFG is to stop it from occurring in the first place. Most frameworks emphasize gear marking, tracking technologies, and the adoption of sustainable materials. The FAO/UNEP (2009), GFCM, and FAO Guidelines (2021, 2023, 2024) highlight the importance of biodegradable fishing gear, mandatory reporting mechanisms for lost gear, and reducing overall fishing effort to limit gear abandonment. The GloLitter and Marelitt projects further advance these goals by integrating RFID technology and Vessel Monitoring Systems (VMS) to enhance traceability and reduce ghost fishing incidents.

Table 1: Comparison of Key Guidelines on Waste from Fishing Vessels and ALDFG

Guidelines	Scope and Focus	Prevention Measures	Mitigation & Retrieval	Waste Treatment & PRFs	Enforcement & Compliance
FAO/UNEP (2009)	Comprehensive roadmap for ALDFG management	Gear marking, tracking tech, PRFs, fishing effort reduction	Biodegradable materials, retrieval incentives, escape panels	Mapping & retrieval, clean-ups, recycling, up-cycling	Strengthening international treaties, national laws, economic incentives, awareness
Honolulu Strategy (2011)	Global framework for marine debris reduction	Standardized data collection, gear tracking, collaboration	Hotspot mapping, ghost net retrieval, innovative removal tech	Recycling, biodegradable gear, waste-to-energy	Port reception facilities (PRFs), MARPOL enforcement, training programs
IMO MARPOL Annexes	Global regulations on ship-generated waste	Ships to minimize waste, pre-arrival notification for PRFs	Port operators must ensure waste disposal adequacy	PRFs for oil, sewage, garbage, and hazardous waste	"Zero tolerance" policy for illegal discharge, minimized waste generation, GISIS database tracking, PRF compliance
Barcelona Convention & REMPEC	Regional framework for Mediterranean Sea	PRFs in Mediterranean ports, cost recovery mechanisms	No-Special-Fee (NSF) system for fishers, gear retrieval programs	Investment in modern PRFs, circular economy initiatives	Harmonized regulations across Mediterranean states, digital tracking tools, and regional cooperation
GFCM & FAO Guidelines	Mediterranean fisheries-specific waste management	Mandatory reporting, remote sensing for lost gear	Incentives for retrieval, ROV-based recovery, cross-sector collaboration	Efficient PRFs, synthetic gear processing, EPR for fishing gear	GFCM & FAO Guidelines: Regional cooperation, port inspections, harmonized laws
EU Directive 2019/883	EU-wide regulation on PRFs for ship-generated waste	PRF planning based on port needs, In advance notification, ship waste minimization	Waste reception handling plans, inspections	Cost recovery incentives, MARPOL compliance	PRFs for all ports, reduced fees for ships producing less waste, Minimum inspections, penalties, capacity-building
GloLitter & Marelitt Projects	Pilot projects for developing countries on marine litter	RFID gear marking, biodegradable gear, seasonal zoning	Sonar mapping, retrieval initiatives, subsidies for clean-ups	Modern PRFs, waste-to-energy solutions	Mandatory lost gear reporting, stricter penalties, regional collaboration
Scientific Expert Recommendations	Evidence-based mitigation of ALDFG	Biodegradable, durable gear, standardized tracking	GPS/sonar retrieval, financial incentives, fishers in clean-up	Expanded PRFs, circular economy, EPR for fishing gear	Stricter penalties, international collaboration, funding for research

Mitigation and retrieval efforts differ across the guidelines, with some prioritizing targeted retrieval programs and others focusing on incentives for fishers to actively participate in gear recovery. The Honolulu Strategy, FAO/UNEP, and GloLitter projects propose mapping high-risk zones using sonar and remote sensing technologies, followed by structured clean-up missions. Meanwhile, the Barcelona Convention's REMPEC framework and GFCM guidelines promote the Fishing-for-Litter (FFL) program, which encourages fishers to voluntarily collect marine debris while at sea. Scientific recommendations also advocate for the use of advanced technologies, such as drones and remotely operated vehicles (ROVs), to enhance retrieval efficiency, particularly in difficult-to-access areas.

Port Reception Facilities (PRFs) and waste treatment play a crucial role in ensuring that fishing waste is managed properly once it is brought ashore. The MARPOL Annexes, Barcelona Convention, and EU Directive 2019/883 emphasize the need for well-functioning PRFs that facilitate waste segregation and incentivize proper disposal. The FAO, GFCM, and IMO further advocate for cost recovery systems that ensure PRFs remain financially viable while encouraging vessel operators to use them responsibly. Circular economy principles, such as repurposing old fishing gear into new materials, are gaining prominence, particularly in recommendations from REMPEC, GloLitter, and scientific studies on sustainable waste management.

Compliance and enforcement mechanisms have been strengthened through the integration of digital tracking tools and regional cooperation initiatives. The IMO MARPOL system and Barcelona Convention use digital monitoring platforms to track PRF efficiency and waste movements, ensuring greater transparency in waste management operations. The EU Directive and REMPEC focus on regular inspections, standardized monitoring, and strict penalties for non-compliance, deterring illegal waste disposal practices. Recent scientific recommendations stress the importance of increased funding and research support for developing innovative materials, monitoring techniques, and waste processing technologies.

Effective enforcement, combined with international and regional collaboration, remains essential for addressing trans-boundary waste issues and improving long-term sustainability in marine waste management.

5 CHALLENGES TO IMPLEMENT PRFs IN THE MEDITERRANEAN SEA

Mediterranean states face several significant challenges in implementing regulations for Port Reception Facilities (PRFs). These challenges arise from environmental, institutional, and operational issues. One challenge is the enforcement of guidelines across different jurisdictions. Given the trans-boundary nature of marine pollution, cooperation between nations, regulatory bodies, and stakeholders is crucial. Additionally, financial constraints in many Mediterranean countries may hinder the adoption of some of the recommended guidelines and measures. In addition, a certain number of operational gaps exist, including

Data Gaps and Monitoring Challenges: The lack of comprehensive and reliable information hinders effective monitoring and evaluation of compliance with MARPOL regulations. This is the case for small-scale and artisanal fisheries, which must be better understood in terms of environmental aspects. The absence of integrated regional systems for sharing environmental data also complicates efforts to ensure consistent implementation across Mediterranean countries.

Institutional Weaknesses: In some EU Mediterranean countries, institutional capacities are weak, making it difficult to enforce PRF regulations effectively. This includes challenges in governance, monitoring systems, and coordination between national authorities. Political instability in some regions also undermines the ability to implement long-term waste management strategies.

Economic Constraints: Many Mediterranean states face financial limitations, restricting their ability to invest in modernizing or expanding PRFs. This is particularly problematic for smaller ports or ports in developing countries, where funding for waste management infrastructure is insufficient. In addition, cost recovery mechanisms for PRFs are not always well implemented, leading to financial inefficiencies and discouraging sustainable practices.

Operational Inefficiencies: Ports often lack adequate facilities to handle the increasing volume and diversity of ship-generated waste from fishing vessels, especially under stricter MARPOL requirements due to the Mediterranean's designation as a Special Area. Poor coordination between maritime activities (e.g., shipping, fishing, and offshore energy) and waste management systems leads to overlapping priorities and inefficiencies.

Regional Disparities: There is a stark contrast between EU Mediterranean states, which benefit from EU directives like Directive 2019/883, and non-EU states that lack similar regulatory frameworks or resources. This disparity creates uneven implementation of PRF standards across the region, affecting overall compliance with MARPOL.

Environmental Pressures: The Mediterranean Sea faces severe environmental stress due to pollution from various sources, including fishing. PRFs must address this within a broader context of marine conservation efforts, adding complexity to their implementation.

Stakeholder Engagement: Limited involvement of local stakeholders, such as civil society organizations and private operators, in the planning and operation of PRFs reduces their effectiveness. The fishing sector may also be reluctant to use PRFs due to high costs or delays caused by inefficient services. As a consequence, addressing the challenges of waste management from fishing vessels in the Mediterranean Sea requires a comprehensive and coordinated approach. This includes strengthening regulatory frameworks and enforcement mechanisms, improving data collection and monitoring systems, investing in infrastructure and capacity building, promoting regional cooperation and knowledge sharing, and engaging stakeholders, including fishers, port operators, and civil society organizations.

The integration of ecosystem-based management tools, as advocated by SAPBIO and the GFCM, is essential for ensuring the sustainability of Mediterranean fisheries and the conservation of its rich biodiversity. Efforts should be undertaken to establish uniform methods for data collection regarding waste generation, composition, and disposal practices in fishing ports. This would include standardizing the indicators used for assessing the performance of PRFs and encouraging countries to participate in regional programs, such as the MEDPOL program of UNEP/MAP, which focuses on data sharing and the assessment of pollution sources.

Implementing Advanced Technologies by promoting the use of remote sensing, satellite imagery, and GIS systems to track marine litter, identify pollution hotspots, and monitor the effectiveness of clean-up operations is also key.

Strengthening Governance Structures with governments to establish clear roles and responsibilities for the various agencies involved in waste management, including port authorities, environmental

agencies, and fisheries departments. This involves drafting and implementing national legislation that aligns with international standards and conventions.

Capacity Building Programs should be designed to enhance the skills and knowledge of port personnel, environmental inspectors, and other relevant stakeholders. Training should cover topics such as waste management best practices, regulatory enforcement, and data collection techniques.

Enhancing Inter-Agency Coordination by setting up inter-agency committees, developing joint action plans, and conducting regular meetings to discuss progress and address challenges is also necessary. To address financial limitations, including deficient cost recovery mechanisms for PRFs that restrict their ability to invest in modernizing or expanding their structures—especially for Mediterranean states with smaller ports or developing economies—there is a pressing need for governments and international funding agencies to prioritize investments in PRF infrastructure. The effective implementation of cost recovery mechanisms is critical for the financial sustainability of PRFs. Governments should ensure that fees are transparent, fair, and based on the "polluter pays" principle. The collected fees should be reinvested in improving PRF operations and infrastructure.

Encouraging public-private partnerships (e.g., build-operate-transfer agreements) can help mobilize private sector expertise and investment in PRF development. Many ports in the Mediterranean region lack adequate facilities to handle the increasing volume and complexity of ship-generated waste. Ports should invest in modernizing their PRF infrastructure to accommodate the increasing volume and complexity of ship-generated waste. This can involve upgrading waste collection systems, installing advanced waste treatment technologies, and constructing additional storage facilities. Each port should develop a comprehensive waste management plan that outlines procedures for collecting, treating, and disposing of ship-generated waste. The plan should be based on best practices and comply with international standards.

To improve coordination between maritime activities and waste management systems, ports should establish dedicated waste management units responsible for coordinating waste collection, treatment, and disposal efforts. PRFs specializing in waste from fishing vessels must be an option for some Mediterranean ports where fishing is the main activity. For synergy and greater efficiency, considering hubs specifically designed to process waste from fishing vessels at the scale of some Mediterranean regions must also be considered. Comprehensive training programs should be offered to port personnel on waste management best practices, safety procedures, and environmental regulations.

To address the significant contrast between EU Mediterranean states, which benefit from EU directives such as Directive 2019/883, and non-EU states that lack similar regulatory frameworks and resources, the legal frameworks governing waste management in non-EU Mediterranean states should be harmonized with EU directives and international standards. This can involve drafting new legislation or amending existing laws to ensure consistency with best practices. Providing technical assistance and training to non-EU countries to support their efforts to improve PRF operations and comply with international regulations, as well as providing financial aid to non-EU countries to help them invest in PRF infrastructure, is necessary. Establishing regional enforcement mechanisms to ensure compliance with MARPOL and other international conventions could involve setting up a regional maritime inspection authority to conduct regular inspections of ships and ports.

Because the Mediterranean Sea faces severe environmental stress due to pollution from various sources, including fishing, PRFs must address marine conservation issues by integrating with broader marine conservation efforts and strategies. Coordinating waste management efforts with other initiatives, such as marine protected areas, fisheries management programs, and coastal zone management plans, is essential. Public awareness campaigns should be launched to educate the public

about the importance of reducing marine litter. These campaigns can target various audiences, including fishing communities, tourists, and local residents.

The involvement of stakeholders, such as civil society organizations and private operators, in the planning and operation of PRFs remains limited, reducing their effectiveness. Operators may also be reluctant to use PRFs due to high costs or delays caused by inefficient services.

Creating Stakeholder Involvement in the planning and operation of PRFs through advisory committees, public consultations, and community-based waste management initiatives will reinforce local stakeholder engagement. Supporting partnerships among governments, port operators, and waste management companies will also improve PRF effectiveness.

Streamlining PRF Services by simplifying the process of using PRFs (reducing administrative burdens, providing clear information on fees and procedures).

Reducing port fees for vessels that use PRFs by implementing streamlined waste discharge procedures will significantly improve operational efficiency.

6 DEVELOPING SPECIALIZED PORT RECEPTION FACILITIES FOR WASTE FROM FISHING VESSELS IN THE MEDITERRANEAN SEA

The Mediterranean fishing fleet, characterized by its artisanal nature and diverse fishing practices, contributes significantly to marine litter, particularly through Abandoned, Lost, or Discarded Fishing Gear (ALDFG) and operational waste. There is an urgent need to address waste management from fishing vessels in the Mediterranean through comprehensive strategies, including the development of specialized Port Reception Facilities. These PRFs must be tailored to the specific characteristics of fishing waste, taking into account the local or regional nature of the waste, the operational constraints of fishing ports, and the socio-economic context of fishing communities. This implies key considerations, planning stages, operational requirements, and collaborative efforts necessary to establish effective and sustainable PRFs adapted to the Mediterranean ecosystem.

Developing specialized Port Reception Facilities (PRFs) for fishing waste in the Mediterranean is a critical step towards protecting the region's marine ecosystems, supporting sustainable fisheries, and promoting the long-term health and prosperity of coastal communities. It requires a holistic approach that integrates prevention, localization, collection, handling, recycling, and associated supporting measures. The following guidelines provide a detailed framework for managing waste in the Mediterranean, drawing upon key international and regional instruments—including the UNEP recommendations, the Honolulu Strategy, IMO Guidelines, FAO and GFCM Guidelines, the Barcelona Convention and REMPEC Operational Guidelines, and scientific project outputs—as well as essential findings from scientific literature. These existing guidelines may present similar approaches and be partly redundant, depending on the final objective of each task. They should be seen as flexible, with implementation varying according to factors such as the type of fishery, the kinds of fishing gear used, their quantities and locations, the feasibility of collection, the economic development level of the

country, access to infrastructure for storage, sorting and recycling, and available funding opportunities. Some recommendations might even lead to options that restrict compliance to certain associated tasks. Nonetheless, all should be perceived as long-term objectives that address the unique challenges of the Mediterranean Sea and its existing gaps. In particular, there is a need for fishing-specific PRFs, adaptation to local or subregional practices, and a focused consideration of artisanal fishing and small-scale fisheries through reinforced studies that define adequate strategies and more precise guidelines. These guidelines must be tailored to different fishing types and practices, the operational constraints of fishing ports, and the socio-economic context of fishing communities. Initial efforts should concentrate on areas of intensive fishing, identified as priorities that justify further studies and pilot developments. Regions such as the Northern Adriatic, the Alboran/SE Spanish Mediterranean coast, the Tunisian-Sicilian Channel, the Iskenderun Gulf, and countries with intensive fishing like Egypt need attention. It is also crucial to account for specific interregional practices that generate significant amounts of fishing waste, such as FADs, and local fisheries such as octopus plastic traps in the Gulf of Gabès, Tunisia, and to propose subregional hubs for managing this waste.

7 TOWARDS SUSTAINABLE MANAGEMENT OF FISHING WASTE: A STRUCTURED AND PROGRESSIVE ROADMAP

In line with Post-2020 SAPBIO Action 7, Table 2 presents a structured guidelines for reducing waste generated by fishing activities in the Mediterranean region. It outlines a series of thematic steps—from building baseline knowledge to implementing concrete port reception facilities—covering key areas such as education, prevention, stakeholder engagement, and regional coordination. The framework is designed to address the specific challenges of different fishing practices, particularly small-scale fisheries, by proposing actionable measures, appropriate technologies, and realistic strategies tailored to various audiences, including policymakers, port managers, and fishers themselves.

Table 2: Guidelines to reduce solid waste from fishing boats in the Mediterranean Sea

STEPS	THEME	TASKS / MEASURES	OUTPUTS
BACKGROUND KNOWLEDGE	RESEARCH	Develop research programs on Small Scale Fisheries, to understand the associated environmental issues and assess their extent.	DATA COLLECTED. AMOUNTS, NATURE, AND VOLUME OF WASTE FROM FISHING VESSELS BETTER EVALUATED AND LIFE CYCLE OF WASTE COMPONENTS BETTER UNDERSTOOD
		Better understand regional disparities. Regions such as the northern and western Adriatic, the Sicilian-Tunisian Channel, the Alboran Sea, and the south-western Mediterranean coast, as well as intensive fishing areas in Egypt (e.g., El Max) and Turkey (e.g., Iskenderun), and specialized fishing zones (e.g. FAD fisheries in the Sicilian-Tunisian Channel, Trap fishing in the Gulf of Gabès, mollusc farming in the Adriatic) should be considered priority areas for detailed scientific assessments (types, amounts, distribution, volumes).	
		Locate and evaluate the importance of ALDFG accumulation areas (hot spots).	
		Evaluate the importance of operational waste (plastics and marine litter, fish boxes, etc.) and micro-plastics from fishing vessels, and the possible need for treatment, when appropriate.	
	TECHNOLOGY	Follow the recent developments of degradable plastics, and their potential usefulness for fishing gear.	
		Encourage and implement research programs on « on site » detection of fishing gear, promote new technologies when appropriate (e.g. acoustic methodology).	
	MONITORING	Implement monitoring of ALDFG in the Mediterranean Sea, taking advantage of existing marine litter monitoring, Regional Action Plan of the Barcelona convention, and ongoing projects (e.g. Marine Litter Med). Involves fishermen in such a monitoring.	
		Use uniform methodologies to monitor fishing gear in coastal areas, sea beds, and pelagic waters.	
	SUPPORTING STRATEGY	An in deep analysis of the possible organization of PRFs, assessing the strengths, gaps, possible actors, possible technologies to implement, economic aspects and potential outputs.	

		Assess the importance of the operational waste generated by fishing vessel activities (e.g., waste waters, fish boxes, etc.) and, if appropriate and relevant, plan specific management pathways for these wastes to be considered by PRFS.	STRATEGY FOR THE MANAGEMENT OF WASTE OTHER THAN ALDFS READY FOR IMPLEMENTATION
		Assess the significance of pollution associated with the abandonment of fishing vessels (amount of plastics and other pollutants, distribution) through studies at the national, regional, or even Mediterranean level, and define a future strategy for establishing a recycling sector in the event of significant pollution.	
EDUCATION / AWARENESS	RESPONSIBLE FISHING PRACTICES	Training Programs for Fishers: Organize workshops and training sessions to educate fishers on best practices for waste management, gear maintenance, retrieval, and reporting lost gear.	COASTAL COMMUNITIES, INCLUDING FISHERMEN AND ENVIRONMENTAL MANAGERS INFORMED
		Launch public campaigns targeting coastal communities and stakeholders to highlight the environmental impacts of marine litter from fishing activities (conferences, workshops).	
		Consider integration of environment-dedicated modules in curricula for fishermen and port managers.	
	ENGAGEMENT WITH STAKEHOLDERS	Collaborate with local associations, port authorities, and NGOs to promote responsible fishing practices and waste prevention measures.	
PREVENTION	FISHERY MANAGEMENT	Reduction of Fishing Effort (limited deployment, restrictions on soak-time, fishing quotas and licensing policies).	FISHING STRATEGIES ADAPTED TO ENVIRONMENTAL CONSTRAINTS
		Spatial Management and Zoning (high-risk areas regulations, limited gear conflicts, sustainable fishing techniques).	
	TECHNOLOGY	Eco-Friendly Design: Encourage the development of fishing gear that is easy to dismantle and recycle at the end of its life cycle.	
		Reducing Ghost Fishing Impacts (escape panels and degradable twine, acoustic deterrents, collaboration with scientists).	

GEAR RETRIEVAL PROGRAMMS	DETECTION/ LOCATION OF WASTE FROM FISHING VESSELS	Promote the use of fishing gear made from durable or biodegradable materials, when appropriate, to reduce environmental persistence if lost at sea.	WASTE FROM FISHING VESSELS ARE PROPERMY COLLECTED
		Locating and mapping Lost Gear using sonar and remote sensing technologies for reporting.	
		Organize reporting of the data, in fishing or convergence zones, promoting mobile applications, and maintain port scale database, harmonized at national and Mediterranean level to collect relevant on collected fishing gear.	
		Gear Marking when appropriate: Mandate unique identifiers on all fishing gear to facilitate tracking, recovery, and accountability in case of loss, harmonize tracking methods, implement integrating registration numbers.	
	MANAGEMENT	Incentives to fishers to retrieve lost gear.	
		Targeted recovery initiatives (e.g. Ghost Net Retrieval Programs) involving government agencies, environmental organizations, and fishing communities.	
		Organize "Fishing for Litter" programmes to collect litter/ waste from fishing vessels during normal operation.	
		Organize Clean-Up Initiatives in hot spots areas.	
		Organized / supported retrieval missions in at risk areas.	
		Incentives to fishers to retrieve lost gear.	
		Introduction of gear buyback programs to remove obsolete fishing equipment from circulation.	
		Partnerships between fishers and environmental organizations.	
		Consider cross-border cooperation (regional collaboration) in areas where transboundary marine litter is a significant concern.	
IMPLEMENTATION OF PRFs	ANALYSIS OF CHARACTERISTICS OF FISHING WASTE	A better understanding of the fishing waste cycle for each of the Mediterranean region, and types of fisheries, giving priorities to areas with intense fishing activities, including Small Scale Fisheries.	STRATEGY FOR SORTING, CLEANING AND STORAGE

(with a focus on the implementation of PRFs)	Operational Waste Composition, including plastic packaging, food containers, plastic bottles, and other debris generated during fishing operations. This waste often contains organic matter and requires proper sanitation to prevent the spread of disease.	OF WASTER FROM FISHING VESSELS DEFINED
	Waste and ALDFG detailed Composition by polymers (nylon, polyethylene, polypropylene, etc.) to facilitate further processing.	
	Volume and Variability: As a consequence or regional disparities, the volume and composition of fishing waste can vary significantly depending on the type of fishing vessel, the fishing practices employed, the location of fishing activities, and the season. PRFs must be designed to accommodate this variability and ensure efficient waste management.	
ALIGNMENTS WITH REGULATORY FRAMEWORKS AND INTERNATIONAL STANDARDS	**IMO & MARPOL Annexes**: "Zero tolerance" policy for illegal discharge, minimized waste generation, Contribution to GISIS database tracking.	PRFs ALIGNED TO NATIONAL AND INTERNATIONAL FRAMEWORK AND REGULATIONS IN A HARMONIZED MANNER
	Barcelona Convention & REMPEC: No-Special-Fee (NSF) system recommended, cost recovery systems / polluters pay principles, circular economy principles, Harmonized regulations across Mediterranean states, digital tracking tools, and regional cooperation.	
	GFCM & FAO Guidelines: Importance of location and retrieval programmes, proper waste disposal at ports, EPR, Regional cooperation, port inspections, harmonized laws.	
	EU Directive 2019/883 (for EU countries): PRFs for all ports, In advance notification, reduced fees for ships producing less waste, minimum inspections, penalties, capacity-building. When appropriate, Non EU countries may converge to EU policy.	
	National regulations, when existing. National governments should adopt clear legislation on gear marking, retrieval, and disposal.	
	GloLitter & Marelitt Projects: Mandatory lost gear reporting, stricter penalties, regional collaboration.	
	Scientific Experts Recommendations: Stricter penalties, international collaboration,funding for research.	

PLANNING AND DESIGN CONSIDERATIONS FOR SPECIALIZED PRFs	Strategic location and accessibility, considering factors such as proximity to fishing quays, vessel traffic patterns, and the availability of land for waste handling and storage.	PRFs INFRASTRUCTURES IN PLACE
	Capacity and scalability: PRFs should be designed with sufficient capacity to handle the anticipated volume of fishing waste, taking into account seasonal variations and future growth in fishing activities. The design should also allow for scalability to accommodate increasing waste volumes or changes in waste composition.	
	Efficient waste segregation and collection systems, including separate containers for ALDFG, plastic waste, organic waste, and other materials. Agreement on Color-coded containers and clear signage at the Mediterranean level could facilitate proper waste segregation by fishers.	
	Waste handling and processing equipment, to facilitate efficient waste management. This may include cranes, forklifts, conveyor belts, shredders, compactors, and balers.	
	Storage facilities designed to prevent leakage, odours, and pest infestations, before further processing or disposal.	
	Treatment technologies, to reduce the volume and toxicity of fishing waste. This may ideally include shredding and baling of ALDFG, composting of organic waste, and treatment of wastewater.	
	Consider alternative waste treatment options, such as incineration and energy recovery from non-recyclable materials.	
	Develop specialized facilities for recycling old or damaged fishing nets, ropes, and traps into new products (e.g. textiles or construction materials). Promote Mechanical and low cost recycling.	
	Environmental safeguards to minimize the risk of pollution. Including measures to prevent spills, control dust, and manage noise.	
	Safety measures to protect workers and prevent accidents (proper ventilation, fire suppression systems, and personal protective equipment).	
	Specific management schemes for operational wastes and FRPs vessels, when appropriate.	

OPERATIONAL REQUIREMENTS AND BEST PRACTICES	Waste collection procedures including establishing schedules for waste collection, providing instructions to fishers on proper waste segregation, and monitoring waste volumes.	OPERATIONAL GUIDELINES AND LOGISTIC ARE DEFINED FOR EACH PORT, BEST PRACTICES ARE DEFINED
	Waste handling and processing (appropriate equipment, established protocols, minimizing waste spillage).	
	Waste storage and disposal using approved storage facilities, transporting waste to authorized disposal sites, and tracking waste volumes.	
	Staff training in waste management best practices, safety procedures, and environmental regulations, ensuring that staff-remain up-to-date on the latest standards.	
	Stakeholder engagement, including fishers, port authorities, environmental agencies, and community groups.	
	Monitoring and reporting, for evaluating the performance of PRFs and identifying areas for improvement, tracking waste volumes, assessing waste composition, and measuring environmental impacts.	
FINANCIAL REQUIREMENTS	Waste reception fees, to recover the costs of waste management services. Fees should be transparent, fair, and based on the volume and type of waste received.	FUNDING IS SECURED
	Polluter Pays Principle, involving charging higher fees for vessels that generate larger volumes of waste or fail to segregate waste properly.	
	Incentive Programs, providing discounts on waste reception fees for vessels that demonstrate compliance with waste management standards.	
	Subsidies and grants, involving governments to support the operation of PRFs and reduce the financial burden on fishers. This can be particularly important in Mediterranean regions with limited financial resources.	
	Public-Private Partnerships, to provide a stable source of funding and ensure efficient waste management services.	
	Revenue Diversification, improving financial sustainability by offering additional services, such as waste recycling, composting, and energy recovery.	

TECHNOLOGY INNOVATION FOR PRFs OPERATIONS	Automated waste collection systems using automated cranes, conveyor belts, and robotic systems to reduce labour costs.	PRFs TASKs ARE OPTIMIZED, INFORMATION ON RECENT DEVERLOPMENTS IS MASTERED
	Smart waste management technologies using sensors, RFID tags, and data analytics platforms to track waste volumes, monitor waste composition, and optimize waste collection schedules.	
	Advanced treatment technologies, using advanced shredding and baling techniques, composting systems, and energy recovery systems to reduce the volume and toxicity of fishing waste.	
	Geographic Information Systems (GIS), to improve the efficiency of waste management and reduce environmental impacts by mapping waste generation patterns, identify pollution hotspots, and optimize PRF locations.	
	Remote sensing technologies, using satellite imagery, aerial photography, and drone technology, to detect marine litter, monitor waste disposal practices, and assess the effectiveness of clean-up efforts.	
STAKEHOLDER ENGAGEMENT AND CAPACITY BUIKDING	Fisher community involvement, consulting fishers on waste management needs, providing training on proper waste segregation, and involving them in monitoring and enforcement efforts.	TASKS FOR EACH OF THE PARTICIPATING COMMUNITY ARE DEFINED, INFOMATION PLATFORMS ARE AVAILABLE
	Port authority collaboration, including coordinating waste collection schedules, sharing data on waste volumes, and participating in joint inspections.	
	Environmental agency partnerships, collaborating on environmental assessments, developing waste management plans, and enforcing environmental regulations.	
	Community outreach programs, conducting educational workshops, distributing informational materials, and organizing clean-up events.	
	Training programs, covering topics such as waste segregation, handling, storage, and disposal, as well as safety procedures and environmental regulations.	
	Knowledge sharing platforms, organizing conferences, workshops, and online platforms and forums.	

	MONITORING AND ADAPTATIVE MANAGEMENT	Key Performance Indicators (KPIs), including metrics such as waste volumes collected, waste segregation rates, recycling rates, and environmental impacts.	MONITORING IS IMPLEMENTED
		Regular assessments, conducting site inspections, reviewing waste management records, and soliciting feedback from stakeholders.	
		Data analysis and reporting, preparing regular reports on PRF performance and sharing findings with stakeholders.	
		Adaptive management strategies, modifying waste collection procedures, improving waste handling equipment, or strengthening enforcement efforts.	
		Stakeholder feedback mechanisms, including conducting surveys, organizing focus groups, and establishing advisory committees.	
	COORDINATION	Strengthen regional cooperation under frameworks like the Barcelona convention to harmonize policies on preventing marine litter from fisheries across Mediterranean countries.	PRFs ARE COORDINATED AND HARMONIZED AT THE NATIONAL AND MEDITERRANEAN LEVELS
		Harmonize unique identifiers on all fishing gear to facilitate tracking, recovery, and accountability in case of loss.	
		Support collaborative initiatives like "Fishing for Litter" programs that incentivize fishers to collect marine litter during regular operations.	
		Define a strategy to better support the future management and recycling of FRPs fishing vessels.	COORDINATED PLAN FOR FUTURE MANAGEMENT OF FRP VESSELS

8 CONCLUSION

Based on recommendations from UNEP, scientific institutions, and aligning with regulatory frameworks, we analysed the existing guidelines, and developed a detailed guidelines to provide a comprehensive framework for specifically managing waste from fishing vessels in the Mediterranean Sea, addressing the key challenges and offering a vision for a cleaner, healthier, and more sustainable marine environment. Targeted and adaptive measures on specific types of waste, specific regions, and specific national or local constraints is key. By implementing these measures, in the long term, step by step, and in a coordinated manner, Mediterranean countries can reduce marine litter, protect marine ecosystems, support sustainable fisheries, and promote the well-being of coastal communities. Successful implementation of waste management initiatives requires comprehensive stakeholder engagement at all levels, supported by clear communication channels and collaborative decision-making processes. This must be balanced with careful consideration of economic, environmental, and social factors. Regular feedback mechanisms, capacity building programs, financial support systems, and technology innovation and adoption are all critical components for creating effective management systems for waste from fishing vessels, translating these guidelines into action, ensuring a lasting positive impact on the Mediterranean Sea and its future.

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