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COP
Circular Ocean-bound Plastic

Ocean-bound plastic collection methodology in Europe

An overview

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Overview on Ocean-bound plastic collection methodology in Europe - Desk research and Information collection

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Content

The COP Project

This report is part of the EU Interreg South Baltic project Circular Ocean-bound Plastic (COP), which addresses ocean plastic problems in the South Baltic Sea. The COP project intends to minimize the amount of plastic waste ending up in the sensitive ecosystem of the Baltic Sea by identifying sources and pathways of plastic waste. Over 80 % of all ocean plastic comes from land-based sources, mainly from rivers in urban areas. The overall aim is the investigation of the collection, reuse, and recycling of ocean-bound plastic. The project, which has received the label “project of strategic importance” by the Interreg program, takes place in Germany, Denmark, Sweden, and Poland. The chosen pilot areas are in Aarhus, Malmö, Rostock, and Gdansk.

The COP project is a continuation of other already ended projects (e.g. EU Interreg Central Baltic project BLASTIC from 2016 – 2018), signifying the relevance and importance of the new COP project.

The present document is part of the deliverables of Work Package 2: Capacity-Building: Desk Research and Information Collection. In this Work Package, information about ocean plastic waste is collected. This includes information about waste streams, collection, treatment possibilities, and current legislation. This report highlights the different collection methods available in Europe to collect riverine waste materials. The information in this report dates from 2023 and is a work-in-progress document. This report does not claim completeness.

1. Introduction: Ocean-Bound Plastic

Ocean-bound plastic (OBP) is plastic waste categorized as “at risk of ending up in the ocean” due to the leakage of waste into the riverine water bodies. This designation applies to “abandoned plastic waste” found within 50 km of coastlines, where waste management is either absent or ineffective. OBP has a high likelihood of ending up in the seas and oceans due to weather influences such as wind, rain, water flow, or tides or through artificial influences such as littering, rain-water overflows, etc. It is estimated that OBP accounts for 80% of plastic marine litter. Plastic represents the predominant component of all marine litter (Zero Plastic Oceans, 2024).

Marine litter, often referred to as marine debris, is defined as “any persistent, manufactured, or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment” (UNEP, 2005). It encompasses items created or utilized by humans that enter the sea

either intentionally or unintentionally. Sources of marine litter include fishing, shipping, dumping, tourism, and coastal recreation. Additionally, rivers, wind, rain, and sewer systems can transport marine litter into the sea.

Marine litter can be found in different parts of the water body, on the sea floor, in the water column, on the water surface, and in biota. OBP research agrees that the majority part of marine plastic waste will sink to the sea floor. The German Federal Environment Office (UBA) assumes that approximately 70 % of the waste sinks to the bottom. About half of the remaining 30 % lands ashore on the beaches, and the other half drifts on the water's surface and into the water column (Umweltbundesamt, 2024). Other studies even suggest that 94 % of the total marine litter ends up on the sea floor (Eunomia, 2016).

OBP or marine plastic waste can include all plastic litter sizes, from nano- to megaplastics (figure 1).

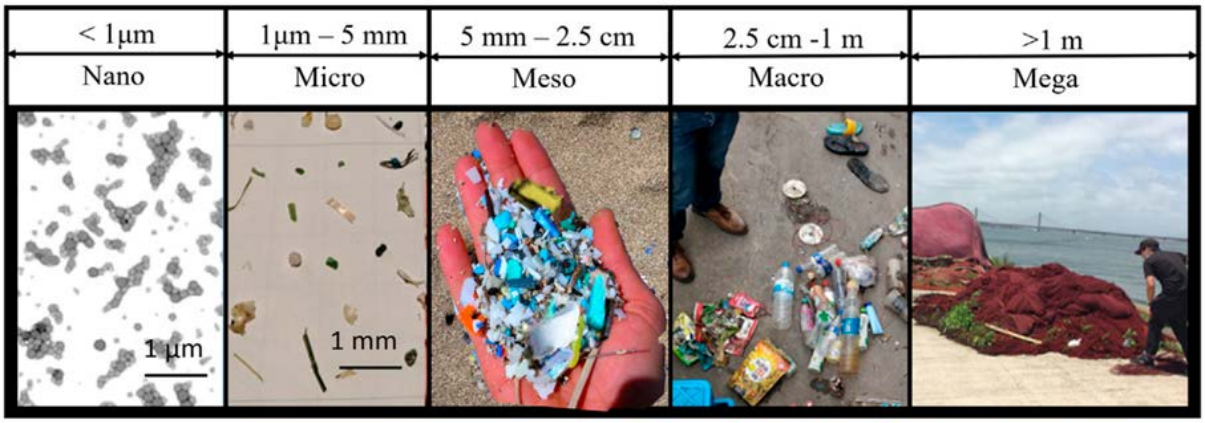

Figure 1: Plastic litter sizes (Source: (Abeynayaka, Amila; et al., 2022))

The OBP Certifications Program defined four categories of ocean-bound plastic (Zero Plastic Oceans, 2024):

1. **Potential Ocean-bound plastic:** inadequately collected plastic waste located within a 50 km distance of the coastline
2. **Waterways Ocean-bound plastic:** inadequately collected plastic waste located up to 200 m from rivers as well as directly in rivers
3. **Shoreline Ocean-bound plastic:** Inadequately collected plastic waste located up to 200 m from shores
4. **Fishing material:** used fishing gears and plastic bycatch

In this project, the primary focus is on ocean-bound plastic in waterways, specifically through the examination of litter in tributaries to the Baltic Sea. OBP can be found in various locations within the river, such as on river banks, flood zones, sediment, or near structures like weirs or harbors.

Previous research has revealed that rivers serve as the primary pathways for transporting plastics into the sea (Helinski et al., 2021). There are still knowledge gaps regarding the exact sources and pathways of plastic pollution. Special attention should also be given to understanding the impact of heavy rainfall events on the amount of waste entering rivers through sewer systems.

Addressing the challenges of Ocean-bound plastic pollution

Ocean-bound plastic, which can transform into marine plastic litter, constitutes a pervasive global pollution issue that jeopardizes not only the environment but also human health and tourism.

- Marine litter poses a threat to animals, leading to entanglement and suffocation. Many species mistake the debris for food, and traces of plastics are found in the stomachs of numerous seabirds or marine mammals. The marine environment is susceptible to the influx of toxic substances through plastic waste, as plastic is often treated chemically or coated with toxic substances. Additionally, marine litter can also serve as a carrier for invasive species.

- Environmental elements like weather, saltwater, and UV radiation contribute to the degradation of plastic litter, breaking it down into smaller particles known as microplastics. These microscopic fragments have the potential to infiltrate even the human food chain.

- Marine litter in shoreline areas, especially beaches, poses a significant threat to tourism due to the unsightly appearance of the marine litter. The visual impact of litter can deter tourists, impacting the appeal of these coastal destinations and the income-generating activities of the region.

2. Marine Litter Collection Methods

The COP project focuses on waterways ocean-bound plastic, specifically targeting macrolitter-sized particles. These particles can be present at the shoreline, in the water column, on the surface, and at the sea floor. The information provided for each collection method is based on a literature review and personal communication through interviews and has not yet been tested within the project.

Collecting marine litter is a complex and labor-intensive process; it is far more effective to prevent pollution at its source. This can be accomplished through initiatives such as raising public awareness or implementing political decisions, such as reducing the use of single-use plastic.

An analysis of the market situation has been carried out to identify the current methods or technologies currently available for the collection of ocean plastic in Europe.

While numerous manufacturers and methodologies are available for collecting marine litter, they can all be categorized into four groups: manual collection, booms/barriers, bins, and drones (figure 2).

Figure 2: Different solutions to collect marine litter

The following section will briefly introduce these four groups, providing examples for illustration. It is important to note that these methodologies described here represent only a selection intended to offer a concise overview for a deeper understanding of the topic.

The various technologies will be introduced by explaining the requirements for their installation and discussing their respective advantages and disadvantages. This information can assist decision-makers in selecting an appropriate methodology based on the prevailing environmental conditions.

2.1. Collection Method 1: Manual collection

Waste collection can be carried out manually through various methods:

- **On foot:** Collecting litter from the shoreside
- **By boat:** Gathering litter from the water surface and upper water layers
- **By divers:** Retrieving litter from the water column and the sea floor

Various entities, including public authorities and private companies, can undertake manual waste collection. However, a significant portion of this work is carried out by volunteers, such as Beach Clean Ups. In the city harbor of Rostock, Germany, the city employs a private company to clean the water surface. This involves the straightforward process of collecting waste from the pier using landing nets. Complementing this effort, divers from the fire brigade routinely incorporate litter collection into their training dives, targeting the harbor floor (figure 3). As an example of collective efforts in manual waste collection of OBP in the city of Rostock, please refer to figure 4.

Figure 3: a) Beach Clean-Up (NABU, 2024), b) Divers of the fire department (Stadt Rostock, Foto: Marcel Knaak, 2024)

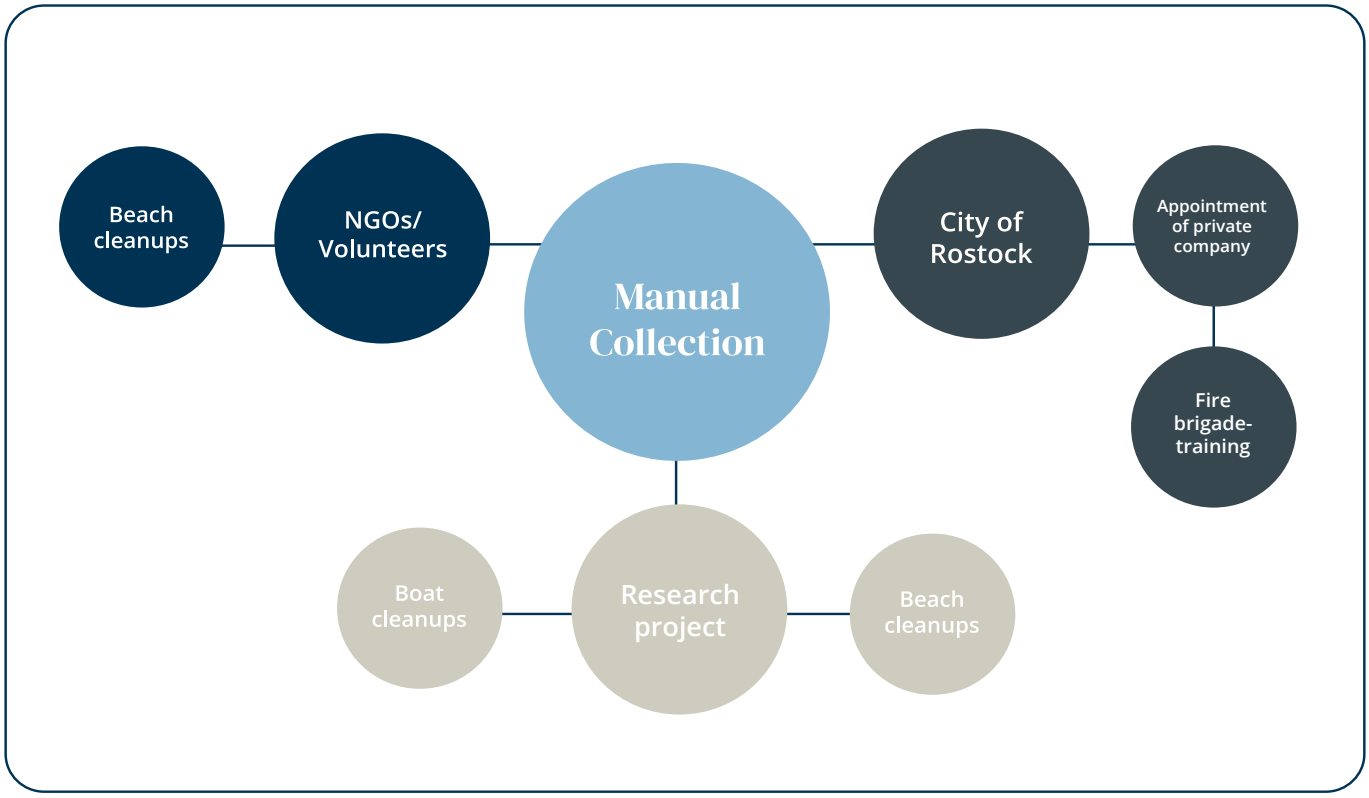

Figure 4: Example of manual collection efforts in the Warnow river, City of Rostock (Germany)

In several cities, innovative models have emerged to engage the community in waste collection. For example, there is a trend of promoting free paddling for litter collecting. In this model, individuals can rent a kayak for two hours at no cost, provided they collect litter during that time (figure 5).

Figure 5: Green Kayak (Stadt Hamburg, 2024)

Advantages	Disadvantages
• Cleaning of hard-to-reach areas is possible • Ship traffic is not hindered • Creates awareness by including society • Low installation cost for technical device	• Requires human effort • Only small scale (short-term) collection is possible

2.2. Collection Method 2: Booms/Barriers

Booms or barriers are utilized to guide marine litter or impede its movement, with various versions available as fixed or floating installations. These structures can be of different forms and sizes based on the water channel dimensions and flow characteristics.

The different forms can be 1) rotatable arm as seen in Aarhus, Denmark, which can open to accommodate small vessels like kayaks, or they manifest as floating options anchored with moorings on the seabed which can either span the whole river width, serve as partial barriers to guide the floating trash into a specific area or to entrap a particular area of the river (such as around a rainwater overflow outlet), 2) constructing a barrier from air bubbles that directs waste particles to a specific corner for collection. Most litter booms effectively gather litter on the water surface and upper water layers. However, the “Great Bubble Barrier” stands out by collecting litter throughout the entire body of water, reaching even deeper water layers (figure 6).

Constant river flow speeds are necessary for using barriers and booms for waste collection.

Figure 6: a) Great Bubble Barrier (The Great Bubble Barrier, 2024), b), Sea Protector One (Artlinco A/S, 2020) c) DESMI boom (DESMI, 2024)

Advantages	Disadvantages
• High collection rate of marine litter • Only minimal human involvement required	• Hindering the ship traffic • Quite expensive

2.3. Collection Method 3: Bins

Litter collection bins consist of a litter collection container and an underwater pump powered by a small electrical engine. The created downward suction pulls in nearby floating waste items, effectively containing them within the bin's interior depository. The bins can be installed using various possibilities, such as 1) direct installation under a floating dock and 2) a mechanically elevating variant (figure 7). These bins are designed to collect litter on the water surface and from the upper water layers. The installation of the bins should be strategically decided based on the flow characteristics, possible locations for the accumulation of the upper layer water marine debris (litter hotspots, debris bays), ease of emptying, and energy access.

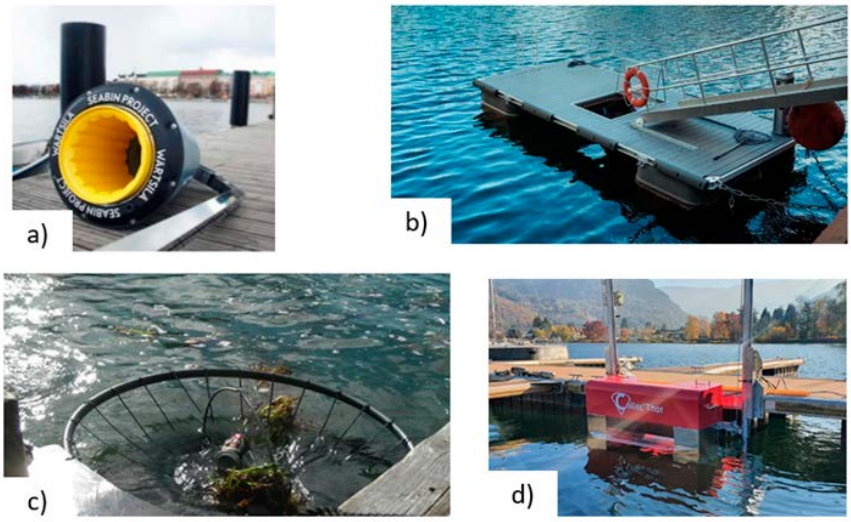

Figure 7: a) SeaBin (NiedersachsenPorts), b), Aquapod (Clean Sea Solutions, 2024), c) Port-bin (SpillTech, 2024), d) Collecthor (PORALU Marine, 2024)

Advantages	Disadvantage
• Comparatively low costs • Shipping traffic not hindered • Only minimal human involvement required	• Collecting litter only at one point

2.4. Collection Method 4: Drones

Waste collection drones are uncrewed vehicles that operate autonomously or are remotely controlled on the water surface, actively gathering litter. The drones achieve this either by pulling a net behind them or by using collecting arms to push the waste and channel it to their integrated collection bin. Small waste collection drones, measuring 80 x 80 cm, as well as larger drones with dimensions of up to 1,60 x 2m, are readily available in the market (figure 8). These drones efficiently collect litter from the water surface and upper water layers. The size of the collected debris depends on the mesh size of the deployed net. Robots designed for collecting litter on the seafloor are still in the research and development phases and are expected to be available in the near future (SEACLEAR, 2024).

Rough weather conditions and high river flow speeds are not suitable, as the drones might drift away (higher suitability for harbors and bays).

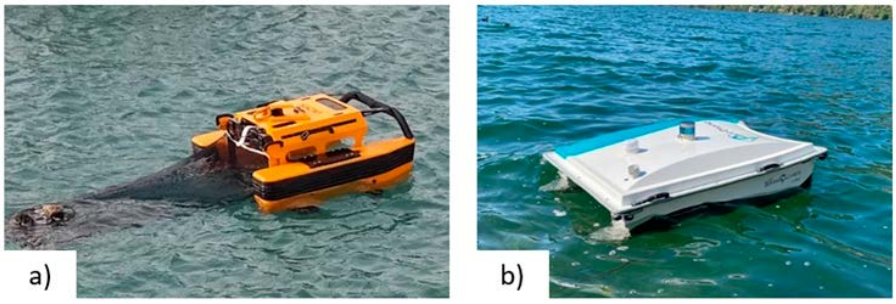

Figure 8: a) Jellyfishbot (IADYS, 2024), b) Pixie Drone (PORALU Marine, 2024)

Advantages	Disadvantage
• Spacious work area • Ship traffic almost not hindered	• Some legal issues in public water bodies

2.5. Conclusion

In conclusion to the overview of waste collection methods, table 2 compares the four presented options. It is important to note that the costs vary widely, mainly depending on the characteristics of the river and the specific waste collection device itself. For instance, barriers must be customized to fit the river, and drones can exhibit varying capabilities.

	Manual	Booms/ barriers	Bins	Drones
Installation costs (in EUR)	Non	up to 700,000	6,000-25,000	12,000-70,000
Ship traffic	Mostly not hindered	Hindered	Not hindered	Almost not hindered
Collecting rate	Depends	Very good	Only at one point	Good
Energy needs	Depends	Depends	Electricity	Electricity
Location	Various	In flowing waters	In a litter corner	Harbors and bays

Table 2: Comparison of solutions to collect marine litter

However, determining the best method is not straightforward, as the choice depends on various factors, such as the river's geography, flow speed, wind conditions, existing ship traffic, and the type and volume of litter. A combination of different methods might be the most effective solution.

For example, a litter boom could yield excellent results in narrow rivers with a constant water flow and minimal ship traffic, given its high collection rate. This technology might not be suitable in wider rivers or rivers with heavy ship traffic.

Figure 9 provides a rough orientation for deciding on the selection of appropriate collection technology.

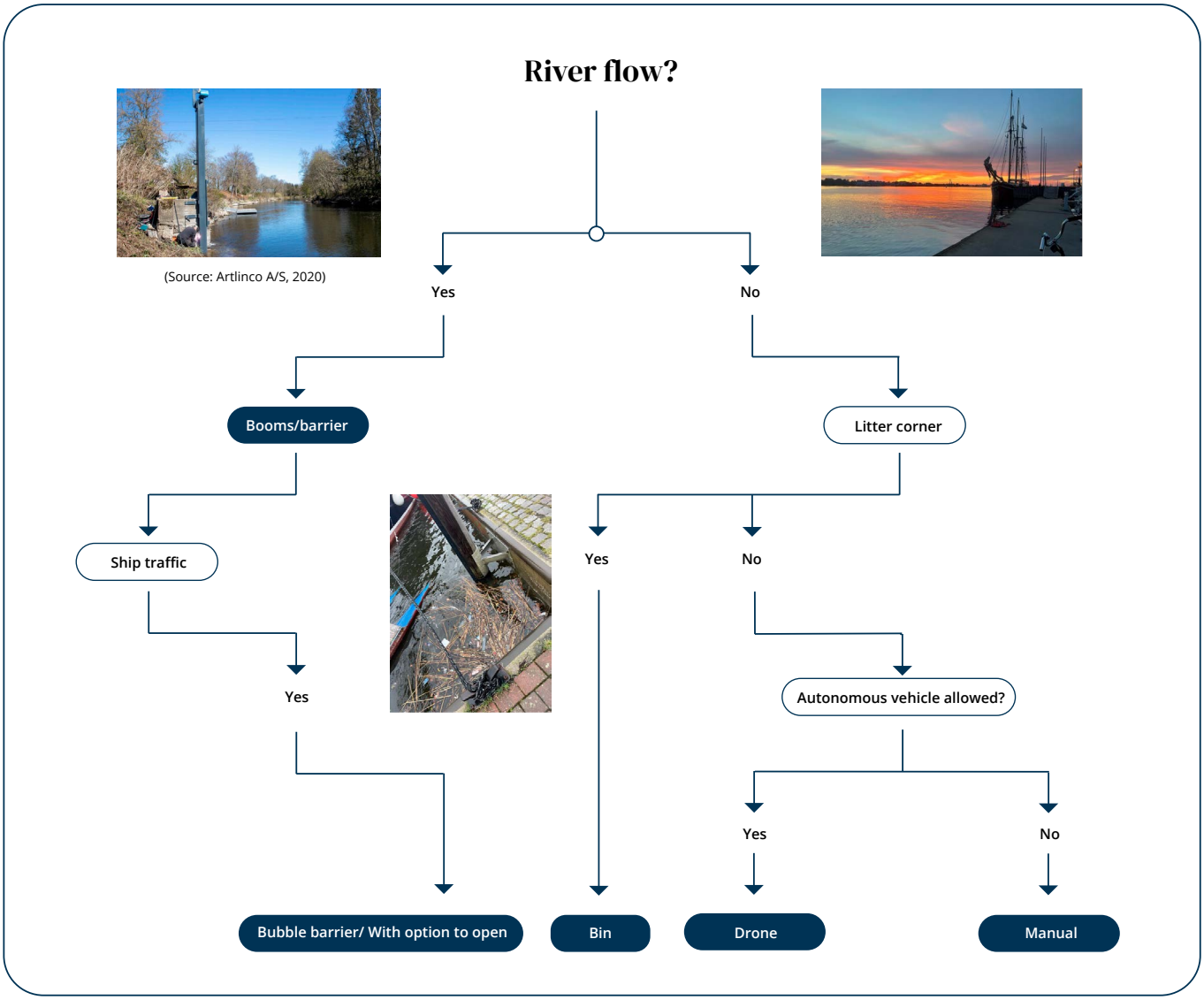

Figure 9: Decision tree for most appropriate waste collection technology

Currently, the market only offers technological solutions for waste collection on the water surface. The technologies for collection at the sea floor or shoreline are currently under development. Despite the majority of marine litter sinking to the seabed, there is currently no mass-scalable technology for its collection. Developing such a technology appears far more complex than developing a device for collecting waste on the water surface, necessitating further research. This emphasizes the need to raise public awareness and underscore the fact that the visible portion of the trash is just the tip of the iceberg.

In general, reducing littering at its source is more effective than relying on collecting waste as an end-of-pipe solution.

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