Fanplesstic-sea

Review of existing policies and research related to microplastics

Summary for Policy Makers

HELCOM

interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Microplastics

October 2019

About the FanpLESStic-sea project

FanpLESStic-sea – "Initiatives to remove microplastics before they enter the sea" (January 2019-June 2021) is an EU INTERREG funded Baltic Sea Region project aimed at decreasing and removing microplastics in the Baltic Sea, through the delivery of the following outputs:

- A model to map, understand and visualize microplastic pathways that will be applied to the partners' cities and/or regions;
- Piloting of new technology:
- for filtering out microplastics;
- sustainable drainage solutions as means for removal of microplastics; and
- to remove microplastics from stormwater
- Defining innovative governance frameworks and engaging a large range of players for the implementation of coordinated and cost-efficient measures resulting in locally adapted investment proposals/plans for each partner's region; and
- Dissemination of project results, including reports on barriers and ways forward, to increase institutional capacity on up-stream and problem-targeted methods to remove microplastics.

FanpLESStic-sea project partners

About this publication

This publication is a summary of the output report of the Activity 2.1 of the FanpLESStic-sea project which reviewed the existing research activities and policies on microplastics at global, regional (referring to the Baltic Sea region), EU and national level. National information and data were acquired through a questionnaire whereas a comprehensive literature review was conducted for compiling information at global, regional and EU levels.

For more detailed information and analysis of findings, refer to the main report.

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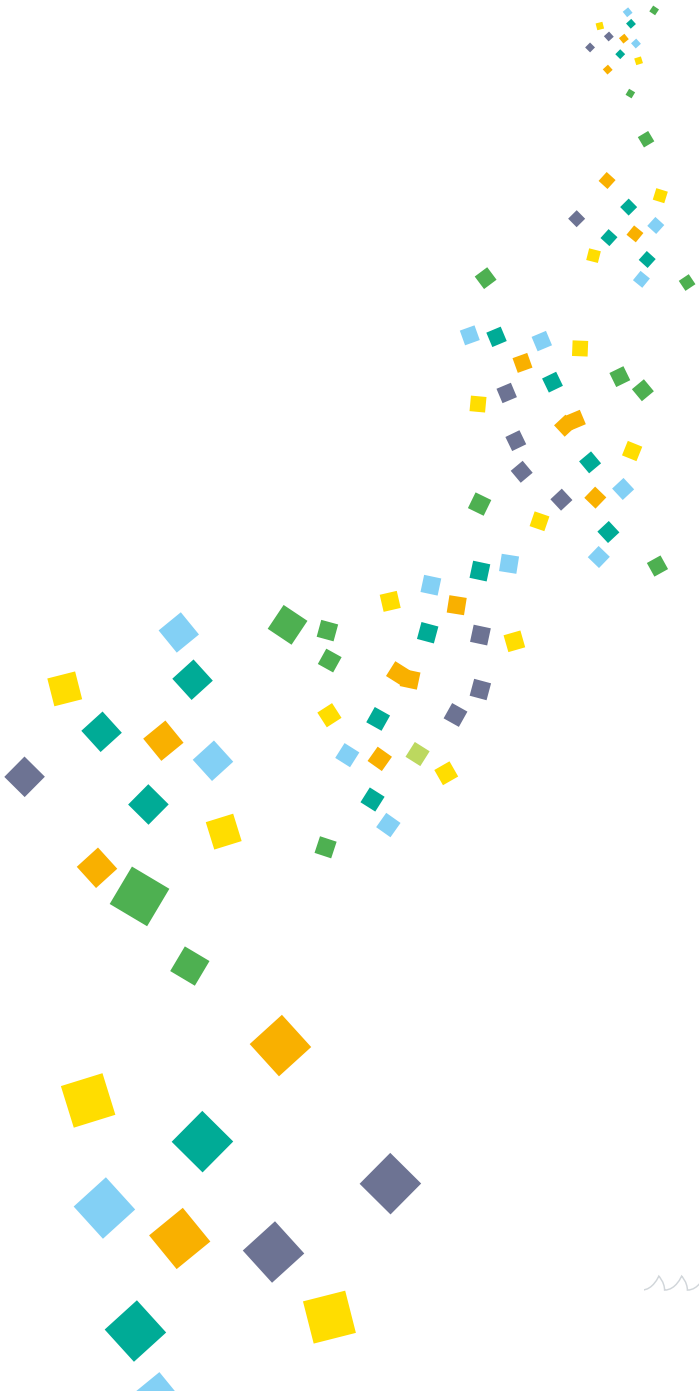

Introduction

Key observations

— Microplastics are not directly addressed through any global instrument even though several of the existing multilateral environmental agreements cover important aspects related to marine litter of which the Basel Convention is probably the most relevant;
— In the Baltic Sea, microplastics are addressed through the HELCOM Action Plan on Marine Litter;
— At EU-level, marine litter and microplastics are addressed through several directives, and EU is currently working on regulating the use of added primary microplastics;
— Global-level research exists on sources, occurrence and fate of microplastics, and the global community is working towards harmonizing monitoring methodologies for microplastics;
— EU-level research on marine litter and microplastics is comprehensive and the main sources of primary and secondary microplastics in the EU have been identified, while the work towards indicators and monitoring is still on-going;
— Regional-level research provides strong evidence of the occurrence of microplastics in water, sediments, beach and biota in the area, but due to the varying monitoring methodologies applied, the comparison between studies, basins and regions is not possible;
— National-level research provides information of the sources of primary and secondary microplastics;
— Several studies in the recent years have demonstrated that due to the large volumes involved, WWTPs are releasing microplastics into the marine environment despite of the advanced and efficient treatment technologies;
— Microplastics in road dust and stormwater is relatively new area of research, but a lot of on-going projects are addressing the issue;
— The development of harmonized monitoring methods for microplastics in general and for the Baltic Sea is of high importance in order to better understand the problem.
— There is still lack of knowledge regarding the effects of microplastics, but on-going research is expected to shed light on the issue at all levels.

Key suggestions

— Support the development of harmonized, cost-efficient, and sufficiently robust monitoring methodologies for microplastics;
— Enough evidence of different sources of microplastics exists to guide the implementation of measures already now (WWTPs, primary microplastics in products and processes);
— Prevent and reduce the secondary sources of microplastics by addressing the products in earlier phase of their life-cycle before they become microplastics or more importantly before they become marine litter;
— Address the known sources of primary microplastics through best available techniques and regulation;
— Focus the research on the secondary sources that are less known such as road dust via stormwater and other pathways and based on the evidence plan measures to address those sources.
— More research is needed regarding the effects and impacts of microplastics.

Existing policy frameworks related to marine litter and microplastics

Several global-level instruments and multigovernmental agreements exist that are relevant to marine plastics litter and microplastics, but none of the existing frameworks is specifically designed to prevent increasing amounts of plastic pollution and microplastics entering the environment nor to remove already existing plastics from the environment.

Global legally-binding instruments such as the United Nations Convention on the Law of the Sea (UNCLOS), the International Convention for the Prevention of Pollution from Ships (MARPOL), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention) and the Convention on Biological Diversity (CBD) all have relevant elements in terms of preventing plastics litter appearing in the environment and hence are also relevant in reducing secondary microplastics.

In addition, several initiatives and organizations such as United Nations Sustainable Development Goals (SDGs), United Nations Environment Assembly (UNEA), International Maritime Organization (IMO), United Nations Food and Agricultural Organization (FAO), G7 and others address the issue through different mechanisms such as action plans, decisions and other instruments.

At Baltic Sea-level, the most important regulatory instrument is the HELCOM Action Plan on Marine Litter that contains, among others, regional actions related to microplastics that are being regularly followed-up. European Union also has a wide range of instruments that target the issue of marine plastics litter and microplastics directly and indirectly, including several Directives and Strategies such as the Marine Strategy Framework Directive (MSFD), the Waste Directive, the Single-Use Plastics Directive (SUP) and the Directive on Port Reception Facilities as well as Circular Economy package including its Plastics Strategy.

At national level, Sweden is the only FanpLESStic-sea project country that has a ban concerning microplastics in cosmetics products in place (July 2018), but other countries are planning similar actions.

In addition, several countries have developed different guidelines and strategies to prevent primary and secondary microplastics emissions to the marine environment, for example from waste- and stormwater or from artificial turfs. Current advanced wastewater treatment plants remove up to 95-99% of the microplastics and fibers even though they are not specifically designed for this purpose. However, due to the large volumes of treated water constantly, they are still releasing considerable amounts of microplastics and fibers to environment and waterbodies directly and or in sludge.

Quick snapshot to the most relevant existing global, regional and EU-level instruments that address the issue of marine plastic litter and microplastics is provided in Figure 1 and Table 1 below:

Figure 1. International organizations that have relevance to marine litter and microplastics (not exclusive)

Globally

Table 1. International frameworks and instruments with relevance to marine litter and microplastics

Instrument	Relevance to marine litter and microplastics
United Nations Convention on the Law of the Sea (UNCLOS)	UNCLOS is the only global instrument that imposes a legally binding obligation upon States for the prevention, reduction and control of land-based sources of pollution through its Article 207, which is also the most relevant UNCLOS obligation in terms of preventing marine litter and microplastics.
Annex V of the International Convention for the Prevention of Pollution from Ships ("MARPOL")	MARPOL is the principal convention of the International Maritime Organization (IMO), the United Nations specialized agency, to address ship-based sources of pollution from international shipping. The most relevant regulations to marine plastic litter and microplastics are covered in its Annex V, which prohibits the discharge of all types of garbage into the sea from ships (with few exceptions such as food waste that are not harmful to the marine environment).
The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention) and its 1996 Protocol (the London Protocol)	Under the London Protocol there is a general prohibition on the dumping of any waste or other matter at sea, including plastics. The objective of the London Convention and Protocol is to promote the effective control of all sources of marine pollution encouraging countries to take effective measures to prevent pollution of the marine environment caused by dumping at sea.
The Convention on Biological Diversity (CBD)	Even though the convention does not directly address pollution of the marine environment since it principally applies to the conservation of biological diversity, it has adopted a resolution (CBD/COP/DEC/XIII/10) to address impacts of marine debris and anthropogenic underwater noise on marine and coastal biodiversity. The decision also has specific part and priority actions related to microplastics.
The Convention on the Conservation of Migratory Species of Wild Animals (CMS)	The Convention on the Conservation of Migratory Species of Wild Animals (CMS) applies to migratory species, but during the recent years, the Convention has put more emphasis on marine litter and the Parties have adopted two resolutions (Res.10.4 and Res.11.30), that encourage or recommend specific measures for Parties to address knowledge gaps relating to the impacts of debris on marine species, implement best practices on commercial vessels, and organize awareness campaigns.
United Nations Fish Stocks Agreement (UNFSA)	The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations Fish Stocks Agreement/ UNFSA) is mainly concerned with the conservation and management of straddling fish stocks and highly migratory fish stocks, but it also includes obligations for States to minimize pollution, waste, discards, and catch by lost or abandoned gear (article 5(f)). In addition, in the Article 18 (3d), the agreement touches upon the issue of marking of fishing gear.
The Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention)	The application of the Stockholm Convention is limited to those plastics produced with POPs listed under the Convention and may have implications for the recycling and reuse of products that contain regulated chemicals.
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention)	The Basel Convention provides maybe the most comprehensive approach to the issue of marine plastics litter and microplastics globally since the provisions of the Convention with respect to waste minimization, the environmentally sound management of wastes generated, and the transboundary movement apply to plastic wastes. In 2017 the Convention decided to further address marine plastic litter and microplastics. In 2019, Governments amended the Basel Convention to include plastic waste in a legally-binding framework which will make global trade in plastic waste more transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment. A new Partnership on Plastic Waste was also established to mobilize business, government, academic and civil society resources, interests and expertise to assist in implementing the new measures.

Table continued on next page ▸

continued *(Table 1. International frameworks and instruments with relevance to marine litter and microplastics)*

The 2030 Agenda for Sustainable Development – The Sustainable Development Goals (SDGs)	Resolution 70/1[1] and the UN Agenda 2030 for Sustainable Development was adopted in 2015 by the United Nations General Assembly with 17 sustainable development goals (SDG), including SDG 14 to conserve and sustainably use the oceans, seas and marine resources. Each SDG includes targets and under the 10 targets for the implementation of SDG 14 ("Life below water"), target 14.1 specifically aims to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine litter and nutrient pollution
United Nations Environment Assembly (UNEA)	The United Nations Environment Assembly (UNEA), often referred to as the world's highest-level decision-making body on the environment, addresses the critical environmental challenges facing the world today. From the very first Environment Assembly (UNEA-1), the issue of marine litter and microplastics has been on its agenda and to date, the Environment Assembly has adopted four resolutions on marine plastic litter and microplastics[2] and several other related resolutions. It's worth mentioning that the resolutions also have specific recommendations related to microplastics.
G7 Action Plan on Marine Litter	In 2015, the G7 countries formally agreed on the Action Plan on marine litter that recognizes the social, economic and environmental impacts of the problem. The G7 action plan also highlights the role of the Regional Seas Conventions (such as HELCOM and OSPAR) and the importance of a stronger collaboration between these Conventions and the Fisheries management bodies in the context of wider global initiatives on fishery management. This collaboration is essential since the "abandoned, lost or otherwise discarded fishing gear" (ALDFG or ghost fishing gear) is one of the major sources of marine pollution and poses a direct threat to marine life and biodiversity.
FAO – Marking of Fishing Gear	The Food and Agriculture Organization of the United Nations (FAO) considers the issue of marine litter and microplastics from the perspectives of i) reducing marine litter that originates from the fishing industry, in particular abandoned, lost or otherwise discarded fishing gear (ALDFG); ii) assessing the ecological impact of microplastics on fisheries resources and aquaculture products; and; iv) assessing food safety risks from marine litter, in particular microplastics, on human health. In 2018 the Committee on Fisheries (COFI33), endorsed FAO's Voluntary Guidelines for the Marking of Fishing Gear (VGMFG)[3] that include not only a framework for undertaking risk assessment to identify the appropriateness or otherwise of implementing a system for marking fishing gear, but also provisions related to associated measures such as retrieval of lost gear, reporting of ALDFG and disposal of end-of-life gear. The VGMFGs are an important tool in preventing and reducing ALDFG and ghost-fishing, and in combatting illegal, unreported and unregulated fishing (IUUF). The VGMFG compliment FAO's Code of Conduct for Responsible Fisheries.
IMO Action Plan to Address Marine Plastic Litter from Ships	In addition to the legally-binding instruments, IMO's Marine Environment Protection Committee (MEPC) recently adopted (on 26 October 2018) the Action Plan to Address Marine Plastic Litter from Ships (Resolution MEPC.310(73)) , to contribute to find a global solution for preventing marine plastic litter entering the oceans through ship-based activities. IMO Member States agreed actions to be completed by 2025, which relate to all ships, including fishing vessels. The action plan also seeks to address possible gaps in MARPOL such as waste from dredging. Further discussions continue in the frame of the MEPC to advance on the implementation of the Action Plan.

1 UNGA, 2015

2 UNEP/EA/UNEA/1/6, UNEP/EA.2/Res.11, UNEP/EA.3/Res.7 and UNEP/EA.4/L.7

3 FAO, 2019

In the Baltic Sea

In the Baltic Sea region, the nine coastal countries and the European Union cooperate on environmental management across national borders through the Convention on the Protection of the Marine Environment of the Baltic Sea (Helsinki Convention of 1974, amended in 1992). Even though the recommendations (see Table 1 below) are not legally binding as such, the fact that they are adopted unanimously, and that countries are required to report on their national implementation, diminishes concerns about their lacking legal nature. While the Convention does not specifically mention plastics, its provisions are applicable to all types of pollution, de facto relating to marine litter – including plastics.

HELCOM has hence recognized and addressed the issue of marine litter for many years, but the 2013 Copenhagen Ministerial Declaration includes a clearer commitment to develop a Regional Action Plan on Marine Litter by the end of 2015[1]. Such an Action Plan was adopted by Contracting Parties as HELCOM Recommendation 36/1[2], containing concrete regional actions and voluntary national actions to reduce the input and presence of marine litter in the Baltic Sea. In particular the Action Plan has two important aims:

1. Significantly reduce marine litter by 2025 as compared to 2015 levels and;
2. Prevent harm to the coastal and marine environment.

Among the regional actions related to microplastics, the ones to benefit from the contribution of the FanpLESStic-sea project are:

— Improvement of stormwater management in order to prevent litter, including microlitter, to enter the marine environment from heavy weather events (RL4);
— Establish an overview of the importance of the different sources of primary and secondary microplastics. Evaluate products and processes that include both primary and secondary microplastics, such as fibers from clothing, assess if they are covered or not by legislation, and act, if appropriate, to influence the legal framework, or identify other necessary measures (RL 6); and
— Investigate and promote best available techniques as well as research and develop additional techniques in waste water treatment plants to prevent micro particles entering the marine environment (RL 7).

1 (HELCOM, 2015a)
2 (HELCOM, 2015b)

Table 2. Relevant HELCOM instruments on marine litter

HELCOM (or other relevant) instrument	Description and Relevance to marine litter and microplastics
Article 3 of the Helsinki Convention	"The Contracting Parties shall individually or jointly take all appropriate legislative, administrative or other relevant measures to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance."
Article 5 of the Helsinki Convention	"The Contracting Parties [shall] undertake to prevent and eliminate pollution of the Baltic Sea Area from land-based sources […] in the catchment area of the Baltic Sea."
Article 11 of the Helsinki Convention	A general prohibition of dumping to the Baltic Sea Area where "Dumping" means any deliberate disposal at sea or into the seabed of wastes or other matter from ships, other man-made structures at sea or aircraft, and any deliberate disposal at sea of ships, other man-made structures at sea or aircraft.
MARPOL Annex V	The Baltic Sea was designated as a special area for discharge of garbage from ships under MARPOL Annex V already in 1973, (in effect from 1 October 1989). Based on this status, the discharge of Annex V waste – which includes plastics – from a ship into the Baltic Sea area is more restrictive than the general provisions of MARPOL Annex V
Regulation 6 of Annex V of MARPOL	It is mandatory for ships operating in the Baltic Sea to discharge all ship-generated wastes to a port reception facility before leaving port.
The Baltic Sea Action plan (BSAP) [1]	The Baltic Sea Action Plan (adopted by the Baltic Sea countries and the EU in 2007) aims to achieve good environmental status (GES) of the Baltic Sea and also addresses marine litter, even if only concisely. The Contracting Parties committed to encourage projects by local governments and local communities to remove litter from the coastal and marine environment, such as beach clean-up operations, "Fishing for litter" initiatives and local litter campaigns, noting the leading role of the voluntary sector in such activities.
HELCOM Recommendation 28E/10[2]	The HELCOM No Special Fee Recommendation is the first HELCOM recommendation specifically addressing marine litter. It applies to garbage as well as litter caught in fishing nets (based on the amendment from 2007), in addition to other types of waste. According to the "no-special-fee" system, a fee covering the cost of reception, handling and final disposal of ship-generated wastes is levied on the ship, irrespective of whether ship-generated wastes are actually offloaded or not.
HELCOM Recommendation 29/2[3]	"Marine litter in the Baltic Sea" adopted in 2008 was the first HELCOM recommendation entirely devoted to marine litter, and largely focusing on sampling and reporting of marine litter found on beach.
The 2010 Moscow HELCOM Ministerial Meeting[4]	A commitment of the Contracting Parties to "take further steps to be able to carry out national and coordinated monitoring of marine litter and identify sources of litter". The current HELCOM monitoring guidelines for marine litter on beaches[5] de facto supersede this Recommendation, even though a related formal process in HELCOM is yet to be finalized.
The 2013 Copenhagen Ministerial Meeting[6]	Marine litter was recognized as a topic that requires a comprehensive response and HELCOM countries committed to significantly reduce marine litter by 2025, compared to 2015, and to prevent harm to the coastal and marine environment. Furthermore, HELCOM countries decided to develop a regional action plan by 2015 at the latest with the aim of achieving such ambitious objective.
HELCOM Recommendation 36/1[7]	HELCOM Regional Action Plan on Marine Litter – see above

1 (HELCOM, 2007a)
2 (HELCOM, 2007b)
3 (HELCOM, 2008)
4 (HELCOM, 2010)
5 (HELCOM, 2018)
6 (HELCOM, 2013)
7 (HELCOM, 2015b)

European Union

The European Union is addressing not only issues related to chemicals and waste but also directly related to the plastics and marine litter through several regulations and directives as well as different strategies and initiatives. The most relevant Directives and other instruments related to the issue of marine litter and microplastics listed in the Table 3.

Table 3. Relevant EU instruments on marine litter

EU instrument	Description
Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	The Marine Strategy Framework Directive (MSFD) was adopted in 2008 with the aim to achieve or maintain good environmental status (GES) in the marine environment by 2020 as stipulated in its Article 1. The implementation of the MSFD is based on eleven qualitative descriptors for determining good environmental status listed in Annex I of the Directive. The Descriptor 10 is relevant to the issue and requires "Properties and quantities of marine litter do not cause harm to the coastal and marine environment".
Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste	The amended waste directive highlights the links between the land-based sources of pollution and marine litter and how the policy should address it. Since marine litter, especially plastic waste, stems to a large extent from land-based activities caused mainly by poor solid waste management practices and infrastructure, littering by citizens and lack of public awareness, specific measures should be laid down in waste prevention programmes and waste management plans. These measures should contribute to the goal of achieving good environmental status in the marine environment by 2020 as laid down in the MSFD above.
Directive (EU) 2019/883 of the European Parliament and of the Council of 17 April 2019 on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC	The European Commission amended Port Reception Facilities Directive aiming inter alia to reduce marine litter from ships, including fishing vessels and recreational craft. The Directive also aims to protect the marine environment against the negative effects from discharges of waste from ships using ports located in the Union, while ensuring the smooth operation of maritime traffic, by improving the availability of adequate port reception facilities and the delivery of waste to those facilities.
Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment	The Single-Use Plastics (SUP) Directive adopted in 2019 addresses marine litter coming from the 10 single-use plastic products most often found on European beaches, as well as abandoned fishing gear and oxo-degradable plastics. It also stimulates the production and use of sustainable alternatives that avoid the generation of marine litter. Measures to point out from the Directive are as follow: — A ban on selected single-use products made of plastic for which alternatives exist on the market: cotton bud sticks, cutlery, plates, straws, stirrers, sticks for balloons, as well as cups, food and beverage containers made of expanded polystyrene and on all products made of oxo-degradable plastic. — Measures to reduce consumption of food containers and beverage cups made of plastic and specific marking and labelling of certain products. — Extended Producer Responsibility schemes covering the cost to clean-up or collect litter (depending on the product), applied to products such as tobacco filters and fishing gear. — A 90% separate collection target for plastic bottles by 2029 (77% by 2025) and the introduction of design requirements to connect caps to bottles, as well as target to incorporate 25% of recycled plastic in PET bottles as from 2025 and 30% in all plastic bottles as from 2030.
An EU action plan for the Circular Economy and the Plastics Strategy	In 2015 the European Commission launched a Circular Economy Action Plan entitled: "Closing the loop - An EU action plan for the Circular Economy" which was designed to develop a sustainable, low carbon, resource efficient and competitive economy by focusing certain key areas such as the Production (design, processes), Consumption and Waste management. Under the Circular Economy Package, the Commission also agreed to adopt a Strategy on Plastics, addressing issues such as recyclability, biodegradability, the presence of hazardous substances of concern in certain plastics, and marine litter.
Microplastics	Following the request from the European Commission, European Chemicals Agency (ECHA) published its official REACH restriction proposal for intentionally added microplastics in January 2019. According to ECHA, if adopted, the restriction could reduce the amount of microplastics released to the environment in the EU by about 400 thousand tonnes over 20 years. The proposed restriction was open to public consultation until September 20, 2019.

Nationally

In general, the issue of microplastics is covered broadly by other legislation such as acts concerning environmental impacts on water bodies and other more general legislation that does not specifically address microplastics.

However, some countries have already introduced bans or other restrictions on the use of microplastics (microbeads) in certain types of products, largely concerning wash-off cosmetic products. From the Baltic Sea Region, Sweden is the only country that is currently implementing a ban that prohibits the provision of a rinse-off cosmetic product that contains plastic particles smaller than 5 mm in any dimension on the market. The ban entered into force on 1 July 2018 and cosmetic products released on the market before that date had to be phased out by the end of 2018.

According to our knowledge, no other FanpLESStic-Sea project countries have implemented restrictions specifically related to microplastics. However, several countries have started different processes targeting microplastics and plastics use in general. For example, a ministerial order is in hearing on a ban of the use of microplastics in cosmetic products in Denmark. Whereas in Finland, a guidance and national indicators related to the implementation of the MSFD includes targets concerning microplastics.

Regarding stormwater, different laws as well as guidelines exist, but typically they do not specifically address microplastics either (such as in Finland, Poland and Sweden). One exception is Norway, where the Road building guidelines (anchored on the Road Act), identify microplastics as one of the pollutants; Sweden is currently working on a similar guidance. In Russia, there are requirements for overall stormwater quality whereas Sweden is developing specific guidance regarding highway runoff pollution. There are also NGO guidelines available that propose ways to reduce microplastics in stormwater in the Baltic Sea region.

In Denmark, the Government has sent out a guideline on managing of artificial lawns including the microplastic aspects of the rubber granulates used in them and Sweden is working on a notification requirement for artificial turfs and compiling specific guidelines to minimize emissions of microplastics from industrial production of primary microplastics.

In summary, even though there is not much specific legislation concerning microplastics in the Baltic Sea area the issue has been recognized at different levels addressing different sources and it is expected that new legislation and guidelines emerge.

Existing microplastics research

Globally

The amount of research regarding microplastics has grown dramatically during the past few years. Globally, there is nowadays lot of research on-going on microplastics in different ecosystem compartments as well as on methodologies for detecting, analyzing and monitoring microplastics of which only few global research compilations are presented here. The reports produced by the GESAMP group are to be pointed out, not only do they present available information on microplastics, but try to harmonize microplastics monitoring methodologies. Regarding microplastics in general, the GESAMP (2016) highlights several important points (see Box 1).

Regarding the sources of microplastics, existing global, regional, EU- and national level studies reviewed for this project have drawn similar conclusions. Figure 2 (SYKE 2019, UNEP 2016) demonstrates the most important identified sources of secondary and primary microplastics as well as their pathways to the water bodies in a simplified but informative format.

A more general picture of the sources and fate of microplastics is shown in the Figure 3 (IUCN, 2019) that illustrates the break-down of pathways and releases of microplastics between land- and ocean-based sources suggesting that majority of microplastics originate from land, but up to half of them get released to the marine environments via mainly road runoff and wastewater and to lesser extent via wind and ocean-base sources.

Microplastics monitoring has become an important topic of discussion, and there is on-going work at global, regional, EU and national levels related to it. Many of the regional-level studies reviewed for this project also showed that lack of international harmonized standards regarding all aspects of monitoring (sampling, sample preparation, identification, characterization etc.), makes it not possible to compare different studies and data among and between regions. Hence, the GESAMP (2019) report makes a set of global recommendations in order to harmonize monitoring methodologies for marine litter and microplastics. Some useful NGO guidelines and protocols for example regarding the use of manta trawl (5Gyros) are also available.

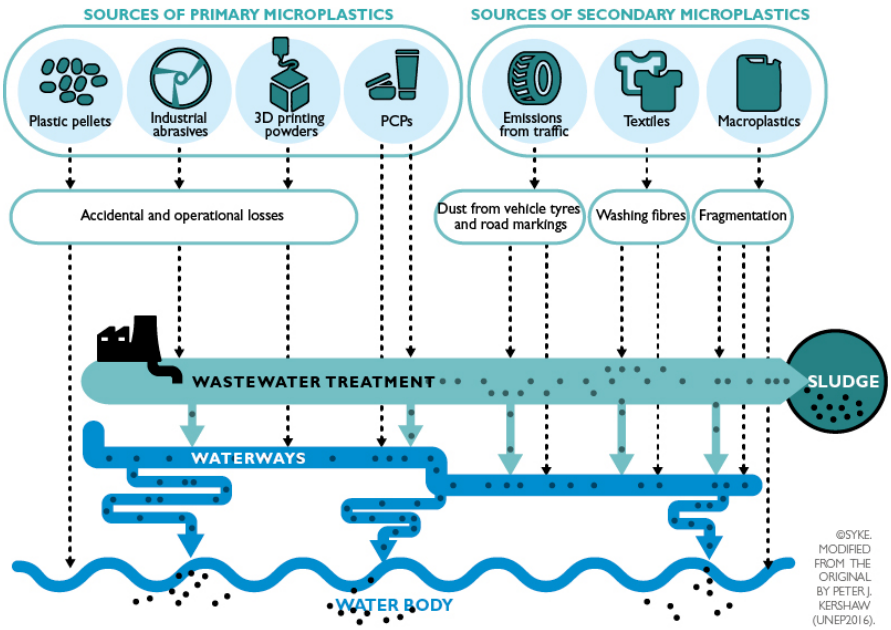

Figure 2. Sources of primary and secondary microplastics (SYKE 2019, originally in UNEP 2016)

Box 1.
GESAMP key reflections on microplasitc

There are **primary and secondary sources of microplastics.** The distinction is based on whether the particles were originally manufactured to be that size (primary) or whether they have resulted from the breakdown of larger items (secondary).

Fragmentation and degradation play an essential role in the formation of secondary microplastics, but the processes are poorly understood.

There is evidence that microplastics are littered into the environment **at all steps in the life cycle of a plastic product** from producers to waste management.

Microplastics can **enter the marine environment** via riverine systems, coastlines, directly at sea from vessels and platforms or by wind-induced transport in the atmosphere.

Methods of defining microplastics, sampling and measurement vary considerably among studies, source sectors and geographical regions making it **difficult to synthetize data** across studies (GESAMP, 2016).

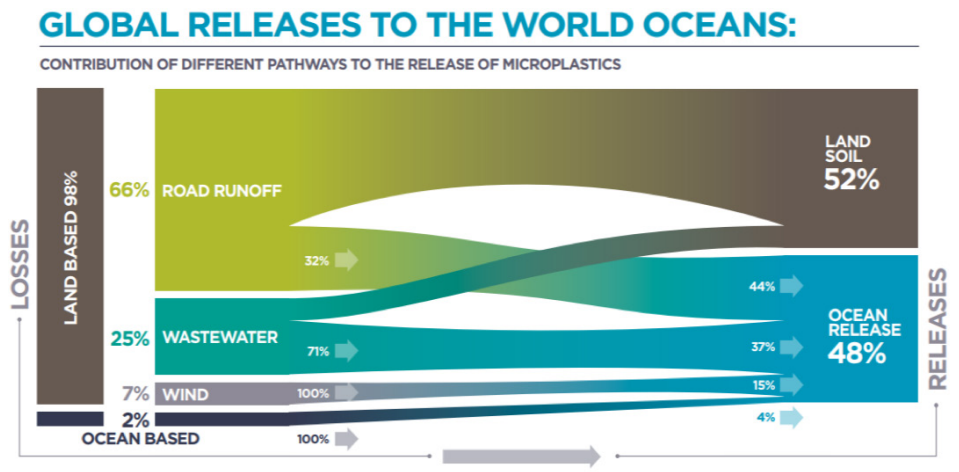

Figure 3. Global releases of microplastics to the world oceans (IUCN 2019)

In the EU

In the framework of European Strategy for Plastics in a Circular Economy and regarding its different objectives and actions (such as actions to curb microplastics pollution in Annex 1 of the Strategy), the European Commission commissioned several publications related to marine litter and microplastics, among which the following two are to be pointed out:

— "Intentionally added microplastics in products", 2017
— "Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products", 2018

Several other publications and research projects related to marine litter and microplastics are being identified and briefly described in the long version of the report.

The report[1] on the intentionally added microplastics came up with a variety of sources for intentionally added microplastics under different categories defining possible emission pathways for each sub-category (Table 5, modified from the original report).

The other report[2] ordered by the European Commission related to microplastics emitted from other than intentionally added sources found out that tires, road markings, pre-production plastic pellets and washing of synthetic textiles are all large sources of microplastics emissions into the environment (Figure 4).

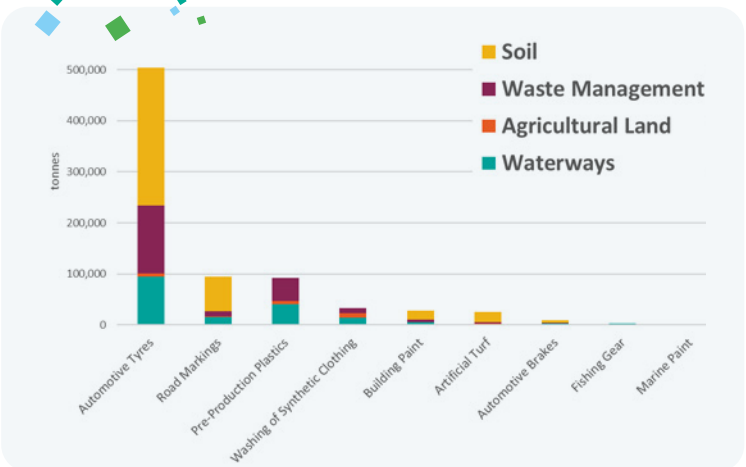

Figure 4. Sources of non-intentionally added microplastics in the EU in EUNOMIA & ICF 2018.

1 (Amec Foster Wheeler Environment & Infrastructure, 2017)
2 (Eunomia & ICF, 2018)

Table 5. Sources of intentionally added microplastics in the EU, 2017

Category	Sub-Category	Emission pathways
Cosmetics and Personal care products	Rinse off	Waste water, direct human uptake
	Leave on	Solid waste (makeup remover), waste water, direct human uptake
	Superabsorbents	Solid waste (disposable hygienic products)
Detergents		Waste water (solid waste)
Paints/Coatings/Inks	Building, Road, Marine	Paint spill during application (soil, water); waste water (rinse brush), formation of secondary microplastics
	Paper making (drainage aid, coating)	Waste water, solid waste
	Laser printer inks	Direct human uptake (inhalation); solid waste (no particles, layer)
	Domestic polishing agents (floor)	Waste water, formation of secondary plastics and possibly abrasion
Industrial abrasives	Abrasive media	Most likely: recovery for reuse plus filter masks for workers; possible: waste water; direct human uptake (lungs)
Agriculture	Controlled release fertilisers (nutrient prills), crops	Dissolution of polymer coating (encapsulated ingredient/fertiliser is released over time), no evidence that particle shape remains
	Soil enhancement (water retention)	Soil, ground water
	Dewatering of manure	Soil, ground water
Medical applications	Pharmaceuticals (additive in drug formulations, controlled release, nanocapsules)	Direct human uptake, (waste water if not dissolved)
	Dental polymers for cavity filling, sealants, dentures, abrasive in dental polish	Direct human uptake, waste water
Waste water treatment	Flocculation agents, sewage dewatering	Through sewage onto agricultural land
Construction	Polymer concrete, fibre reinforced concrete (PP, Nylon, PET), Insulation (EPS)	During construction period: emission of product into water, soil after demolition of buildings into environment (water, soil)
Others	Furniture/soft toys (e.g. expanded PS)	Solid waste
	Adhesives and sealants	No evidence that particle shape remains (solid waste)
Oil and Gas	(Drilling fluids, flocculant)	Unintentional releases in the marine (or terrestrial) environment

In the Baltic Sea

Figure 5 demonstrates potential fate and pathways and biological interactions of microplastics in the marine environment. Depending on several factors, including the density of the particle, the pathways and fate also vary. Hence, research is needed and has also been carried out in different ecosystem compartments in the Baltic Sea. For this project, studies of microplastics on water surface, in the water column, in sediment, on strandline as well as in biota (fish and invertebrates) were reviewed.

As part of the "Status, Pressures and Impacts, and Social and Economic evaluation in the Baltic Sea marine region" (SPICE)-project[3], co-financed by the EU, HELCOM compiled regional data on microlitter research for the Baltic Sea area, which has been used as a basis for this section.

According to the SPICE outputs[4], the earliest sampling for microlitter in the Baltic Sea was conducted on water surface from the Swedish coast (2007), whereas from sediments came at a later stage (Denmark, 2012). There is also data just outside the Baltic Sea area (near Gothenburg, Sweden) already from 2007. For microlitter on strandline, earliest studies date back to 2014 from Germany, and for microlitter in biota from to 2013 (Denmark). The environmental sampling was done mainly for research purposes, but some pilot monitoring activities are also ongoing in several Baltic Sea countries such as Denmark (biota and sediment), Estonia and Finland (surface), and Sweden (road dust). In Denmark, there are also historical samples from biota that date back to 1987.

3 http://www.helcom.fi/helcom-at-work/projects/completed-projects/spice/

4 (HELCOM, 2017)

In Poland, monitoring of microplastics is carried out as part of the State Environmental Monitoring (SEM). In the Polish Maritime Areas microplastics monitoring was performed for the first time in 2016 at 6 stations (including 1 station at the Vistula Lagoon as part of complementary water monitoring in the shallow water zone). Since 2018 (up to 2021), microplastics in sediments and water column are monitored at 6 stations once in each testing year.

In most of the cases, the main objective of the research in different water compartments was to detect (and possibly further analyze) plastic polymers.

After these pioneering studies, there has been an increasing amount of research regarding microlitter and specifically regarding microplastics in different ecosystem compartments and biota also in the Baltic Sea.

However, as also confirmed by the SPICE project, there is great variability in the methods used for sampling as well as sampling preparation and analyses. The sampling methods and sampling devices vary even in cases where samples are collected from the same ecosystem compartment. In addition, different devices and extraction protocols are further used to separate microlitter from the matrices, biological material or sediment, or to digest organic material (sediment and biota).

Common to all sampling methodologies in different compartments is that mesh/cut-off size varies enormously, which makes the comparison between different studies difficult if not impossible. In some studies, the differences in the number of observed particles have been reported to be 2500 times bigger (even up to 100,000 times bigger in one study) when using smaller mesh size. The only exception is for water surface studies because most of them use manta trawls.

Regarding microplastics in sediments, the results also vary greatly depending on the size of the particles considered, but in general the

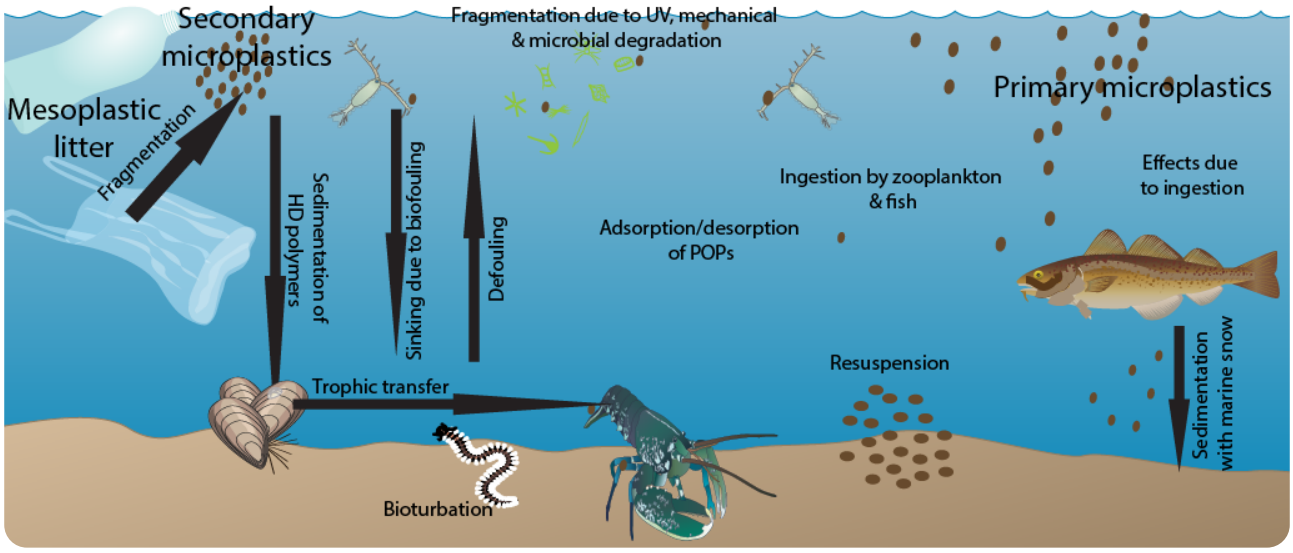

Figure 5. Potential fate and pathways and biological interactions of microplastics (NIVA, 2014, originally in Wright et al., 2013).

microplastics studies from the sediments have used smaller cut-off size (down to 10µm) than the trawling studies for example.

Regarding microplastics in biota, in 2017, the Nordic Council of Ministers funded a study[5] called "Micro-and macro-plastics in marine species from Nordic waters" which is a comprehensive summary of existing relevant studies of microplastics in different biota in the Nordic waters. Since, according to the report, most of the studies were made in the North and Baltic seas, it gives a good overview of the status of knowledge on microplastics in biota (fish and invertebrates) for the Baltic Sea. In the above-mentioned report, a total of seven studies from the Baltic Sea were analyzed of which five concerned fish and two invertebrates. Herring and cod are the most studied species by number and by study location and their percentage of ingestion of microplastics ranged from 0–34% and 1.4–26%. For the Chinese mitten crab the ingestion rate in two studies varied between 9-28% whereas for the blue mussel ingestion rates as high as 67% were reported. However, the study reminds that the comparability between and within studies from the Nordic environment (including Baltic) and other regions is difficult as there is a limited number of studies, also a limited number of studies on the same species from different locations and different methods are used. In addition, several other factors are believed to impact the level of plastic ingestion in species, especially for fish which are not easily accounted for.

5 (Bråte, et al., 2017)

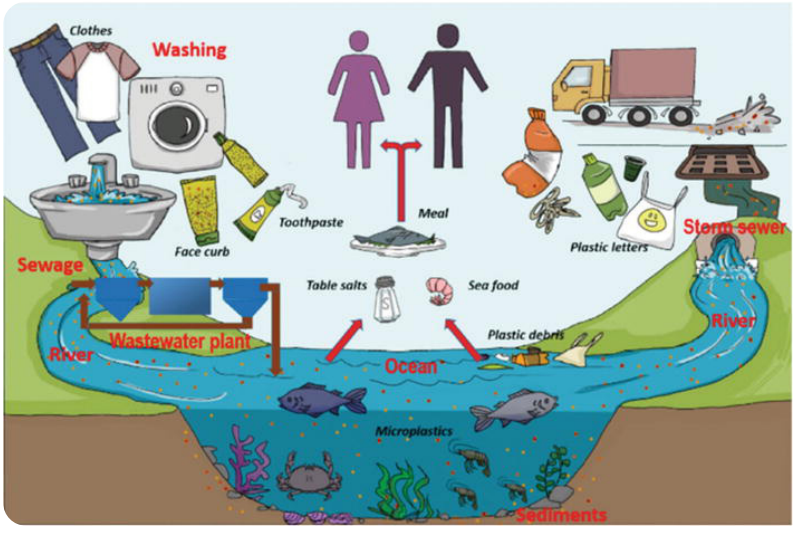

Figure 6. Commonly understood sources and pathways of microplastics in Wu, Yang, & Criddle, 2017

Nationally

As demonstrated by studies from different Baltic Sea basins, the occurrence of microplastic in the Baltic Sea is evident. Some of the sources are also identified. However, a clear picture of the pathways of microplastics into the Baltic Sea is still largely unknown.

Therefore, the survey that was carried out as part of the FanpLESStic-sea project included questions regarding ongoing and concluded national-level research on microplastics, on availability of data, on the current knowledge of the sources of microplastics and on the presence of microplastics in waste- and stormwater.

In general, it seems that on a national-level there is a good understanding of the sources of microplastics, some of the pathways (such as wastewater) as well as the potential of WWTPs in removing the microplastics. However, microplastic emissions via stormwater is much more ambiguous, and available information, methodologies and technologies to deal with microplastics in this matrix are limited. In addition, the full picture of sources, pathways and fate is currently not clear. This means for example the mass balance between different sources (secondary vs. primary), the importance of different pathways (wastewater vs. stormwater vs. direct emissions), and the final fate (surface vs. water column vs. sediments vs. biota) of microplastics is not yet well-known.

Sources

Regarding the sources of the microplastics, Denmark (2015), Germany (2015), Norway (2014) and Sweden (2015, 2016, 2017, 2019) have carried out national-level analysis of the sources of microplastics. Out of the other project partner countries, Finland is also in a process of preparing such an assessment. Based on the results, the main sources at a national level are very similar than at a global and European level: secondary microplastics emissions from road-related sources, primary microplastics in personal care and cosmetics products and washing of synthetic clothes. In addition, accidental losses of plastic pellets, artificial turfs, different paints as well as sand blasting by using microparticles have been identified as sources. Microplastics from some of the identified sources pass through the wastewater treatment, some through the stormwater and some are emitted to the water bodies directly as also represented in the Figure 6.

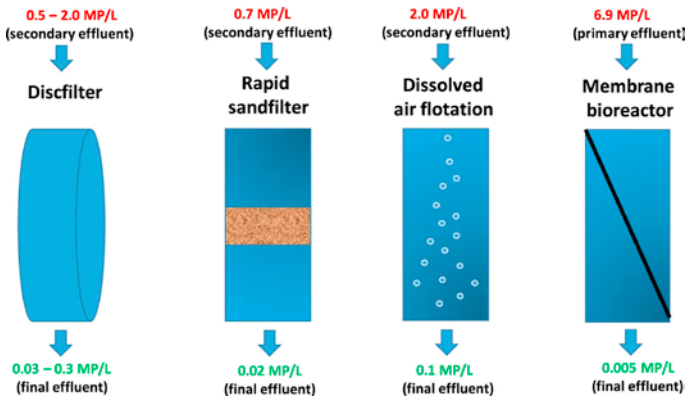

Figure 7. Efficiency of different wastewater treatment technologies in removing microplastics in Talvitie et al., 2017

Wastewater

Wastewater and wastewater treatment plants (WWTPs) as sources of microplastics has become an important research topic in Denmark, Finland, Germany, Norway, Poland, Russia and Sweden. At least 20 different national-level studies and/or reports concerning microplastics in wastewater were reported. These studies often examined the retention efficiency of the WWTPs in capturing microparticles and microfibers by comparing the amounts of these in the influent and effluent. Based on the results, conventional WWTPs can efficiently remove up to 80-95% of microplastics whereas the capability of advanced WWTPs using tertiary treatment technologies to capture microplastics and fibers is high (95-99%). However, due to the large volumes of treated wastewater constantly, the WWTPs are considered important sources of microplastics to the environment (Figure 7). Hence, almost without exception, the concentrations of microplastics at the discharge area were found to be higher than in the reference sites. In addition, the sludge from the WWTPs containing microplastics is often used in agriculture as a fertilizer, and the impacts of microplastics in sludge to the recipient ecosystem are mostly unknown.

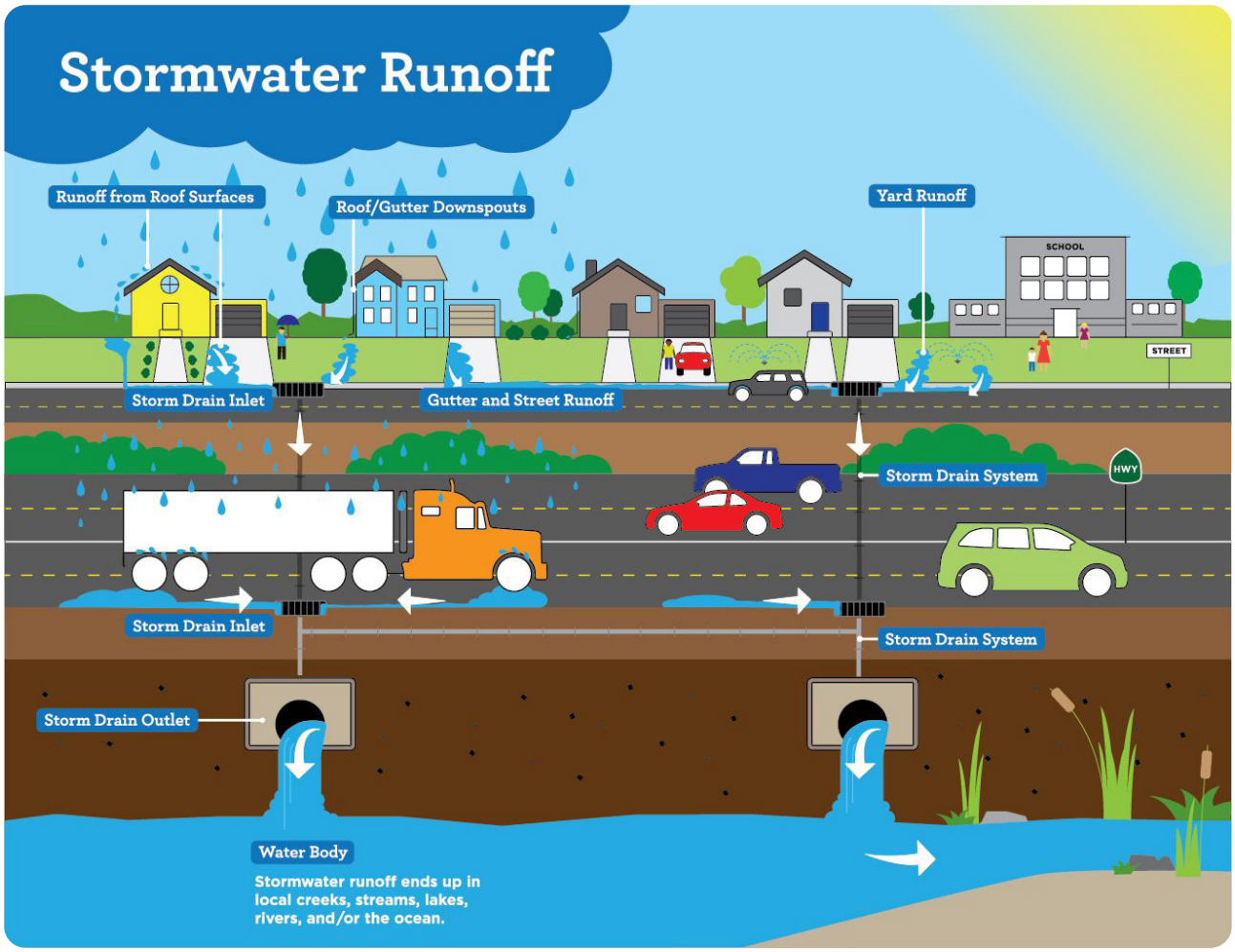

Figure 8. Overview of urban stormwater runoff (Kitsap County, 2018)

Stormwater

This section refers to microplastics in stormwater, including microplastic emissions from the car tire wear / road dust. Studies on road and tire dust have already been carried out in Norway, but several new projects have been initiated including in Denmark, Finland, Germany and Sweden. There are also few examples of concluded studies of microplastics in stormwater from Denmark and several on-going projects in other Baltic Sea countries. Figure 8 demonstrates different sources of microplastics via stormwater runoff, including from road. A recent study[6] from Denmark revealed 270 microplastic item /L in the stormwater pond water (corresponding to 4.2 µg/L). Microplastics in the pond were highly concentrated in its sediments, reaching 0.4 g/kg (corresponding to nearly 106 item /kg). The study also showed that microplastics accumulated in vertebrates in the pond (three-spined sticklebacks and young newts) reaching levels nearly as high as in the sediments (particle numbers).

Figure 9 represents the linkages between wastewater and cleaner stormwater. When the two discharges are combined, the stormwater receives the same wastewater treatment except for sewer overflow occasions when it is released untreated to the environment. When separated, only the wastewater is treated at the WWTP whereas the stormwater is treated in retention ponds or not treated at all (see Figures 7 and 8). The adequacy of one system in detriment of the other depends on a case-by-case scenario.

Other

This category covers more specific studies, such as microplastics in drinking water, microfibers from washing machines (laundry), microplastics in biota or in snow. In addition, microplastic emissions specifically from artificial turfs and other artificial surfaces e.g. play grounds and sporting facilities, are under investigation in the project partner countries.

6 (Borg Olesen, Stephansen, & van Alst, 2019)

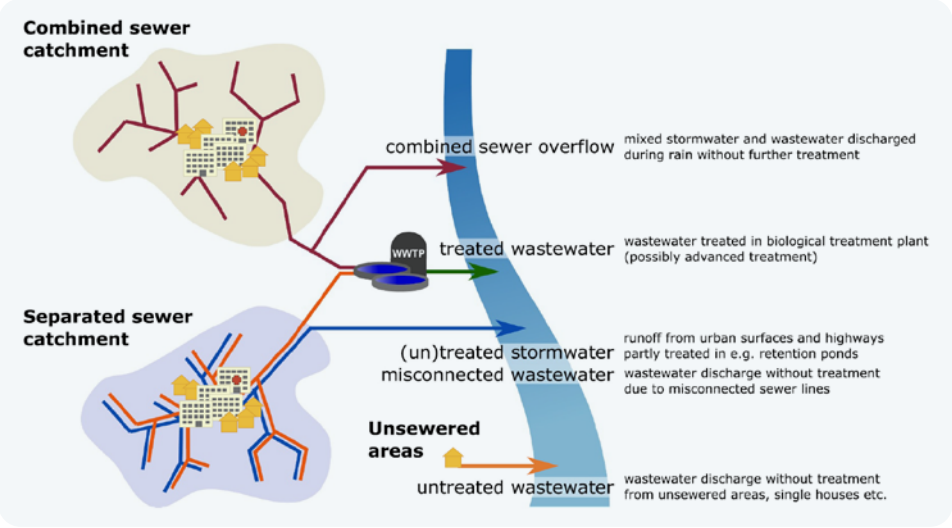

Figure 9. Overview of urban wastewater and stormwater discharges in different sewer systems in Bollmann, Simon et al., 2019.

Discussion

Based on the full report and this summary, it can be observed that there is an increasing amount of information available on microplastics also in the Baltic Sea area. This includes the sources of primary and secondary microplastics, the occurrence in different ecosystem compartments as well as in biota (mainly fish and bivalves). Regarding the sources, there is a relatively good understanding of the sources of primary microplastics as well as certain sources of secondary microplastics, such as from road emissions and from washing off synthetic fibers. However, the fragmentation process of (other) larger plastic items and more importantly the contribution of it to the total amount of microplastics in the environment seems to be known in theory, but poorly understood in practice.

There are also a lot of studies concentrated on detecting and possibly identifying the plastic particles and fibers in different water ecosystem compartments, biota and wastewater. It also appears there is fairly good understanding of microplastics in wastewater, what is not the case for other issues, such as microplastics emission from stormwater.

In terms of policy measures, there is no global approach specifically addressing microplastics, even though the issue is partially included in the scope of several international schemes. Nationally, policy initiatives focus on the design of measures to address mainly larger plastic items (from reduction of production and use of plastic items, to improvement of their management once turned into waste) and at a lesser extent specific type of microplastics, such as those present in cosmetics. However, it seems to be a tendency to increase and further specify national measures and initiatives.

It is also worth noting that as many countries aim to increase the recycling of plastics for new products, this may lead to a risk for new sources of microplastics. Thus, the application of risk assessments to new outdoor material applications before their introduction into the market may need to be taken into consideration.

Despite the advances done regarding monitoring of microplastics, it seems that both researchers and policymakers are struggling to come up with harmonized monitoring protocols for the different ecosystem compartments.

Proposals on where further research could focused on is on (i) harmonization of monitoring methodologies; (ii); further advance on the quantification of the input of the identified sources of primary and secondary microplastics; (iii) development of technologies to prevent microplastics leakage, both primary and secondary microplastics; (iv) assessment of the effectiveness of measures to reduce the input of microplastics to the different ecosystem compartments; and (v) increasing the knowledge regarding effects and impacts of microplastics.

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