The Baltic Sea - Microplastic

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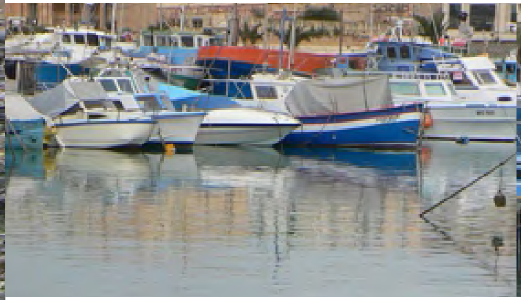
Overview

1. Background
2. Plastic in the Baltic
3. Microplastic – a challenge
4. Microplastic – behaviour in the Baltic Sea
5. Microplastic - measures to reduce emissions
6. Conclusions

1. Plastic in the sea



- It is a global problem,
- covers a wide spectrum of plastic types, shapes and size-classes and
- most plastic finally ends-up at coasts.

1. The EU Marine Strategy Framework Directive

Objective: A good status of the marine environment

Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

10.1. Characteristics of litter in the marine and coastal environment

- Trends of litter washed ashore…
- Trends of litter in the water column and on the sea- floor…
- Trends of micro-particles (in particular micro-plastics)….

10.2. Impacts of litter on marine life

- Trends of litter ingested by marine animals

Baltic Sea Action Plan

Programme of measures for a healthy marine Baltic Sea environment (HELCOM - Helsinki Commission)

Definitions

Microplastic: <5 mm

Mesoplastic: 5 – 25 mm

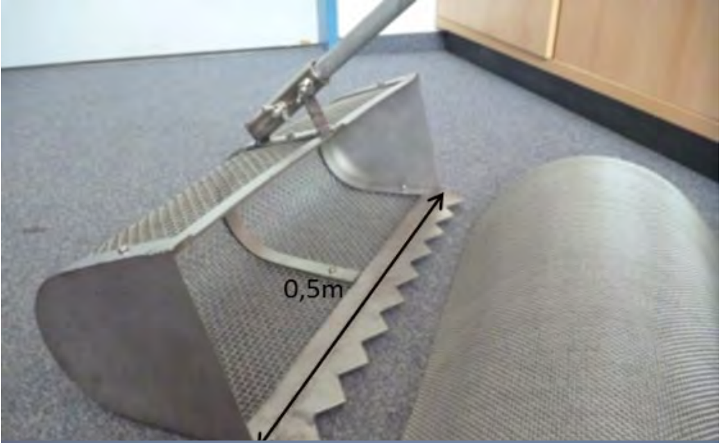
Macroplastic: >25 mm

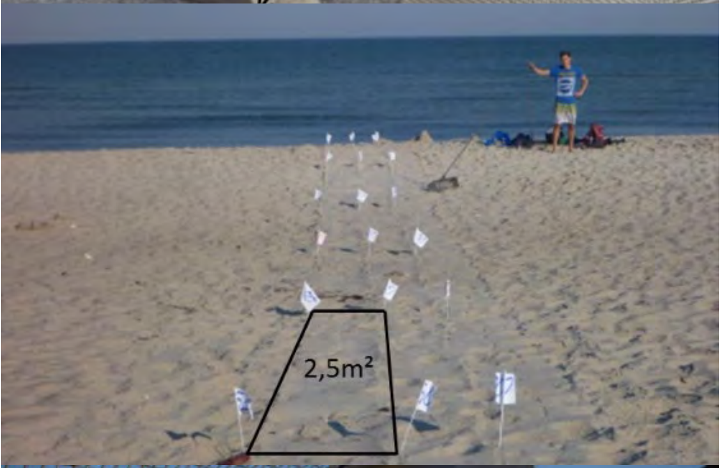
http://marinedebris.noaa.gov/info/plastic.html

2. Macroplastic in the Baltic – state of art

- The majority of marine macrolitter is plastics (~80%).
- Local emissions (coastal cities, seaside resorts, tourism hot-spots and events) are most important in the Baltic Sea.
- Plastic emissions from ships to the open sea reach coasts within days.
- Plastics is partly deposited in deeper, sheltered areas (shipping channels). This is true for floating plastic as well, as soon as it is overgrown with organic matter.
- Concentrations of macrolitter at Baltic beaches are spatially and temporally highly variable.
- With a median below 100 pieces/100m, Baltic beaches show a much lower pollution compared to North Sea/Atlantic beaches (about 500 pieces/100m).

Schernewski et al. (2018). J Coast Conserv 22





M. Haseler

2. Macroplastic in the Baltic – lessons learnt

- The closed Baltic Sea, lower emissions (e.g. fisheries) and beach cleaning activities seem to be major explanations for relatively low concentrations.
- The common 100 m beach monitoring is not well suitable for the Baltic Sea (lack of remote beaches, disturbance due to cleanings, extreme spatio-temporal variability of results, very local sources).
- Macrolitter at beaches is only a poor indicator for Baltic Sea litter pollution (according Marine Strategy Framework Directive).
- Mesolitter monitoring methods (e.g. Rake method) are a suitable complementation to overcome several weaknesses of the OSPAR method (Haseler et al. 2018, 2019, 2020).

But what about microplastics?

Schernewski et al. (2018). J Coast Conserv

2. Microplastic in the Baltic – state of art

Some data exists for microplastic concentrations in the sea, in sediments, at beaches and in animals…but:

- The observed concentrations depend on the applied sampling, preparation and analytical methods.
- Costs and effort to study microplastic in the field are high and this limits the gain of knowledge.
- As a consequence, the data is rare, varies within wide ranges, shows an extreme spatial variability and can hardly be regarded as reliable.

Could macro- or mesoplastic items serve as indicator for microplastics?

2. Are larger items indicators for microplastics?

- No, larger plastics cannot serve as reliable indicator for microplastic pollution because of different sources and pathways.
- However, since the sampling of larger items is easy, it can provide insights into spatial pollution pattern.

Schernewski, Radtke, Robbe, Haseler, Hauk, Meyer, Piehl, Riedel, Labrenz (2021): Environmental Management

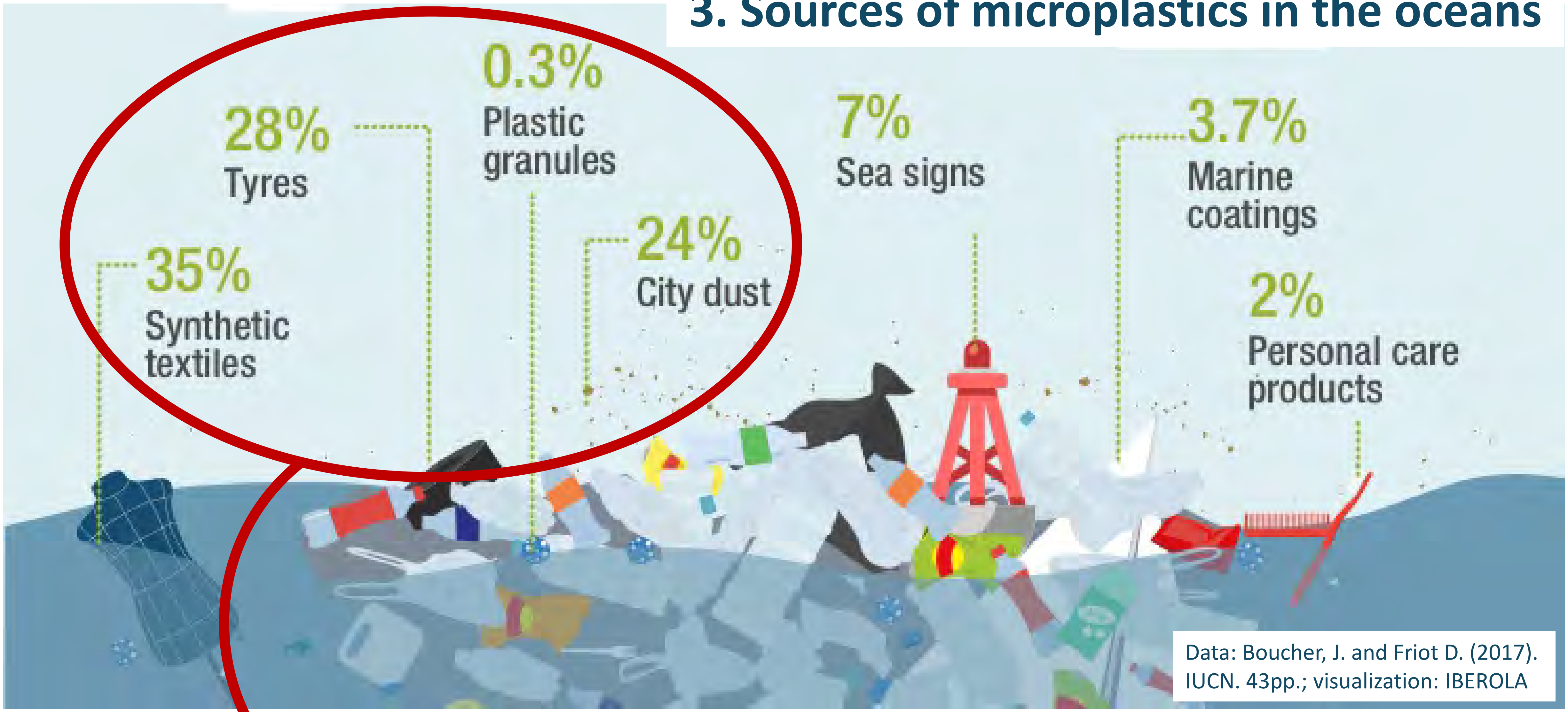
3. Microplastic – a challenge Questions

How can we get an insight into

- the state of the microplastic pollution in the Baltic Sea,
- spatial and temporal microplastic concentration pattern in the sea, sediments and at coasts as well as
- transport and behaviour in the marine environment?

Photo: H. Schulz-Vogt

3. Sources of microplastics in the oceans



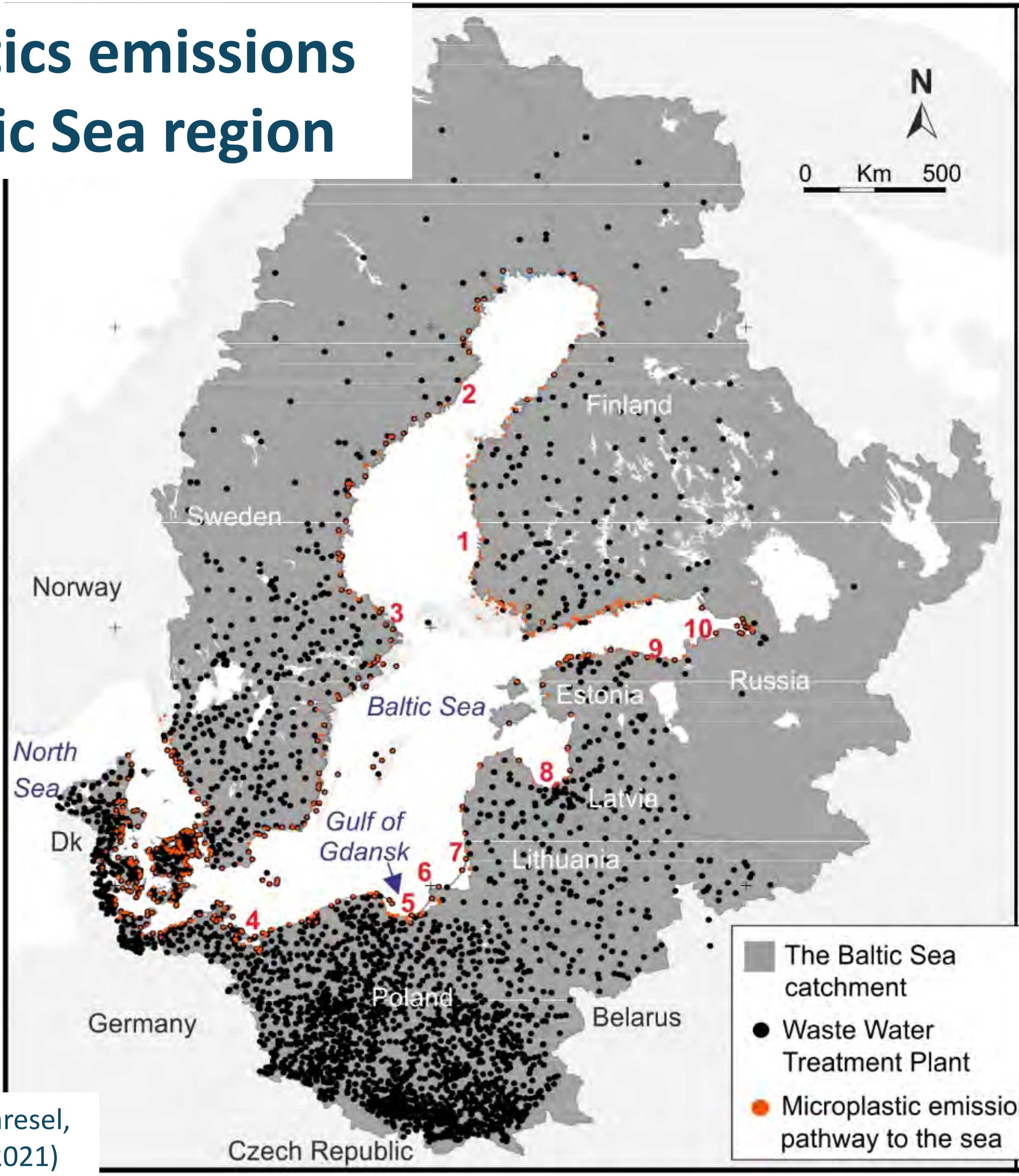
Data: Boucher, J. and Friot D. (2017). IUCN. 43pp.; visualization: IBEROLA

Water-bound emissions from urban areas are dominating!

3. Microplastic – a challenge Approach

- Compilation of data on waste water amounts and treatment technologies for the entire Baltic Region.
- Calculation of annual microplastic emissions for every urban pathway and location based on literature data.
- Calculation of riverine and direct microplastic emissions to the Baltic Sea.
- Model simulations on microplastics transport, behavior and deposition in the Baltic Sea.
- Comparisons of results with field data.

3. Microplastics emissions in the Baltic Sea region

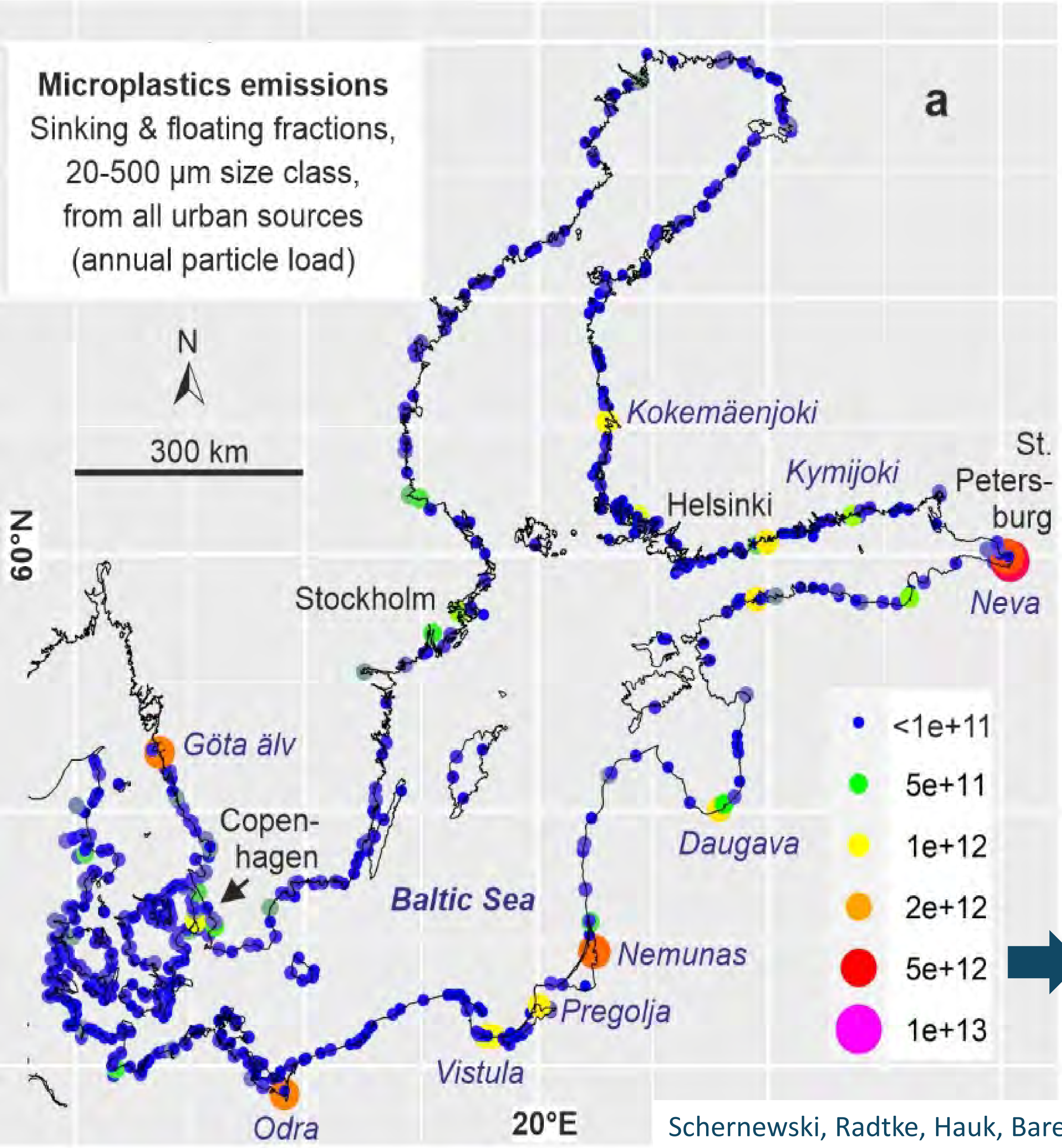


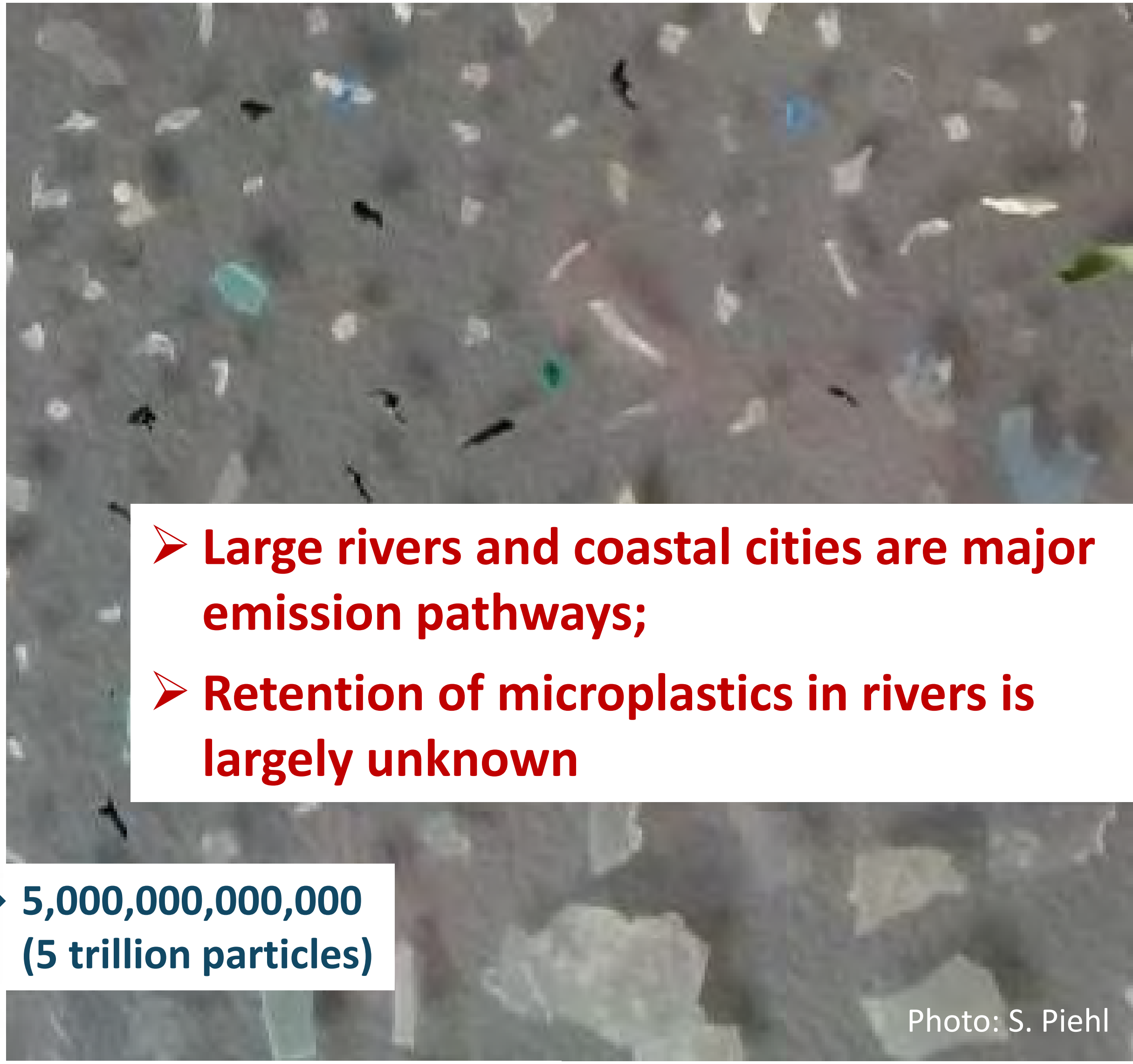
Emissions to the Baltic Sea basin: urban sources	**Microplastics** 20-500 µm size-class, particles/year	
Wastewater Treatments Plants (WWTPs):	1.7E+13	25%
Not connected wastewater:	8.4E+12	13%
Sewer overflow (combined & separated systems):	4.2E+13	62%
Sum:	**6.7E+13**	**100%**
	(67 trillion particles)	

River	Particles/year	
1 Kokemäenjoki (Fin.)	3.1E+11	1.9%
2 Umeläven (Sweden)	6.8E+10	0.4%
3 Dalälven (Sweden)	1.4E+11	0.8%
4 Odra (Poland)	1.0E+12	6.0%
5 Vistula (Poland)	1.0E+12	6.2%
6 Pregolya (Russia)	7.8E+10	0.5%
7 Nemunas (Lit./Rus.)	6.1E+11	3.6%
8 Daugava (Latvia)	2.2E+11	1.3%
9 Narva (Est./Rus.)	1.3E+11	0.8%
10 Neva (Russia)	3.2E+11	1.9%

Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021)

3. Microplastics emissions to the Baltic Sea



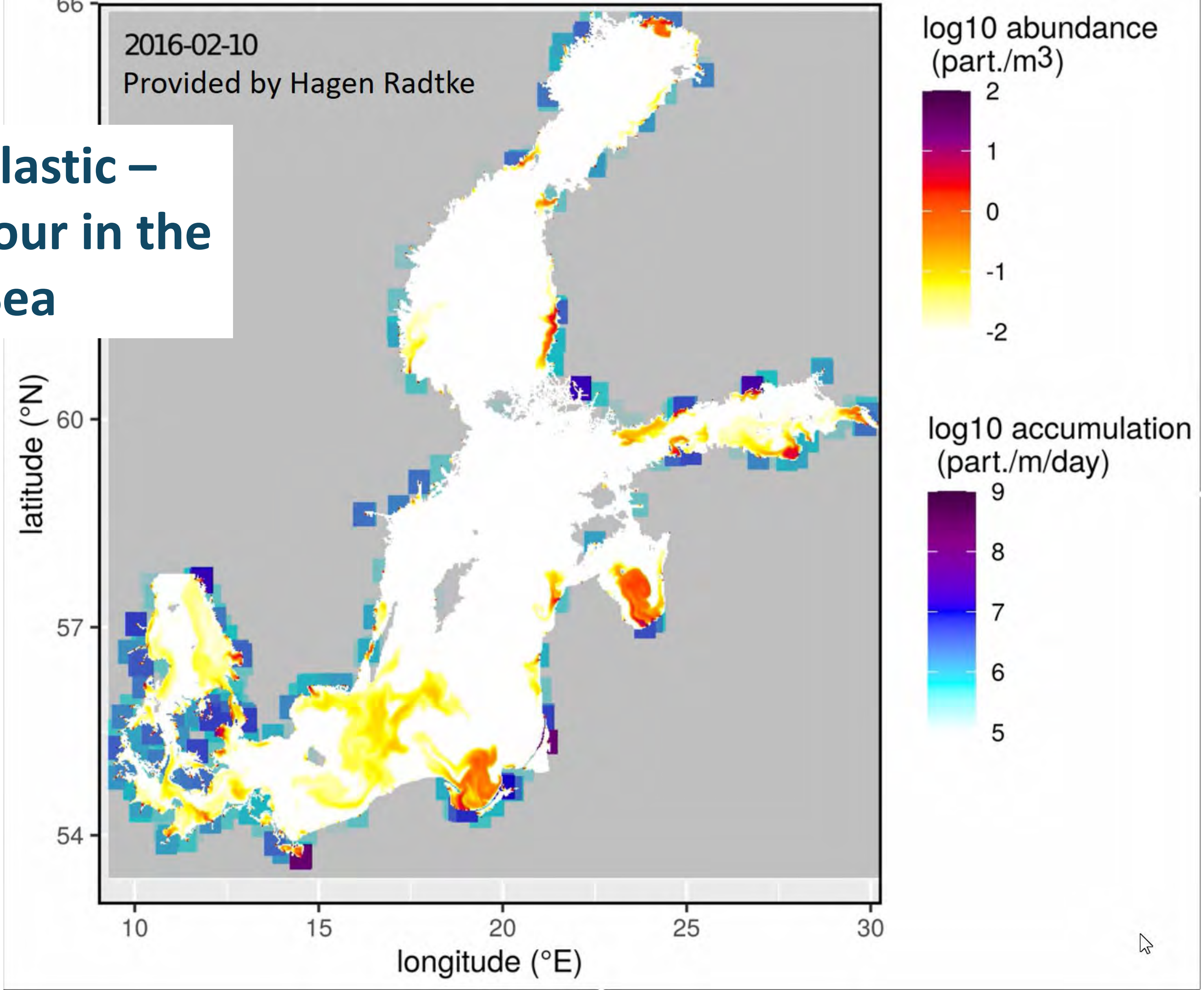


- ➢ Large rivers and coastal cities are major emission pathways;
- ➢ Retention of microplastics in rivers is largely unknown

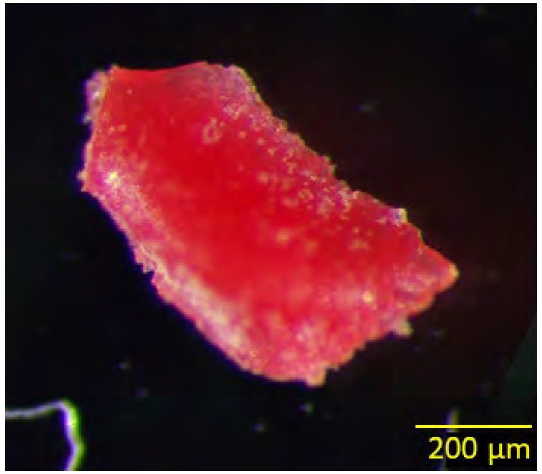
5,000,000,000,000
(5 trillion particles)

Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021)

4. Microplastic – behaviour in the Baltic Sea

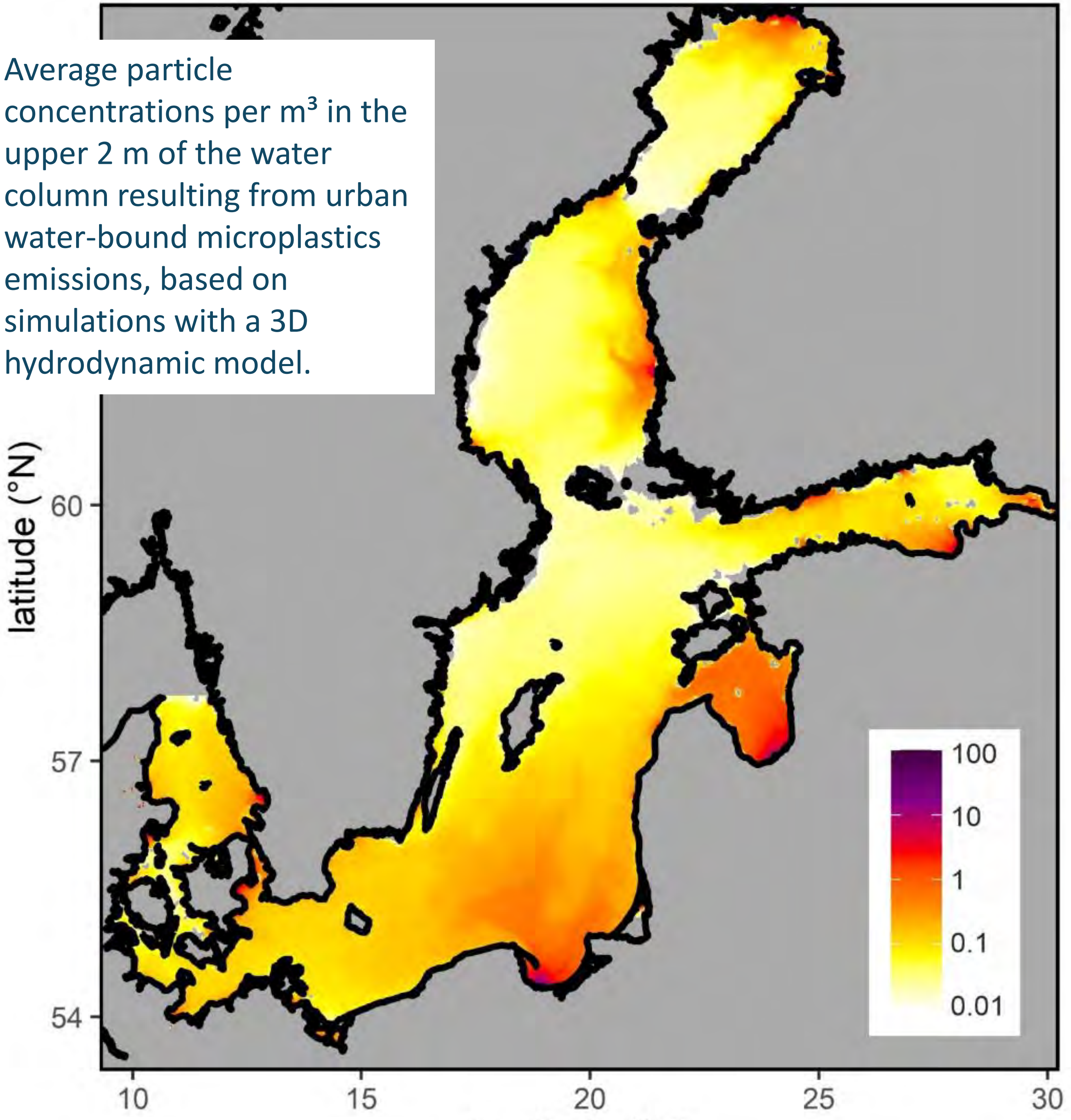


4. Microplastics in the sea

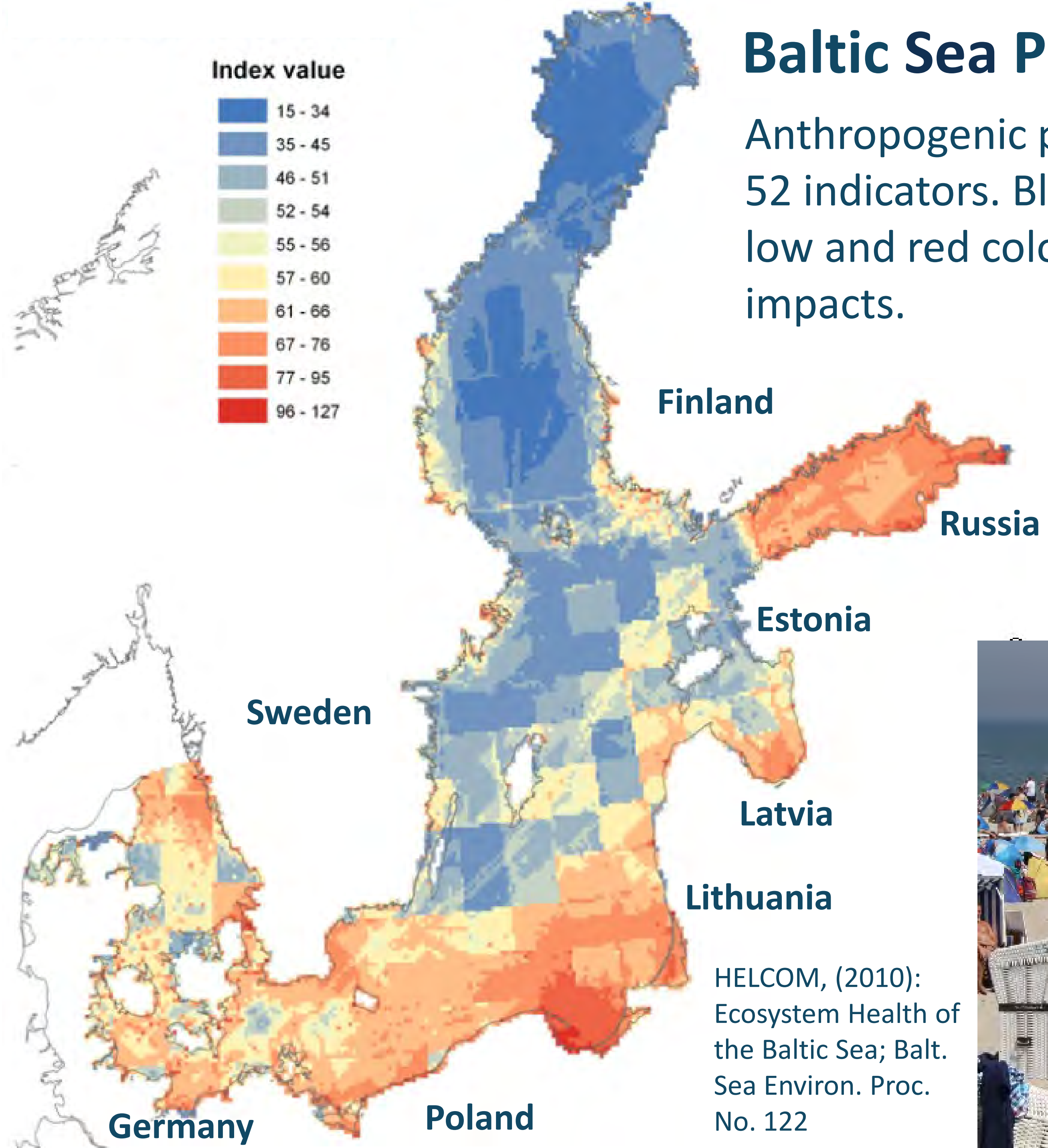


- **Microplastic concentrations in the sea are relatively low.**
- **No long-term accumulation in the sea is visible.**
- **Concentrations show strong spatial gradients and high temporal variability.**
- **Microplastic sampling in the sea seems not cost-effective.**

Average particle concentrations per m³ in the upper 2 m of the water column resulting from urban water-bound microplastics emissions, based on simulations with a 3D hydrodynamic model.



Schernewski et al. (2021)

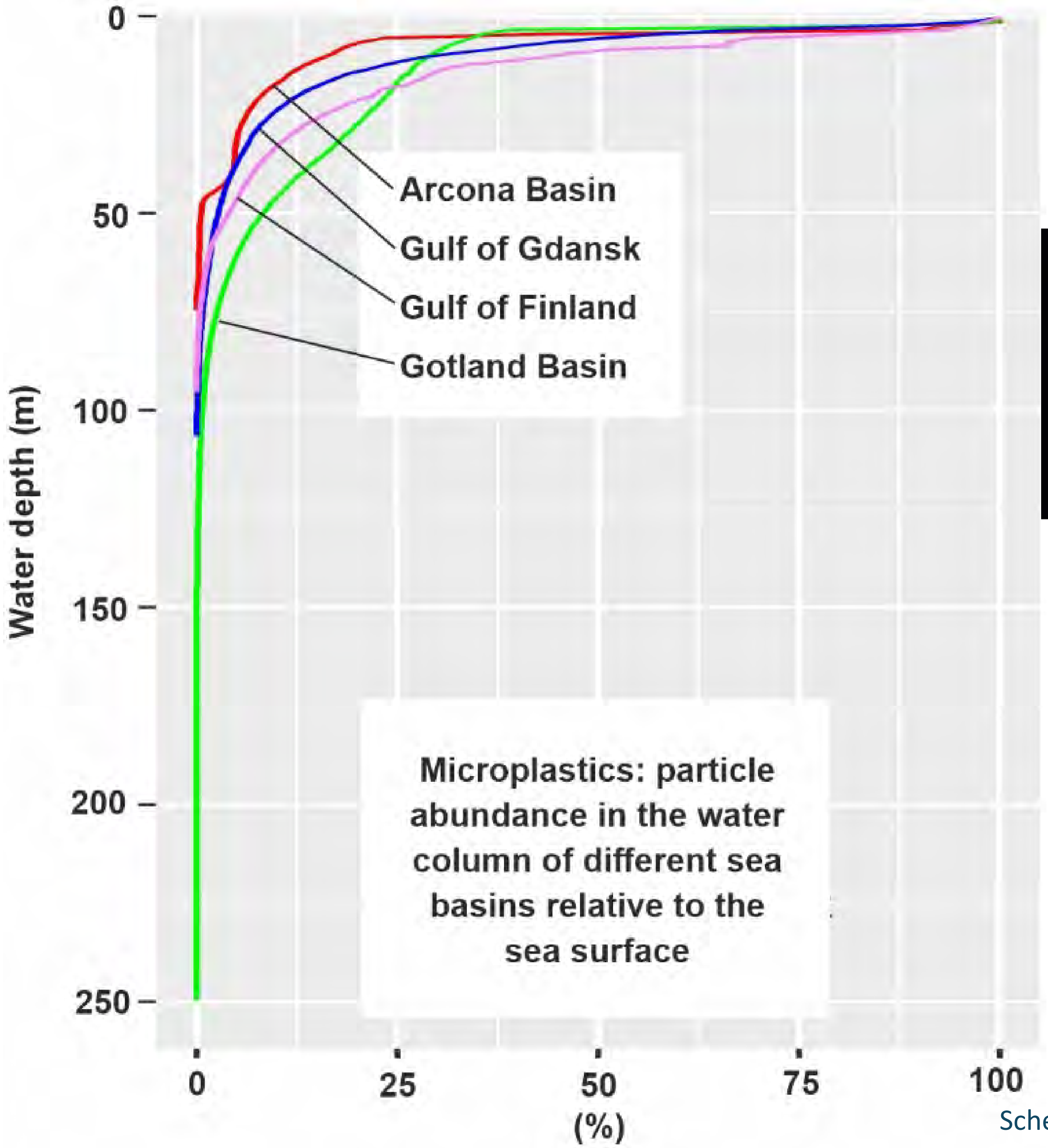


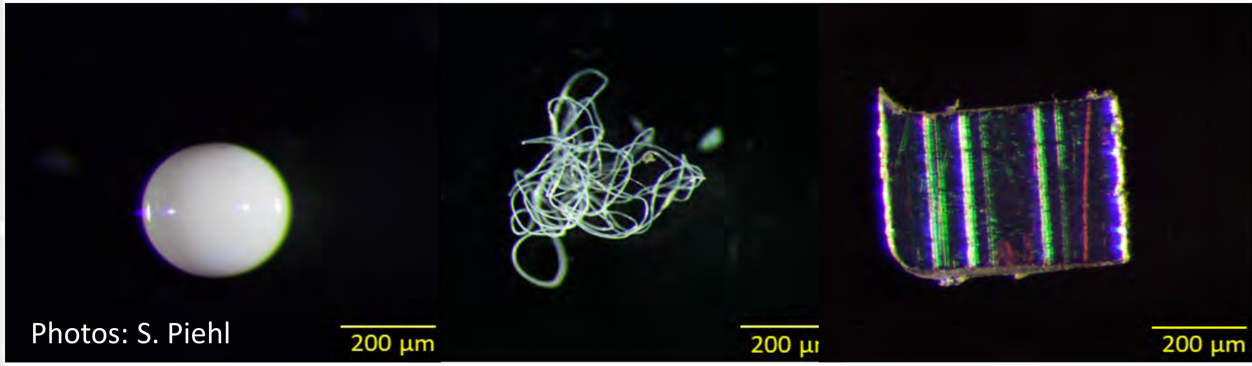
Baltic Sea Pressure Index

Anthropogenic pressures based on 52 indicators. Blue colors indicates low and red colors high cumulative impacts.

HELCOM, (2010): Ecosystem Health of the Baltic Sea; Balt. Sea Environ. Proc. No. 122

4. Microplastics Vertical distribution

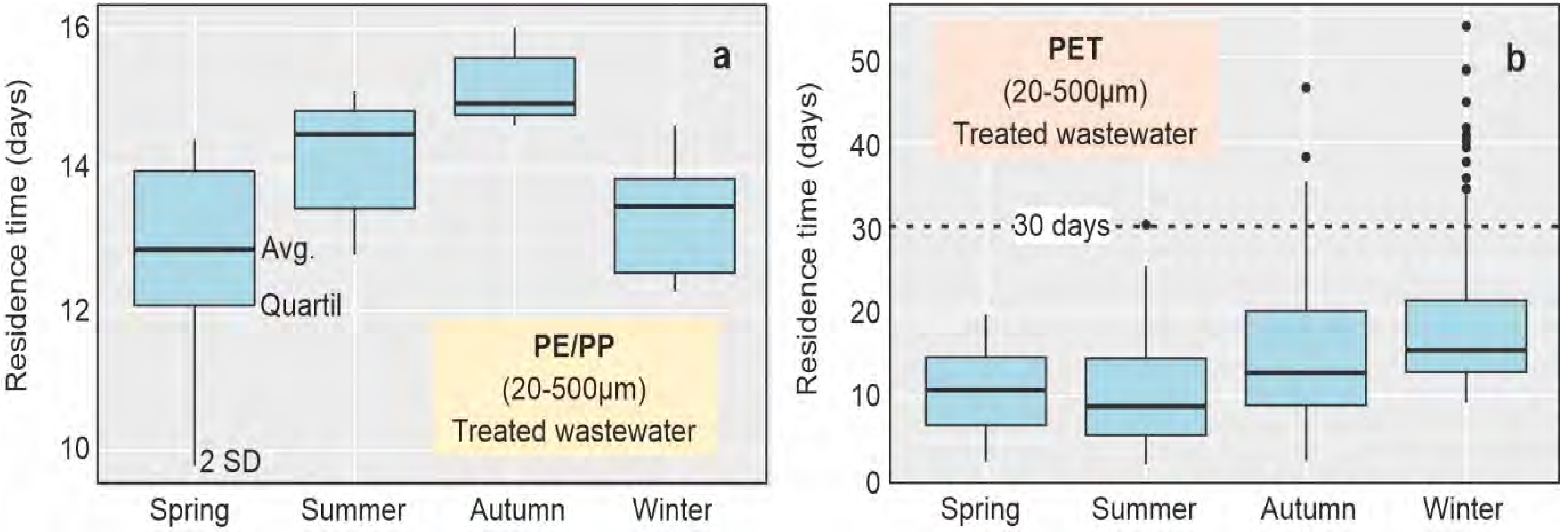




- Floating and sinking microplastics concentrations (densities 0.9-1.4 g/cm³) are highest near the sea surface.
- Differences in shape and size play only a minor role.
- Biofilms may play a role.

Schernewski, Radtke, Hauk, Baresel, Olshammar, Osinski, Oberbeckmann (2020)

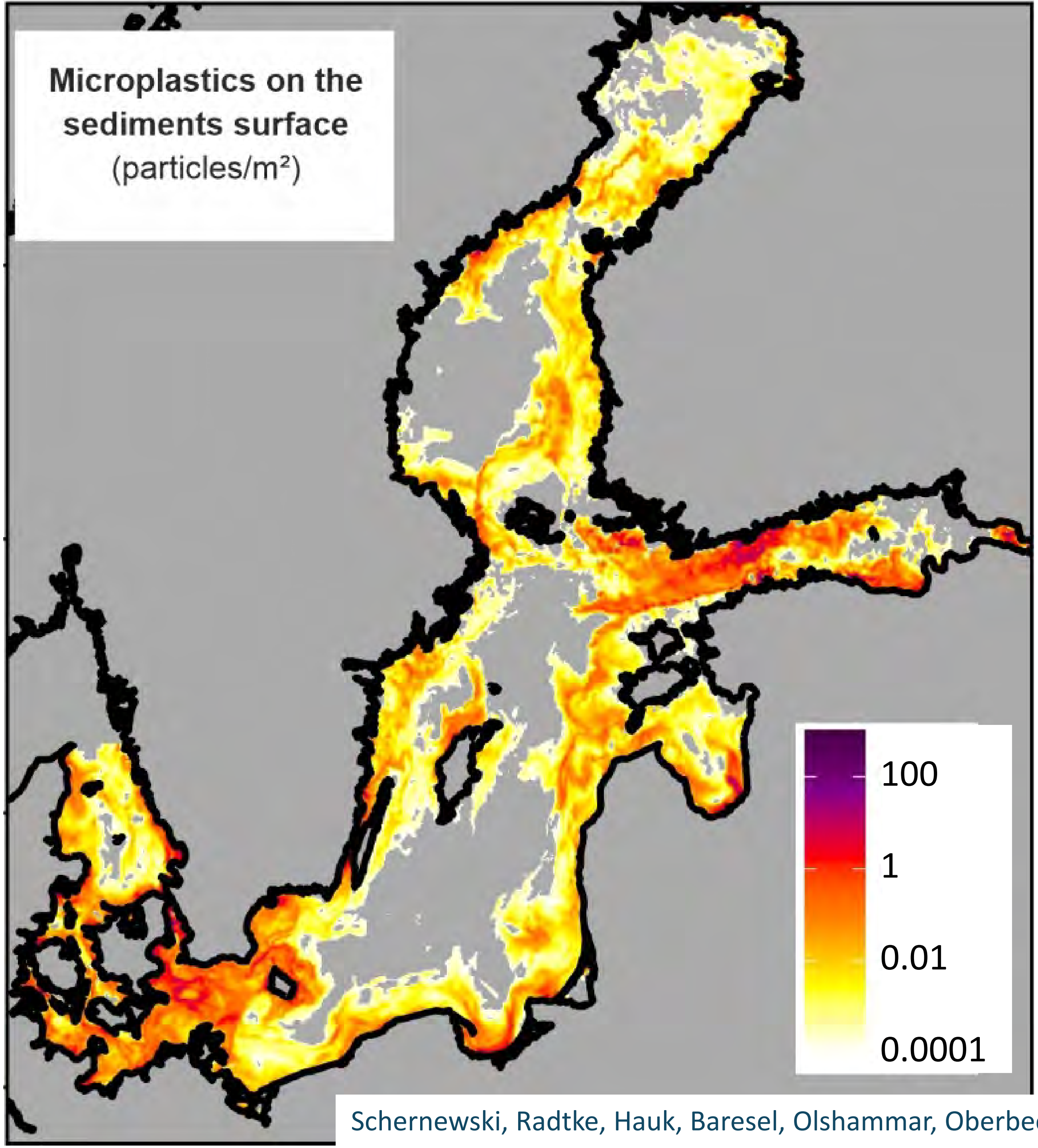
4. Microplastics: Residence time in the Baltic Sea water body



Residence time of Polyethylen (PE)/Polypropylen (PP) and Polyethylenterephthalat (PET) mirco-plastic particles in the Baltic Sea based on simulations with a 3D hydrodynamic model. PE/PP represents floating and PET sinking plastic. The emissions cover all three urban sources and the 20-500 µm size fraction.

➢ **The average residence time in the Baltic Sea is only about 2 weeks (independently of the plastic type, floating or sinking).**

Schernewski, Radtke, Hauk, Baresel, Olshammar, Osinski, Oberbeckmann (2020)



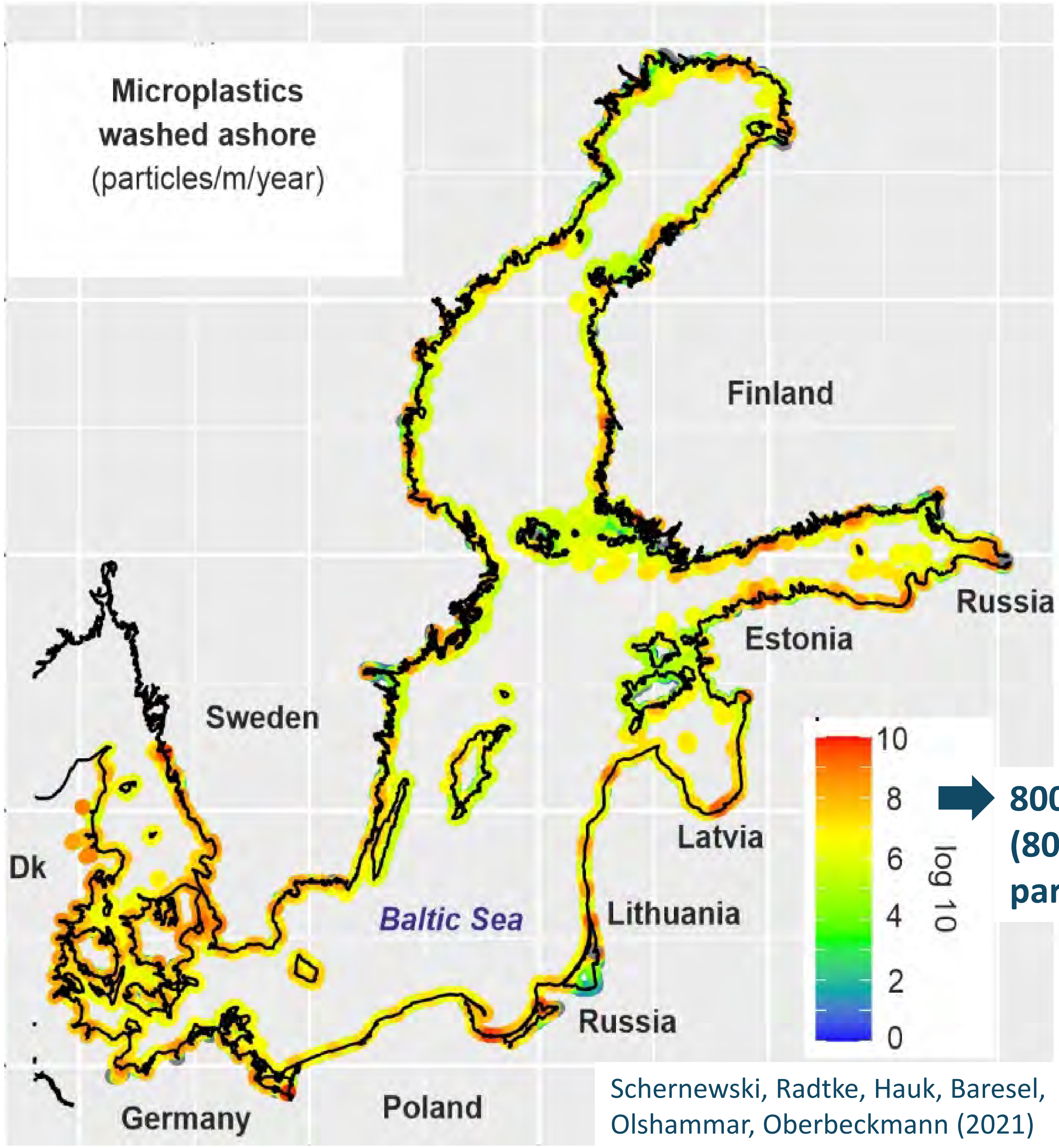
Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021)

4. Microplastics: Sediments

- Microplastics concentrations at sediment surfaces are relatively low.
- No permanent accumulation takes place on sandy near coast sediments.
- Storms with wave induced resuspension and transport to the coast cause a sediment ‚cleaning'.

4. Microplastics: Beaches

- ➢ **Coasts are major sinks for microplastic.**
- ➢ **Accumulation at coasts takes place close to the emission points.**
- ➢ **Monitoring should focus on the floodsam/tidal zone of beaches.**



➡ **800,000,000 (800 million particles/m/year)**

Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021)

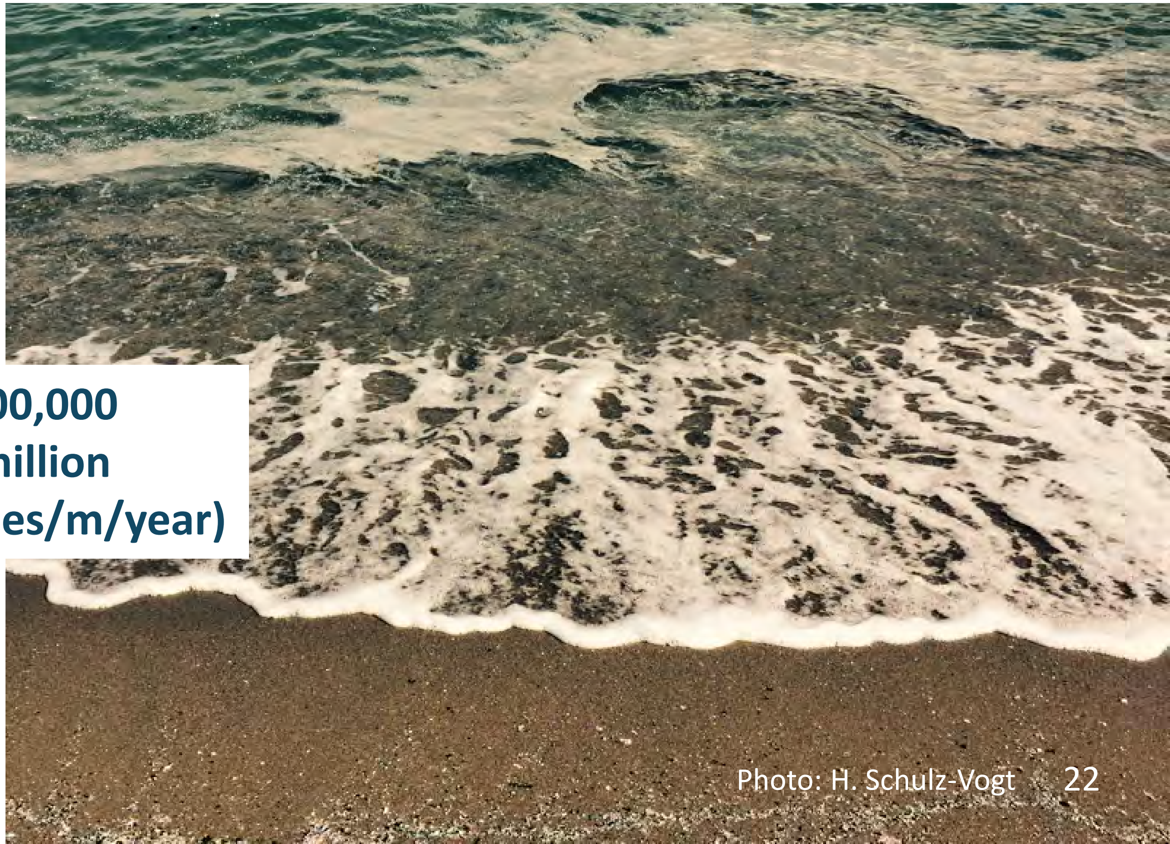
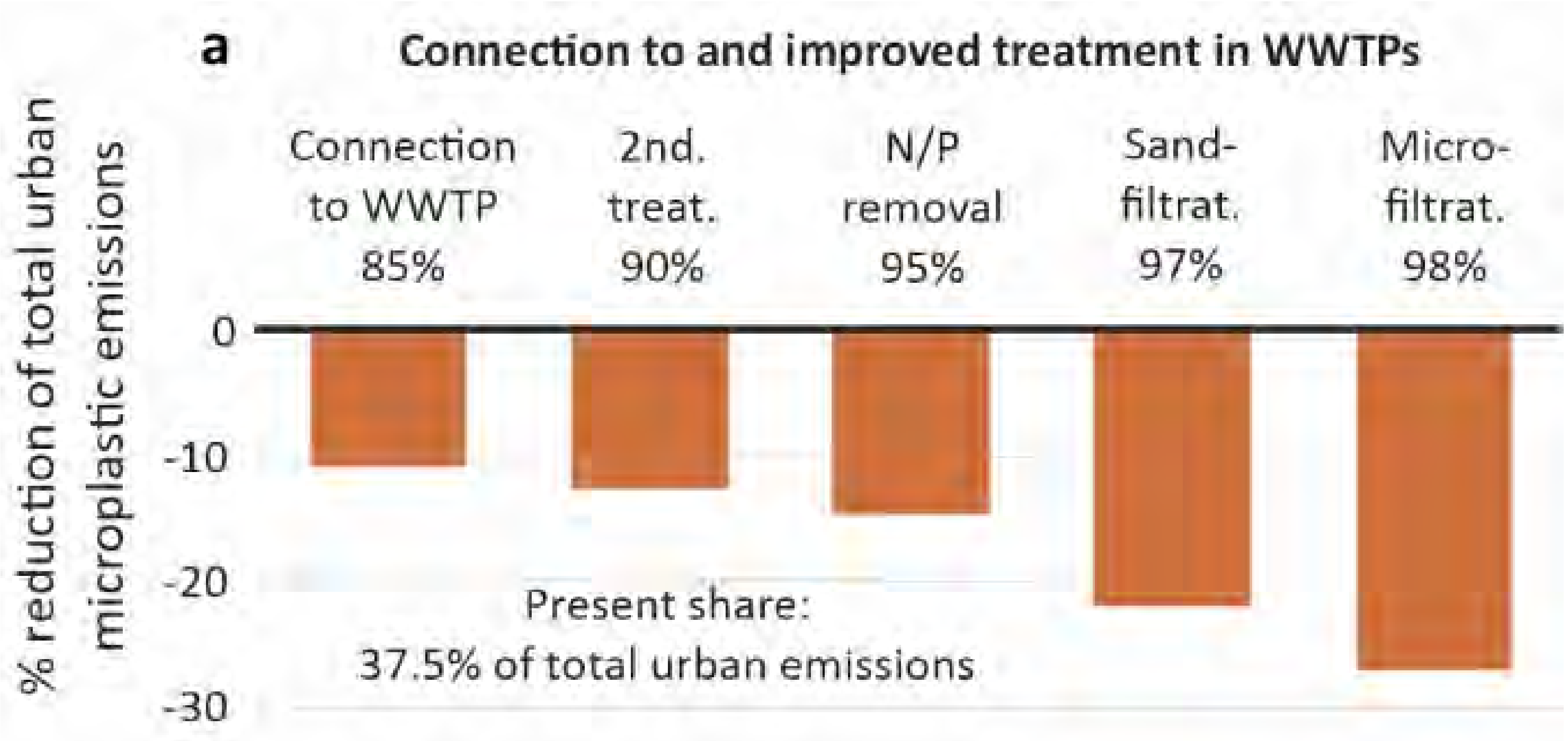


Photo: H. Schulz-Vogt

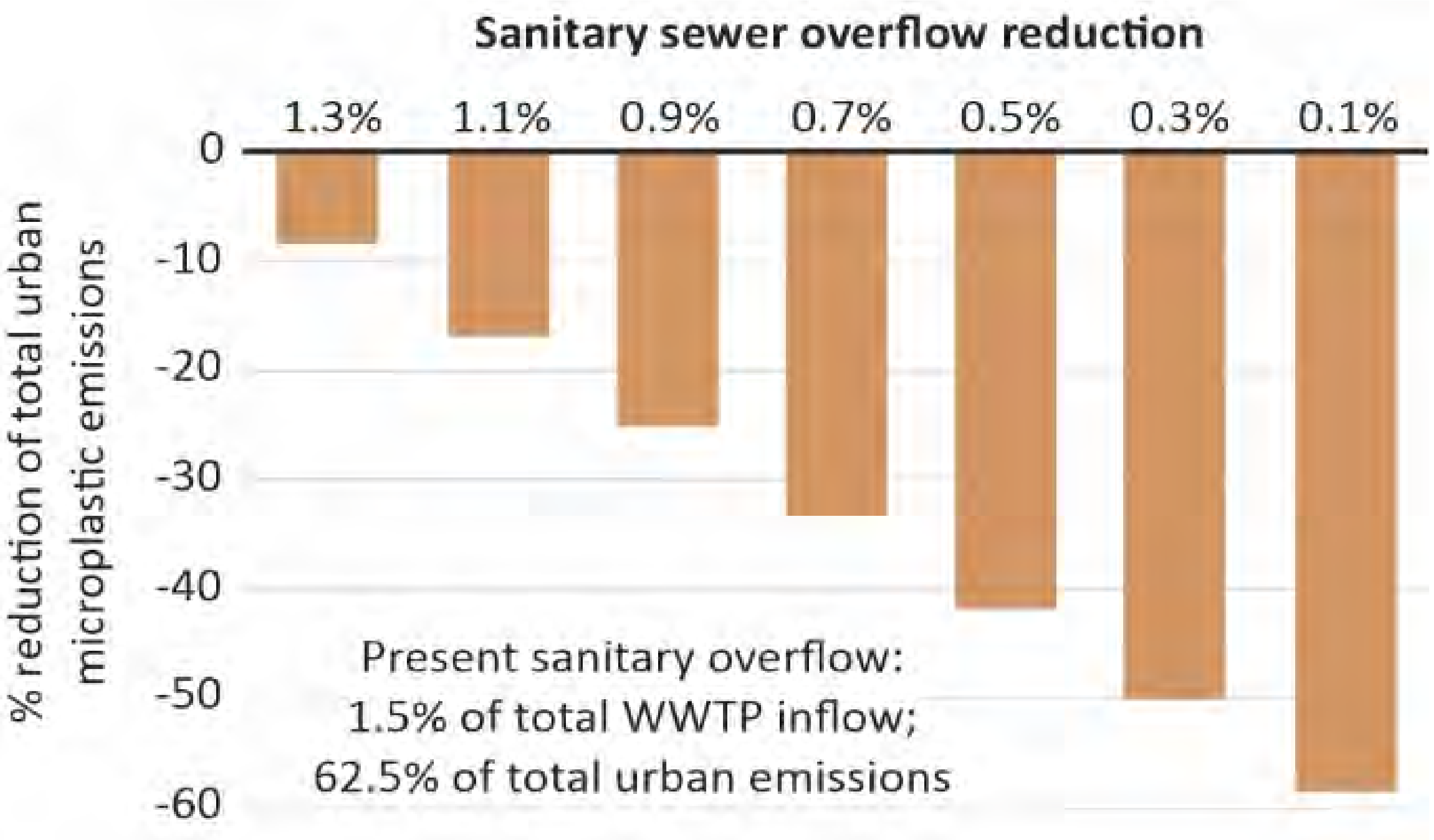
5. Measures to reduce emissions: Improved sewage treatment



- **Wastewater treatment plants (WWTPs) are efficient traps for microplastics.**
- **In the Baltic Sea region, improved treatment (beyond 3 steps) would have only limited effects on plastic load reduction and seems not-cost effective.**

Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021)

5. Measures to reduce emissions: Reduction of stormwater and sewer overflow



Schernewski, Radtke, Hauk, Baresel, Olshammar, Oberbeckmann (2021). Front. Mar. Sci. 8: 594415

In the Baltic stormwater and sewer overflow seem to be the major microplastic pathways. Recommendable mitgation measures are:

- ➢ **Separated sewer systems & stormwater retention systems!**

6. Conclusions

- **Mitigation and load reduction measures** should address stormwater and sewer overflow with focus on coastal urban areas.
- **Further research** is required on retention of microplastics in rivers (and estuaries).
- **Microplastic monitoring** should focus on the floodsam/tidal zone of beaches, especially in close proximity to emission sources.

Alexandria, Egypt, 2021

Thank you for your attention!

Supported by projects BMBf-MicroCatch, Bonus MicroPoll, Eranet-Rus BalticLitter & TouMaLi.

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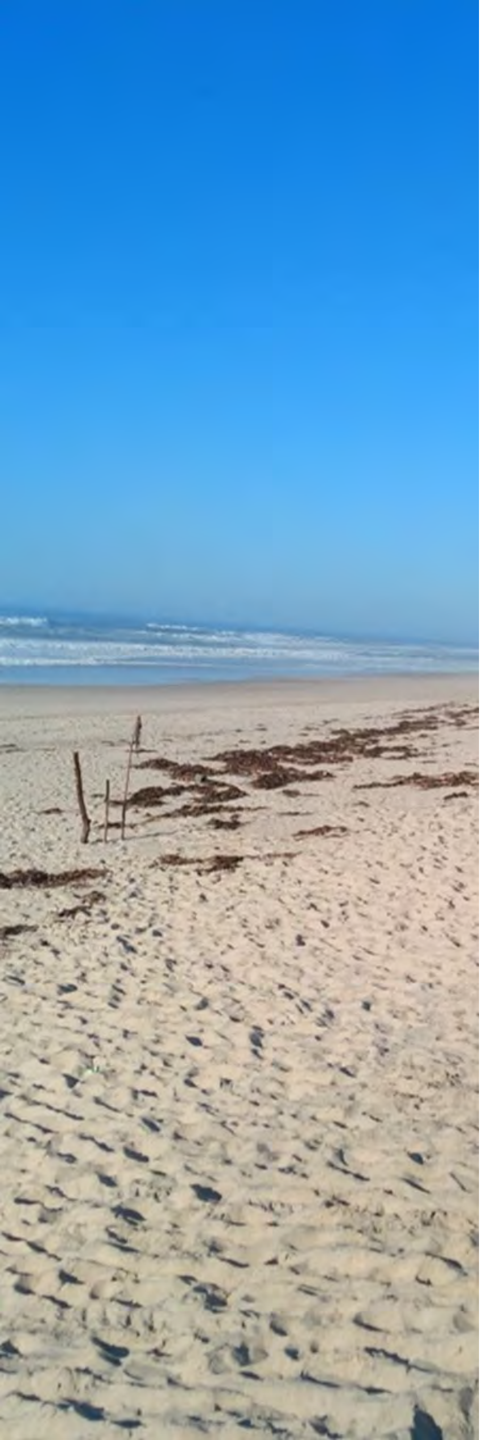

Related recent peer-review articles

- Haseler et al. (2019): Cost-effective monitoring of large micro- and meso-litter in tidal and flood accumulation zones at south-western Baltic Sea beaches. Marine Pollution Bulletin 149
- Piehl et al. (2021): Combined Approaches to Predict Microplastic Emissions Within an Urbanized Estuary (Warnow, Southwestern Baltic Sea). Front. Environ. Sci., 616765
- Schernewski et al. (2020): Transport and Behavior of Microplastics Emissions From Urban Sources in the Baltic Sea. Front. Environ. Sci., 8: 579361
- Schernewski et al. (2021): Urban Microplastics Emissions: Effectiveness of Retention Measures and Consequences for the Baltic Sea. Front. Mar. Sci., 8 587500
- Schernewski et al. (2021): Emission, transport and deposition of visible plastics in an estuary and the Baltic Sea – a monitoring and modelling approach. Environmental Management