Plastic in the sea - a global problem

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Overview

1. Marine litter - Definition
2. Plastic litter background: impacts, sources, sinks, first studies, plastic production & size classes
3. Floating plastic
4. Seafloor plastic
5. Baltic Sea
6. Mediterranean Sea
7. Conclusion

1. Marine litter - Background

Definition

- Marine litter is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.
- Marine litter consists of items that have been made or used by people and
  - deliberately discarded into the sea or rivers or on beaches;
  - left by people on beaches and shores;
  - brought indirectly to the sea with rivers, sewage, storm water or winds;
  - accidentally lost, including material lost at sea in bad weather (fishing gear, cargo).[1]

Artificial polymers/plastics are responsible for approx. 70-90% of all litter found in the marine environment. [2]

[1]UNEP (2005) [2]Fleet et al., 2021

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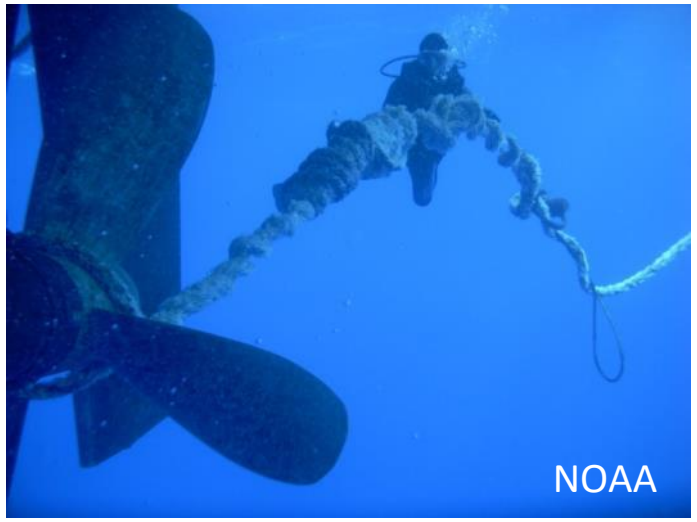
2. Plastic litter - Background

Impacts

- Damage from marine litter globally was $18.3bn in 2015, equating to $21.3bn in 2020.[1]

- If plastic production increases as predicted, damages through marine litter could be $−229bn by 2030 and $−731bn by 2050.[1]



82% of 296 demonstrated impacts on wildlife were caused by plastic.[2]

[1]McIlgorm A, et al., (2022) Photos: www.marinedebris.noaa.gov [2]Wagner and Lambert, 2018

2. Plastic litter - Background

Sources

Marine plastic-litter is originating from land-based and sea-based sources.

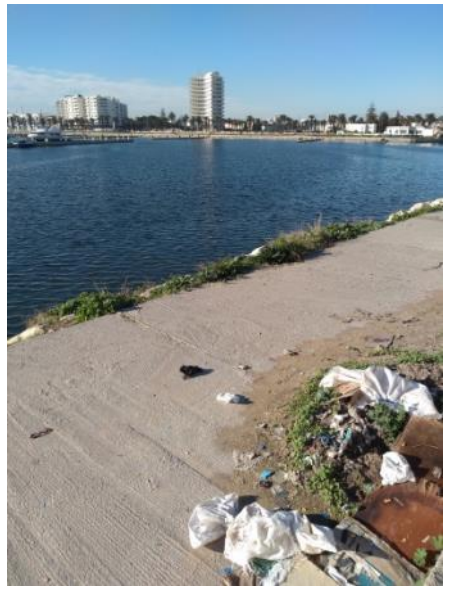
All figures by: www.awi.de/im-fokus/muell-im-meer/muell-im-meer-infografik.html

2. Plastic litter - Background

Sources: Coastal areas

In 2010 alone, **4.8 to 12.7 million metric tonnes** of plastic entered the ocean generated by population living 50 km of the coast.[1]

- In a recent update it was estimated that **19 to 23 million metric tons** of plastic entered aquatic ecosystems in 2016; 11% of plastic waste generated globally.[2]
  - More research is needed to estimate the true amount of plastic entering the oceans from coastal areas.



[1]Jambeck JR, et al., (2015) [2]Borrelle SB, et al., (2020)

2. Plastic litter - Background

Sources: Rivers

- Between **1.1 and 2.4 million tonnes** of plastic currently enters the ocean every year from rivers, the top 20 polluting rivers, mostly located in Asia, account for 67% of the global total.[1]
- Other study results: More than 1000 (smaller urban) rivers account for 80% of global annual plastic emissions, which range between **0.8 million and 2.7 million tons** per year.[2]
- More research is needed to estimate the true amount of plastic entering the oceans from rivers.

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[1]Lebreton LCM, et al., (2017)

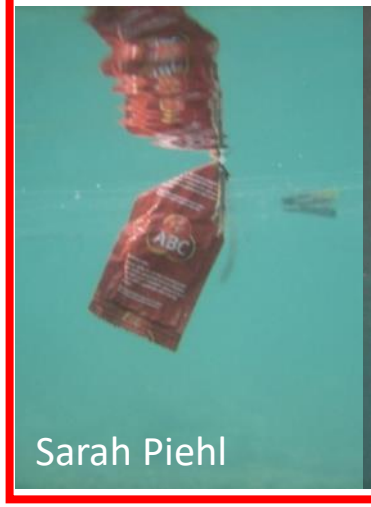
[2]Meijer L, et al., (2021)

Photo: www.marinedebris.noaa.gov

2. Plastic litter - Background

Sinks

- Coast; Wildlife; Sea surface; Water column; Seafloor

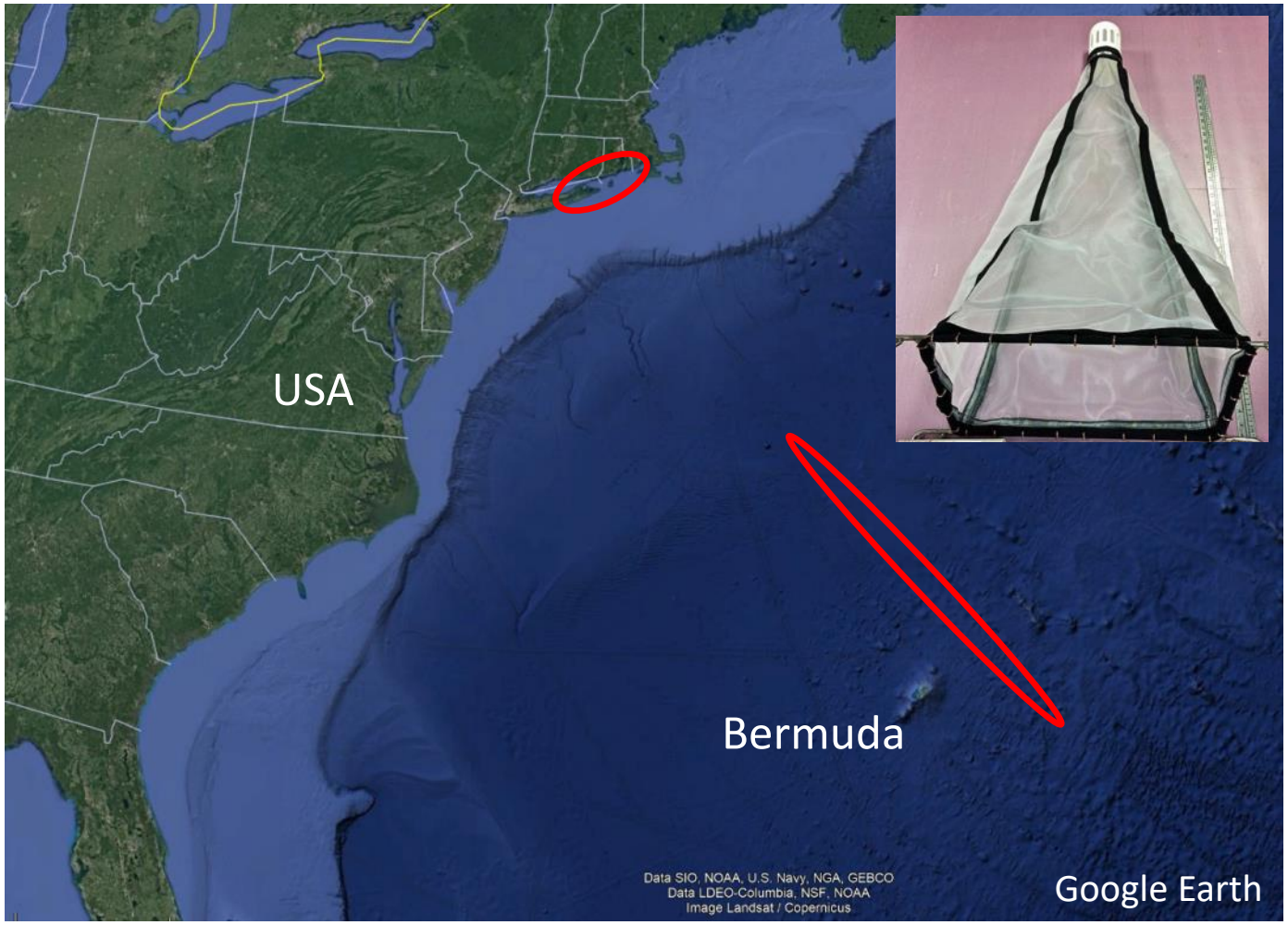


Photos: www.marinedebris.noaa.gov

2. Plastic litter - Background

First studies

<u>Publications in ‘Science’ in 1972</u>
Plastic pellets and fragments were collected in the western Sargasso Sea (1971)[1] and in coastal waters around New England (1972).[2]



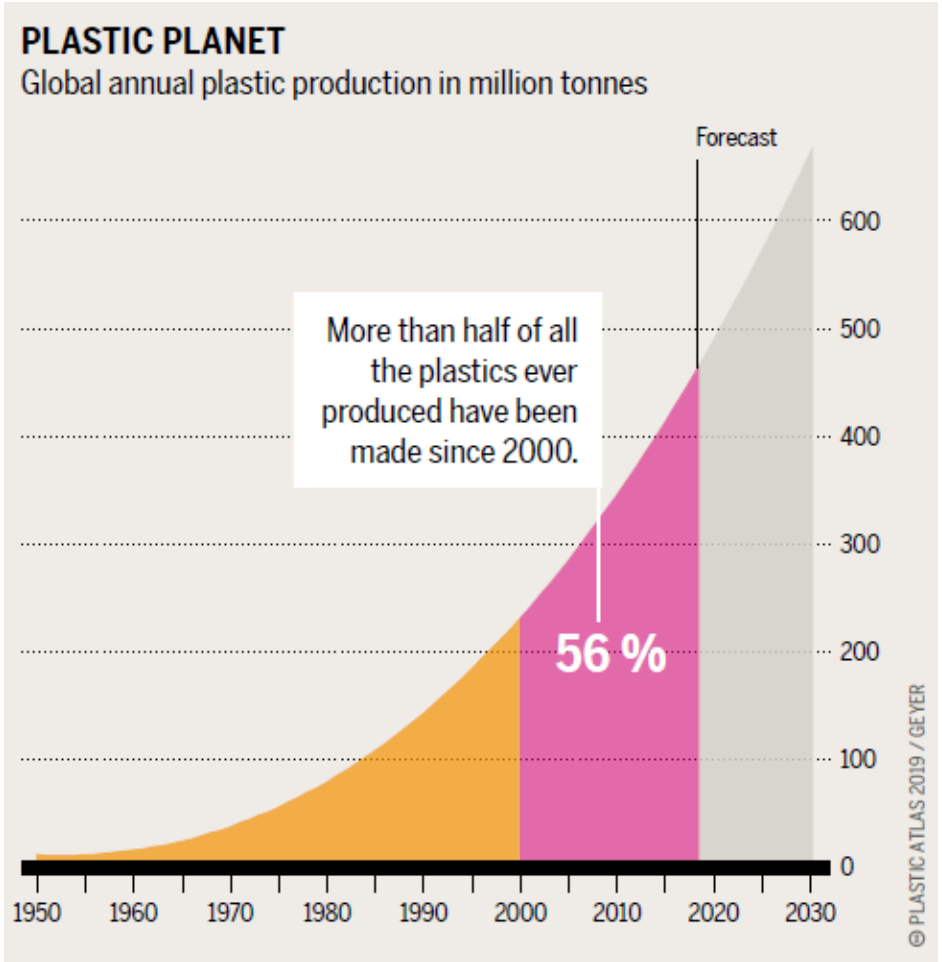
Statement from 1972:

- Increasing plastic production with the present waste management will probably lead to higher plastic pollution on the sea surface.[1]

[1]Carpenter EJ, et al., (1972)
[2]Carpenter EJ, et al., (1972b)

2. Plastic litter - Background

Plastic production



The worldwide plastic production increased from 1.7 million tonnes (Mt) in 1950[1] to 368 million tonnes in 2019.[2]

Of all plastic ever produced (until 2015):

- 9% had been recycled,
- 12% were incinerated, and
- 79% accumulated in landfills or the natural environment.[4]

- Therefore, the amount of plastic in the marine environment has certainly increased over the last decades and will further increase in future.

[1]Gourmelon G, (2015)
[2]Plastics Europe (2020)
[3]Figure by: Heinrich Böll Stiftung (2019)
[4]Geyer R, et al., (2017)

2. Plastic litter - Background

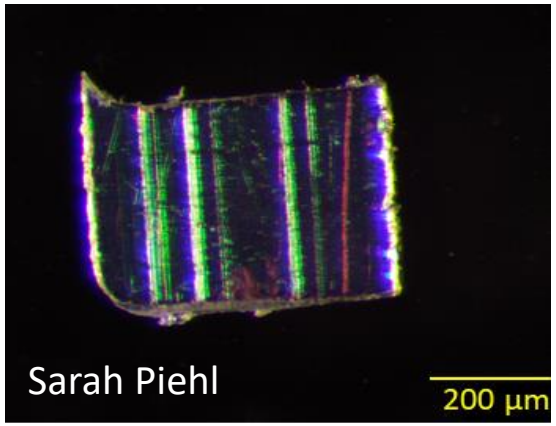
Plastic size classes

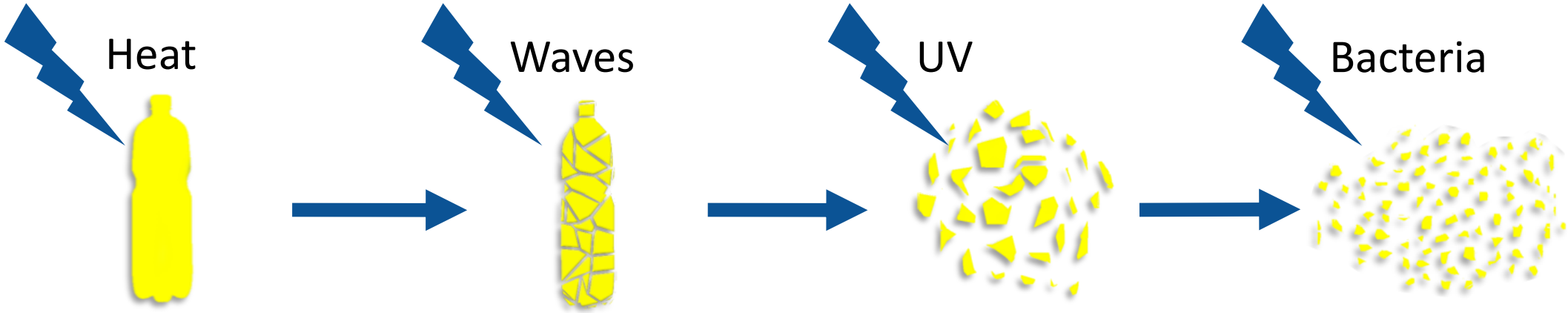
Macro (> 25 mm)

Meso (25-5 mm)

Large Micro (1-5 mm)

Small Micro & Nano (< 1mm)





- Fragmentation is responsible for the majority of micro-plastic and it seems inevitable that the quantity of micro-plastic will increase in the environment.

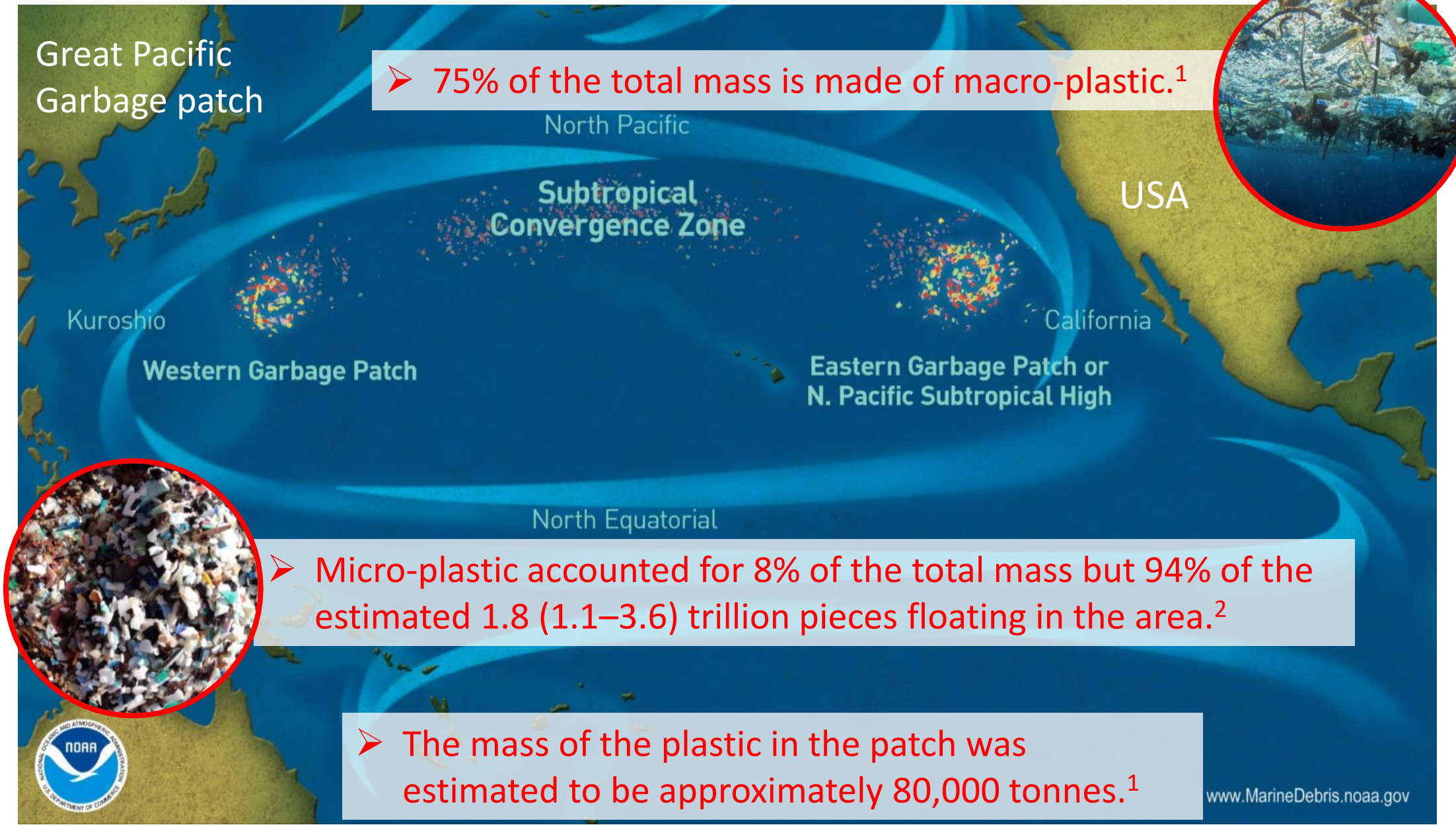
Photo: www.marinedebris.noaa.gov

3. Floating plastic

Garbage patches

- Plastic is dispersed by ocean currents and winds and can travel thousands of kilometers away from its entry point.

3. Floating plastic



- 75% of the total mass is made of macro-plastic.[1]
- Micro-plastic accounted for 8% of the total mass but 94% of the estimated 1.8 (1.1–3.6) trillion pieces floating in the area.[2]
- The mass of the plastic in the patch was estimated to be approximately 80,000 tonnes.[1]

[1]The ocean clean up (2022) [2]Lebreton L, et al., (2018) Photos: (left) by Sustainable Coastlines Hawaii; (right) by NOAA

3. Floating plastic

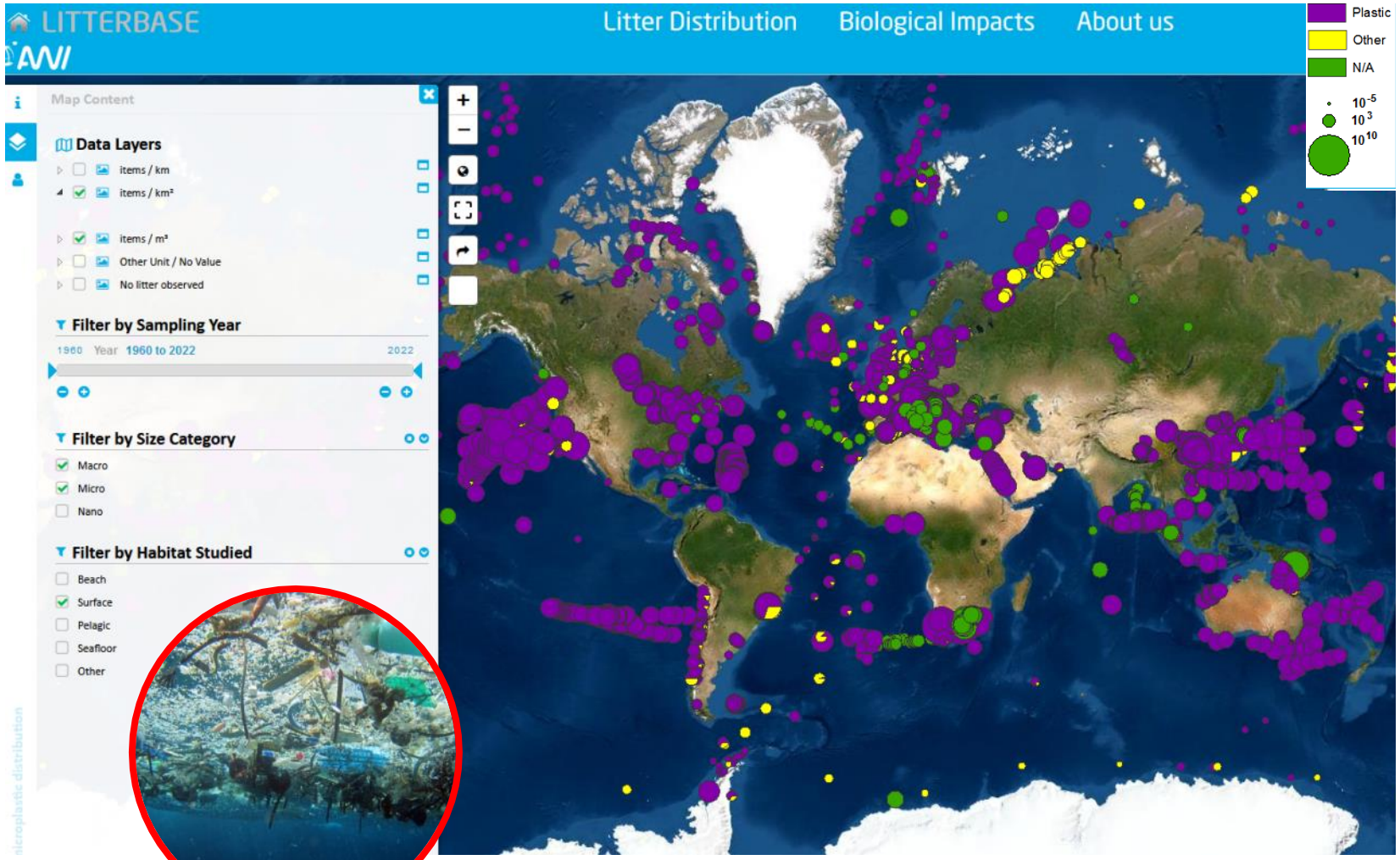


Photo by: NOAA

Median pollution of surface litter 86kg/km² ; 10 items/km² (all litter) up to 25.000 items /km².[1]

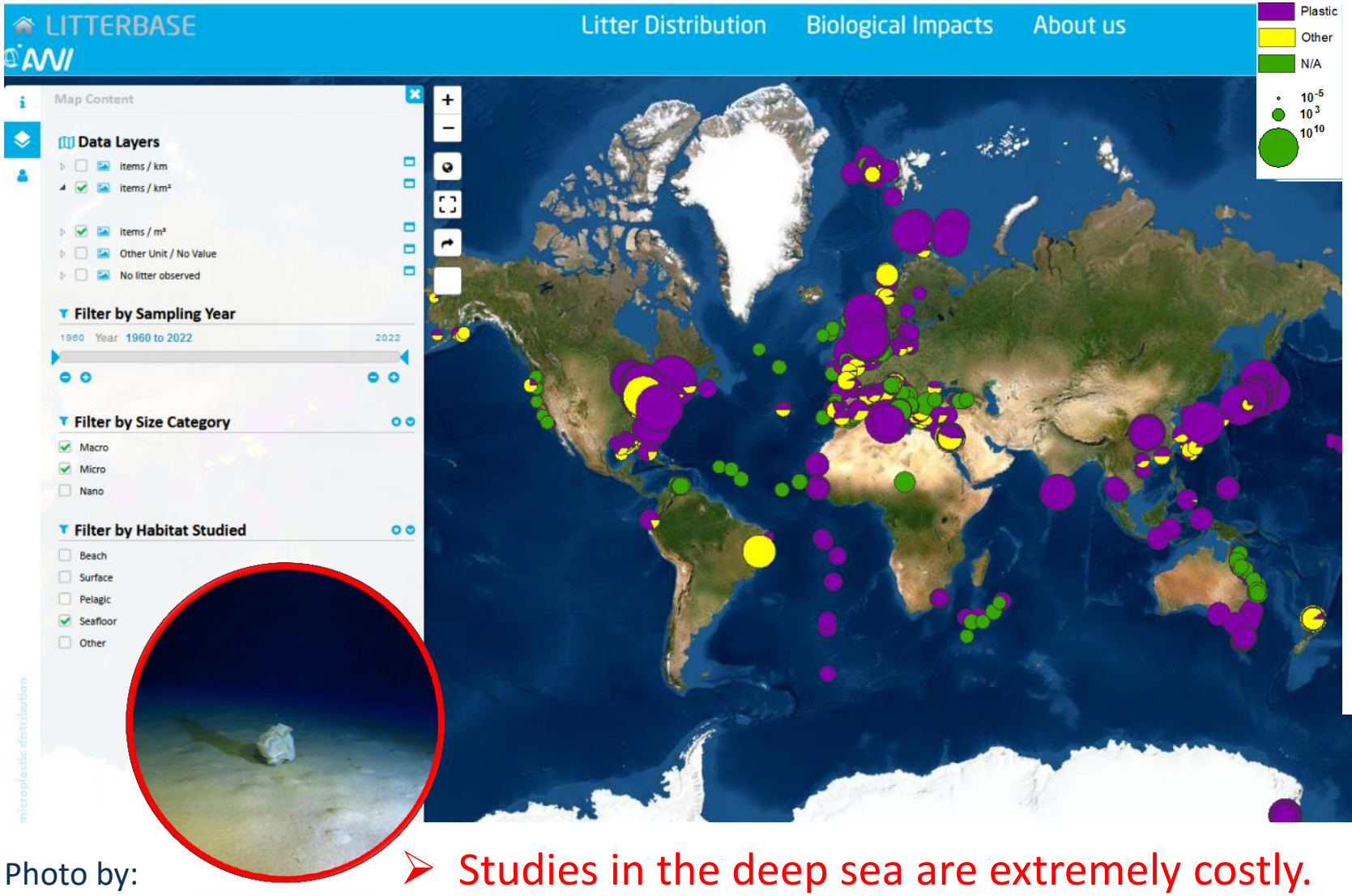
Most studies on floating plastic litter were conducted in coastal waters. [1]

Data of the southern hemisphere and of low-income countries are lacking. [1]

➢ Lack of data for surface waters (Southern hemisphere) and the deeper water column plastic pollution.[1]

Map by: https://litterbase.awi.de/litter [1]Haarr ML, et al., (2022) Photo: www.marinedebris.noaa.gov

4. Seafloor plastic



Median pollution of macro-seafloor litter is 2000kg/km²;
6000 items /km² (all litter). [1]

Most studies (87%) in shallower coastal waters[1]

- North Sea,
- Baltic Sea,
- Mediterranean Sea.

Photo by:
Caladan Oceanics

- Studies in the deep sea are extremely costly.
- Lack of data regarding plastic pollution in the deep sea.[1]

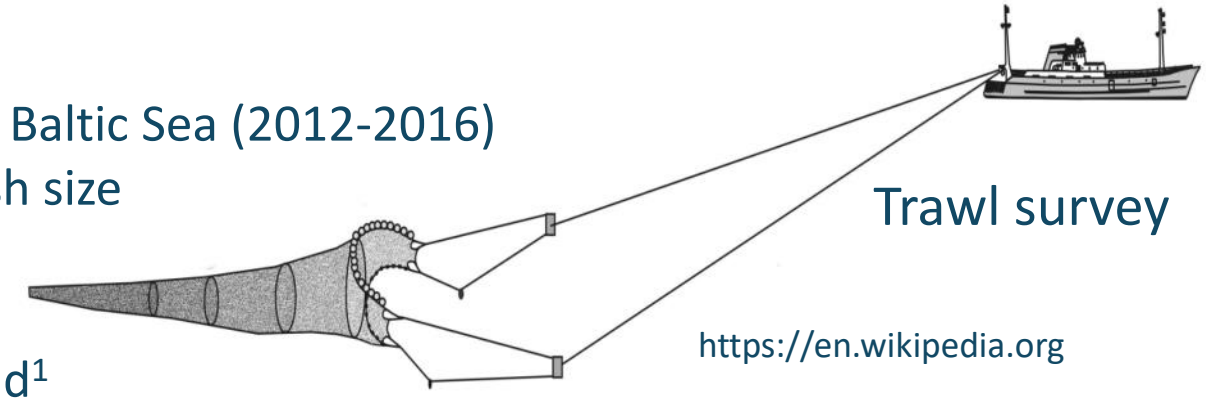
Map by: https://litterbase.awi.de/litter

[1]Haarr ML, et al., (2022)

5. Baltic Sea - Seafloor

2377 seafloor surveys in the Southwestern Baltic Sea (2012-2016)

- Depth between 6 to 128m / 20 mm mesh size



Trawl survey

https://en.wikipedia.org

In 47% of the surveys no litter was found

- 6268 litter items with 2412kg were found[1]

Plastic was responsible for:

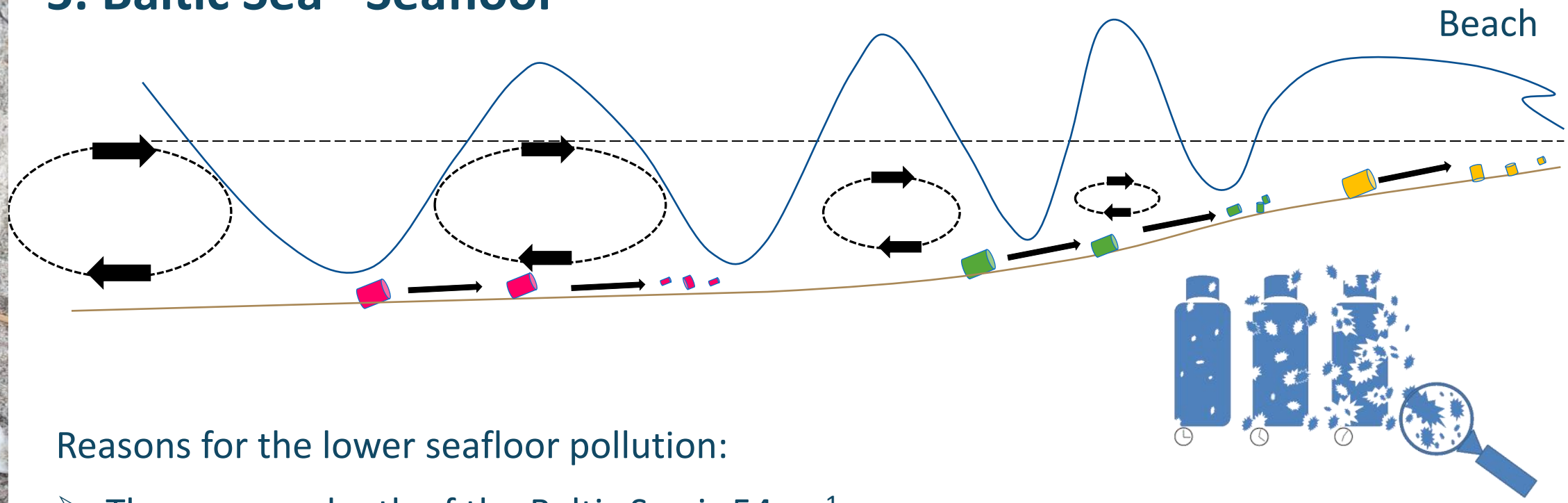
- 35% in number of litter items
- Mostly natural products were found (wood, coal, clinker).[1]

- Results show lower percentages of seafloor plastic (35%) than the widely cited world average (70%).[1]
- Other studies show higher percentages of Baltic seafloor plastic (9.6 items/km²); but it is lower than in the North Sea (70.7 items/km²). [2]

Photo by:
Caladan Oceanics

[1]Zablotski, Y & Kraak, S.B.M., (2019) [2]Int-Veen I, et al., (2021) Map by: https://litterbase.awi.de/litter

5. Baltic Sea - Seafloor



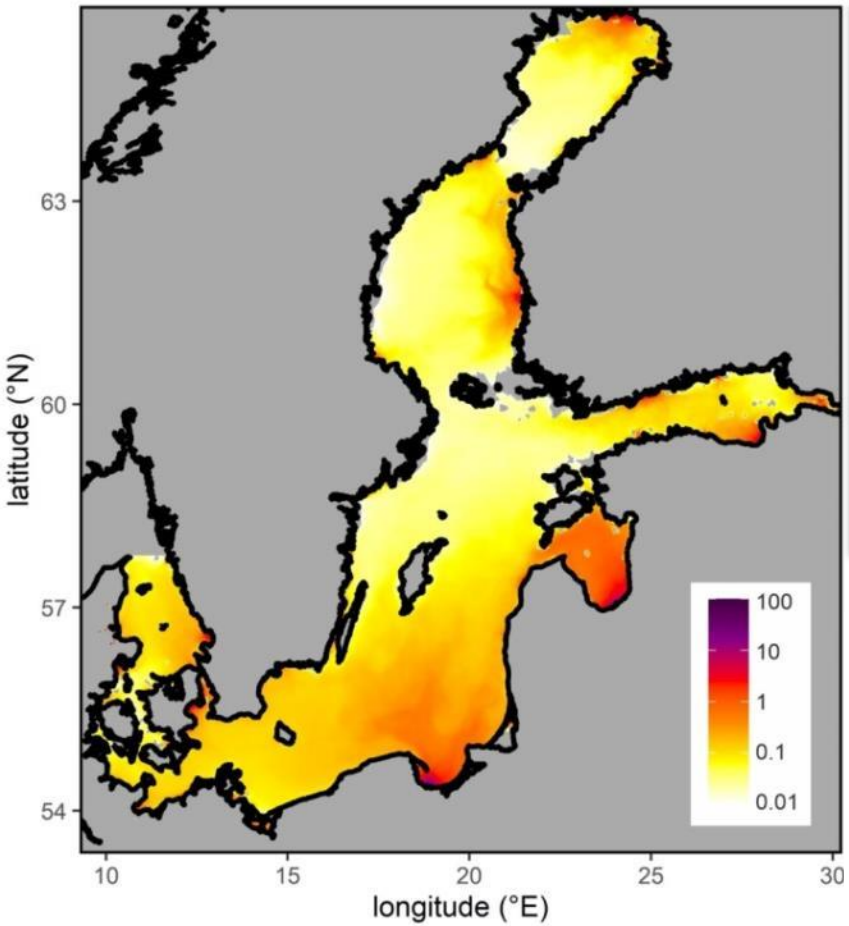
Reasons for the lower seafloor pollution:

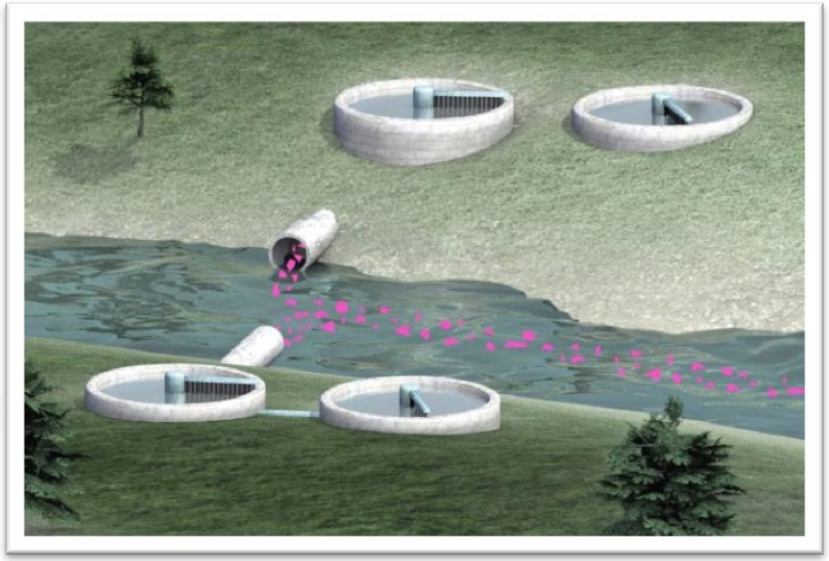
- The average depth of the Baltic Sea is 54 m.[1]
- The deformation of larger waves begins from the depths of 50 – 70 m.[1]
- Fragmentation of plastic into smaller pieces.
- Plastic is transported from the shallow seafloor to the coast.

[1]Chubarenko and Stepanova (2017)

5. Baltic Sea - surface plastic

Micro-plastic from land-based sources reaches the coast within days or weeks, driven by currents.[1]



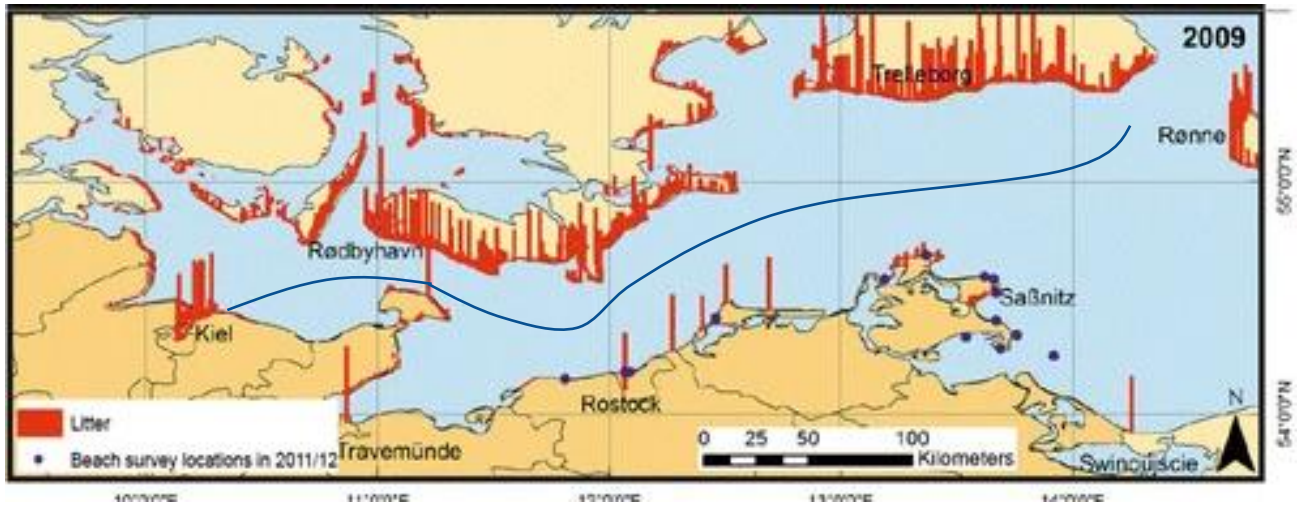


Average particle concentrations per m^3 in the upper 2 m of the water column resulting from urban water-bound microplastics emissions, based on simulations with a 3D hydrodynamic model.

Graphic adapted by: [1]Schernewski, G, et al., (2021) Figure on the right by: www.awi.de

5. Baltic Sea - surface plastic

Larger plastic from sea-based sources accumulated preferably at Scandinavian coasts, driven by winds.[1]



Simulations with the 3Dflow and transport model GETM. Hypothetical emissions of floating litter particles by ships. Location and amount of emissions reflect shipping intensity. Seasonal litter accumulation for the year 2009. Background Maps by Natural Earth 2013, BKG and EuroGeographics

Graphic adapted by: [1]Schernewski, G, et al., (2018) Figure on the right by: www.awi.de

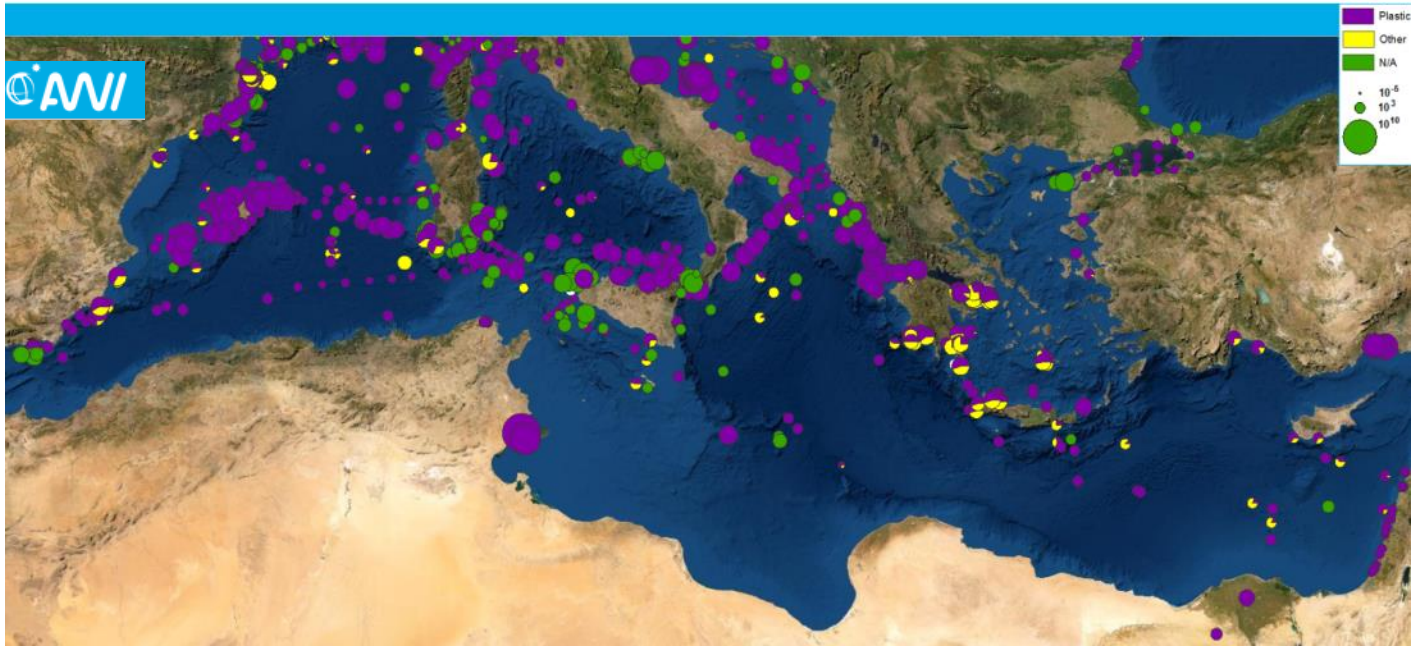
6. Mediterranean Sea

High densities of seafloor litter, locally exceeding 100,000 items km^2.[1]

- Plastics (72%) and lost fishing gear (17%) dominate.
- Seafloor litter densities (items km^2) were generally highest within the first 100 m from shore.[2]

For litter on the surface and in the water column, the greatest litter density was reported within a km of shore.[1]

- mostly land-sourced litter.



[1]Ryan PG (2015) [2]Haarr ML, et al., (2022) Map by: https://litterbase.awi.de/litter

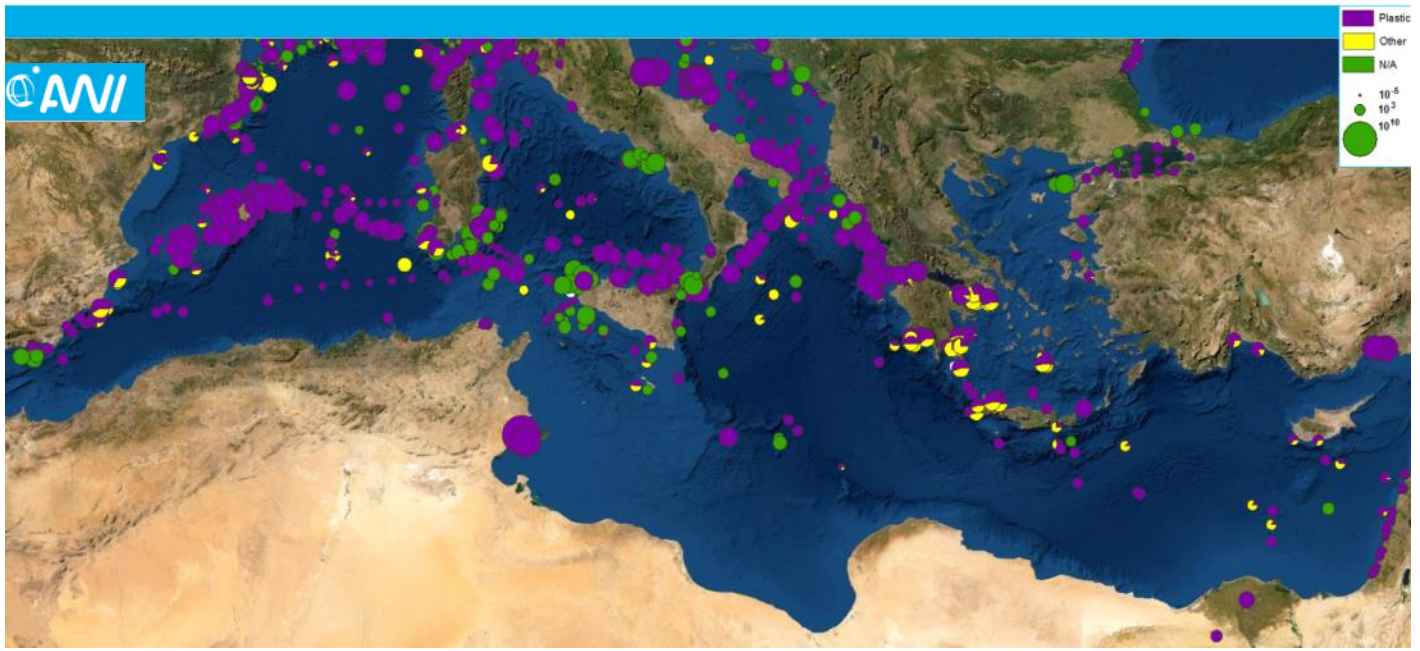
6. Mediterranean Sea

Boomerang effect:

- in the majority of Mediterranean countries more than 60% of plastics found comes from their own land-based.[1]

- Long-term accumulation of plastics at the sea surface is unlikely in the Mediterranean[1]
- The Mediterranean Sea is highly polluted but seafloor surveys are expensive.

- For the North African states pollution data is missing.
- Beach litter monitoring is cost effective and could provide a good pollution overview.



[1]Liubartseva S, et al., (2018) Map by: https://litterbase.awi.de/litter

7. Conclusions

- Plastic pollution costs $−billions each year and has negative ecological impacts on hundreds of marine species.

- The estimated amount of plastic that enters the sea (based on models) and the estimated amount of plastic in the marine environment (based on empirical data) generally do not match.
  - Further research in terms of plastic input and plastic sinks is needed.

- The global ocean is capable of accumulating floating plastic in the zones of sea surface currents (garbage patches) on a long term.
  - This is not the case for the Baltic and Mediterranean Sea.
  - Further research in the Baltic & Mediterranean Sea should focus on beach litter monitoring, as it is an easy and cost effective way to gather pollution data.

- There is a lack of knowledge regarding plastic litter pollution in the deep sea.

- Increasing plastic production and inadequate waste management will lead to a higher plastic pollution in the marine environment.
  - Therefore, plastic litter prevention strategies are urgently needed.

Thank you for your attention!

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Photo by NOAA

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