THÜNEN

Project *brief*

Thünen Institute of Fisheries Ecology 2022/04a

PlasM – Microplastic in fish

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- **The seafloor of the North and Baltic Sea is mainly polluted with plastic litter.**
- **Fish take up microplastic orally.**
- **Microplastic fibers in the water do not affect fertilization and early development of fish.**
- **Ingested microplastic fibers had no effect on growth and the immune system of sticklebacks.**

Background and aims

The pollution of the marine environment with anthropogenic litter is a known problem since the 1970ies. The scientific research on this topic steadily increased and accelerated especially in the last decade. Next to the fact, that around 80% of marine litter comprise of plastic, the focus on plastic litter is accounted for by the persistence and high mobility of plastic litter in the marine environment. Thus, around 80% of all plastic litter items end up, sooner or later, at the seafloor.

Plastic litter is subject to different physico-chemical processes, which lead to its embrittlement and consequently in the formation of small plastic particles and fibers, the so-called microplastic (< 5 mm). Due to its tininess microplastic is bioavailable for a great range of marine organisms. Until today microplastic was found in almost all investigated marine organisms ranging from small zooplankton species, over various fish species to huge marine mammals.

The main aims of the PlasM project were, on the one hand, the development of a consistent monitoring of litter at the seafloor including the identification of the polymers of plastic litter. On the other hand, investigations on the oral uptake of microplastics by different fish species in the North and Baltic Sea were conducted. In order to investigate possible effects of microplastic encounter on fish, exposure studies were conducted under controlled laboratory conditions.

Approach and methods

The litter at the seafloor as well as the wild fishes were sampled by bottom trawling in different regions of the North and Baltic Sea twice a year. We categorized the litter via an international protocol and analyzed potential plastic litter by Attenuated Total Reflection-Fourier Transform Infrared spectroscopy (ATR-FTIR) for their polymer groups.

The sampled wild fishes were dissected in the laboratory, where the gastrointestinal tracts were removed. Subsequently, the gastrointestinal tracts were treated with different chemical agents in order to isolate the potential microplastics in the samples. We applied µFTIR spectroscopy to analyze the processed samples, with the isolated microplastics. By that, the microplastics can be described in their abundance, polymer type, size, and mass for each individual fish.

The experimental fishes (three-spined sticklebacks; *Gasterosteus aculeatus*) were offspring from breeding adults, which were caught in the Weser estuary, Bremerhaven. We conducted the exposure studies with microplastic fibers since those are a prevalent microplastic component in the environment but were neglected in most previous effect studies. On the one hand, we tested if microplastic fibers in the water can affect fertilization rates of the fish eggs and the subsequent development of embryos and larvae of the sticklebacks. In addition, we prepared fish feed that contained homogeneously distributed microplastic fibers. We fed the fiber-supplemented and control feeds to subadult sticklebacks for nine weeks and analyzed growth performance, body condition parameters, and immune parameters for potential negative effects due to ingestion of microplastic fibers.

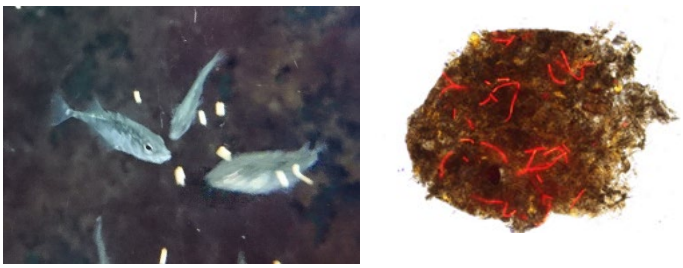

Fig. 1: Experimental sticklebacks ingest microplastic fibers provided via their feed (left). Efficient egestion of the autofluorescing microplastic fibers in feces gets visible with fluorescence microscopy (right). © Anja Bunge, Thünen Institute.

Results

Our investigations regarding the litter at the seafloor of the North and Baltic Sea corroborate with former studies in the fact that the majority of litter (91.3%) comprises of plastic items, followed by small abundances of natural products, rubber and metal.

The sampled regions of the North and Baltic Sea showed highly different amounts and composition in their litter pollution.

While the seafloor in the North Sea showed 70.7 litter items per km², the Baltic Sea is just polluted with 9.6 litter items per km².

We additionally proved that both Seas differ in their percentages of plastics related to total litter: 91.3% in the North Sea and 62.2% of total litter in the Baltic Sea were confirmed to be plastics. By using ATR-FTIR spectroscopy we verified the polymers polyethylene, polypropylene and polyamide to be most abundant. The vast majority of polymers showed a neutral or positive buoyancy in seawater, thereby excluding polymer density as the main driver of vertical plastic litter transportation. Other external mechanisms as attachment of organisms, biofouling or leaching of certain additives seem to be important in the vertical transport of marine plastic litter. We could show that plastics at the seafloor basically reflect the entirety of polymers entering marine environments.

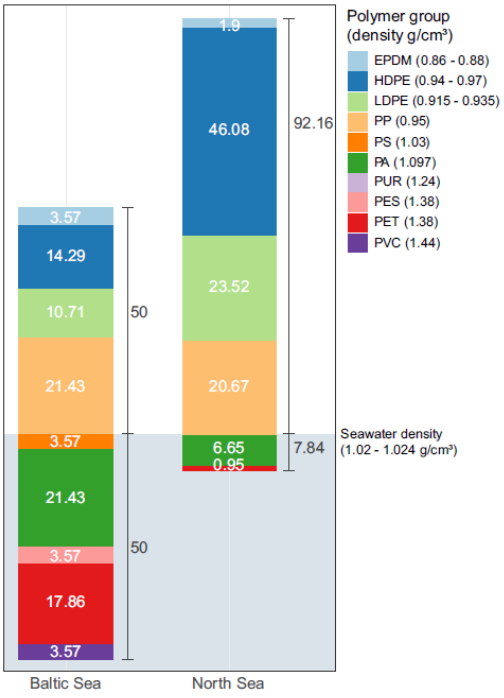

Fig. 2: Mean percentages of identified plastic polymer groups for the North Sea and the Baltic Sea. All litter items were collected during three consecutive bottom trawl surveys in 2017, 2018 and 2019. The white area represents a density above and the grey area a density below the seawater density. Density values refer to polymer groups and are not experimentally determined. The following polymers were detected: ethylene propylene diene monomer (EPDM), high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP), polyamide (PA), polyester (PES), polyethylene terephthalate (PET), polystyrene (PS), polyurethane (PUR) and polyvinylchloride (PVC). *N* = 449 plastic litter items.

We were able to prove the oral uptake of microplastics by wild fishes of the North and Baltic Sea, namely dab (*Limanda limanda*). We found typically less than 10 particles per individual dab. Our µFTIR analyses revealed the polymer polypropylene to be mostly taken up by dab.

We observed in the laboratory exposure studies that the microplastic fibers present in the water column did not affect fertilization rate and the early development of fish embryos and larvae. Though some fibers attached to the outer eggshells, those did not impair the early life stages of fish.

The oral uptake of microplastic fibers included in the feed did not induce significant changes in growth performance and maturation of the exposed sticklebacks. We could detect (natural) differences between males and females in body condition and some immune parameters. However, the supplemented microplastic fibers did not cause any negative effects – neither in male nor in female fish. Efficient excretion of ingested fibers within feces presumably prevented impairment of fish health by microplastic fibers – even at fiber concentrations considerably higher than currently reported from nature.

Conclusions

According to current scientific knowledge, the small amounts of microplastics that are taken up by fish in the North and Baltic Sea do not affect fish health and fitness, as well as consumers. We expect even at moderately higher future microplastic concentrations in the sea no significant negative effects on fish. The polymer composition of marine litter can be used to predict vertical transport proceses. Further on it should be part of future monitoring activities.

Further information

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Publications

Rebelein et al. (2021). Microplastic fibers—Underestimated threat to aquatic organisms? Sci Total Environ 777, 146045.
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