Hydrophobic organic contaminants are not linked to microplastic uptake in Baltic Sea herring

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Abstract

Due to its ubiquity in the environment, microplastic debris (MP) is commonly ingested by a range of aquatic organisms. A commonly held paradigm states that this can lead to lower food intake and the bioaccumulation of organic contaminants carried by MP. However, causal links between MP and contaminant levels in biota are poorly understood and *in situ* data are scarce. By examining the stomach contents of herring (*Clupea harengus membras*) caught along the Swedish east coast for the presence of plastic particles, and relating MP burden to hydrophobic organic contaminant concentrations in the fish muscle, we found that MP were present in about one third of herring, although the degree of ingestion exhibited a large geographic variability. This result is in good agreement with previous findings for Baltic Sea herring. If present, the mean number of MP particles was 8.4 ind^{-1}. MP burden normalized to gut content volume did not differ significantly between sea basins. The observed MP abundance was in agreement with values predicted by an individual based model that had been parameterized for clupeids of a similar size and the ambient MP abundances reported for surface waters in the Baltic Sea. MP abundance in the gastrointestinal tract decreased with reproductive stage but increased with body size. Contaminant concentrations in the muscle tissue were found to be unrelated to the number of MP present in gastrointestinal tract, suggesting a lack of correlation between the bioaccumulation of contaminants and MP ingestion. Thus, despite their ubiquity, MP are unlikely to have a measurable impact on food intake or the total body burden of environmental contaminants in Baltic herring.

Capsule: Ingested microplastic abundance is not correlated to hydrophobic organic contaminant body burden in Baltic herring.

Keywords: *Microplastic, Baltic Sea, herring, hydrophobic organic contaminants, marine monitoring*

Introduction

Plastic debris, and especially microplastics (MP < 5 mm), can be found in a variety of aquatic organisms across several trophic levels (Cole et al., 2013; Lusher et al., 2015, 2013). Due to the importance of commercial fish and shellfish species for human consumption, the ingestion and presence of MP in these organisms has become a matter of concern (EFSA Panel on Contaminants in the Food Chain (CONTAM), 2016), and several studies have been aiming to provide a quantitative assessment of MP ingestion in several fish species (Beer et al., 2017; Budimir et al., 2018; Foekema et al., 2013; Lusher et al., 2013; Rummel et al., 2016).

Several experimental studies have found a link between microplastic ingestion and decreased food intake (Cole et al., 2015; Ogonowski et al., 2018, 2016) and the bioaccumulation of hydrophobic organic chemicals (HOCs) (Besseling et al., 2013; Oliveira et al., 2012; Rochman et al., 2013b) sorbed to the MP particles (Mato et al., 2001; Rochman et al., 2013a; Rusina et al., 2010). However, other studies indicate that plastic polymers could have a net cleaning effect, relieving the organisms of contaminants by acting as passive samplers (Gouin et al., 2011; Herzke et al., 2016; Koelmans et al., 2016). Hence, the relative importance of microplastics as vectors for contaminant transport remains unresolved, possibly also due to the lack of environmental data linking HOC body burden to ingested MP.

Here, we study MP ingestion by Baltic Sea herring (*Clupea harengus membras* L.), a commercially relevant species. Being facultative pelagic filter-feeders (Huse and Toresen, 1996), herring stand a high risk of MP ingestion. We used a modelling approach with reported parameters on clupeid feeding, food processing and ambient MP concentrations to estimate realistic intervals of MP ingestion in Baltic herring. The model was validated with *in situ* samples collected from various locations along the Swedish coast, stretching about 1500km from the Bothnian Bay in the north to the Bornholm basin (Hanö Bight) in the south. Furthermore, by investigating the relationship between consumed MP abundance and HOC concentrations in muscle tissue, we assess whether MP significantly contribute to HOC body burden in Baltic Sea herring.

Materials and Methods

Fish collection and sample characteristics

The Baltic herring used for our analyses were collected along the Swedish east coast as a part of the Swedish National Monitoring Program for Contaminants in Marine Biota, an initiative by the Swedish Museum of Natural History (Stockholm, Sweden). In order to avoid possible bias by known point sources, we randomly selected a total of 130 specimens that had been collected at thirteen reference monitoring stations, thus providing a sufficiently large geographical area and a representative range of HOC and MP levels for analysis (Figure 1).

The sex ratio in our sample was approximately 50:50 and uniform across sampling sites. The fish were 3-7 years old, with an average total length of 173 ± 18 mm. The reproductive phase was determined by gametocytic maturity and varied geographically. It ranged from immature to mature and also included post-spawned individuals. The entire gastrointestinal tract (GIT) was removed, packed in aluminum foil, frozen at -20 °C, and stored until MP –analysis at the Department of Environmental Science and Analytical Chemistry, Stockholm University, Sweden.

MP quantification in the gastrointestinal tract of fish

The GITs were individually placed in glass Petri dishes, dissected with surgical scissors, and rinsed with deionized, particle-free water. Each sample was carefully examined under a stereo microscope and any bolus items resembling plastic were extracted using stainless steel pincers and transferred to Eppendorf tubes for further analysis. To account for variable feeding rates and the corresponding variability in the amount of ingested plastic, we standardized the plastic counts per GIT using the gut fullness weighed by the mass of the fish, calculated as: gut fullness (%) × body weight (g wet weight); gut fullness was assessed using a semi-quantitative scale with five possible values: 0% (empty), 25%, 50%, 75% or 100% (full). Furthermore, stomach volume was assumed proportional to body length (Pirhonen and Koskela, 2005).

Criteria for the visual identification of MP followed the recommendations of Norén (2007) and Hidalgo-Ruz et al. (2012). A particle with diameter between 1-5 mm was classified as MP if all the following criteria were met: (i) uniform, unnaturally bright or of an unnatural color, (ii) lack of organic structures, and (iii) uniform diameter over the entire length of a fiber. Each putative plastic particle was categorized according to its shape (fiber or fragment) and color. Particles with diameters smaller than 1 mm were discarded while particles > 5 mm were recorded but not used for further analyses. To test the accuracy of the visual identification method, a random subset of 20 samples containing MP (i.e., the gut contents of 20 individual fish) was analyzed using the hot needle test (De Witte et al., 2014).

Controls and blanks

To prevent cross-contamination by airborne particles during sample examination, the dissections were performed under a Fumex local extractor; each sample being analyzed for 10 min. A Petri dish filled with filtered deionized water was placed next to a test sample to serve as a blank for the quantification and characterization of potential contamination during the analysis. A cotton lab coat and nitrile gloves were used at all times to minimize contamination by clothing. The type and color of clothing were also recorded for each dissection event in order to back-trace potential contamination. Samples that would display quantifiable amounts of background contamination (plastic particles < 1 mm) were excluded.

Chemical analysis

Fish muscle samples for contaminant analysis were taken from the middle dorsal muscle layer and tissue sampling was performed according to standard procedures (TemaNord 1995). The samples were analyzed for polychlorinated biphenyls (PCB 28, 52, 101, 118, 138, 153 and 180), organochlorine pesticides (DDE, DDD, DDT, HCB, AHCH, BHCH, and Lindane) and polybrominated flame retardants (BDE 28, 47, 99, 100, 153, 154 and HBCD), according to the guidelines of the Swedish National Monitoring Program for Contaminants in Marine Biota. For the analysis of most compounds, 10 g of muscle tissue from individual fish was used, whereas 1 g samples of muscle tissue from 10 individuals were pooled for a few analytically challenging compounds. An overview of the analyzed contaminants and their average concentrations in herring muscle tissue are provided in

Table 1, while details of the analytical procedures are given elsewhere (Bignert et al., 2016).

Data analysis and statistics

Relationships between biological factors, geography and ingested microplastic

Regional differences in microplastic abundance in the GIT (both at a station and basin level) were tested using Permanova (Anderson, 2001), while relationships between specific biological variables were tested using generalized additive models (GAM). Due to an overrepresentation of zeros in the data (overdispersion), the models were run using zero-inflated Poisson error structures. Model performance was assessed using residual plots. All analyses were performed in R 3.5.0 (R Core Team, 2014).

Relationships between HOCs and ingested microplastic

Prior to statistical analyses, the measured values in samples whose chemical body burdens were below the limit of quantification (LOQ) were imputed by LOQ divided by the square root of two (Succop et al., 2004). The analyzed chemical concentrations were summed and grouped into their respective contaminant groups (PCBs, PBDEs and organochlorine pesticides). A factor analysis was performed to assess the degree of association between the chemical variables and microplastic abundance in the GIT.

Modeling plastic ingestion by herring

To evaluate whether the observed number of MP in the GIT could be predicted using ambient MP abundance data and fish feeding rate, we modeled the ingestion of MP using literature-derived parameters on food uptake, egestion, and MP abundance in the study area. The two main assumptions in the model were: (i) non-selective feeding by fish on ambient MP (1 to 5 mm) and (ii) non-discriminatory gut evacuation, i.e., MP being egested at the same rate as prey remains.

Then, the amount of MP in the GIT at any given time, t, can be written as the mass balance between uptake and loss rates (Eq. 1):

$$MP_t = MP(t - dt) + (IR - Eg)\,dt, \qquad (1)$$

where *IR* and *Eg* are the ingestion and egestion rates (number of MP h^{-1}), respectively. They can be written as:

$$IR = CMP \times FE \times CR \qquad (2)$$

and

$$Eg = GER \times MP_t\,, \qquad (3)$$

where *CMP* is the ambient MP concentration (number of MP L^{-1}), *FE* the effective feeding period (unitless; proportion of time spent feeding per day), *CR* the clearance rate (L h^{-1}; the volume of water swept clear of particles per individual and hour, and *GER* the gut evacuation rate (h^{-1}).

Model parameterization

In the absence of published rates for adult Baltic herring, we used the gut evacuation and clearance rates of European pilchard (*Sardina pilchardus*) (Table 2), which is a clupeid with a feeding ecology similar to Baltic herring (c.f. Costalago and Palomera, 2014; Möllmann et al., 2004). Since neither herring nor pilchard are particular night time feeders (Arrhenius and Hansson, 1994; Costalago and Palomera, 2014), the effective feeding period was set to the average number of daylight hours in Sundsvall, Sweden (62°23′28″ N, 17°18′22″ E) during August; as this represents both the latitudinal and temporal midpoints of our sampling locations and times.

To determine a plausible range of MP burden under environmentally relevant conditions, we modeled two extreme scenarios. In the first and the more conservative scenario, we used the lowest reported ambient MP abundance for the northern Baltic proper (0.19 MP m^{-3}, Gewert *et al.* 2017) established from surface manta trawls (335 µm mesh, MP size range = 0.335-5 mm) as well as the lowest reported experimental clearance rates when using *Brachionus plicatilis* (~190 µm) and *Artemia salina* nauplii (≤ 724 µm) as a prey (Garrido et al., 2007). In the second scenario, we used the highest known ambient MP abundance of 1.13 MP m^{-3} (Gewert et al., 2017) and the highest clearance rates observed when feeding on low densities of fish eggs (Garrido et al., 2007).

Results

Observed microplastic concentrations in the GIT

Microplastic particles identified by visual inspection were found in 37 out of the 130 analyzed herring (33.8%; range: 0 to 51 pieces of plastic fiber and/or fragments per individual). In those 37 individuals, the mean abundance was 8.4 particles ind^{-1}. The dominant type of MP were fibers of various colors (87.6%), while fragments were less frequent (12.4%). When excluding black particles that had been identified as non-plastic by the hot needle-test, the proportion of fibers decreased slightly (86.2%).

All procedural blanks contained plastic (mainly single fibers) of unknown origin. However, these particles all were < 1 mm and did thus not measurably contribute to the MP counts used for statistical analysis. The variation in total MP burden between stations and basins was high (Table 3), and we did not find any significant differences between the normalized abundances of MP from the different basins (*station* nested within *basin* as a random factor, pseudo $F_{4,117} = 1.06$, $p = 0.40$).

Predicted microplastic concentrations in the GIT

The model scenario using the lowest reported ambient MP concentrations (Gewert et al., 2017) and clearance rates (Garrido et al., 2007) yielded an average number of MP in the gastrointestinal tract of 0.01 particles ind^{-1} for clupeid fish of sizes similar to those analyzed here. The highest MP abundance and CR modelling scenario resulted in an average number of MP in the GIT of 0.88 particles ind^{-1}.

Linkage between ingested plastic and HOCs

We found no relationship between the number of consumed MP and the concentration of any of the HOCs (Figure 2). Microplastic occurrence in GIT displayed a significant negative loading on the first axis and positive loading on the second. In contrast, the organochlorine pesticides and PBDEs loaded strongly only on the first axis, while the PCBs displayed some degree of positive loading on both axes. Hence, no contaminant group loaded in the same direction as MP abundance.

Biological factors related to MP occurrence in fish GIT

The amount of plastic found in the GIT was positively related to fish body weight for individuals > 50 g (GAM, $\chi^2 = 306.7$, $p < 0.0001$, Figure 3 A), but not in the smaller fish. In contrast, an inverse relationship was found for individuals in their *reproductive phase*, where MP occurrence in the GIT was significantly lower in fish that had reached sexual maturity and recently spawned ($\chi^2 = 78.5$, $p < 0.0001$, Figure 3 B). Both *Gut fullness* (Figure 3 C) and *Age* (Figure 3 D) displayed weak bell-shaped relationships with MP occurrence. However, albeit significant (GAM, $\chi^2 = 17.7$, $p < 0.0002$, $\chi^2 = 32.4$, $p < 0.001$, *Gut fullness* and *Age*, respectively), these relationships were not particularly strong and likely of low biological importance.

Discussion

Microplastics are only a small dietary component in planktivorous herring

Microplastics were found in about one third of the gastrointestinal tracts, with a high proportion of fibers (88 %). While these values are in good agreement with those reported by Lusher et al. (2013) for the English Channel (36.5% of individuals containing MP, with 68% being fibers) and Beer et al. (2017) for the central Baltic Sea (20% containing MP, with 93% fibers), other studies found considerably lower MP prevalence and fiber contributions. Both Foekema et al. (2013) and Rummel et al. (2016) found plastics in only 2% of herring samples from the North Sea and the Southern Baltic Sea, with fibers accounting for less than 10% of MP. Having excluded fibers from their analyses, Budimir et al. (2018) reported a frequency of occurrence as low as 1.8% in herring from the northern Baltic Sea. These discrepancies between different studies could be related to differences in fish size and gut fullness. For example, Foekema et al. (2013) used fish that were considerably larger (>200 mm total length) which most likely already had switched from filter feeding to raptorial feeding on larger prey (Huse and Toresen, 1996). This change in feeding behavior would result in a lower ingestion rate of zooplankton-sized plastic particles and thus result in lower overall MP burden. In the study by Rummel et al. (2016), many fish stomachs were empty, which probably was related to arrested feeding related to spawning, and possibly, stress-induced gut evacuation caused by the fish sampling (Vinson and Angradi, 2011; Wilkins, 1967). This lends further support to our findings that MP burden increases with fish size and decreases with reproductive phase. In addition, one would expect the amount of ingested MP to scale with gut bolus size or gut fullness. However, our findings do not support this assumption. This could be due to one of our underlying model assumptions (see methods), namely that the rate of plastic egestion is equal to the egestion of natural food. If the egestion of plastic in herring occurs at a slower rate, as observed with plastic fibers in amphipods (Au et al., 2015), one would observe a higher rate of accumulation of MP in the GIT. While normalizing the ingested MP content by gut fullness seems to have little impact on the absolute amount of ingested particles (as indicated by the associated weak bell-shaped response curve), fish size appears be a better candidate for standardizing internalized MP concentrations. Nevertheless, there are several other factors that must be considered. They include ontogenetic changes in feeding modes, behavior, maturity levels, fishing methods, and time of capture (diurnal differences in feeding activity).

No correlation between MP presence and HOCs

The so-called "Trojan horse" effect (Cole et al., 2011) denotes a transfer of hydrophobic contaminants from ingested plastics to biota. While this effect has been demonstrated under laboratory conditions (Batel et al., 2016; Besseling et al., 2013; Browne et al., 2013; Rochman et al., 2013b), recent modelling studies seem to indicate that compared to MP, natural sources play a much more important role in explaining HOC bioaccumulation patterns in aquatic organisms (Koelmans, 2015; Koelmans et al., 2016). Since we did not find any correlation between HOC concentrations in herring muscle tissue and MP abundance in the GIT, it could be argued that omitting MP with diameters < 1 mm from our analyses, could have biased the results by ignoring the potential influence a higher total surface area and thus higher HOC desorption rates (Hartmann et al., 2017; Hendriks et al., 2001). However, this is rather unlikely since filter feeding herring have a relatively low capacity to retain smaller particles due to their rather wide gill raker spacing (Gibson, 1988). In fact, this line of reasoning has been confirmed by several other studies who found a predominant retention of MP with diameters > 1 mm (Beer et al., 2017; Lenz et al., 2016). Given the short residence time (Grigorakis et al., 2017) of internalized plastics and the slow desorption kinetics of many HOCs, we would moreover only expect a rather weak correlation between the two, or no correlation at all.

Although causality is difficult to prove using environmental samples where many different parameters contribute to the contaminant body burden of an organism (Hartmann et al., 2017), our findings strongly suggest that there is no tenable relationship between the amount of ingested microplastic particles and tissue contaminant concentrations (Fig. 2). This findings contrasts the currently held paradigm according to which microplastics are an important source of HOCs in aquatic organisms (Mato et al., 2001; Rochman et al., 2013b). Similarly, no correlation has been found between the amount of ingested plastic and HOC concentrations in northern fulmars (*Fulmarus glacialis*) from the Norwegian coast (Herzke et al., 2016), although the birds had ingested much larger amounts of plastic and their gut passage times for plastic particles are several orders of magnitude longer than for herring (Ryan, 2015). In light of present and past findings regarding the role of MP as vectors for contaminant transport, our study further strengthens the view that MP only play a minor or even negligible role in explaining contaminant bioaccumulation in aquatic biota.

Conclusions

Our findings suggest that microplastic ingestion by filter-feeding fish is relatively low, even in a semi-enclosed sea like the Baltic, where the MP loading is expectedly high. A rather large discrepancy exists in the literature with regard to the interpretation of MP ingestion demonstrating the urgent need to find suitable standards for MP quantification in gut content analyses. Several studies also demonstrated that biological factors such as fish size and reproductive state may affect both feeding in general and selectivity towards MP, and hence MP burden. We found no correlation whatsoever between the amount of ingested plastic and muscle tissue HOC concentrations. These results provide an additional challenge to the commonly held paradigm that MP are important vectors for the transfer of contaminants to biota.

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Figures and tables

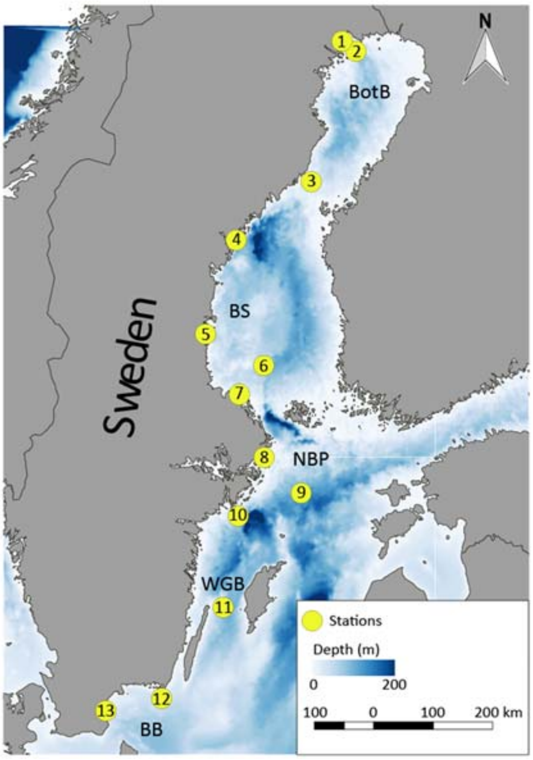

Figure 1. Sampling sites within the Swedish National Monitoring Program for Contaminants in Marine Biota included in this study, BotB Bothnian Bay, BS Bothnian Sea, NBP Northern Baltic Proper, WGB Western Gotland Basin and BB Bornholm Basin. 1 Rånefjärden, 2 Harufjärden, 3 Holmöarna, 4 Gaviksfjärden, 5 Långvindsfjärden, 6 Bothnian Sea offshore site, 7 Ängsskärsklubb, 8 Lagnö, 9 Baltic proper offshore site, 10 Landsort, 11 Byxelkrok, 12 Utlängan and 13 Western Hanö bight.

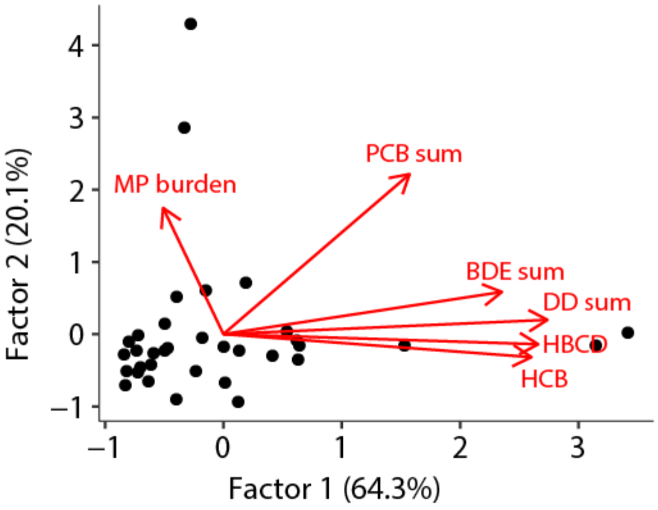

Figure 2. Factor scores (axes) and loadings (arrows) of contaminants (HBCD, HCB and the sum of PCBs, BDEs and DDs) and average plastic content (*MP burden*).

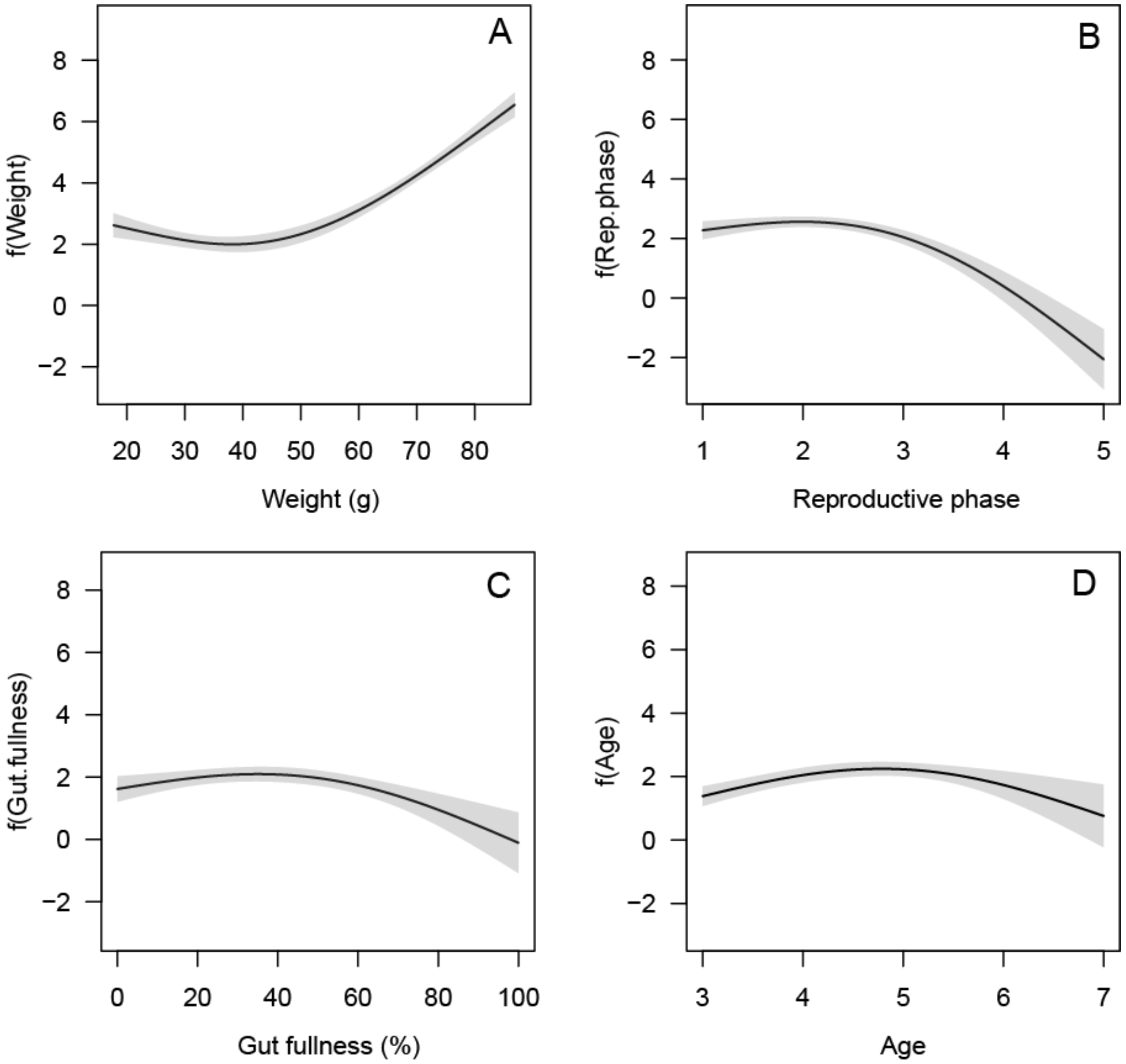

Figure 3. Generalized additive model partial response curves for the measured biological variables: *body weight* (A), *reproductive phase* (B), *gut fullness* (C) and *age* (D). The classes for *reproductive phase* correspond to: 1 = immature, 2 = developing gonads, 3 = mature gonads, 4 = post-spawned and 5 = deformed gonads. The vertical axes, indicate the relative influence of each explanatory variable on the prediction on the base of partial residuals. Grey bands indicate 95% confidence intervals for each curve.

Table 1. **Overview of the chemicals analyzed in herring muscle tissue and their average concentrations (µg g^{-1} fish muscle).**

Chemical group	Chemical species	Abbreviation	Mean concentration in fish muscle (µg/g)	S.D	Median	Min	Max
Polychlorinated biphenyls (PCBs)	2,4,4′-PCB	PCB 28	0.0039	0.0019	0.0033	0.0018	0.0106
	2,2′,5,5′-PCB	PCB 52	0.0067	0.0044	0.0057	0.0025	0.0199
	2,2′,4,5,5′-PCB	PCB 101	0.0222	0.0149	0.0176	0.0069	0.0713
	2,3′,4,4′,5′-PCB	PCB 118	0.0204	0.0135	0.0155	0.0062	0.0694
	2,2′,3,4,4′,5′-PCB	PCB 138	0.0591	0.0408	0.0444	0.0152	0.1896
	2,2′,4,4′,5,5′-PCB	PCB 153	0.0417	0.0280	0.0345	0.0120	0.1320
	2,2′,3,4,4′,5,5′-PCB	PCB 180	0.0181	0.0114	0.0149	0.0029	0.0551
Organochlorine pesticides	4,4′-DDT	DDT	0.0205	0.0218	0.0134	0.0037	0.0966
	4,4'-DDE	DDE	0.1055	0.0960	0.0815	0.0160	0.4130
	4,4'-DDD	DDD	0.0284	0.0333	0.0163	0.0016	0.1391
	α-1,2,3,4,5,6-Hexachlorocyclohexane	AHCH	0.0029	0.0005	0.0030	0.0018	0.0039
	β-1,2,3,4,5,6-Hexachlorocyclohexane	BHCH	0.0056	0.0027	0.0057	0.0018	0.0099
	γ-1,2,3,4,5,6-Hexachlorocyclohexane	Lindane	0.0029	0.0005	0.0030	0.0018	0.0039
Brominated flame retardants (BDEs)	2,4,4′-TriBDE	BDE 28	0.0002	0.0001	0.0002	0.0001	0.0005
	2,2′,4,4′-TetraBDE	BDE 47	0.0051	0.0032	0.0041	0.0016	0.0160
	2,2′,4,4′,5-PentaBDE	BDE 99	0.0012	0.0009	0.0009	0.0005	0.0044
	2,2′,4,4′,6-PentaBDE	BDE 100	0.0012	0.0007	0.0011	0.0004	0.0035
	2,2′,4,4′,5,5′-HexaBDE	BDE 153	0.0002	0.0002	0.0002	0.0001	0.0009
	2,2′,4,4′,5,6′-HexaBDE	BDE 154	0.0006	0.0004	0.0005	0.0002	0.0018
	1,2,5,6,9,10-Hexabromocyclododecane	HBCD	0.0114	0.0096	0.0088	0.0025	0.0470
Other	Hexachlorobenzene	HCB	0.0289	0.0209	0.0246	0.0114	0.1013

Table 2. Parameters used to model microplastic ingestion in Baltic Sea herring.

Parameter	Unit	Average/estimate	Min	Max	Species	Meaning	Reference
CMP	MP L^{-1}		0.00019	0.00113		MP concentration in water column.	Gewert et al. 2017
CR	L ind.$^{-1}$ h^{-1}		21.6	304.2	*Sardina pilchardus*	Clearance rate.	Garrido et al. 2007
FE	unitless	0.625			*Clupea harengus*	Feeding efficiency.	Batty et al. 1986
GER	h^{-1}	0.259	-0.215[a]	0.733	*Sardina pilchardus*	Gut evacuation rate.	Costalago & Palomera 2014
IR	MP h^{-1}					Ingestion, amount MP ingested at time *t*.	
MP	MP					Number of MP in fish stomach at time *t*.	
——Eg	MP h^{-1}					Amount MP egested at time *t*.	

[a] The minimum estimate for GER is the reported lower 95% confidence limit of the mean. A negative gut evacuation rate is not biologically meaningful, therfore the mean value was used as the minimum rate in the model.

Table 3. Descriptive statistics for the microplastics recovered from the gastrointestinal tract of Baltic Sea herring. The data are presented as particle shape and color as well as total MP burden (mean of presences) and range (min-max) Values are given per basin and ordered north to south.

	Fiber				Fragment				Black fibers incl.					Black fibers excl.				
Basin	Black	Red	Brown	Green	Clear	Black	Red	Green	Prevalence (%)	Median MP content	Mean MP content	Mean MP content of presences	Range (min-max)	Prevalence (%)	Median MP content	Mean MP content	Mean MP content of presences	Range (min-max)
Bothnian Bay	0-7	0-38	0-4	0-0	0-3	0-0	0-3	0-12	31.8	0	4.1	9.5	0-38	35.1	0	3.5	8.2	0-38
Bothnian Sea	0-8	0-18	0-0	0-0	0-5	0-7	0-0	0-2	27.3	0	1.3	5.2	0-18	24.3	0	1.0	4.3	0-18
Northern Baltic Proper	0-1	0-0	0-0	0-0	0-51	0-0	0-2	0-2	13.6	0	6.7	32.8	0-51	10.8	0	6.6	32.7	0-51
Western Gotland Basin	0-1	0-3	0-0	0-1	0-1	0-0	0-7	0-0	18.2	0	1.0	2.7	0-7	18.9	0	0.9	2.6	0-7
Bornholm Basin	0-1	0-13	0-0	0-0	0-2	0-0	0-0	0-0	9.1	0	0.9	4.5	0-13	10.8	0	0.9	4.3	0-13
Total	**0-8**	**0-38**	**0-4**	**0-1**	**0-51**	**0-7**	**0-7**	**0-12**	**33.8**	**0**	**2.7**	**9.1**	**0-51**	**28.5**	**0**	**2.4**	**8.4**	**0-51**