Supporting information for

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

*Ogonowski M.[1,2], Wenman, V.[1], Danielsson S.[3] and Gorokhova E.[1]

[1] Department of Environmental Science and Analytical Chemistry, Stockholm University, SE-10691, Stockholm, Sweden

[2] AquaBiota Water Research, Löjtnantsgatan 25, SE-115 50, Stockholm, Sweden

[3] Swedish Museum of Natural History, Department of Environmental Science and Monitoring, P. O. Box 50 007, SE-104 05, Stockholm Sweden

*corresponding author:
martin.ogonowski@aces.su.se

1.1 Model parameterization

1.1.1 Clearance rate (CR)

Clearance rates (CR) for Baltic herring were calculated based on intake rates of *Calanus finmarchicus* in the North Sea (Fig. 5 in Varpe and Fiksen 2010), which is the main prey for herring in this area. These copepods are also of similar size (2-3 mm prosome length) as the microplastic particles considered in this study (Pasternak et al. 2004). We used the reported values on *C. finmarchicus* consumption by herring expressed as (J copepod [J herring]$^{-1}$ day^{-1}) and ambient *C. finmarchicus* abundance to obtain the CR.

The average CR of the Baltic herring population examined in this study (L h^{-1}) was calculated assuming an energy content of 3.5 kJ and 10 kJ g wet weight^{-1} for *C. finmarchicus* and herring, respectively (Varpe et al. 2005). The average weight of the sampled Baltic herring (35 g) was used to derive the consumption rate on an individual basis and using a first-order exponential decay function fitted to data on the CR and prey abundance for the North Sea herring feeding on *C. finmarchicus* (Fig. S2). The asymptote value (1.04×10^3 L ind.$^{-1}$ h^{-1}) was assumed to represent CR of the Baltic herring, because mesozooplankton abundance in the Baltic Sea normally supersede the maximum reported abundance for *C. finmarchicus* in the North Sea (cf. Varpe and Fiksen 2010, Gorokhova et al. 2016).

1.1.2 Ambient MP concentrations in the Baltic Sea (CMP)

We used the average microplastic concentrations reported by Gewert et al. (2017) in the outer Stockholm archipelago (0.58 MP m^{-3}) estimated by surface manta trawls (335 µm mesh). These values were used, because the size range (median MP size and inter quartile range, IQR: fragment diameter = 1 mm (IQR 0.6-1.5 mm), fiber length = 1 mm (IQR 1-3 mm)) fits well the size of MP recovered from the fish guts. Also, the polymer materials have been rigorously identified by FT-IR in this selection of the field-collected MP, thus ensuring that the fragments collected were indeed microplastics.

1.1.3. Gut evacuation rates (GER)

We were not able to find data on gut evacuation rates for adult herring; therefore, a lower and an upper limit reported for two clupeid species of similar size and feeding ecology as the herring analyzed here (Collard et al. 2015) were chosen. The lower limit (0.05 h^{-1}) was adopted from the experimental and field data collected for adult South American pilchard (*Sardinops sagax*) (van der Lingen 1998). The upper limit (0.26 h^{-1}) was experimentally derived for adult European pilchard (*Sardina pilchardus*) (Costalago and Palomera 2014).

1.2 Monte Carlo simulation of MP burden in the Baltic herring

To estimate MP burden (MP ind^{-1}) dynamics at a given MP abundance from time 0 to the point when it is stabilized (48 h), we performed Monte Carlo simulation with 1000 permutations using STELLA® ver. 9.4.1 software (iSee systems, Inc. Lebanon, NH, U.S.A.), with the equations (Eqs. 1 to 3) integrated as shown in figure S3. Ambient MP concentrations (CMP) were allowed to vary randomly following a Poisson distribution as were the data presented in Gewert et al. 2017), whereas the CR values were normally distributed with a mean and SD of 1041 L h^{-1} and 27 h^{-1}, respectively, and GER values varied randomly between 0.05 and 0.26 h^{-1} without any assumption regarding the distribution (Table S 2). The final value of each run was used to represent an individual in the population.

SI Tables and Figures

Table S1. Descriptive statistics for the microplastics recovered from the gastrointestinal tract of Baltic Sea herring as well as gut fullness of the examined fish. For each basin, the number of differently colored fragments and fibers that were recovered from the fish are shown as well as MP frequency of occurrence (FO), median, range (min-max) and mean; moreover, the mean values were calculated for all fish and for the fish that contained MP in their GIT (i.e., excluding zero values). Gut fullness (GF) is presented as percent of fish with empty stomachs, median gut fullness and the corresponding inter-quartile range (IQR). Values in parentheses represent values where non-plastic black fibers > 1 mm have been excluded. Data are ordered north to south.

	Fibers					Fragments			MP total					GF		
	Black	Red	Brown	Green	Clear	Black	Red	Green	FO (%)	Median	Mean all samples	Mean of presences	Range (min-max)	% fish with empty GIT	Median	IQR
Bothnian Bay	0-7	0-38	0-4	0-0	0-3	0-0	0-3	0-12	46.7 (43.3)	0	4.1 (3.5)	9.5 (8.2)	0-38	10	50	25-50
Bothnian Sea	0-8	0-18	0-0	0-0	0-5	0-7	0-0	0-2	30.0 (22.5)	0	1.3 (1.0)	5.2 (4.3)	0-18	7.5	25	25-50
Northern Baltic Proper	0-1	0-0	0-0	0-0	0-51	0-0	0-2	0-2	30.0 (20.0)	0	6.7 (6.6)	32.8 (32.7)	0-51	25	25	19-50
Western Gotland Basin	0-1	0-3	0-0	0-1	0-1	0-0	0-7	0-0	40.0 (30.0)	0	1.0 (0.9)	2.7 (2.6)	0-7	10	25	25-25
Bornholm Basin	0-1	0-13	0-0	0-0	0-2	0-0	0-0	0-0	20.0 (20.0)	0	0.9 (0.9)	4.5 (4.3)	0-13	0	50	25-56
Total	**0-8**	**0-38**	**0-4**	**0-1**	**0-51**	**0-7**	**0-7**	**0-12**	**33.8 (28.5)**	**0**	**2.7 (2.4)**	**7.8 (8.4)**	**0-51**	**9.2**	**25**	**25-50**

Table S2. Variables and simulation settings used to model microplastic ingestion in Baltic Sea herring. Details regarding derivation of the values are provided in the Supporting Information 1.1.

Parameter	Unit	Average	Min	Max	S.D	Distribution	Species	Meaning	Reference
CMP	MP L^{-1}	5.8×10^{-4}				Poisson		MP concentration in the water column	Gewert et al. 2017
CR	L $ind.^{-1}$ h^{-1}	1.04×10^{3}			2.6×10^{2}	Normal	*Clupea harengus*	Clearance rate	Varpe & Fiksen 2010
GER[1]	h^{-1}		5×10^{-2}	2.6×10^{-1}			*Sardinops sagax, Sardina pilchardus*	Gut evacuation rate	Van der Lingen 1998, Costalago & Palomera 2014
IR	MP h^{-1}							Number of MP ingested at time *t*	
MP	MP							Number of MP in fish stomach at time *t*	
Eg	MP h^{-1}							Number of MP egested at time *t*	

1. The lower value for GER is based on data for *Sardinops sagax* (Van der Lingen 1998) while the higher is derived from *Sardina pilchardus* (Costalago & Palomera 2014).

Table S3. Descriptive statistics for the predicted (modelled) and observed distributions of the MP burden in the Baltic herring. The data are presented as either "Total", i.e., where individuals without MP in the GIT are included, or "Zeros excluded" that shows only the fish with positive MP burden.

	Total		Zeros excluded	
	Mod	Obs	Mod	Obs
n	1000	130	806	37
Mean	4.7	2.4	5.9	8.4
SD	4.7	7.8	4.5	12.9
Median	3.6	0.0	4.4	2.0
Min	0.0	0.0	1.3	1.0
Max	33.3	51.0	33.3	51.0
Range	33.3	51.0	32.0	50.0
Skew	1.8	4.4	2.0	2.0
Kurtosis	5.0	20.0	5.7	2.8
SE	0.1	0.7	0.2	2.1

Table S4. Summary statistics and factor loadings for the variables used in the factor analysis. WS MP burden = weight specific MP burden. Factor loadings > 0.7 are considered statistically significant.

	Factor 1	**Factor 2**
WS MP burden	-0.129	0.615
BDE sum	**0.917**	0.258
HBCD	**0.997**	-0.026
DD sum	**0.951**	0.099
HCB	**0.943**	-0.083
PCB sum	0.548	**0.834**
SS	3.946	1.158
Proportion var	0.658	0.193
Cumulative var	0.658	0.851

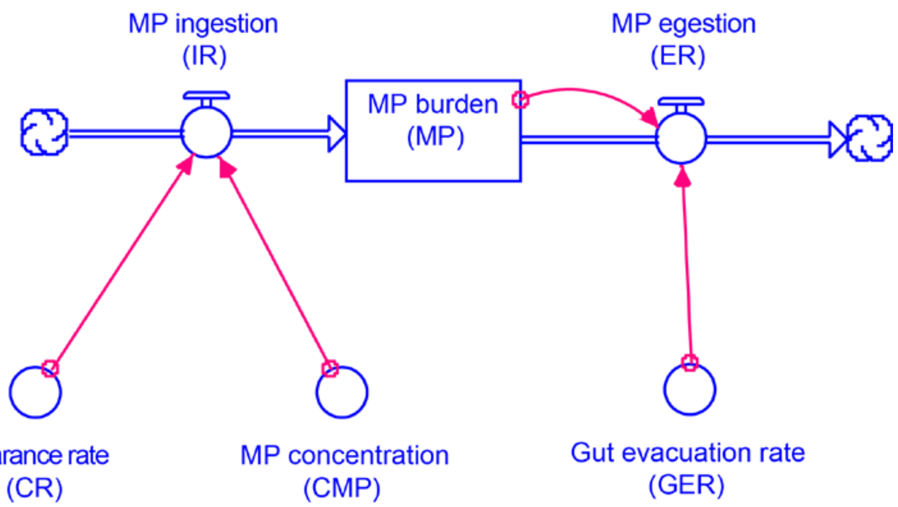

Figure S1. Schematic representation of the model used to predict microplastic ingestion in Baltic herring.

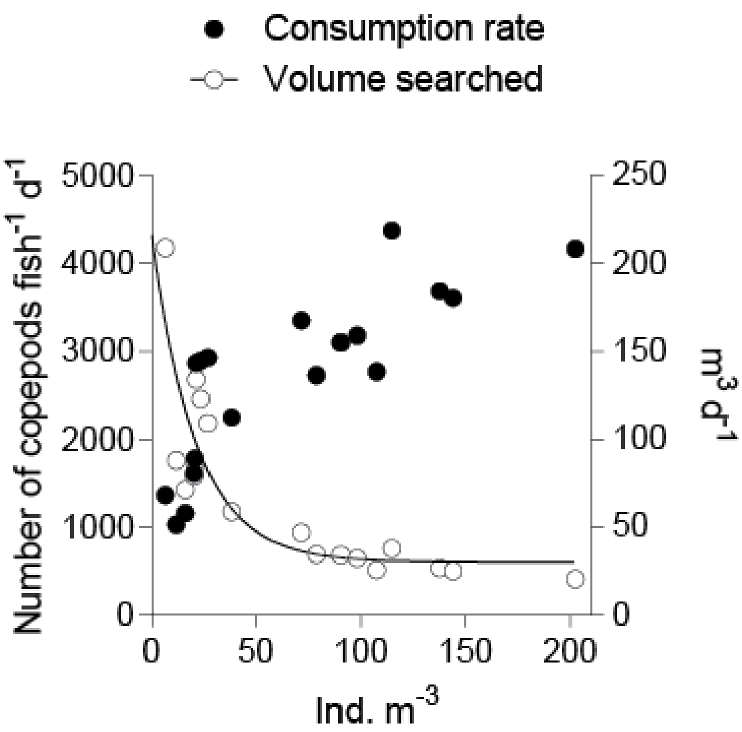

Figure S2. Consumption rates (left axis) and clearance rates (right axis) as a function of *Calanus finmarchicus* abundance. The values are based on the data presented in Fig. 5, Varpe and Fiksen (2010) and adjusted for fish with average body weight of 35 g.

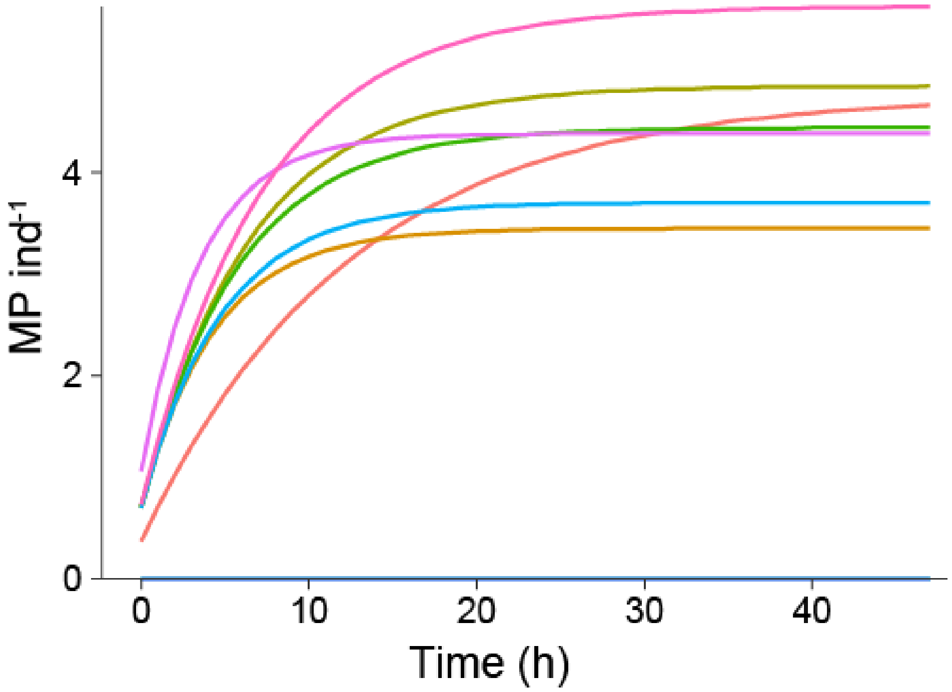

Figure S3. Modeled MP burden (MP ind^{-1}) in the first ten simulation runs for 48 h. Observe that values are stabilized at the end of the simulation; these values are used to represent intrapopulation variability. Three out of ten individuals contain no MP.

References

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