POPS ON PLASTIC DEBRIS FROM THE NORTH PACFICIC ACCUMULATION ZONE

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THE OCEAN CLEANUP

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Pollutants in Plastics within the North Pacific Subtropical Gyre

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ABSTRACT: Here we report concentrations of pollutants in floating plastics from the North Pacific accumulation zone (NPAC). We compared chemical concentrations in plastics of different types and sizes, assessed ocean plastic potential risks using sediment quality criteria, and discussed the implications of our findings for bioaccumulation. Our results suggest that at least a fraction of the NPAC plastics is not in equilibrium with the surrounding seawater. For instance, "hard plastic" samples had significantly higher PBDE concentrations than "nets and ropes" samples, and 29% of them had PBDE composition similar to a widely used flame-retardant mixture. Our findings indicate that NPAC plastics may pose a chemical risk to organisms as 84% of the samples had at least one chemical exceeding sediment threshold effect levels. Furthermore, our surface trawls collected more plastic than biomass (180 times on average), indicating that some NPAC organisms feeding upon floating particles may have plastic as a major component of their diets. If gradients for pollutant transfer from NPAC plastic to predators exist (as indicated by our fugacity ratio calculations), plastics may play a role in transferring chemicals to certain marine organisms.

Unprocessed sea surface sample from the North Pacific subtropical gyre

PLASTIC DEBRIS IN THE NORTH PACIFIC SUBTROPICAL

A

Surface current systems of N. Pacific

Currents in red:

- North Pacific subtropical gyre

Source: Talley et al. 2011.

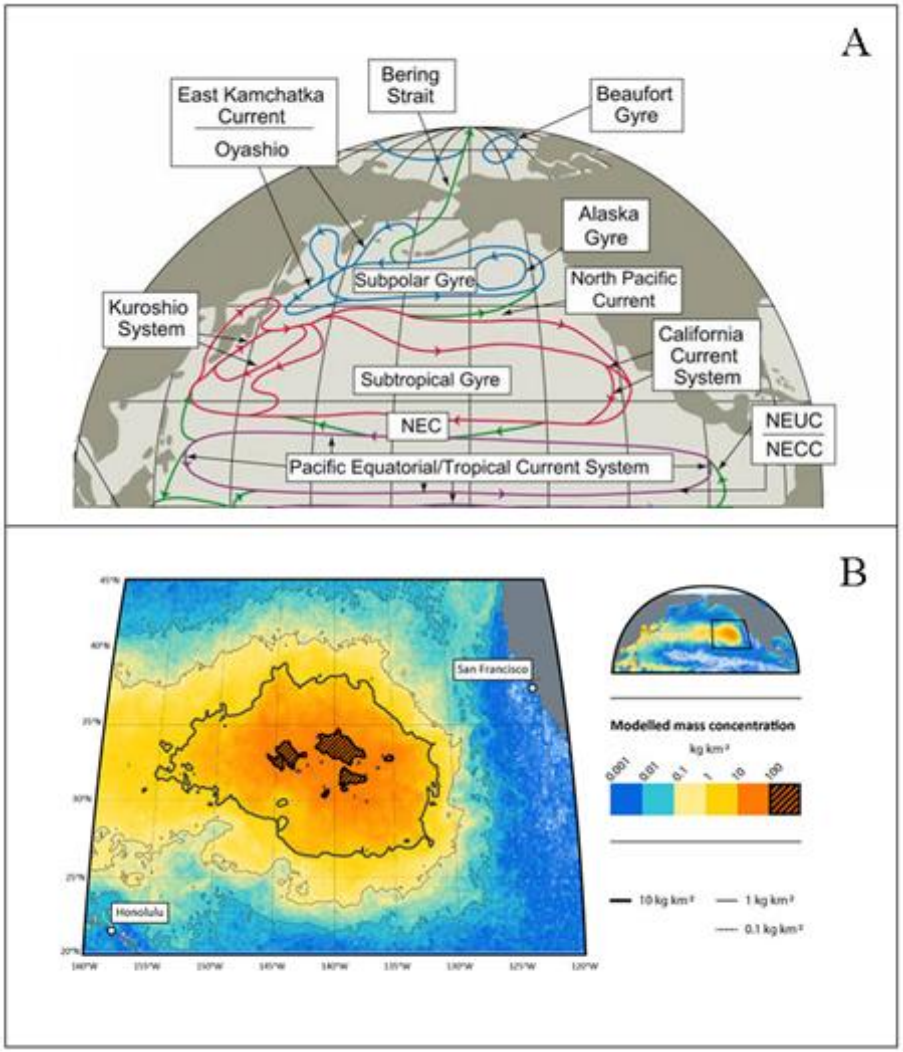
B

Ocean plastic mass concentrations

Area within the bold line:

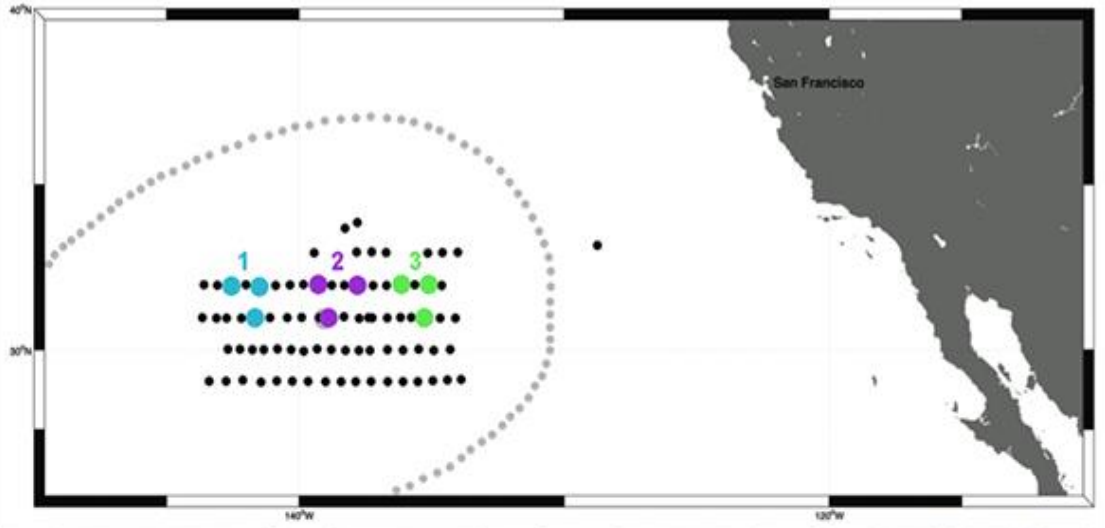
- North Pacific accumulation zone

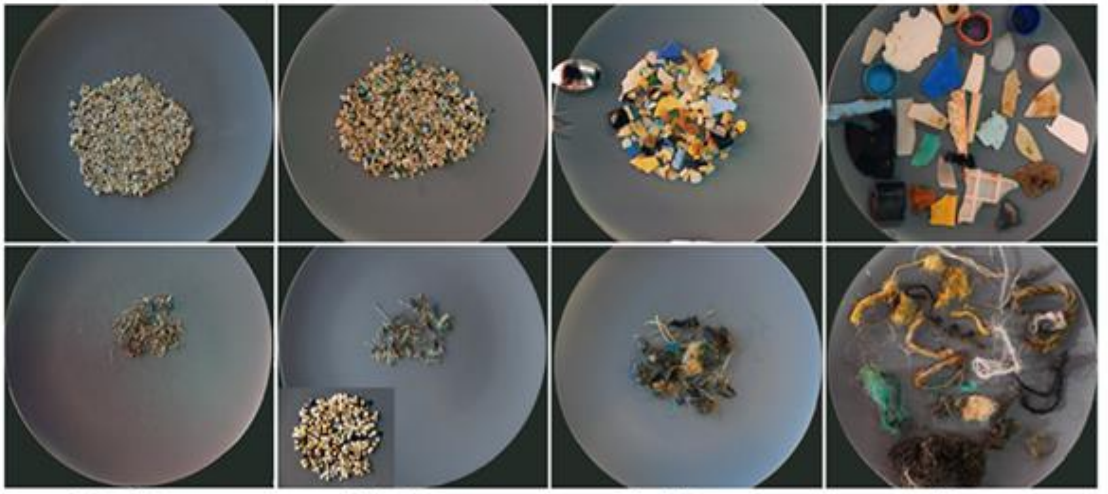
> 10 kg of plastic per km^2 [Lebreton et al.2018]

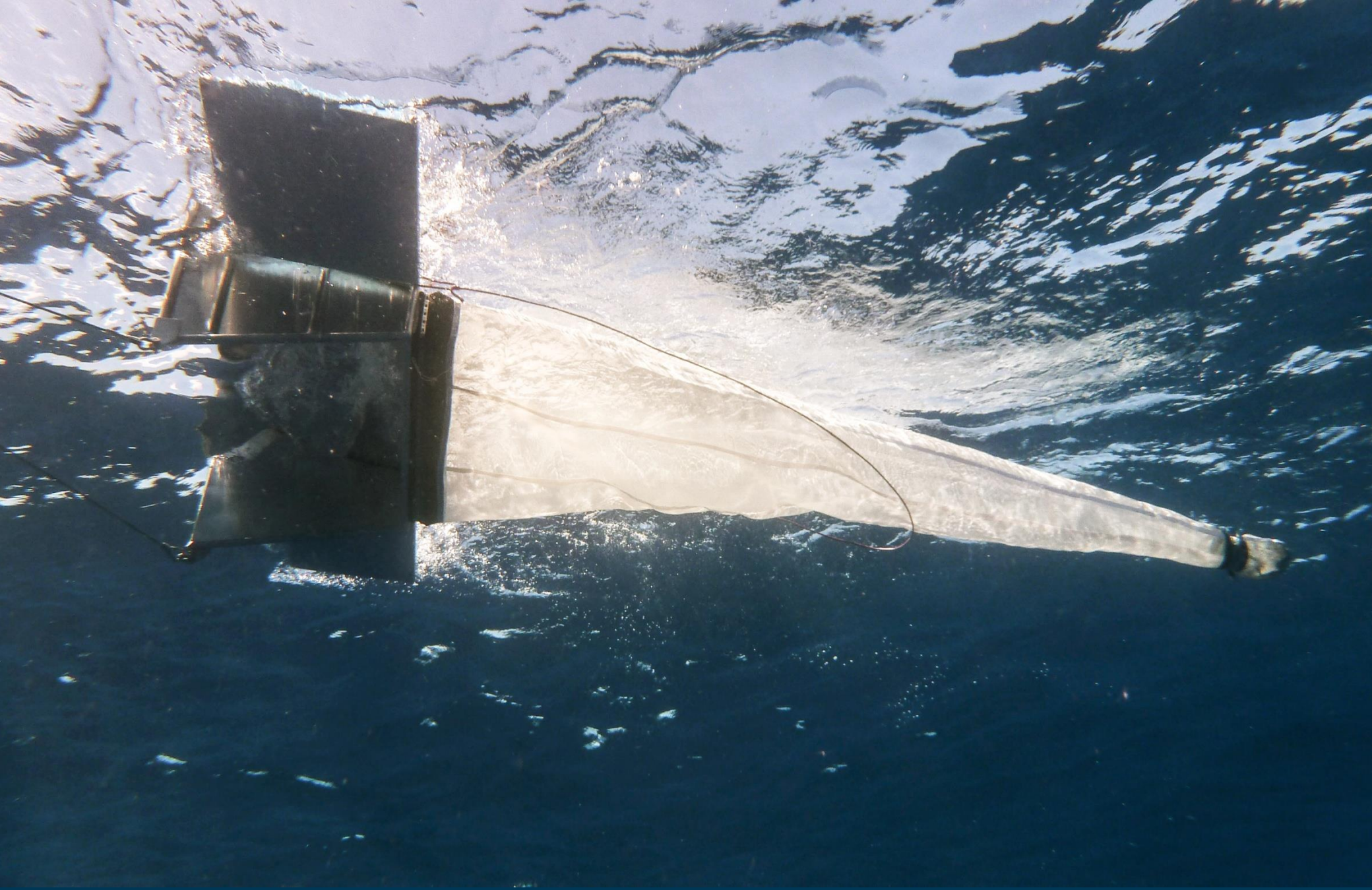


NORTH PACIFIC ACCUMULATION ZONE (NPAC)

NPAC
North Pacific Accumulation zone







PLASTIC TYPE AND SIZE SEPARATION

Three plastic types:

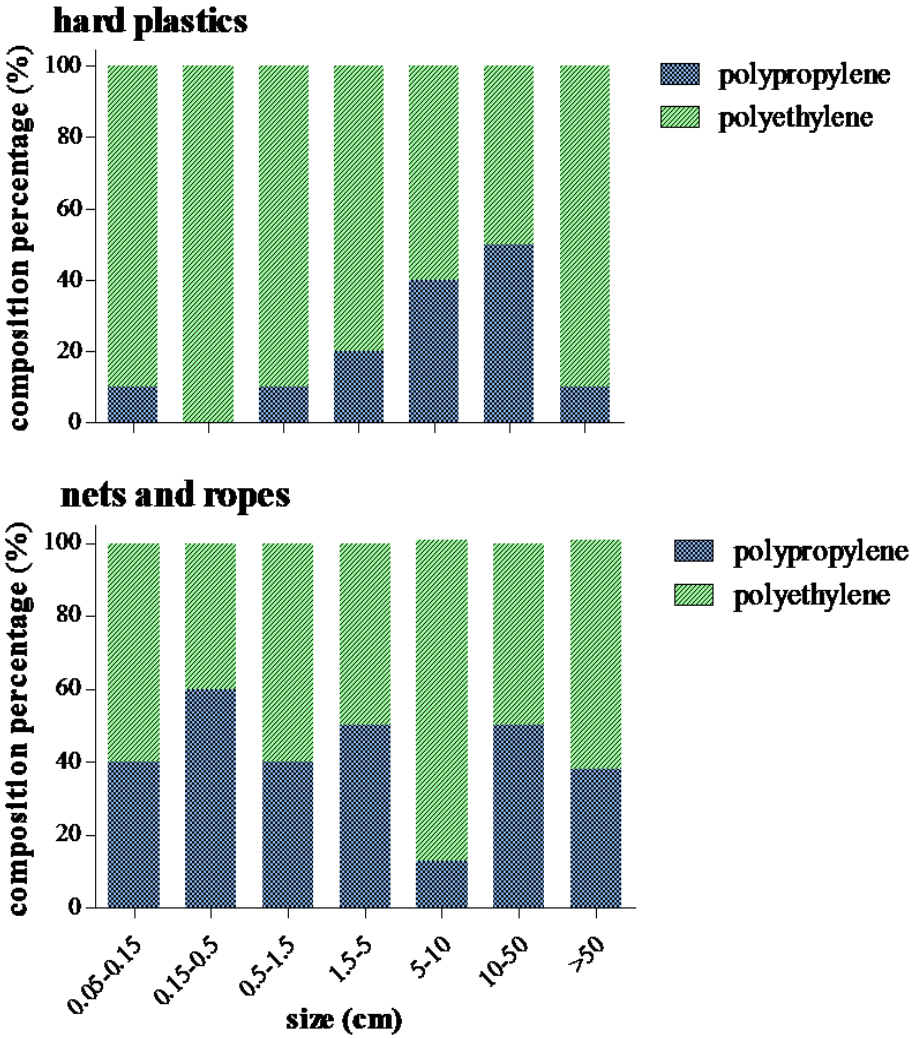
- Hard plastics
- Nets and ropes
- Pellets

Seven plastic sizes:

- 0.05-0.15 cm
- 0.15-0.5 cm — Microplastic particle
- 0.5-1.5 cm
- 1.5-5 cm — Mesoplastic particle
- 5-10 cm
- 10-50 cm — Macroplastic particle
- >50 cm

composition:

polyethylene(PE)/polypropylene(PP)



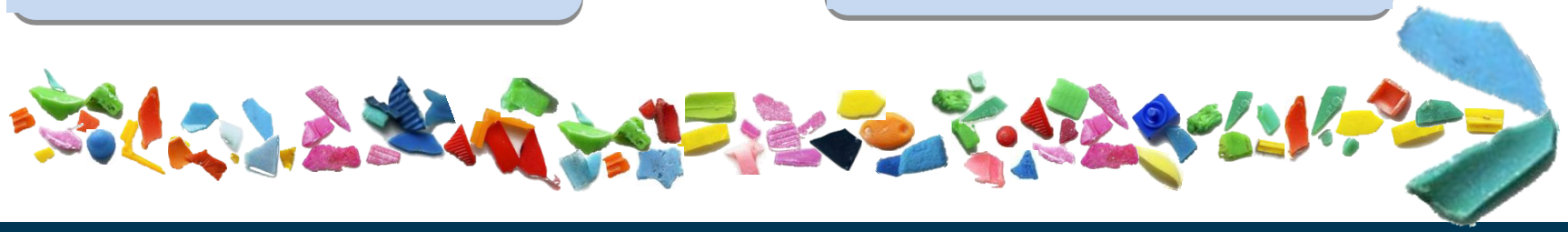
POTENTIAL ECOLOGICAL EFFECTS?

direct input

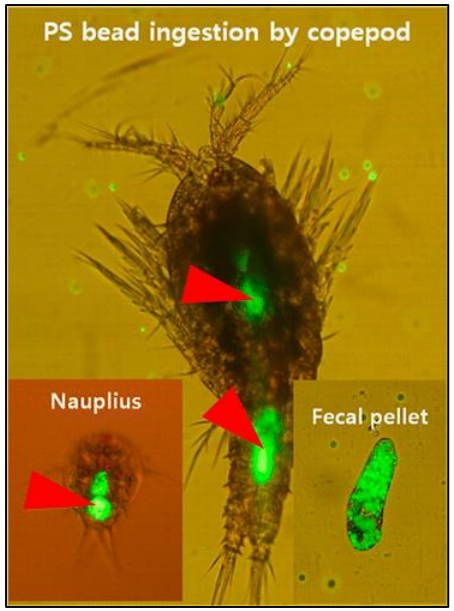
indirect input

Plastics in environment

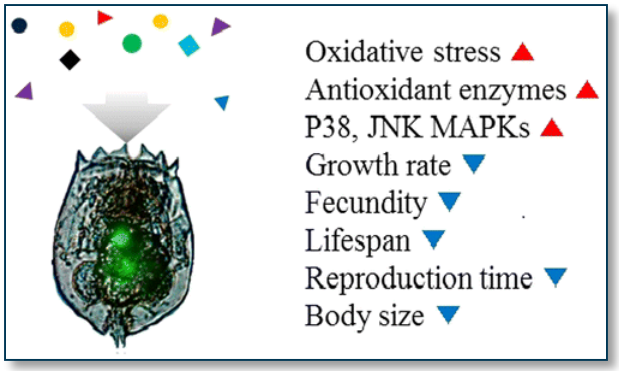
Effects+carrier function



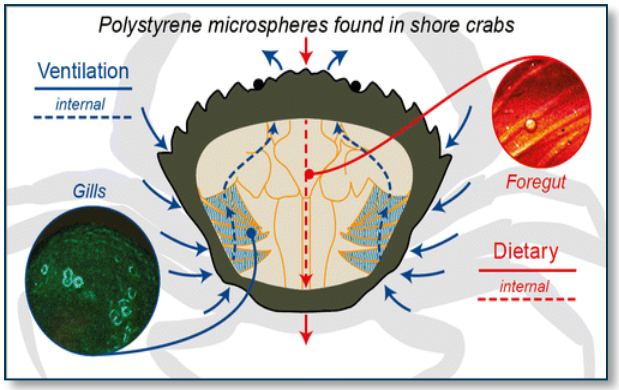
DIRECT EXPOSURE TO PLASTIC DEBRIS



Marine Copepod
(*Tigriopus Japonicus*)

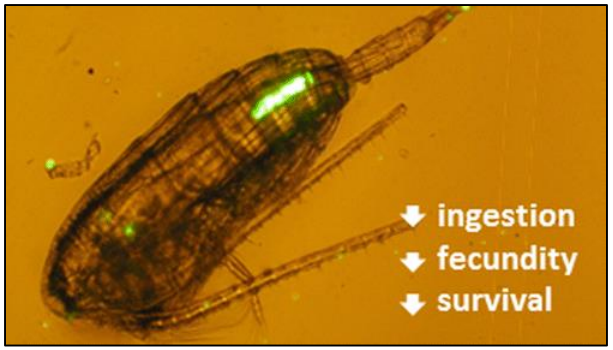


Monogonont Rotifer (*Brachionus koreanus*)



Shore Crab (*Carcinus maenas*)

direct exposure



Marine Copepod (*Calanus helgolandicus*)

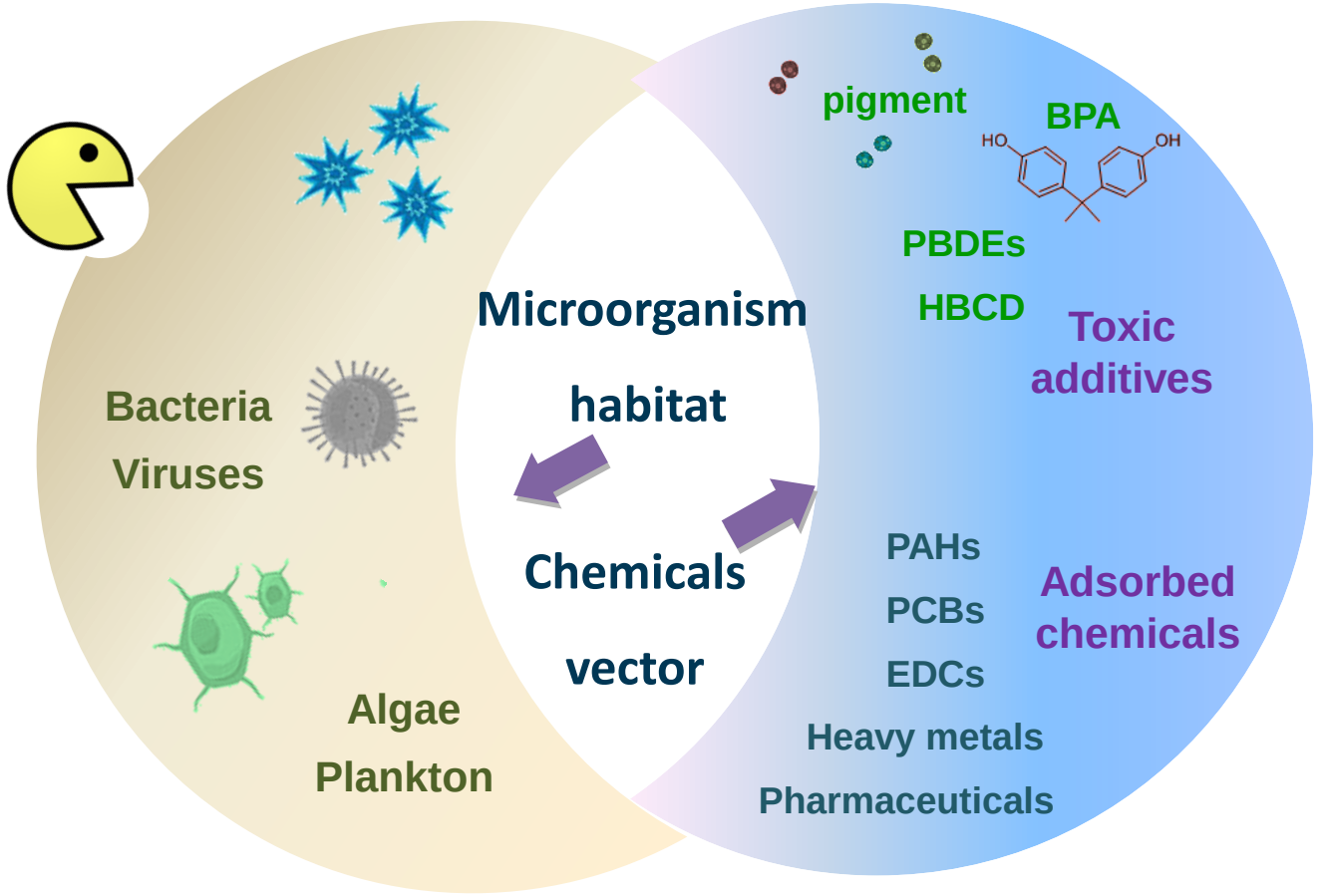
Sub-lethal effects
decreased feeding;growth retardants
oxidative damage; behavioral abnormality

PLASTIC CARRIER FUNCTIONS FOR MICROORGANISMS AND CHEMICALS

POPs :
Persistent
Organic
Pollutants

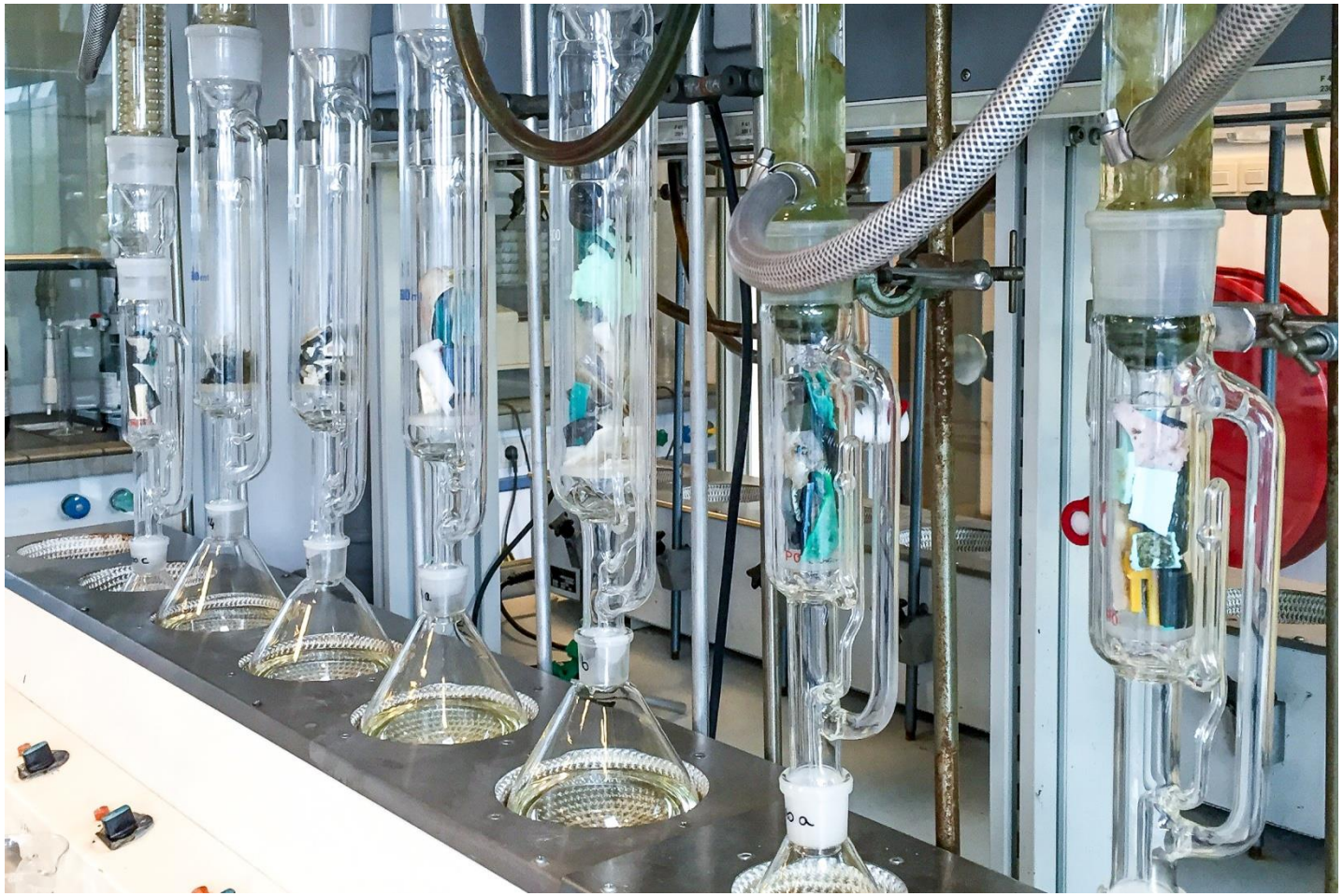
Direct addition to plastics
- Flame retardants
- by-products
- legacy pollution

Sorption from water



Question: How many contaminants are on marine plastic debris?

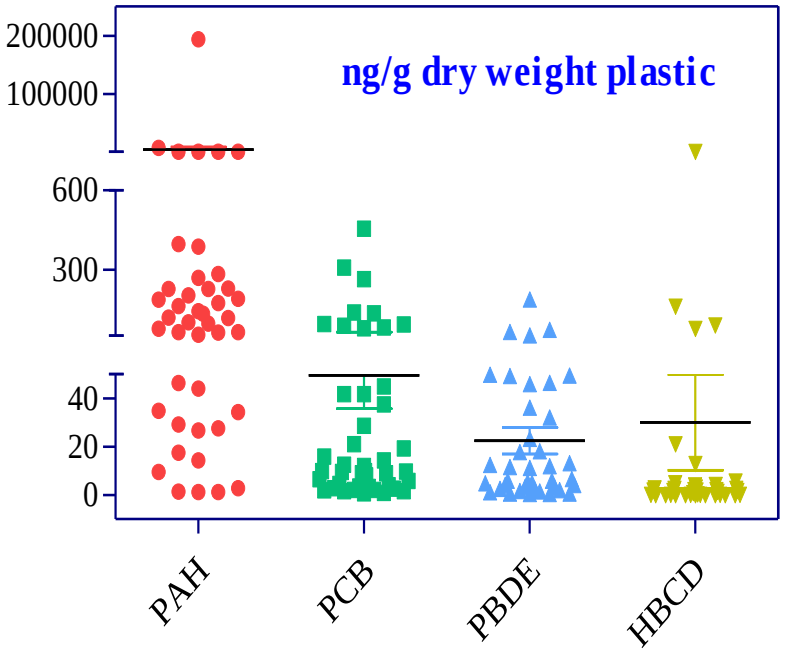
OCEAN PLASTIC SAMPLES UNDERGO A POPS ANALYSIS



Ocean plastic samples undergoing a persistent organic pollutants analysis at the IMARES institute, Wageningen (NL). Photo credits: IMARES/The Ocean Cleanup

POPS CONCENTRATIONS ON PLASTIC DEBRIS

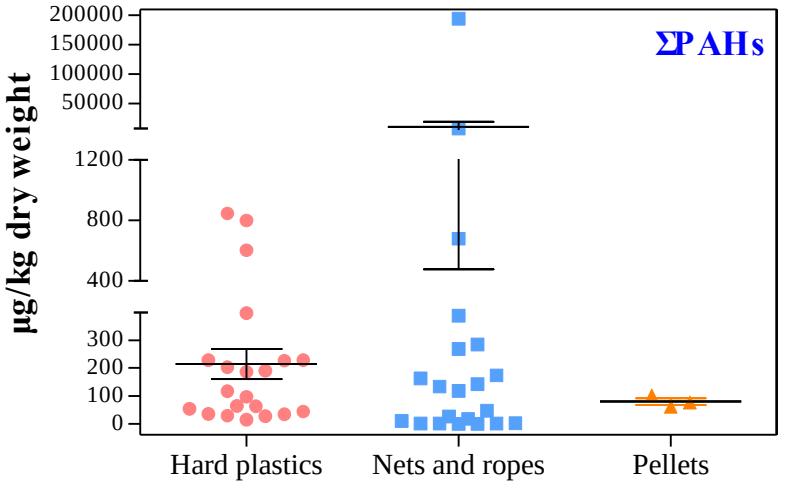
PAHs	PCBs		PBDEs	HBCD
congener	congener		congener	Combination
Naphthalene	CB-28	CB-128	BDE-28	α-HBCD
Acenaphthene	CB-31	CB-137	BDE-47	β-HBCD
Fluorene	CB-47	CB-138	BDE-49	γ-HBCD
Phenanthrene	CB-49	CB-141	BDE-66	
Anthracene	CB-52	CB-149	BDE-71	
Fluoranthene	CB-56	CB-151	BDE-75	
Pyrene	CB-66	CB-153	BDE-85	
Benzo(a)anthracene	CB-85	CB-156	BDE-99	
Chrysene	CB-87	CB-170	BDE-100	
benzo[e]pyrene	CB-97	CB-180	BDE-119	
benzo[b]fluoranthene	CB-101	CB-187	BDE-138	
benzo[k]fluoranthene	CB-105	CB-194	BDE-153	
benzo[a]pyrene	CB-110	CB-202	BDE-154	
dibenzo[a,h]anthracene	CB-118	CB-206	BDE-183	
Benzo(ghi)perylene			BDE-190	

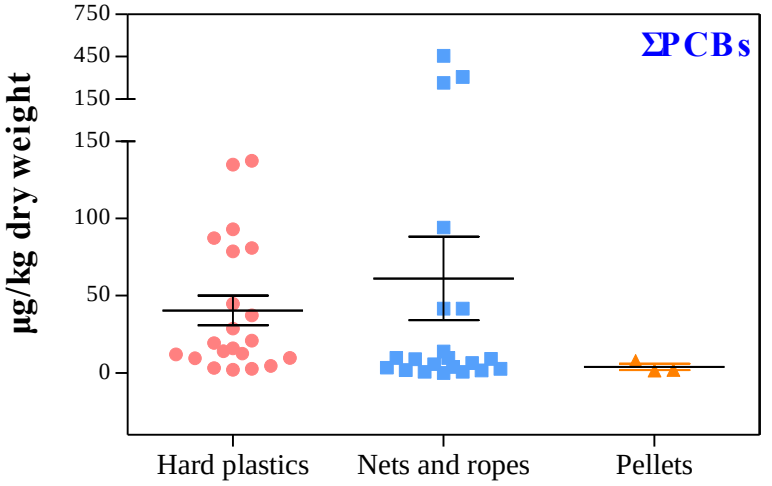


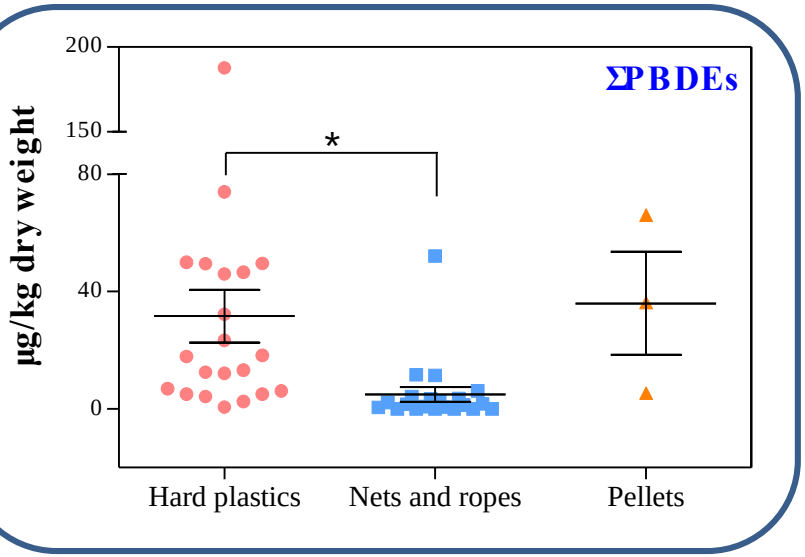
1. Not all reached equilibrium
2. Differences among POPs

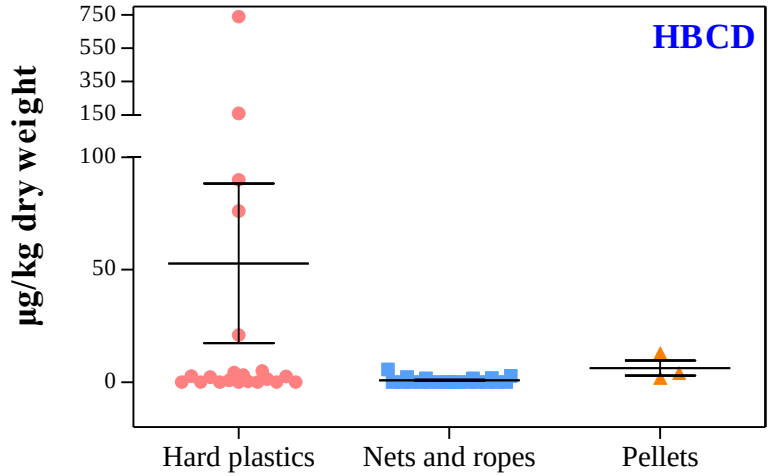
POP concentration trend?

EFFECTS OF **TYPE** ON POP CONCENTRATIONS









THE POTENTIAL PRESENCE OF PLASTIC ADDITIVES

Type	Size (cm)	Dry weight (g)	PCBs	Aroclor 1254
hard plastics	0.05-0.15	7.91	20.99	
hard plastics	0.05-0.15	10.29	19.35	
hard plastics	0.05-0.15	14.75	37.49	
hard plastics	0.15-0.5	10.11	12.1	
hard plastics	0.15-0.5	23.61	80.95	
hard plastics	0.15-0.5	23.97	44.96	
hard plastics	0.5-1.5	26.18	4.63	.974**
hard plastics	0.5-1.5	26.3	78.67	
hard plastics	0.5-1.5	28.7	9.57	
hard plastics	1.5-5	52.04	137.46	
hard plastics	1.5-5	55.95	2.2	.911**
hard plastics	1.5-5	64.01	28.72	.943**
hard plastics	5-10	39.92	15.97	
hard plastics	5-10	47.11	12.62	
hard plastics	5-10	81.69	14.29	
hard plastics	10-50	39.84	134.99	.948**
hard plastics	10-50	54.62	9.91	
hard plastics	10-50	65.05	87.46	
hard plastics	>50	18.51	3.38	
hard plastics	>50	25.43	2.83	
hard plastics	>50	40.14	93.14	.981**

Similarity to commercial products

Congener composition analysis:

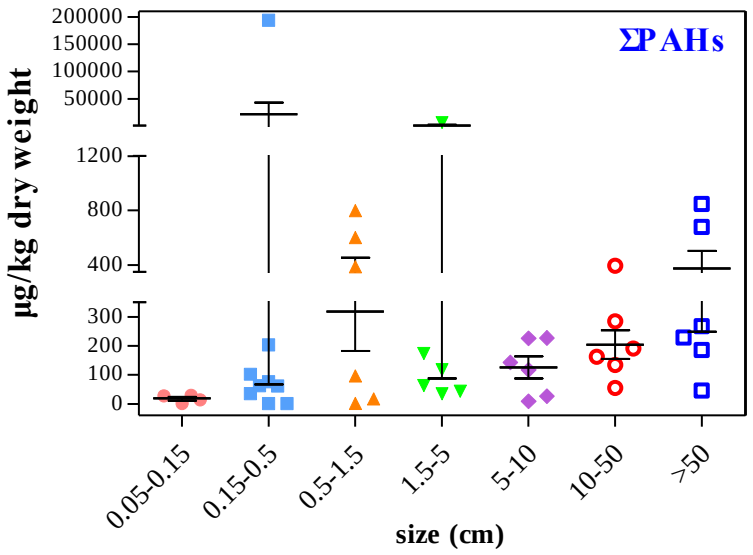
- 28% of hard plastics:

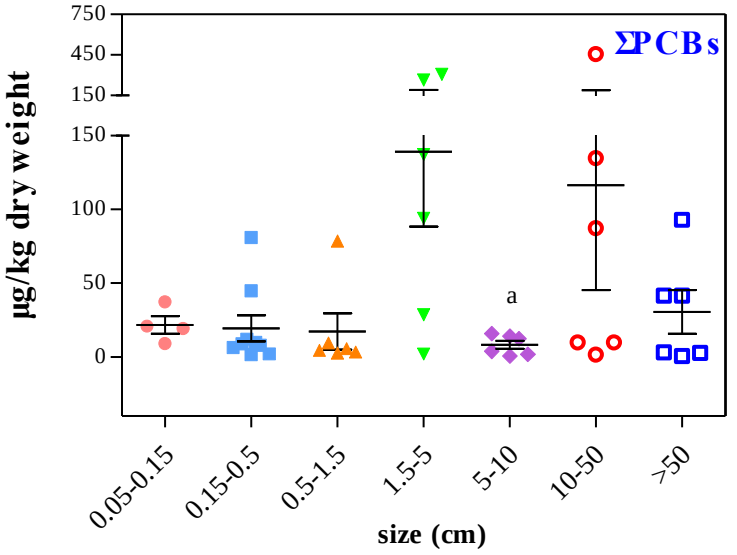
  DE-71 (Penta-PBDE)

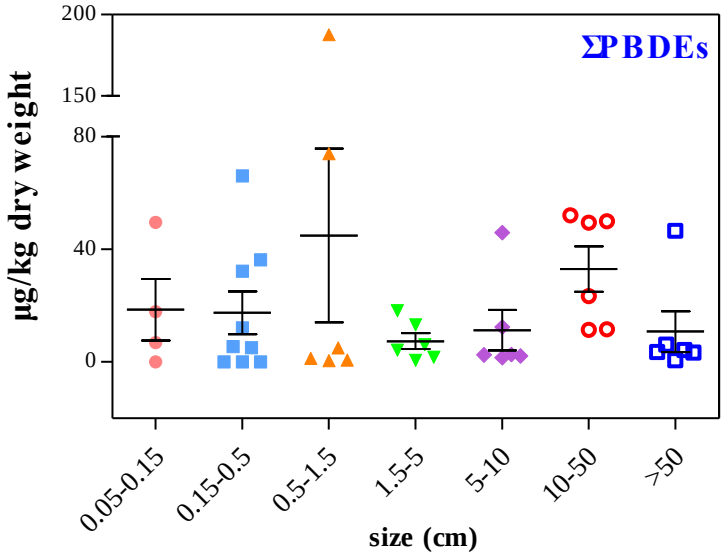
- 42% big hard plastics

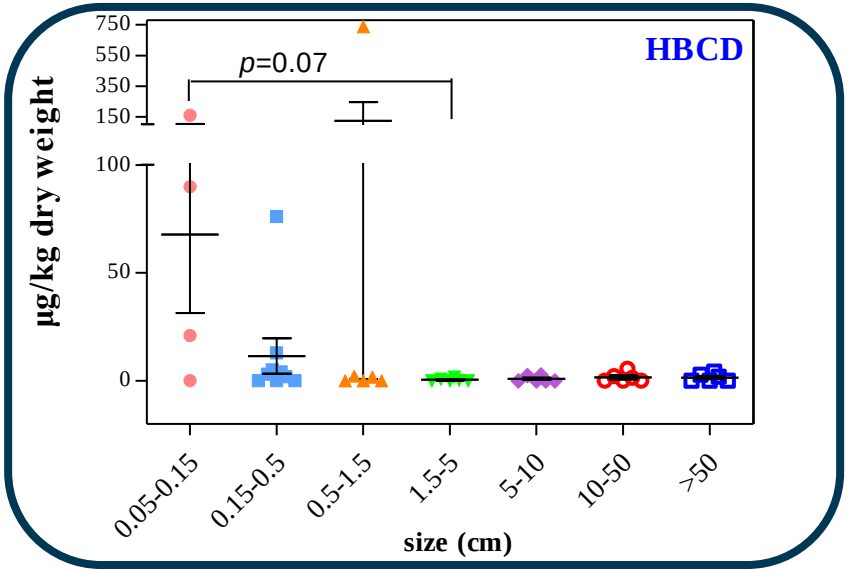
  PCBs composition similar to Aroclor 1254

EFFECTS OF **SIZE** ON POP CONCENTRATIONS

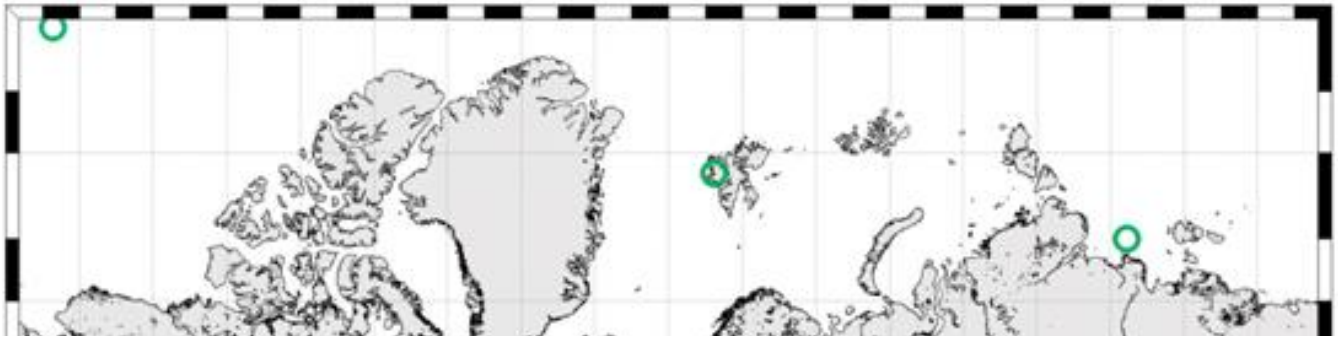








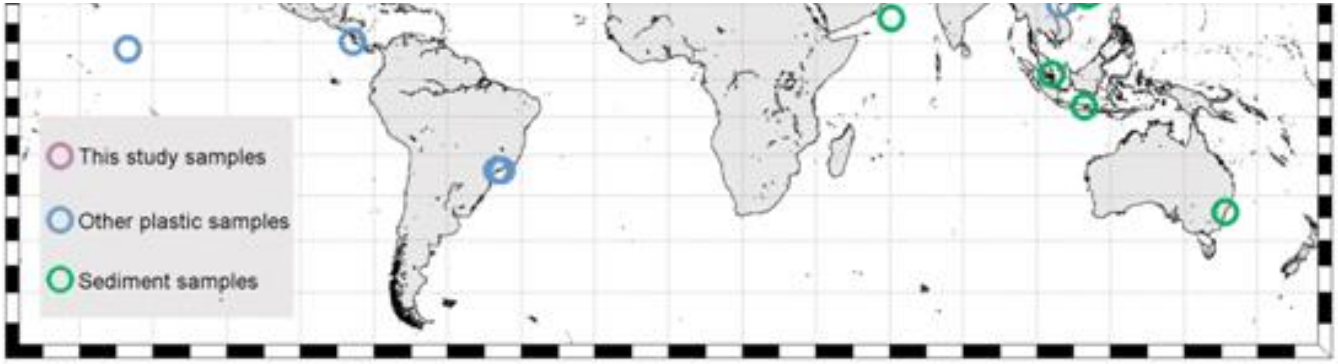
COMPARISON WITH MARINE SEDIMENT-16 PBTS



★ **This study samples**

Other plastic samples

84% OF PLASTIC SAMPLES HAD AT LEAST ONE **CHEMICAL** POLLUTANT IN EXCESS



Similar Burdens of POPs
On plastics and sediments

- 16 congeners compared
- If OM normalized
- – OM sediment concentration
- higher than that in plastic

FUGACITY DIFFUSION OF POPS

POPs	K_{ow}	K_{PE}	$C_{plastic}$ (ng/g)	C_{lipid} (ng/g)	F1 ($C_{plastic}/K_{plastic}$) (ng/g)	F2 (C_{lipid}/K_{ow}) (ng/g)	F1/F2
BDE-28	5.8	5.7	1.01	0.35	0.18	0.06	2.94
BDE-47	6.5	6.3	1.73	3.58	0.27	0.55	0.50
BDE-66	6.5	6.4	0.33	0.06	0.05	0.01	5.59
BDE-85	7.2	6.9	0.57	0.1	0.08	0.01	5.95
BDE-99	7.2	7	2.6	2.44	0.37	0.34	1.10
BDE-100	7.3	7	0.98	0.24	0.14	0.03	4.26
BDE-153	8	7.6	3.82	0.11	0.50	0.01	36.56
BDE-154	8	7.6	1.73	0.07	0.23	0.01	26.02

If equilibrium not reached:

- Fugacity exists between plastics and organisms
- It may take place in the yellow tail fish in NPAC

Gassel, M.; Harwani, S.; Park, J. S.; Jahn, A., Detection of nonylphenol and persistent organic pollutants in fish from the North Pacific Central Gyre. *Mar. Pollut. Bull.* 2013, *73*, (1), 231-242.

PREY-PLASTIC RATIO IN NPAC

Size >0.5 mm (dw)
Plastic: biomass= 180:1

Size <0.5 mm (dw)
Microplastic:zooplankton= 40:1

180x MORE **PLASTIC** THAN **BIOMASS** AT THE SURFACE OF THE GREAT PACIFIC GARBAGE PATCH

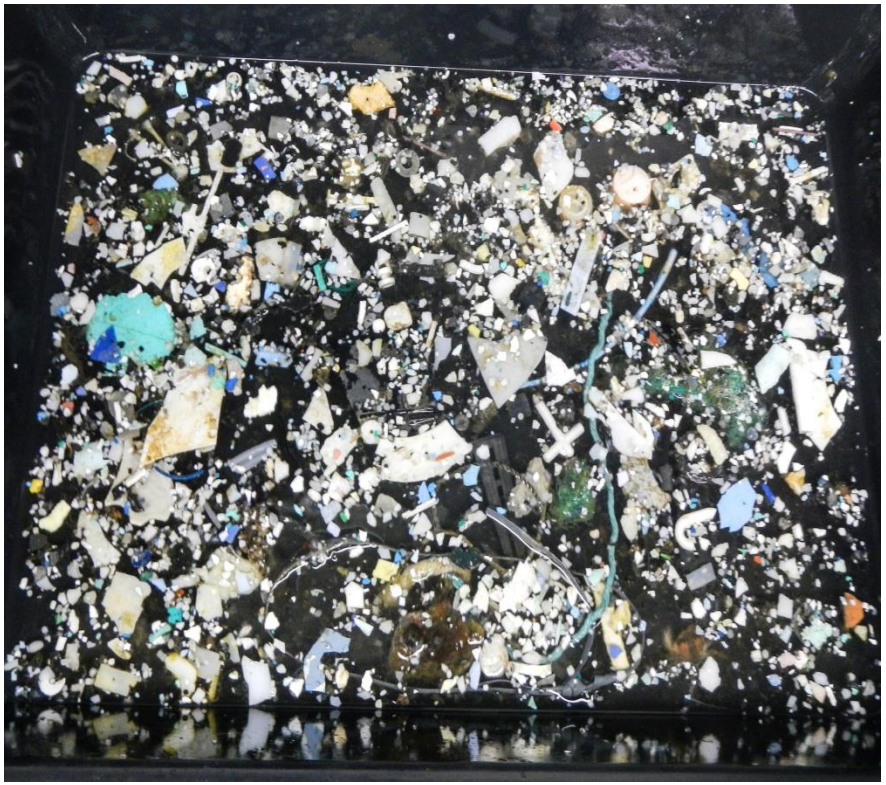
287X DURING **DAY** TIME
100X DURING **NIGHT** TIME

Plastic debris collected during The Ocean Cleanup Mega Expedition 2015

Bird surrounded by plastic photo by Matthew Chauvin

CONCLUSIONS

- POPs in the plastic debris are comparable to those on sediments, but not OM normalized ones.
- 84% exceeded TEL/ PEL value; POP fugacity may exist.
- Plastic debris may become food source in NPAC; plastics bring POPs– can expose a different community of taxa.



Plastic debris collected during
The Ocean Cleanup Mega Expedition 2015

Check more:
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THANK YOU

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