Microplastic Contamination across Trophic Levels: Insights from Benthic Ecosystems and Large Marine Animals

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MARINE ZOOLOGY LAB.

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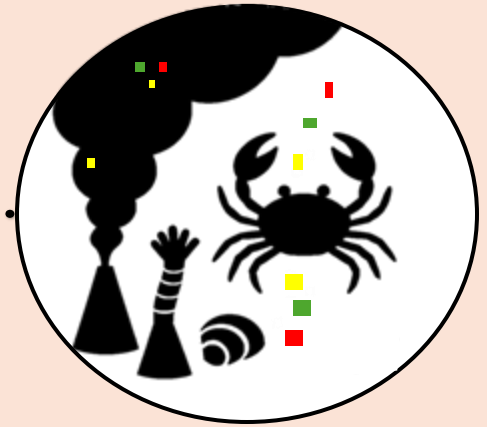

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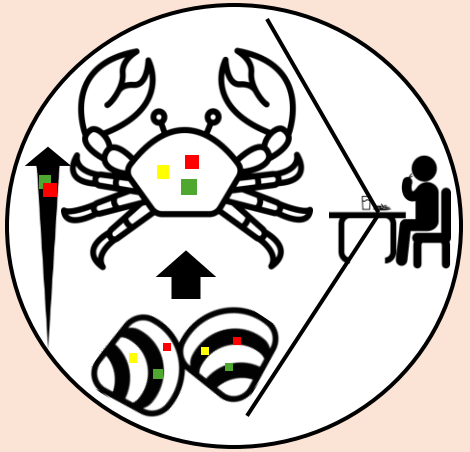

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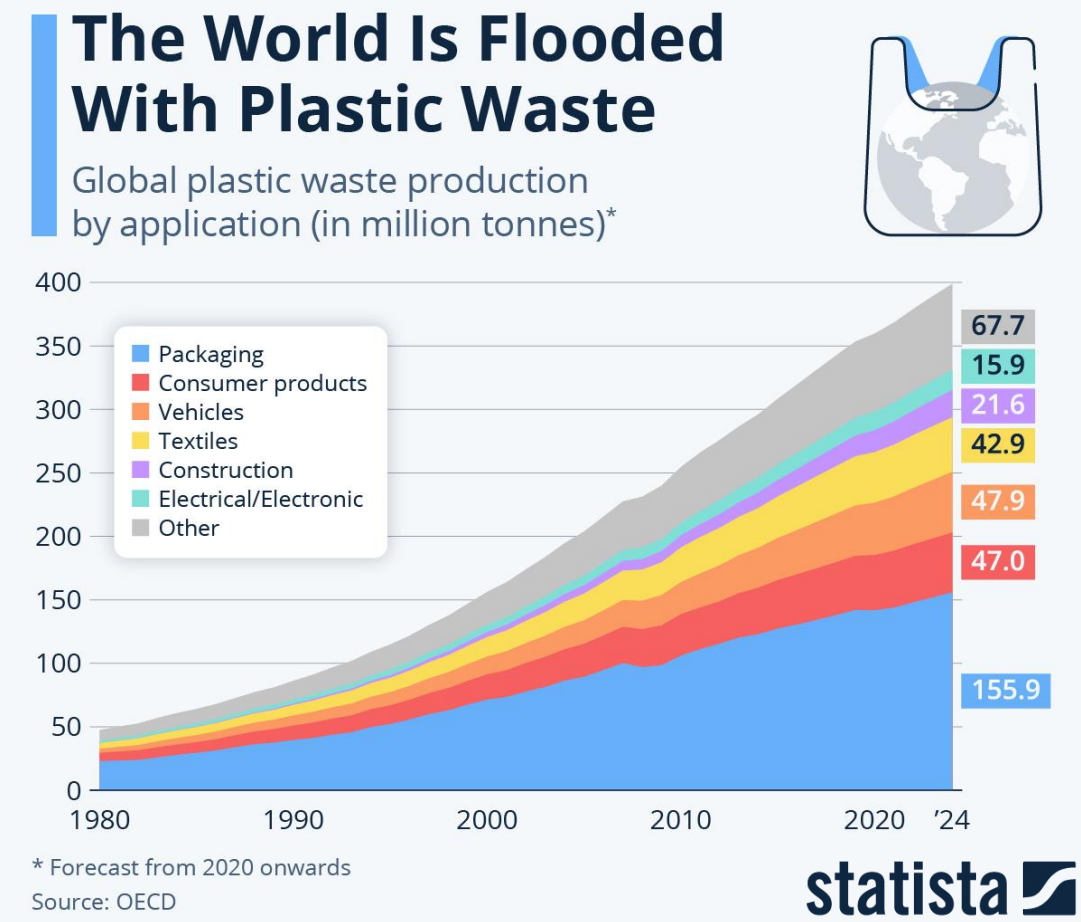
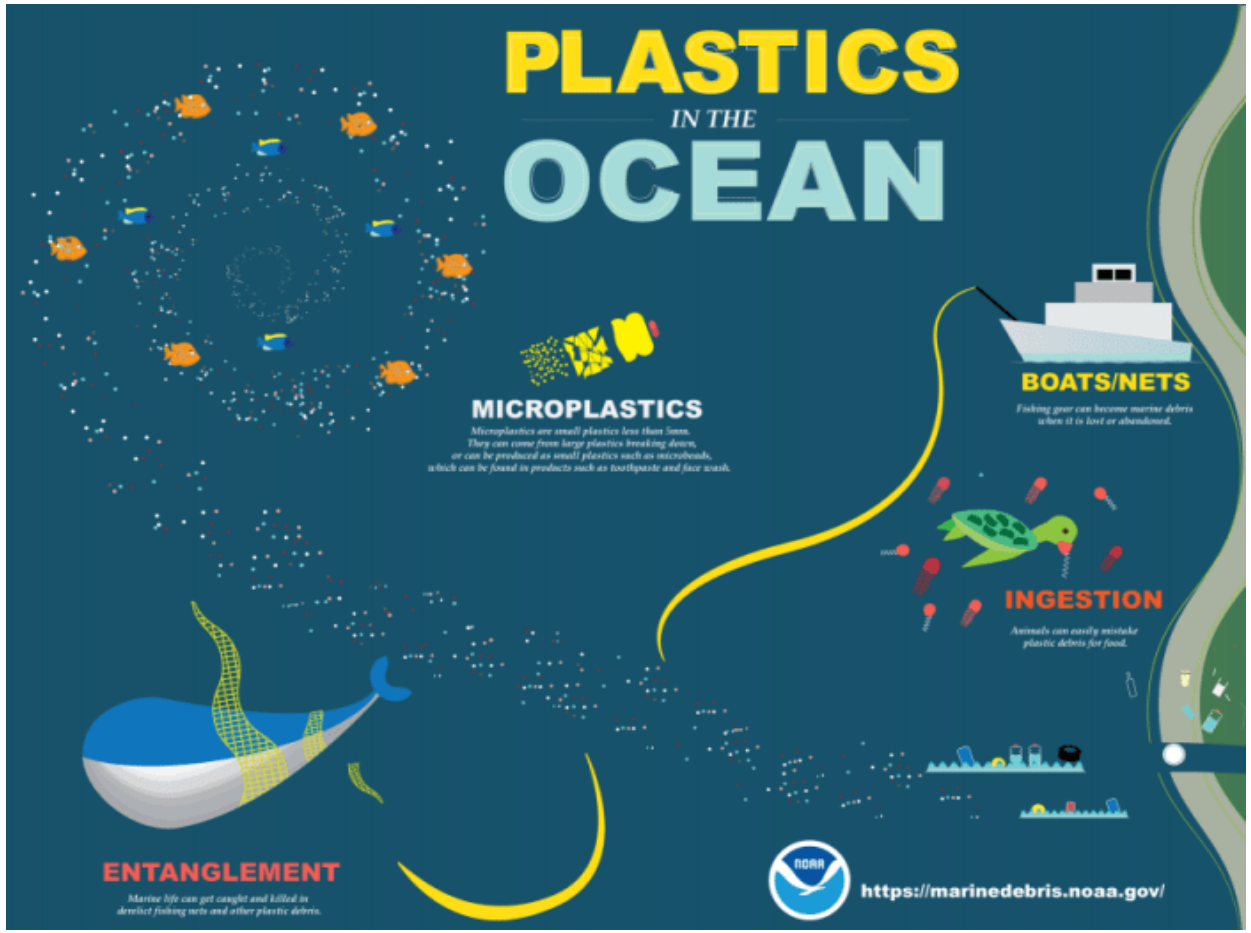
1. Introduction

- **Serious plastic and microplastics problems in the ocean**



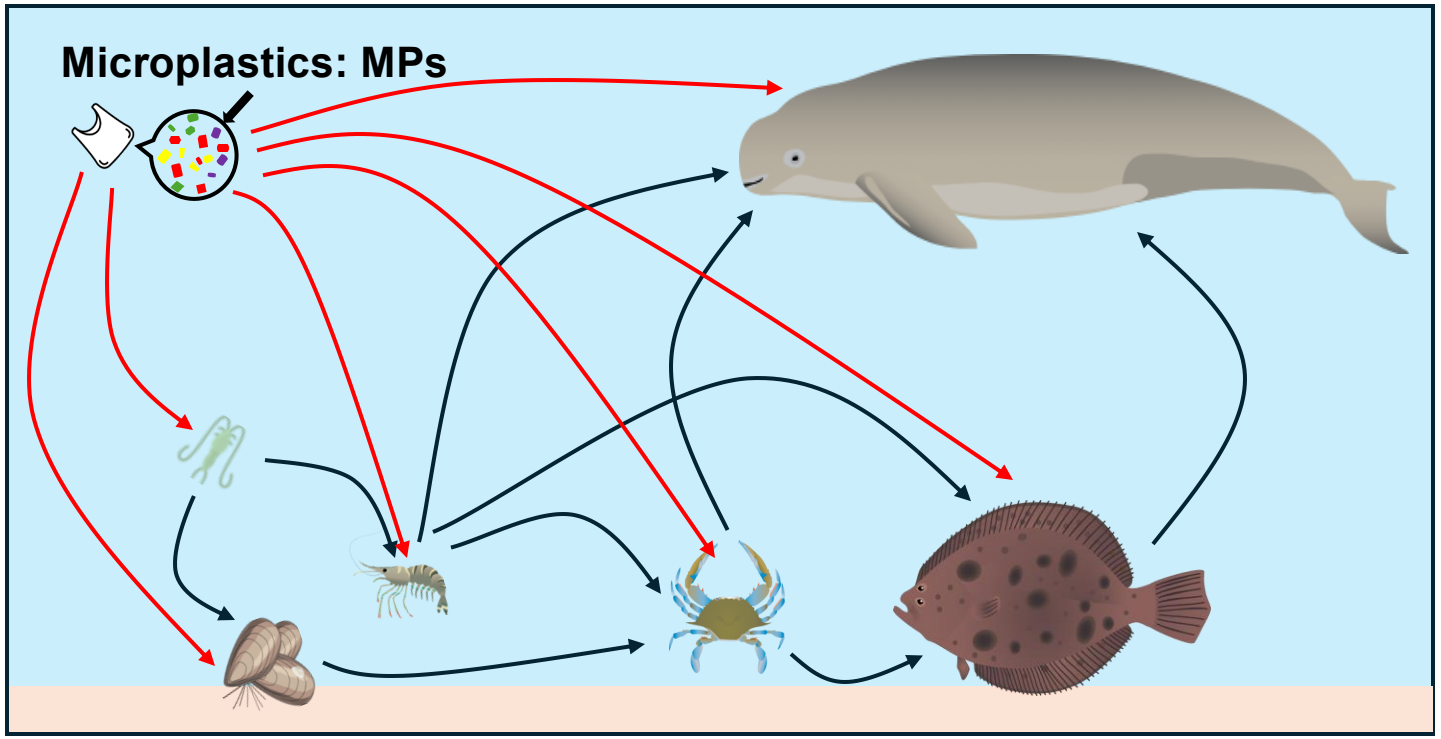


- Plastic pollution continues to grow up.
- Every year, 4 million tons of plastic waste is generated and ends up in the ocean.

- Many marine animals affected by plastic and microplastic (ingestion and entanglement)

1. Introduction

- **What is microplastic Bioconcentration and Biomagnification?**

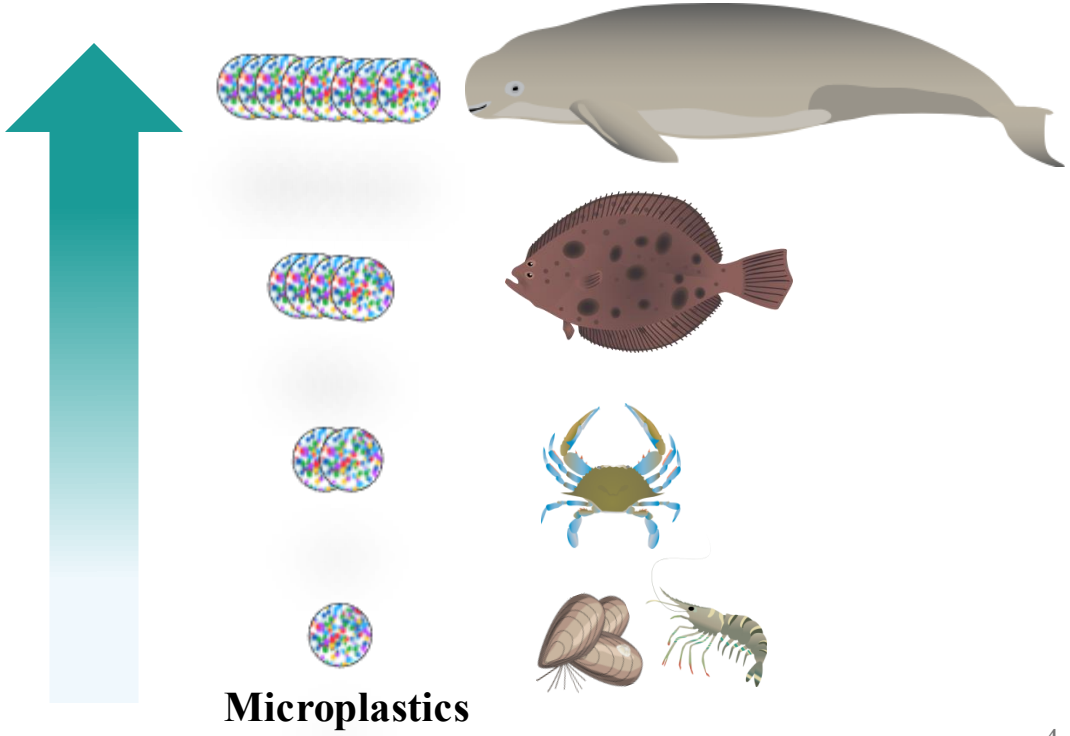


Biomagnification

- It refers to an increase in the concentration of a substance as it is transferred through the food web.
- These processes are important because contaminants can accumulate across trophic levels of organisms, causing problems such as disease and even death.

- **Bioconcentration**

  It is a form of bioaccumulation that occurs when substances are absorbed directly from the environment, such as seawater or sediment.

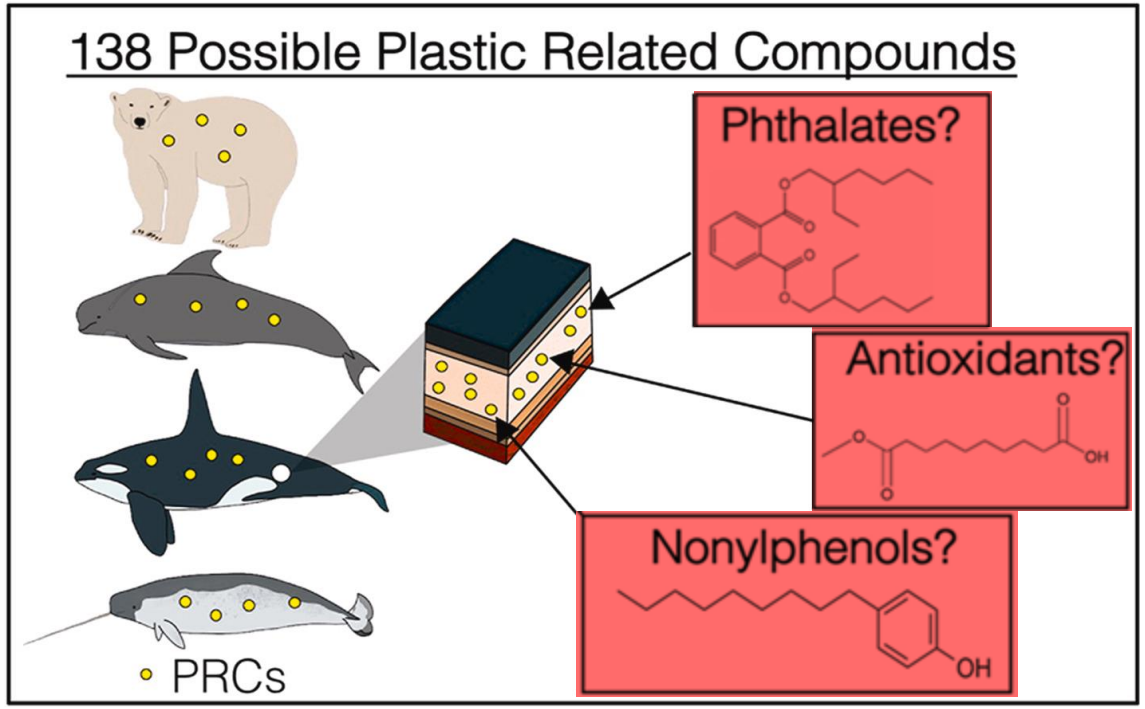


1. Introduction

- **The accumulation of MP through the food web can be fatal to top predators.**

- **Top predators** play a critical role in maintaining marine ecosystem balances and food webs.
- **Cetaceans**, as top predators, have long lifespans and may therefore be especially vulnerable to the impacts of environmental change.

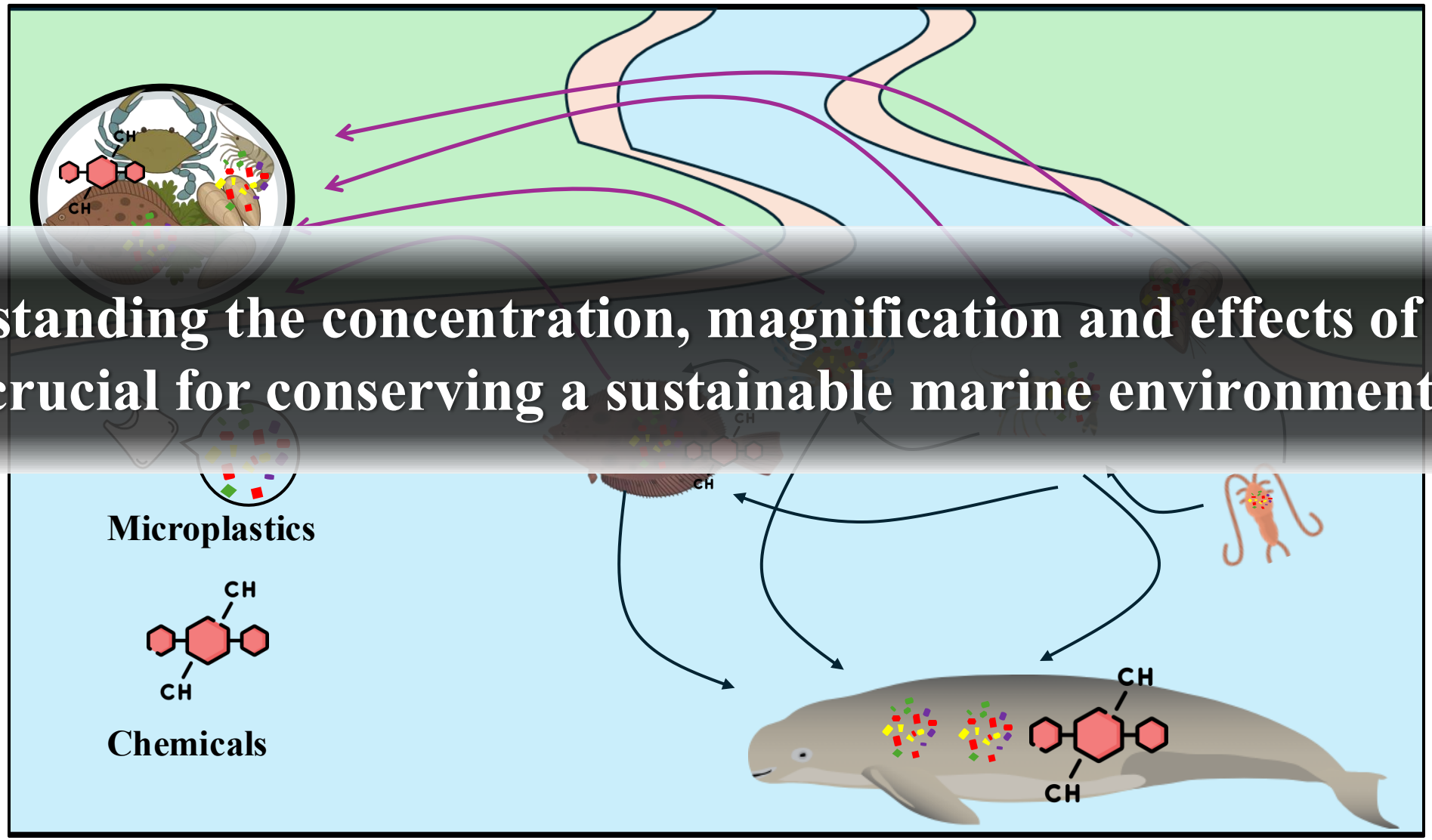
- In addition, plastics contain **chemical additives**, which can accumulate in their bodies (top predators) along with the plastics.



Miller et al., 2023

1. Introduction

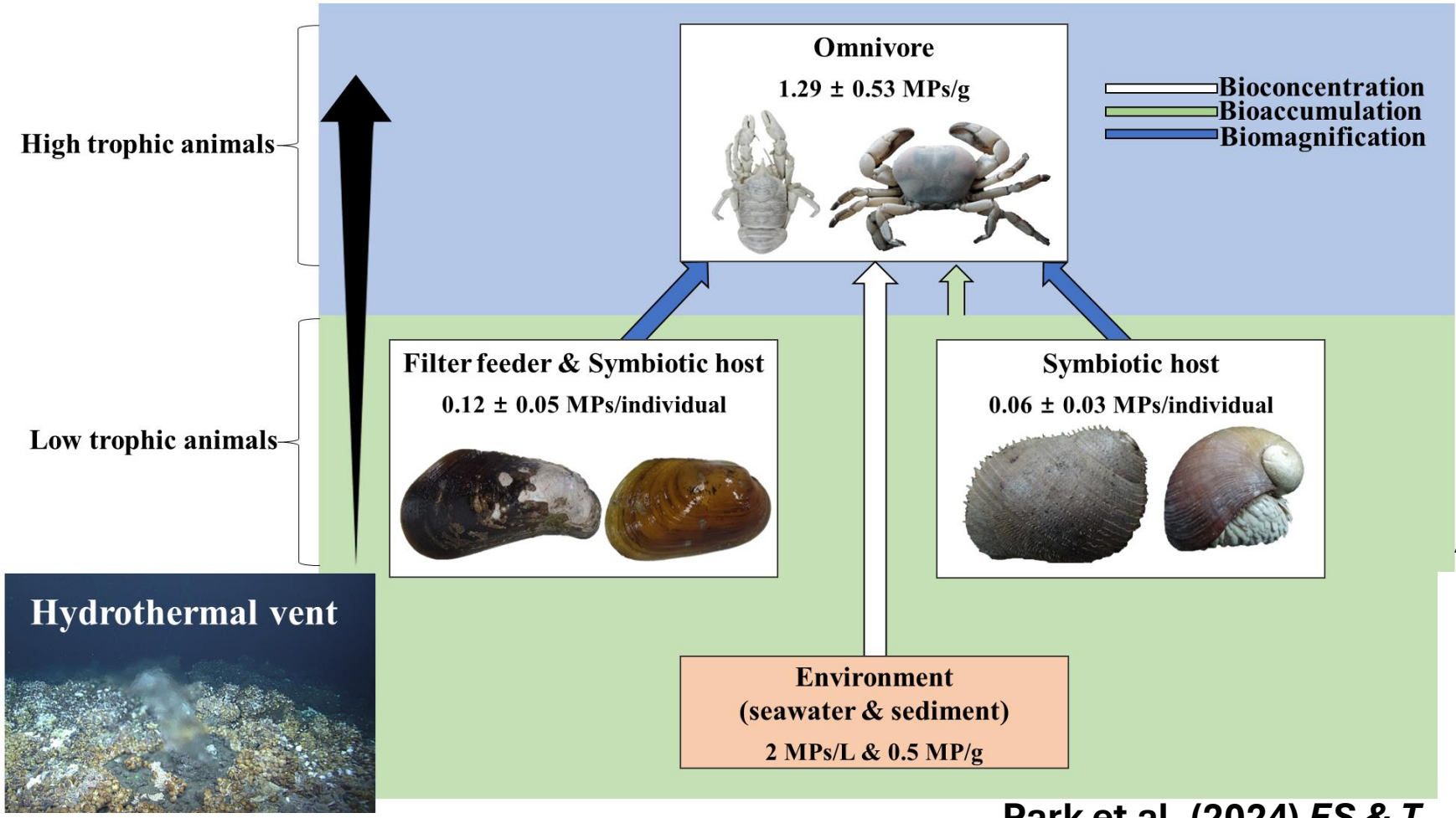
Towards a Sustainable Marine Environment



Understanding the concentration, magnification and effects of MPs is crucial for conserving a sustainable marine environment.

2. Concentration and magnification of microplastic in the food chain

2.1. Hydrothermal vent



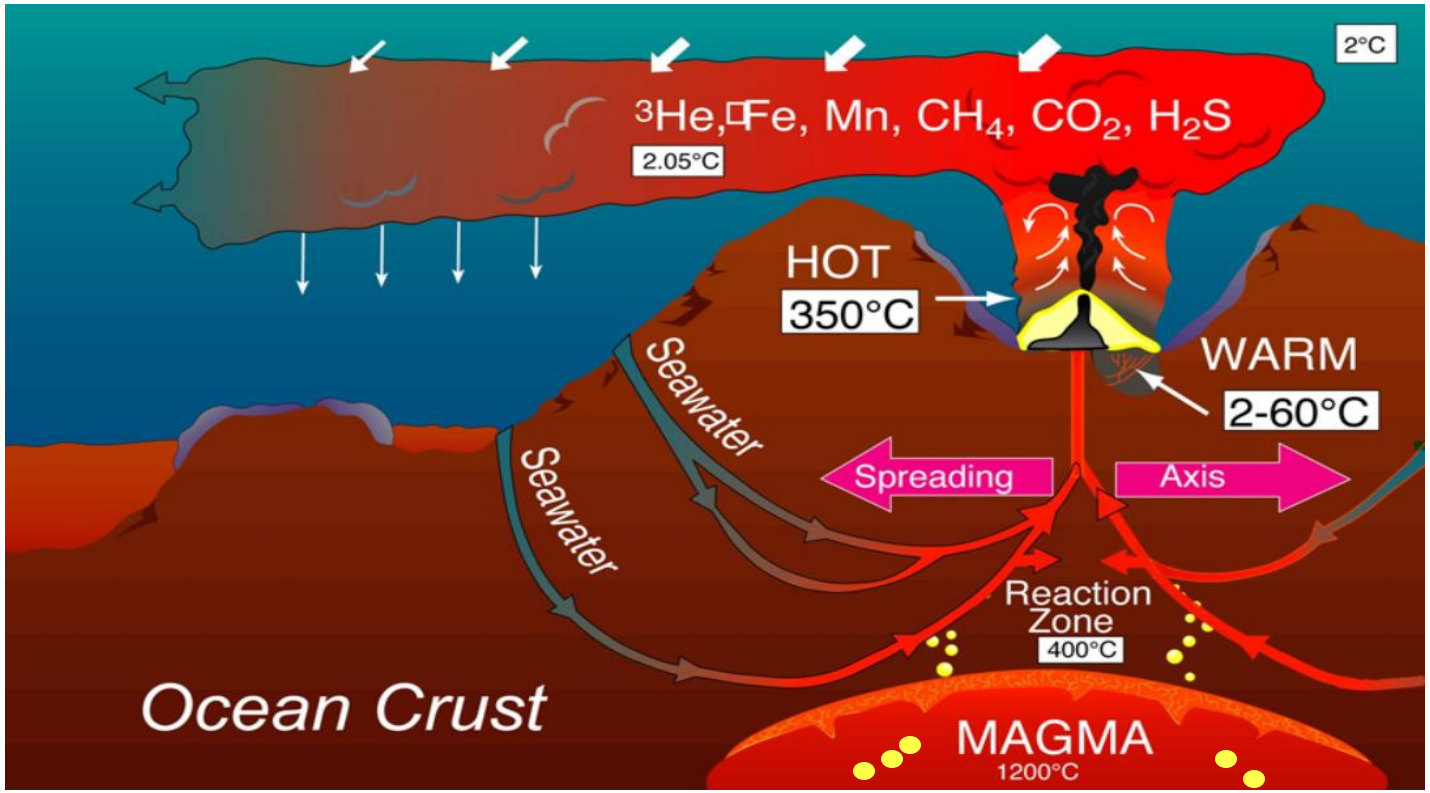
Article QR:

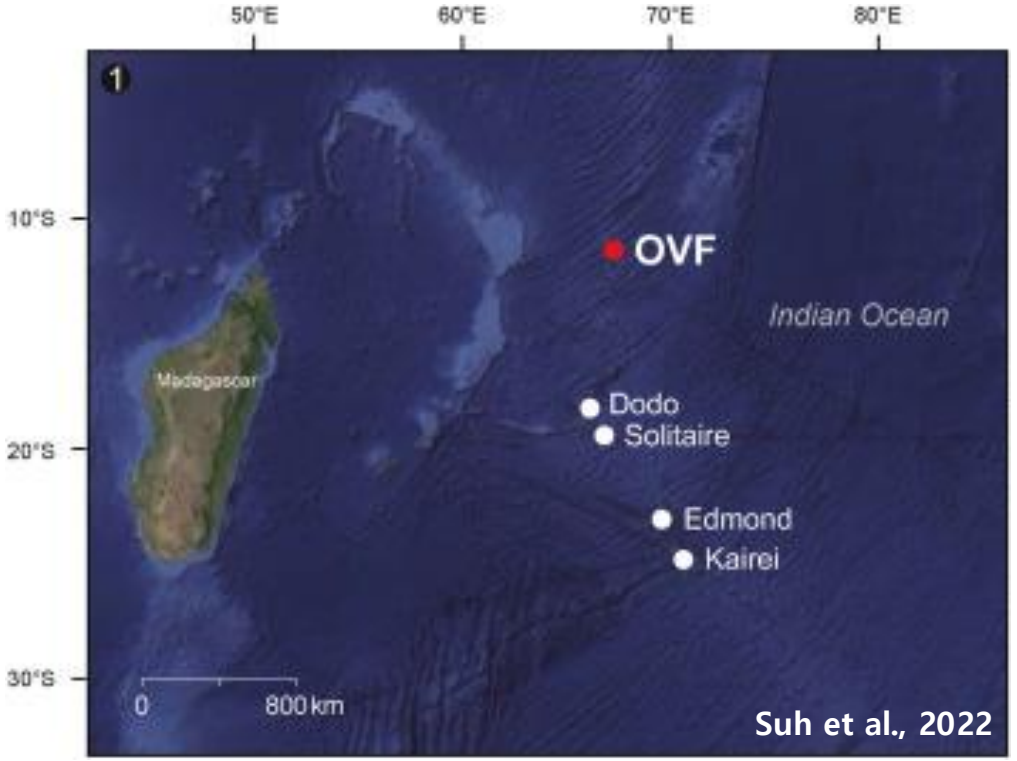
Park et al. (2024) *ES & T*

2.1. Hydrothermal vent

Research Area: Hydrothermal Vents

- Hydrothermal vents are extreme area to survive.
- Magma gases rising from underground cause high temperatures.
- When gases from the magma are released to the seafloor through hydrothermal vents, they release heavy metals in gaseous



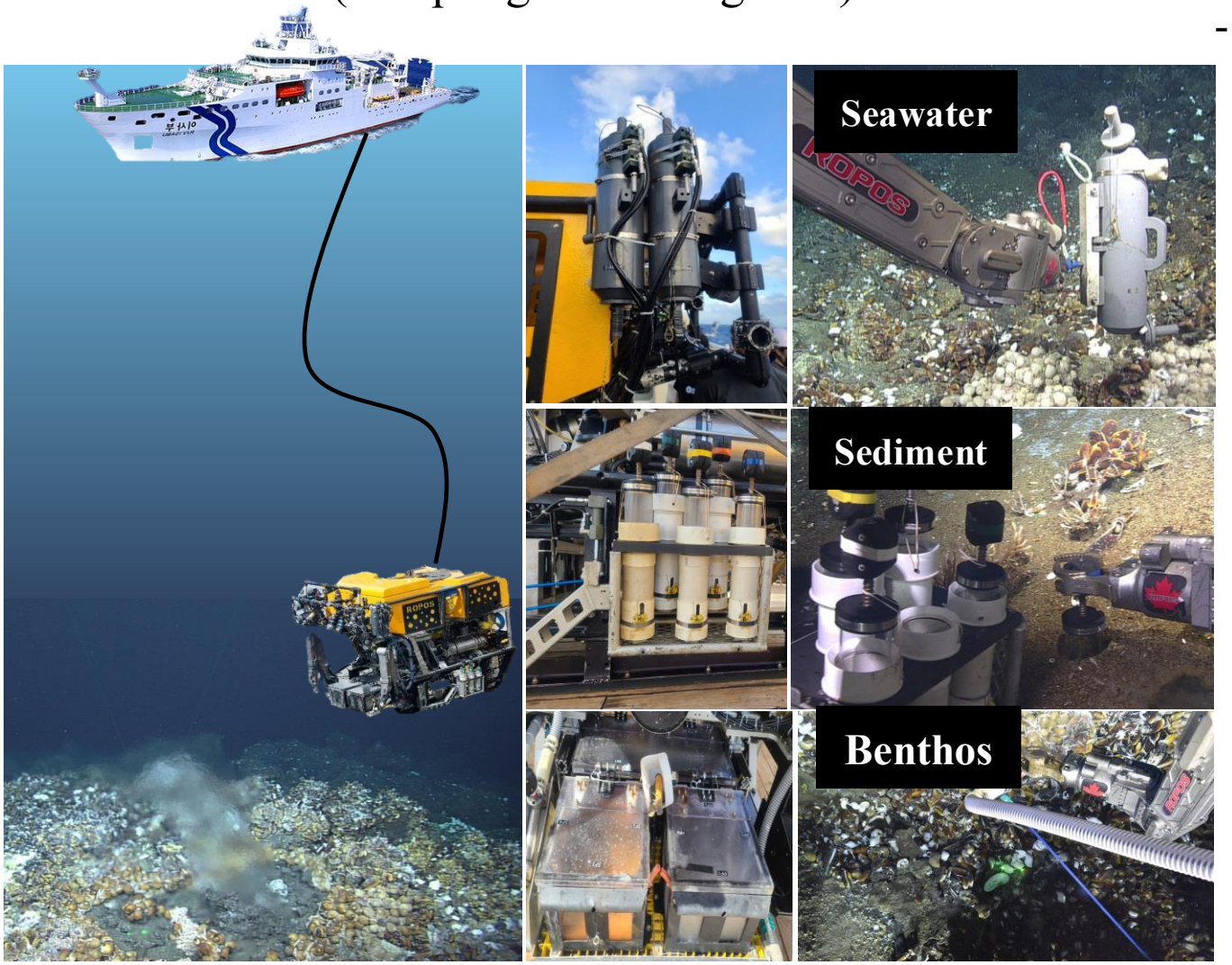


- Research site is Indian Ocean, near the Mauritius.
- The Onnuri Vent Field depth is over 2000 meters.
- Crabs, lobsters, mussels, and snails live in the OVF.

2.1. Hydrothermal vent

- **Sampling Methods for Deep Hydrothermal Vents**

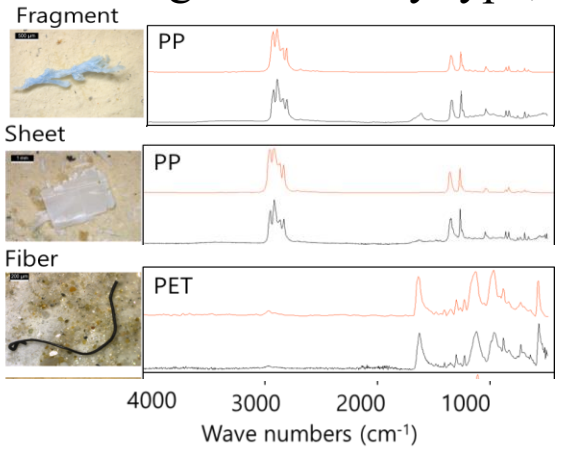
- Field work (Sampling & investigation)



- **Laboratory work (Identification & Quantification)**

- Using acidic and alkaline solutions to remove obstructions

- To distinguish MPs by type, color, size, and shape.



FT-IR (Lumos2)

◆ **Analysis of Bioconcentration, Bioaccumulation, and Biomagnification**

$$\text{bioconcentration factor : BCF} = \frac{Co}{CE}$$

$$\text{bioaccumulation factor : BAF} = \frac{Co}{CE + CP}$$

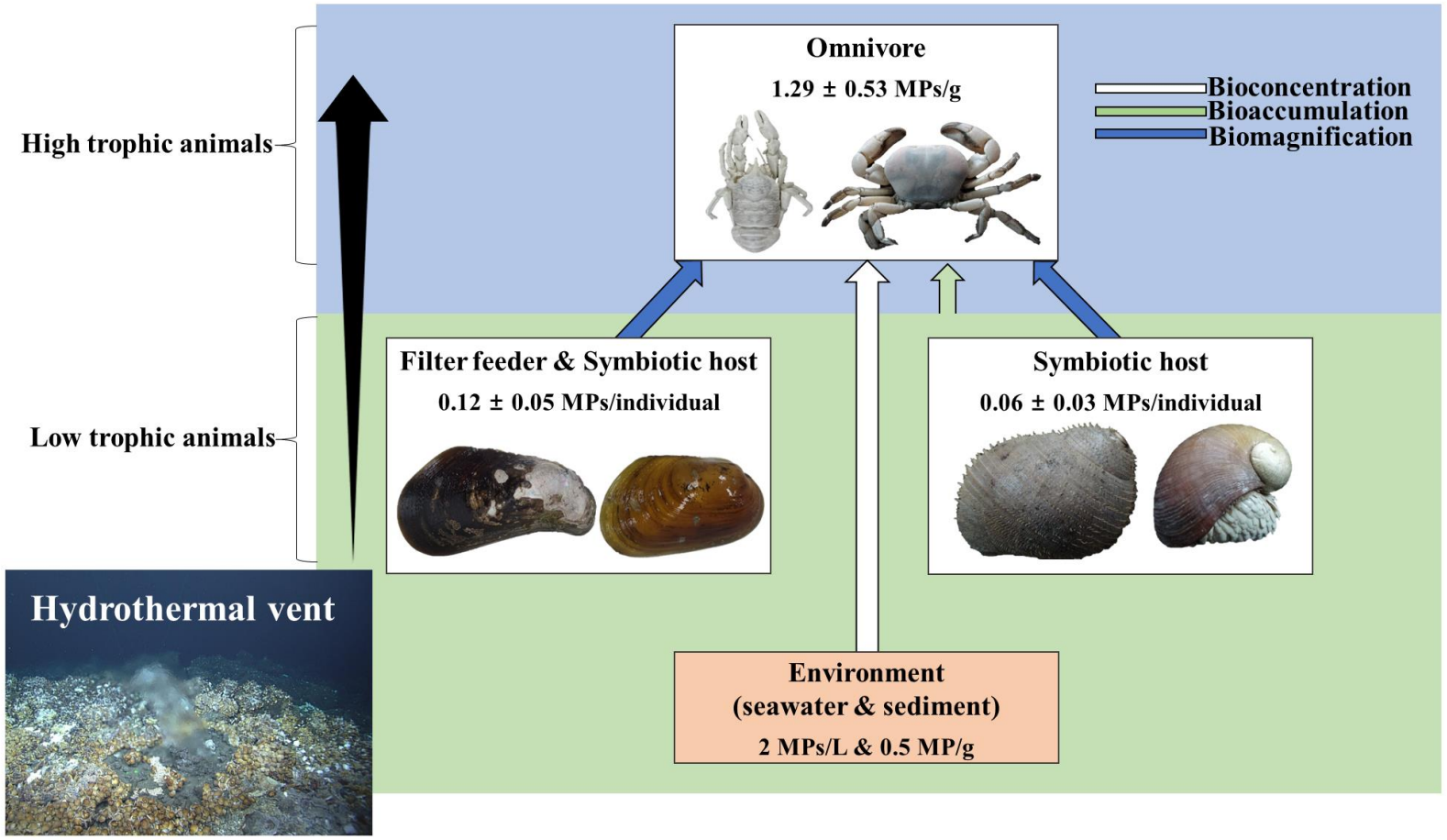
$$\text{biomagnification factor : BMF} = \frac{Co}{CP}$$

- **Co** is the the concentration of MPs in the apex predators,
- **CE** is the environment, **Cp** is the low trophic levels

2.1. Hydrothermal vent

- Results

Bioaccumulation of microplastic



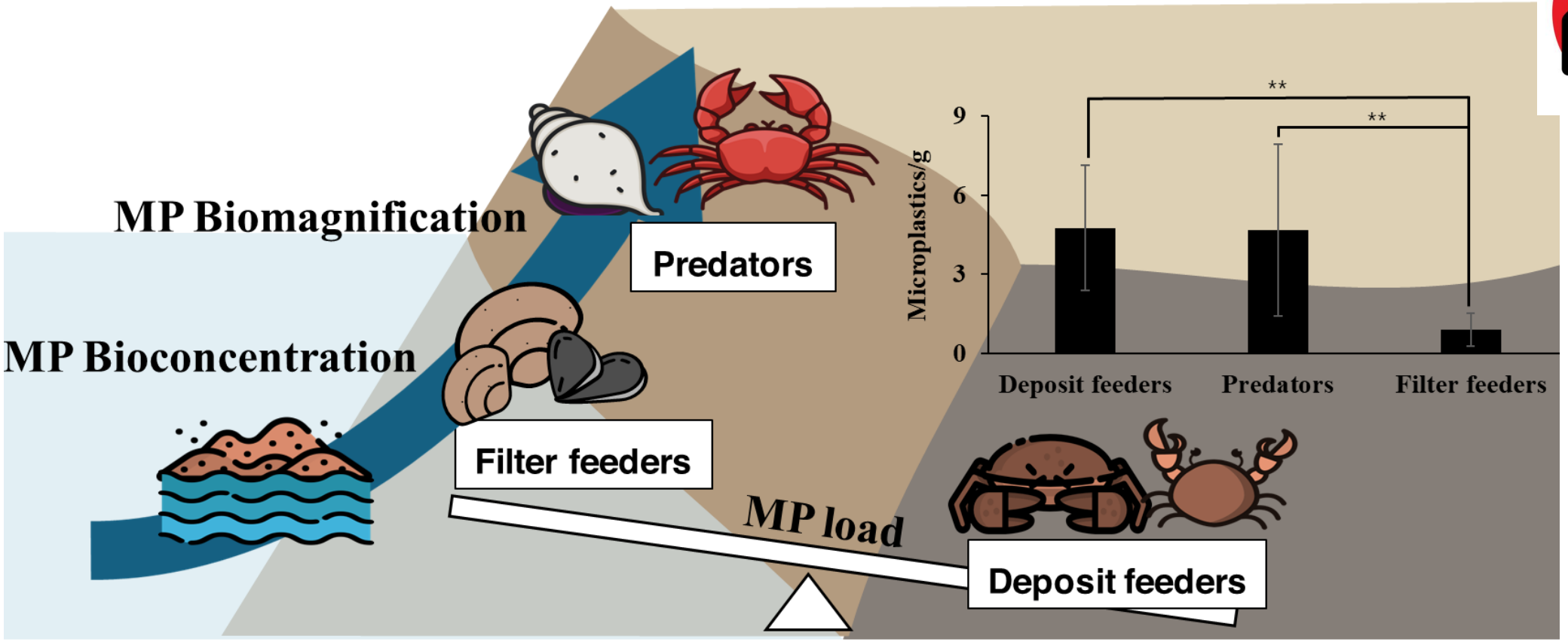
Sample	BCF	BAF	BMF
Seawater	-	-	-
Sediment	-	-	-
Austinograea sp.	3.3	3.4	10.7
Munidopsis sp.	5.6	5.6	17.9
Gigantidas sp.	0.4	-	-
Bathymodiolus sp.	0.5	-	-
Chrysomallon sp.	0.2	-	-
Alviniconcha sp.	0.2	-	-

- BCF, BAF, and BMF values > 1 indicate that MP bioconcentration, bioaccumulation, or biomagnification is occurring.

- Finally, we calculated the Bioconcentration (BCF), Bioaccumulation (BAF), and Biomagnification (BMF) factors , and found that all three processes occurred in top-predator omnivores.
- Our research represents the first case to confirm MP BCF, BAF, and BMF in a natural ecosystem.

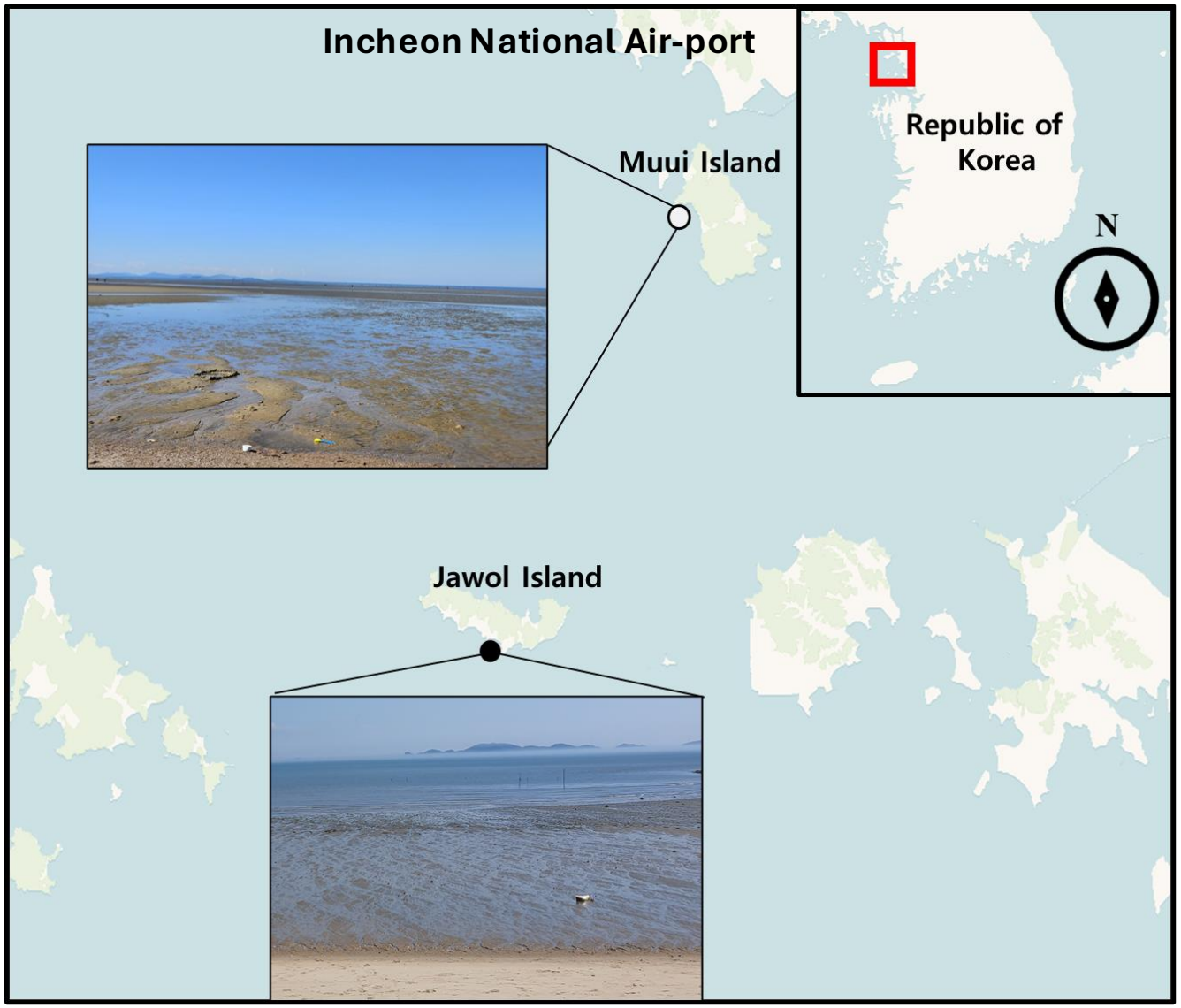
2. Concentration and magnification of microplastic in the food chain

2.2. Tidal flats



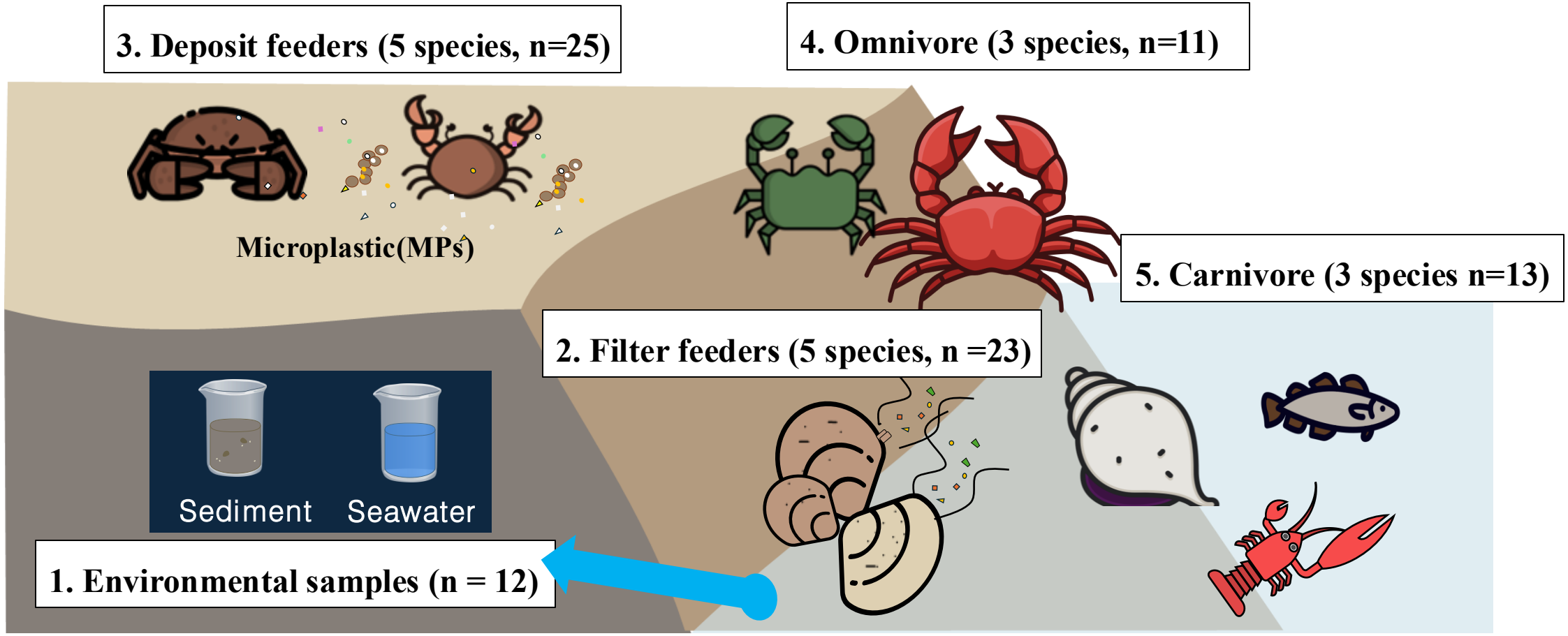
2.2. Tidal flat

- Sampling areas



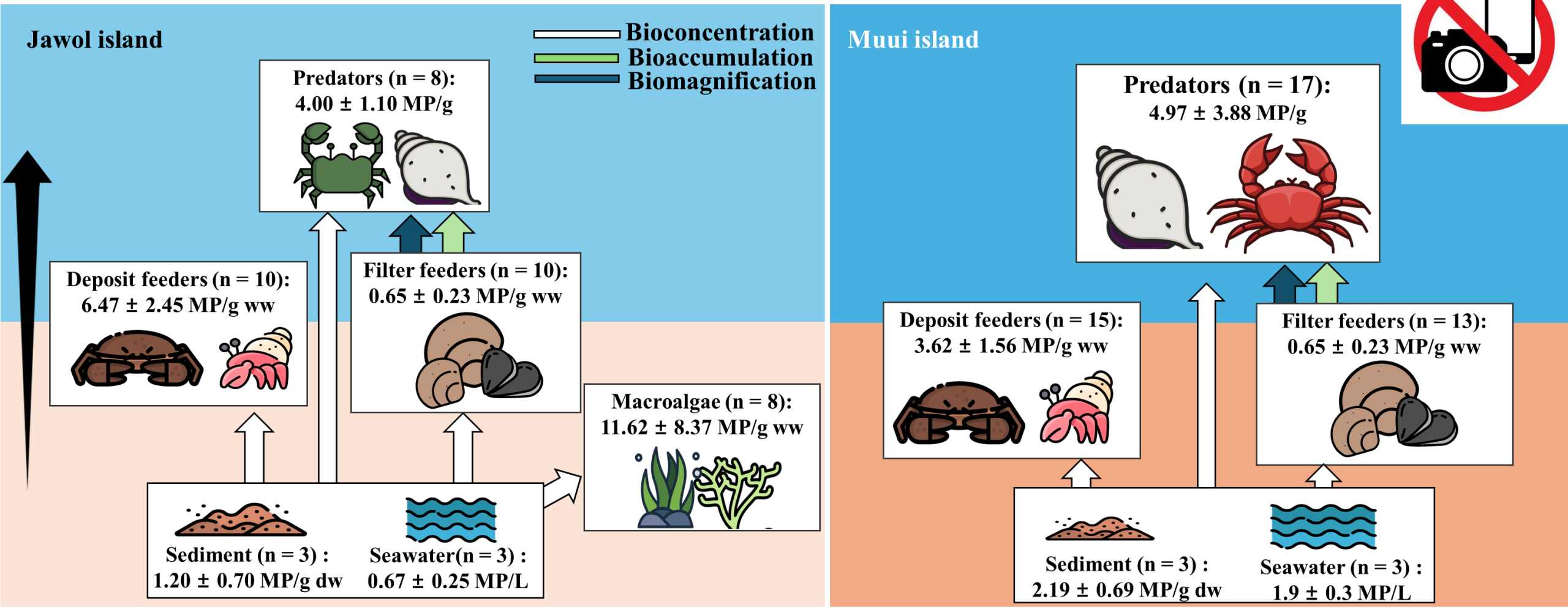
2.2. Tidal flat

- Materials & Methods



2.2. Tidal flat

- Results



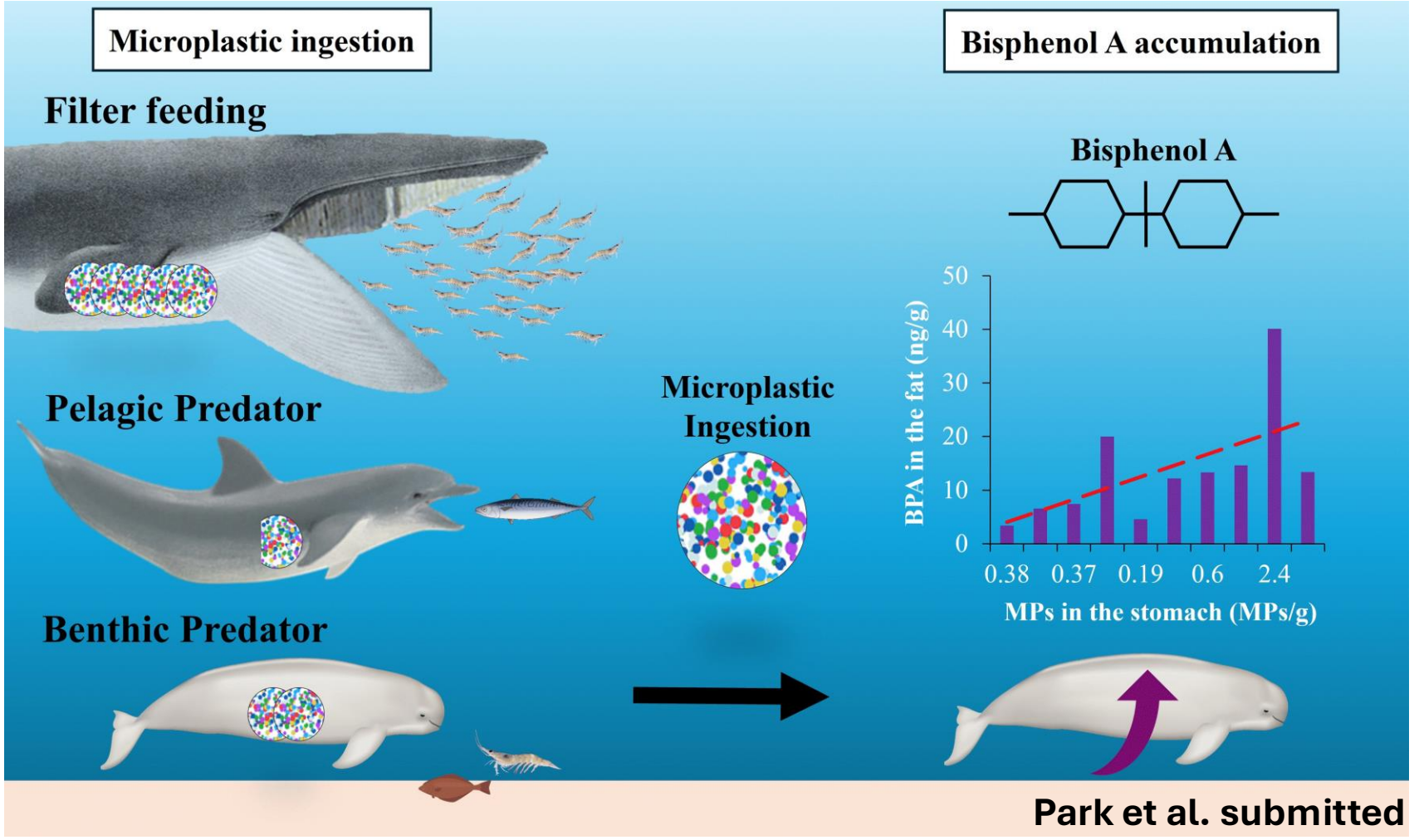
- **Bioconcentration occurred in all organisms**, while **biomagnification was found in predators** through the food web, especially from filter feeders to higher trophic levels.
- It is a serious concern that MPs are ingested by animals in our habitats and magnified through the food web.

3. Microplastic ingestion of top predators

3. Top predators ingest microplastic

3.1. Feeding types

3.2. Bisphenol A



Park et al. submitted

3.1. Feeding types

- **Study Site & Species**

Filter feeder

Fin whale (*Balaenoptera physalus*) (n = 1)

Sei whale (*Balaenoptera borealis*) (n = 1)

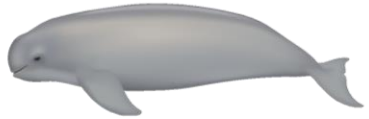
Pelagic predator

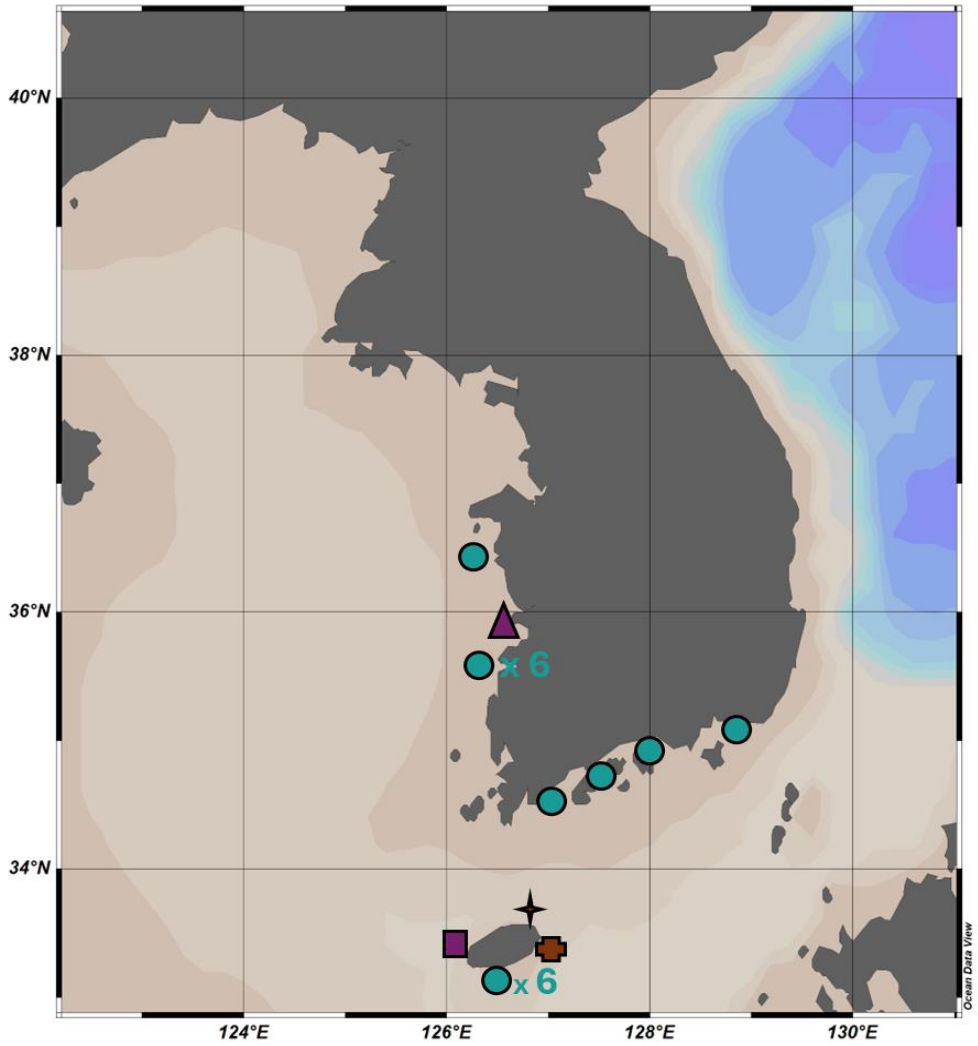
Bottlenose dolphin (*Tursiops aduncus)* (n = 1)

Common dolphin (*Delphinus delphis*) (n = 1)

Benthic predator

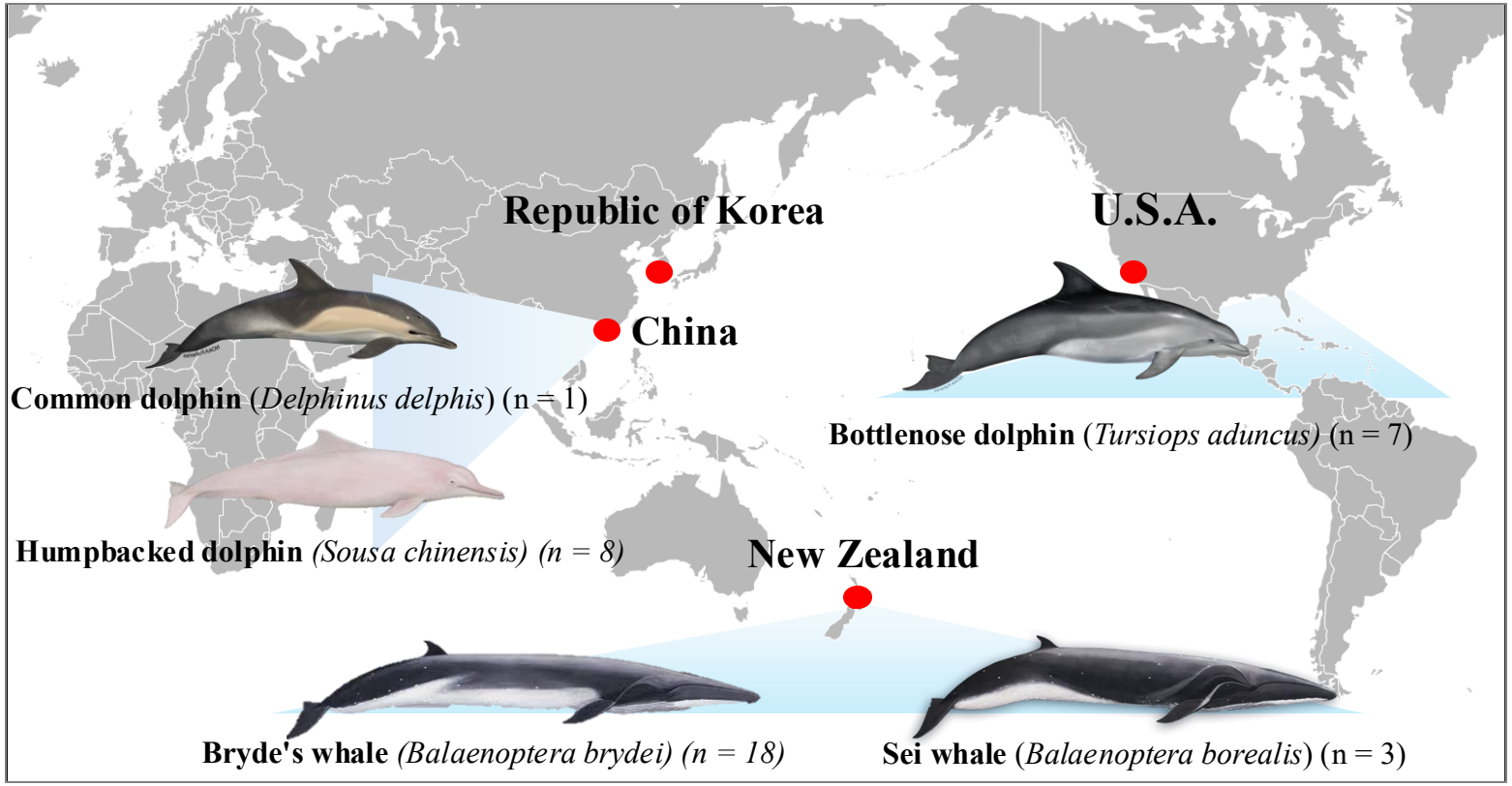
Finless porpoise (*Neophocaena asiaeorientalis)* (n = 17)





- We analyzed MP in gastrointestinal tract of stranded in south Korea.
- We cited all other studies we could find, **expressed in MP/g**, to maximize sample size.
- **For BPA accumulation, we analyzed the blubber of 10 benthic predators.**

3.1. Feeding types



Feeding Type	Species	MP/g (± S.D)	Number of individuals	Contents	References
Filter feeder	Fin whale	3.94	1	Gut contents	Park et al., 2023
	Sei whale	4.21	1	Gut contents	Present study
		4.72 ± 2.56	3	Feces	Zantis et al., 2022
	Bride whale	5.44 ± 4.28	18	Feces	Zantis et al., 2022
Pelagic predator	Bottlenose dolphin	0.46	1	Gastrointestinal contents	Park et al., 2023
		1.43 ± 1.03	7	Gastrointestinal contents	Battaglia et al., 2020
	Common dolphin	0.48	1	Gastrointestinal contents	Park et al., 2023
		0.075	1	Gastrointestinal contents	Aierken et al., 2024
	Humpback dolphin	0.55 ± 0.25	3	Gut contents	Zhu et al., 2019
		0.67 ± 0.68	5	Gastrointestinal contents	Aierken et al., 2024
Benthic predator	Finless porpoise	2.03 ± 2.8	17	Gastrointestinal contents & Gut contents	Park et al., 2023 & Present study

3.1. Feeding types

- **Study Site & Species**

Filter feeder

Fin whale (*Balaenoptera physalus*) (n = 1)

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Pelagic predator

Bottlenose dolphin (*Tursiops aduncus)* (n = 1)

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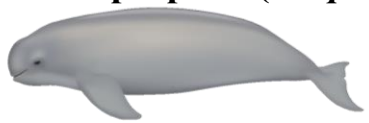
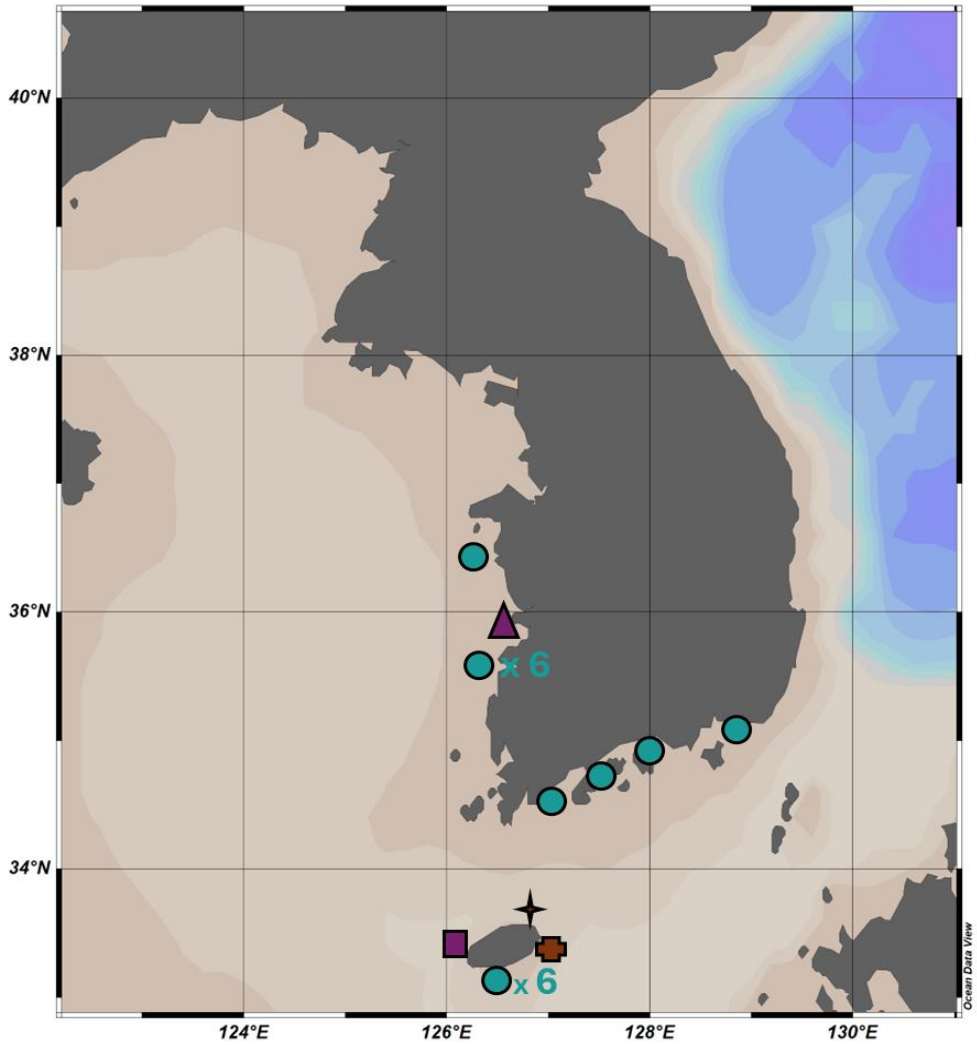
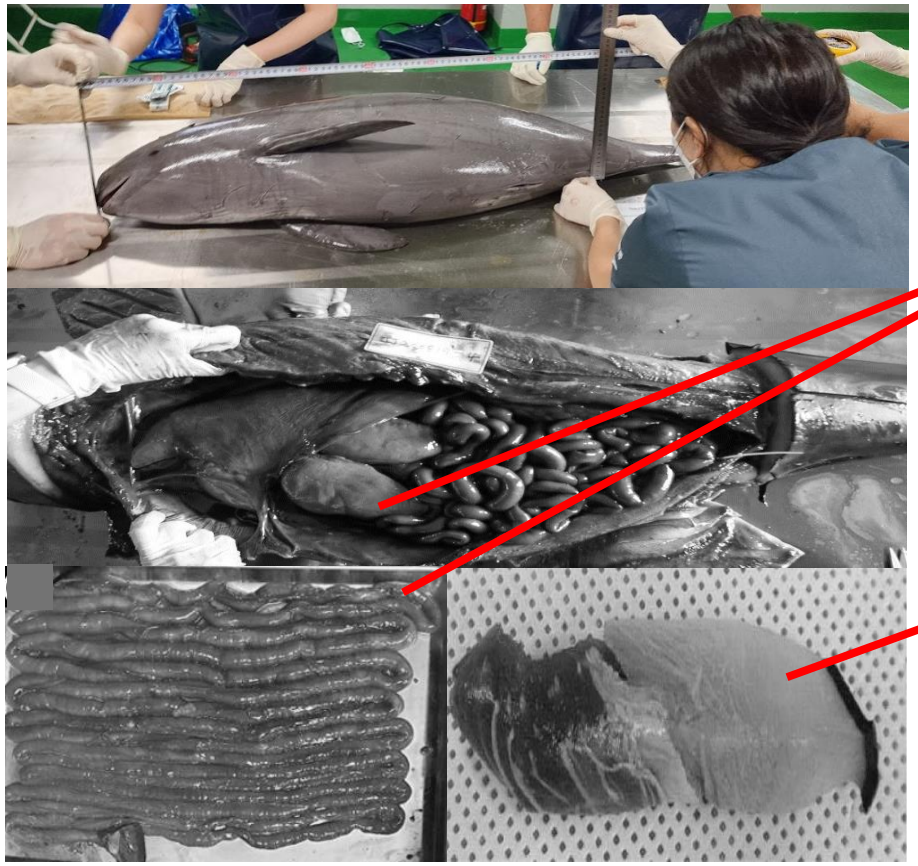


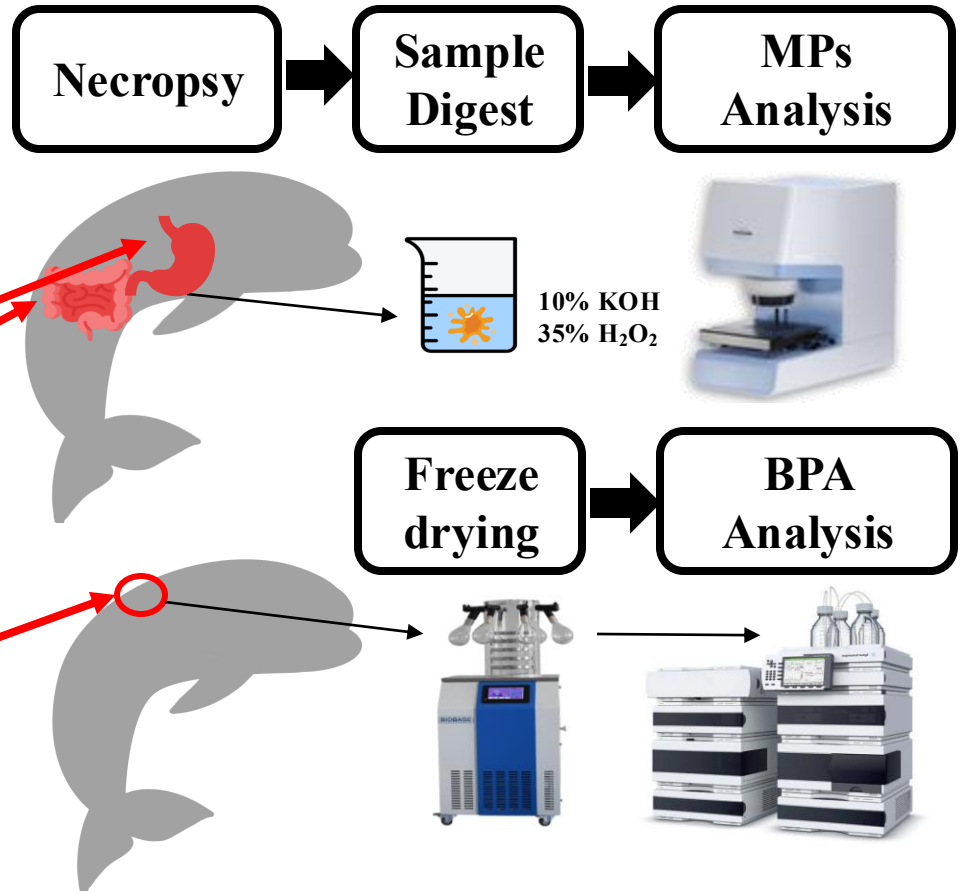


- **For BPA accumulation, we analyzed the blubber of 10 benthic predators.**

3.1. Feeding types

- **Necropsy & Sampling**

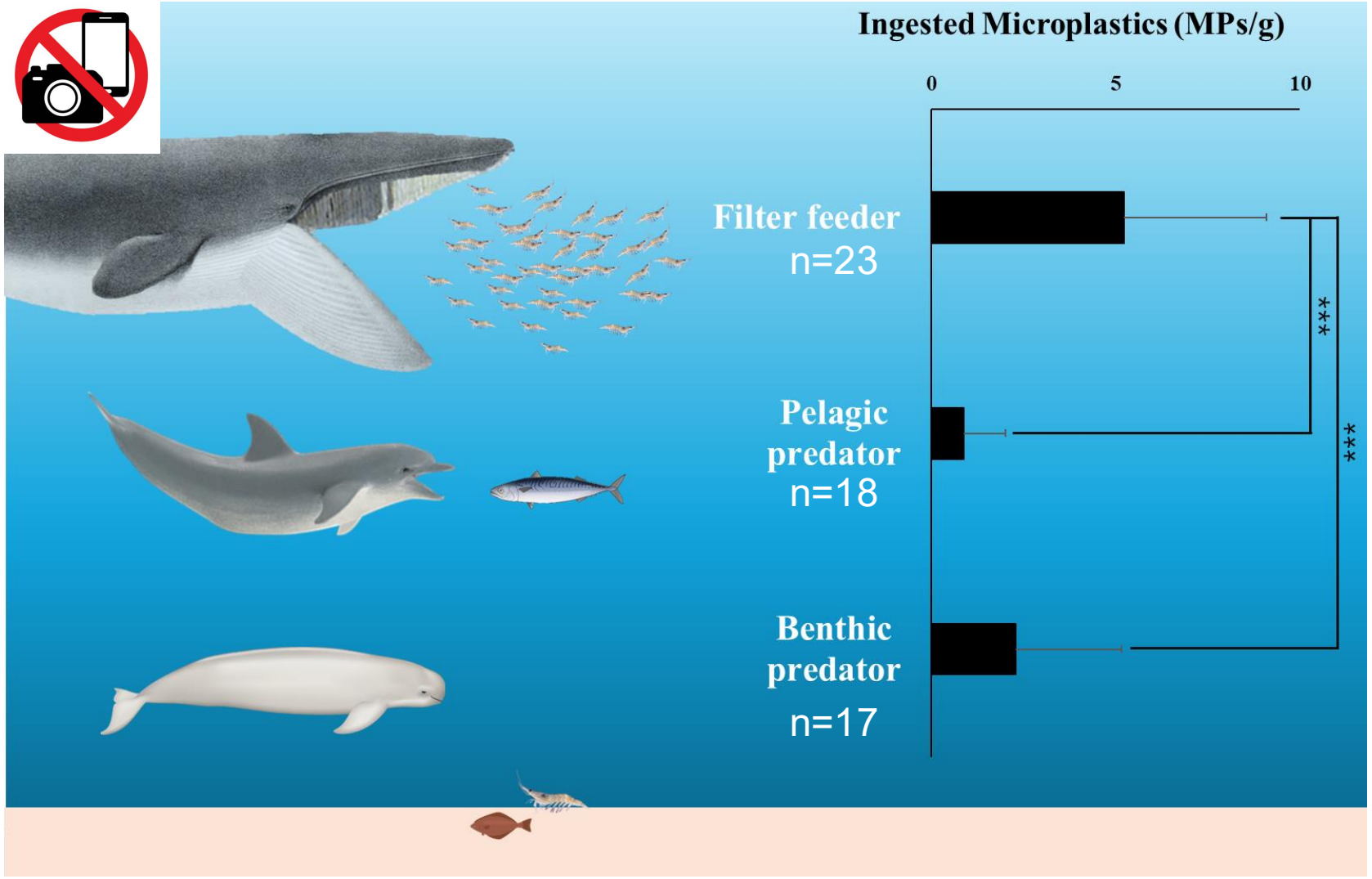


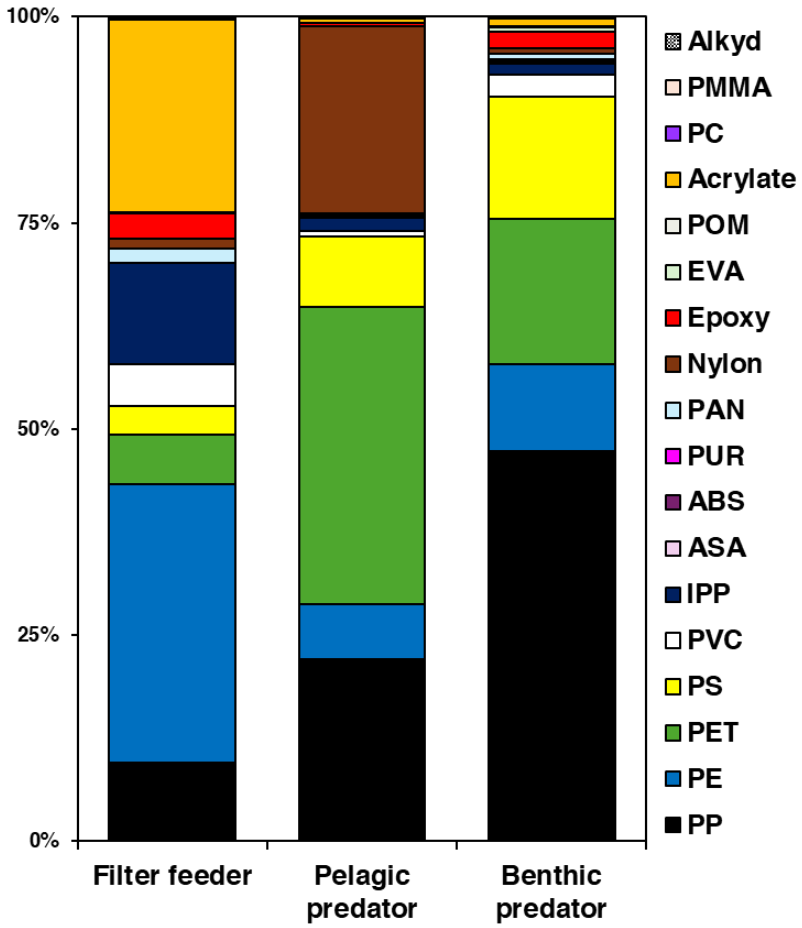


- For the cetacean necropsy conducted with the vet, we used metal tools and 100% cotton clothes to minimize contamination.
- For MP analysis, we digested the GIT content and analyzed it using FT-IR.
- For BPA analysis, we freeze drying the blubber and analyzed it using LC-MS/MS.

3.1. Feeding types

- Results • **Difference in MP ingestion among the three feeding types.**



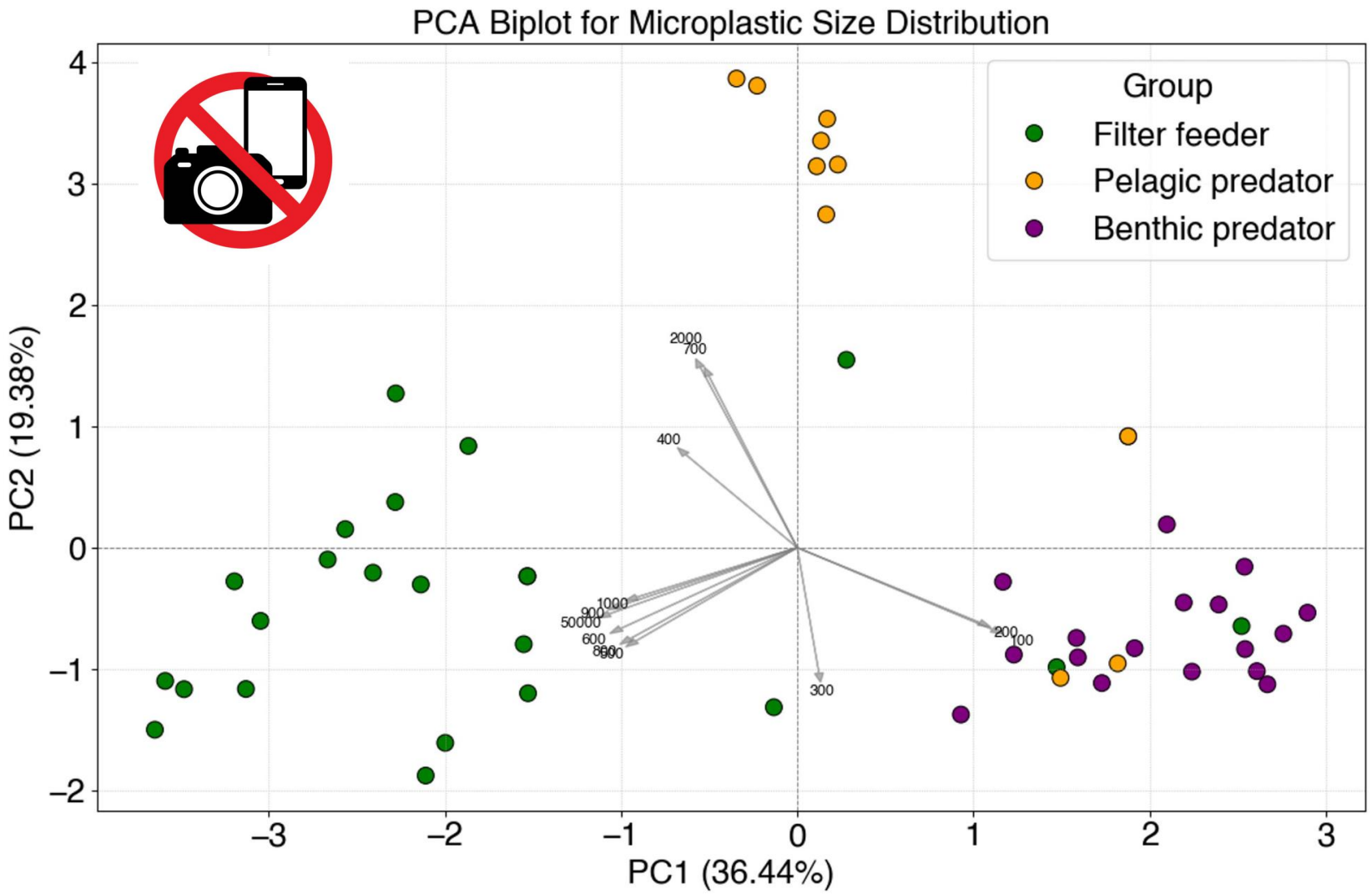


- Filter feeders ingested significantly more MPs than others (Kruskal–Wallis test, $p < 0.001$, $p < 0.001$)

- The predominance of **PE** in **filter feeders**, **PET** in **pelagic predators**, **PP** in **benthic predators**.

3.1. Feeding types

- **Difference in MP size distribution by feeding type**

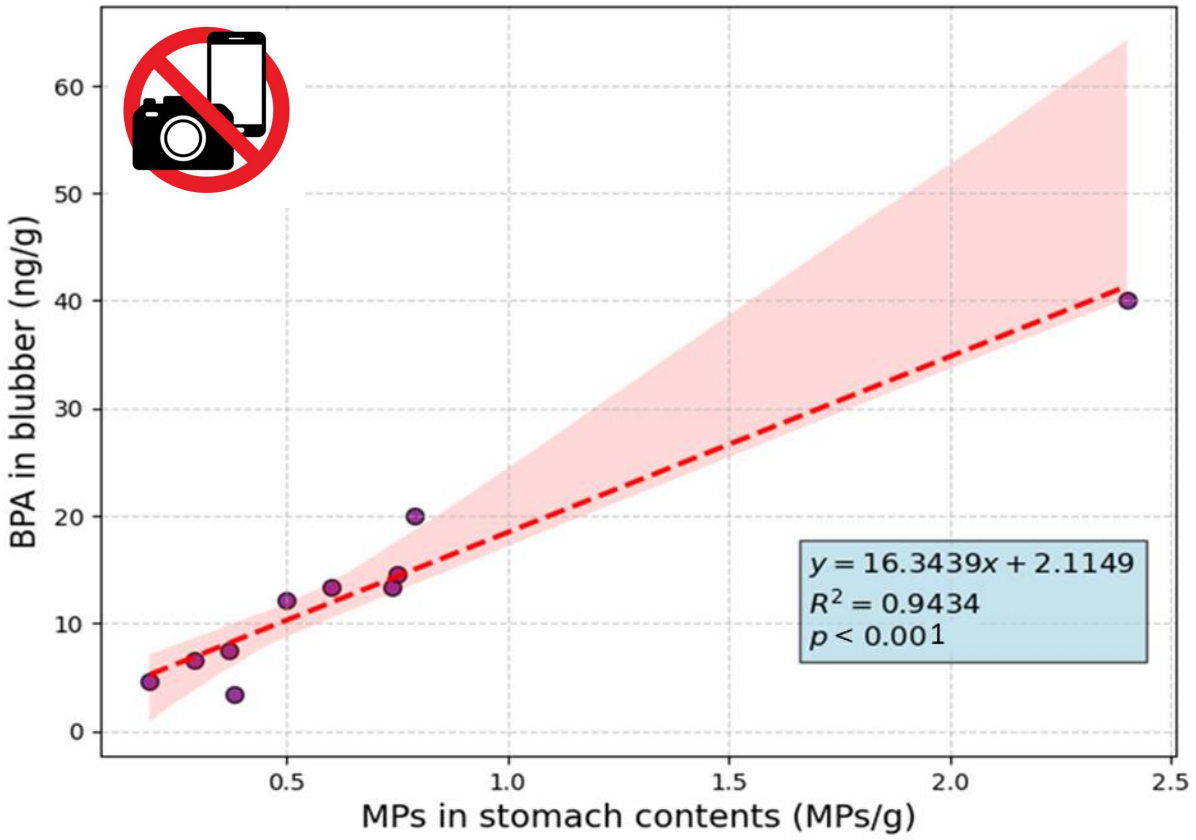


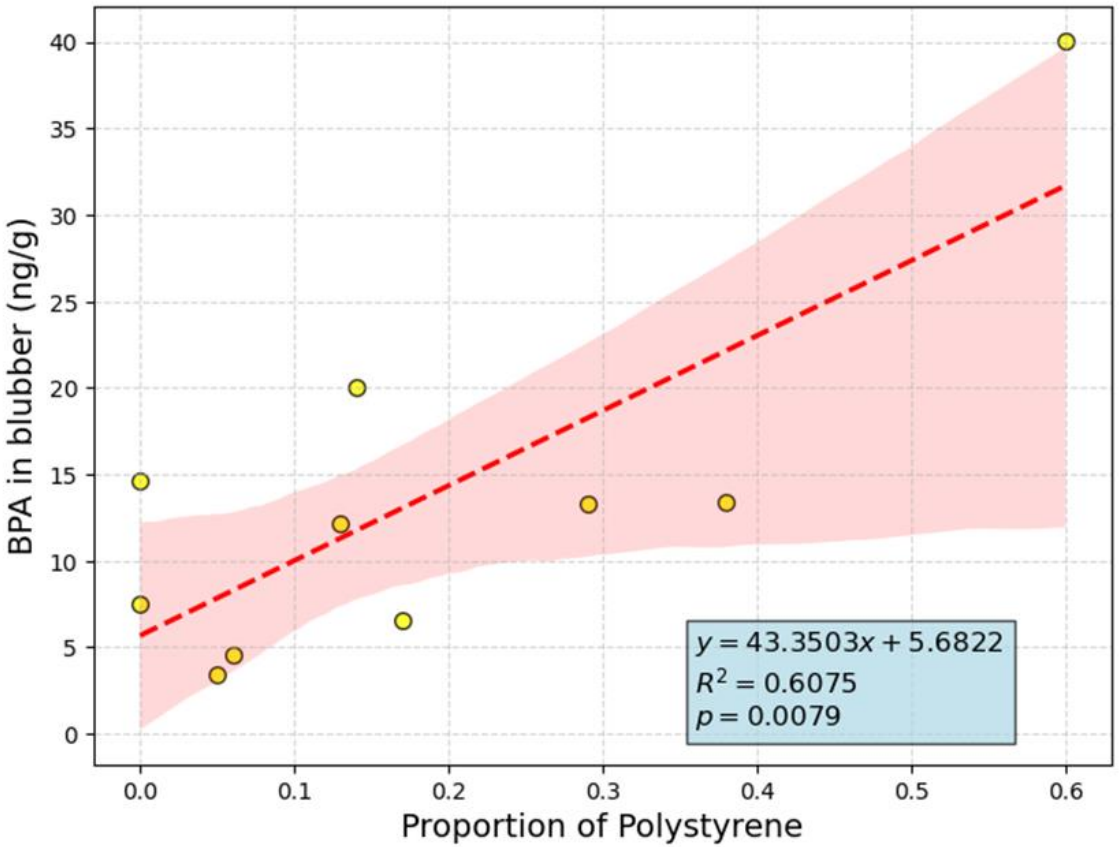
- The size distribution of ingested MPs differs depending on the feeding type ($\chi^2 = 52.62$, $df = 22$, $p < 0.0001$).

- **Filter feeders** tended to ingest larger particles.
- **Pelagic predators** consumed a wide range of sizes.
- **Benthic predators** mostly ingested smaller MPs and were strongly associated with the **100 µm size.**

3.2. BPA

- **Higher microplastic ingestion leads to more chemical accumulation in finless porpoises.**

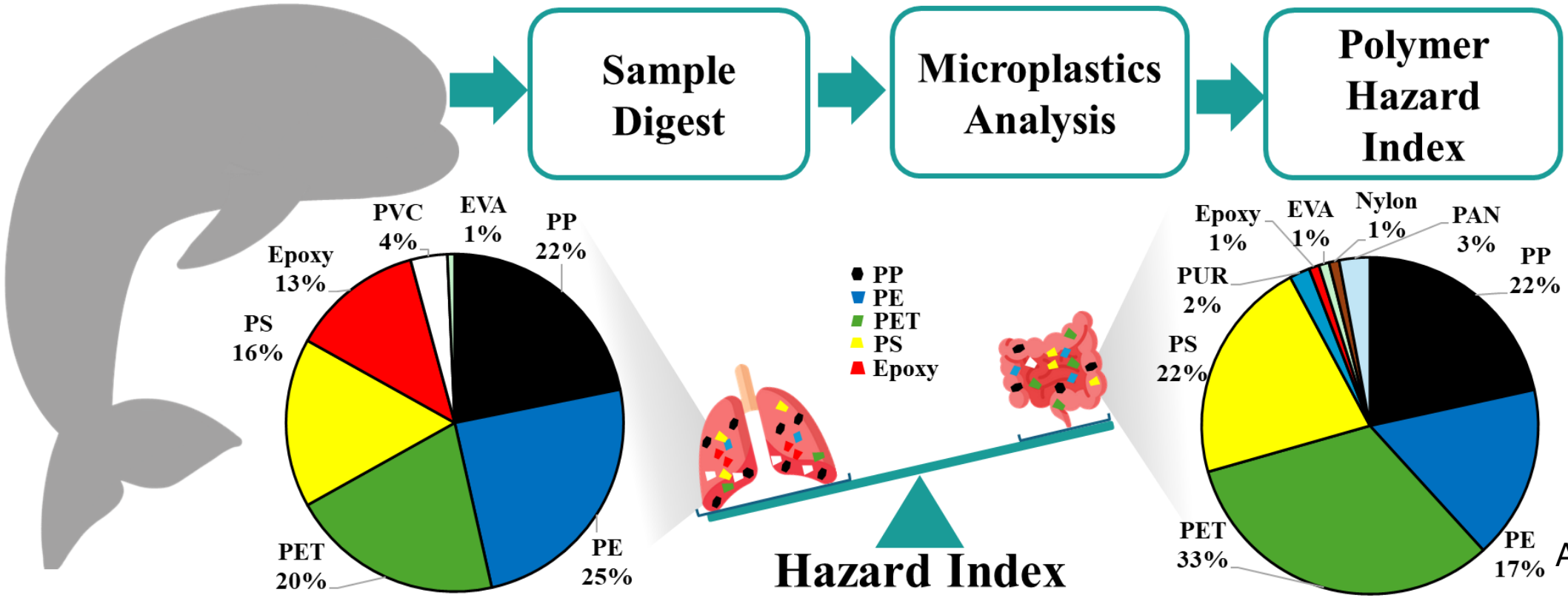




- **A strong positive correlation** was observed MP ingestion and BPA accumulation in finless porpoises.
- BPA accumulation showed **no significant** correlation with **age, sex, body size, or cause of death.**
- BPA accumulation showed a positive correlation was observed the **proportion of PS**.

3. Microplastic ingestion of top predators

3.3. Inhalation



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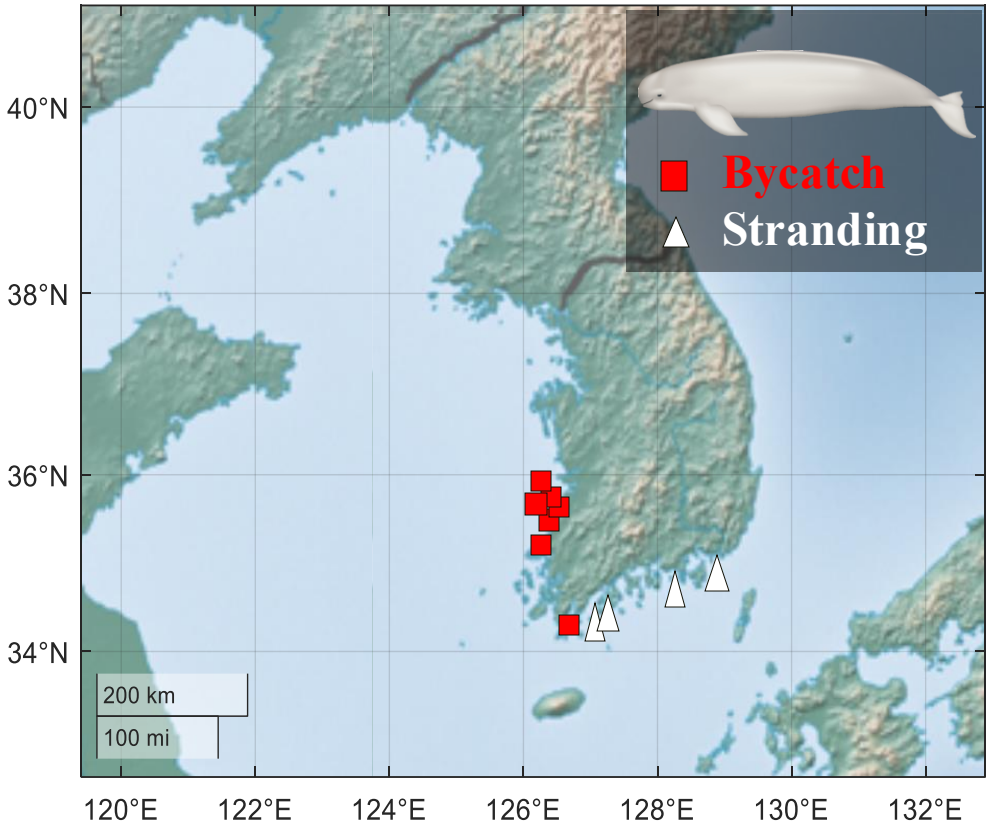
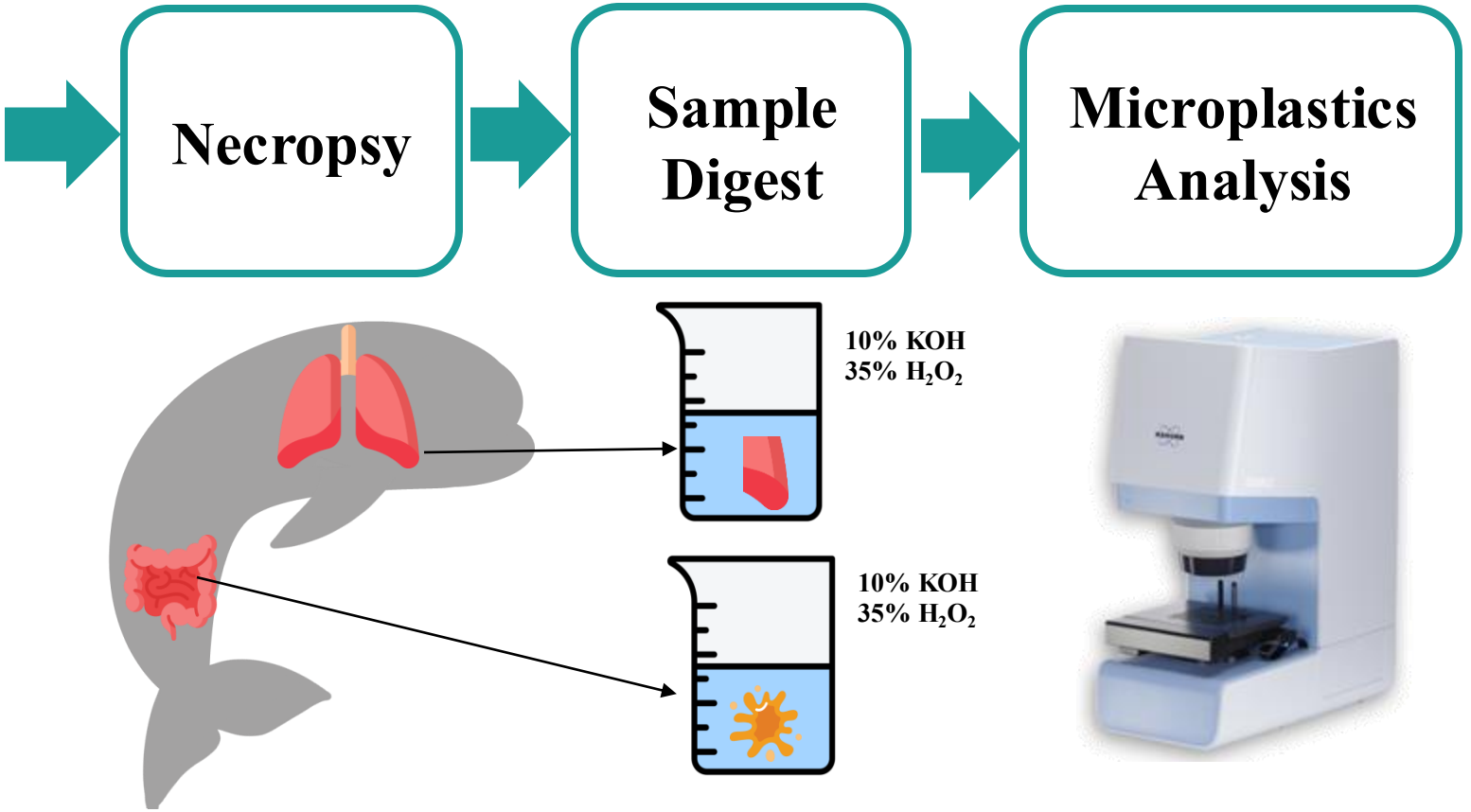
3.3. Inhalation

- **Materials & Methods**

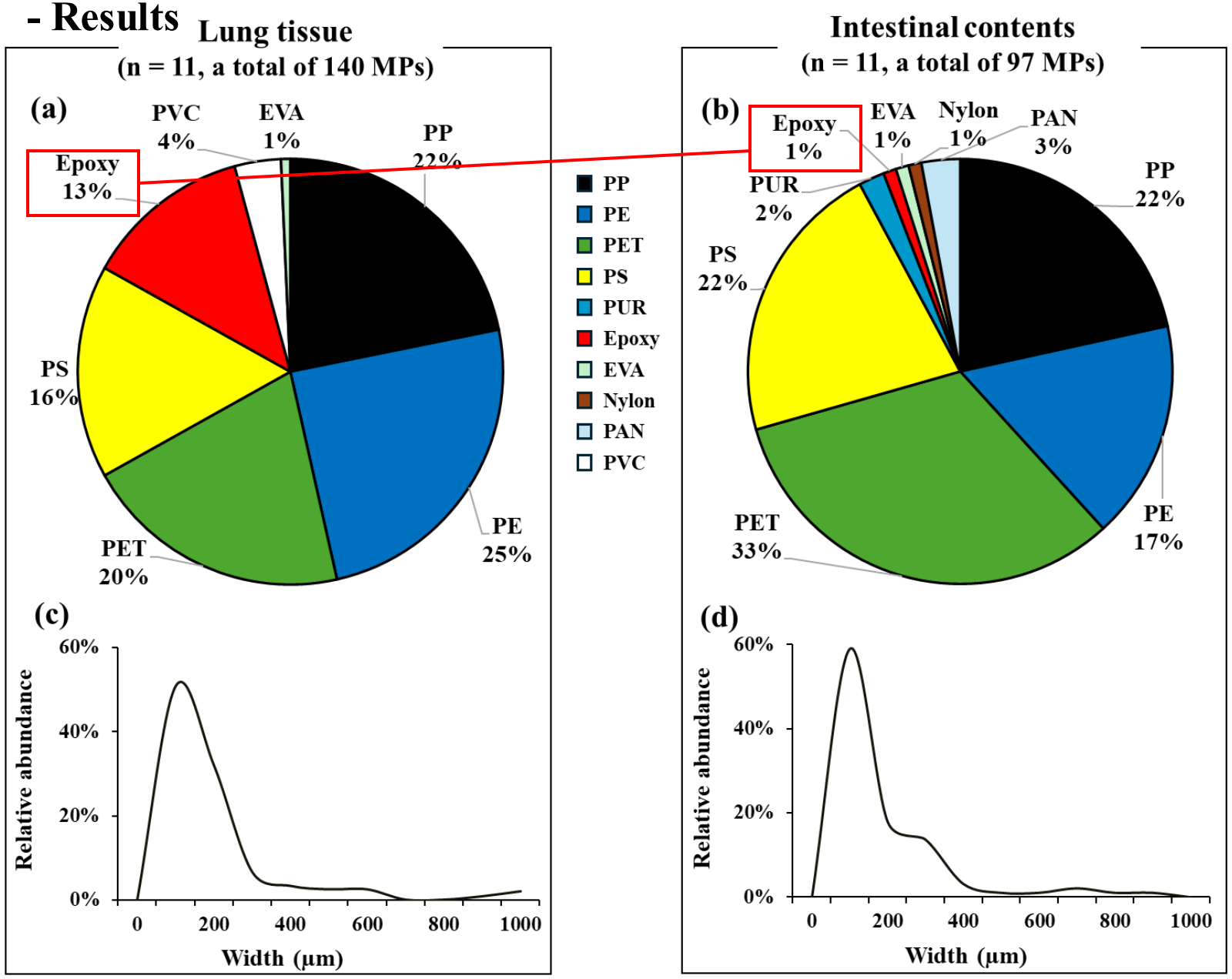




- We analyzed 11 finless porpoise died in South Korea.
- We used only the left lower lung lobe and 50 g of intestine content and applied the same process.

3.3. Inhalation

- Results



- **The shape and size of the plastics found were similar** between the intestinal contents and lung tissues, with a predominance of fragments ranging from 20 to 200 μm in size.
- However, significant differences were observed in **polymer types** (Chi-square test, $p < 0.001$), with a higher proportion of epoxy found in the lungs (Mann-Whitney U test, $p < 0.05$)

3.3. Inhalation

- **Microplastic Health Risk Evaluation: Polymer Hazard Index (PHI)**

$$PHI = \sum pnSn$$

- **Lung tissues** were classified as **a high-risk group**, whereas the **intestinal contents** were classified as **a low-risk group** (Mann-Whitney *U* test, $U_{11,11} = 24.00$, $Z = -2.53$, $p < 0.05$)

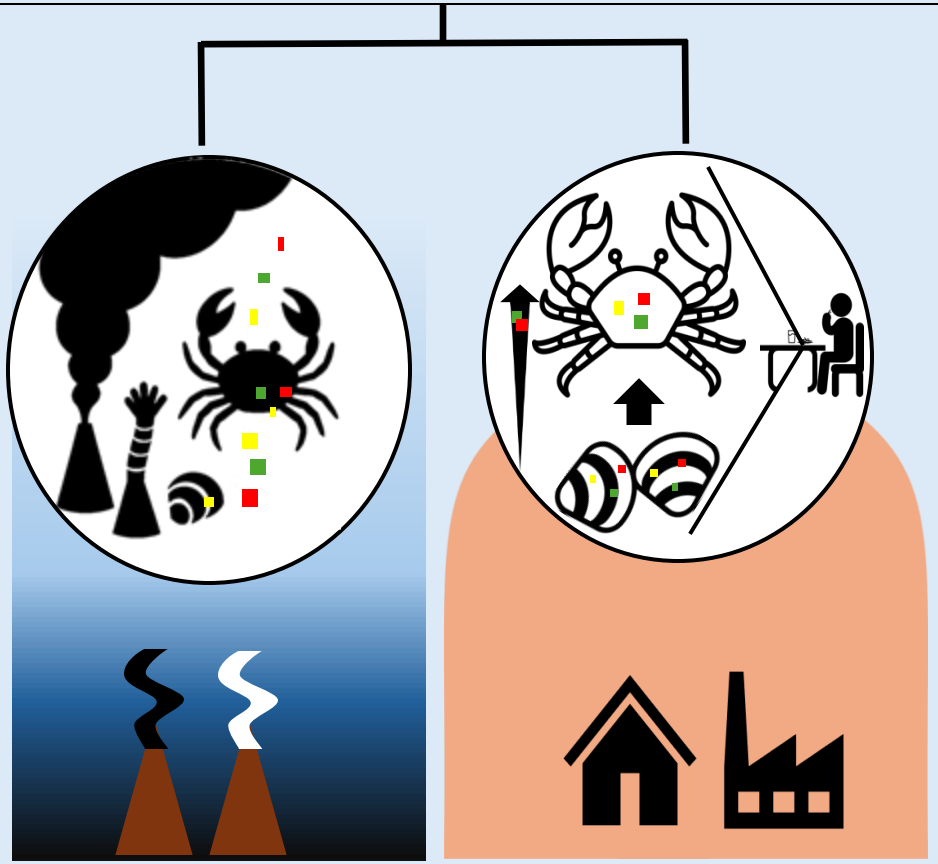
- **Inhaled MPs can pose greater risks than ingested MPs.**

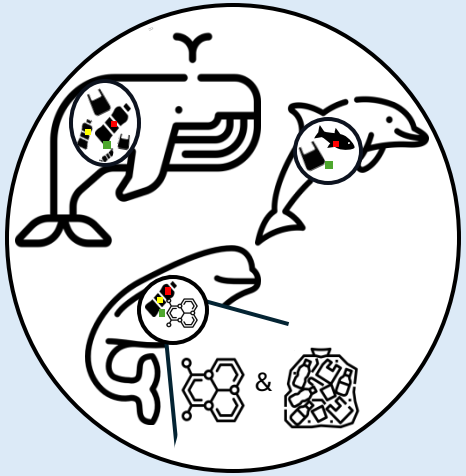
	Lung tissue		Intestinal contents	
Sample number	Hazard index	Category	Hazard index	Category
FP-1	12	Medium	15	Medium
FP-2	982	High	3	Low
FP-3	1515	Danger	10	Low
FP-4	897	High	195	High
FP-5	1656	Danger	4	Low
FP-6	13	Medium	9	Low
FP-7	17	Medium	15	Medium
FP-8	571	High	8	Low
FP-9	17	Medium	5	Low
FP-10	421	High	15	Medium
FP-11	11	Medium	198	High

(Pn ≤ 10 indicates a low risk; 10 < Pn ≤ 100 indicates a medium risk; 100 < Pn ≤ 1000 indicates a high risk; and Pn > 1000 indicates a dangerous risk of MP pollution)

6. Summary

1. MPs are transferred and accumulated in animals in the higher trophic level through the food web in hydrothermal vent and tidal flat ecosystems.





2. Feeding types influenced the amount, types, and size of MPs ingested.

3. In finless porpoises, MP ingestion was correlated with BPA accumulation, especially polystyrene.

4. MPs inhaled by finless porpoises can pose greater risks than ingested MPs.

Thanks for attention

Hydrothermal vent QR:

Cetaceans QR:

Inhalation QR:

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