Microplastic research in the Republic of Korea

Joint NOWPAP-TEMM Workshop on Marine Litter Management
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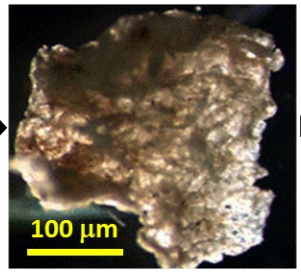
Paradigm Shift : fate and effect of marine debris

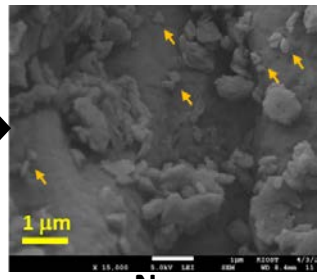

Mega


Macro

Meso



Micro



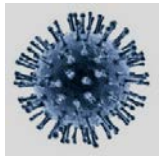
Nano


Hippo


Dog


Ant


Dust mite


Virus

Increasing …

- Numbers
- Bioavailability
- Target organisms
- Toxicity
- Detection difficulty
- Cleanup difficulty

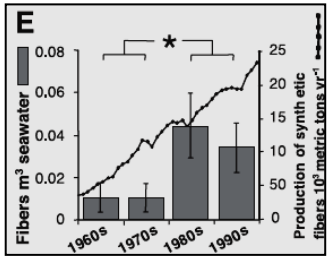
Decreasing …

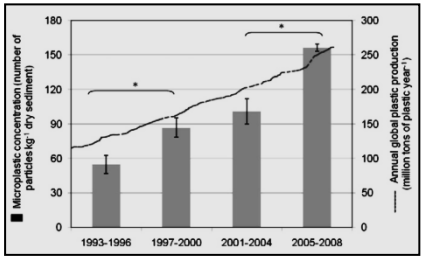
- Volume
- Entanglement
- Settling velocity

Why microplastics?

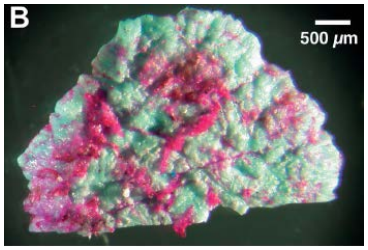
- **Ubiquitous from coast to Arctic**
  (Browne et al., 2011, ES&T; Hidalgo-Ruz et al., 2012)

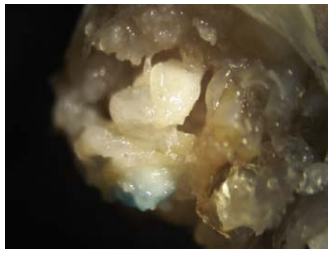
- **Increasing trend**
  (Thompson et al., 2004, Science; Classens et al., 2011, MPB)



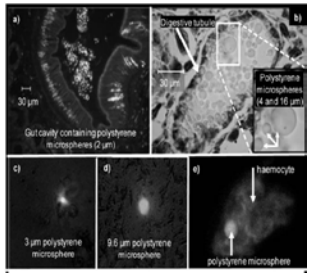


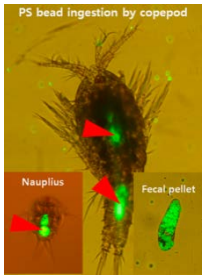
- **Ingestion by small organisms**
  (Boerger et al., 2010, MPB; Davison and Asch, 2011, MEPS)



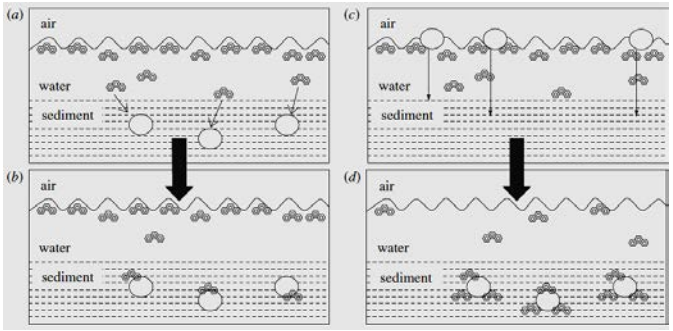


- **Toxicity of microplastics** (Browne et al., 2008, ES&T; Lee et al., 2013, ES&T)

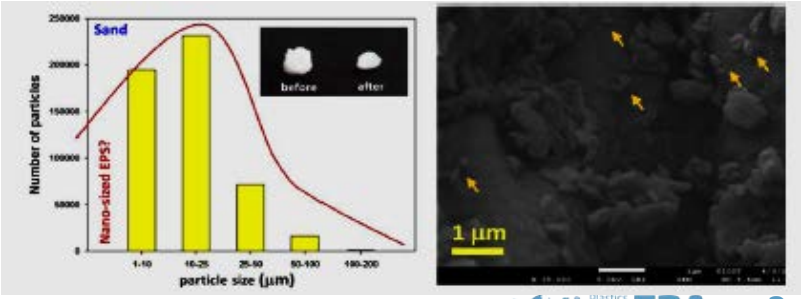




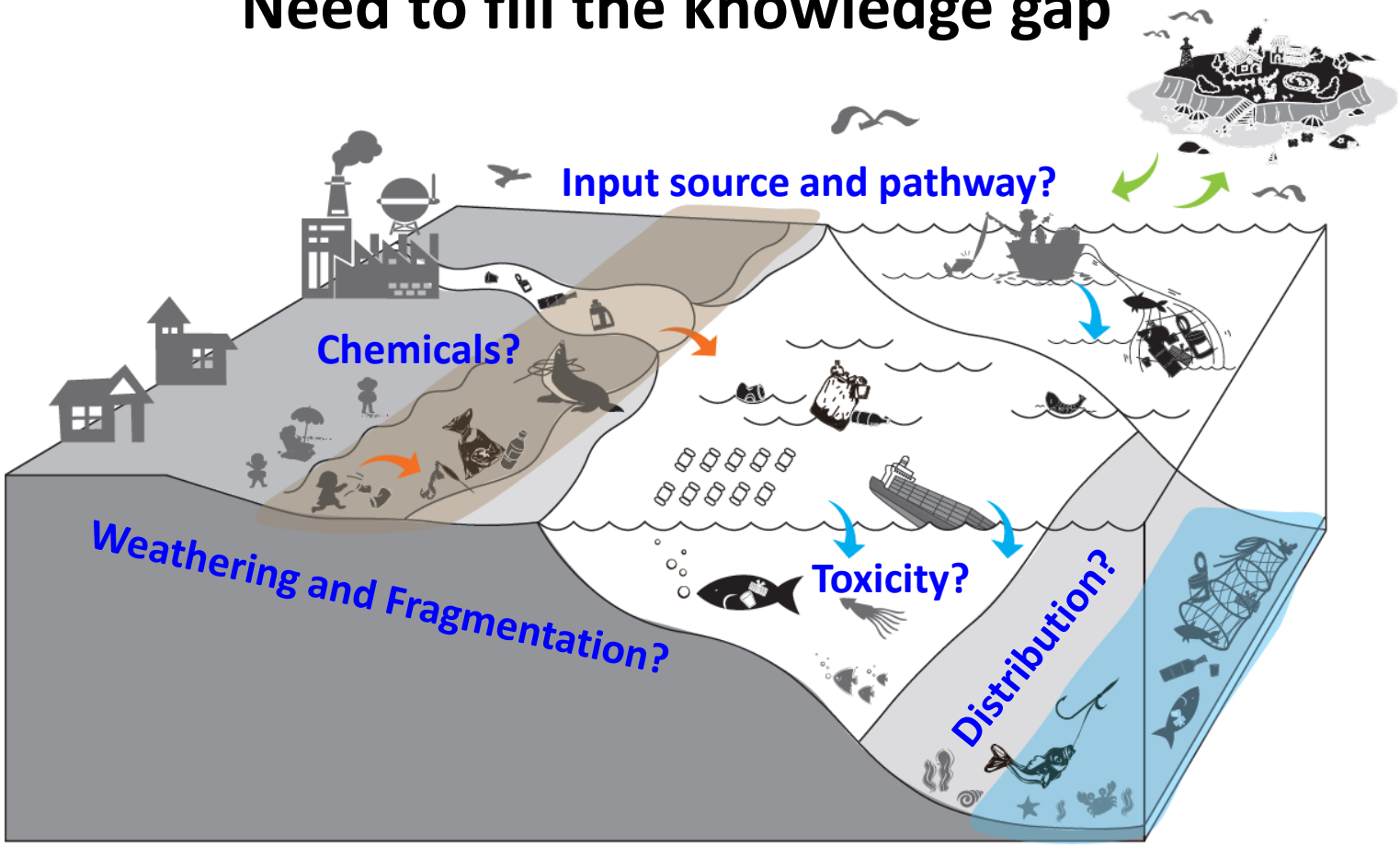
- **Transporting media of pollutants**
  (Tueten et al., 2009, Phil. Trans R. Soc.)



- **Nanoplastics by weathering**
  (Shim et al., 2014, SETAC)



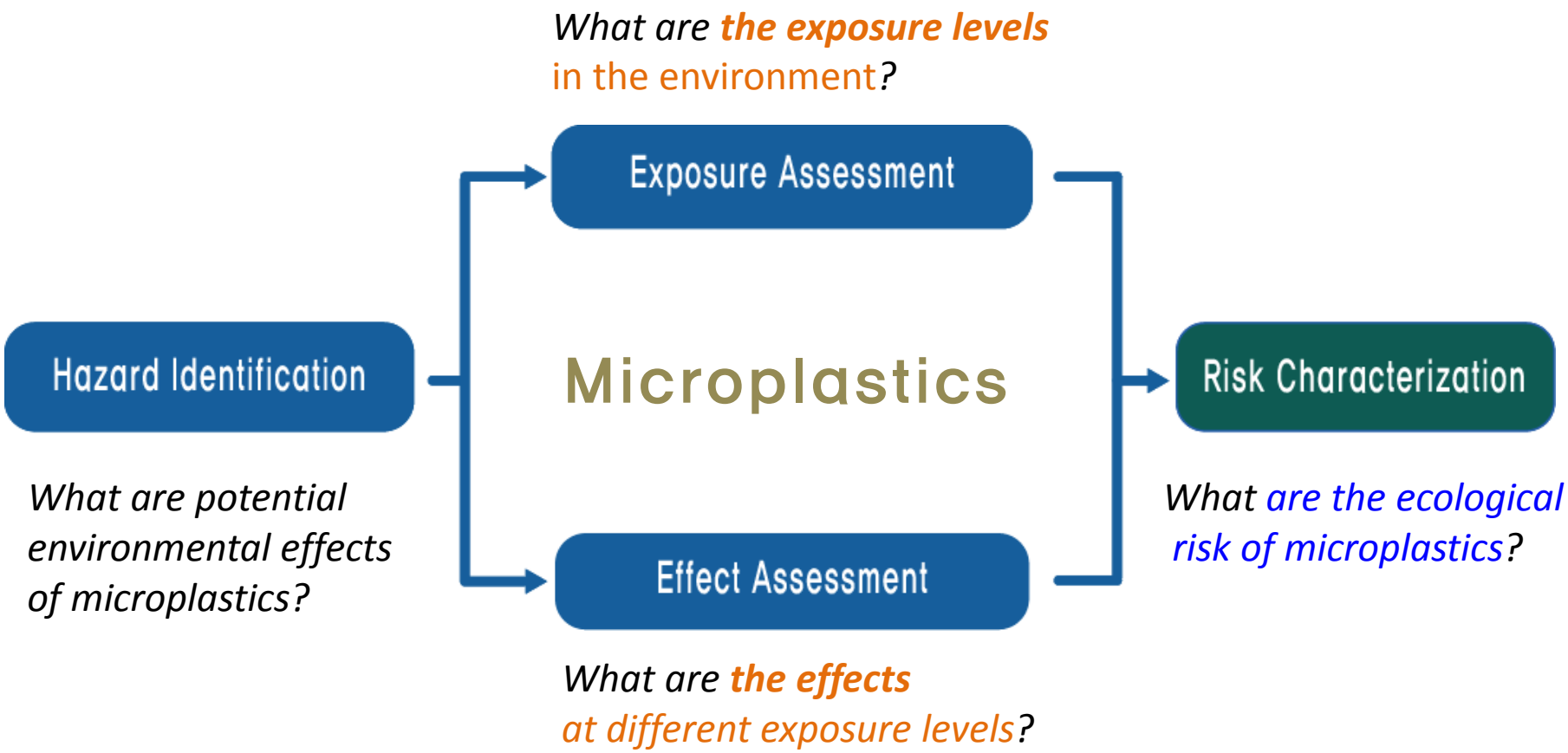
Need to fill the knowledge gap



Growing need to conduct scientific research and monitoring

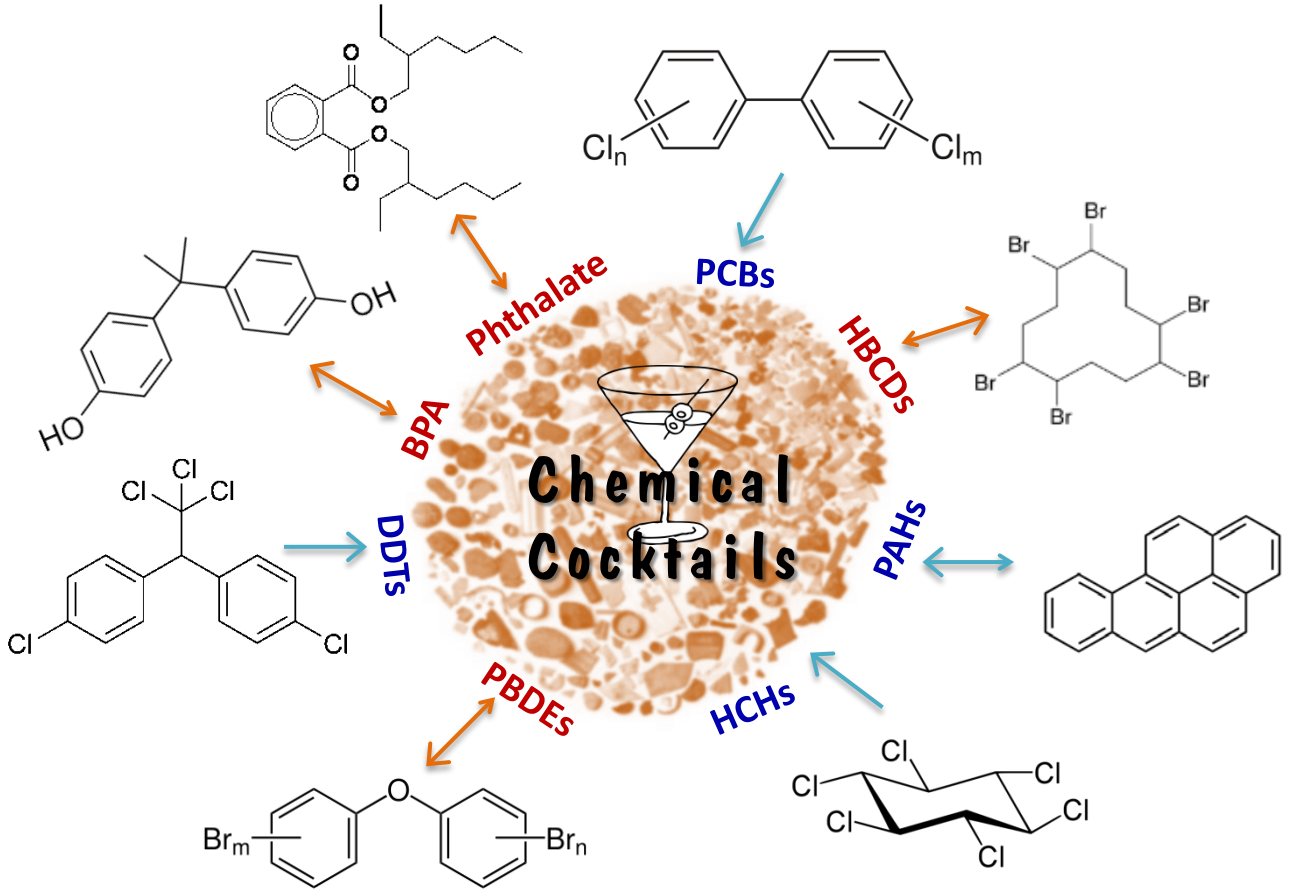
Is marine debris (microplastics) a 'serious problem' or a 'red herring'?

Research project: Assessment of environmental risk of microplastics in the marine environment (2015-2020)



Targets for the assessment

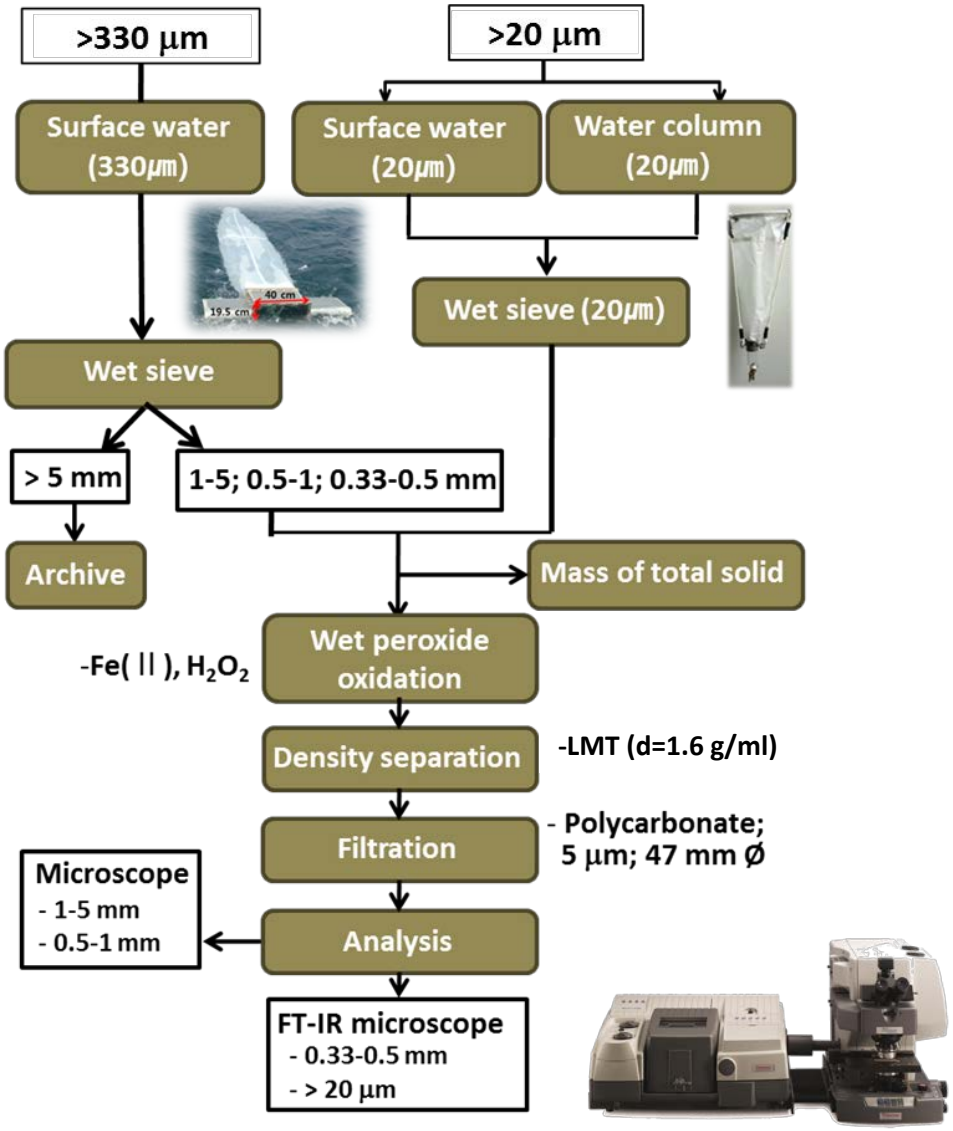
Microplastics + Associated Chemicals



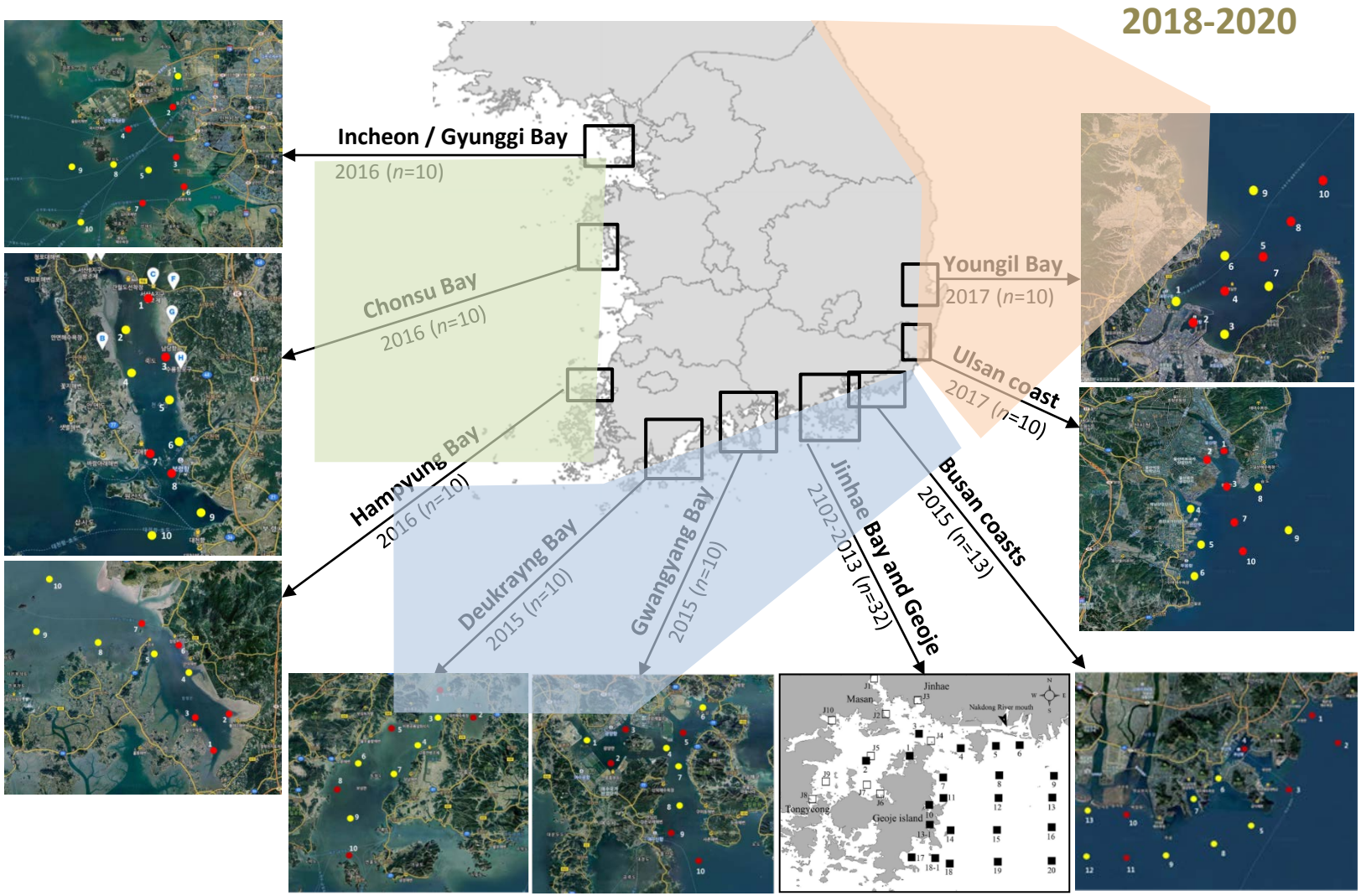
Main research content

- **Development of techniques for the assessment** of microplastic pollution and biological effects
- **Assessment of microplastic pollution** in the marine environment [water column, sediment, and biota / chemicals in microplastics]
- **Assessment of input pathway and transportation** of microplastics [rivers, sewage treatment plants / weathering and fragmentation / transportation]
- **Assessment of effects** of microplastics on marine organism [laboratory and field / MP, MP + chemicals]
- **Assessment of ecological risk of microplastics** in the marine environment

Monitoring and assessment protocols of floating microplastics



Monitoring of floating microplastics (2012-2017)



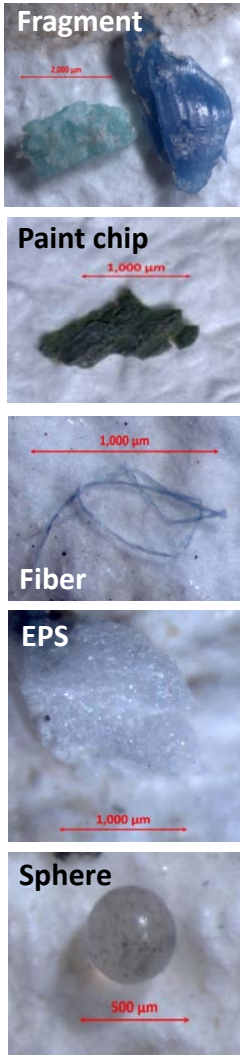
Surface water sampling with a Manta trawl net (330 μm)

Vertical (surface, middle and bottom water) sampling with a Hand net (20 μm)

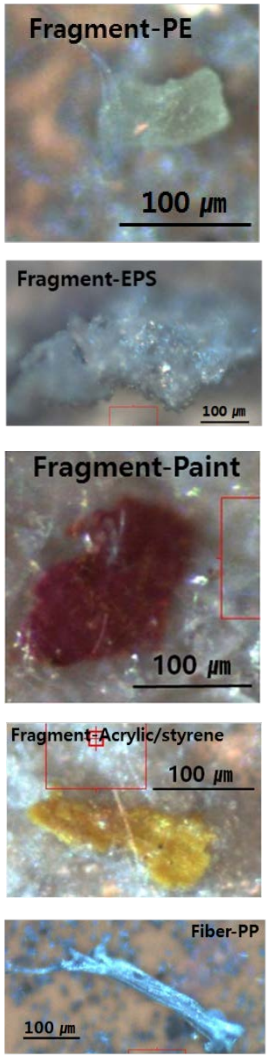
Microplastics

Large MP (1-5 mm) and Mesoplastics (5-25 mm)

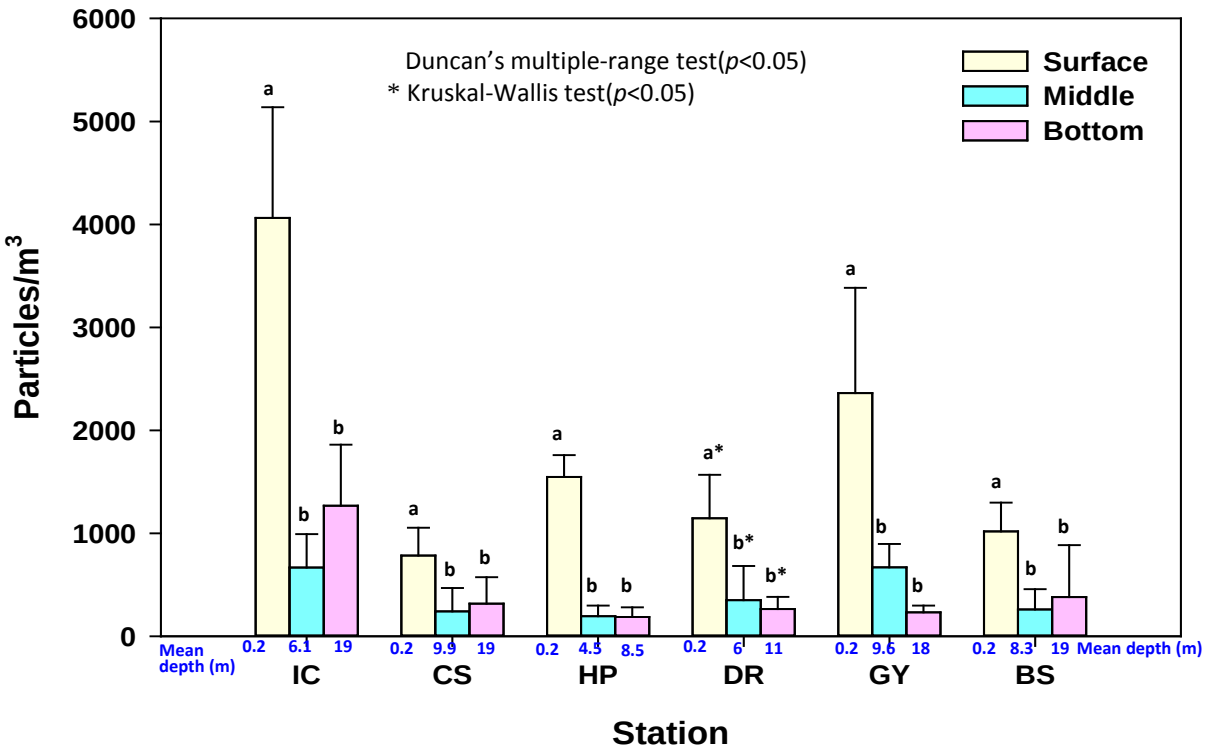
Large MP (1-5 mm)

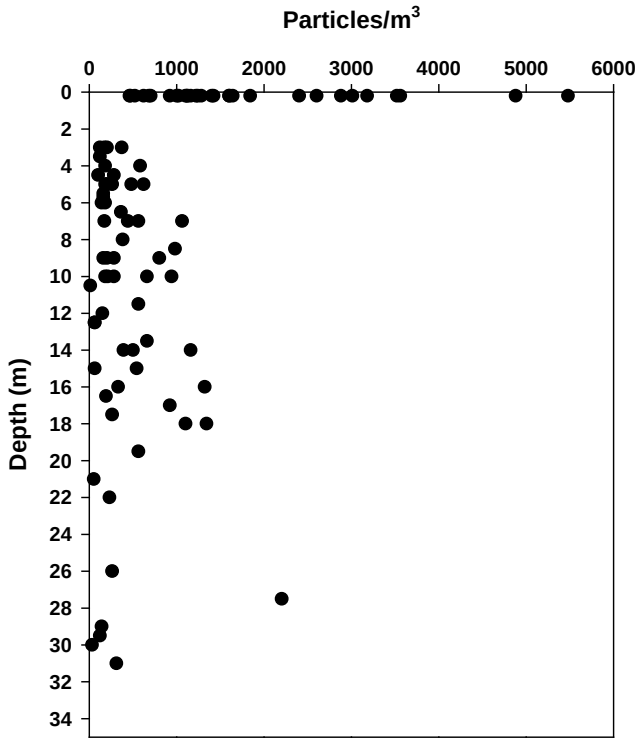


Small MP (< 1 mm)

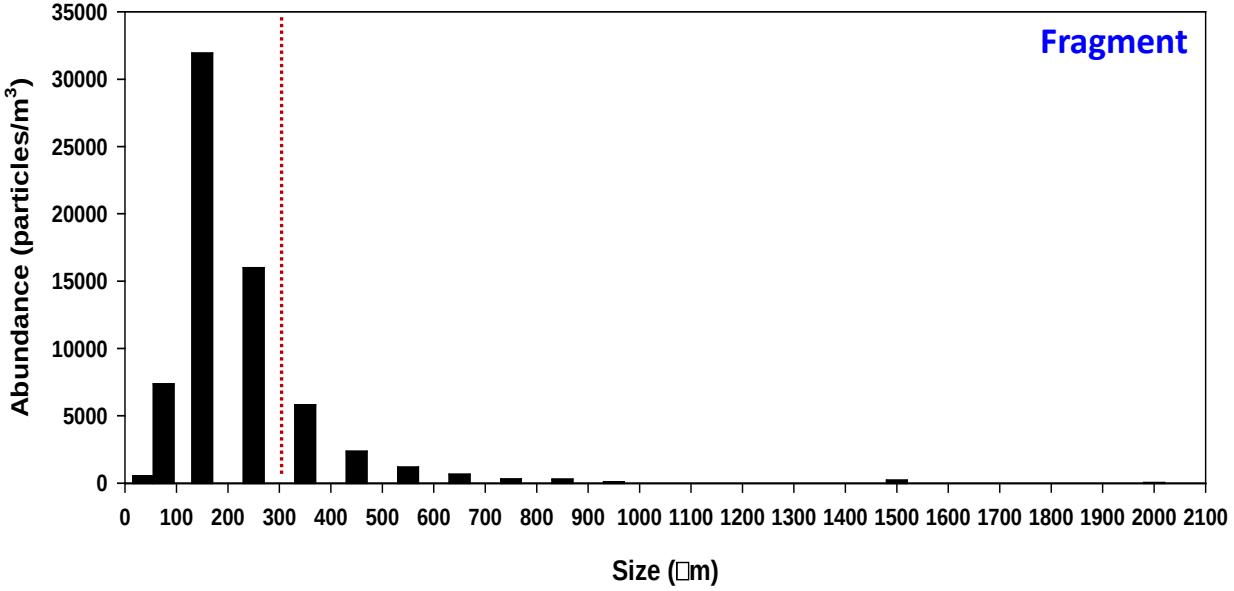


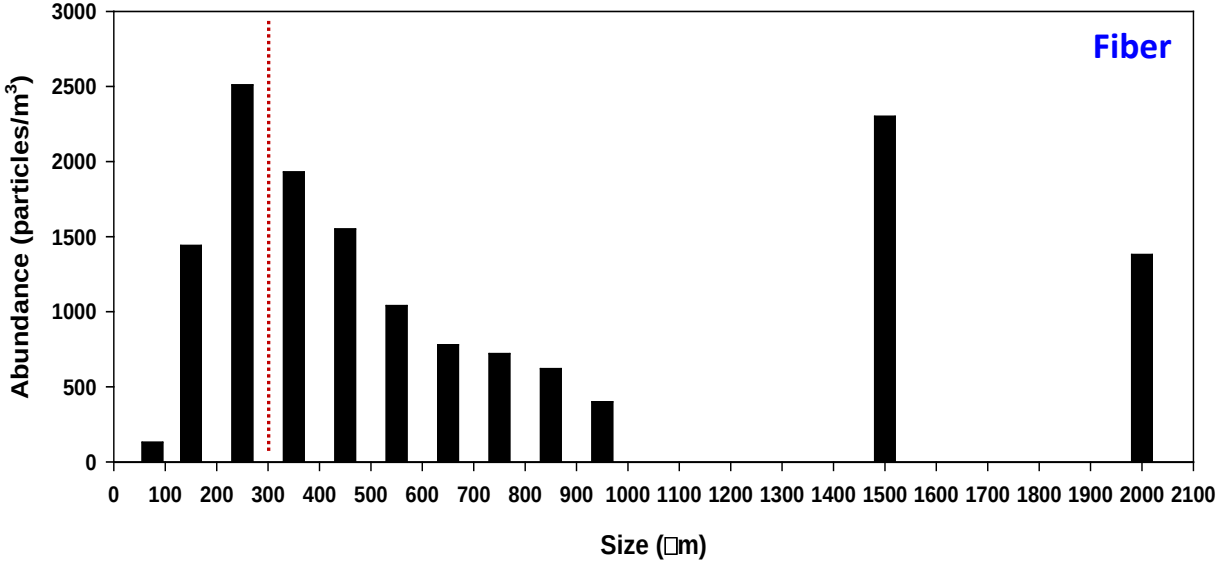
Horizontal and vertical distribution of MP (>20 μm) in Korean coastal water



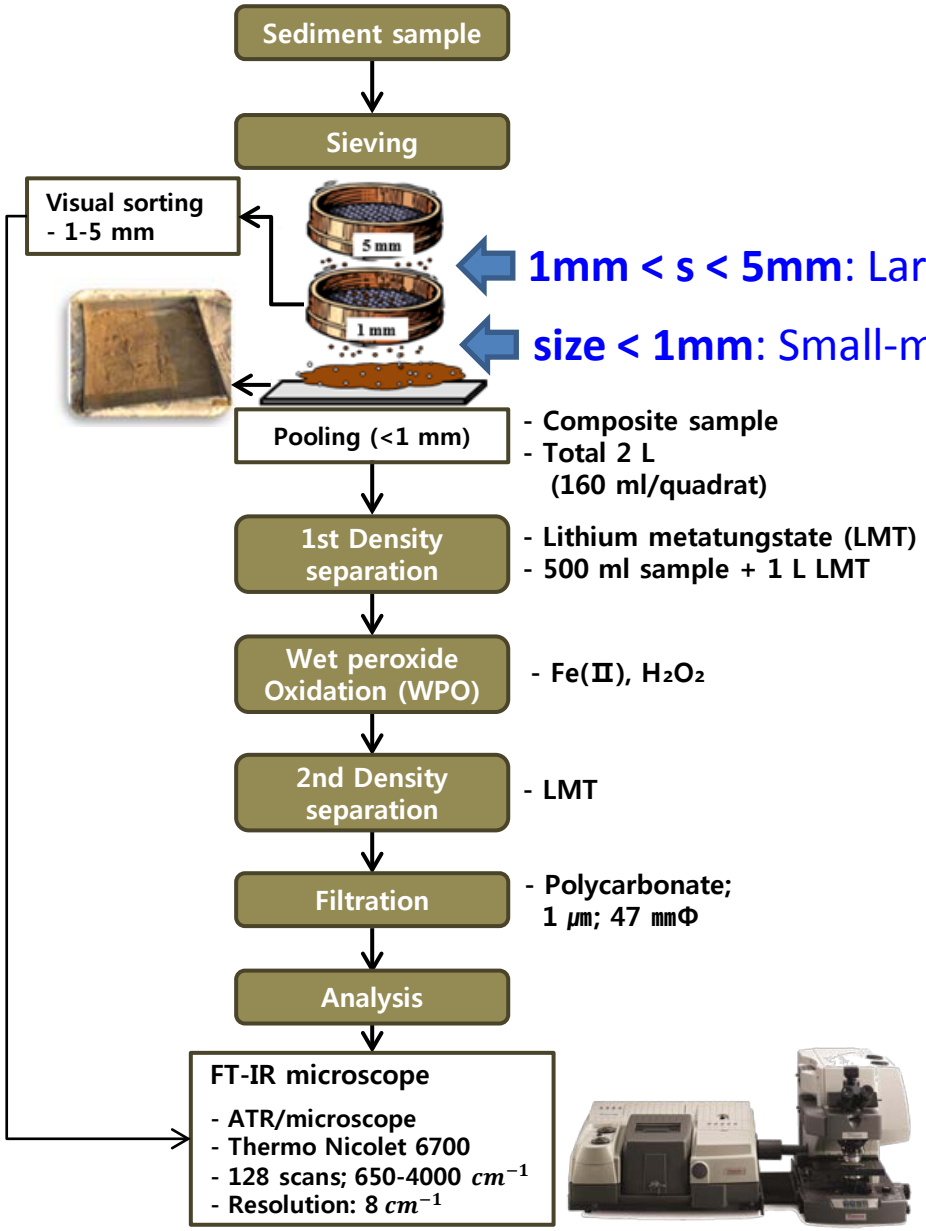


Size distribution of MP (>20 μm) in Korean coastal water

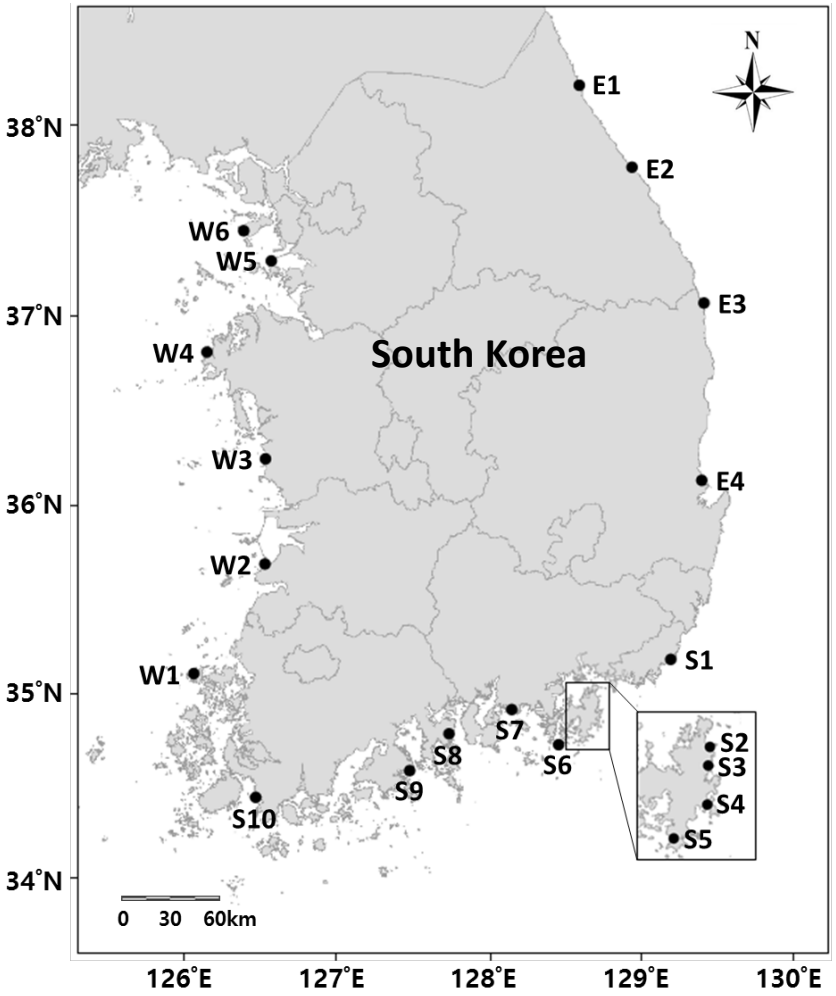


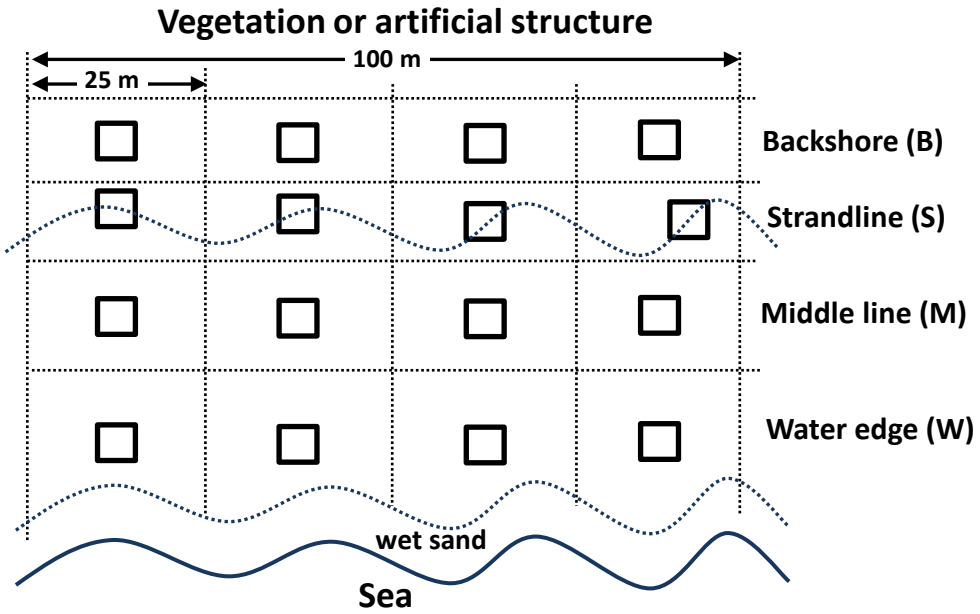


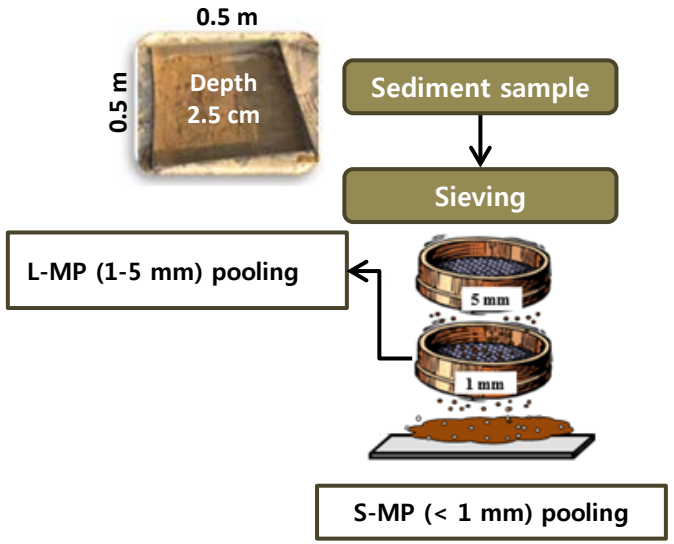
Monitoring and assessment protocols of microplastics in sediment



Monitoring of microplastics along the shoreline

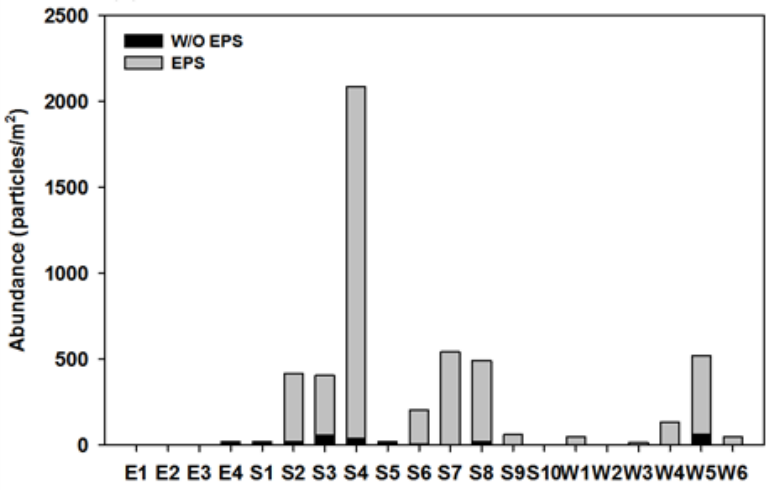




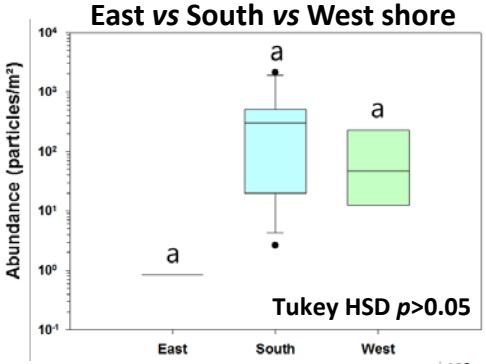


Abundance of MP on sand beach

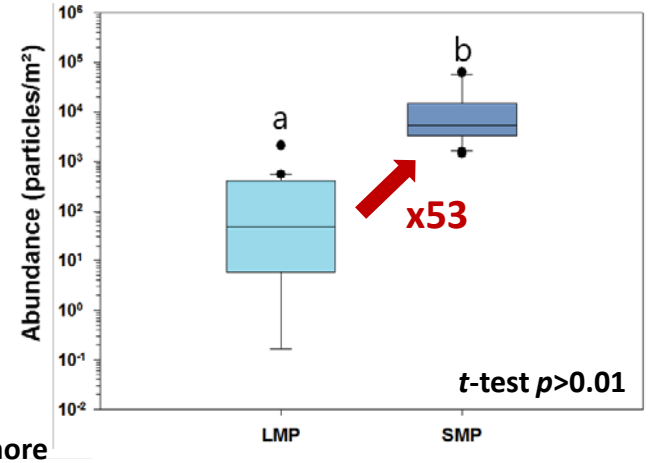
L-MP (1-5 mm)



East *vs* South *vs* West shore

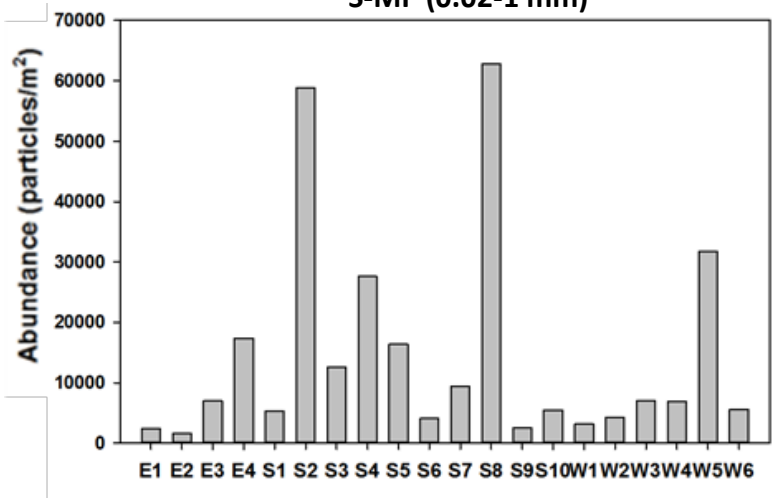


L-MP *vs* S-MP

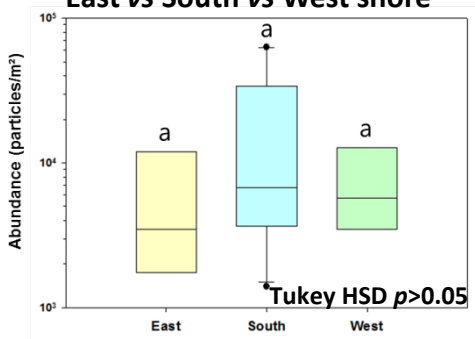


1 to 5mm < 1 mm

S-MP (0.02-1 mm)



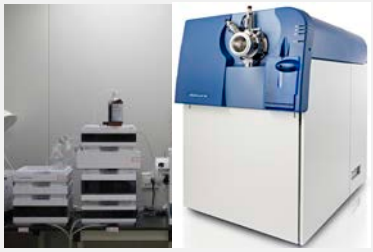
East *vs* South *vs* West shore



Non-target screening of marine plastic debris

Selection of Target Plastic Items

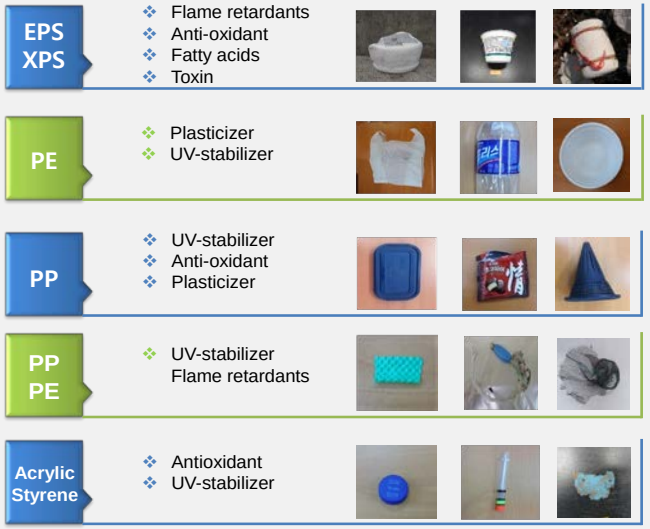
Non-target Screening Analysis



Identification of chemicals included in plastic debris

More than 200 chemicals

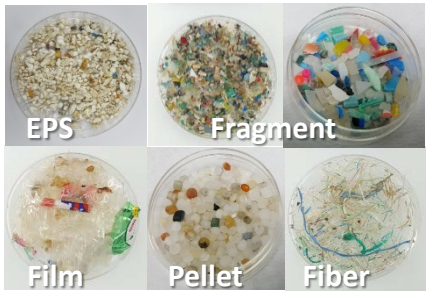
- **Antioxidant**
- **Plasticizer**
- **UV stabilizer**
- **Flame retardant**
- **Fatty acid**
- **Pesticide**
- **Lubricant**
- **Intermediate**
- **Toxin *etc.***



Rani et al. (2015) *Arch Environ Contamin Toxicol 69: 352*

Quantitative analysis of chemicals in plastic samples

Fragment, Fiber, EPS, Pellet, Film



Microplastic Sampling

Polymer Identification

Grinding

< 1mm | 1mm < size < 5mm | Size > 5 cm

Plasticizers, UV stabilizers Antioxidants, HBCDs

Surrogate standard

Extraction (Soaking)

Filtration (0.20 ㎛)

Concentration

Internal standard

LC-TOF/MS
LC-MS/MS

Surrogate standard

Extraction (Soaking)

Si/Al cleanup

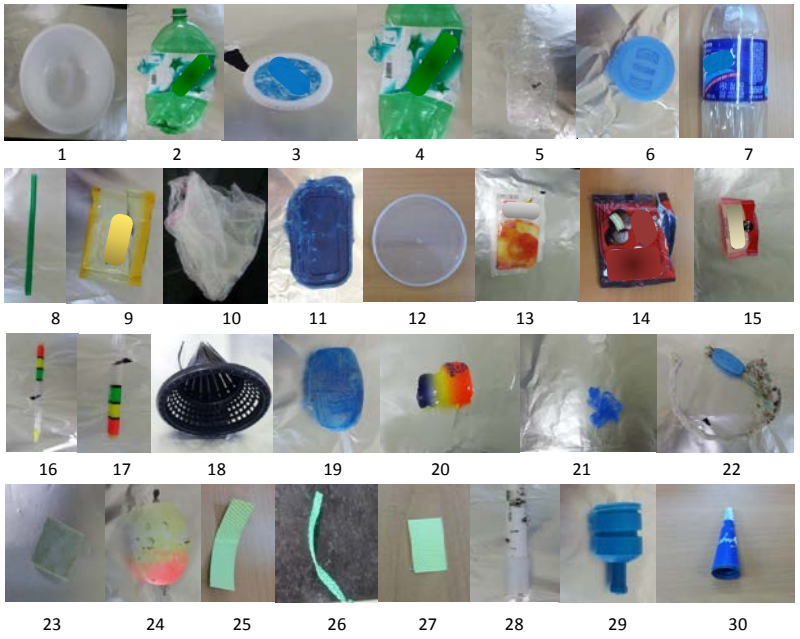
GPC cleanup

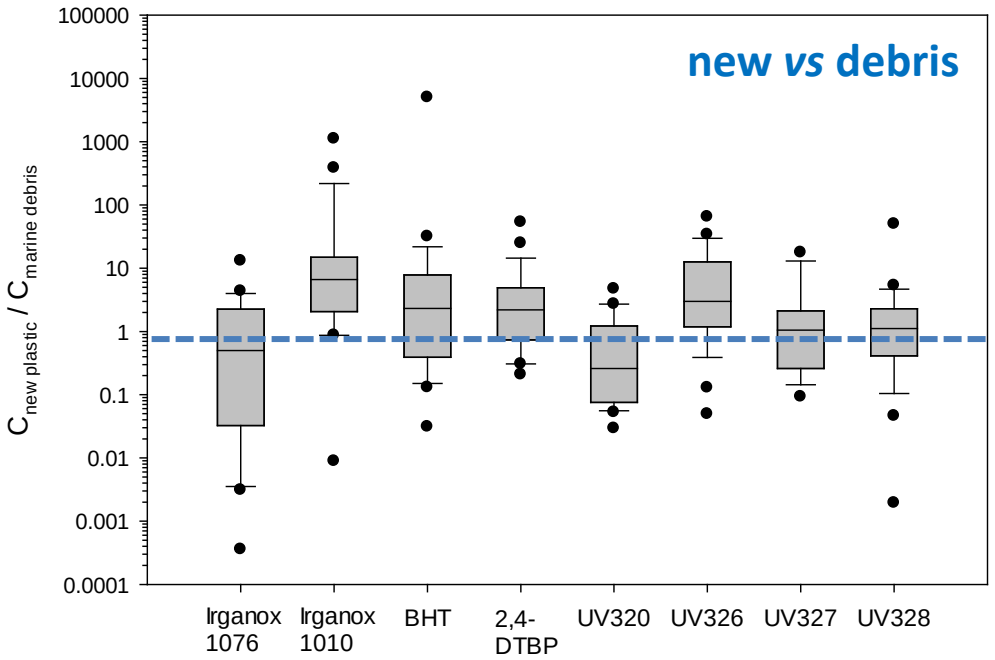
Internal standard

GC-HRMS (EI)
GC-MS(EI)(PAHs)
GC-MS (NCI) (PBDEs)

PCBs, OCPs, PBDEs, PAHs

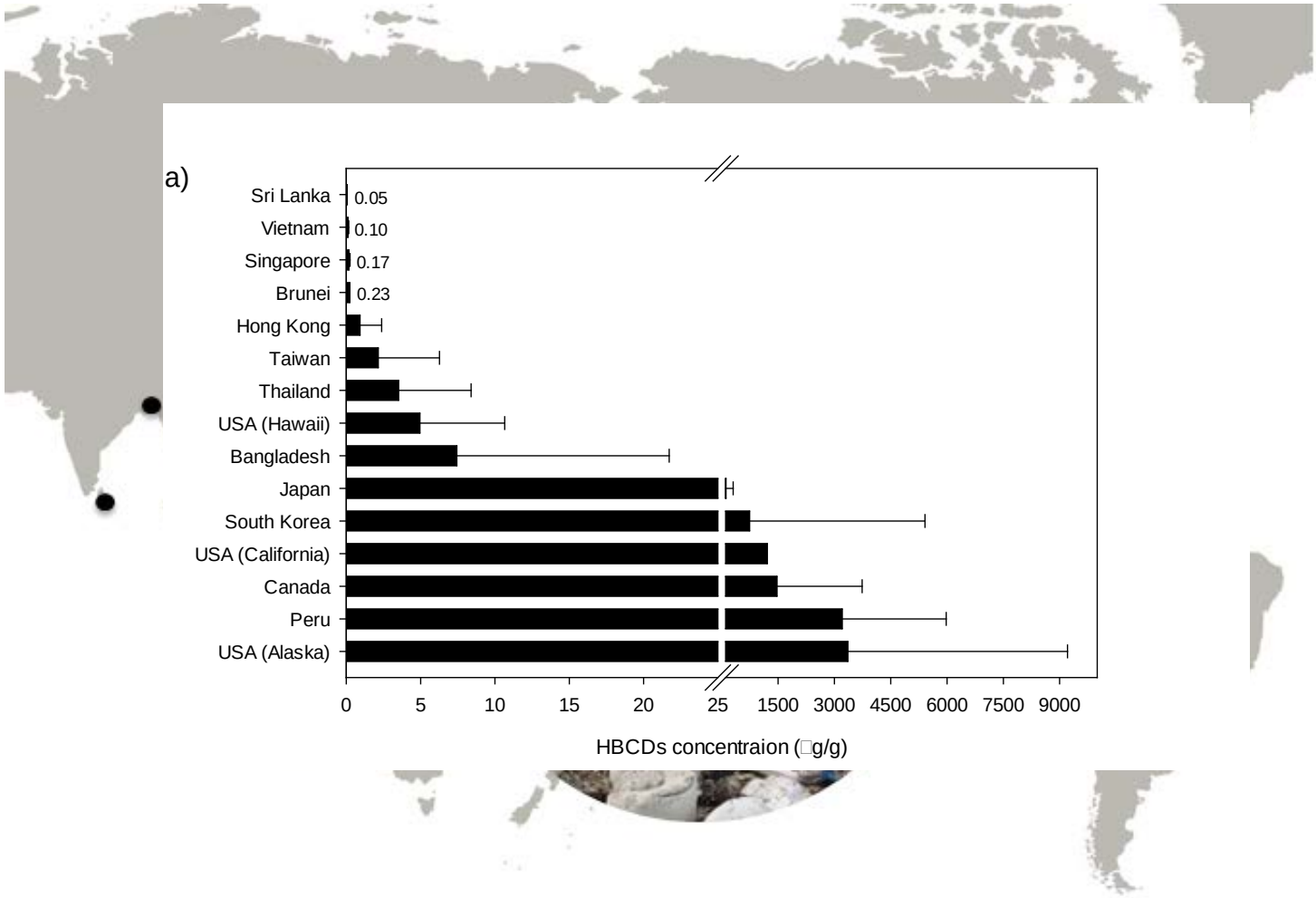
Antioxidants and UV stabilizers in plastic debris





Rani et al. (2017*) Sci. Total Environ.* 579: 745

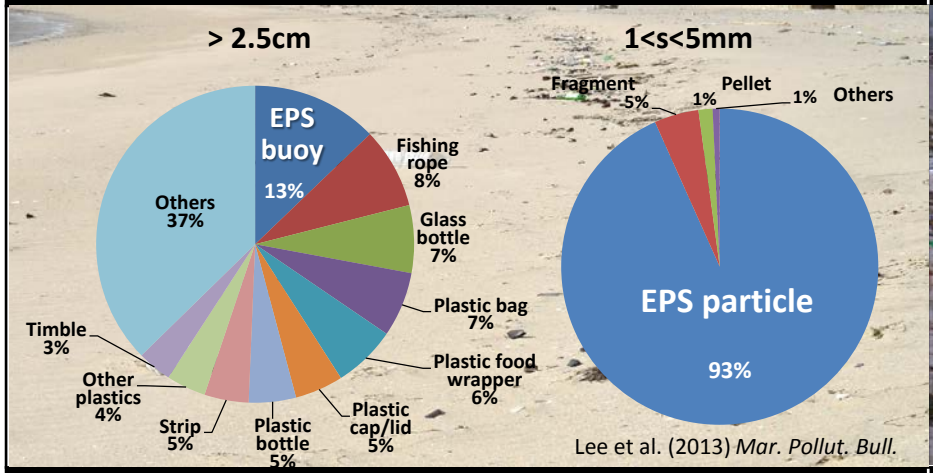
A brominated flame retardant (HBCD) in EPS debris



Jang et al. (2017) *Environ. Pollut.* 231: 785

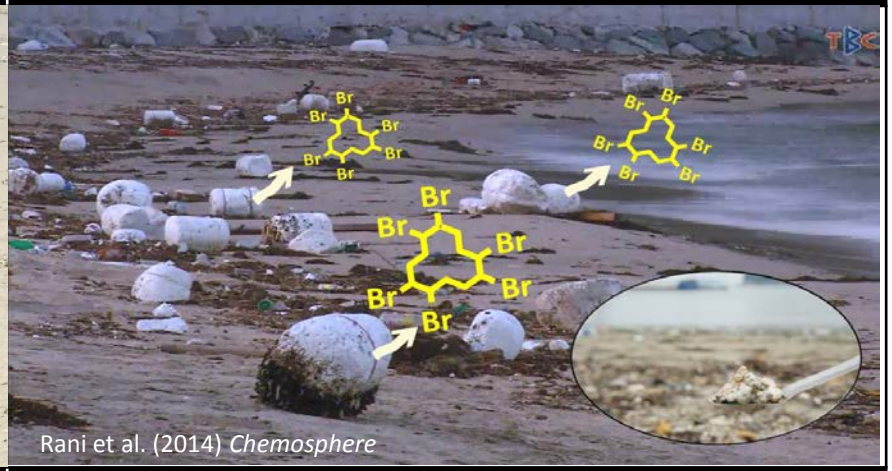
From Scientific Findings to Policy change

① High contamination of styrofoam MP



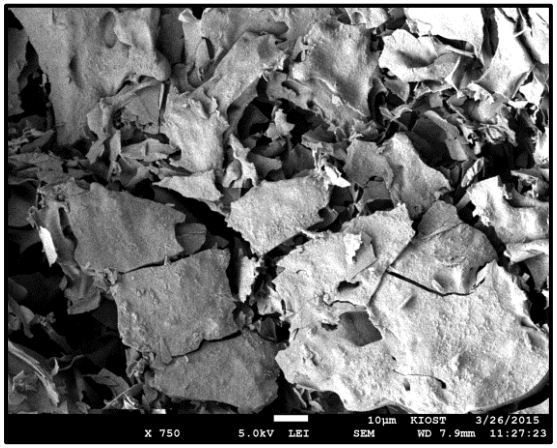
Lee et al. (2013) *Mar. Pollut. Bull.*

② Inclusion of hazardous chemical



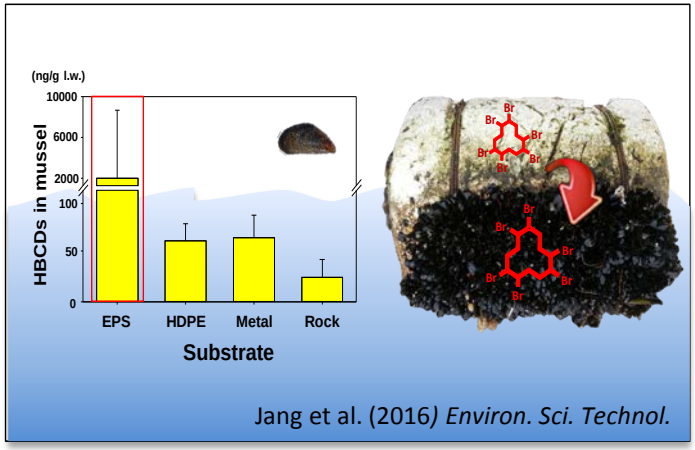
Rani et al. (2014) *Chemosphere*

③ Rapid fragmentation to microplastics

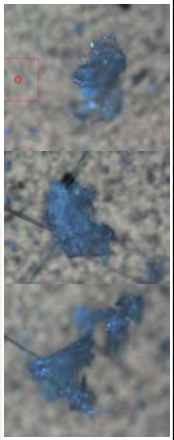


Song et al. (2017) *Environ. Sci. Technol.*

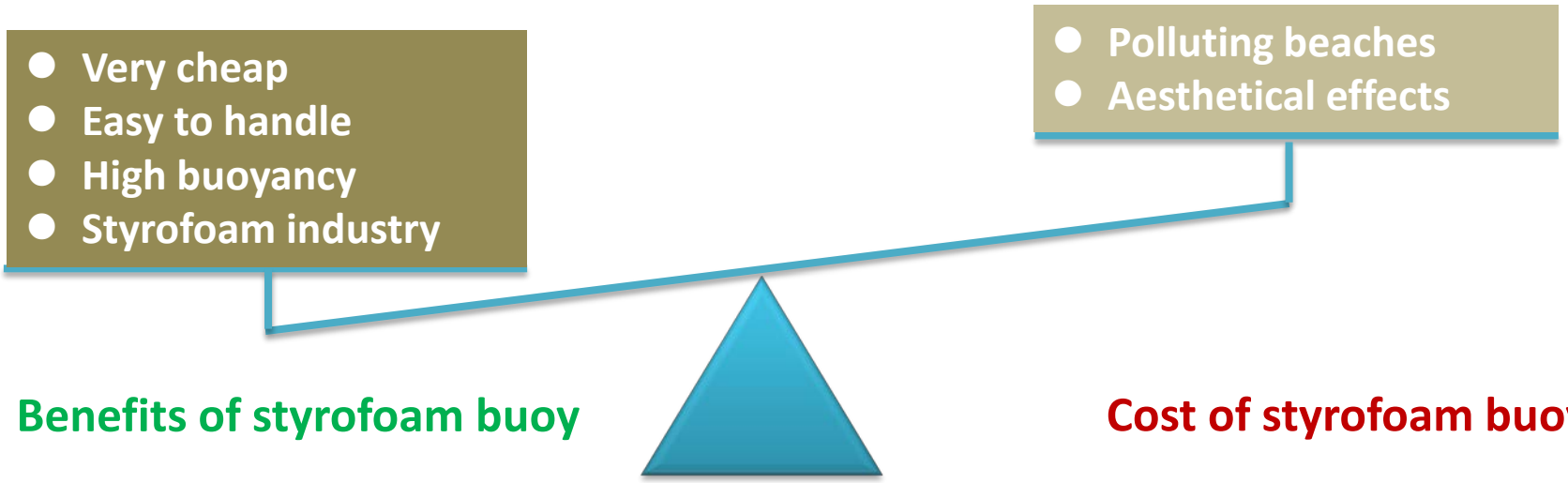
④ Ingestion by marine organisms and chemical transfer



Jang et al. (2016*) Environ. Sci. Technol.*



Weight of cost and benefits



Policy changed

- Replace EPS to alternative buoy (Government support 40% of price)
- Increase recovery rate of the used buoy (10% →30%)
- Regulate HBCD use in EPS buoy from 2017
- Development of alternative buoy

- Increasing cost
- Easy to handle
- High buoyancy
- Effects on EPS industry

- >90% in mesoplastics
- Rapid fragmentation
- Leaching HBCDs
- Ingestion by organisms

- Polluting beaches
- Aesthetical effects

Benefits of styrofoam buoy

Cost of styrofoam buoy

Thank you!

Acknowledgement

Ministry of Oceans and Fisheries

KIOST
KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY