

2017 SGs Science Day: Waste Prevention Audit:

30 March 2017

IMO Headquarters, London

Styrofoam debris in the Republic of Korea

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&

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October 2016 after Typhoon Chaba (Geogje Coast, Korea) @ SHH



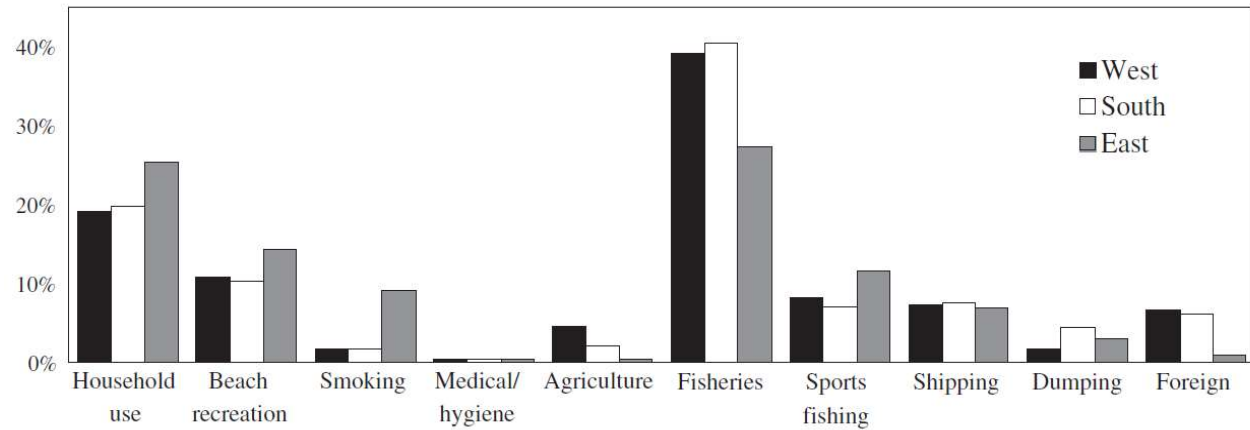
October 2016 after Typhoon Chaba (Geoje Coast, Korea) @ 홍상희

National Beach Monitoring Program: Macro Debris

- Ref.: S Hong et al. (2014) Mar. Pollut. Bull. -



● Sources of beach debris



- **Most common items**

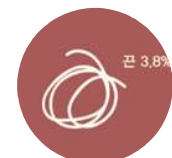
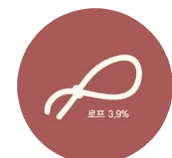
Rank	Items	%
1	Styrofoam buoys	12.8
2	Fishing ropes	8.2
3	Beverage bottles (glass)	6.9
4	Plastic bags	6.6
5	Plastic food wrappers	6.4
6	Plastic caps and lids	4.9
7	Beverage bottles (plastic)	4.8
8	Plastic strapping bands	4.5
9	Miscellaneous plastic items	4
10	Timber (for ships and aquaculture facilities)	3.5
Total		62.7



Top 10 Macro-Marine Debris (>2.5 cm)

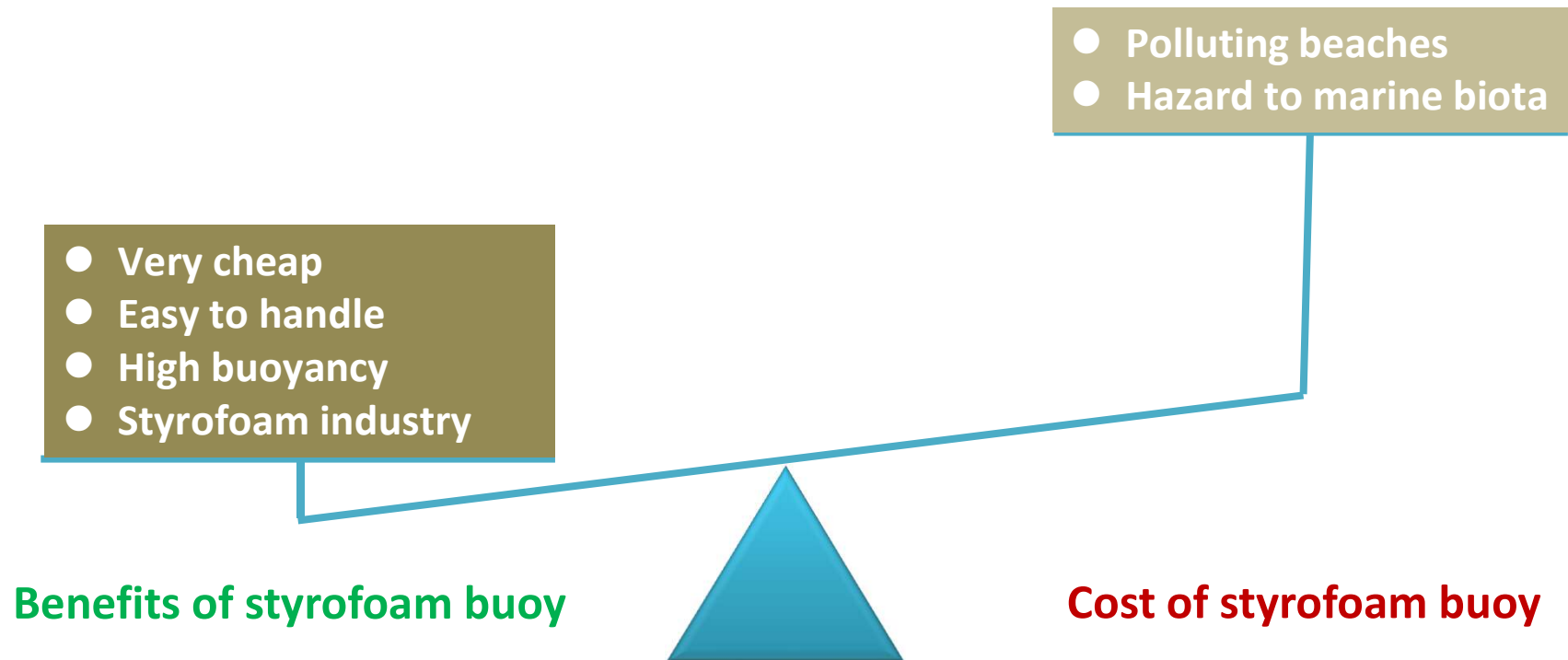
[International Coastal Clean-up 2001-2010]

- Plastic items are dominant
- Buoy and rope represent a large portion of marine debris in South Korea compared to other countries

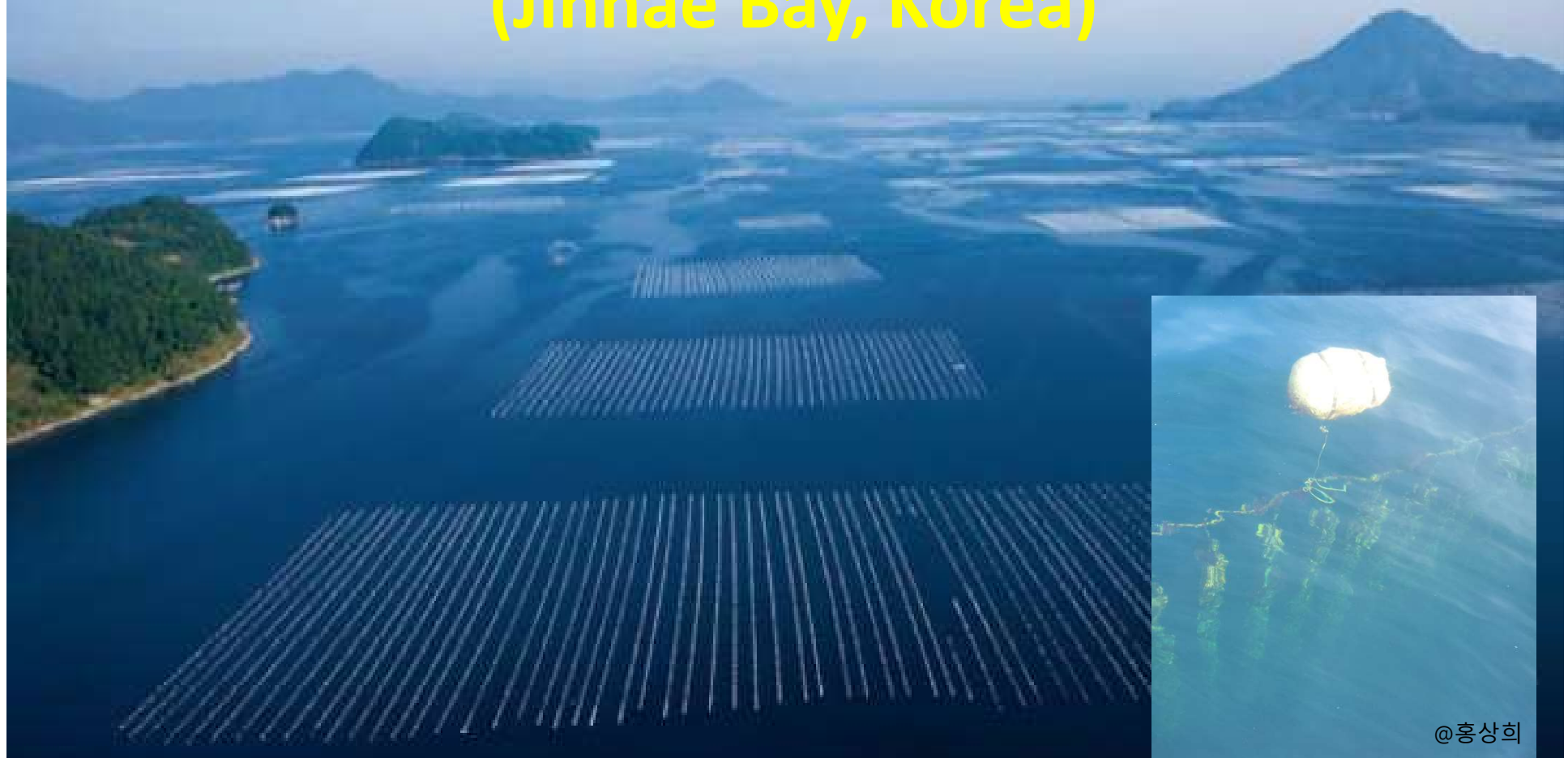


Rank	World	South Korea	
1	Cigarettes/filters	Cigarettes/filters	18%
2	Food wrappers	Grocery bags (plastic)	8.6%
3	Beverage bottle (plastic)	Beverage bottle (plastic)	8.6%
4	Caps, Lids (plastic)	Buoy	7.0%
5	Straws, Stirrers	Caps, Lids (plastic)	6.9%
6	Grocery bags (plastic)	Beverage bottles (glass)	6.1%
7	Beverage bottles (glass)	Beverage cans	4.9%
8	Other plastic bags	Food wrappers/containers	4.5%
9	Paper bags	Rope	3.9%
10	Beverage cans	Strip	3.8%

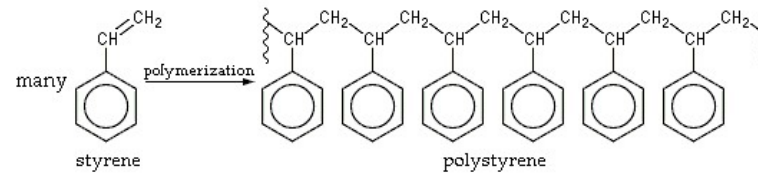
A few initial findings from scientific studies triggered several administrative actions



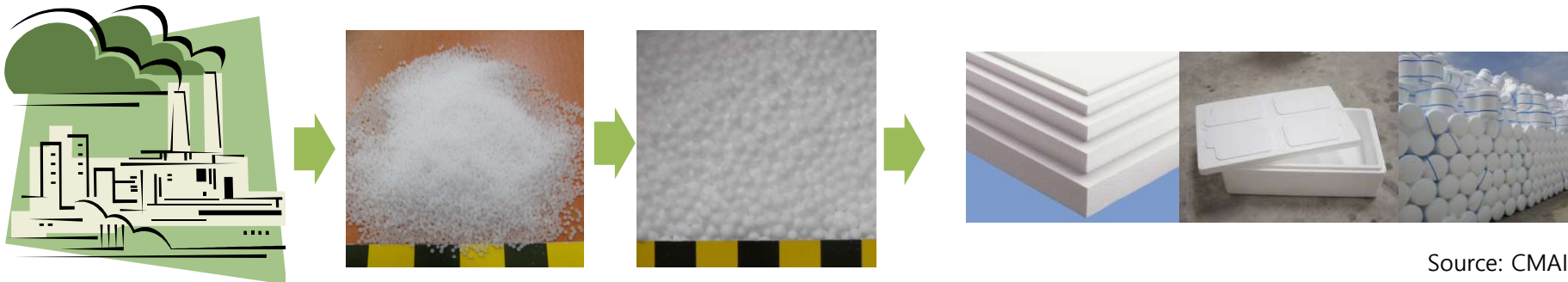
Expanded Polystyrene (EPS) [Styrofoam] Buoys being used extensively by coastal aquaculture industry (Jinhae Bay, Korea)



Expanded Polystyrene (EPS)



- Polystyrene (PS): synthetic aromatic polymer made from monomer styrene
- Type of PS in the market: expanded PS (EPS), extruded PS foam (XPS), extruded PS
- **Commonly known as Styrofoam**
- Useful properties: insulation, lightweight, durability, very cheap
- Application: insulation materials for construction, packing materials, floatation devices
- Enormous growth in EPS market in the last decades



Source: CMAI

EPS market in South Korea

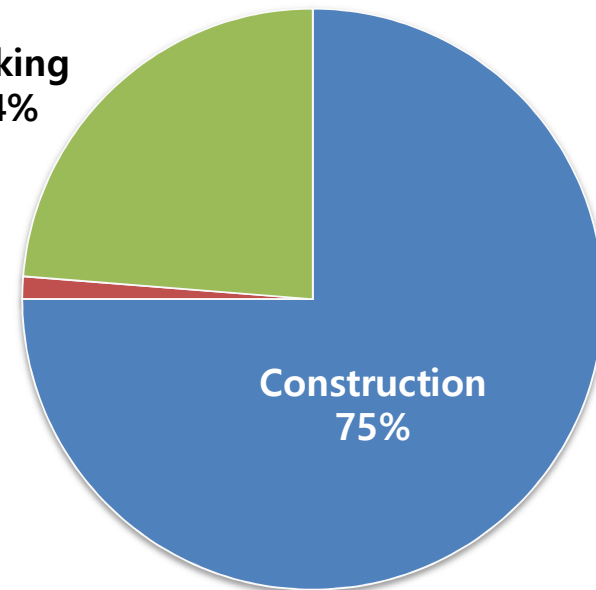
Annual production of EPS : 200,000 tons

- ✓ Construction materials: 150,000 tons
- ✓ Packing materials: 47,500 ton
- ✓ **Aquaculture buoy: 2,500 tons**



Packing
24%

Buoy
1.25%



Life cycle of EPS at Sea

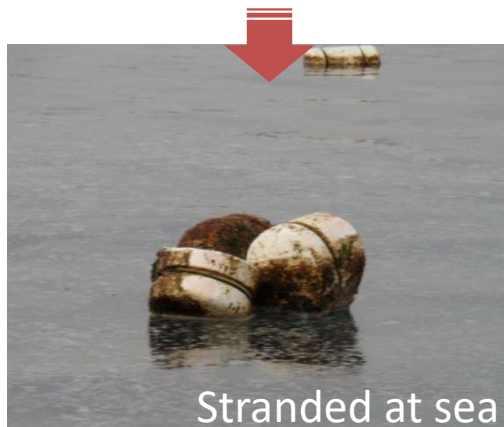
Placement



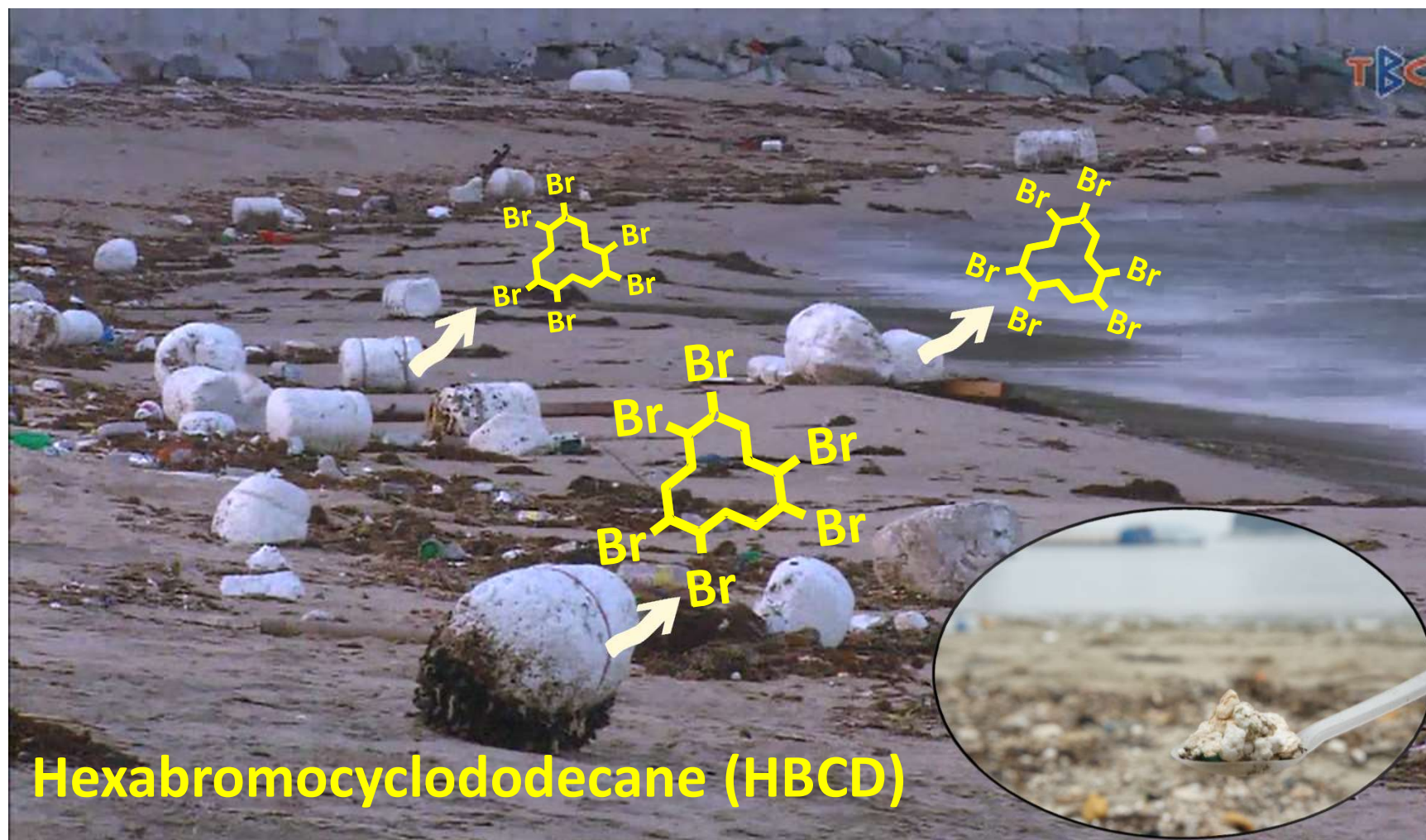
Retrieval



Lost

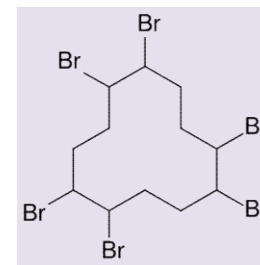


EPS debris laden with hazardous chemical HBCD

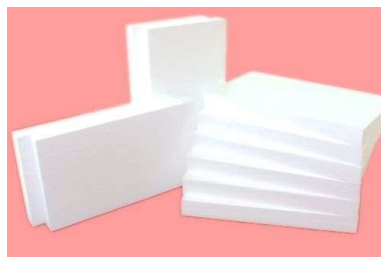


Al-Odani et al. (2014) *Sci. the Total Environ.*
Rani et al. (2014) *Chemosphere*
Jang et al. (2016) *Environ. Sci. Technol.*

Hexabromocyclododecane (HBCD)



- EPS is equipped with brominated flame retardants (BFR) as most EPS is used as insulation material
- Use : An additive to **styrofoam construction materials (0.7 to 2.5% HBCD w/w)**



Insulation material in building



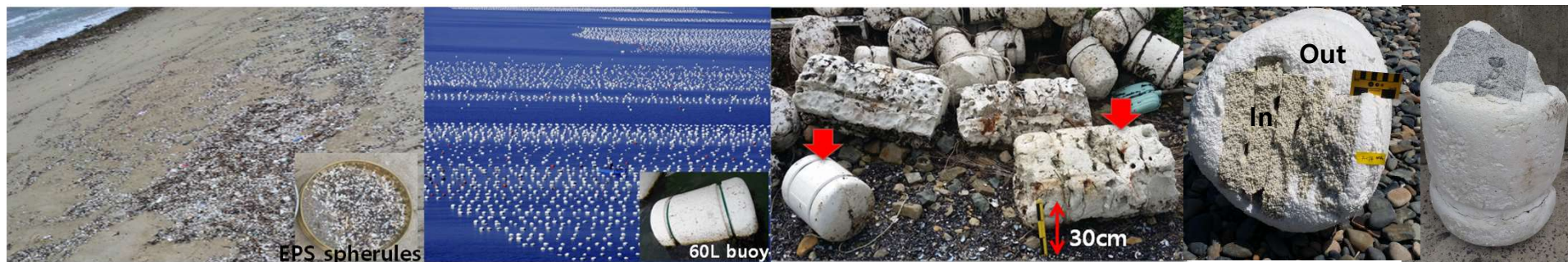
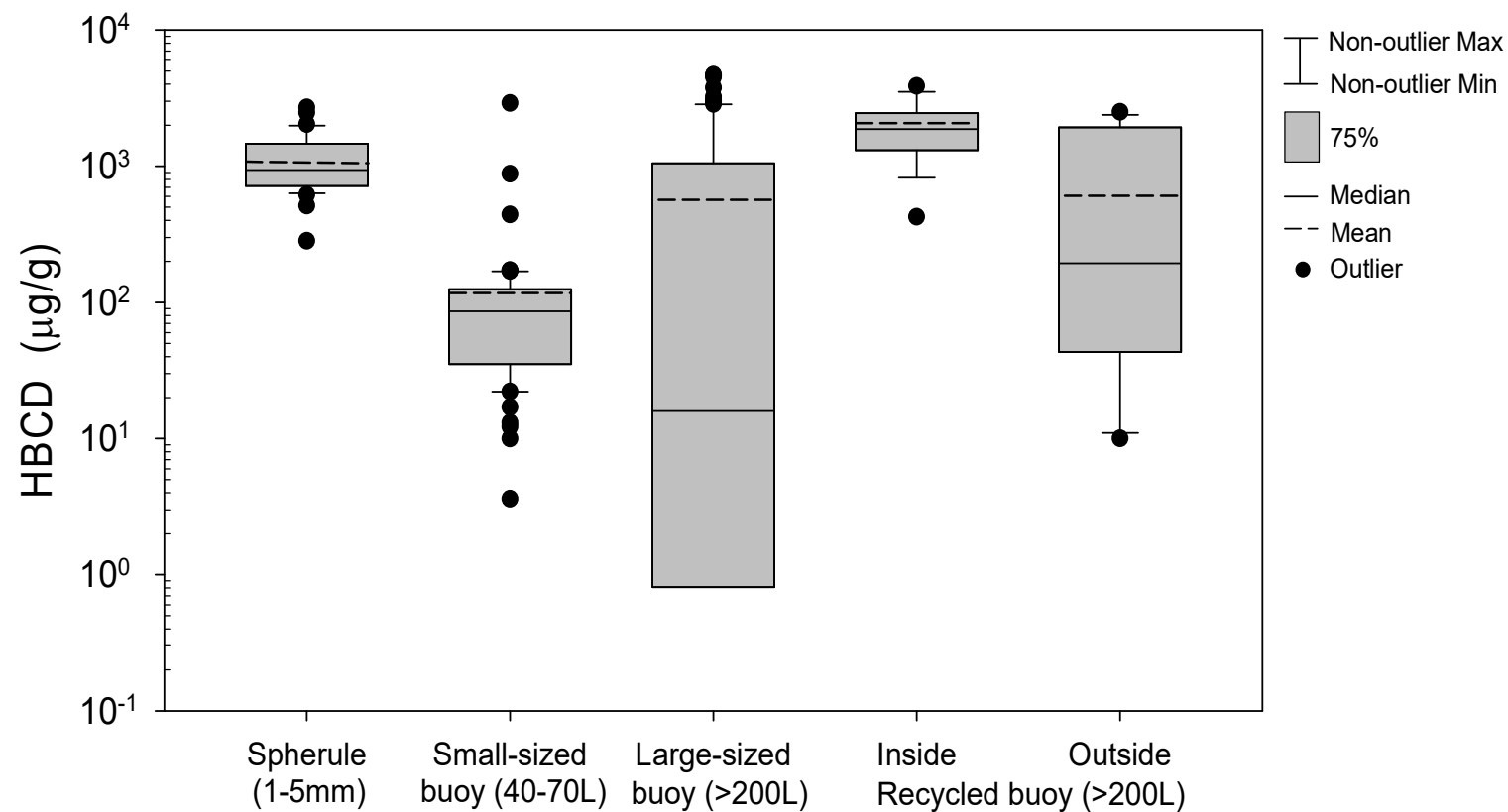
Textile industry



Electronic housing
(high impact polystyrene)

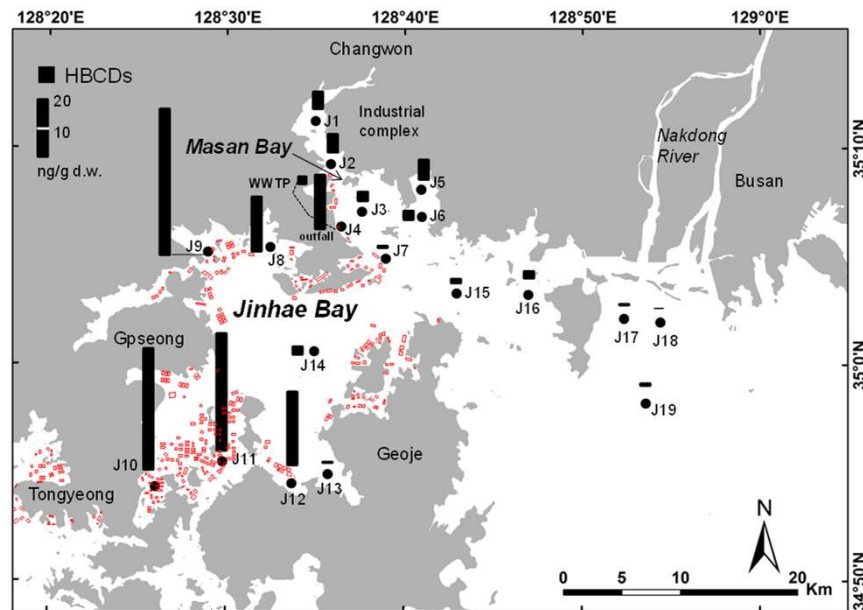
- Persistent, long-range transport, and bioaccumulative ($\text{Log } K_{ow} = 5.6$) ;
- High toxicity: carcinogenicity, mutagenicity, and neurotoxicity;
- Third highest-volume BFR after tetrabromobisphenol-A (TBBPA) and polybrominated diphenyl ethers (PBDE);
- **Listed in the Stockholm Convention on Persistent Organic Pollutants (May 10, 2013)**

HBCDs in EPS debris from the Korean coast

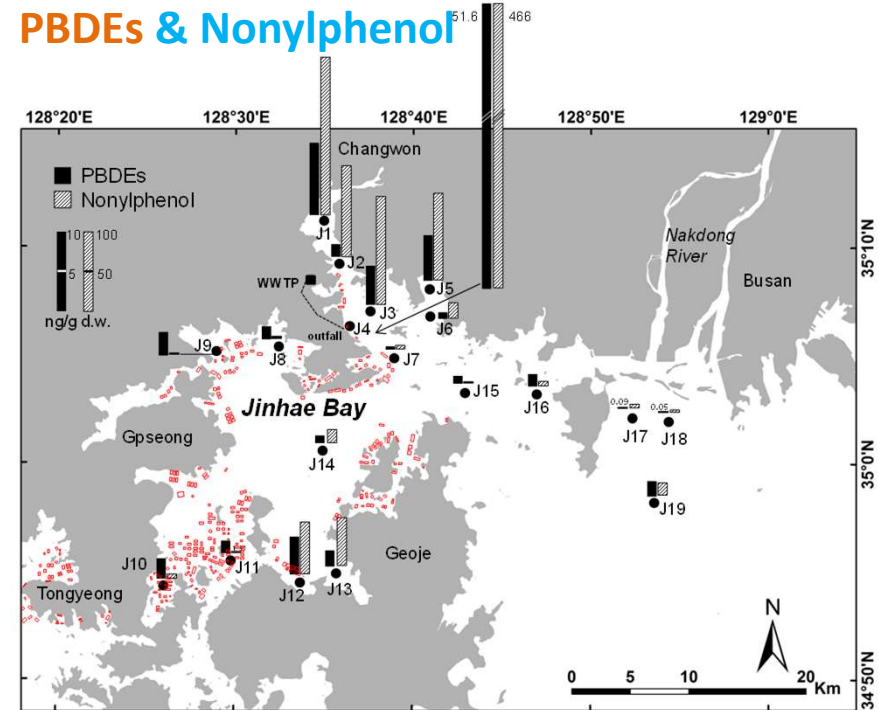


Bottom sediments enriched with HBCDs

HBCDs



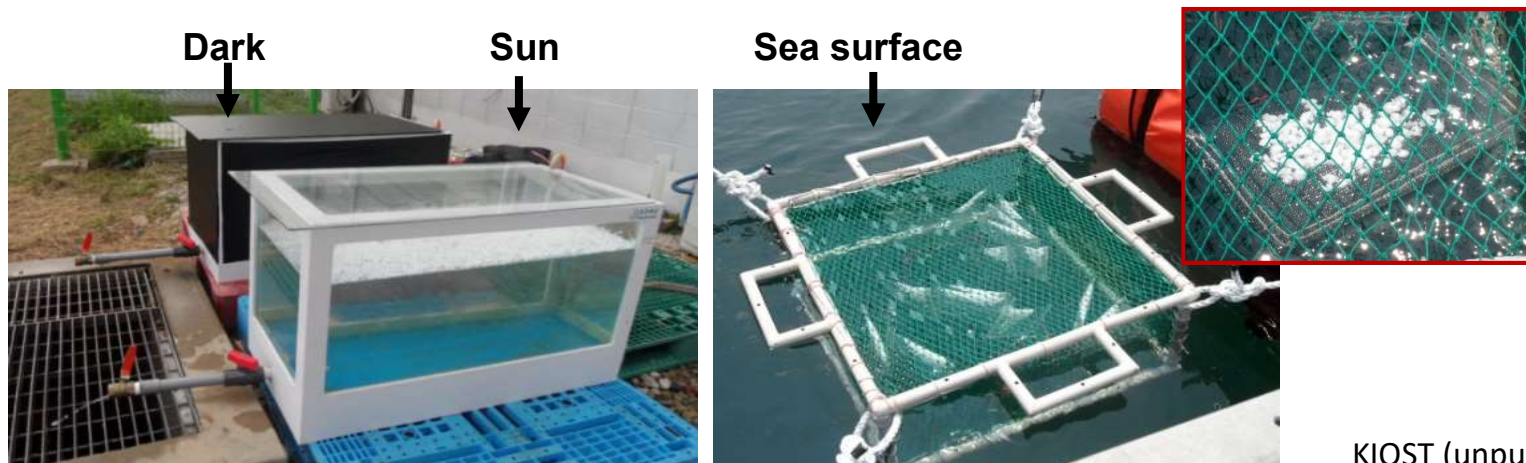
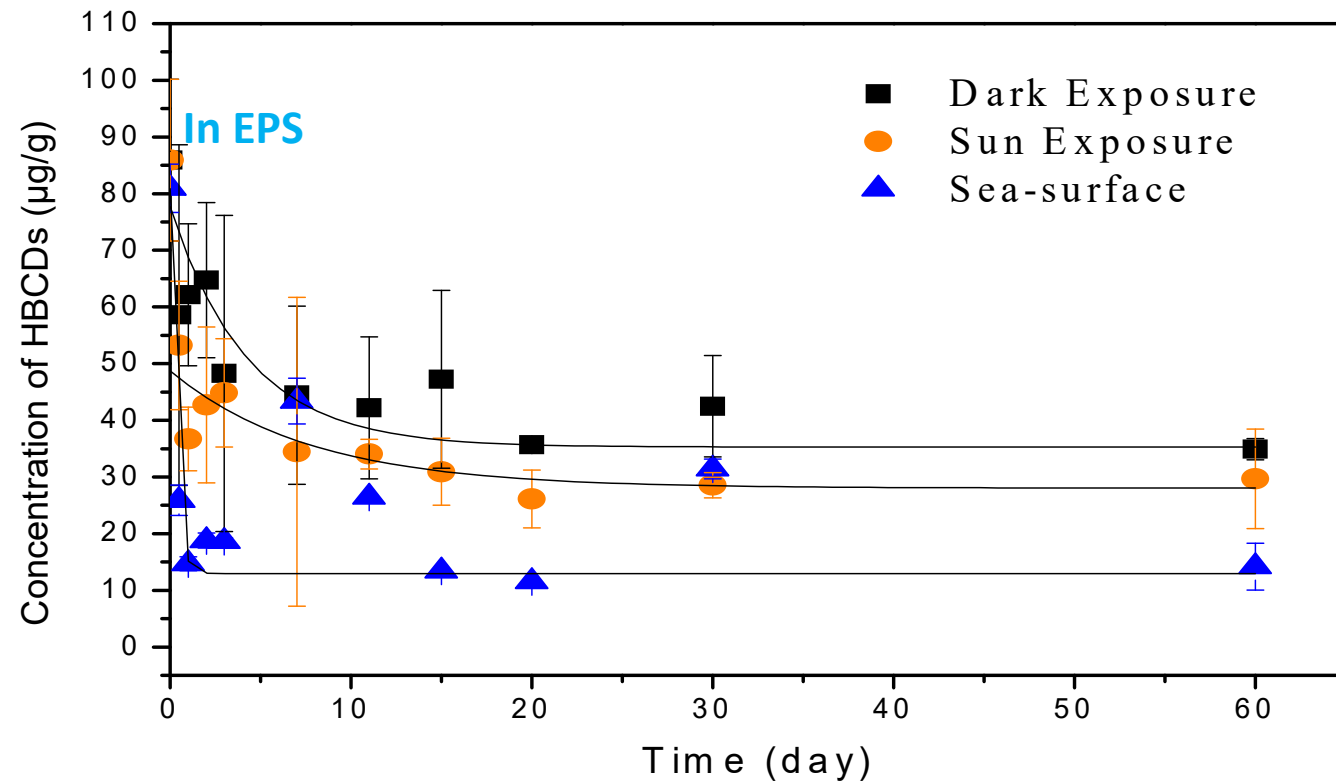
PBDEs & Nonylphenol



@ Donga Science

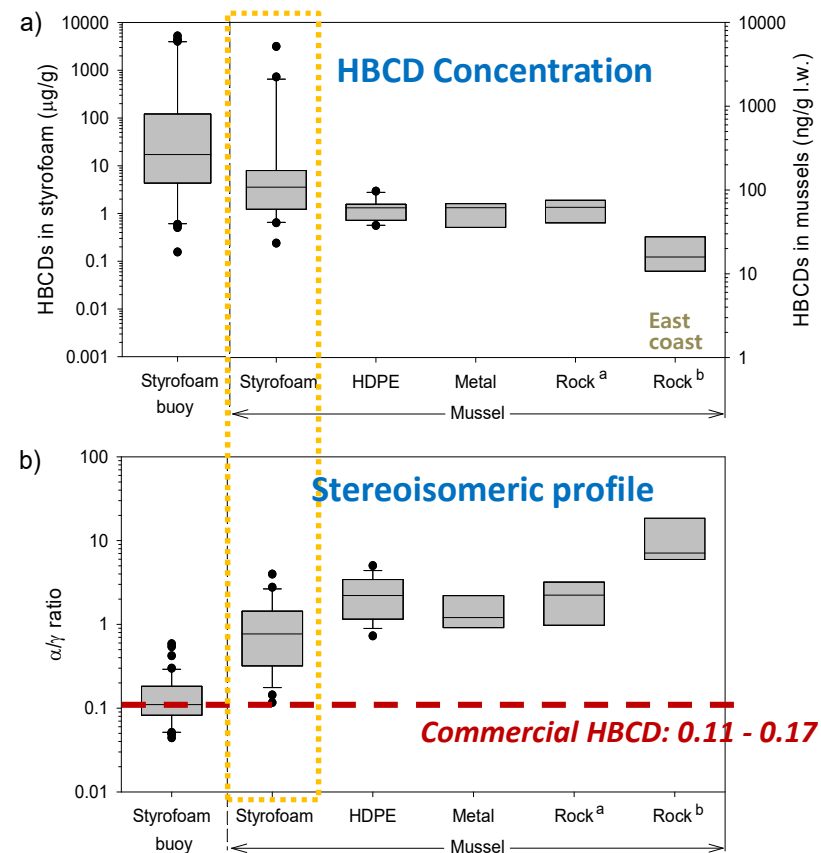
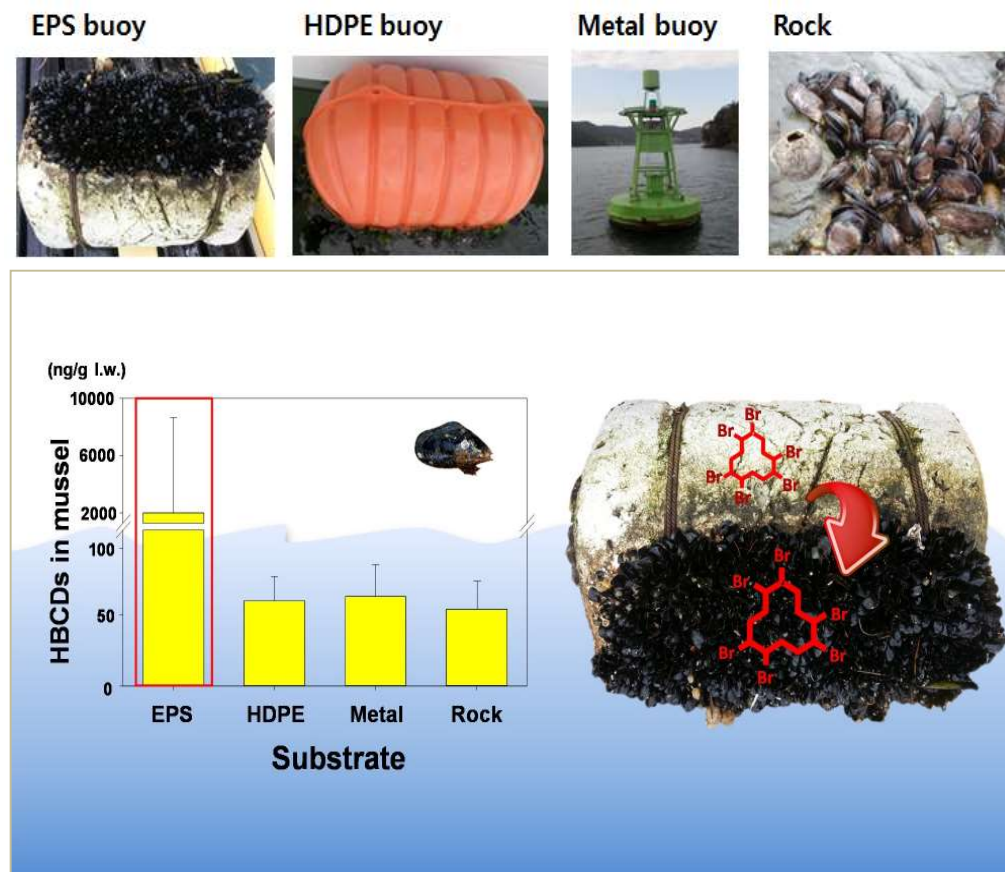
Al-Odani et al. (2014) *Sci. the Total Environ.*

HBCD leaches rapidly from EPS particles into seawater



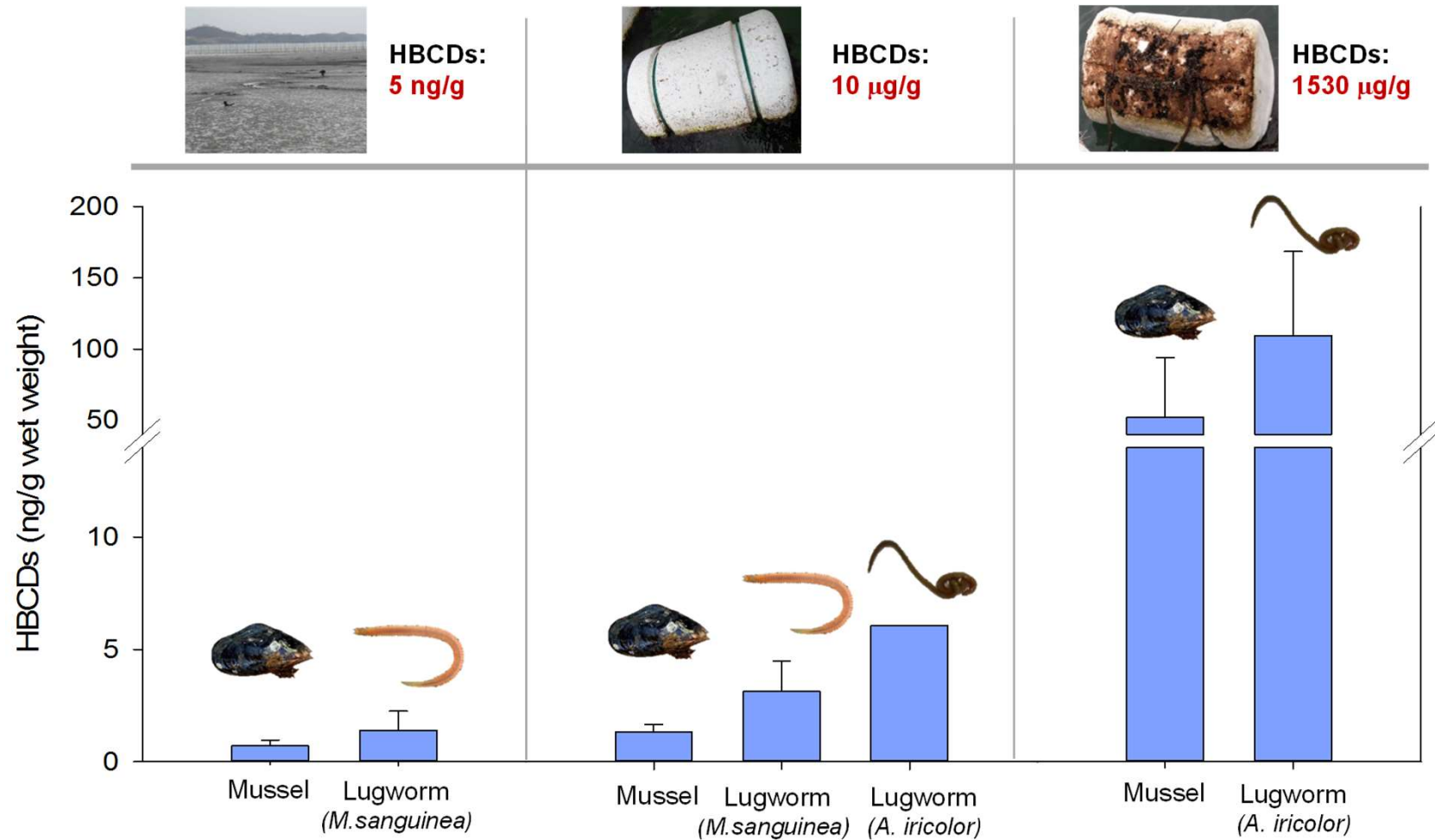
KIOST (unpublished data)

Transfer of HBCD from EPS to marine organism



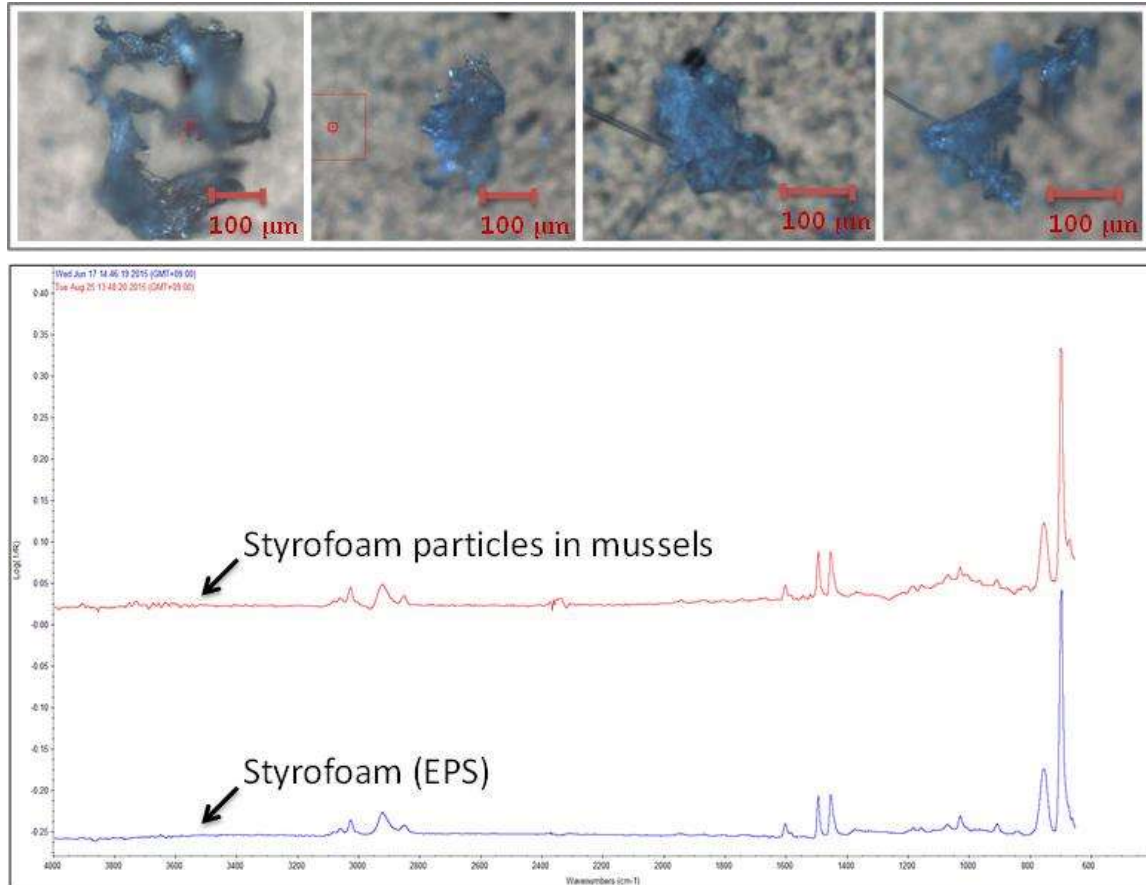
Jang et al. (2016) *Environ. Sci. Technol.*

HBCD in EPS habitats transferred into the inhabiting animal bodies



Jang et al. (2016) *Environ. Sci. Technol.*
KIOST (unpublished data)

EPS particles ingested by marine organism



-Mussels inhabiting EPS debris-

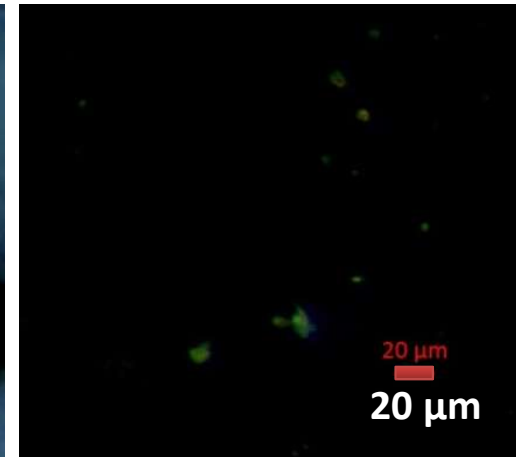
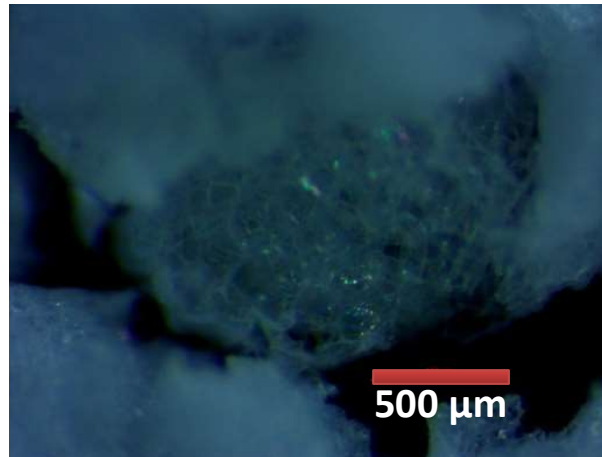
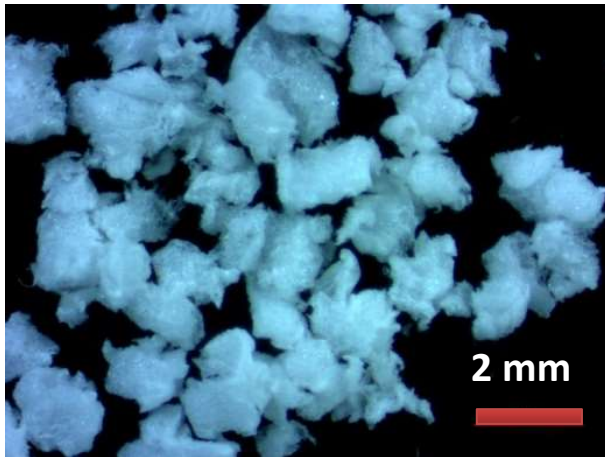
Jang et al. (2016) *Environ. Sci. Technol.*

EPS particle ingestion by marine organism

-lugworms inhabiting EPS debris-

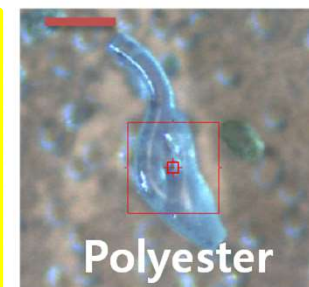
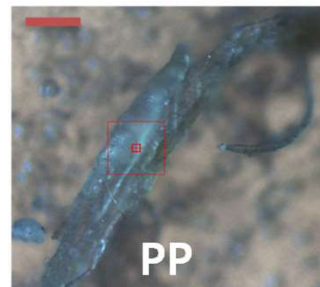
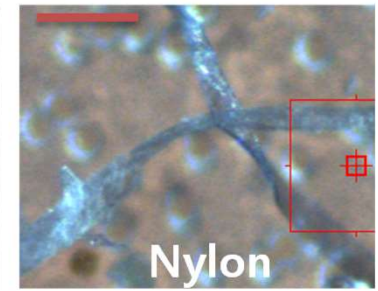
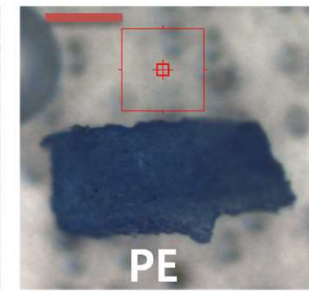
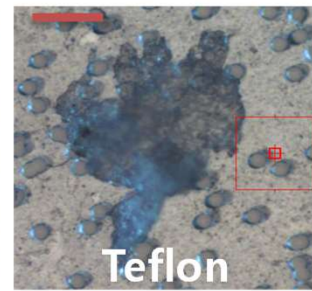
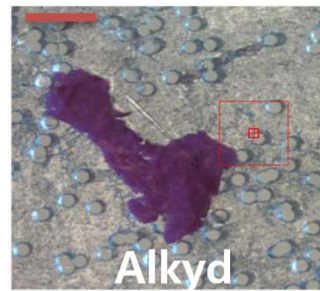


Feces



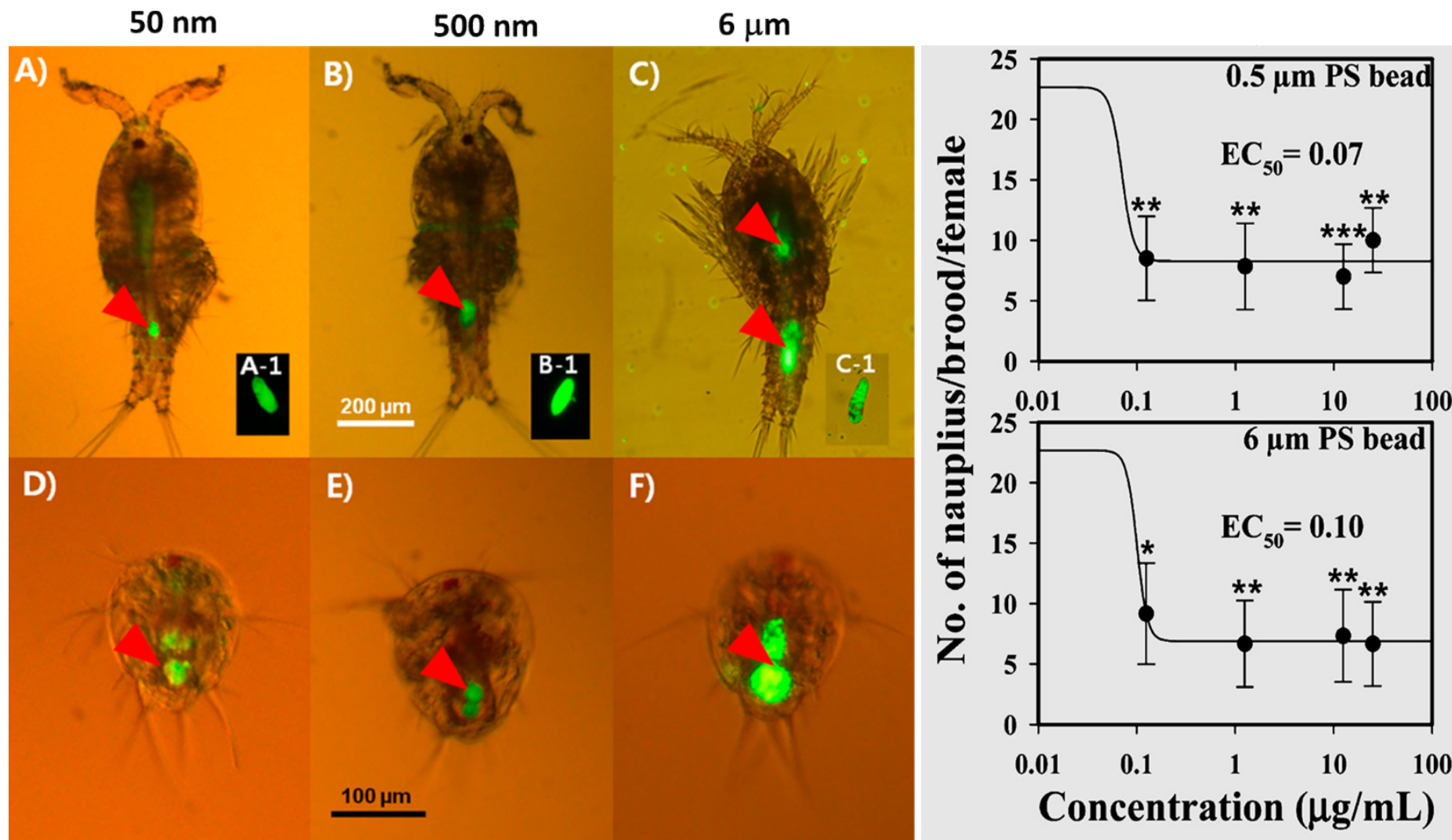
EPS particle ingestion by marine organism

-Bivalves and lugworms inhabiting natural habitat-



50μm

Nano and micro-PS bead ingestion by zooplankton



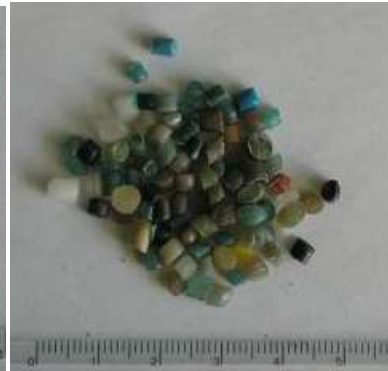
Lee et al. (2014) *Environ. Sci. Technol.*

Plastic resin pellets (primary microplastics) are small granules (19-26 mm³) generally with shape of a cylinder or a disk with a diameter of a few mm. These plastic particles are industrial raw material transported to manufacturing sites where "user plastics" are made by re-melting and molding into the final products.

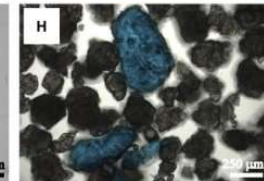
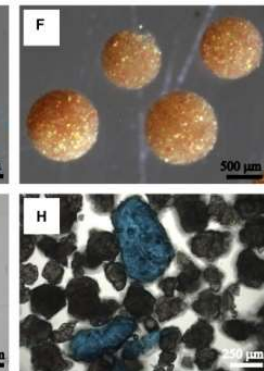
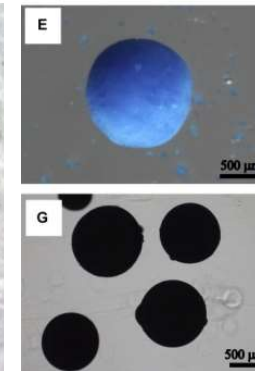
● Primary microplastics



Resin pellets (Geoje, Korea/ KIOST)

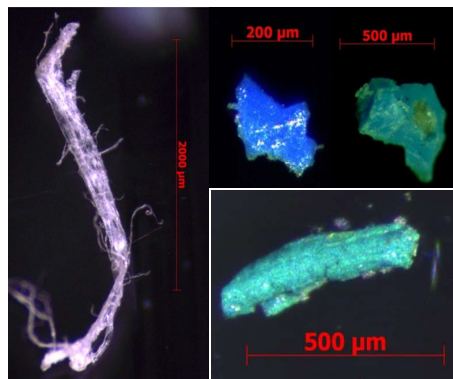


PE microbead in cosmetics

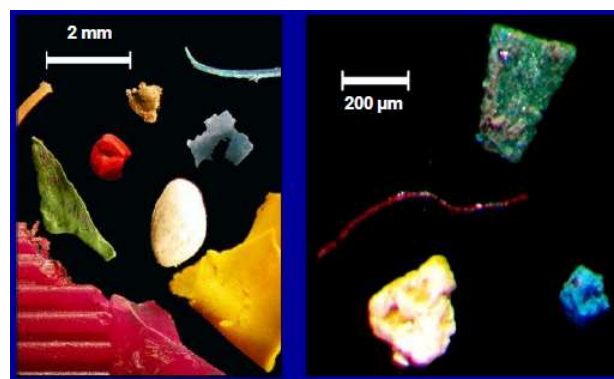


PE microbead (Fendall & Sewell, 2009)

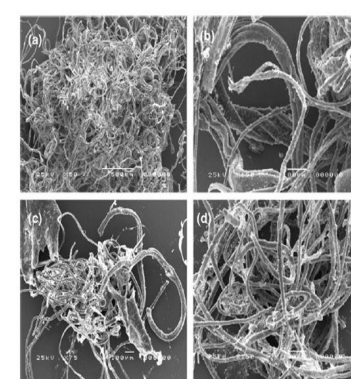
● Secondary microplastics



Fragment (Geoje/KIOST)



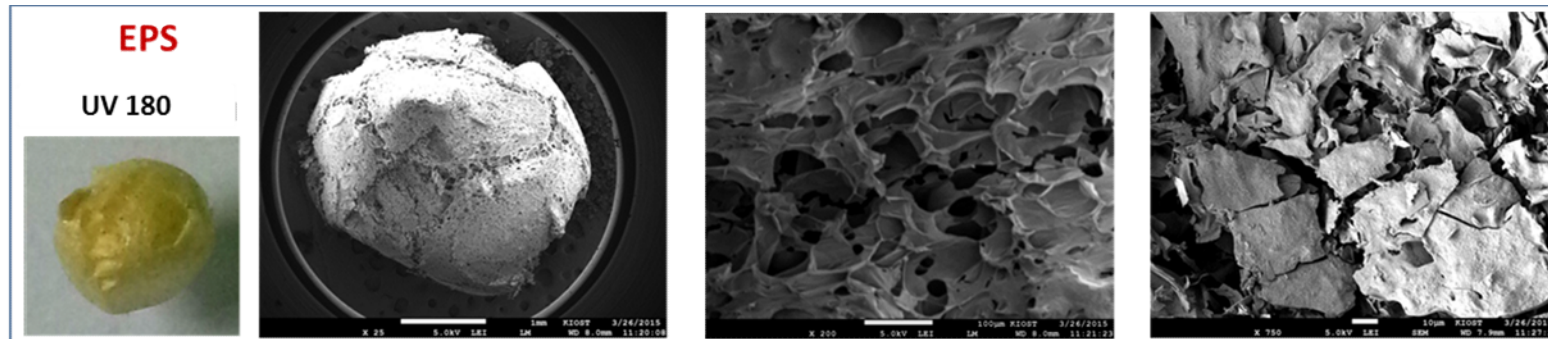
Sewage sludge (Zubris & Richards, 2005)



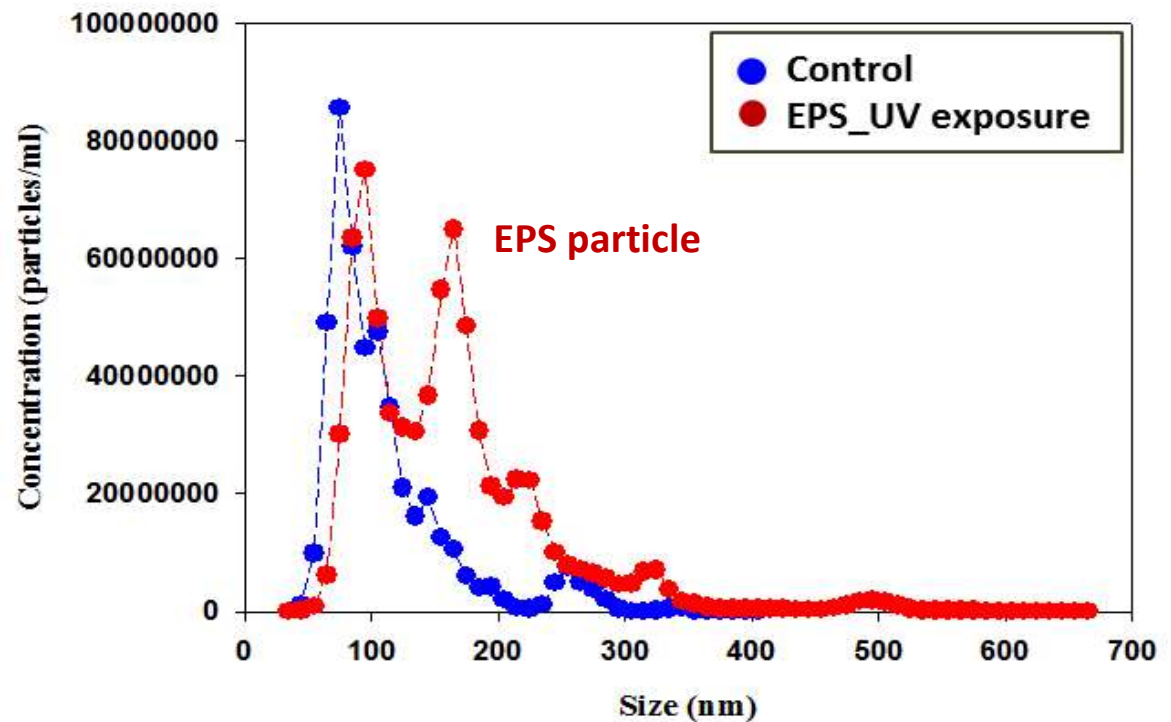
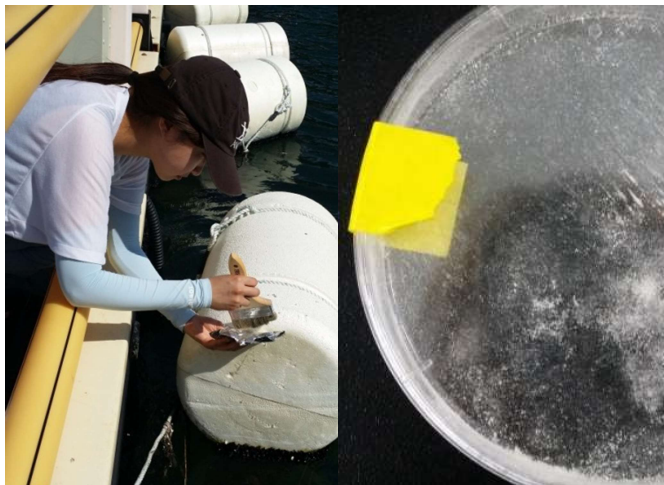
Microfiber in lobster
Murray and Cowie (2011)

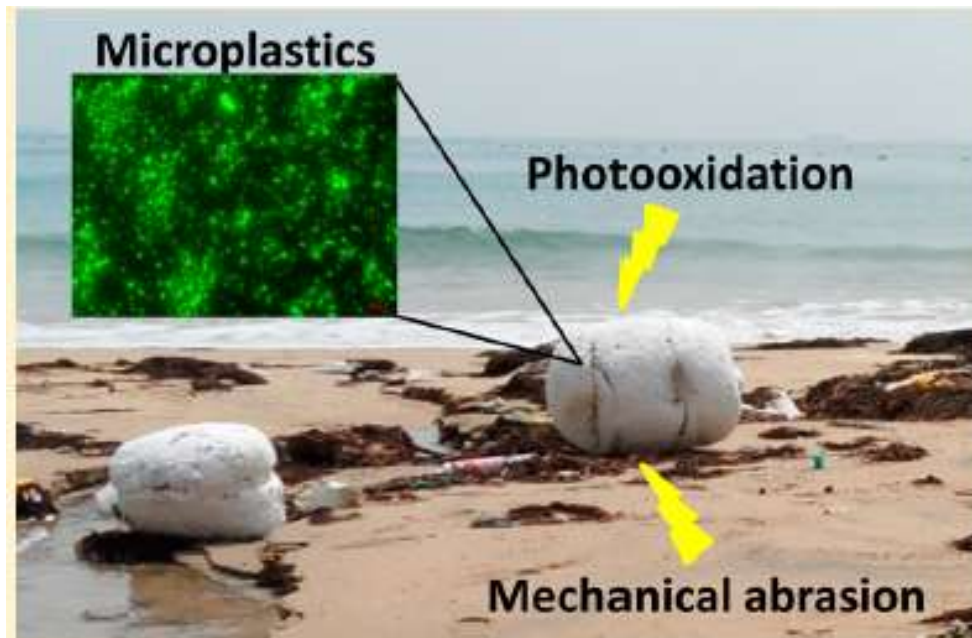
Tens of million nano-sized plastic particles generated from 1 ml volume of weathered EPS debris at sea

UV exposure



In situ





Weathering EPS buoy at sea results in micro- and nano-sized plastic particles

EPS pellets were susceptible to Mechanical Abrasion (MA) alone ($4,220 \pm 33$ particles/pellet), while the combination of 6 months of UV exposure followed by 2 months of MA produced $12,152 \pm 3,276$ particles/pellet.

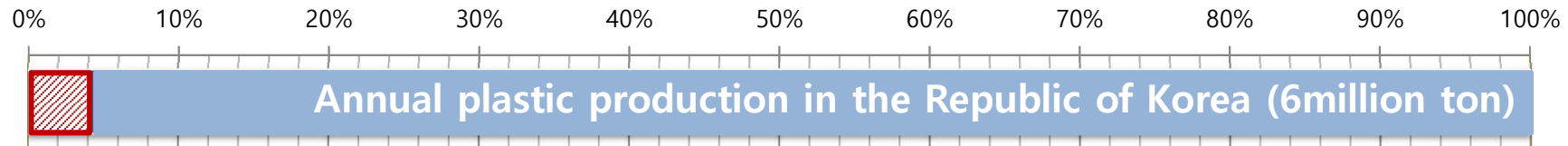
Up to 76.5% of the initial EPS volume was unaccounted for in the final volume of pellet produced particle fragments, indicating that a large proportion of the particles had fragmented into undetectable sub-micron particles.

How do we detect and determine concentration of nano-sized plastic particles with low cost and rapid analytical methods? (Thomas Maes, CEFAS)

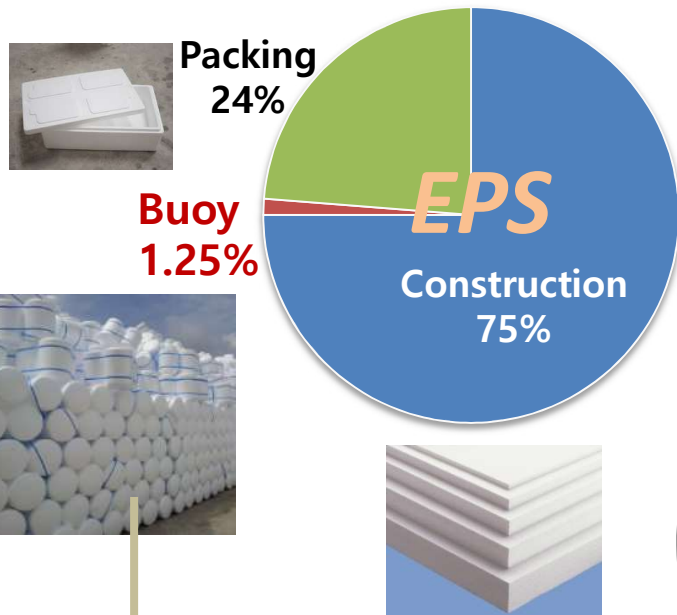
- Standard buoy: 62 L
- 7,580,000 spherules/buoy
- 2 million buoys/[yr over Korean waters] = 15×10^{12} spherules



Curbing EPS buoys at sea to reduce marine plastic pollution at sea

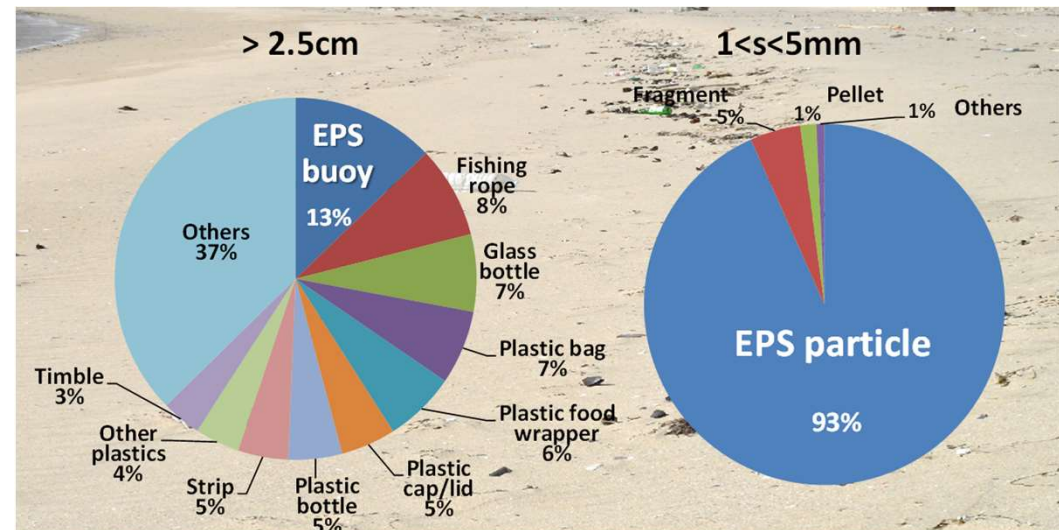


EPS: 4% of total plastic production



EPS buoy accounts for only 0.05% of plastic production.

Marine environment

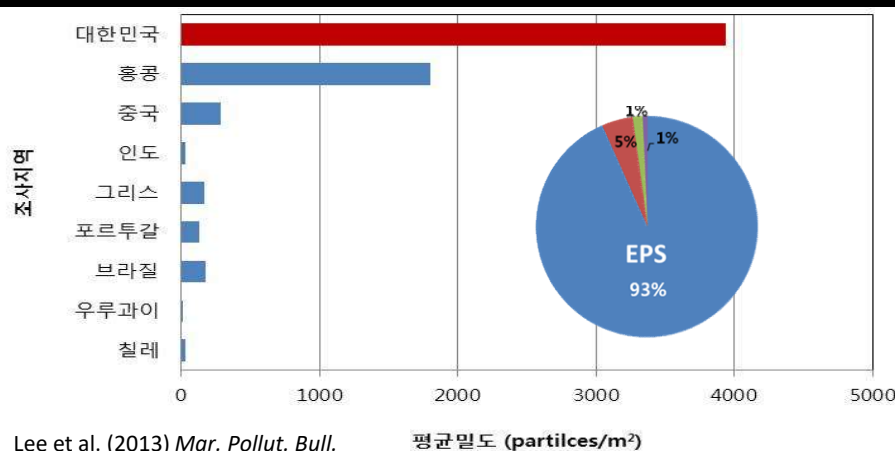


EPS debris are found to be the predominant macro debris and microplastics.

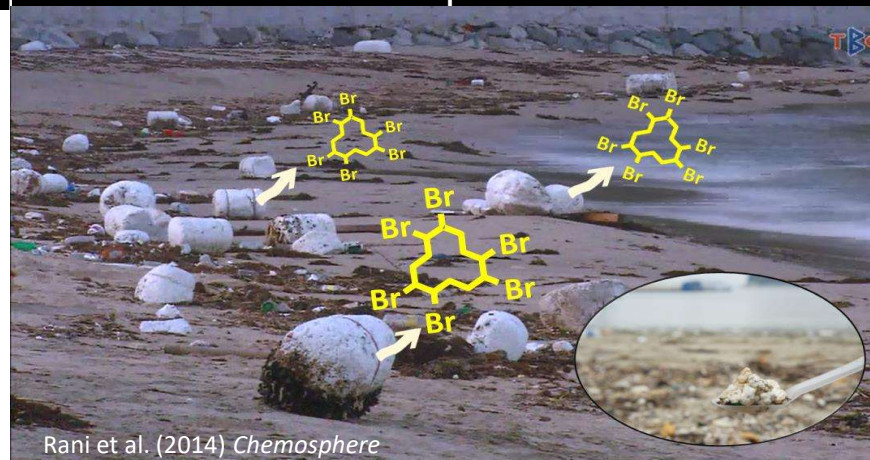
➤ Preventing EPS use is the most urgent task for reducing plastic pollution at sea.

Policy formulation based on new scientific evidence

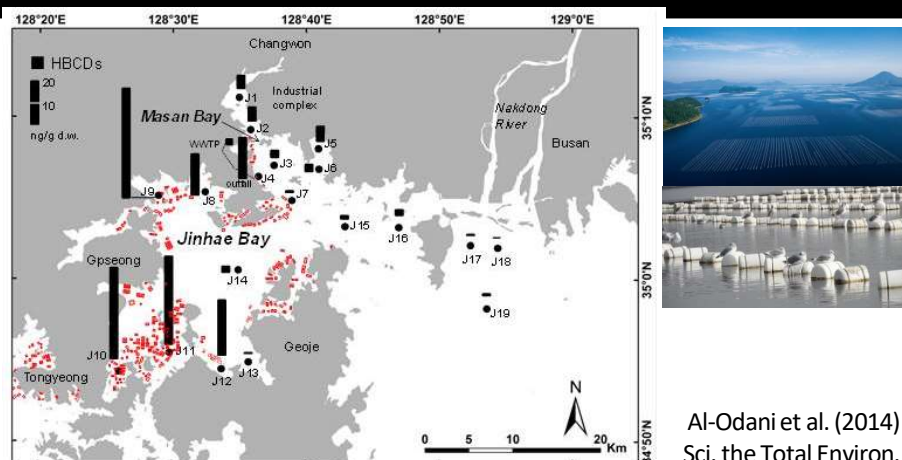
① Highly abundant EPS microplastics at sea



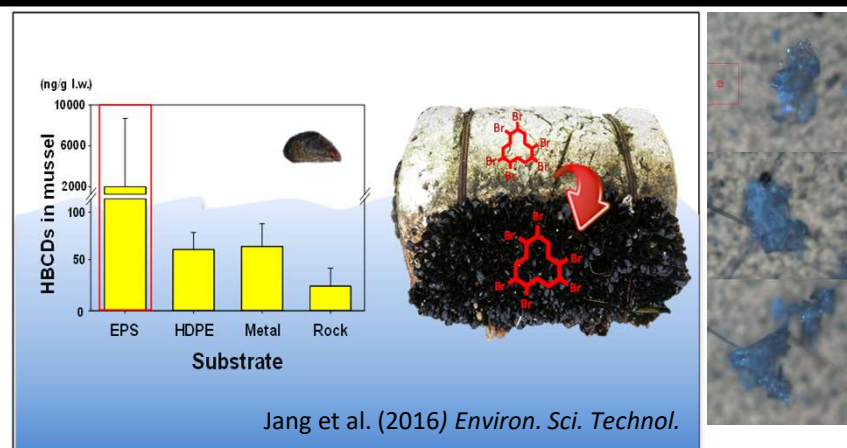
② hazardous chemicals entrained on the surface of EPS particles



③ Leaching to and enrichment in marine sediment

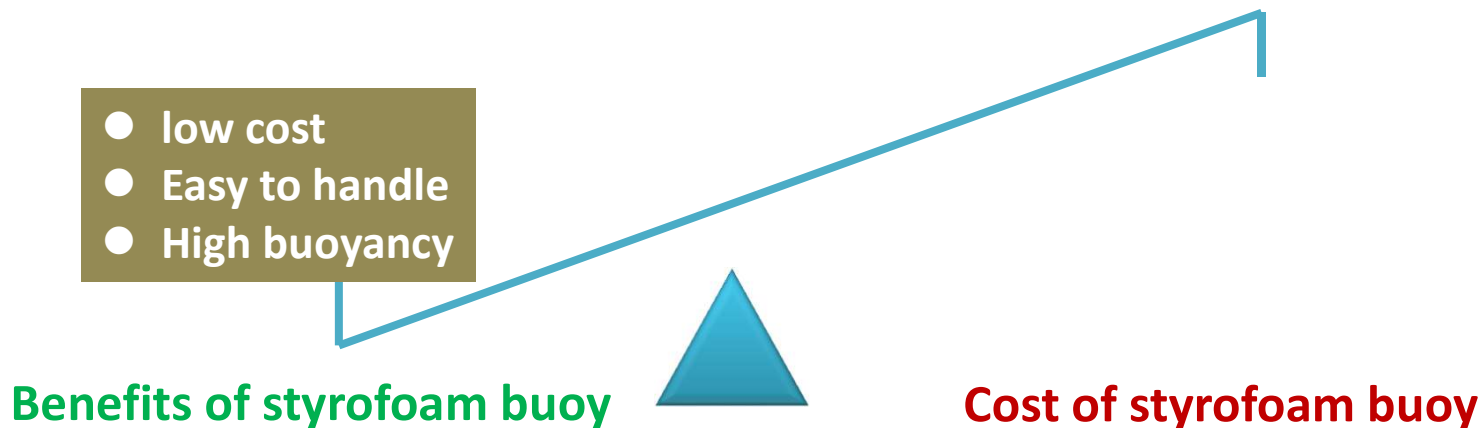


④ Ingestion by marine organisms and chemical transfer








Benefit-Cost Ratio (BCR)

- >90% in meso, micro, and nano-plastics in the sea
- Rapid fragmentation.
- HBCD associated with EPS leaches into seawater
- EPS Ingested organisms are subject to starvation.
- Polluting beaches
- Beach nuisance-destroy scenic view of the coastal sea



Consultation with all stakeholders: producer, fishermen, fishing industry, various government offices and local administration, etc.

Eco-Friendly Buoys

Encased type		Expanded type	Extruded type	
				
(polyurea coating)	(PE thin-film coating)	(Hybrid coating)	(Polypropylene buoy)	(Extruded PVC buoy)

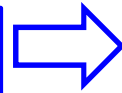


Administrative measures formulated and being executed

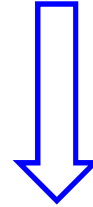
- Enhance retrieval rate of the used EPS buoys (10% → 30%);
- Establish a criterion: Buoy material should not result in microplastics in the marine environment: High-density buoy ($> 0.2 \text{ g/cm}^2$) coated or covered with polymers (or polymer films).
- Replace EPS buoys with non-particle resulting buoys with financial aid from the Government: subsidizes 40% of replacement cost; 0.36 million USD (2015), 3.5 million USD (2016), and ► If more than 50% of the current EPS buoys are replaced, then will amend the Fishing Area Management Act.
- Ban HBCD use in EPS buoy manufacturing process (January 2017); and
- Continue to develop low-priced and environmentally sound buoys.

LP Waste Prevention Audit Scheme

Scientific research



Significant Waste Pollution at sea



Trigger administrative actions:

Investigate the nature of waste pollution

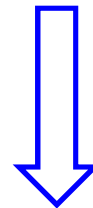
Scientific research : Evaluate type, amounts, relative hazard of wastes in the marine environment



Evaluate details of the production processes, additives



Establishing new criterion : buoy material should not result in microplastics in the marine environment



Trigger administration actions:

Legislation, alternatives and finance

Prevents Marine Pollution due to using EPS buoy

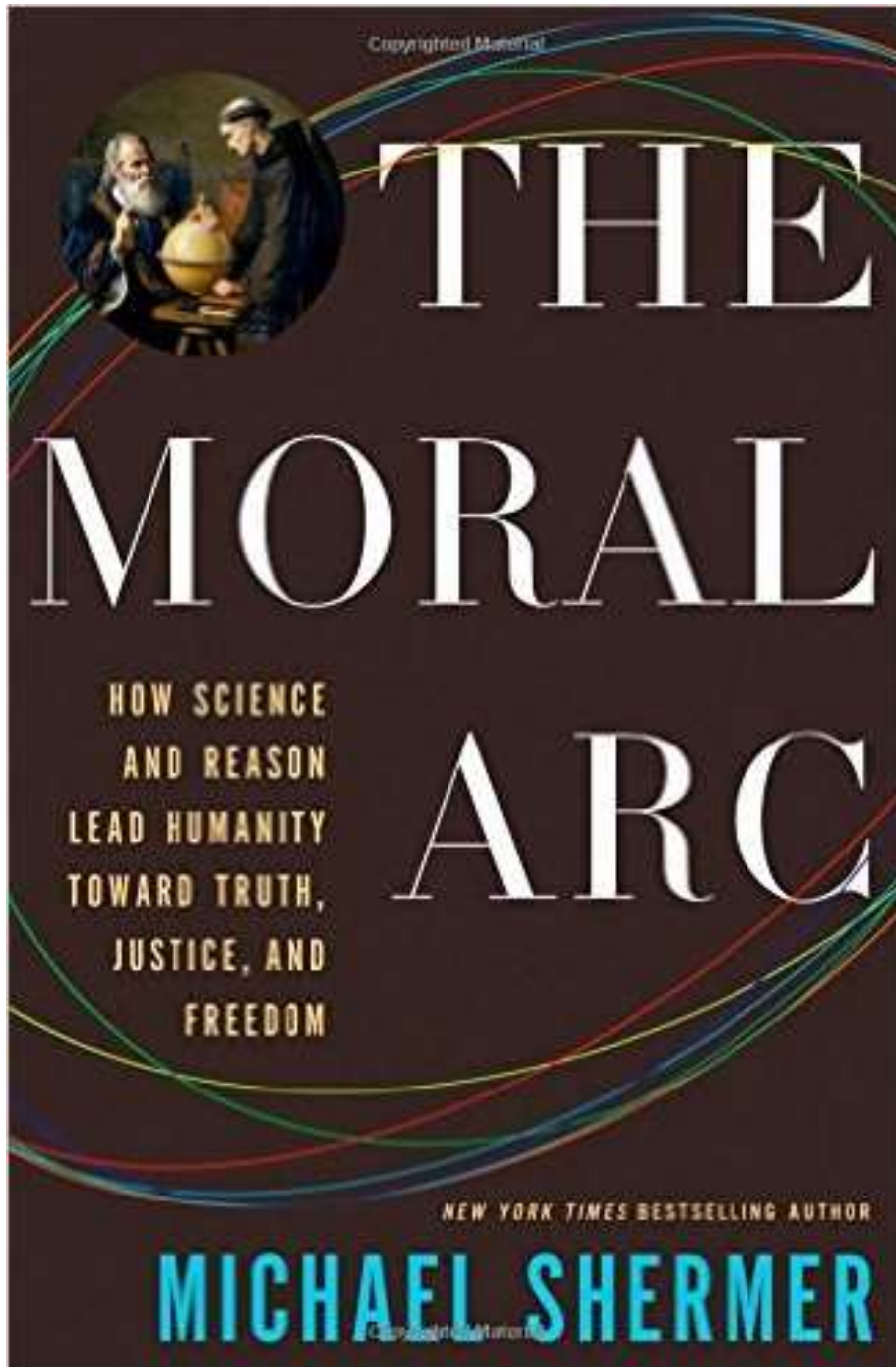
LP Annex 2 Assessment of wastes or other matter that may be considered for dumping

WASTE PREVENTION AUDIT

The initial stages in assessing alternatives to dumping should, as appropriate, include an evaluation of:

- .1 types, **amounts** and **relative hazard** of wastes generated;
- .2 **details of the production process** and the **sources of wastes within that process**; and
- .3 feasibility of the following waste reduction/prevention techniques:
 - .1 product reformulation;
 - .2 clean production technologies;
 - .3 **process modification**;
 - .4 **input substitution**; and
 - .5 on-site, closed-loop recycling.

In general terms, if the required audit reveals that opportunities exist for waste prevention at source, an applicant is expected to formulate and implement a waste prevention strategy, in **collaboration with relevant local and national agencies**, which includes specific waste reduction targets and provision for further waste prevention audits to ensure that these targets are being met. Permit issuance or renewal decisions shall assure compliance with any resulting waste reduction and prevention requirements.



London Protocol:
global treaty at the
forefront of
protection our
oceans for present
and future
generations

Thank you!

E-mail: ghong@kiost.ac.kr

Acknowledgements



Ministry of Oceans
and Fisheries

