

## PLASTIC AND MICROPLASTICS: UNDERSTANDING AND MANAGING MARINE LITTER IN THE YELLOW SEA



Microplastics at 1.5-1.6 mm. (Photo by Weiwei Zhang)



### What is marine litter?

Marine litter is defined by UNEP (2009) as 'any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned that ends up in the marine environment'. Marine litter accumulates on beaches, shorelines, sea surface and the sea floor. About 80% of marine litter comes from land-based sources, while 20% comes from sea-based sources.

### IMPACTS OF MARINE DEBRIS

#### Ecological/environmental:

- Coastal and marine biodiversity affected by:
  - > Ingestion by at least 233 marine species including marine turtles, >1/3 of seal species, 59% of whale species, 59% of seabirds, 92 species of fish, and 6 species of invertebrates (Ritchie and Roser, 2020).
  - > Entanglement of at least 344 species, including all marine turtle species, >2/3 of seal species, 1/3 of whale species, and ¼ of seabirds, 89 species of fish, and 92 species of invertebrates (Ritchie and Roser, 2020).

#### Economic:

- Lost revenues in fishing, seafood, and coastal tourism industry
- Navigational hazard. Frequency of propeller entanglement in navigation is 2.3 times per ship and 397.7 times per year (Hong et al., 2017).
- Loss of time and money on removal of marine debris, repairs of damaged vessels, gears, etc.

#### Social:

- Diminished intrinsic and social values of coastal and marine environments

#### Human Health and Safety:

- Reduced food security (low fish stocks) and food safety (possible contamination of human food chain with toxic chemicals)
- Dangers posed by navigational hazards
- Water contamination

### Why is plastic the No. 1 concern on marine litter?

Marine litter primarily consists of plastics. Global production of plastic reaches 270 million tonnes per year. At least 8 million tonnes are estimated to end up in the ocean every year, and 90% of the litter collected from sea floor trawls is made up of plastic. It is feared that there will be more plastic in the ocean than fish (by weight) by year 2050.

### What is microplastics?

**Microplastics** are small plastic pieces or fibers smaller than 5mm in size. They are composed of carbon and hydrogen atoms bound together in polymer chains. Microplastics are often accumulated in shoreline, coastal areas, and offshore.

Primary microplastics are derived from manufactured microspheres, fibers and other plastics used in industrial and personal care products. They enter the environment through product use, unintentional loss from spills during manufacturing and transport, or abrasion during washing.

Secondary microplastics can be formed from the fragmentation and weathering of larger plastic particles, mainly through exposure to wave action, wind abrasion, and ultraviolet radiation from sunlight.

### Does microplastics matter?

Potential effects of microplastics can occur at different biological levels ranging from sub-cellular to ecosystems. There are evidences that microplastic ingestion can impact on prey's food consumption that can lead to energy depletion, inhibited growth and fertility impacts. While more rigorous studies are needed to determine possible impacts of microplastics to humans.

## MARINE LITTER IN THE YELLOW SEA

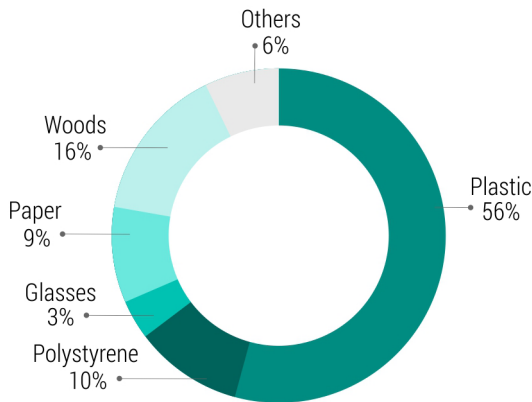
### PR China

Beach litter, floating litter and benthic litter are monitored through sighting and trawling since 2007 in 11 coastal sites in western Yellow Sea. Results are published in the annual National Marine Environmental Status Bulletin hosted by the Ministry of Ecology and Environment (MEE).

#### Floating litter

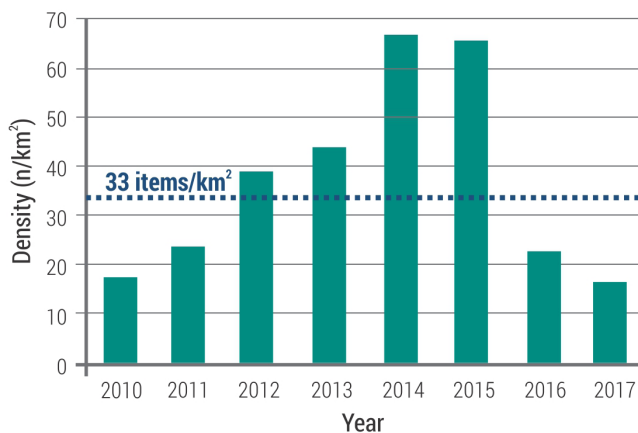
In 2018, plastic accounts for 56% of the total count of floating litter, and consists of polystyrene foam, plastic bags, plastic bottles and cigarette filters (Fig.1). And 97.7% comes from land sources and 2.3% from sea activities.

**Figure 1: Composition of floating litter in surface water of Yellow Sea of PR China in 2018 (Zhang, 2019)**



The mean density of large floating litter (>10cm) was at 31 items/ km<sup>2</sup> and the average density of smaller floating litter (<10cm) was at 1681 items/ km<sup>2</sup> in the surface water of the Yellow Sea. The mean density of marine litter in sea surface shows a decreasing trend from 2015 to 2018 (Fig.2).

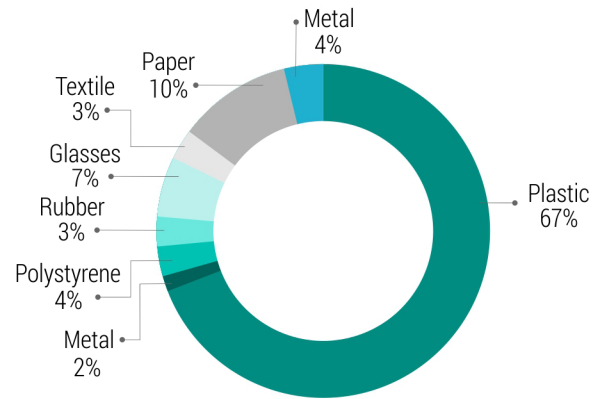
**Figure 2: Floating macro (>10cm) and meso (<10cm) litter in surface water of Yellow Sea of PR China from 2010 to 2018 (Zhang, 2019)**



#### Beach Litter

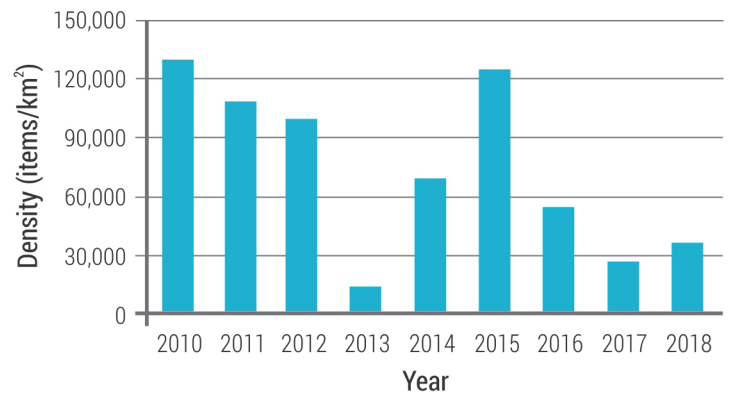
In 2018, it is shown that beach litter in coastal areas of Yellow Sea consists of plastic, paper and glasses, accounting for 67%, 10% and 7% of the total amount of collected litter respectively (Fig. 3). Results show that 91.4% of beach litter comes from land sources and 8.6% from sea activities.

**Figure 3: Composition of beach litter in the monitoring sites of Yellow Sea of PR China in 2018 (Zhang, 2019)**



From 2010 to 2018, the average density of beach litter of the monitoring sites is 72,825 items/km<sup>2</sup>. In 2018, the density is 35,502 items/km<sup>2</sup> (Fig.4).

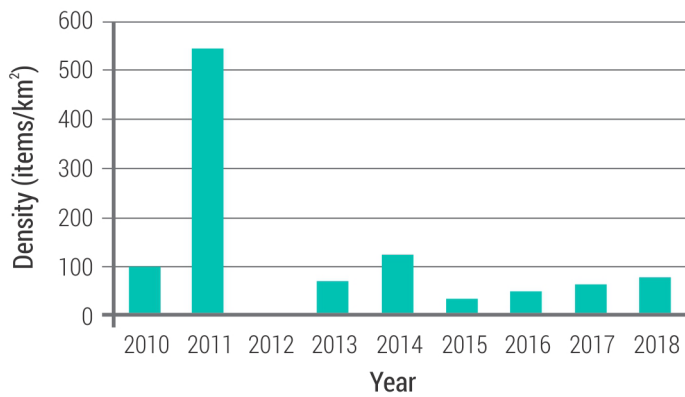
**Figure 4: Beach litter of the 11 monitoring sites along the coast of Yellow Sea of PR China from 2010 to 2018 (Zhang, 2019)**



#### Benthic litter

From 2010 to 2017, the mean density of benthic litter of monitoring sites is about 130 items/km<sup>2</sup>. In 2018, the density of benthic litter, primarily plastics, in the monitoring sites of the Yellow Sea was 75 items/km<sup>2</sup> (Fig.5).

**Figure 5: Benthic litter of the Yellow Sea of PR China from 2010 to 2018 (Zhang, 2019)**



**RO Korea**

**Beach litter**

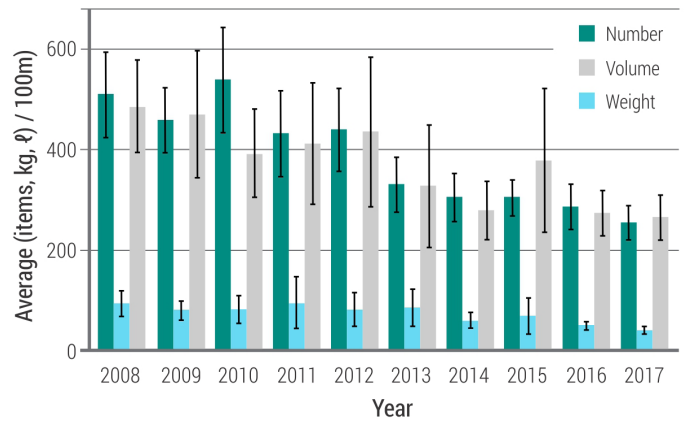
In RO Korea, the Korean National Marine Debris Monitoring Program (KNMDMP) has been continuously implemented to monitor macro litter in 20 beaches around the Korean Peninsula since 2008. The number of monitoring sites has increased to 40 since 2015.

**Macro litter on beaches**

Monitoring surveys of macro litter (> 2.5 cm) from 2008 to 2009 under the KNMDMP showed that plastic occupied 49.8% of all anthropogenic litter on the basis of number, followed by styrofoam (16.9%) and wood (8.4%). Wood took the first place in weight, occupying 37.9% of all, and plastics were placed the second, making up 30.3%. By volume, styrofoam ranked the first, occupying 31.6%, followed by plastic (30.7%), and wood (23.6%) (Fig. 6).

Temporal trend of distribution of macro debris indicates that the number, weight and volume decreased significantly along the coastline in the 10-year period based on KNMDMP (Fig. 7).

**Figure 7: Temporal distribution trend of macro litter from 2008 to 2017 in Korea (Hong et al., 2018)**

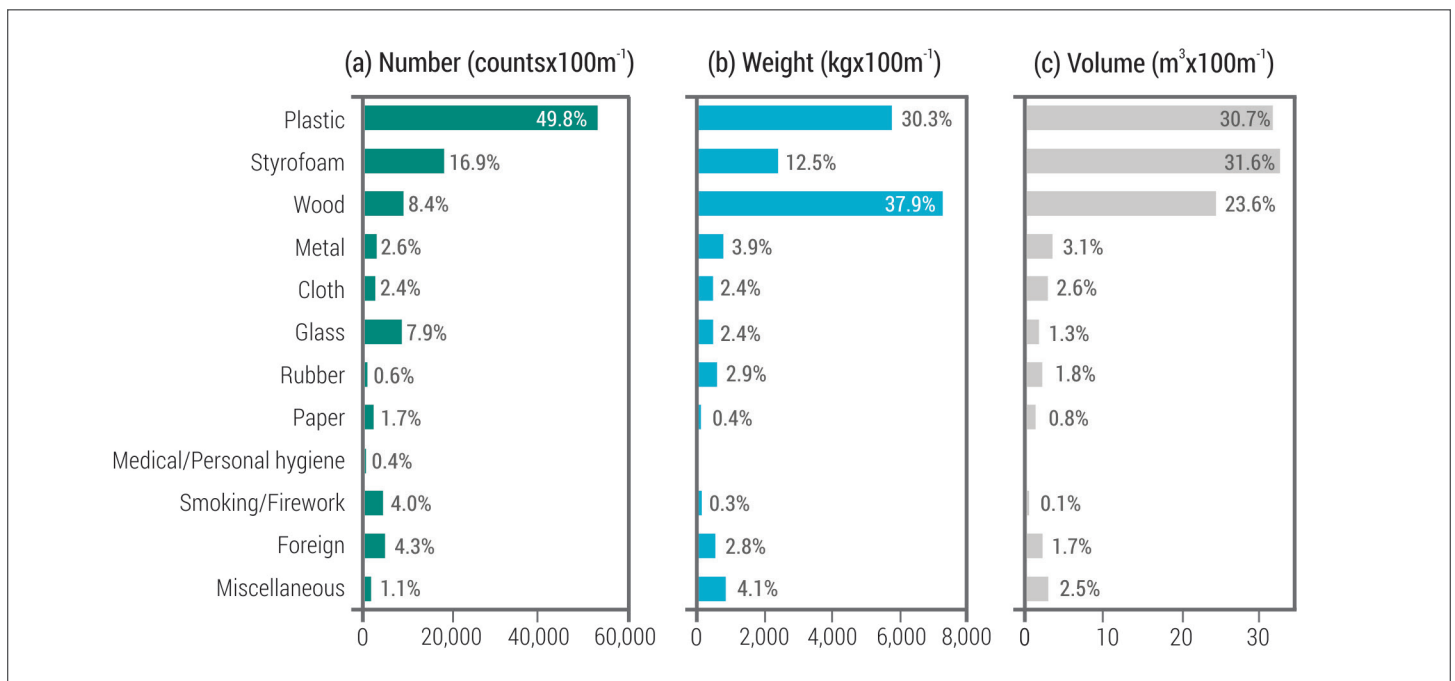


A study by Jang et al. (2014) in six beaches showed that macro litter in Korean beaches was mainly composed of sea-based items, accounting for 56% in average. Reports confirm that plastics and styrofoam as the major debris derived from fishing activities, including commercial fisheries and marine aquaculture (Hong et al., 2014).

**Meso litter on beaches**

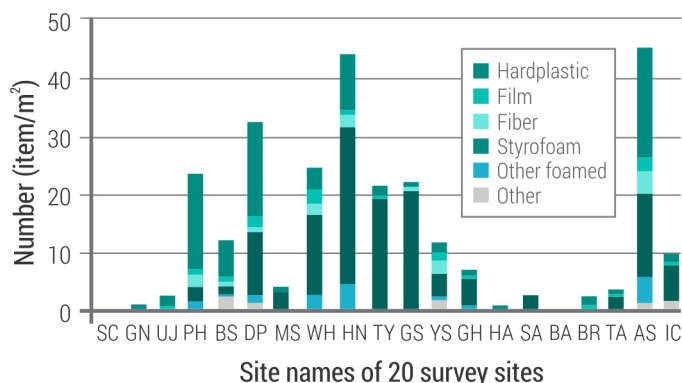
Lee et al. (2013, 2015 and 2017) conclude that styrofoam is the dominant component of the meso plastics (5 mm–25 mm) in Korean beaches, followed by hard plastics (Fig. 8).

**Figure 6: Composition of marine litter from 2008 to 2009 KNMDP (Hong et al., 2014)**



Styrofoam buoys used without covers are very easily exposed to environment through fragmentation into numerous small pieces.

**Figure 8: Composition of meso plastics on 20 beaches in Korea (Lee et al., 2017)**



**Benthic litter**

Abundance of submerged marine litter in Korea is shown in Table 1. In Heuksan-do on the west coast of Korean Peninsula, 1,686 kg/km<sup>2</sup> of fishing gears were found under the water of 40 meters. The litter was composed of traps, anchors, ropes, nets, and wires.

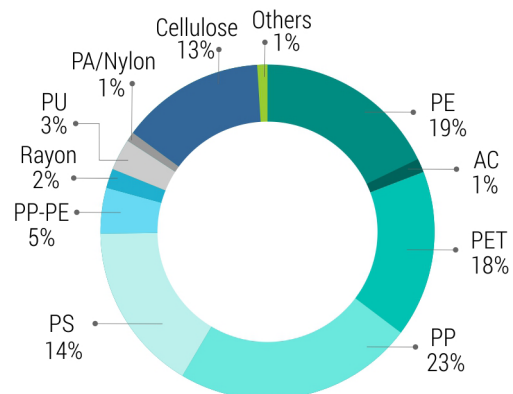
**Table 1: Marine litter abundance on seafloor in RO Korea (Hong et al., 2020)**

Location	Sampling depth	Target size	Abundance	unit	References
Pohang Port		Mainly fishing gear	528.30	kg/km <sup>2</sup>	Park et al. (2016)
Wanndeung-do	30 m	Mainly fishing gear	686	kg/km <sup>2</sup>	Kim and Kang (2012)
Younghung-do	20 m		4,350		
Jawol-do	15 m		534		
Saengil-do	25 m		708		
Heuksan-do	40 m		1,686		
Busan Port		Fishing gear, household item	355	kg/km <sup>2</sup>	Kim et al. (2006)

**MICROPLASTICS IN THE YELLOW SEA**

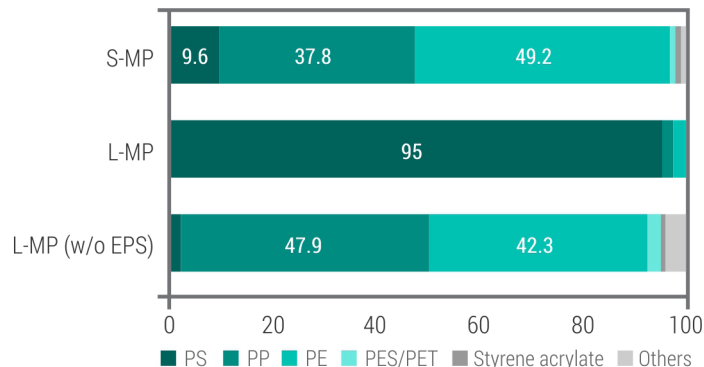
Monitoring of microplastics in PR China started in 2016 in 17 stations of the coastal areas of the western Yellow Sea. The average density of microplastics in surface water is 0.35 items/m<sup>3</sup>. Polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET) and polystyrene (PS) accounting for 23.4%, 19.1%, 17.6% and 14.2% respectively (Fig.9). The main shapes are fiber and flake.

**Figure 9: Composition of microplastics in the southern Yellow Sea of China in 2018 (Zhang, 2019)**



In Korean sand beaches, expanded polystyrene (EPS) accounts for 95% of large microplastics (1-5mm). Small microplastics were predominantly composed of polyethylene (PE) and polypropylene (PP) (<1mm) (Fig. 10).

**Figure 10: Composition of microplastics on 20 beaches in Korea (adapted from Eo et al., 2018)**

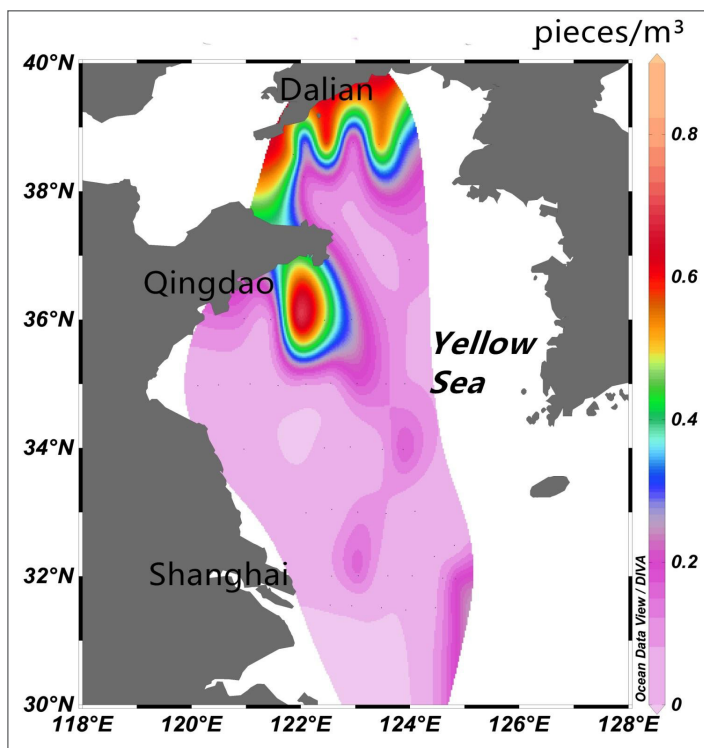


Various researches and studies are also being conducted in both PR China and RO Korea in recent years that collectively provide a better picture of the availability, distribution, pathway, and magnitude of microplastics in the Yellow Sea.

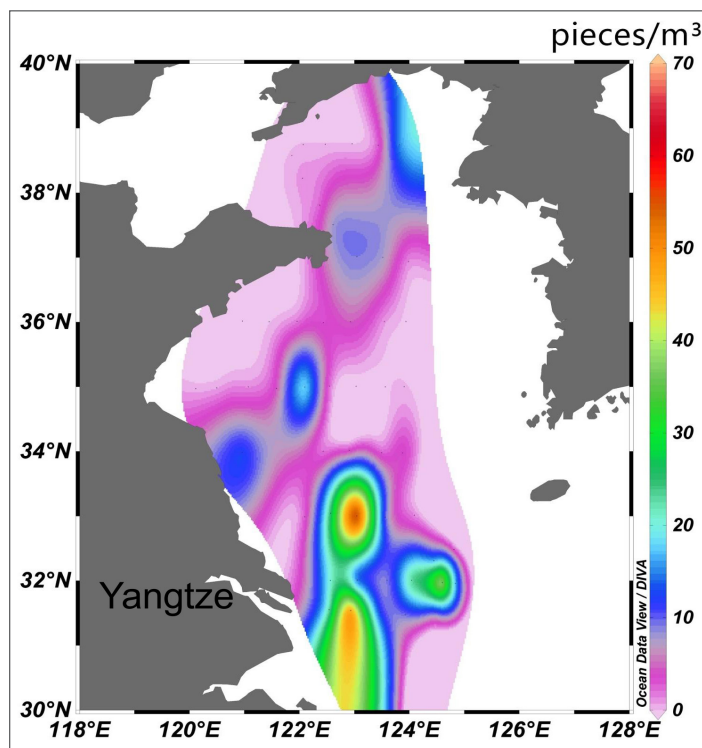
**Microplastics in seawater**

Items of microplastics in seawater of the Yellow Sea varies from mesh size of net. Sun et al. (2018) studied the characteristics of microplastics in seawater using 500 μm mesh size of sampling net and zooplankton in the Yellow Sea. For microplastics in seawater, the average concentration is 0.13 ± 0.20 pieces/m<sup>3</sup>, dominated by fragments (42%). The average size is 3.72 ± 4.70 mm, with the most frequent size appearing at 1200 μm. The major polymer types are polypropylene and polyethylene, accounting for 88.13% in total. The distribution of microplastics in seawater is patchy, with high concentrations close to the coastal cities (Fig.11).

**Figure 11:** Distribution and abundance of microplastics in the surface water of the Yellow Sea (Sun et al., 2018)



**Figure 12:** Distribution and abundance of microplastics in the zooplankton of the Yellow Sea (Sun et al., 2018)



Zhu et al. (2018) indicated that the abundance of microplastics was  $545 \pm 282$  items/ $m^3$  in surface seawater in North Yellow Sea using 30  $\mu m$  mesh size of sieve.

### Microplastics in zooplankton

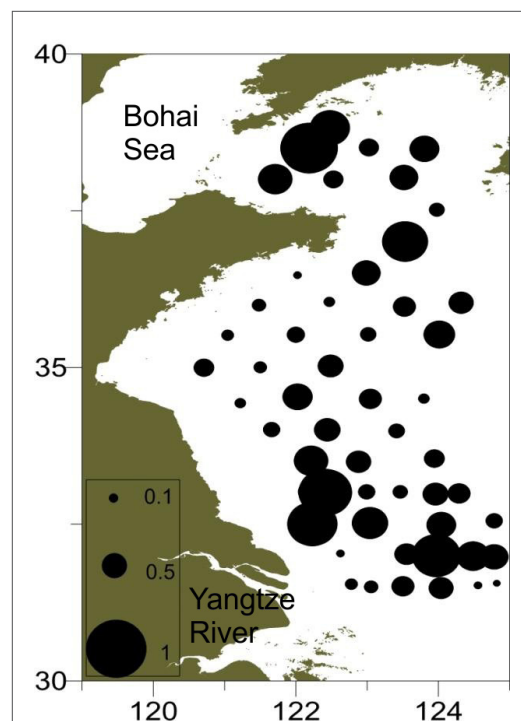
The average concentration of microplastics in 11 total zooplankton groups is  $12.24 \pm 25.70$  pieces/ $m^3$ . The average size is  $154.62 \pm 152.90$   $\mu m$ , with 90% being  $<500$   $\mu m$ . Fiber is the dominant shape of microplastics found in zooplankton, accounting for 46%, but the composition of the polymer type is diverse. The retention of microplastics in zooplankton depends on the taxa and their abundance in the Yellow Sea. Siphonophorae, Copepoda, Euphausiacea and Amphipoda are the main repositories compared to other groups, achieving 3.57, 2.44, 1.41 and 1.36 pieces/ $m^3$ , respectively. The high concentration area of microplastics in zooplankton appeared near the adjacent waters of the Yangtze estuary (Fig.12).

### Microplastics in fish

Microplastics were detected in all 19 fish species sampled, ranging from 0.18 to 0.91 for different species with an average of 0.42 pieces/fish (Sun et al., 2018).

The sea area adjacent to the Yangtze River Estuary and the Bohai Sea showed high values of microplastic/fish, while the values of microplastic/fish in the central Yellow Sea are relatively low (Fig.13).

**Figure 13:** Distribution and abundance of microplastics in fish of the Yellow Sea (Sun et al., 2018)

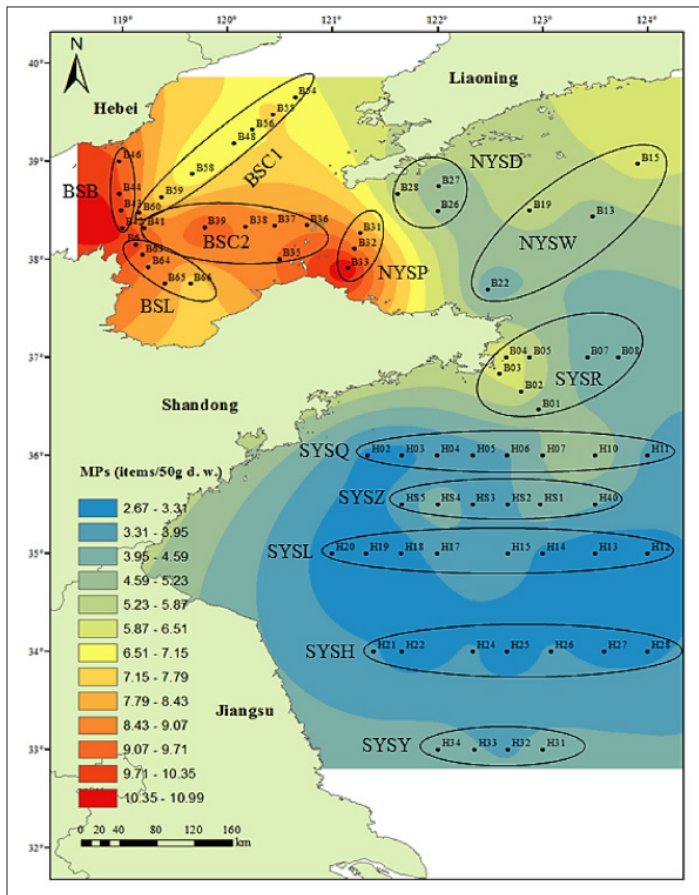


### Microplastics in sediments

Zhao et al. (2018) found widespread distribution of microplastics in sediments from the Yellow Sea. The average abundance was 123.6 and 72.0 items/kg of dry weight sediment for the Northern Yellow

Sea and Southern Yellow Sea. Among the sampled microplastics, fiber (93.88%) and small microplastics (<1000 µm) (71.06%) were the most frequent types. The main types of microplastics were rayon (RY), polyethylene (PE) and polyethylene terephthalate (PET) (Fig. 14). Zhu et al. (2018) also indicated that the abundance of microplastics of  $37.1 \pm 42.7$  items/kg dry weight in sediments in North Yellow Sea.

**Figure 14: Distribution of microplastics in sediments of the Yellow Sea (Zhao et al., 2018)**



Hong et al. (2020) compared monitoring results of microplastics using Manta trawl and neuston nets with 250-505 µm mesh size. Results indicate that the abundance in Kyeonggi and Asan Bays in RO Korea showed the same order of those in Bohai Sea and Rudong offshore wind farms in China (Table 2).

**Table 2: Abundance of microplastics collected with 300-333 µm mesh size in seawaters (adapted from NOWPAP, 2020)**

Region	Location	Mesh size (µm)	Abundance (items/m <sup>3</sup> )	References
RO Korea	Southeastern Sea	330	1.92-5.51	Kang et al. (2015a)
	Kyeonggi and Asan Bays	330	0.19	Chae et al (2015)
	Geoje, southeastern Sea	330	47	Song et al (2014)

**Table 2: Abundance of microplastics collected with 300-333 µm mesh size in seawaters (adapted from NOWPAP, 2020) (cont.)**

Region	Location	Mesh size (µm)	Abundance (items/m <sup>3</sup> )	References
PR China	Bohai Sea	330	0.33	Zhang et al (2017)
	Rudong offshore wind farm (Yellow Sea)	333	0.330	(Wang et al. (2018)
	Jiaojiang, Oujiang, and Minjiang Estuary (East China Sea)	333	100-4100	Zhao et al (2015)
Other region	North Pacific Gyre	333	2.23	Moore et al. (2002)
	Seto inland	335	0.39	Isobe et al (2014)

## RESPONSE ACTIONS

### Global

The direct threat posed by marine litter to ocean health and productivity also figures significantly in the UN Sustainable Development Goals (SDG) of the 2030 Agenda. Several SDGs relate to marine litter, but SDG14 on Life Below Water, in particular, highlighted a commitment to significantly reduce marine debris by 2025 (Table 3).

**Table 3: Key SDG targets related to marine litter**

 <p><b>12</b> RESPONSIBLE CONSUMPTION AND PRODUCTION</p>	<p><b>Target 12.5:</b> By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.</p>
 <p><b>14</b> LIFE BELOW WATER</p>	<p><b>Target 14.1:</b> By 2025, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.</p>

At the global level, a number of initiatives have been launched in response to the increasing clamor to address marine litter, particularly on plastic pollution, including the Global Partnership on Marine Litter; UN Environment Clean Seas Campaign; The New Plastics Economy Global Commitment; and The Honolulu Strategy, among others.

The Honolulu Strategy, in particular, was adopted in 2011 as a framework document for a comprehensive and global effort to reduce ecological, human health and economic impacts of marine debris globally. While it does not prescribe specific targets, it is expected that progress toward the achievement of Honolulu Strategy's goals would occur by 2030.

HONOLULU STRATEGY	
<b>Goal A:</b>	Reduced amount and impact of land-based litter and solid waste introduced into the marine environment
<b>Goal B:</b>	Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, abandoned, lost or discarded fishing gears (ALDFG), and abandoned vessels introduced into the sea
<b>Goal C:</b>	Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters.

### Regional

At the regional level, the UNDP/GEF Yellow Sea Large Marine Ecosystem (YSLME) Project, guided by its Strategic Action Programme (SAP) has been providing a collaborative platform to address marine litter in the Yellow Sea. In particular, Target 6 of the SAP focuses on reduction of marine litter in the Yellow Sea.

YSLME SAP Target 6: Reduced standing stock of marine litter to the level of 2007	
<b>Management Action 6-1:</b>	Control source of litters and solid wastes
<b>Management Action 6-2:</b>	Improve removal capability of marine litter
<b>Management Action 6-3:</b>	Increase public awareness of marine litter

Guided by the YSLME Regional Working Group on Pollution Reduction (RWG-P), a number of initiatives have been undertaken to monitor and promote collaboration in addressing marine litter.

To date, the regional implementation of YSLME SAP Target 6 has resulted to the following:

- Baseline Survey Reports on Marine Litter in China and in RO Korea, with results presented in the previous sections.
- Technical support to Weihai, PR China to develop regulatory measures for marine litter management

- Through the Yellow Sea Grant Program (YSGP), support to Shanghai Rendu Ocean NPO Development Center (Rendu Ocean) to monitor fishery and aquaculture marine debris, and Blue Ribbon Ocean Conservation Association (BROCA) to establish a system for management of marine debris in fishing village to reduce the quantity of garbage ending up into the sea and to improve recycling of resources and efficiency.

### National

#### National legal and regulatory frameworks

ENABLING LEGAL FRAMEWORKS	
<b>CHINA</b>	<ul style="list-style-type: none"> <li>• Marine Environment Protection Law 1999, 2013, 2016, and 2017 (with key provisions on Pollution Prevention and Control)</li> <li>• Law on the Prevention and Control of Environmental Pollution by Solid Waste (1996)</li> <li>• Regulation on the prevention and control of pollution by land-based pollutants (1990)</li> <li>• Regulation on control over dumping of wastes in the ocean</li> <li>• Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment</li> <li>• 13th Five-Year Plan for Protection of Ecological Environment (by MEE)</li> <li>• 13th Five-Year Plan for Marine Economy Development (by NDRC and SOA)</li> <li>• Nearshore Coastal Pollution and Prevention Plan/Programme</li> </ul>
<b>RO KOREA</b>	<ul style="list-style-type: none"> <li>• Marine Environment Management Act</li> <li>• 2nd National Marine Litter Management Plan (2014-2018)</li> <li>• 3rd National Action Plan on Marine Litter (2019-2023)</li> </ul>

#### National reduction programs

### PR China

- Imposed in 2018 a waste import ban resulting to significant drop of plastic imports of almost 99%.
- Undertaking of local level initiatives such as: the Regulation on Reducing Packages in Shanghai (2018); Regulation Prohibiting the Producing, Selling and Providing One-Time Non-Degradable Plastic Bags and Tableware in Jilin (2015), etc.(CCICED, 2019)
- Implemented the “Green Fence” program putting a temporary restriction for plastic imports with significantly less contamination (Brooks et al., 2018).

## RO Korea

- Set-up and operation of marine litter barges at ports and fishing ports to prevent occurrence of abandoned, derelict and discarded fishing gears (Park, 2019).
- Compensation for recovered litter during fishing where central and local government share the costs to buy recovered litter and prevent re-entry into the marine environment.
- Implementation of marine environment education programs to all age groups through mobile classrooms, lectures, etc.
- Establishment of MALI Center and Marine Litter Information System in 2011, in collaboration with the Ministry of Oceans and Fisheries and various entities from the academe, research institutes, and local NGOs.

## WAY FORWARD

Based on various studies and monitoring, and consultation with stakeholders at regional, national and local levels, the following recommendations are proposed to guide future interventions by YSLME partners:

- Strengthen legal and regulatory framework by: amending the relevant laws and regulations; issuing national marine pollution and control action plan; and formulating local regulations for prevention and control marine litter
- Provide incentives for public participation and financial subsidies in recollection of sea-based debris
- Recycle solid waste and kitchen organic waste through market-based mechanisms
- Strengthen capacity building on media and other data sharing platforms
- Introduce measures to reduce uncontrolled usage of foam plastic in fishery and initiating recollection system of EPS buoys or foam boxes
- Strengthen capacity in monitoring of marine litter and microplastics to address the gaps after the institutional restructuring in PR China
- Exchange experiences in developing alternatives to plastic floats in particular to biodegradable floats
- Promote collection and reuse of seashells and oysters from household and restaurants
- Establish partnership with public benefit institutions in monitoring and awareness raising of the general public about sea and land-based sources of marine litter in particular plastics
- Undertake monitoring and collection of debris in non-recreational coastal areas as a priority in the future.

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