Output 3.4.1 procedures in place to control and remove marine litter at demonstration sites

Deliverable 17:
Baseline survey report of marine litter

National Marine Environmental Monitoring Center

2019.11

Content

Baseline assessment for marine litter of the Yellow Sea of China

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1. Introduction

Every year large amounts of plastic debris enter the ocean. Plastic debris has been documented in all marine environments, from coastlines to the open ocean (Barnes et al., 2009), from the sea surface to the sea floor (Schlining et al 2013), in deep-sea sediments (Woodall et al, 2014) and even in Arctic sea ice (Obbard et al., 2014). A study suggested there could be between 7000 and 35,000 tons of plastic floating in the open ocean (Cózar et al. 2014). Another study estimated that more than five trillion pieces of plastic and >250,000 t are currently floating in the oceans (Eriksen et al. 2014). Once in the sea, microplatic are transported by ocean currents around the globe, where they persist and accumulate (Amy Lusher, 2015).

Plastics are by far the most prevalent debris recorded, with an estimated contribution from 60 to 80 percent of the total floating marine debris. Marine debris commonly stems from shoreline and recreational activities, commercial shipping and fishing, and dumping at sea. The majority of marine debris (approximately 80 per cent) entering the seas and oceans is considered to originate from land-based sources (Allsopp, et al., 2006). The presence of debris in the marine environment is cause for concern. It is known to be harmful to organisms and to human health, it presents a hazard to shipping, it is aesthetically detrimental, and it may also have the potential to transport contaminants over long distances. Furthermore, it can cause or contribute to economic losses to industries, such as commercial fishing and shipping, as well as to recreation and tourism.

The plastic debris entered the ocean includes large pieces and microplastics. Microplastics are plastic particles or fragment that less than 5 mm in size (Arthur et al., 2009). There are two kinds of microplastics, primary microplastics and secondary microplastics, in the marine environment. The primary microplastics are microspheres, particles, fibers and other plastics that less than 5mm. Such microplastics are often used in industrial and personal care products, which can end up into the marine

environment through the discharge of waste water. The large plastic debris released to the marine environment will break into smaller pieces until the size to 5 mm or less (Andrady, 2011). This kind of plastics is known as secondary microplastics. Microplastics have a great potential threat to the marine ecological environment and human health. It's called PM2.5 in the ocean and is the key point of marine plastic debris prevention and control.

The semi-enclosed nature of the Yellow Sea and rapid economic development of the surrounding area have resulted in an increasing polluted and over-exploited Sea. Based on the transboundary diagnostic analysis of the Yellow Sea, one of the major environmental problems is the marine litter in the Yellow Sea. Identifying patterns of marine litter distribution and assessment of baseline for marine litter of the Yellow Sea can benefit an understanding of the scale of their potential effect on the environment and organisms.

2. Marine litter monitoring along coastal areas of the Yellow Sea of China

2.1 Data collection and assessment

Marine litter monitoring is an important approach to master the characteristics of marine litter pollution of coastal areas. Since 2007, National Marine Debris Monitoring Programme was carried out by State Oceanic Administration of China. The monitoring contents include surface water litter, beach litter, and seafloor litter. The monitoring results have been published in Bulletin of Marine Environment Status of China every year. In this report, all data were collected from National Marine Environmental Status Bulletin. According to National Marine Environmental Status Bulletin, marine litter was monitored in 11 coastal areas (Fig. 1). The monitoring stations are shown in the Fig.1. Since 2016, we had focused on microplastics, the global hot environmental issue. The microplastics was monitored in 17 stations. The monitoring stations are shown in the Fig. 2.

Fig 1. The monitoring stations of marine debris along the coastal areas of Yellow Sea of China

Fig 2. The monitoring stations of microplastics of Yellow Sea of China

2.2 Methodology of marine litter monitoring

Marine litter has been defined by UNEP (2009) as “any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment”. Marine debris consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores (UNEP, 2005). In China, guideline for marine debris monitoring and assessment was released in 2007. In the guideline, the definition of marine litter is in accordance with UNEP (2005, 2009). Marine debris comprises of various material types, and can be classified into several distinct categories (Edyvane et al., 2004; Ribic et al., 1992; Galgani et al., 2010):

(a) Plastics, covering a wide range of synthetic polymeric materials, including fisheries-related equipment; consumer goods, such as plastic bags, plastic packaging; nappies; smoking-related items; plastic resin pellets; microplastic particles;

(b) Metal, including drink cans, aerosol cans, foil wrappers and disposable barbeques;

(c) Glass, including bottles, bulbs;

(d) Processed timber, including pallets, crates and particle boards;

(e) Paper and cardboard, including cartons, cups and bags;

(f) Rubber, including tires, balloons and gloves;

(g) Clothing and textiles, including shoes, furnishings and towels.

In China, the marine litter monitoring time is from September to October. The monitoring was conducted once a year, and the monitoring content and methods was shown in Tab. 1. **Tab.1 Marine litter monitoring contents and methods**

contents	Monitoring Methods	Sample size	Time and Frequency
Beach debris	Transect survey	>0.5mm	From September to October. Once per year
Floating debris	Sighting survey	>10cm	
	Trawling survey	>0.5mm	
Seafloor debris	Sighting survey	>10cm	
	Trawling survey	>5cm	

For floating litter shipboard survey, sighting survey and trawling survey methods were used according to the debris size. If the debris size were greater than 10cm, belt/line transect sighting surveys method were used. For belt survey, during observation, investigator searched the debris floating on the water surface. Only objects within a specified distance from the side of the ship are counted. For line transect survey, all objects were counted regardless of the distance from ship. The vertical distances from the object to the ship and the angle between object and investigator need to be measured.

For beach litter monitoring, within a sampling unit, at some point in time, the amount of debris on the beach is surveyed. Standing stock is to survey current status of beach debris. In 2016, guideline for marine microplastic debris monitoring was released. For the microplastics floating on the surface of the water, trawling survey methods were used. Sampling work was carried out by using manta net. Four monitoring sections (one section in the Southern Yellow Sea and three sections in the North Yellow Sea) were arranged in the Yellow Sea. The towing speed was 1-3 knots, sampling time lasts about 15 min.

3. Distribution of marine litter in the Yellow Sea

3.1 Distribution of floating litter

According to National Marine Environmental Status Bulletin in 2018, (Ministry of Ecological and Environment of the People's Republic of China, 2018), the main types of floating litter along the coast of Yellow Sea of China were plastic, of which accounted for 66% of the total amount of collected litter, and 10% of them are polystyrene foam (Fig. 3). Main plastic litters are polystyrene foam, plastic bags, plastic bottles and cigarette filters. 97.7% of floating litter comes from land and 2.3% from sea activities.

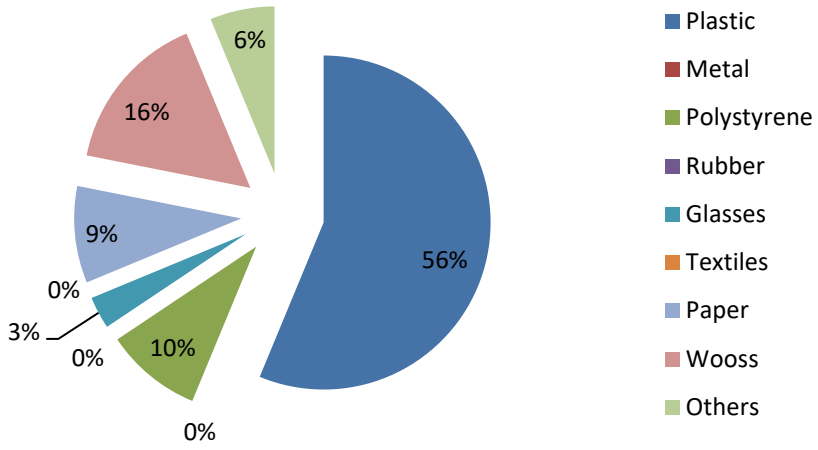


Fig.3 Types of floating litter in surface water of Yellow Sea of China in 2018

From 2010 to 2018, the mean density of macro- litter (>10 cm) floating on the sea surface by sight survey of the Yellow Sea was 34 items/ km^2. The mean density of meso- and macro litter (> 5 mm) by trawling survey was 1971 items/ km^2.

In 2018, the mean density of macro- litter (>10cm) by sight survey in the sea area was 14 items/ km^2, and the mean density of meso- and macro litter (>5 mm) by trawling survey was 1465.5 items / km^2. The mean density of floating litter in sea surface increased from 2010 to 2013, and then decreased from 2014 to 2018 (Fig. 4). The results show that the average density of floating garbage in the Yellow Sea in 2018 is obviously lower than the average level in recent years.

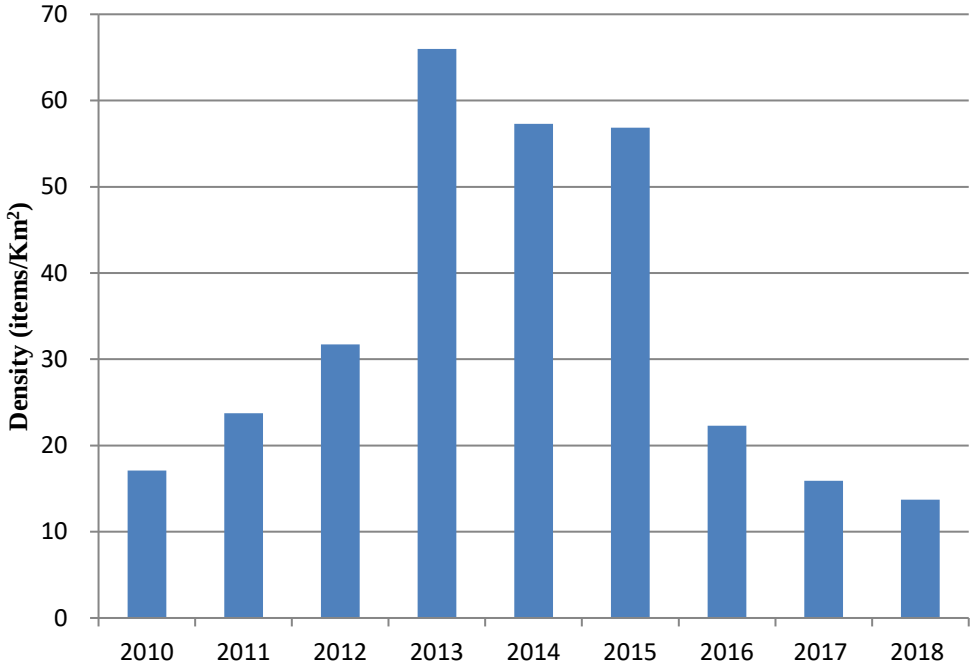


Fig.4 Macro-floating litter (＞10 cm) by sight survey in surface water of Yellow Sea of China from 2010 to 2018

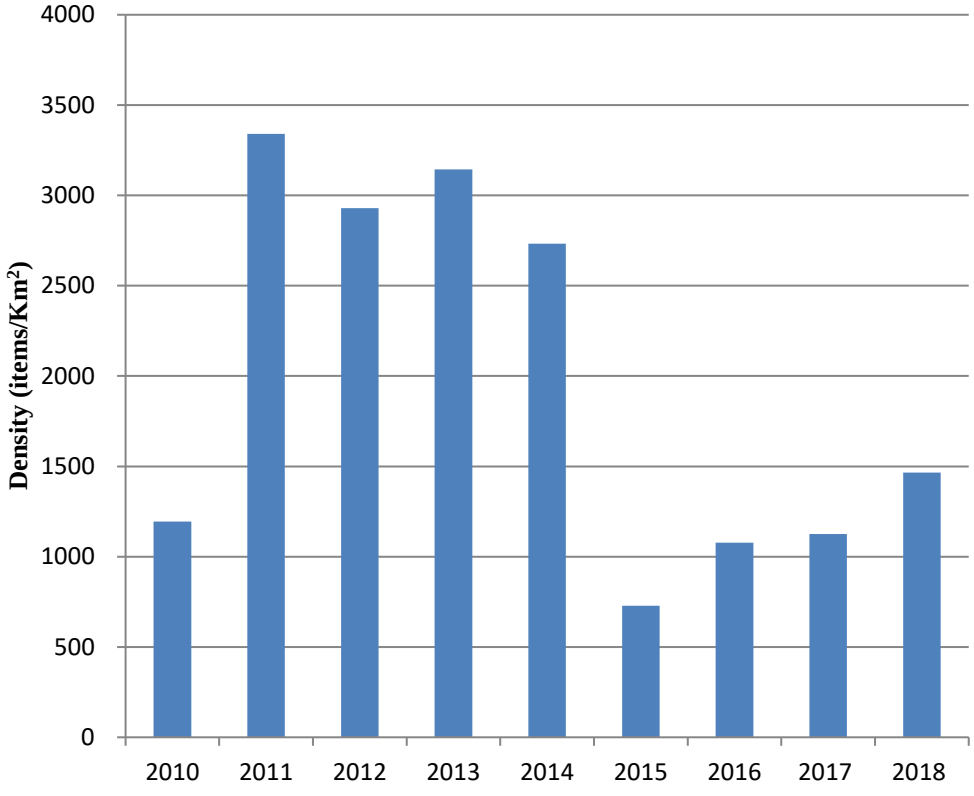


Fig.5 Meso- and macro litter（> 5 mm） by trawling survey in surface water of Yellow Sea of China from 2010 to 2018

3.2 Beaches litter

According to National Marine Ecology and Environmental Status Bulletin in 2018, (Ministry of Ecological and Environment of the People's Republic of China, 2018), the main types of beach litter of Yellow Sea along coast beaches of China were plastic, paper and glasses, accounting for 67%, 10% and 7% of the total amount of collected litter respectively (Fig. 6).

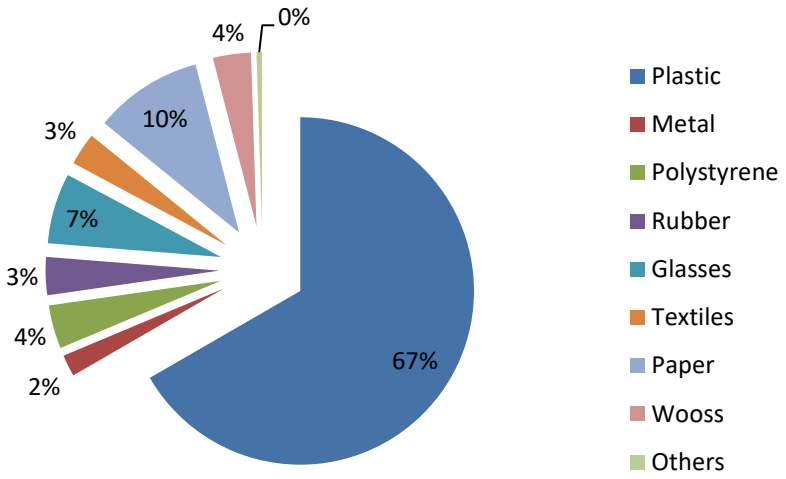


Fig.6 Types of litter in beaches of Yellow Sea of China

From 2010 to 2018, the average density of beach litter of the Yellow Sea was 72825 items/ km^2. In 2018, the density was 35502 items/ km^2.

For beach litter, the average density decreased since 2015, and the results showed that the density of beach litter of the Yellow Sea in 2018 is obviously lower than the average level in recent years (Fig. 7).

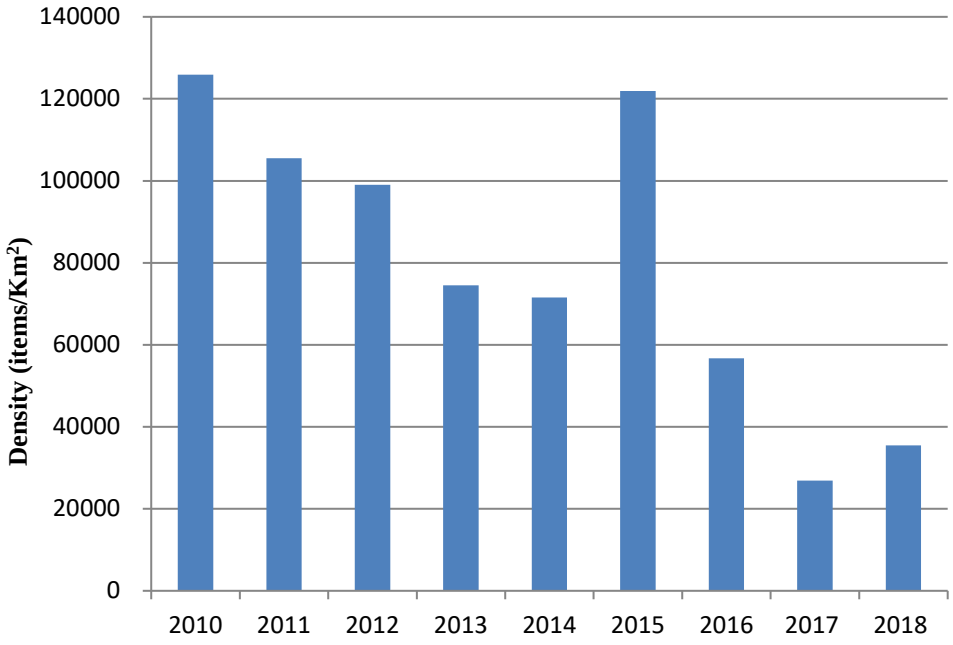


Fig.7 Beach litter along coast of Yellow Sea of China from 2010 to 2018

3.3 Benthic litter

In 2018, the density of benthic litter of the Yellow Sea was about 75 items/ km^2, and main type of the collected of the litter was plastics. From 2010 to 2017, the mean density of benthic litter of the Yellow Sea was about 130 items/ km^2 (Fig. 8). It should be noted, as only one site was monitored in 2011, and the density of this area is significantly higher than mean density, and then this led to the underrepresentation of the monitoring results in 2011.

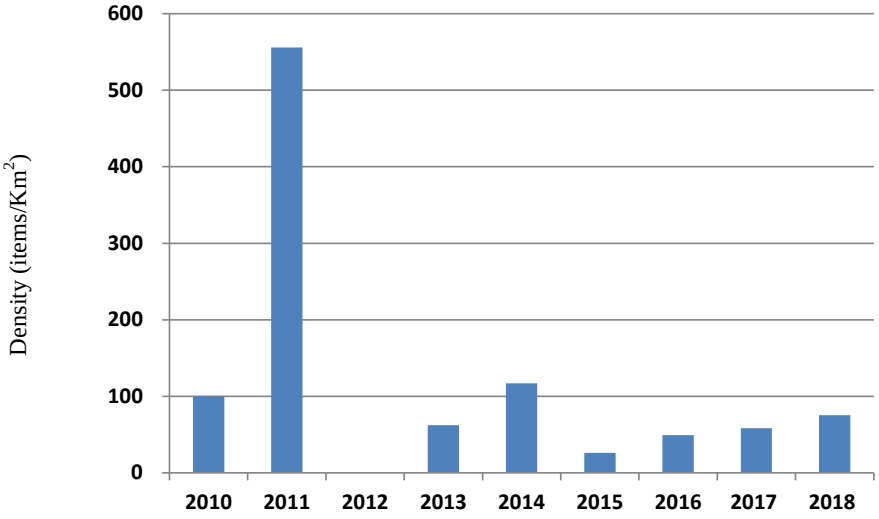
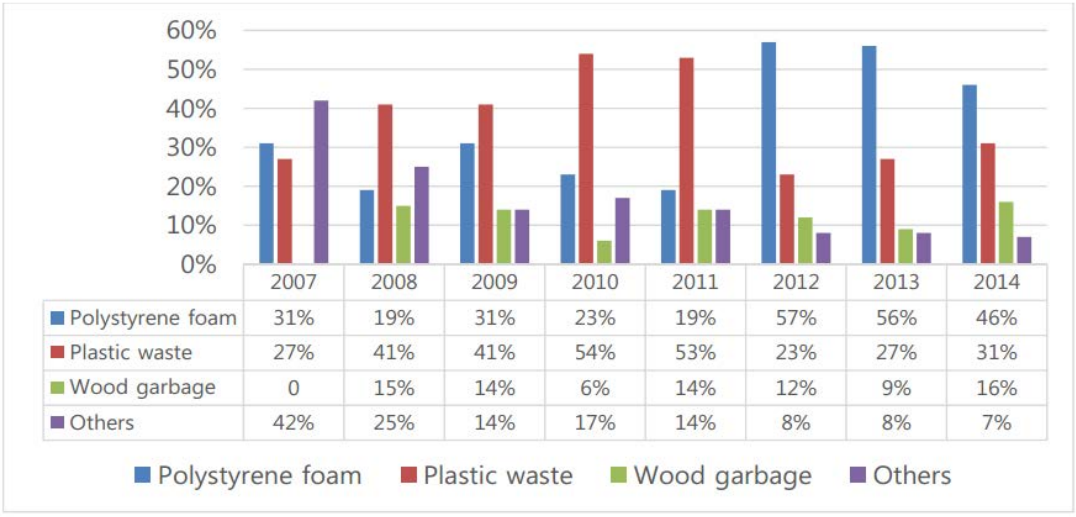


Fig.8 Benthic litter of the Yellow Sea of China from 2010 to 2018

3.4 Comparison of marine litter of China and Korea

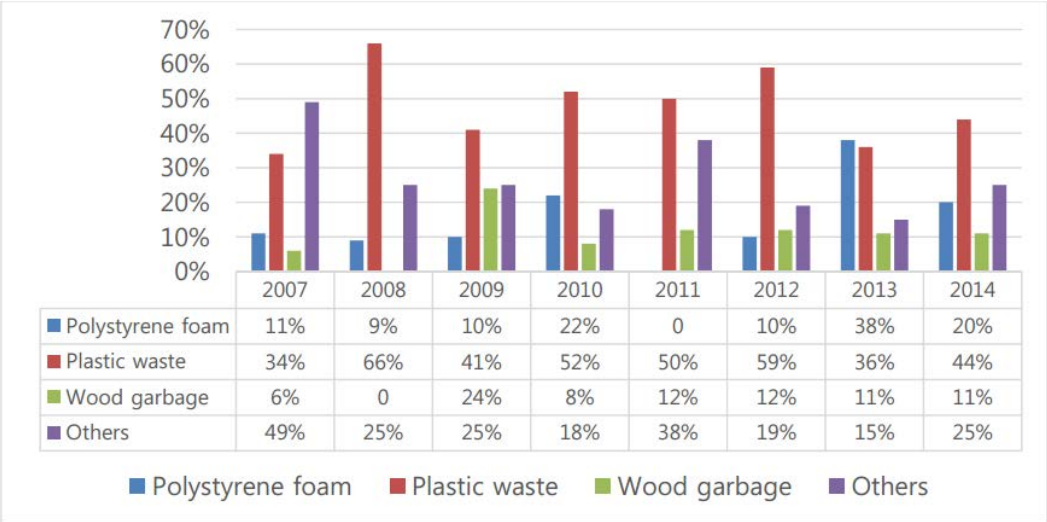
From 2007 to 2014, main type of floating marine litter was plastic, accounted for 37%, followed by polystyrene foam with (35%) and wood garbage (12%) (Fig. 9). The mean density for the macro- litter by sight survey was 23.5 pieces /km^2, and the meso- and macro- litter by trawling survey was 2,992 pieces /km^2. Statistics results showed that the main composition of plastic litter were plastic bags, and bottles etc.



	2007	2008	2009	2010	2011	2012	2013	2014
Polystyrene foam	31%	19%	31%	23%	19%	57%	56%	46%
Plastic waste	27%	41%	41%	54%	53%	23%	27%	31%
Wood garbage	0	15%	14%	6%	14%	12%	9%	16%
Others	42%	25%	14%	17%	14%	8%	8%	7%

Fig.9 Composition of the floating marine litter in China (Data from NOWPAP)

It was showed that the main type of beach litter was plastics, accounted for 48%, followed by polystyrene foamand wood garbage, accounted for 17% and 12% respectively (Fig. 10). The mean density of the litter was 43,207 pieces /km^2. The main composition of plastic litter included plastic bags, bottles as well as plates and ropes.

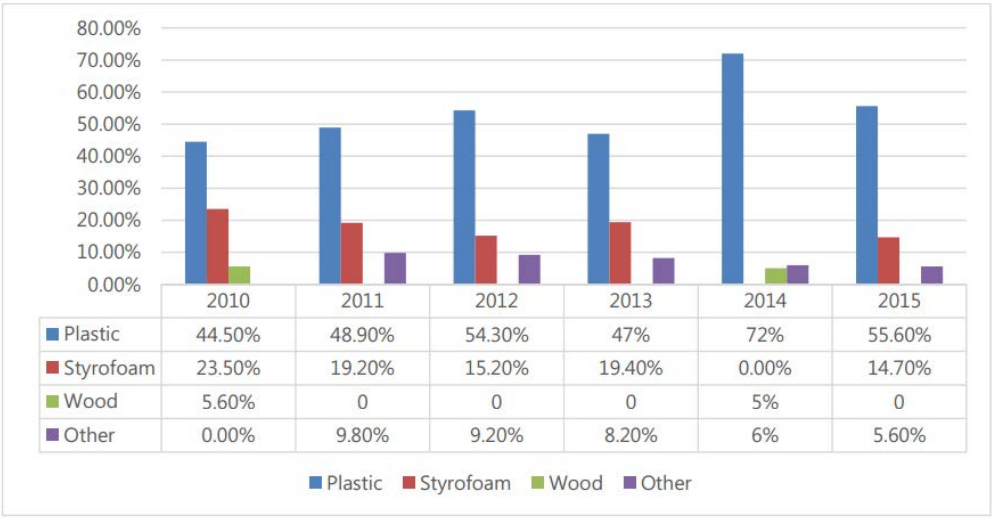


	2007	2008	2009	2010	2011	2012	2013	2014
Polystyrene foam	11%	9%	10%	22%	0	10%	38%	20%
Plastic waste	34%	66%	41%	52%	50%	59%	36%	44%
Wood garbage	6%	0	24%	8%	12%	12%	11%	11%
Others	49%	25%	25%	18%	38%	19%	15%	25%

Fig.10 Composition of the beach litter in China (NOWPAP)

In Korea, the total number of collected marine litter decreased from 2010 (64,406 items) to 2014 (33,600 items), however it increased in 2015 , it reached to 72,399 items, this maybe due to the survey sites change, the number of survey sites were doubled from twenty to forty in the fifth survey of 2014 (Fig. 11).

The results showed that most of discarded debris were plastic and Styrofoam, . Among the total amount of the collected marine litter between 2010 and 2015, around 20-30% (slightly varying depending on the year) was fishery-related waste, such as Styrofoam/plastic buoys or ropes. On the other hand, the rest (around 70-80%) of marine litter originated from land-based activities (MOF, Korea, 2015).



	2010	2011	2012	2013	2014	2015
Plastic	44.50%	48.90%	54.30%	47%	72%	55.60%
Styrofoam	23.50%	19.20%	15.20%	19.40%	0.00%	14.70%
Wood	5.60%	0	0	0	5%	0
Other	0.00%	9.80%	9.20%	8.20%	6%	5.60%

Fig.11 Total number of collected marine litter and its composition ratio (%) during 2010-2015in Korea (NOWPAP)

3.5 Floating marine microplastic debris

According to National Marine Ecology and Environmental Status Bulletin in 2018 (Ministry of Ecological and Environment of the People's Republic of China, 2018), the mean density of floating microplastics in the Yellow Sea of China is 0.35 items/ m^3. The main type of microplastics were Polypropylene (PP), Polyethylene (PE), Polyethylene terephthalate (PET) and polystyrene (PS), accounted for 23.4%, 19.1%, 17.6% and 14.2%, respectively (Fig. 12). The main shapes were fiber and flake (Fig. 13).

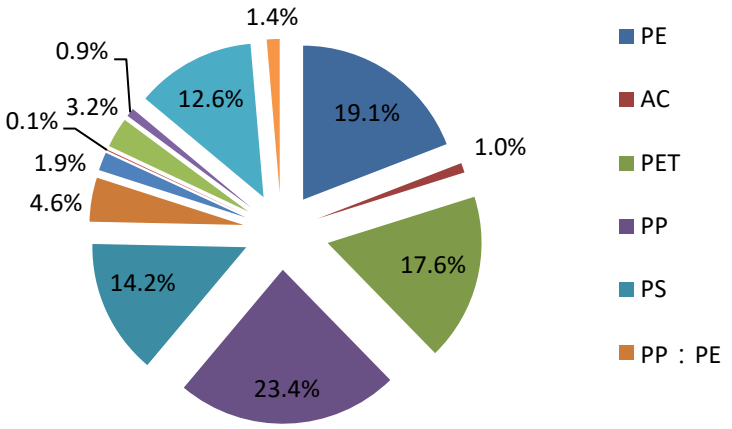


Fig.12 Composition of microplastics of the southern Yellow Sea of China in 2018

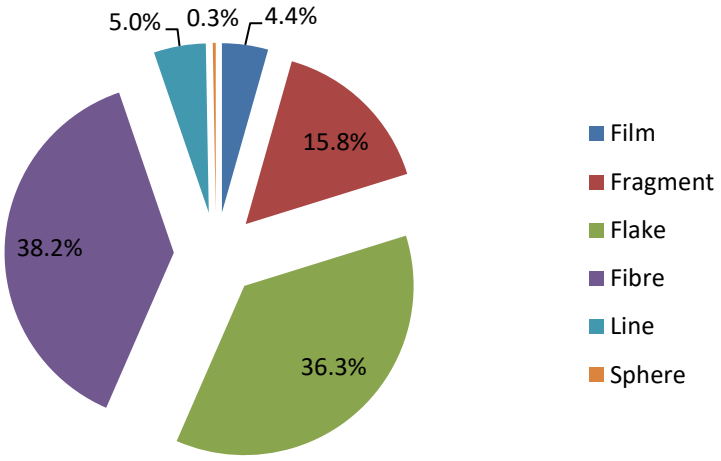


Fig.13 Shapes of microplastics of the southern Yellow Sea of China in 2018

These microplastics were classified into five size categories: < 1, 1–2, 2–3, 3–4, and 4–5 mm. The percentage of microplastics 1–2 mm was 40.9% (Fig. 14). Color of most of the collected microplastics was white and translucent, accounting for 38.4% and 34.8% (Fig. 15).

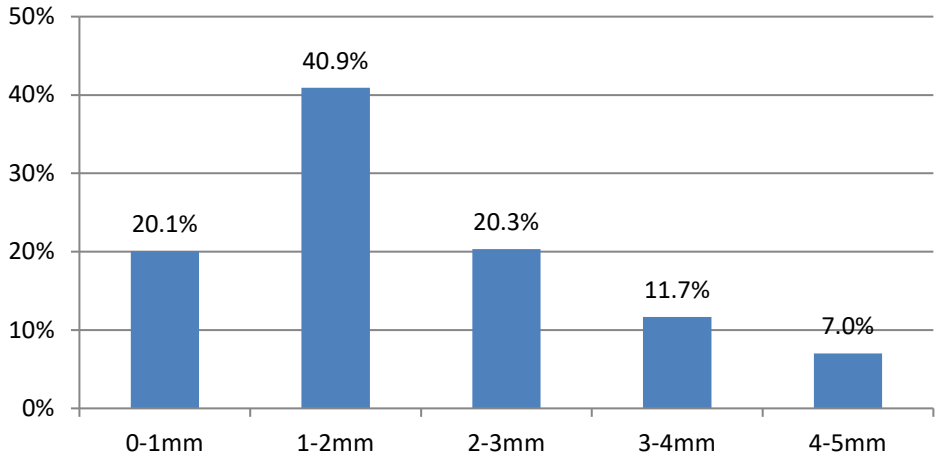


Fig.14 Size of microplastics of the southern Yellow Sea of China in 2018

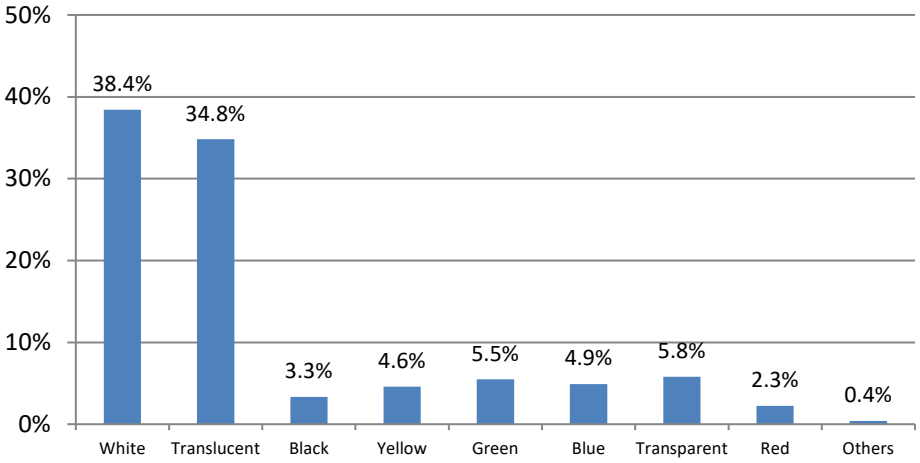


Fig.15 Color of microplastics of the southern Yellow Sea of China in 2018

3.6 Floating/ Sediment microplastic debris of the Yellow Sea

Sun et al. (2018) performed a comprehensive study of the distribution characteristics of MPs in seawater of the Yellow Sea. A total of 50 stations were designed in order to cover the coastal and the offshore area of the Yellow Sea (Fig. 16). The results showed that the average concentration of microplastics in seawater is 0.13 ± 0.20 pieces/m^3 (Fig. 17), 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. It is noteworthy that the mesh size of sampling net is 500 μm (Sun et al., 2018).

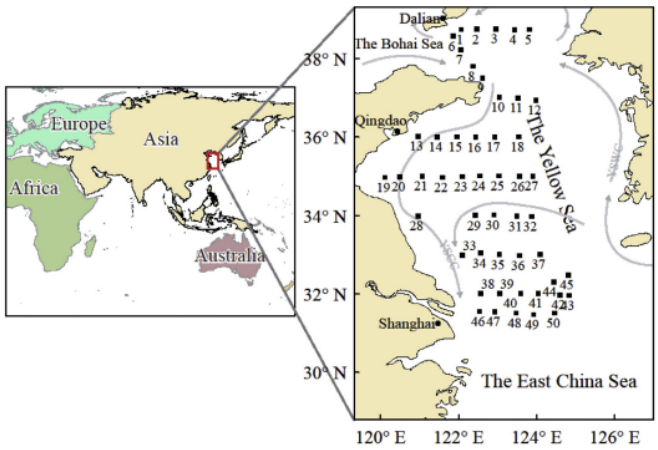


Fig.16. Sampling stations for MPs in seawater and zooplankton in the Yellow Sea in the summer of 2015 (Sun et al., 2018).

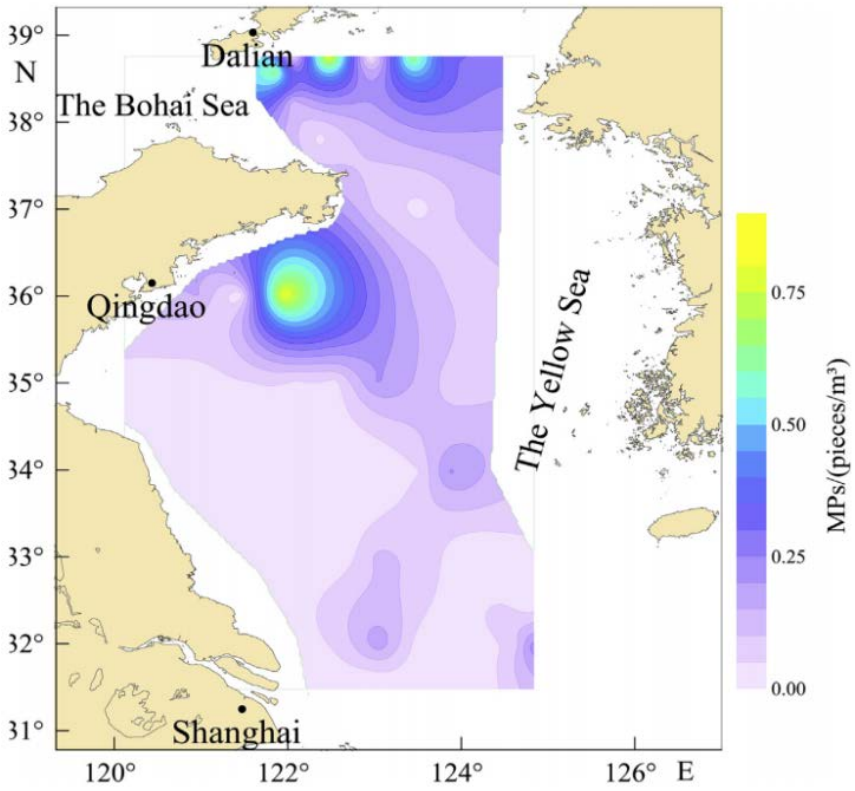


Fig.17. Distribution of MPs in the surface water of the Yellow Sea (Sun et al., 2018).

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

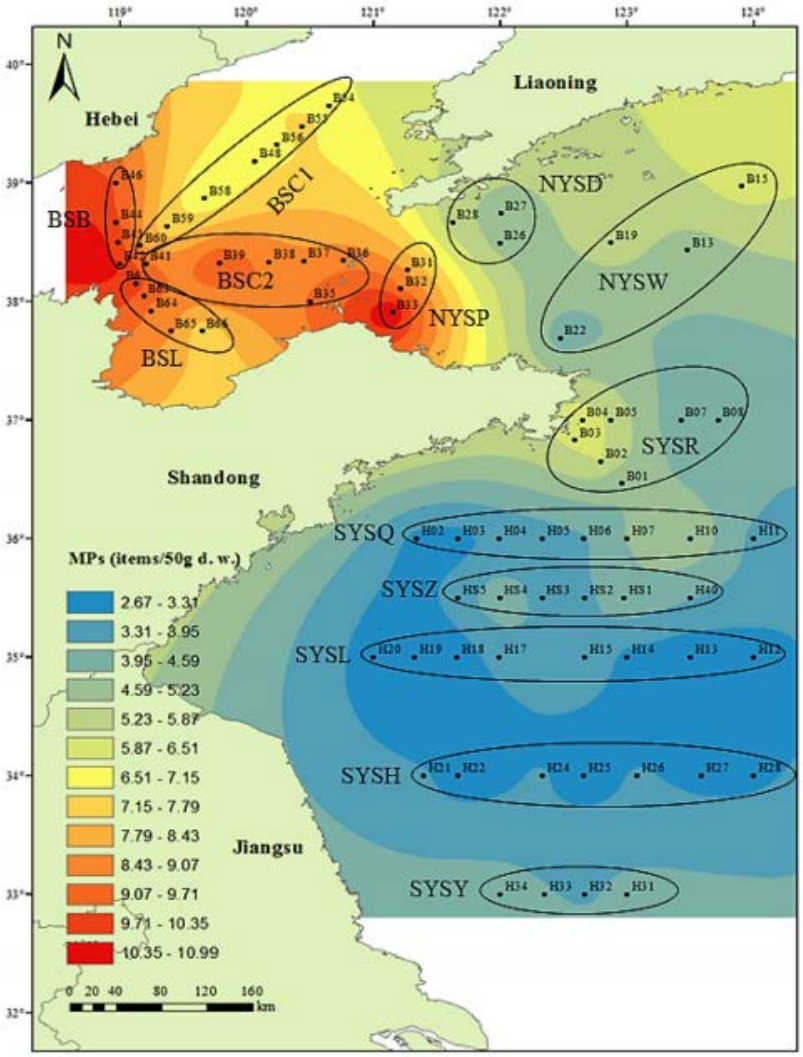


Fig.18. Distribution of microplastics in in sediments from the Yellow Sea (Zhao et al., 2018).

Another study investigated the abundances, distributions and characteristics of microplastics in surface seawater and sediments from the North Yellow Sea. The abundance of microplastics was 545 ± 282 items/m^3 in surface seawater (the mesh size of sieve is 30μm) and 37.1 ± 42.7 items/kg dry weight in sediments, representing a medium microplastic pollution level compared with other sea areas (Zhu et al., 2018). The results showed that small microplastics (＜1 mm) made up 70% of the total microplastic numbers. Films and fibers were the dominant shapes of microplastics in both the surface seawater and sediments. Transparent microplastics were generally more common than microplastics of other colors. Polyethylene (PE) was the dominant composition of microplastics in surface seawater, while polypropylene (PP) was the most common polymer type in sediments.

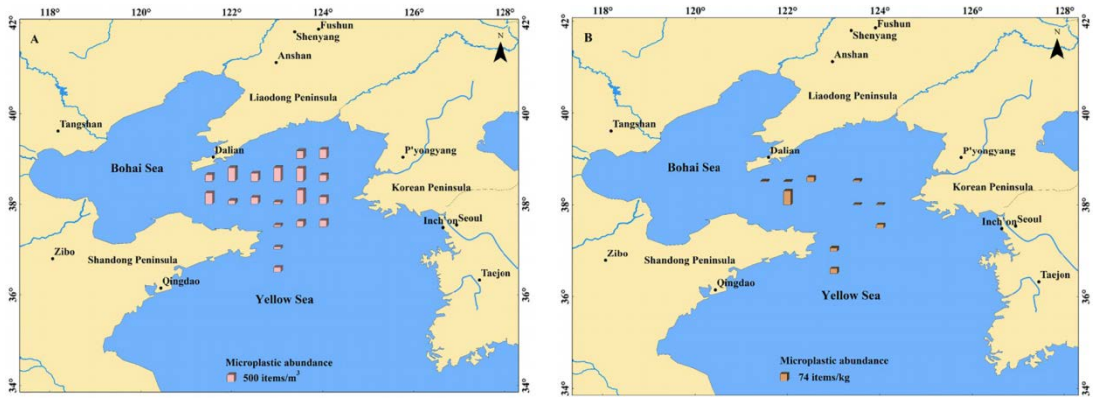


Fig.19. Abundances and distributions of microplastics collected from the North Yellow Sea: (A) surface water and (B) sediments (Zhu et al., 2018).

4. Conclusion

Although China was considered a hot spot of plastic debris pollution (Jambeck et al., 2015), compared data of National Marine Ecology and Environmental Status Bulletin and the published reports (Table 2)showed, thatthe density of microplastics in surface water of the Yellow Sea was of the same order of magnitude as that in the central-western Mediterranean Sea (de Lucia et al., 2014), Seto inland Sea (Isobe et al., 2014), East China Sea (Zhao et al., 2014), and Arctic polar waters (Lusher et al., 2015). The microplastic density is lower than that in the near shore waters of the Black Sea (Aytan et al., 2016), the southeastern seashore of South Korea (Kang et al., 2015), the East Asian Sea (Isobe et al., 2015), and the Black Sea waters (Aytan et al., 2016). Of cause, because of the differences in monitoring methods, there is still difficulty in comparing data from different regions, and further research on normalization methods should be developed.

Table 2. Microplastic abundances reported for surface waters around the world.

Location	Net mesh	Density (particles/m^3)	Source
Black Sea waters	200 μm	600–1200	Aytan et al., 2016
Central-Western Mediterranean Sea	500 μm	0.15	de lucia et al., 2014
Seto inland	335 μm	0.39	Isobe et al., 2014
East Asian Sea	335 μm	3.7 ± 10.4	Isobe et al., 2015
Southeast Korea, coast	330 μm	1.92–5.51	Kang et al., 2015
Southern California offshore	333 μm	3.92	Lattin et al., 2004
Northeast Atlantic (Celtic sea)	250 μm	2.46	Lusher et al., 2014
Arctic polar waters	333 μm	0.34 ± 0.31	Lusher et al., 2015
East China Sea	333 μm	0.167 ± 0.138	Zhao et al., 2014

Yellow Sea, China	330 μm	0.33	Zhang et al., 2017

Compared the results with other published data (Table 3), the microplastic density in Yellow Sea sediment (37.1-123.6 particles/kg dry sediment) was significantly lower than that in Lagoon of Venice (Vianello et al., 2013) and Mediterranean Sea (Alomar et al., 2016). Microplastic density in the sediments of the Yellow Sea was about four times of that in Baltic Sea sediment (Zobkov et al., 2017).

Table 3. Microplastic abundances reported for marine sediments across the world

Location	Microplastic abundance	Extraction method	Study
Belgian coastal harbours	166.7 ± 92.1 particles/kg dry sediment	Density separation (saline solution)	Claessens et al., 2011
Lagoon（Adriatic Sea）	1445.2 particles/ kg dry sediment	Density separation (NaCl)	Vianello et al., 2013
Mediterranean Sea (coastal shallow)	0.90 ± 0.10 MPs/g dry sediment	Density separation (filtered water)	Alomar et al., 2016
Baltic Sea	34 ± 10 items/kg dry sediment	Density separation ($ZnCl_2$)	Zobkov et al., 2017
Southern Yellow Sea	72.0 items/kg dry sediment	Density separation (NaCl)	Zhao et al., 2018
Northen Yellow Sea	123.6 items/kg dry sediment	Density separation (NaCl)	Zhao et al., 2018
Northen Yellow Sea	37.1 items/kg dry sediment	Density separation (NaCl)	Zhu et al., 2018

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