Fishery and Aquaculture Marine Debris Survey Report

--in the Yellow Sea Area of China

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[1], This publication was made through the support provided by the UNDP/GEF Yellow Sea Large Marine Ecosystem (YSLME) Phase II Project.

Abstract:

This study approached to assess the level of fishery-based beach debris in the Yellow Sea Area of China with contribution from trained local civic groups. We conducted 3 replications at 9 sites along the Yellow Sea coastline from May to September 2019. The results show that the average distribution of fishery-based beach debris was 1,249 count per 300 meter and 30,668 g per 300 meter. Foam fragments are the most common debris in terms of count (48.3%) and weight (36.0%), followed by fishing net in terms of count (18.2%) and weight (31.9%). The main source of the items could be the floats to mark the position of gear installation, combining with bamboo sticks and ropes for aquaculture.

Keywords: fishery-based, beach litter, Yellow Sea Area, citizen science, China

1. Introduction

Marine litter, defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (UNEP, 2009), is nowadays found in most of all sea areas worldwide and recognized as a major stressor for the marine and coastal environment. It is meanwhile even identified as one of the main global environmental problems alongside other key issues such as climate change and the loss of biodiversity (Sutherland *et al*., 2010; Werner and O'Brien, 2018) because it can cause a wide spectrum of environmental, social-economic, and human health impacts (Cheshire *et al*., 2009).

Despite international, national and local prohibitions (ANZECC, 1996; GESAMP, 2001; Barnes, 2002; Kiessling, 2003), the level of marine litter pollution is substantial, increasing on almost all coasts, due to the slow rate of degradation or decomposition, mainly plastics, together

with continuously growing quantity of litter disposed in the oceans and world shores (Cheshire *et al*., 2009; UNE, 2019).

Shanghai Rendu Ocean NPO Development Center (Rendu Ocean) has conducted beach cleanups and beach litter monitoring along China's coastline since 2015. The debris items from fishing have not received much attention so far in the publication. Based on the experiences and information we accumulated. However, fishing-related beach debris will be highlighted in this report. This report aims at attempting to assess the level of fishery-based beach debris in the Yellow Sea Area of China, according to the data on abundance, composition, and source of debris collected from May to September 2019.

2 Materials and methods

2.1. Survey area

A total of 9 sites were selected along the coastline of the Yellow Sea area in China. The most important factor to select survey sites was to avoid direct interference by human activities. Eight sites have no residents, villages, and public activities near the beaches and only one site (Site 1) was adjacent to the fishing port. The second factor was to find an appropriate survey organization near each site. That's why from Site 7 to Site 9, the distance between sites is very far (Figure 1).

Prior to the survey, we organized a 3-day training workshop with the advisory group from Our Sea of East Asia Network in Korea (Figure 2). The workshop consisted of a theoretical understanding of marine litter issue, how to assess the pollution of marine debris, the importance of citizen science program, how to develop the potential solution and policies using survey data, and field exercise. Fourteen people from 6 nonprofit organizations participated and learned the methodology to apply to 9 sites. After the workshop, they conducted three periods of the field survey in the designated site every other month from May to September. A total of 27 surveys at 9

sites were conducted and one survey was excluded in data analysis for details of fishing gears because it had a missing part of data filling.

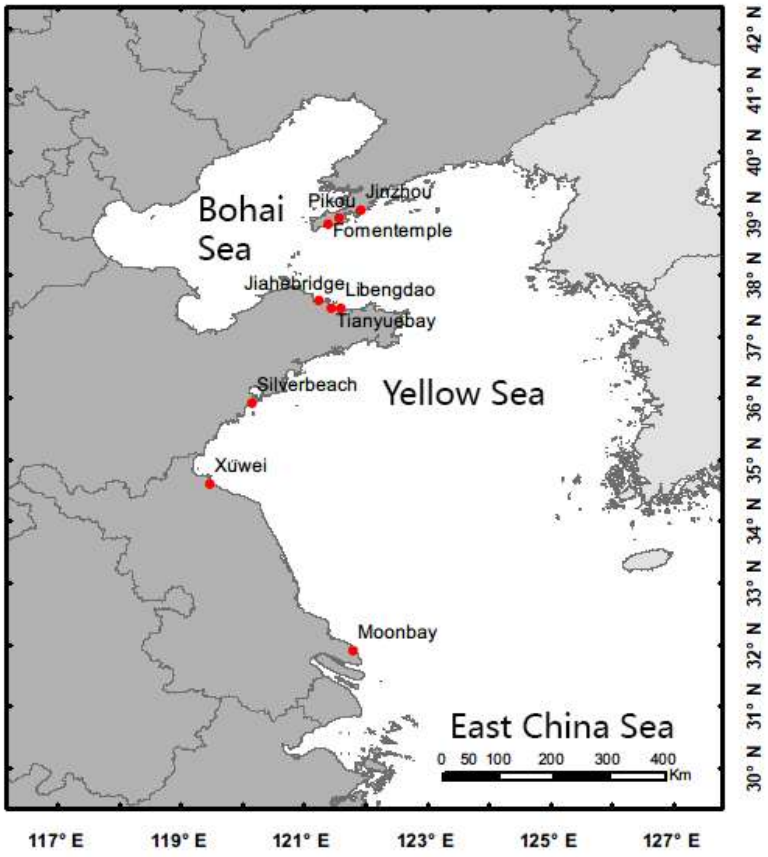


Fig. 1 Location of monitoring sites in Yellow sea coastline of China

Table 1. Information on each survey site

Site No.	Province	City	Site	Description
1	Liaoning	Dalian	Pikou	Sand and pebble beach, near a fishing port, no directly pull up in survey area, but could be affect from surrounding environment.
2	Liaoning	Dalian	Jinzhou	Sand and pebble beach, near an industrial factory and a golf yard.
3	Liaoning	Dalian	Fomentemple	Sand beach, near a temple, a few tourists might reach the beach.
4	Shandong	Yantai	Jiahebridge	Sand beach, near a highway
5	Shandong	Yantai	Tianyuebay	Sand beach, near a residential area
6	Shandong	Yantai	Libengdao	Sand beach, uncultivated area nearby
7	Shandong	Qingdao	Silverbeach	Sand beach, near a residential area
8	Jiangsu	Lianyungang	Xuwei	Sand beach, near cultivated area
9	Jiangsu	Qidong	Moonbay	Sand beach, near a residential area

Figure 2. Training workshop to instruct the methodology of the survey (18th-19th May 2019)

2.2. Methods

105-m-long coastline was located as a survey area with GPS coordinates on each site. Within every survey area, 5 transects that 5-m-long each which were separated by 20-m-long gaps were determined as survey transects (Fig.3). All debris items over 2.5 cm between the low tide and the back of shoreline were collected and classified into 8 categories according to the type of materials (general plastic, polystyrene/foam plastic, glass/ceramic, rubber, metal, paper, timber/wood and others) (see Appendix 1). Sixty-two individual items were recorded in each survey for their type, count and weight. Eight items of fishing gears (hard plastic buoy, cage, fishing line, rope, fishing

net, EPS buoy, foam box and foam fragment) were included (Figure 4). Foam fragment was recognized as fishing gears because *fishing gears like EPS buoys could be the major source of it (Figure 4.g, 4.h).* After the survey, all debris was removed for the following surveys.

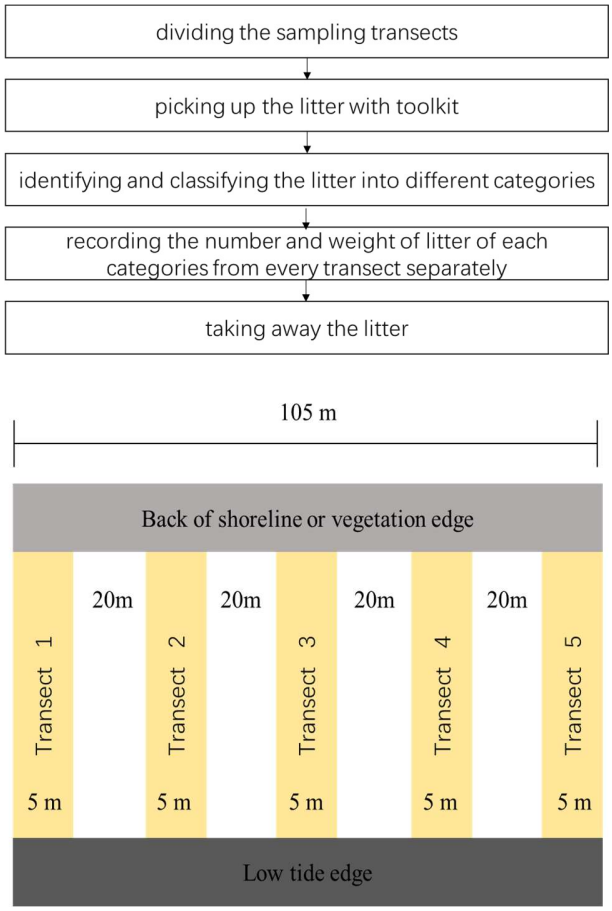


Figure 3. Study diagram (above) and survey area and 5 transects (below)

(a) Fishing line

(e) Cage

(b) Fishing rope 

(f) Foam box 

(c) Fishing net 

(g) EPS buoy 

(d) Hard plastic buoy 

(h) Foam plastic fragment 

Figure 4. Photos of fishing-related items

2.3 Statistical analysis

There were a few cases which have missing information on count or weight of 59 items. So we analyzed only the transects having both counts and weight and standardized raw data for 300 m length of the beach for comparison (Table 2).

Kruskal–Wallis's test and Tukey's HSD test were performed to identify and specify the significantly different at 5% level between survey sites.

3. Results

3.1. Abundance (Quantities and distribution)

A total of marine debris collected from 26 surveys at 9 sites are 108,113 pieces and 5,807.7 kg for 300 m of beach length including fishing gears are 32,468 pieces and 797.4 kg (Table 2) , accounting for 30% and 14% respectively. The first survey of Libengdao was excluded in data

analysis because it didn't produce enough data. The average amount and weight distribution on each survey site can be calculated to be 4,158 count per 300 meter and 223,374 g per 300 meter (Table 1). For fishing gear, average distribution can be calculated to be 1,249 pieces (including foam fragments) and 30,668 g in weight per 300 meter. In Libendao (31-83%) and Jiahebridge (33 - 55%), their proportions of fishing gears were especially higher than other sites.

Table 2. Amount and weight distribution on 9 sites along Chinese coastline in the Yellow Sea area

		Number(counts·300m^{-1})			Weight(g·300m^{-1})		
Site	Period	All debris	Fishing gear	% of fishing gear	All debris	Fishing gear	% of fishing gear
Pikou	1	5160	1340	26%	258171	44721	17%
	2	2840	240	8%	46965	1545	3%
	3	2772	108	4%	188570	33099	18%
Jinzhou	1	960	216	23%	14711	7014	48%
	2	2916	732	25%	23383	4428	19%
	3	1260	60	5%	7313	610	8%
Fomentemple	1	5720	460	8%	326238	19220	6%
	2	3780	456	12%	150846	18993	13%
	3	3780	396	10%	280950	5193	2%
Jiahebridge	1	7608	3684	48%	239902	60883	25%
	2	5484	1788	33%	116916	25881	22%
	3	4560	2520	55%	152990	65235	43%
Tianyuebay	1	2265	480	21%	46409	19941	43%
	2	7340	1420	19%	135414	10824	8%
	3	7180	2720	38%	146500	26506	18%
Libengdao	2	5352	1668	31%	80932	36790	45%
	3	12276	10236	83%	314865	80487	26%
Silverbeach	1	2880	696	24%	12781	1943	15%
	2	3456	36	1%	29918	247	1%
	3	2244	540	24%	39678	1141	3%
Xuwei	1	3980	400	10%	778320	5080	1%

	2	3200	260	8%	256800	15600	6%
	3	5940	980	16%	576520	80280	14%
Moonbay	1	2292	600	26%	272484	31620	12%
	2	1788	192	11%	1019196	154800	15%
	3	1080	240	22%	290946	45288	16%
Total		**108113**	**32468**	**30%**	**5807716**	**797368**	**14%**
Av		**4158**	**1249**	**30%**	**223374**	**30668**	**14%**

The most frequently detected items were listed in total in terms of count and weight (Table 3). The top 10 items were 2,526 counts which are 60.7% of the total. Foam fragment was the most abundant item, accounting for 14.5% of total counts. Among the top 10 most frequent items, foam fragment, fishing net and fishing rope occupied 23.4% of the counts. The individual sites showed the various pattern in terms of the most frequent items (Appendix Table 2). Foam fragment was included in 7 sites among 9 sites and the most or second most abundant in 5 sites (Jiahebridge, Jinzhou, Libengdao, Moonbay, and Tianyuebay).

Table 3. Top 10 items in total

Items	Count (/300m)	Proportion (%)	Note
Foam fragment	603	14.5%	Fishing gear
Other plastic	297	7.2%	
Other wood/timber	250	6.0%	
Plastic packaging	240	5.8%	
Fishing net	227	5.5%	Fishing gear
Other plastic bag	209	5.0%	
Cigarette butt	203	4.9%	
Other glass/ceramic	201	4.8%	
Plastic bottle cap	153	3.7%	
Fishing rope	142	3.4%	Fishing gear
Subtotal	2526	60.7%	
Total	4158	100.0	

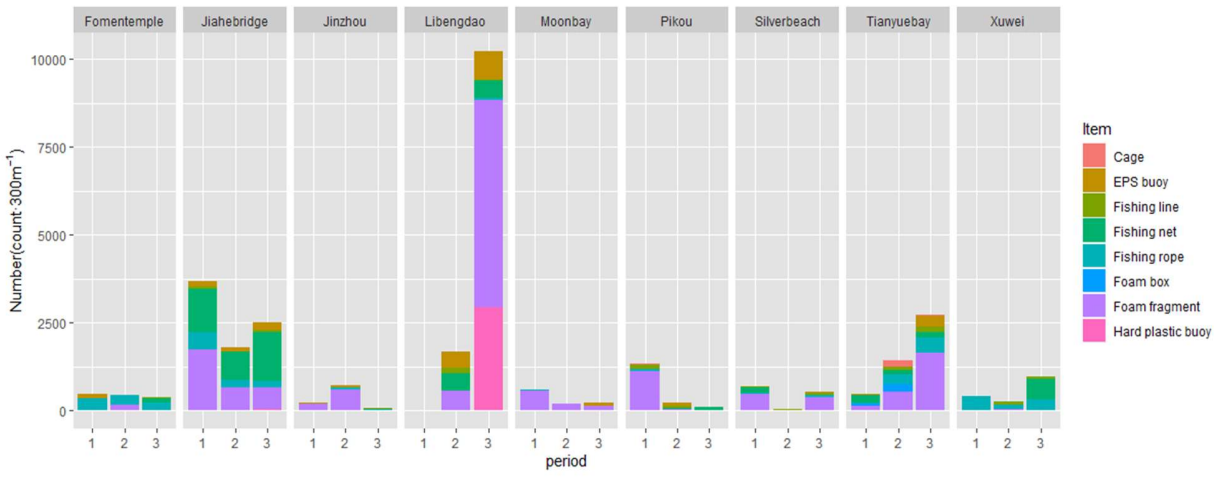
3.2. Rank of fishing gears debris

Above all fishing gear debris, foam fragments are no doubt the most common debris in both count (48.3%) and weight (36.0%), followed by the fishing net as the second rank in count (18.2%) and weight (31.9%) (Table 4). Only top two items (foam fragment and fishing net) accounted for over 60 % in number and weight. Foam fragment was dominant in most of the individual surveys in number. However, in terms of weight, foam fragment was dominant in the second survey of Moonbay (Site 9) only. Fishing net occupied high proportion only in Jianhebridge (Site 4) in number. In terms of weight fishing net comprised a high proportion in several surveys (Figure 6).

Table 4. Fishing gear debris ranked by count and weight

Item	Count (pieces/300m)	%
Foam fragment	603	48.3%
Fishing net	227	18.2%
Fishing rope	142	11.3%
Hard plastic buoy	118	9.4%
EPS buoy	99	7.9%
Fishing line	40	3.2%
Foam box	12	0.9%
Cage	9	0.7%
Total	**1249**	**100.00%**

Item	Weight (g/300m)	%
Foam fragment	11053	36.0%
Fishing net	9790	31.9%
Fishing rope	4948	16.1%
EPS buoy	2605	8.5%
Hard plastic buoy	1205	3.9%
Fishing line	793	2.6%
Cage	155	0.5%
Foam box	120	0.4%
Total	**30668**	**100.00%**



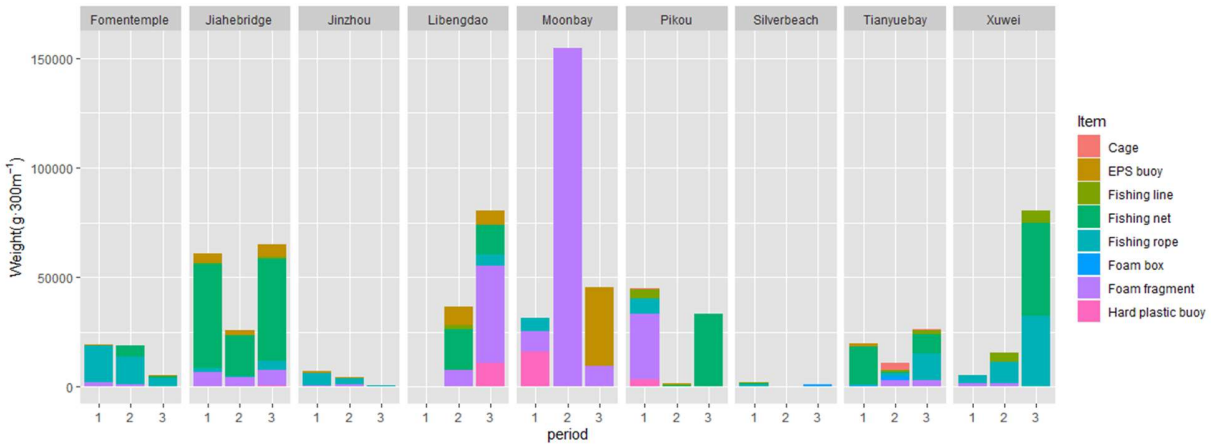


Figure 6. Abundance of fishing gear items (8 items) at each survey. The raw data was recalculated for each transect: count per 300 m (above) and weight (gram) per 300 m (below).

3.3. Comparison among sites

The Kruskal–Wallis test shows significant differences among survey sites both in terms of count distribution (χ^2 = 59.485, *df* = 8, *p* <0.001) and weight distribution (χ^2 = 43.949, *df* = 8, *p* <0.001). The post hoc Tukey's test ($p<0.05$) reveals that site Jiahebridge (Site 4) and Libengdao (Site 6) is significantly different from other sites besides Tianyuebay (Site 5) in terms of count distribution (Fig. 8). In terms of weight Jiahebridge (Site 4) is also significantly different from almost all other sites besides Libengdao and Moonbay(Site 6,9). Overall, Jianhebridge and Libengdao (Site 4,6), which are located in Yantai City, showed significantly higher abundance of fishing gear than other sites. There is no clear evidence to show significant different among different survey periods (Appendix Figure 1).

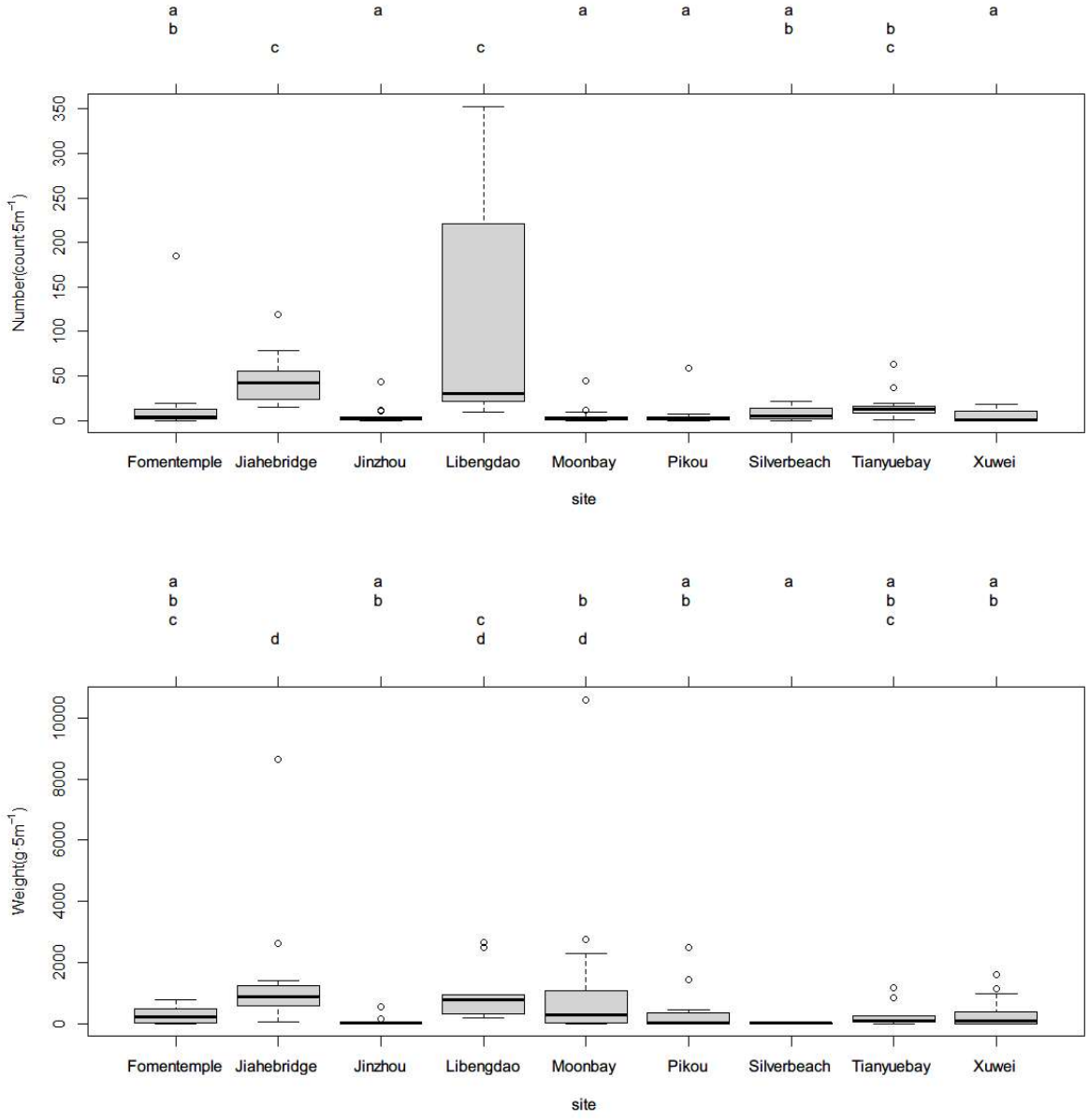


Figure 7. Debris count (above) and weight (below) distribution among different survey sites

4. Discussion

4.1 Assessment of fishery-based beach debris in Yellow Sea Area of China

The proportion of fishing gears in Yellow Sea region in this survey was 30% of total marine debris in number. It is comparatively high ratio considering that land based debris is believed to be

80% of marine debris. Especially we only counted explicit fishing gear excluding beverage bottle, plastic bag, and other items which could come from both land and sea based sources. The most abundant item was foam fragment which is potentially originated from fishery, indicating that fishing activities should be highlighted.

Hong et al. (2014) reported that the proportion of fishing related debris was also high in western coast of Korea. Yellow Sea is intensively used by fishing activities including capture fisheries and aquaculture. Both findings implicit fishing activities has been contributing to high proportion of fishing debris in this region.

The results from this study show that the average distribution of fishing gear debris along Chinese coastline in Yellow sea area is 1,249 pieces per 300 meter and 30,668 kg per 300 meter. Although the survey sites were selected to avoid direct impact from human activities except one site (Pikou, Site 1), the result says fishing debris should be dealt with more attention. Long term monitoring and further study are suggested for better understanding the situation among seasons and different land-use areas.

Lipiatte et al. (2013) classified the survey types into accumulation rate and standing stock. At the first survey of this study, we collected the debris which has been accumulated in the site during the unknown period. It can be expected the accumulated debris must have been high in abundance but the first survey result at each site was not always highest among three-time surveys (i.e., Site 2, 4, 5and 8). Other factors such as seasonal variation or unknown reasons can affect the result. Further studies should be continued for a better understanding.

4.2 Dominance of foam fragment and fishing net

During the study, foam fragments are no doubt the most frequently found not only from near fishing port (Site 1) but also from other sites along the coastline. Foam plastic like polystyrene has been wildly used in fishery and aquaculture industries. This type of material is fragile under waves,

sunlight or other forces or chemical works and impossible to cleanup when it is broken into tiny pieces.

Lee et al. (2015) elucidated that foam fragment was exceptionally high in meso and micro plastic debris of Korean coast. They suggested that these foam fragments came from aquaculture buoys which are extensively used on the west and south coasts of Korea. The high abundance of foam fragment in most of survey sites in this study implicates aquaculture could be an important source like in Korea. So further study is needed.

Fishing net is the second abundant fishing debirs in terms of count (18.2%) and weight (31.9%) in this study. Derelict fishing nets usually contribute to deterioration of habitats of fishery resources and entanglement of wildlife. Fishing net debris could also be used as cage component.

Lack of information on how to use those abundant items in fishing ground should be studied with priority. Actions against uncontrolled usage of foam plastic in fishery work should be taken into consideration. Recollecting system of EPS buoys or foam boxes are urged to be built.

5 Acknowledgments

Thanks to full support from UNDP, GEF and UNOPS as sponsors and partners, this study was possible to be conducted.

We are grateful to Nature-Exploring Camp (自然探索营), Environmental League of Colleges in Dalian（大连高校环境联盟（槐盟）), Yantai Original Life Public Welfare Development Center (烟台本源生活公益发展中心), Blue Ribbon Marine Conservation Association in China University Of Petroleum (中国石油大学（华东）蓝丝带海洋保护协会), Lianyungang Shoreline Cleanup Volunteer Service Center（连云港市清洁海岸志愿服务中心）and Qidong

Environmental Protection Volunteer Association（启东市环境保护志愿者协会）for conducting the surveys. We also thank all the volunteers from for participating in our surveys to collect data.

Specially grateful to Dr. Jongmyoung Lee and Dr. Sunwook Hong from OSEAN（Our Sea of East Asia Network）as supervisors and training supporters. And Dr. Jongmyoung Lee, Dr. Sunwook and Jongsu Lee are contributed to finish this report.

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Appendix

Supplementary Table 1: Debris total counts and weight

Material	item	Note	Counts		Weight(g)	
			Total	per 300m	Total	per 300m
General plastic	Cage	Fishing gear	232	9	4031	155
	Fishing line	Fishing gear	1036	40	20618	793
	Fishing net	Fishing gear	5902	227	254530	9790
	Fishing rope	Fishing gear	3683	142	128644	4948
	Hard plastic buoy	Fishing gear	3064	118	31324	1205
	Lighter		428	16	7713	297
	Mesh bag/woven bag		1136	44	232636	8948
	Other paper		964	37	2214	85
	Other plastic		7733	297	161087	6196
	Other plastic bag		5424	209	175530	6751
	Other plastic bottle		428	16	25345	975
	Plastic bag		2504	96	127877	4918
	Plastic beverage bottle		3407	131	377339	14513
	Plastic bottle cap		3974	153	19881	765
	Plastic cup/platte/bowl		598	23	5710	220
	Plastic glove		108	4	7610	293
	Knife/fork/spoon/chopsticks		1603	62	24513	943
	Plastic lid/cap		1612	62	13367	514
	Plastic packaging		6244	240	120319	4628
	Plastic shoe		168	6	63152	2429
	Plastic take-away container		555	21	26861	1033
	Plastic toothbrush		168	6	1426	55
Foam plastic	EPS buoy	Fishing gear	2561	99	67730	2605
	Foam box	Fishing gear	304	12	3112	120
	Foam cups/plate/bowl		72	3	223	9
	Foam fragment	Fishing gear	15686	603	287379	11053
	Foam package/infilling		1875	72	73015	2808
	Foam take-away container		1643	63	1091	42
	Other foam		1294	50	45055	1733
Glass/ Ceramic	Spoon/mug/plate/bowl		88	3	7582	292
	Glass beverage container		1311	50	170578	6561
	Light globe/tube		60	2	4177	161
	Other glass/ceramic		5227	201	129647	4986
Rubber	Condom		152	6	606	23
	Other rubber		1280	49	204442	7863

	Glove/shoe	800	31	227808	8762
	Tyre	256	10	55090	2119
Metal	Metal beverage can	824	32	53458	2056
	Metal cap/lid	260	10	1885	72
	Knife/folk/spoon/chopsticks	12	0	156	6
	Other metal	1299	50	278574	10714
Paper	Paper cup/platte/bowl	480	18	54927	2113
	Paper packaging	447	17	52447	2017
	Paper shoping bag	12	0	70	3
	Paper tissue	1000	38	7101	273
	Plastic straw/muddler	843	32	47055	1810
Wood/ Timber	Other wood/timber	6508	250	333402	12823
	Chopsticks/bamboo stick	546	21	6546	252
Mix/ Other	Cigarette butt	5286	203	24105	927
	Cigarette package	887	34	31758	1221
	Cloth	3307	127	1357536	52213
	Construction waste	416	16	95346	3667
	Firework	132	5	3180	122
	Medical litter(container)	216	8	1019	39
	Multi-layer beverage box	383	15	7476	288
	Other mix	1372	53	268407	10323
	Sanitary napkin	192	7	47370	1822
	Syringe	12	0	78	3
	Wipes	99	4	26558	1021
Total		**108113**	**4158**	**5807716**	**223374**

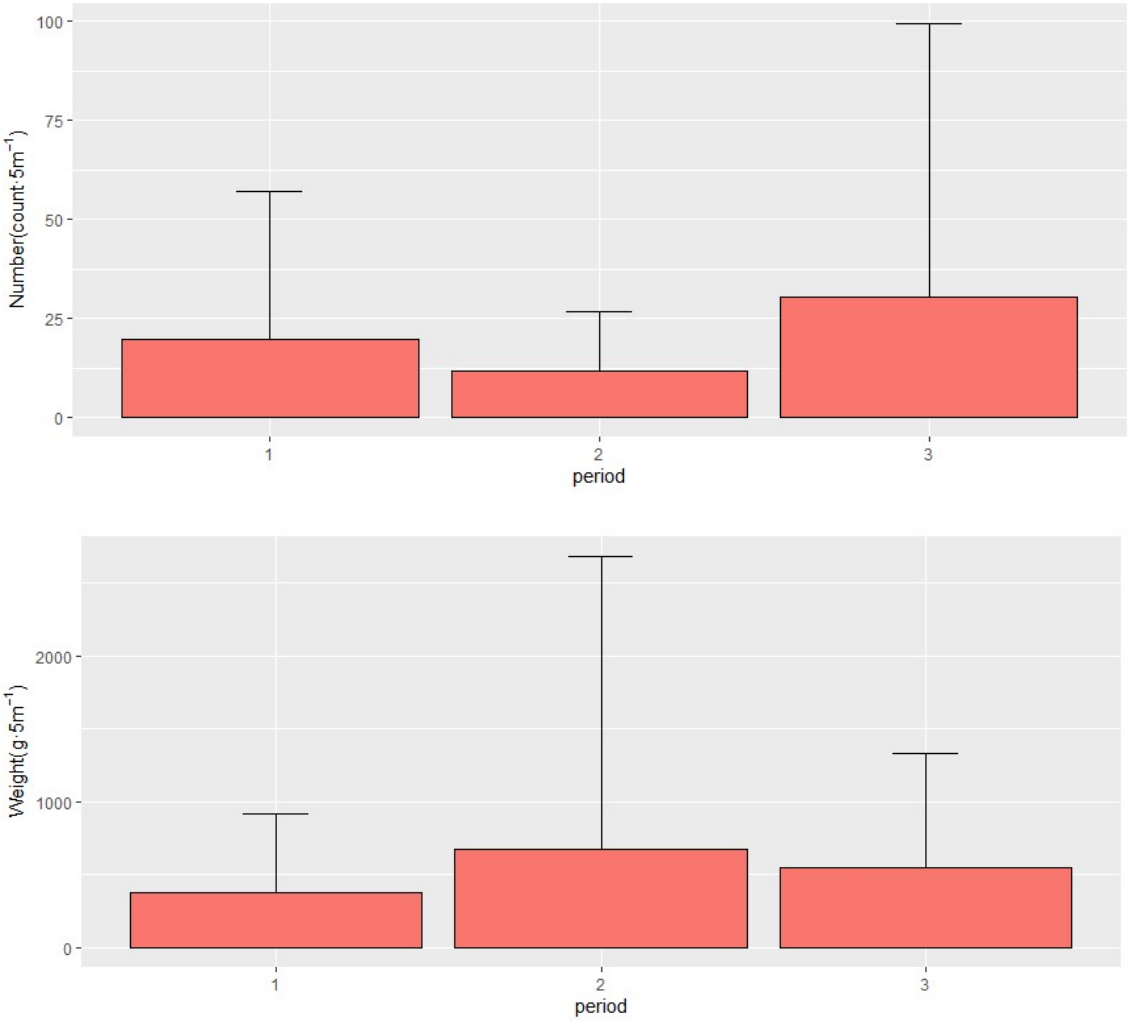
Supplementary Table 2: top 10 item of count in individual sites

Site	Items	Count/300m	Note
Pikou	Other plastic bag	1216	
	Plastic bag	1152	
	Foam fragment	**1140**	*Fishing gear*
	Other glass/ceramic	1104	
	Other plastic	924	
	Glass beverage container	900	
	Plastic packaging	588	
	Plastic bottle cap	444	
	Other rubber	312	
	Plastic take-away container	260	
Jinzhou	Other glass/ceramic	2208	
	Foam fragment	**792**	*Fishing gear*

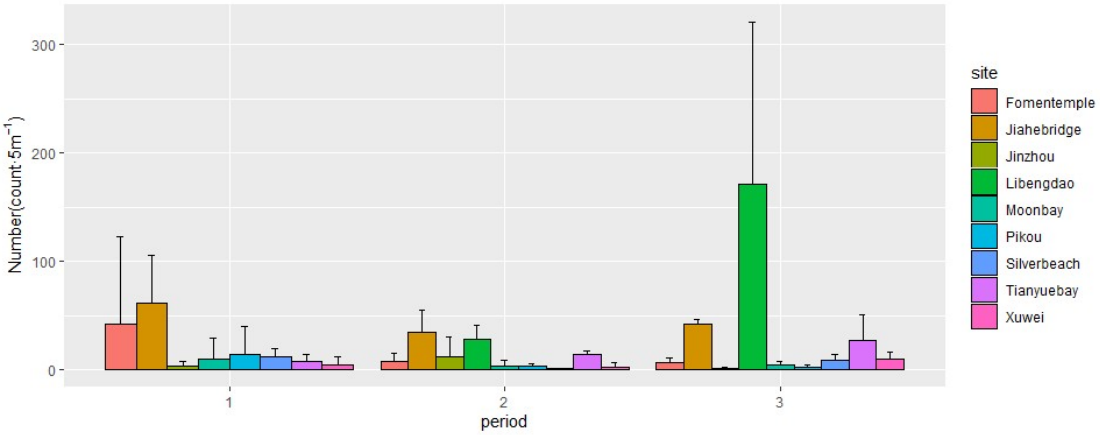
	Other plastic	372	
	Plastic bottle cap	276	
	Plastic packaging	264	
	Other plastic bag	240	
	Cloth	168	
	Plastic beverage bottle	120	
	Other metal	84	
	Other wood/timber	84	
Fomentemple	Foam take-away container	1484	
	Cloth	1400	
	Other glass/ceramic	1364	
	Plastic beverage bottle	1064	
	Plastic packaging	912	
	Fishing rope	*844*	*Fishing gear*
	Metal beverage can	560	
	Cigarette package	548	
	Other plastic bag	528	
	Plastic bag	344	
Jiahebridge	*Fishing net*	*3420*	*Fishing gear*
	Foam fragment	**3024**	*Fishing gear*
	Other wood/timber	2460	
	Plastic packaging	972	
	Fishing rope	*900*	*Fishing gear*
	Other plastic bag	804	
	Plastic straw/muddler	612	
	Other plastic	552	
	Cigarette butt	528	
	EPS buoy	*516*	*Fishing gear*
Tianyuebay	**Foam fragment**	**2310**	*Fishing gear*
	Cigarette butt	2190	
	Other wood/timber	2160	
	Other plastic bag	1260	
	Foam package/infilling	955	
	Other plastic	925	
	Plastic packaging	920	
	Fishing rope	*735*	*Fishing gear*
	Paper tissue	700	
	Fishing net	*470*	*Fishing gear*
Libengdao	**Foam fragment**	**6468**	*Fishing gear*
	Hard plastic buoy	2928	
	Other plastic	2268	

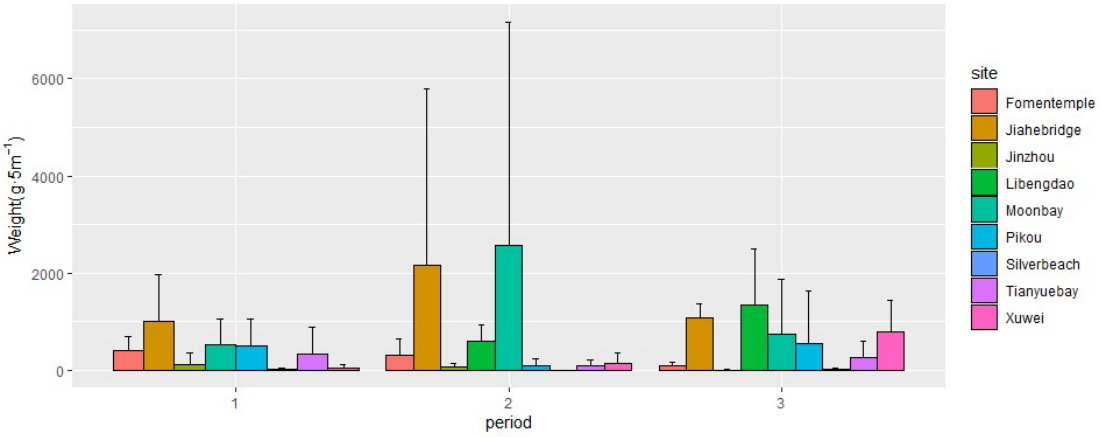
	EPS buoy	*1260*	*Fishing gear*
	Fishing net	*984*	*Fishing gear*
	Plastic bottle cap	396	
	Plastic packaging	348	
	Other wood/timber	312	
	Other foam	276	
	Cigarette butt	264	
Silverbeach	Cigarette butt	1920	
	Other wood/timber	936	
	Other plastic	912	
	Foam fragment	**852**	*Fishing gear*
	Plastic packaging	600	
	Plastic bottle cap	468	
	Other paper	408	
	Mesh bag/woven bag	336	
	Construction waste	192	
	Fishing net	*168*	*Fishing gear*
Xuwei	Plastic bottle cap	1600	
	Plastic packaging	1460	
	Other plastic	1400	
	Other plastic bag	1160	
	Plastic knife/fork/spoon/chopsticks	1000	
	Plastic lid/cap	960	
	Cloth	820	
	Fishing rope	*820*	*Fishing gear*
	Plastic beverage bottle	620	
	Fishing net	*600*	*Fishing gear*
Moonbay	**Foam fragment**	**852**	*Fishing gear*
	Plastic beverage bottle	804	
	Foam package/infilling	372	
	Other glass/ceramic	312	
	Plastic bag	240	
	Other rubber	192	
	Paper cup/platte/bowl	192	
	Cloth	180	
	Plastic packaging	180	
	Other foam	144	

Supplementary Figure 1: Debris count (above) and weight (below) distribution among period



Supplementary Figure 2: Debris count (above) and weight (below) distribution among period and sites


Number(count·5m⁻¹)
300
200
100
0
1
2
3
period
site
Fomentemple
Jiahebridge
Jinzhou
Libengdao
Moonbay
Pikou
Silverbeach
Tianyuebay
Xuwei


Weight(g·5m⁻¹)
6000
4000
2000
0
1
2
3
period
site
Fomentemple
Jiahebridge
Jinzhou
Libengdao
Moonbay
Pikou
Silverbeach
Tianyuebay
Xuwei