UNDP/GEF-YSLME

Research Progress Report on Developing Regulatory Measures for Marine Litter Management in Weihai City of PR China

Shandong Marine Resources and Environment Research Institute

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Introduction

Marine litter is a persistent, man-made/processed solid waste in the marine and coastal environment. It mainly includes litter on the beach, floating litter and submarine litter. With the continuous deepening of human development and utilization of the marine coast, the amount of the marine litters increases rapidly. It is reported that the increase rate of the beach litter reached 140% between 1994 and 2013 in Britain. The damage caused by marine litter to marine ecosystem and biological resources is increasingly serious. And the litter has been one of the major pollution phenomena in the coastal environment. Data shows that there are about 8 million wastes per day, and up to 6.4 million tons of wastes per year entering the sea. It is estimated that the stock of plastic garbage has reached 36 times of the plankton biomass in the Pacific. Plastic marine litter can not only directly lead to the injury or death of marine organisms, but also the micro plastic particles produced after aging and fragmentation will enter the food chain and cause hidden dangers to human health.

Since 2007, the status of marine litter has been listed in “Marine Environment Status Bulletin in China” as one of the contents. In the same year, the marine litter monitoring in coastal cities has been carried out in Shandong Province. In the present project, Xiaoshi Dao and Weihai Bay in Weihai city are selected as the research area, and 17 sea and land monitoring sections are set up to
monitor the type and density of marine litter. The historical data in the project comes from marine litter monitoring data of Xiaoshi Dao in Weihai from 2009 to 2017 and the special monitoring data of marine litter from “Marine Litter Prevention and Management in Weihai City between China and the United State- ‘Sister Cities’”. And meantime, to get more information about the status of wastes generation and recovery/disposal of marine aquaculture and marine fishing in Shandong province, we have selected Rongcheng City and Rushan City as the representative areas to investigate the specific conditions of marine aquaculture and marine fishing.

1. Survey and Analysis Methods

1.1 Survey Methods

(1) The methods of section layout, classification and specification statistics are referred to “Technical Regulations for Marine Litter Monitoring and Evaluation (Trial)” (Haihuan Zi [2015] No. 31). The width of the monitoring section is 5 m, and the length is from the edge of water surface or beach perpendicularly to the average high tide line or the vegetation cover area. The collected samples were simply cleaned, measured, classified, counted, and weighed. The marine litter were divided into small blocks (size <2.5 cm), medium blocks (size ≥ 2.5 cm and ≤ 10 cm), large blocks (size > 10 cm and ≤ 1 m) and larger blocks (size >1 m).

Tab.1 Contents and methods of marine litter monitoring

<table>
<thead>
<tr>
<th>Monitoring contents</th>
<th>Survey Methods</th>
<th>Survey Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter on the Beach</td>
<td>Visual and Gravimetric Method</td>
<td>The Type and Density of Litter Debris</td>
</tr>
<tr>
<td>The Floating Litter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large and Larger Blocks</td>
<td>Belt Transect Method</td>
<td></td>
</tr>
<tr>
<td>Small and Medium Blocks</td>
<td>Trawl</td>
<td></td>
</tr>
<tr>
<td>Submarine Litter</td>
<td>Trawl</td>
<td></td>
</tr>
</tbody>
</table>

(2) The statistical classification method of the Northwest Pacific Ocean and Coastal Regional Environmental Protection Organization (NOWPAP) was used to analyze the sources of the litter on the beach (Tab.2). The sources are analyzed according to five categories, including human coast activities, shipping/fishing activities, smoking supplies, medical/hygiene products, and other wastes.
Tab.2 Classify category of the beach litter sources

<table>
<thead>
<tr>
<th>Number</th>
<th>Sources</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Human Coast Activities</td>
<td>Plastic Bottles, Fast Food Boxes, Beverage Cans, Newspapers, Plastic Bags, etc.</td>
</tr>
<tr>
<td>S2</td>
<td>Shipping/Fishing Activities</td>
<td>Abandoned Fishing Nets, and Debris, Fishing Lines, Floats, etc.</td>
</tr>
<tr>
<td>S3</td>
<td>Smoking Supplies</td>
<td>Cigarettes, Cigarette Cases, Lighters, etc.</td>
</tr>
<tr>
<td>S4</td>
<td>Medical/Hygiene Products</td>
<td>Syringes, Waste Bottles, Sanitary Napkins, Diapers, etc.</td>
</tr>
<tr>
<td>S5</td>
<td>Other Wastes</td>
<td>Tyres, Fluorescent Tubes, Screens, Wires, Light Bulbs, Glass, etc.</td>
</tr>
</tbody>
</table>

1.2 Data Analysis Methods

The density of some kind of litter \( i \) on the beach is calculated as follows:

\[
D_i = \frac{n_i}{Lw}
\]

In the Formula:

- \( D_i \) — The density of the litter on the beach (ind./km\(^2\) or kg·km\(^{-2}\));
- \( w \) — The width of survey section (km);
- \( L \) — The length of survey section (km);
- \( n_i \) — The sum of the number or quantity of some beach litter on the survey section (ind. or kg).

There are many types of litter on the beach with regional differences. It is of positive significance for the targeted prevention to determine the main components of litter in a certain area. Referring to the concept of the share rate of pollutants by Zhao Wei, et al., the share rate of some litter \( i \) on the beach is calculated as follows:

\[
K_i = \frac{n_i}{n} \times 100\%
\]

In the Formula:

- \( K_i \) — The share rate of some litter \( i \) on the beach;
- \( n \) — The sum of the number or quantity of some beach litter on the survey section (ind. or kg).

In order of magnitude, the cumulative percentage greater than 80% is the main component of the beach litter.
2. The Status of Marine Litter in Weihai City

2.1 Litter on the Beach

2.1.1 Litter on the Beach in Weihai City

(1) Distribution of the Litter

The monitoring results showed that beaches under sanitary management, such as International Bathing Beach and Gold Beach Bathing Beach, were relatively clean with a small density; the natural beaches with frequent artificial activities, such as the north sea of Chu village and the west coast of Xiaoshi Dao, had a high density of litter; The demolition and relocation on some Boyu beaches was in progress, and the litter distribution density was not stable, so the monitoring results were not recorded.

(2) Classification of the Litter

The litter on the beach in Weihai city was dominated by living waste, including plastics, wood products, glass, paper, polystyrene foam, metal, and other types. The main stocks were medium and small, and the average density was 1989 kg·km^{-2}. Plastic wastes was the main litter in amount, accounting for 49%, followed by polyethylene foam and wood products, accounting for 22% and 12%, respectively.

(3) Sources of the Litter

The sources of litter were as follows. The first was left by tourists sightseeing and sea-catching, such as cigarette butts, beverage bottles, food packaging bags, etc. The second was the land-based light waste blown into the sea, such as light and thin polyethylene foam, etc. The third was the fishing boat remnants by seawater conveyor, such as Fishing nets, ropes, etc.

2.1.2 Litter on the Xiaoshi Dao beach in Weihai city

(1) Component Analysis

The total amount of the collected litter on Xiaoshi Dao beach was 220 in Weihai city. The amount and mass of the samples are shown in Tab.3. The proportion in the order of high to low were plastics, other types, wood products, polystyrene foam, paper, metal, glass, fabric (cloth), and rubber. Plastic was also the highest in mass.

Results showed that the highest quantity of beach litter in Xiaoshi Dao was plastics (37.73%). The results is consistent with Zhao, et al., who reported that the main types of beach litter in China was plastics (37.37%), and the percent of plastics in beach litter was about 50% to 80% in the coast of New South Wales, Australia and Balearic Islands, Spain. And moreover, the joint survey of Japan's coastal countries revealed that plastics accounted for about 55% to 93.4%.
Tab. 3 Composition and quantity of litter on Xiaoshi Dao beach

<table>
<thead>
<tr>
<th>Types</th>
<th>Number/Ind.</th>
<th>Number Proportion/ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Rubber</td>
<td>2</td>
<td>0.91</td>
</tr>
<tr>
<td>Plastics</td>
<td>83</td>
<td>37.73</td>
</tr>
<tr>
<td>Wood Products</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Paper</td>
<td>14</td>
<td>6.36</td>
</tr>
<tr>
<td>Metal</td>
<td>12</td>
<td>5.45</td>
</tr>
<tr>
<td>Other Artifacts and Unidentifiable Materials</td>
<td>42</td>
<td>19.09</td>
</tr>
<tr>
<td>Styrofoam</td>
<td>18</td>
<td>8.18</td>
</tr>
<tr>
<td>Fabric (cloth)</td>
<td>5</td>
<td>2.27</td>
</tr>
</tbody>
</table>

(2) Density Distribution

The average amount of beach litter in Xiaoshi Dao was 27,063 ind.·km\(^{-2}\) (Tab.3), which was respectively lower than those in Shandong Province (75,958 ind.·km\(^{-2}\)), East China Coast (31,001 ind.·km\(^{-2}\)) and China's marine litter monitoring area (54,371 ind.·km\(^{-2}\)). According to the mass statistics, the average mass of litter on Xiaoshi Dao beach was 3428.33 kg·km\(^{-2}\), which was respectively higher than those in Shandong Province (1186.47 kg·km\(^{-2}\)), East China Coast (1633 kg·km\(^{-2}\)) and China's marine litter monitoring area (1589 kg·km\(^{-2}\)). The litter on Xiaoshi Dao beach had lower amount and higher mass, which revealed that the litter was dominated by light litter with medium and large blocks (93.18% and 2.73%, respectively) and large masses. The statistical results of the inter-annual variation coefficient of density (Tab.4) revealed that the distribution varies of beach litter were great and was affected by the distribution of beaches, functional types, human disturbances and exotic.

Tab. 4 The density of beach litter in Xiaoshidao, Weihai City in China, 2009-2017

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Xiaoshi Dao in Weihai</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ind.·km(^{-2})</td>
<td>28571</td>
<td>4000</td>
<td>3000</td>
<td>12000</td>
<td>19000</td>
<td>37000</td>
<td>33000</td>
<td>50000</td>
<td>57000</td>
<td>27063</td>
<td>19240</td>
<td>71.09%</td>
</tr>
<tr>
<td>Xiaoshi Dao in Weihai</td>
<td>6057.14</td>
<td>2672</td>
<td>1420</td>
<td>1654.5</td>
<td>2573</td>
<td>11370.5</td>
<td>1989</td>
<td>512.8</td>
<td>2606</td>
<td>3428.33</td>
<td>3348.89</td>
<td>97.68%</td>
</tr>
<tr>
<td>/kg·km(^{-2})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring Area in Shandong /ind·km²</th>
<th>67898</th>
<th>62574</th>
<th>61841</th>
<th>111762</th>
<th>101611</th>
<th>78984</th>
<th>70395</th>
<th>90900</th>
<th>37658</th>
<th>75958</th>
<th>20282</th>
<th>26.70%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring Area in Shandong /kg·km²</td>
<td>1530.92</td>
<td>895.05</td>
<td>593.18</td>
<td>1158.00</td>
<td>1584.14</td>
<td>2310.13</td>
<td>635.29</td>
<td>576.98</td>
<td>1394.52</td>
<td>1186.47</td>
<td>519.20</td>
<td>43.76%</td>
</tr>
<tr>
<td>Monitoring Area in China /ind·km²</td>
<td>12000</td>
<td>30000</td>
<td>62686</td>
<td>72581</td>
<td>70252</td>
<td>50142</td>
<td>69203</td>
<td>70348</td>
<td>52123</td>
<td>54371</td>
<td>19834</td>
<td>36.48%</td>
</tr>
<tr>
<td>Monitoring Area in China /kg·km²</td>
<td>688</td>
<td>770</td>
<td>1114</td>
<td>2494</td>
<td>1622</td>
<td>3119</td>
<td>1105</td>
<td>1971</td>
<td>1420</td>
<td>1589</td>
<td>726.49</td>
<td>45.72%</td>
</tr>
</tbody>
</table>

**Tab.5 Distribution and source analysis of litter in the monitoring area on Xiaoshi Dao beach**

<table>
<thead>
<tr>
<th>Monitoring Area</th>
<th>Type of the Functional Area in Adjacent Waters</th>
<th>Beach Sediment Type</th>
<th>Amount/ind·km²</th>
<th>Mass/kg·km²</th>
<th>The Main Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xiaoshi Dao</td>
<td>The Sea Area Near to the Harbor</td>
<td>Fine Powder Sand</td>
<td>27063</td>
<td>3428.33</td>
<td>S1，S2，S5</td>
</tr>
</tbody>
</table>

(3) Characteristics of the Inter-annual Change

The inter-annual variations of litter on Xiaoshi Dao beach during the period from 2009 to 2017 are shown in Fig.2 and Tab.4. Similar changes were recorded in the inventory of beach litter in the marine litter monitoring area of China and the seven coastal beach cities in Shandong Province in the same period. Quantitatively, the amount of litter on Xiaoshi Dao beach in Weihai decreased from 2009 to 2010, and increased from 2011 to 2017, with the exception of 2015. The overall situation showed a continuous upward trend. Qualitatively, the mass of litter continuously decreased from 2009 to 2011, and increased year after year from 2012 to 2014, and then returned to the average annual levels.

![Fig.2 Annual change characteristics of beach litter](image-url)
(4) Sources Analysis

The analyzed results about the litter sources were shown in Fig.3. The results showed that human coastal activities were the main litter source, accounting for 52.47%. The second source was other wastes and shipping/fishing activities, accounting for 25.11% and 16.59%, respectively. The source of smoking articles and medical/hygiene supplies was relatively low, accounting for 3.59% and 2.24%, respectively. The main sources of litter on Xiaoshi Dao beach were human coastal activities, other wastes, and shipping/fishing activities.

![Fig.3 Sources of litter on Xiaoshi Dao beach](image)

2.2 Floating Litter on the Sea

2.2.1 Distribution of the Litter

The density of floating litter was not uniform and affected by the time and sea area.

Human activities in winter and spring were not strong, and the source of marine litter is relatively small. At the same time, due to seasonal northerly winds, some floating litter landed on the beach and become beach litter. The amount of floating litter was small, and some monitoring sections (from Chubei village to Jingzi Tou area) were not even monitored.

In summer and autumn, the amount of sea vessels, near-shore, human tourism and bathing beaches increased. Thus, the amount of floating litter increased significantly, which mainly distributed in tourist and recreation areas, agricultural and fishery areas, port shipping areas, and adjacent sea areas. Among them, the distribution of floating litter in the agricultural and fishery areas was significantly higher than other sea areas.

2.2.2 Classification and Sources of the Litter

The floating litters in Weihai City were mainly plastic paste, polystyrene foam chips, plastic bags and plastic bottles. The average amount was 3 ind./km² for large block, 102 ind./km² for the medium and litter block. And the average density was 2.06 kg·km⁻². Plastics posted the highest
amount, accounting for 52%, followed by polystyrene foam, accounting for 34%. 61% of the floating litter source was from sea activities and 39% from land.

2.3 Submarine Litter

Results showed that the density of submarine litter in Weihai City is relatively low, and the main source was the deserted operational tools of fishery production.

From the Beihai in Chucun village to Jinzitou sea-area, three sections seabed trawls were carried out. 9 plastic nets, 6 plastic nets, and 1 scallop cage were detected on the west side of Xiaoshi Dao. The total weight was 4.05 kg, and the average density was 7.5 kg·km⁻². 4 plastic webs, 1 glass bottle, 1 plastic water bag were collected, and the total weight was 389 g, and the average density was 0.7 kg·km⁻². No litter was detected in the International Bathing area.

Three sections of submarine litter trawls were carried out in the Haixitou sea area. 2 aquaculture floats were monitored in the northern waters of the Acacia, with a total weight of 3.2 kg. 2 floating floats were detected in the eastern part of the Yinshan Bay, with a total weight of 3.5 kg. The submarine litter was not detected in the northern sea area of Shijia River.

2.4 Conclusion

(1) The main sources were human coast activities, other wastes, and shipping/fishing activities.

(2) Marine litter was detected in tourist and recreation areas, agricultural and fishery areas, port shipping areas and adjacent sea areas. Among them, marine litter in tourist and recreation areas was mostly household garbage such as plastic bags and plastic bottles. Litter in agricultural and fishery areas was mostly production waste, such as plastic and polystyrene foam. The density was higher in agricultural and fishery areas than that in tourist and recreation areas and port shipping areas.

(3) Among the marine litter components, the amount and mass of plastic waste accounted for the highest proportion.

3. Survey Results of Marine Aquaculture and Marine Fishing

3.1 Survey Results in Rongcheng City

3.1.1 Marine Aquaculture

The specific species of Rongcheng marine aquaculture mainly include shrimp (*Penaeus vannamei*, *Fenneropenaeus chinensis*, and *penaeus japonicus*), crab (*Portunus trituberculatus*), shellfish (oyster, abalone, arcoidea, etc.), algae (*Saccharina japonica*, *Undaria pinnatifida*, and *gracilaria*), and other species (sea cucumber, sea urchin, etc.). The total aquaculture area is approximately 34,423 hectares, and the total production is approximately 753,763 tons/year. And
the main breeding methods include pond culture, raft culture, sowing culture, mudflat aquaculture, etc.

The main breeds in Rongcheng are algae and shellfish, which could generate no additional litter.

3.1.2 Marine Fishing

(1) Offshore Fishing

There are 6,800 offshore fishing vessels with a net tonnage of 497,700 tons and a total power of 563,800 kilowatts. The main fuel is diesel. The working time is 6 months/year and 20 days/month for the fishing vessels, and 8 months/year and 25 days/month for the farming vessels. The litter is mainly living waste with an annual production of about 2,000 tons. The treatment methods include garbage bins, garbage bags, salvage, etc.

(2) Ocean Fishing

There are 300 ocean fishing vessels with a total tonnage of 180,243 tons and a total power of 316,330 kilowatts. The main fuel is diesel, with a total annual fuel consumption of 300,079 tons. The work is through the whole year. And the main methods of the work include tuna fishing, squid fishing, purse seine, trawling, and transportation. The litter is mainly living waste, and the ships are equipped with corresponding garbage bins.

(3) The Production Cuts of Fishing Vessels

Since 2017, a total of 161 fishing vessels have been completed in the production cuts with a total power of 13,562 kw.

3.1.3 Litter Disposal

A work plan for waste control in light of actual conditions has been formulated in Rongcheng City. And the relevant laws and regulations include “Environmental Protection law of the People's Republic of China”, “Marine Environmental Protection law of the People's Republic of China”, “Fisheries law of the People's Republic of China”, “Regulations for the investigation and handling of pollution incidents in fishery waters”, “Environmental protection administrative penalties”, “Provisions on Fisheries Port and Navigation Supervision of the People's Republic of China”, etc.

The scope of governance includes solid waste, floating litter on the sea and oil sewage in the port area of the city. The governance measures mainly include (1) Increase the environmental protection propaganda of fishing port terminals; (2) Establish an integrated management process for the disposal of source management; (3) Joint enforcement to vigorously promote the implementation of governance objectives. And the main implementation mechanisms include (1) Establish an operational mechanism for the management of the main body of the fishing port; (2) Strengthen the source governance mechanism for fishing vessels and aquaculture production areas; (3) Implement the territorial management mechanism; (4) Improve the input guarantee mechanism;
(5) Strengthen organizational leadership Mechanism; (6) Establish an assessment and evaluation mechanism.

3.2 Survey Results in Rushan City

3.2.1 Marine Aquaculture

The main marine aquaculture species in Rushan City is oyster. The breeding scale is 80 000 mu and the aquaculture capacity is 300 000 tons/year. The main breeding method is raft culture. The marine litter could be neglected, as there is basically no feeding.

3.2.2 Marine Fishing

(1) Offshore Fishing

There are 1,446 offshore fishing vessels (including 714 fishing vessels and 732 auxiliary fishing vessels) with a total power of 36,291 kW. The main fuel is diesel, with a total annual fuel consumption of approximately 17,978 tons. The working time of the fishing vessels is as follows: 15 days/month except the off-season fishing for purse seine fishing, 5 months/year and 28 days/month for the trawling and gill-netting. The working time of the auxiliary fishing vessels is as follows: year-around and 28 days/month for the farming vessels, 5 months/year and 28 days/month for the fishery transport vessels, and 8 months/year and 18 days/month for the law-enforcement vessels.

There are no hazardous wastes from the fishing vessels in Rushan City. And the solid wastes mainly come from the living wastes during the production and life of fishing vessels and the production equipment for discarded nets. The annual living wastes and waste net production equipment are about 2,660 tons.

(2) Ocean Fishing

There are 11 ocean fishing vessels, 7 of which are for ocean-going operations with a total power of 6,400 kw. The main fuel is diesel, with a total fuel consumption of about 3,300 tons/year. The working method is longline fishing. The busy season is from October to December every year, and the leisure season is from March to July. The type of garbage is mainly living wastes and has not been counted.

(3) The Production Cuts of Fishing Vessels

Since July 2017, a total of 52 fishing vessels have been completed in the production cuts with a total power of 1,615 kW in two batches.

3.2.3 Litter Disposal

We will focus on the publicity and training to continuously enhance the awareness of marine environmental protection at all levels. The persons in charge of the fishing vessels and the responsible persons at the first, second and third levels will be indoctrinated of the marine environmental protection. And meanwhile, the training on marine environmental protection and
the recycling of marine living wastes, waste equipment and production equipment will be increased during the annual crew certificate training.

4. Next Work Plan of the Project

(1) 2018/08~2018/09, the site survey of marine litter in Xiaoshi Dao and Weihai Bay in Weihai will be carried out. The types, distribution, quantity and composition of litter will be assessed. And the sources and stakeholders of marine litter will be identified.

(2) 2018/10~2018/11, the current policies and regulations as well as best available technologies for reducing litter will be reviewed. And the cost efficiencies of their application in other cities if applicable will be assessed. The policy, regulatory framework, financial and technological gaps based on historical and second-hand monitoring data assessment will be identified.

(3) 2018/12~2019/04, the research foundation of policy or financial incentives for prevention, control, recycling, and reuse of litter originated from identified sources will be drafted.