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The path of transboundary marine plastic waste management in China, Japan, and South Korea from the perspective of the blue economy

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Marine plastic waste is one of the most difficult global ocean governance issues at present, and is also the focus of marine waste governance in the Yellow Sea and East China Sea region surrounded by China, Japan, and Republic of Korea (ROK). China, Japan, and Republic of Korea (ROK)are now aware of the importance of this issue to their surrounding waters and their country's development. However,the poor implementation of marine governance gives rise to the unsatisfactory effect of marine plastic waste governance in the sea area. Based on the concept of blue economy and the data of plastic pollution in the Yellow Sea and East China Sea, this paper discusses the feasibility of establishing binding legal norms and policies to promote the progress of marine plastic waste treatment in China, Japan and Republic of Korea. By using research methods of text analysis and status survey, this paper analyzes the differences and common demands of China, Japan and Republic of Korea for marine plastic pollution control. It is concluded that three countries have common demands in the management of the whole life cycle of marine plastic pollution, the establishment of flexible legal instruments, and the participation of stakeholders. Finally, through the case experience of the blue cycle model of marine plastic waste in Taizhou, Zhejiang Province, China, this paper proposes that this model can also be used in the management of marine plastic waste in China, Japan and Republic of Korea. Three countries can gradually promote the cooperation of marine plastic waste laws and regulations by starting with the treatment of\ fishery plastic waste, and innovate the blue cycle model, so as to finally promote the conclusion of the regional marine waste treatment agreement.

KEYWORDS

marine plastic waste, blue economy, fishery plastic waste, Yellow Sea and East Sea, source control

1 Introduction

It is estimated that the total weight of man-made plastic on the earth is nearly 8 billion tons in 2020 (Elhacham et al., 2020). Even if the world were to unite and take immediate actions to reduce plastic consumption, the plastic pollution is still expected to be around 710 million tons by 2040 (Lau et al, 2020). The total weight of plastic in the ocean will gradually exceed that of fish (World Economic Forum, 2016). The production and consumption of masks during the fight against COVID-19 also make plastic waste a more serious problem. According to "Impacts of Plastic Pollution in the Oceans on Marine Species, Biodiversity and Ecosystem", a report released by World Wide Fund for Nature (WWF) in February 2022, East China Sea and Yellow Sea have already exceeded plastic waste thresholds beyond which significant ecological risks can occur, and several more regions are expected to follow suit in the coming years (WWF, 2022).

The international academic community has conducted extensive research on source-sink analysis, flux estimation, migration mechanisms of marine plastic and microplastic pollution, and ecosystem and human health risk assessment (Wang, 2023). In the regional aspect, most of the research focus on the models and experiences of regional governance in the EU (Li and Li, 2022), the Northwest Pacific (Kong, 2022), etc. In addition, the marine plastic waste governance in China (YANG et al, 2020), Japan (Zenbird, 2022), and South Korea (Yong, 2020) has been analyzed from respective domestic perspectives, and relevant national governance strategies and regulations have been developed (McKayla, 2022).

The United Nations Environment Assembly has adopted resolutions on marine plastic waste governance for five consecutive sessions (Marinelitterhub, 2019), and the establishment of a new legally binding global convention on plastic pollution has become a consensus (Jørgen, 2021). The first session of the Intergovernmental Negotiating Committee (INC1, 2022) developed an internationally legally binding instrument on plastic pollution, including in the marine environment [(unep.org)(http://unep.org)]. The country representatives at the meeting[1] took different positions(UN Environment Programme, 2022). As major countries in the East China Sea and Yellow Sea region, China, Japan and South Korea have a broad consensus on the scope of international instruments, objectives, flexibility of framework conventions, and stakeholder participation. However, there are also many differences in terms of core obligations, control measures, and means of implementation (Gao, 2022). China focuses on plastic products leaking into the environment, and believes that there is a need to take into account the domestic situations and capacities of each country in terms of obligation implementation. As for assessment mechanism and compliance mechanism, it is necessary to consider China's domestic situation and capacity as a developing country, which showcases flexibility (Chinese National Development and Reform Commission and the Ministry of Ecology and Environment, 2021). Korea supports the whole-life-cycle control of plastics (Hum, 2022) and pays special attention to the proper management and recycling of marine plastic waste. Meanwhile, the Ministry of Oceans and Fisheries of Korea has invested heavily in establishing environmental standards according to the characteristics of marine plastics (Korea Ministry of Oceans and Fisheries, 2022). Japan focuses on the recycling of marine plastic pollution (Yuji, Kanako, 2018), and in 2019, Japan released the Action Plan for Marine Plastic Waste Management to curb the flow of microplastics into the ocean. Through support to local self-governments, Japan promotes the recycling of coastal drifting materials, and also focuses on technology and monitoring issues related to microplastics (Ministry of Foreign Affairs of Japan, 2021). At the 23rd Tripartite Environment Ministers Meeting among China, Japan and Republic of Korea (TEMM 20), three countries also expressed their hopes for cooperation in plastic pollution control (Energydaily, 2022). From the focuses of the three countries, one can conclude that although the three countries have differences on the issue of technology and standards, the governance of the whole life cycle of plastic pollution, the establishment of flexible legal instruments, and the participation of stakeholders are common demands. However, due to the different situations of the East China Sea and Yellow Sea and the surrounding countries, the practices of other regions, such as the EU, cannot be replicated. Therefore, this thesis mainly adopts text analysis for the research method. And the existing research data and current situations of China, Japan and South Korea are used to discover the common interests of the three countries. This paper proposes to promote the cooperation mechanism of the three countries with the common pursuit for blue economy development by strengthening the participation of stakeholders.

2 The inherent requirement of establishing the China-Japan-ROK mechanism of marine plastic waste governance of the East China Sea and Yellow Sea

2.1 The current worsening problem of marine plastic waste in the East China Sea and Yellow Sea region

The East China Sea and the Yellow Sea near China, Japan, and South Korea are typical semi-closed seas (A/CONF.62/C.2/

1 The meeting took place in the Punta del Este Convention and Exhibition Centre from 28 November to 2 December 2022.

SR.43, 1974), with poor circulation with the open ocean and thus limited self-purification capacity. The data collected from 2007 to 2014 shows that plastic waste accounted for 37% of the floating marine waste, polystyrene foam accounted for 35%, and wood waste accounted for 12%. The composition of the main plastic waste includes plastic bags, bottles, plates, ropes, etc. The floating marine waste is distributed mainly in ports and tourism, fishing, industrial and recreational areas along the coast of China (East Asia: Ocean Community, 2018).

From recent years' monitoring data of China, Japan, and South Korea on their own offshore in this region, marine plastic waste has caused serious damage to the region's oceans in both the quantity and weight sense.

According to the data from the Communique on the State of China's Marine Ecological Environment in 2020 (Ministry of Ecology and Environment, 2021), plastic waste takes up 83.1% in the seabed waste of the monitored area, 85.7% in the floating waste on the sea surface, and 84.6% in the beach waste. According to " Research Report on Some Typical Coastal Garbage Monitoring in China 2020" released by Shanghai Rendu Ocean NPO Development Center, the "Guarding the Coastline" project conducted scientific research to monitor the waste along the Chinese coast in 2020. (Related data refer to Table 1). It found that the quantity density and weight density of marine litter along the East China Sea and Yellow Sea coast is the highest in China. And these marine litter are mostly plastic (Shanghai Rendu Marine Public Welfare Development Center, 2020a).

The Japanese Ministry of the Environment has also made a lot of efforts to monitor the amount of marine plastic waste. The distribution of waste in Japanese waters shows large regional variations, with particularly large amounts of waste around the northern part of the Kyushu region and the northern part of the Tohoku region (Isobe, 2016). The Seto Inland Sea is a closed one, which explains its huge amount of waste. However, there are also a large amount of waste near the remote Ryukyu Islands. According to surveys in Japan, the Sea of Japan is considerably more polluted than other sea areas (Ministry of the Environment of Japan, 2021). Between 20°N and 30° N in southern Japan (up to 6.63 × 102 fragments/ha), microplastic abundance is low near the coast and

TABLE 1 China's marine microplastic waste monitoring data since 2016.

China's marine floating waste monitoring data in China since 2016							
Year		2016	2017	2018	2019	2020	2021
Number of monitoring points		45	49	57	49	49	51
Marine floating waste	Number of floating waste visually observed (pcs/km2)	20	20	21	50	27	24
	Number of floating waste trawled in surface water bodies (pcs/km2)	2234	2845	2358	4027	5363	4580
	Density/ (kg/km2)	65	22	24	6.8	9.6	3.6
	Percentage of plastic waste	84	87	88.7	84.1	85.7	92.9
from the 2016-2021 Bulletin of Marine Ecology and Environment Status of China							
China's beach waste monitoring data since 2016							
Year		2016	2017	2018	2019	2020	2021
Number of monitoring points		45	49	57	49	49	51
beach waste	Number(pcs/km2)	70348	52123	60761	280043	216689	154816
	Density (kg/km^2)	1971	1420	1284	1828	1244	1849
	Percentage of plastic waste	68	76	77.5	81.7	84.6	75.9
from the 2016-2021 Bulletin of Marine Ecology and Environment Status of China							
China's seabed waste monitoring data since 2016							
Year		2016	2017	2018	2019	2020	2021
Number of monitoring points		45	49	57	49	49	51
Seabed waste	Number(pcs/km2)	1180	1434	1031	6633	7348	4470
	Density (kg/km^2)	671	43	18	15.9	12.6	11.1
	Percentage of plastic waste	64	74	88.2	92.6	83.1	83.3
From the 2016-2021 Bulletin of Marine Ecology and Environment Status of China.							

south of 31°30'N, but particularly high near 32°-33°N where the Kuroshio Current flows. It supports the hypothesis of Day and Shaw (Day and Shaw, 1987) that the Kuroshio current plays an important role in the transport and distribution of microplastics in the North Pacific Ocean. Kuroshio is a major reason for these microplastics. (Related data refer to Table 2).

South Korea has also monitored marine waste on the east and west coasts. From the data from 2018-2021 shown in the table below, the amount of marine waste was climbing along with the increase in monitored sea area.(Related data refer to Table 3).

In addition, the East China Sea and Yellow Sea are rich in fish resources. From the monitoring of plastic waste in the offshore of China, the fishery industry contributes to a large proportion of plastic waste (Shanghai Rendu Marine Public Welfare Development Center, 2020a; Shanghai Rendu Marine Public Welfare Development Center, 2020b). A study (Lebreton et al., 2017) by Scientific Reports shows that 86% of the large-piece floating plastic litter in the North Pacific Garbage Patch are from fishing boats, either discarded or lost, which indicates that mariculture and fishing are important aspects of plastic waste management in the East China Sea and Yellow Sea region when combined with South Korea and Japan's statistics on the sources of marine plastic waste.

2.2 The existing cooperation mechanism is not effective and the demand for integration is increasing

Under the guidance of the United Nations Environment Programme, two regional action plans, the Northwest Pacific Action Plan (NOWPAP) People's Republic of China, Japan, South Korea and Russian Federation (1994) and East Asian Seas Action Plan (EASAP)[2], four sub-regional action plans and several regional environmental cooperation mechanisms[3] have been established in Northeast Asia. These regional environmental cooperation mechanisms have contributed to the implementation of marine environmental protection and cooperation in the Yellow Sea and East China Sea region by holding meetings, selecting topics for discussion, raising funds, and formulating action plans. However, the marine environmental cooperation that can mobilize and coordinate the whole region is still at the initial stage. The existing marine environmental cooperation is still at a low level, mostly through forums, meetings and other soft laws that is not compulsory. Thus, it has not yet produced a binding legal document, which makes it ineffective in practice.

Since Japan and South Korea started earlier on plastic waste pollution management, they have a better waste classification and

2 Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) is an intergovernmental organization operating in East Asia to foster and sustain healthy and resilient oceans, coasts, communities and economies across the region. Http://www.pemsea.org/about-pemsea/our-organization.

3 Such as the China-Japan-Southeast Korea Environment Ministers' Meeting (TEMM), Northeast Asia Sub-Regional Environmental Cooperation Program (NEASPEC), Northeast Asia Environmental Cooperation Conference (NEAC), Yellow Sea Large Marine Ecosystem Strategic Action Project (YSLME), etc.

TABLE 2 Mass distribution density.

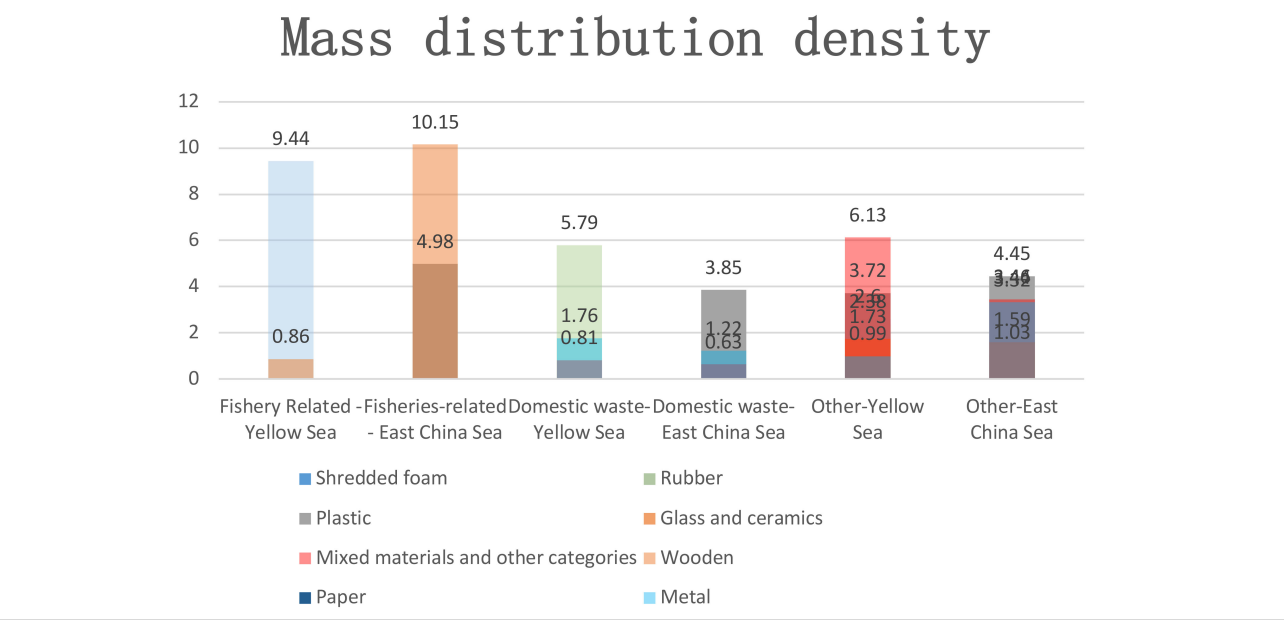

TABLE 3 South Korea monitors the amount of marine waste on its coasts.

Year	Quantity (EA)	Weight (kg)
2018	31817	4396.9
2019	30720	2698.4
2020	32213	2207.1
2021	124452	5653.9
Total	219202	14956.3

legal system, and set stricter standards for pollution. Before China began controlling the import of garbage in 2016, Japan and South Korea imported large amounts of plastic garbage into China. It has put great pressure on the marine environment of the East China Sea and Yellow Sea. The development of a unified standard and governance system requires the integration of existing mechanisms. In addition, the low level of public participation in previous cooperation mechanisms, coupled with significant differences in the responsibilities and obligations of coastal states in marine environmental cooperation, can lead to a "prisoner's dilemma" or "free-rider" phenomenon in environmental cooperation. Therefore, it is necessary to establish a rules-based plastic waste management mechanism to prevent the "prisoner's dilemma" and push forward marine plastic waste management.

2.3 Common wishes and demands of China, Japan, and South Korea

In December 2019, at the 8th China-Japan-South Korea Leaders' Meeting, Chinese Premier Li Keqiang highlighted the need to "pay attention to the challenges posed by marine plastic waste, strengthen the exchange of monitoring methods and governance technologies, and promote scientific research on the impact of marine plastic waste on the marine ecology and polar ecology." (Keqiang, 2019). The 2019 Joint Communiqué of the 21st Tripartite Environment Ministers Meeting also pointed out that marine plastic waste is particularly important, and that actions such as proper waste disposal and reduction of shopping bags will be promoted to prevent plastic waste from being discarded into the sea. The three countries also envisioned research cooperation with the goal of clarifying the actual state of marine pollution (Ministry of Ecology and Environment, 2021). The Tripartite Joint Action Plan on Environment Cooperation (2021-2025) (hereinafter referred to as the Action Plan) and the Joint Communiqué of the 22nd Tripartite Environment Ministers Meeting introduce the progress of the three countries in addressing marine environmental issues and show their practical cooperation in marine plastic waste management to effectively handle global and regional environmental issues (Ministry of Ecology and Environment, 2022) From the meeting of the leaders of China, Japan, and South Korea and related documents, it is clear that three countries have a common will and need for marine plastic waste management, and will actively advance practical cooperation.

2.3.1 The need for blue economy development

The blue economy aims to promote economic growth, social inclusiveness, and to sustain and improve livelihoods while ensuring the environmental sustainability of marine and coastal areas. In terms of characteristics, the concept of blue economy emphasizes sustainable and inclusive development as well as linkages and synergies between multiple entities. For China, Japan, and South Korea, the marine economy is a significant source of national wealth, and the harm that plastic waste pollution has done to sectors like marine fisheries, marine tourism, and port shipping has hindered the growth of the marine economy.

As people pursue for a higher living standard, the detection of microplastics in fishery products will not only affect the price but will also have a significant impact on the development and competitiveness of fish markets. In 2020, the production of aquatic animals in fishery and aquaculture in Asian countries accounted for 70% of the global total, most of which were from China, Japan, and South Korea (World Fisheries and Aquaculture, 2022). Marine plastics not only endanger fish's health but also block fishing nets and boat engines, which can hinder fishing operations. The fishing industry loses nearly €138 million annually due to plastic pollution (WWF, 2019a). Taking China as an example, the annual fishery economic losses caused by marine pollution exceed $500 million (WWF, 2019b). The annual global economic costs of marine plastic pollution with respect to tourism, fisheries, and aquaculture, together with other costs including clean-up activities, are estimated to be at least US$ 6-19 billion (Deloitte, 2019). However, the Deloitte (2019) estimate does not directly include impacts on human health or marine ecosystems. The marine economy accounts for 9% of China's GDP (Ministry of Natural Resources, 2021) and about 10% of South Korea's GDP (Li, 2016). Marine plastic waste will seriously restrict the economic development of the three countries.

2.3.2 The need for transformation in marine plastic waste management in China, Japan, and South Korea

The demand for marine plastic waste and microplastic pollution control will inevitably lead to a structural upgrade of the entire plastics industry. With the continuous upgrading of environmental protection and supply-side reform in China, Japan, and South Korea, especially in recent years, China's environmental protection standards have been improved, and the plastic recycling industry has also been constantly upgrading. It is obvious that the development of the plastic processing industry is driven by the market and the industrial policy guidance, which accelerates adaptive adjustments and upgrading of the whole industry.

As the economy grows, public demand for higher quality products and awareness of environmental health are gradually influencing consumer preferences. Moreover, people care more about marine ecology and have a higher demand for the quality of marine products. Changing consumer preferences are reflected in housing, tourism or product purchases. People are willing to pay for cleaner beaches, clearer water, and healthier seafood. This will also lead to green industrial upgrading and high quality development of a wider range.

2.4 The specificity of marine plastic waste management requires multi-entity cooperation

Plastic pollution is mainly caused by people's bad disposal behavior and unorganized disposal process. Normally plastic pollution is formed through a process of "plastic products- plastic waste- plastic recycling- plastic waste- plastic pollution" (Blight and Burger, 1997). The formation mechanism of microplastic pollution (excluding plastic fibers) is more complex (Thompson, 2004), which includes plastic particles cracked by physical, chemical, and biological forces, as well as plastic microparticles from everyday life scenarios (Arthur et al, 2009). Therefore, coordination among the three nations is required to implement governance measures that will curb pollution at its source. In terms of pathways of plastics into the Yellow Sea and the East China Sea, there are not only land-based ones such as rivers (Lebreton et al., 2017), but others including fishing vessels, aquaculture activities, and marine operations (Ole et al., 2011). Therefore, compared to other marine pollutions, plastic waste pollution is more complex. Especially because of the overlap of exclusive economic zones of China, Japan, and South Korea, it is necessary for the three countries to continue to deepen their cooperation on how to prevent plastic waste pollution from fishing, and aquaculture. In addition, plastic waste in the ocean can bring problems like biological entanglement, reduction in fishery production; microplastics are also extremely harmful to marine organisms because they can be easily ingested and passed along the food chain. Moreover, the major fishes in the Yellow Sea and the East China Sea will migrate, which will have a certain impact on the countries around the seas, and cannot be managed by one country alone. Therefore, it becomes more urgent for the three countries to work together.

3 External dynamics for establishing a China-Japan-South Korea marine plastic waste governance mechanism

3.1 The global and regional push for marine plastic waste governance

3.1.1 Global actions on marine plastic waste governance

Many international discussions have focused on the formulation of international rules for the management of plastic wastes and the control of the transboundary transport of hazardous wastes, as well as the analysis of the underlying causes of the failure of marine plastic waste management, such as insufficient policy and fragmented governance system. The international community has taken a global political, economic and environmental perspective to develop multiple options for limiting and managing marine microplastic pollution, mainly including:

(1) The global political and economic discussions

The current international discussions on microplastics mainly focus on the treaties and documents issued by various political and economic cooperatives. (Related data refer to Table 4).

From the global efforts one can find that no targeted regulation and binding governance mechanism for plastic litter and microplastics has been formed, and it is also difficult to form a unified legal regulation in short term due to the diversity of governance entities. However, global conferences and actions provide a relatively broad legal framework and code of conduct for marine litter pollution governance, which play an important guiding role in stimulating cooperation and participation among countries.

3.1.2 Regional marine plastic waste management achieves significant results

The international community has devoted much effort to the marine microplastics governance, and is working to develop a comprehensive treaty serving as a guidance for marine microplastic litter governance. However, due to different comprehensive national strengths and governance capabilities,

TABLE 4 The global political and economic discussions.

International marine environmental events/conferences/organizations	Time	Main content
G7 Toyama Environment Minister's Meeting	2016	The G7 and the EU held the meeting in Toyama in May 2016. It adopted seven topics including the 2030 SDGs, resource efficiency and the 3Rs (reduction, reuse, and recycling), biodiversity, climate change, chemicals management, the role of cities, and marine waste (G7 Toyama Environment Minister's Meeting, 2016; G7 Environment ministers communique, toyama meeting, 2017).
	2017	At the Environment Minister's Meeting held in Bologna, Italy, in June 2017, dealing with microplastics in marine waste as a global threat was confirmed G7 Bologna Environment ministers' meeting (Bologna).
	2018	G7 environment ministers adopted the G7 Innovation Plastic Challenge (G7, 2018) for tackling marine plastic waste, and the Oceans Plastics Charter (Oceans Plastic Charter, 2019) was launched in June 2018. As of April 2020, 26 governments and 69 major businesses and institutions around the world have ratified the Charter.
G20 Summit	2017	The G20 considered that it is urgent to take measures to prevent and reduce marine waste, and encouraged the public and private sectors to participate in activities to reduce marine garbage. In 2017, it approved the G20 Action Plan adopted in Hamburg, Germany (G20 Action Plan on Marine Litter, 2017). In the same year, the G20 Resource Efficiency Dialogue was established and has been exchanging insights and experiences on policy options and examples of the overall life cycle and resource efficiency of natural resources, products, and infrastructure (G20 Resource Efficiency Dialogue 2017).
World Economic Forum	2016	The World Economic Forum and the Ellen MacArthur Foundation published a report entitled "The New Plastics Economy: Rethinking the Future of Plastics" (WEF, 2016). The report reveals that negative externalities such as ocean leakage could be significantly reduced if the principles of recycled plastics were applied to the global plastic packaging.
	2017	The second report, "The New Plastics Economy: Catalyzing Action", sets out a strategy to increase the reuse and recycling rate of plastic packaging materials from 14% today to 70% MacArthur Foundation, (2017). The report concludes that the plastics industry worldwide offers a number of clear, industry-accepted action plans to design better packaging and increase recycling rates (MacArthur Foundation, 2017).
World Bank	2015	The World Bank established Pollution Management and Environmental Health Program (PMEH) in 2015. It aims to reduce the impact of urban air, land and water pollution on human health and the environment in target low- and middle-income countries (The World Bank, 2019).
(2) The global environmental discussions		
International marine environment agencies/ organizations	Time	Main content
UN 2030 Sustainable Development Goals	2015	Many targets in the UN 2030 Sustainable Development Goals (SDGs) adopted in 2015 are related to microplastic pollution (United Nations Environment Programme, 2015). And the target 14.1, which has the highest relevance to microplastics, says that "by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution"(UN, 2022).
The United Nations Environment Assembly (UNEA)		UNEA adopted a resolution on marine litter and microplastics in 2016 (UNEP, 2016). The resolution further identifies both the prevention and the environmentally sound management(ESM) of waste as crucial measures necessary to successfully combat marine pollution in the long term, including marine plastic debris and microplastics. UNEA adopted the 3/7 resolution on marine waste and microplastics in December 2017 (UNEP, 2017). The resolution stipulates to avoid losses in marine ecological communities, and prevent damages caused by human activities which depend on marine ecology. It also stipulates to reinforce the measures mentioned in SDG Goal 14 for all actors by 2025, and encourage all member states to prioritize their policies and measures.
World Agri-Food Organization		The FAO projects and standards are included in a series of self-initiated and worldwide- applicable action programs related to responsible fisheries, including provisions for marine litter, and reduction of port reception facilities, inboard storage, organic waste, lost or discarded fishing gear (COFI/2014/SBD.3, 2014).
Strategy Honolulu		At the 5th International Marine Debris Conference, cohosted by UNEP and the National Oceanic and Atmospheric Administration (NOAA) in March 2011, the "Strategy Honolulu" framework for marine waste management was adopted. The strategy aims to improve collaboration and coordination among the multitudes of stakeholders across the globe concerned with marine debris (Honolulu Strategy, 2015).

it will take some time for a global legal regime to be reached. In some regional waters, especially in the closed sea and semi-closed sea areas, such as the Mediterranean Sea waters, the East China Sea and Yellow Sea waters surrounded by China, Japan and Korea, marine plastic litter has already seriously damaged the ecosystem. Environmental, health and economic problems have been gradually revealed and constantly threatening the balance of the ecosystem.

In contrast to global governance, which lacks centralized governance, it is easier to spontaneously reach agreements on specific substantive norms among sovereign states in a region. A typical example is the European Union. It has introduced a variety of policies, legislation and initiatives aimed at marine litter strategies through the Marine Strategy Framework Directive (MSFD). Adopted in 2008, it is the first EU legislative regime related to marine biodiversity conservation. The main goal of the Marine Directive is to achieve Good Environmental Status of EU marine waters by 2020. The Directive defines Good Environmental Status (GES) as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". The EU and the European Commission have also drawn up a series of detailed standards and methodological standards for the implementation of other European laws on Marine waste, including EU guidelines on harbor facilities for the disposal of wastes and cargo residues from ships of the countries concerned.

The marine environmental governance in EU started earlier, and thus its regional marine governance mechanism is a model for other regions in the world. The EU started the internal integration of marine plastic waste governance, and continued to promote a multi-stakeholder governance transition. Its experience in marine plastic waste treatment has also become an important reference for countries to introduce relevant policies.

3.2 China's progress in marine plastic waste governance

In recent years, China has taken a number of positive measures in marine plastic waste governance, especially in international cooperation, which has laid a foundation for promoting cooperation among China, Japan, and South Korea.

Chinese research teams have conducted researches on microplastics in a variety of environmental media, including rivers, lakes, estuaries, beaches, and offshore, and have even extended to international waters such as pelagic, polar, and deep-sea waters (Peng et al., 2022). By 2022, China has developed a series of policies and management measures to address this environmental pollution problem, as shown in the table.(Related data refer to Table 5).

From these documents, it is clear that China has made great strides in addressing marine plastic waste and microplastic pollution. These documents have played an important role in reducing plastic waste from land-based sources and controlling plastic waste into the sea, and have helped address marine plastic pollution problems in the East and Yellow Seas.

China has conducted joint research on marine plastic pollution with scientific teams from more than a dozen countries in the Asia-Pacific region. By leveraging regional synergies, a number of important results have been achieved. China has also organized a series of international academic and training conferences on tackling marine plastic and microplastic pollution to let international scholars understand the actual situation of marine plastic waste pollution in China and advocate the development of marine microplastic monitoring methods, which has greatly promoted the monitoring, research and response to marine microplastic pollution in Asia-Pacific countries. Meanwhile, China and Asia-Pacific countries endorse the establishment of a working group in IOC/WSETPAC to

TABLE 5 Policies and governance measures related to plastic and microplastic governance.

Issuing time	Title	Institution
27 July, 2017	Implementation Plan for Banning the Entry of Foreign Waste and Promoting the Reform of Solid Waste Import Management System	Development and Reform Commission
2 August,2017	Notice on Jointly Carrying Out the Clean-up and Rectification of the Recycling Industry of E-waste, Waste Tires, Waste Plastics, Used Clothes and Waste Household Appliances Dismantling	Development and Reform Commission
16 January, 2020	Opinions on Further Strengthening the Prevention and Control of Plastic Pollution	Development and Reform Commission of the Ministry of Ecology and Environment
10 July, 2020	Notice on Solidly Promoting the Treatment of Plastic Pollution	Development and Reform Commission
28 August, 2020	Notice on Further Strengthening the Treatment of Plastic Pollution in the Business Sector	Ministry of Commerce
8 September, 2021	Notice of the National Development and Reform Commission and the Ministry of Ecology and Environment on the issuance of the "14th Five-Year" Action Plan for the Treatment of Plastic Pollution	Development and Reform Commission

cooperate in the study of marine transport plastic waste fluxes in Asian and Western Pacific countries, so as to comprehensively grasp the real plastic waste export fluxes to the sea from major rivers in the Asia-Pacific region, instead of relying on the estimated results. In 2019, the Ministry of Ecology and Environment also organized a seminar for scientists from China and the United States on the amount of marine plastic waste entering the sea, so that the U.S. side understands China's efforts in eliminating marine plastic waste and the real state of marine plastic pollution in China.

China also cooperates with various international organizations to reduce marine plastic waste, for example, UNEP、UNEA、UNESCO-IOC/WSETPAC, and APEC. These efforts are all for China and the international community to formulate further action plans for reducing marine plastic waste, so as to achieve the vision of zero-emission of marine plastic waste worldwide in the future (Li, 2020).

4 Requirements of regional cooperation mechanism for marine plastic waste and microplastics treatment from the perspective of blue economy

Cooperation is one of the important means to realize the blue economic model. China, Japan, and South Korea are the most important three countries in the East and Yellow Seas region. The management of marine plastic waste and the development of the blue economy cannot be achieved only by relying on the strength of a single member. The blue economy, based on coordinated cooperation, promotes regional economic growth through the sustainable development of marine resources and ecosystems. In essence, the key to the blue economy is sustainability. If the marine environment and fishery trade activities are sustainable, then the blue economy can correspond to the inland green economy. An important obstacle to the marine environment and fishery trade between China, Japan, and South Korea is the marine plastic waste in the surrounding waters. Therefore, the cooperative governance within the region is of great significance for the adoption of the blue economy model. The prominent threat of plastics has caused systematic damage to marine resources and the blue ecological environment. China, Japan, and South Korea urgently need to strengthen cooperation and effective supervision to ensure the long-term sustainable development of the blue economic partnership. In the East Sea and Yellow Sea region, China, Japan, and South Korea all want to be the leaders in this regard, But due to political and historical factors, there is a lack of closeness among the three countries. As a new model of the marine economy, the Blue Economic Partnership is more inclusive. It can establish consultation, cooperation, network, and partnership among the government, international organizations, civil society, and the private sector, so as to achieve coordinated governance and common development of public issues, which is also the requirement of the new regionalism theory. The new regionalism theory especially emphasizes the decentralization of regional governance and the necessity of non-governmental organizations' participation. Regions can jointly participate in environmental governance through the system construction of diversified subjects to solve the environmental problems faced by economic development. This, to a certain extent, can also solve the current problems of the lack of leadership, inconsistent standards and a single approach to marine environmental governance in China, Japan, and South Korea, and thus promote the orderly progress of regional marine environmental cooperation and governance, promote the organic combination of regional marine environmental protection and blue economy development, and realize the sustainable development of this region.

4.1 Establishing binding legal regulations and policies

A complete legal system of environmental protection can promote the internalization of environmental costs to achieve continuous improvement of environmental quality. Therefore, in order to solve the problem of plastic waste pollution in the East China Sea and Yellow Sea region and achieve blue economy development, it is necessary to improve relevant laws and regulations as a solid guarantee to make regional countries commit to the statute of unified action, and to add compulsoriness to the existing laws.

First, to integrate the existing laws and regulations on marine plastic waste management in China, Japan, and South Korea, determine the standards and directions of cooperative management, and guarantee the orderly implementation of regional management activities. Second, governments need to establish a regional mechanism for the regular exchange and coordination on legal norms and guidelines to enhance the connectivity of information related to plastic waste governance and monitoring. Third, governments need to improve the governance and cooperation linkage mechanism. Since the transboundary plastic waste pollution governance involves a wide range of issues, and needs a complex operation mechanism, which can easily cause regional conflicts, it is important to establish a marine plastic waste governance institution beyond the three countries' governments. It can be achieved on the basis of the existing environmental meetings of China, Japan, and South Korea, setting up special meetings on marine plastic waste pollution, discussing issues of coordination and cooperation, and conducting unified research on and

treatment of major plastic waste pollution sources, and further, strengthening the supervision and inspection of plastic waste into the sea.

The construction of a regional plastic waste management policy system is conducive to balancing the interests of regional plastic waste management subjects, and thus resolving many obstacles in regional environmental management. Firstly, regional plastic waste management policies need to be innovated; regional plastic waste emission regulations need to be improved; scientific and democratization of management need to be promoted. Second, to innovate regional plastic waste management economic policy, and actively guide fishermen and related waste discharge enterprises to upgrade their facilities by introducing a benefit distribution mechanism of plastic resources that combines government macro-control and market competition. Third, to innovate regional plastic industry policy, develop recyclable plastic industry as much as possible, and strictly regulate the use and discharge of plastic waste.

4.2 Renewing the governance concept

In terms of industry and employment, the sustainable development of the marine industry, which is dominated by marine oil and gas, port shipping, marine tourism, and marine fishery, has become the key aspect of the development of blue economy. And since plastic pollution is closely related to marine fisheries and tourism, how to transform the development concepts of marine tourism and fisheries and the management concepts of plastic waste among China, Japan, and South Korea has become the key to the cooperation and governance of plastic waste in the East China Sea and the Yellow Sea.

First of all, China, Japan, and South Korea should upgrade their concepts, clarify their responsibilities in the governance of marine plastic waste, and use policies to guide the participation of multiple entities, including markets, citizens, and social organizations, in the management of marine plastic waste, thus forming a polycentric governance structure paradigm. Secondly, governments should enhance the awareness of related enterprises involved in plastic waste pollution and let them undertake social responsibility in regional environmental governance. By transmitting the concepts of social responsibility, eco-environmental awareness, and sustainable development awareness to enterprise managers and employees involved in plastic waste pollution, enterprises' awareness of environmental protection can be enhanced, plastic waste emissions can be reduced, and a circular economy can be developed. Thirdly, the government should guide the public and encourage active participation in regional environmental governance in order to increase their awareness. It is necessary to establish a complete education mechanism for plastic waste management by the integrated use of television, newspapers, new media to enhance people's awareness of environmental responsibility and participation. Meanwhile, people's rights to participate and supervise in plastic waste management decisions should be strived for and guaranteed in order to encourage active public participation and supervision of environmental protection work, and promote transparency and openness in the management of regional plastic waste management.

5 The path of marine plastic pollution management in China, Japan, and South Korea

5.1 Implementation of binding regional legal norms together with domestic law

Although there are common marine environmental interests and incentives for institutionalized cooperation and development between China, Japan, and South Korea, the three countries have different standards and demands on plastic waste. Mutual distrust between countries, security issues, territorial issues, and maritime disputes make cooperation more difficult. Marine plastic pollution from land-based sources is mainly limited within the scope of each country, so it needs to be regulated under domestic law. However, marine fisheries involve more transboundary fishing issues, which can be seen as an starting point for promoting cooperation on the legal regulation of marine plastic waste among the three countries.

5.1.1 In terms of the scope and target of plastic litter management

The types of marine plastic litter pollution need to be clarified. According to the analysis of marine litter types in the East China Sea and Yellow Sea region (Ryberg et al, 2018), marine plastic litter accounts for the largest proportion, which is about 92.9% (China National Marine Environment Monitoring Center, 2021), mainly consisting of fishing lines, plastic ropes, plastic debris and plastic bags, etc. And the largest proportion of the plastics is from fishery activities. Since it is difficult to cover all types of litter through the cooperation of three countries, litter from fishery activities should be set as the primary target. For the legal regulation of fishery plastic litter in China, Japan and Korea, it is suggested to adopt a combination of dynamic and static approaches under the principle of flexibility, i.e., adopting different governance rules according to different time and monitoring volume, as well as the different degrees of damage to marine ecology.

5.1.2 In terms of the obligations

The East China Sea and Yellow Sea region is different from the European Union. The economic growth situations of the EU countries are largely similar to each other. China still lags behind

Japan and Korea in technology and relevant standards, though China's economy has made rapid progress in recent years. It is still a big challenge for China to adopt uniform standards and technologies. Especially in the fishery industry, where China is making great efforts to reform. However, there is still a need to further improve small fishing boats, norms for the use of fishing nets and the quality of fishermen. Therefore, it is suggested that the obligation of each country should be considered in accordance with the amount of fishery waste monitored in the East China and Yellow Sea waters and other factors such as the number of fishing vessels and fishing volume of the three countries.

5.1.3 In terms of regulating control measures

China, Japan and South Korea all support the control measures for the whole life cycle of marine plastic waste. The management measures of marine plastic litter and microplastic pollution basically follow the ideas of source reduction and process management, supplemented by sea input control and sea salvage, to achieve the whole life cycle control of plastic through production and consumption reduction, disposal process management and recycling and reuse (YANG et al, 2020). But the current situation is that marine plastic waste at the source, limited by production technology and cost, have relatively low possibility of reuse. Especially for fishery waste, no unified mechanism has been formed for sorting and recycling. And China's waste separation has just started, and a good mode has not yet been formed. Therefore, we should think about how to establish an effective benefit-guided mechanism to realize the whole life cycle control of plastics. It is recommended to strengthen the prevention and control at the source of input into the sea, seek plastic substitutes from the source, and increase the number of plastic products recycled. In fishing gear and ship operations, it is suggested to establish a unified recycling system to form a closed-loop industrial chain for marine plastic waste prevention and control. In addition, for enterprises and fishing vessels, tax relief, green certification, enterprise green credit rating, emission reduction certification and offsetting system can be introduced.

5.1.4 In terms of monitoring and assessment

China, Japan and Korea have devoted much energy to monitoring the East China Sea and Yellow Sea waters, but the information is not unified and shared. so it is recommended to establish a tripartite scientific institution for long-term monitoring of marine plastic litter. The dynamic monitoring and assessment of marine plastic litter should be carried out through a sound system and good operation mechanism, and be complemented by legislation and standardization of monitoring methods. The three countries urgently need to establish a unified environmental monitoring database, which will be compiled by each domestic local department and then aggregated to the national and finally to the regional master database. However, environmental monitoring requires a large amount of funding, and it is recommended to open up participation to various entities, such as enterprises and individuals. In this regard, it is possible to learn from the Japanese approach to environmental monitoring. Japan establishes a special scientific department to coordinate data from various countries and effectively utilize private funds, and adopts the policy of regular reporting to be exposed to public scrutiny.

At the same time, there is a need to clarify monitoring items. The marine litter monitoring network in Japan and South Korea is relatively complete, with comprehensive projects and advanced technology. However, there is a wide variety of marine plastic litter, and there is still a need for targeted monitoring of several key categories, such as fisheries plastic litter, to ensure the accuracy of key data.

5.1.5 In terms of domestic legislation in each country

It is recommended that efforts be made at three levels: value, mechanism, and operation.

First, in terms of value, It is necessary to strengthen the conceptual consensus. Marine plastic pollution is a common concern and is related to common marine interests for China, Japan, and South Korea. The need for governance is highly compatible with the connotation of the "Maritime Community with a Shared Future". Therefore, China, Japan, and South Korea need to take the overall interests of the whole region as their responsibility while focusing on their own interests, and strive to promote marine sustainable development. "Extensive consultation and joint contribution" should be elevated to the level of "cooperation and sharing", and ultimately realize win-win results.

Second, at the institutional level, the legal construction needs to be combined with respective legislation and policies of China, Japan, and South Korea, relevant environmental agreements, the UNCLOS, and the provisions of international law. As a regional major country, China is supposed to promote the linkage of these variables and boost cooperation. At the macro level, this can be done by strengthening regional cooperation at the national government level. And at the micro level, coordination between relevant law enforcement and scientific research units in China, Japan, and South Korea needs to be strengthened.

Third, at the operational level, the transformation of fisheries fishing and aquaculture is a good opportunity. It is suggested to form a binding legal framework and to foster effective governance strategies and actions based on the prospect of fisheries fishing and aquaculture. The design of incentive mechanisms should be systemically considered, and fishermen should be guided to cultivate gradually habits of fisheries standardized fishing and aquaculture. And the establishment of a sound industrial chain for the production and recycling of fishing gear should also be considered.

5.2 Innovating blue circulation model and promoting stakeholder participation

At present, there is a huge growth potential of the blue economy, whose rate even exceeds that of global economic growth (Bu, 2022). Therefore, to create a "blue circulation model" for the East China Sea and Yellow Sea region and to build an environmental management system with government as the leader, enterprises as the main body, and social organizations and the public as participants are significant for promoting the management of marine plastic waste pollution in this region.

The so-called blue circulation model refers to the establishment of a market-oriented and diversified ecological compensation mechanism. It needs the leading role of the governments of China, Japan and South Korea, and emphasizes corporate social responsibility. It aims at increasing public awareness of green consumption, and encourages the participation of social organizations. In the implementation of the "extended production responsibility mechanism", it opens up the renewable and recycling plastic industry chain, broadens the source of funds for marine litter and marine microplastic pollution control, improves the recycling and resource utilization rate of plastic waste, explores the feasibility in the following areas: participation of enterprises in marine environmental management to obtain tax relief, green behavior certification, inclusion of corporate green credit ratings, certification of emission reductions and offsetting system. The model has been piloted by Taizhou City, Zhejiang Province, China, and has achieved good results (the Department of Ecology and Environment of Zhejiang Province, 2022). The authors of this paper argue that the model can be replicated in Shandong Province, Jiangsu Province, Zhejiang Province, and Fujian Province, which are four major Chinese provinces around the East China Sea and Yellow Sea region. They are ranked among the top 5 provinces in China in terms of GDP (Zhejiang Provincial Bureau of Statistics, 2021), with a small gap in economic growth level between cities, and also with Japan and Korea. In addition, China has improved the legal rules and public awareness of marine plastic waste as mentioned above. Together with the successful pilot project in Taizhou, it is feasible for China, Japan and South Korea to cooperate in building a closed-loop platform for "blue circulation".

5.2.1 Building a closed-loop platform for "blue circulation"

China, Japan and South Korea share the same philosophy of controlling the whole life cycle of plastic waste. The establishment of the whole life cycle control of marine plastic waste has become a key issue. Drawing on the practice of Taizhou City, Zhejiang Province, the (Figures 1, 2), an IOT device, can reduce the quantity of marine plastic waste by about 90%. Through intelligent algorithm, the transportation route can be well planned, and wastes can be transported to standardized enterprises for batch recycling, which reduces the intermediate flow and improves production efficiency. In this way, we can build a closed-loop governance system that visualizes the whole process of marine plastic garbage collection, transportation, disposal and recycling, and calculate the carbon emission reduction of the whole process to achieve pollution and carbon reduction.

When the fishing boat enters the area surrounded by electronic fence, the system will automatically send messages

FIGURE 1
Marine plastic unmanned capacity reduction device: Blue Cloud Warehouse (to improve collectors' efficiency and income) (Regenerative Plastics, 2022).

FIGURE 2
Blue Cloud Warehouse (Taizhou Ecological Environment Public, 2022).

to remind the fishermen to declare the pollutants according to the rules. Then the marine garbage will be connected to the pipeline, and the management process of "declaration- storage-disposal" will be established. For the collected marine plastic garbage, 30% of the non-recyclable part enters the municipal system for harmless treatment, and the remaining 70% is recycled after deep processing, forming a whole process of "collection-transport-disposal-recycling" of marine plastic garbage closed-loop management system.

5.2.2 Building a unified value-added platform for marine plastic carbon trading in China, Japan and Korea

The three countries need to integrate the demand for marine plastics from related enterprises with the marine ecological and environmental management effectively; set up a "Blue Alliance" by the operating enterprises jointly with environmental protection organizations, certification agencies and industrial chain enterprises in the three countries; establish an "international trading center for marine plastics"; and carry out carbon labeling and carbon footprint calibration for the whole life cycle of marine plastics through blockchain traceability technology; break the green barriers of marine plastics certification in the international high-end market with standard governance system and industry chain appreciation system; obtain international authoritative certification; enhance the environmental competitiveness of plastic export enterprises; build a credible and economically driven sustainable governance model; and realize high-value utilization.

5.2.3 Constructing the industry value redistribution system of China, Japan and Korea

China, Japan and South Korea are recommended to jointly establish the "Blue Ecological Wealth Fund". Through "Internet of Things Plus Big Data" technology, the front-line collectors can reduce costs increase efficiency, and achieve direct profits. And based on that, 20% of the dividends obtained from the high-value utilization of marine plastics and carbon trading can be extracted to establish the "Blue Ecological Wealth Fund". With blockchain smart contract technology for secondary distribution of profits, each link and each participant of the industry chain can be accurately targeted so as to improve the overall profit of the industry and realize market-based management of marine plastic pollution. At the same time, the disadvantaged groups in coastal villages should be highly focused by expanding their

income channels and providing basic social security. Through industrial value redistribution, individuals and industrial enterprises can be fully mobilized to achieve active participation. In this way, a sustainable multi-governance system and ecological common wealth can be achieved.

5.2.4 Building a tripartite public database of China, Japan and Korea

The marine plastic governance cannot go without the sharing, integration and tracing of information. Therefore, it is suggested to build a multi-dimensional brain that integrates the management end, application end and visualization center to realize the application of common management mechanism, visualization of the whole process of governance, integration of industry chain resources, value redistribution, and traceability of product carbon footprints, and form a cross-level, cross-sector and cross-regional collaborative governmental public database.

5.2.5 Non-governmental organization participation

Utilizing the role of NGOs and civil society and fostering the growth of environmental protection agencies of marine plastic waste management is another effective way to achieve marine environmental protection. In many successful marine environmental protection cooperation cases, many NGOs have played an important role. Although China, Japan and Korea share common interests, they do not all have the same environmental aspirations. This is compounded by the fact that governments promote environmental cooperation in a top-down manner, which inevitably requires consideration of the complex political environment. Private marine plastic litter environmental organizations' participation can reduce sensitive political problems to a large extent, and can settle divergences in responsibilities for marine environmental protection. At the same time, private NGOs can also stimulate private energy, enhance trust between people, and promote cooperation.

Developing private environmental organizations and promoting cooperation at the government level with private exchanges can help locate common interests more accurately and enhance cooperation depth. Currently, private environmental organizations lack policy guidance, talent and financial support, and are in urgent need of support from the government. Specifically, China and Japan can learn from Korea's more advanced model of private environmental protection agency development and related experience, give private groups the market flexibility to prevent marine pollution, promote funding and project support and management of private marine environmental cooperation, give full play to the functions and roles of non-governmental organizations, and mobilize private forces to create a good environment for environmental protection cooperation. At the same time, active support in the participation of private environmental protection organizations in international marine environmental protection projects should be fostered. It's also necessary to introduce advanced international technology and foreign funding, which will not only benefit the development of private environmental protection organizations themselves, but also help promote the improvement of regional environmental quality.

5.2.6 Improving the willingness of public participation

Active public participation requires more information disclosure. Therefore, it is suggested that the joint marine plastic waste management agency established by China, Japan and South Korea should enhance supervision by establishing a big data platform and publicly monitoring the amount of waste in accordance with the law. In terms of public participation, it is suggested that a public participation channel be opened specifically in the public database of the blue circulation model above. It is recommended to promote information transparency in a digital way to stimulate public input and participation in marine plastic waste pollution control.

6 Conclusion

It has become a consensus to establish a binding global agreement to combat plastic pollution. However, due to different perspectives, it will take time to reach a global agreement. Marine plastic pollution in the East and Yellow Seas has seriously affected the lives of people in the surrounding areas. China, Japan, and South Korea share similar goals and pursuits in marine plastic pollution management, and the global and regional practices have provided experience to the governance of this region. Under the concept of blue economy, the "blue circulation" governance model becomes possible. Therefore, the conclusions of this paper are as follows: 1. The conditions are ripe for China, Japan and Korea to establish regional binding legal regulations. Under the concept of blue economy, China, Japan and South Korea can achieve the goal of marine plastic pollution control through a new model featuring government guidance, enterprise as the mainstay, industrial coordination and public participation.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

Two authors together contributed to the paper. HH, who completed the first draft and also the revised version. She has made the main contribution to the content of the article and is the project leader. CJ has revised the charts of the paper and contributed to the data sources, literature presentation and formatting changes. The paper also benefited from valuable comments of two anonymous reviewers.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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