Chapter 3
Global Ocean Governance and Ecological Civilization

3.1 Introduction

The ocean is fundamentally important for humankind. The ocean is also vital for the world's economic development. A healthy ocean environment is a prerequisite for drawing on these direct and indirect benefits that the ocean provides. However, global ocean conditions are being seriously affected by large-scale environmental pressures such as global warming, increased ocean acidification under a continuously higher atmospheric carbon dioxide level, microplastics pollution, and overexploitation of natural resources.

At the same time, China, like many other coastal nations, is facing the reality of seeing its own coastal seas declining in quality, caused by both terrestrial and marine development and activities, such as increasing discharge of terrestrial pollutants into the ocean, land reclamation, overfishing, pollutants from mariculture, and so on.

Clear and directed actions are needed to limit the threats and minimize the impacts to the oceans, and thereby lay the foundation for the oceans' ability to continue to serve as the basis of human life. Dedicated efforts are required to ensure further development of current and emerging industries in a sustainable manner. **The principle of ecosystem-based integrated ocean management needs to weave through ocean management like a red thread in order to achieve these goals**.

Marine fisheries are one of the main ways for humans to develop and utilize the ocean. As a major marine fishing country in the world, China shoulders a major responsibility in conserving fishery resources and ensuring the sustainable development of fisheries industry. For this, the current management system, measures and strategies for fisheries still need improvement. Thus, CCICED established the task team (TT1) "Establishing China's Sustainable Fisheries Policy".

With the rapid development of social economy and the urbanization process of coastal areas, more and more attention has been paid to the pollution from land and sea. Since the "reform and opening up" 40 years ago, China's marine environment quality has experienced a process from overall good to overall deterioration, and

China Council for International Cooperation on Environment and Development (CCICED) Secretariat, *Green Recovery with Resilience and High Quality Development*, https://doi.org/10.1007/978-981-19-9470-8_3

then gradual improvement, especially after the call for the "construction of ecological civilization" at the 18th National Congress of the Communist Party of China. Nevertheless, it is still a long way towards the restoration of the health of the coastal and marine environment. Thus, CCICED established the task team (TT2) "Marine Pollution" to promote the prevention and control of marine pollution, as well as the healthy development of marine ecosystem.

By drawing on both national and international experience and competence, CCICED is well placed to identify and highlight relevant policy actions that could be taken by China's administration to ensure healthy oceans domestically and to contribute to sustainable oceans globally. To this end, CCICED established the task team (TT3) "Future ocean research roadmap" to provide a research roadmap for CCICED to embark on over the following years.

3.2 Sustainable Management of China's Offshore Capture Fisheries

Marine fisheries are one of the main ways for humans to develop and utilize the ocean, and are closely related to the production, life, and even survival and development of hundreds of millions of people around the world. As a major marine fishing country in the world, China has played an important role in promoting industrial development and maintaining world food security; on the other hand, it also shoulders a major responsibility in protecting the marine ecological environment, conserving fishery resources, and ensuring the sustainable development of fisheries industry. Due to continuous overfishing for decades, as well as environmental pollution, climate change and other factors, China's coastal fishery resources have severely declined. In recent years, China has continuously improved its fisheries policy, and it has continuously explored more effective management policies and modes in terms of fishing capacity control, attempts to promote quota fishing management, and the development of green aquaculture. These attempts have been positive and beneficial and have produced some economic and ecological benefits.

However, China's marine fisheries have a huge catch volume and employ a large number of employees, involving complex and diversified range of fishery operations, fishing species, and fishing waters, which prove to be highly challenging to manage and regulate. The current management system and mechanisms, measures and strategies still need improvement. To this end, the China Council for International Cooperation on Environment and Development (CCICED) established the "Global Ocean Governance and Ecological Civilization" special policy study (2020–2021), with one of the task teams (TT1) "Establishing China's Sustainable Fisheries Policy" aiming to compare and analyze the implementation of China's marine fishery policies. The outcomes of this study will provide an important reference for China to improve fisheries policy and management, better balance ecological protection and fishery development, and to enhance its ocean governance capabilities during the "14th Five-Year Plan" period.

3.2.1 China's Coastal Capture Fisheries

China's marine fisheries have developed rapidly since 1949. Marine fishing output exceeded 10 million tons in 1995 and reached 14.775 million tons in 2000 [1], ranking at the forefront of the world's marine fishing countries (Fig. 3.1). However, with the enhancement of fishing capacity and the continuous growth of fishing output, China's coastal fishery resources have experienced a serious decline; fishes with larger size and higher economic value have gradually been replaced by small pelagic fishes.

3.2.1.1 Overview of the Fishing Economy

(1) Fishing boats

Fishing boats operating in China coastal oceans are classified by power. According to China's Fishery Statistical Yearbooks [1], in 2019, there were 147,000 marine fishing vessels in China with a total power of 13.547 million kilowatts (kW). Among the vessels, fishing boats larger than 441 kW accounted for 2.1%, fishing boats between 44.1 kW and 441 kW accounted for 33.7%, and fishing boats less than 44.1 kW accounted for 64.2%.

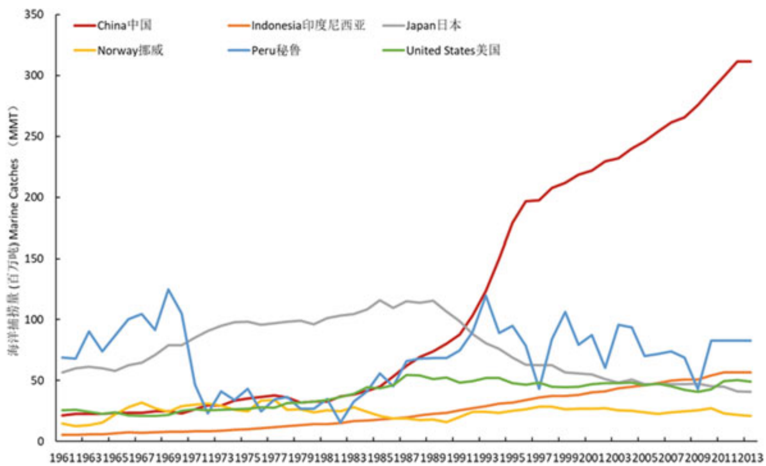

Fig. 3.1 The world's largest marine fishing countries and their catch changes

With the advancement of marine fishing capacity control policies, the total number and total power of marine fishing vessels in China began a downward trend after peaking in 2013 and 2015, with annual decline rates of 3.6% and 1.5%, respectively, as shown in Figs. 3.2 and 3.3. Among them, the number and power of fishing boats of less than 44.1 kW have dropped most significantly, from 130,000 and 2.09 million kW in 2012 to 90,000 and 1.44 million kW in 2019, with the rates of decrease at 28.5% and 31.3% respectively; The number and power of fishing boats of 44.1–441 kW decreased slightly. The number and power of fishing boats with power greater than 441 kW have increased, from 1737 and 1.16 million kW in 2012 to 3023 and 2.79 million kW in 2019, with an increase of 74.0% and 135.3% respectively. Due to the difficulty in defining artisanal fisheries and the lack of separate production statistics, coastal fisheries are represented by fishing boats with a power of less than 44.1 kW and their production.

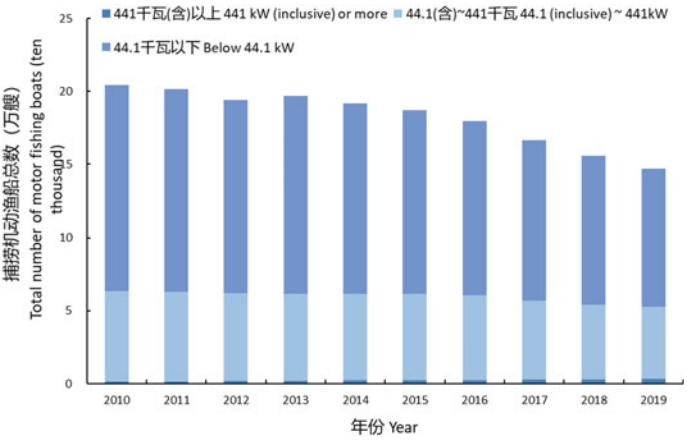

Fig. 3.2 The total number of motorized fishing vessels in China (10,000)

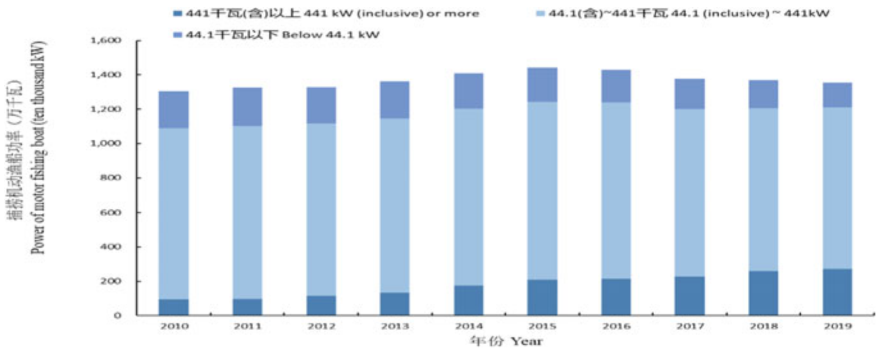

Fig. 3.3 The total power of fishing vessels in China (10,000 kW)

(2) Output

In 2019, China's marine fishing output was slightly over 10 million tons, 21.1% down from 12.7 million tons in 2012. Among the marine fishing regions, fishing output in the East China Sea area is the highest, with an average output of 4.8 million tons from 2012 to 2019, accounting for 40.2% of the total coastal fishing output in China. The average output of the South China Sea and the Yellow Sea was 3.5 million tons and 2.9 million tons, accounting for 29.1% and 24.6% of the total fishing output respectively. The Bohai Sea has the lowest output of 902 thousand tons, accounting for about 7.6% of the total coastal fishing output in the country.

In terms of types of net fishing, China's marine fishing has the highest trawl output, with an average output of 5.7 million tons from 2012 to 2019, accounting for about 48.2% of the country's total coastal fishing output. The second is gillnet, with an average output of 2.7 million tons, accounting for about 22.4% of the total output. The average outputs of other fishing gear such as nets, purse nets and fishing tackles were 1.5 million tons, 98 thousand tons and 1.2 million tons, accounting for approximately 12.3, 8.3, and 10.3% of the country's total marine fishing output.

Fish account for the the largest catches, with an average of 8.3 million tons from 2012 to 2019, accounting for about 69.9% of the country's total marine fishing production. The second is crustaceans, with an average output of 2.211 million tons, accounting for about 18.7% of the country's total marine fishing output. The third is cephalopods, with an average output of 655 thousand tons, accounting for about 5.5% of the country's total marine fishing output. The other species totaled 879 thousand tons, accounting for about 7.4% of the country's total marine fishing output.

(3) Fishery Economic Output

According to China's Fishery Statistical Yearbook [1], in 2019, the total output value of China's fishery economy was about 260 million yuan, of which the fishery output value was about 130 million yuan, accounting for 49.0% of the total output value. In the fishery output value, marine fishing accounted for 16.4% of the total amount of approximately 21.16 million yuan, ranking the third. The two largest production activities are freshwater aquaculture and marine aquaculture, with output values of 61.86 million and 35.75 million yuan, accounting for 47.8% and 27.6% of the fishery output value, respectively. From 2012 to 2019, China's total fishery output value continued to grow, with an average annual growth rate of 5.2%. As a general trend, the output value of freshwater aquaculture and marine aquaculture has been increasing year by year, with annual growth rates of 5.7% and 6.7%, respectively. The output value of marine fishing fluctuated greatly and declined twice after 2015 and 2018 respectively. In all provinces, regions, and cities across the country, coastal provinces such as Shandong, Guangdong, Fujian, Jiangsu, Hubei, and Zhejiang have a relatively high total fishery output value, together accounting for 71.4% of the country's total fishery output value in 2019.

3.2.1.2 Fishery Resources

China's coastal fishery resources are relatively rich with diverse species. China has recorded 2028 species of marine fish, more than 1000 species of crustaceans (more than 40 species of krill, more than 600 species of crab, and more than 300 species of shrimp), and more than 90 species of cephalopods, of which only a few species that are large in quantity have become the main fishing targets [2, 3]. According to the China's Fishery Statistical Yearbook, in the past half century, the main fishing targets in China's coastal waters have changed significantly. With the enhancement of marine fishing capacity and the expansion of fishing scale, China's fishery resources have begun to decline significantly. Small pelagic fishes have gradually begun to replace fish with larger individuals and higher economic values. For example, major fishery resources in the Bohai Sea at the end of the 1950s, such as small yellow croaker, hairtail, and prawns, all declined significantly. The dominant species of fishery resources in the Yellow Sea have also undergone major changes. In the 1950s and 1960s, the fishery resources in the Yellow Sea were still dominated by high-quality demersal and near-demersal fish with high economic value, such as small yellow croaker, hairtail, and flounder. After entering the 1970s and 1980s, Pacific herring, blue-spotted mackerel, and mackerel became the dominant species. By the end of the 1990s, yellow anglerfish and fine-striped lionfish, which have low economic value, gradually became the dominant species in the Yellow Sea.

Studies have confirmed that overfishing is the main reason for the decline of fishery resources, changes in the composition of dominant species, and decline in species biodiversity. Four seasonal bottom trawl surveys from 1959 to 1999 showed that the fishery resources, dominant species composition, and community structure of Laizhou Bay have undergone major changes during the 40 years. Its species diversity index began to show a downward trend after reaching its peak in 1982. This shows that external disturbances such as moderately intensive fishing may increase the diversity of fish, but excessive fishing would reduce the diversity index. The fishery bottom trawl survey conducted in the waters of Laizhou Bay from August 2009 to 2013 also found that the fishery resources of Laizhou Bay are declining year by year, with obvious replacement of dominant species, significant changes in community structure, and a downward trend in species diversity.

While accelerating the decline of fishery resources, excessive fishing will also further interfere with the ecological balance and ecological health of the marine ecosystem, causing serious ecological and environmental disasters. The impacts of overfishing on the marine ecological environment and fishery economic production may be reflected by jellyfish outbursts frequently occurring in the East China Sea and the Yellow Sea in recent years.

3.2.1.3 Fisheries Challenges

Firstly, although China is now a major fishing country in the world, and its volume of fishery catch and aquaculture production far exceeds that of other countries in the world, the supply gap in the domestic seafood market is still increasing.

Second, the fishery law enforcement system is not robust. In recent years, China has continuously stepped up its crackdown on illegal fishing and has introduced a series of special law enforcement action plans for the fishery administration. However, various illegal fishing behaviors still occur.

Third, the rapid development of the coastal economy has brought tremendous environmental pressures to the marine ecosystem. A large number of pollution from agricultural and industrial sources have destroyed the habitats of many wild fish species. How to manage and control the potential marine environmental impacts of large-scale aquaculture will be a major challenge in the process of China's sustainable fishery development.

Fourth, climate change is inducing rapid changes for the marine resources in China's waters. Sea surface temperatures in the Bohai Sea, Yellow Sea, and East China Sea have significantly increased over the past century, with some of the strongest warming (~ 1.96 °C) in the East China Sea [4]. Sea level rise (SLR) rates for Chinese coastal areas are projected to be 3.1–11.5 mm/year by 2050, which is higher than the global SLR rate of 3.2–80 mm/year by 2050 [5]. Such rates imply severe coastal flooding and potential loss of remaining coastal wetlands [6].

A growing body of literature presents clear evidence that climate change that is already underway presents many challenges for China's fisheries. Its impacts on coastal marine habitats and shifting of marine species pose risks on fishing communities in China and along its supply chains. To effectively mitigate these risks, funding and research are required to develop a scientifically informed adaptation plan.

An additional challenge is recent and potential new catastrophic events, causing serious disruptions for the entire China aquatic products supply chain. Catastrophic events are occurring more frequently, and the scope and duration of their impacts continue to exceed historical records. In particular, the novel coronavirus pneumonia (Covid-19) outbreak resulted in a global epidemic and triggered a serious public crisis, with great impacts on all links along the China and global fishery supply chain, including catch fisheries, aquaculture, processing, transportation, and wholesale and retail sales markets. While some disasters are short-term, others can last for years. Although China has actively taken countermeasures to mitigate the impact of Covid-19 and achieved good results, there is a need to strengthen the early warning system and long-term impact assessment of the disaster.

3.2.2 *Coastal Capture Fishery Management System*

3.2.2.1 Top-Level Design of China's Fishery Management

The 18th National Congress of the Communist Party of China clarified the overall layout of China's coordinated promotion of economic construction, political construction, cultural construction, social construction, and ecological civilization construction. Under the guidance of the ecological civilization construction, the proposal of Marine Ecological Civilization (MEC) has further promoted the transformation of China's fishery management mode [7]. Marine ecological civilization emphasizes the use of healthy marine ecosystems to support the prosperity and development of the blue economy. Through intensified policies, it aims at strengthening the protection and restoration of coastal and marine ecosystems and improving the utilization efficiency of fishery resources [8]. To this end, China issued a series of policy documents during the "13th Five-Year Plan (FYP)" period, emphasizing marine environmental protection, the sustainable use of fishery resources and the establishment of eco-friendly mariculture. The 14th FYP was released in 2021. The annual plan and the 2035 long-term goal outline (draft) emphasize the creation of a sustainable marine ecological environment, the optimization of the layout of coastal green aquaculture, the construction of marine ranches, the development of sustainable coastal fisheries, and the synergy between the development of the blue economy and marine protection [9].

3.2.2.2 Fishery Management System Based on the Input Control

In order to use fishery resources more rationally and adjust the fishing intensity, China has established specific management systems for fishing vessels, fishing gear, fishing time, and regions under the guidance of the Fisheries Law. Such systems focus on avoiding unreasonable fishing methods and excessive investment in fishing capacity, thereby protecting the sustainable prosperity of fishery resources and the benign development of the fishing economy.

(1) Fishing gear management system

To effectively reduce the adverse effects of overfishing on living marine resources, China has enacted strict regulations controling the permitted fishing gear. To protect juvenile fish, juvenile shrimps, and juvenile crabs, China prohibits the use of fishing gear with mesh sizes smaller than the limits set by the national regulations. On the other hand, China prohibits the use of fishing methods that destroy fishery resources such as electric fishing, explosive fishing, and poison fishing, and has issued specific notices on prohibited fishing gears for marine fishing.

(2) Protection of aquatic germplasm resources

China first proposed the concept of aquatic germplasm resource protection zone in the "China Aquatic Biological Resources Conservation Action Program" in 2006. The third part of this outline requires the establishment of an aquatic germplasm conservation zone in the main breeding areas of aquatic germplasm resources with high economic value and genetic breeding value, and to develop appropriate management practices, strengthen and standardize the management of protected areas. Up to 2021, China announced it has validated eleven groups of 535 state-level aquatic germplasm resource conservation zones in total. These protected areas can protect hundreds of national key protected fishery resources and key habitats such as spawning grounds, feeding grounds, overwintering grounds, migratory channels, etc., and initially constructed the protected area network of aquatic germplasm resources covering various sea areas and major inland rivers and lakes.

(3) Fishing season closure in summer

China's seasonal moratorium system first began in 1980. The former State Fisheries Administration in 1980 and 1981 issued the "Notice of Collective Trawlers Fishing Moratorium and the Joint Inspection of the Proportion of Young Fish in the State-run Fishing Vessel" and "Provisional Regulations on the Protection of the Aquatic Resources of the East Sea and Yellow Sea Area", which requires a two-month moratorium on collective trawlers in the Yellow Sea area from July to August each year, and a four-month moratorium on collective trawlers in the East China Sea from July to October. Since then, China has continuously adjusted the scope, period, and specific requirements of the fishing moratorium according to the endowment of fishery resources and production conditions. As of 1999, China's fishing moratorium system has covered the Bohai Sea, Yellow Sea, East China Sea, and South China Sea (not including latitude 12° south of the Sea). The fishing moratorium system implemented in 2007 is called by Chinese "the strictest regulations in history" of the fishing moratorium. The system put fishing start time advanced to May 1st and extend the moratorium period 1 month, keeping the pressure crackdown situation for fishing violations. During the annual fishing moratorium in 2017, there were a total of 7427 cases of prosecuting illegal, 10,343 people involved, of which involved 1369 were transferred to judicial processes. More than 7000 "Sanwu" ships and more than 400,000 extreme nets were cleaned up and banned [10].

(4) Dual control of fishing boats

In order to control fishing intensity and conserve and rationally utilize marine resources, China has started to strengthen the total amount control of marine fishing intensity since the 8th Five-Year Plan and the 9th Five-Year Plan and implemented the dual control of fishing boats. Subsequently, in 1999 and 2000, the "zero growth" and "negative growth" policies were introduced for marine fisheries. The dual control of fishing vessels sets a clear control target for the number of vessels and power of marine fishing vessels nationwide. For example, the "Views on Implementing Marine

Fishing Vessel Control System in 2003–2010" proposed that the number of national marine capture fisheries boats and power would be within 193,000 and 1142.7 kW in 2010. However, affected by factors such as employment pressure in coastal areas, subsidies for conversion of fishermen, and unmatched fishing employment policies, the effect of the implementation of the dual control system for fishing vessels is not satisfactory. In 2010 there were still 205,000 coastal fishing vessels in China.

To solve this dilemma, China reiterated the goal of dual control of fishing vessels in 2010 during the 12th Five-Year Plan period and issued Several Opinions on Promoting the Sustainable and Healthy Development of Marine Fisheries in 2013, emphasizing the strict execution of marine fishing moratorium, fishing access, aquatic germplasm resources protection system at the same time, in particular, to clarify pilot of coastal fishing quotas, strict control of the coastal fishing intensity, and to improve its marine fishing vessels control system, and gradually reduce the number of fishing vessels and total power. On this basis, the former Ministry of Agriculture issued the Notice on Further Strengthening the Control of Domestic Fishing Vessels and Implementing the Total Management of Marine Fishery Resources in 2017, with a view to further improving the scientific and refined level of utilization and management of marine fishery resources. The notice requires reducing 20,000 marine fishing motorboats and 1.5 million kW power, reducing domestic marine capture production to less than 10 million tons by 2020. As mentioned above, the number of China's marine fishing vessels has been decreasing since 2013 and has dropped to 147,000 ships in 2019.

3.2.2.3 China's Fishing Quota Pilot

To strengthen the total marine fishery resource control, the Ministry of Agriculture and Rural Affairs started total allowable catch (TAC) pilots in 2017 in Zhejiang and Shandong provinces and in 2018 extended the range to Liaoning, Fujian, and Guangdong provinces. Relying on the special fishing license system during the fishing moratorium period, these 9 coastal provinces (municipalities) have been carrying out the quotas experimentally.

Although the species, distribution methods, and specific requirements of these TAC pilot projects are different, they still have many similarities. First, almost all pilots use special fishing licenses to limit the total catch under TAC, while special licenses regulate the fishing time, waters, and species for fishermen. Second, most of the pilots began from single-species quotas. Although the pilots in Fujian involve four different types of *Portunus* crabs, they are not treated differently during the quota allocation and monitoring process. Third, most of the pilot projects have improved catch monitoring by implementing fishing logs, fishery observers, and fishing quota early warning systems.

These pilots not only actively accumulated significant experience in implementing TAC systems for its deployment nationwide, but also identified the potential problems and obstacles.

First China's fishery resources survey and basic evaluation have deficiencies and it is difficult to offer a clear basis catch for TAC.

Second, the pilots have not yet established a real-time, accurate, and efficient capture and monitoring system.

Third, because the majority of China's fisheries have a characteristic of multipe fish species, it is difficult for the main pilot work at this stage to focus on a single species to gain experience for the TAC across the country. In addition, with the expansion of the scope of TAC control, if the exclusiveness of fishing in the controlled waters and possible cross-regional fishery management issues are guaranteed, it will be an important challenge that will be faced in the development of the TAC system in the future.

Finally, the legal basis for the implementation of TAC in China is still not solid. Although the revised "Fisheries Law" in 2000 has put forward the implementation of the fishing quota system, the relevant supporting documents have not been published. The specified regulations on log management of fishing, boat inspection, and designated transaction mechanisms are still missing. In addition, although China has defined fishing licenses as a kind of property right, according to the "Fishing License Management Regulations", the Ministry of Agriculture still prohibits the transfer and trading of fishing licenses. This limitation will affect the further development of the Individual Transferable Quota (ITQ) system in the future in China.

3.2.3 The Institutional Framework of China's Marine Ecological Economy

3.2.3.1 Marine Protected Areas and Ecological Red Lines

As of 2020, 271 marine nature reserves of various types have been established in the waters under China's jurisdiction, with protected areas of about 124 thousand km^2 and a 4.1% coverage of the coastal ocean areas under China's jurisdiction. The protection targets include rare and endangered marine biological species including dugongs, harbor seals, and Chinese white dolphins; typical ecosystems such as mangroves, coral reefs, coastal wetlands; marine natural historical sites, etc. All the eleven coastal provinces, autonomous regions, and municipalities have marine nature reserves, and a network system of marine nature reserves has been initially formed. Since 2018, China has integrated marine protected areas into the natural reserve construction system with national parks as the main body.

However, China's current marine protected area management system still has certain limitations. First of all, despite the relatively large number of protected areas, they account for only 4.1% of China's total ocean area, which is lower than the 10% target set by the Convention On Biological Diversity and the target of "5% of the coastal ocean under China's jurisdiction being protected by 2020" set by the National Marine Major Function Zone Planning (2015) [11, 12]. Second, in the absence of top-level coordination, the distribution of many marine protected areas is inconsistent with the priority areas identified in the National Biodiversity Strategy and Action Plan, and the protective effect is poor [13, 14]. Third, the delineation of existing protected areas has not yet fully considered the connectivity of the ocean and the differences in the utilization of different habitats by organisms. The ocean has high mobility and connectivity, which determines that many marine organisms have a relatively large range of movements, and there are many types of river-sea migration. Organisms may use different types of habitats at different stages of their life history, and their spawning grounds, nursery grounds, and feeding grounds may be distributed in different waters such as estuaries, seagrass beds, mangroves, and tidal flats. If only part of these areas are protected, it means that only part of the life history stage is protected, and the goal of comprehensive protection of marine life and ecosystems cannot be achieved. Therefore, only by setting up protected areas with appropriate and sufficient area and scope can the purpose of continuation and expansion of the protected populations be achieved.

To strengthen the protection of marine ecosystems, the former State Oceanic Administration has integrated marine protected areas and aquatic genetic resource reserves, and delineated the Red Line of Marine Ecological Protection (red-lining) under the framework of marine functional zoning. The Red-line is the bottom line of marine ecological security. By delimiting important marine ecological function areas, ecologically sensitive areas, and ecologically fragile areas as the key control areas, it strictly controls the space boundaries and management boundaries in terms of natural ecological service functions, environmental quality and safety, and natural resource utilization, in order to maintain marine ecological functions, environmental quality and safety, and the sustainable use of natural resources, and to promote the balanced development of economy, society, and the environment. Red-lining is an important institutional innovation for environmental protection in China.

The red-line protection is essential to the health of the marine ecosystems. The red line includes marine aquatic genetic resource reserves, special marine reserves, important coastal wetlands (such as mangroves, coral reefs, and seagrass beds), islands, natural landscapes, historical and cultural relics that need special protection, concentrated distribution area of rare and endangered species, and important fishery waters. In a way, the Redline is similar to marine protected areas (MPA), which includes marine natural reserve and MPA for historical and cultural conservation. Fishing is usually permitted in a MPA in China. National park is an MPA with the highest protection status, but only a small percentage of MPA can be consolidated into the national park system. The Bohai Sea is the first region in China to adopt the marine ecological red line system [15]. In the four provinces (municipalities) adjacent to the Bohai Sea, the coverage of the marine ecological red line is about 10% (Tianjin) to 45% (Liaoning) of the sea area under its jurisdiction [16]. Drawing on the experience of the Bohai Sea, China will further expand the scope of the pilot red-lining and plans to achieve a Red-line coverage of more than 30% [17].

3.2.3.2 Nature-Based Coastline Restoration Plan

China has nearly 3 million km^2 of sea area and 32,000 km of coastline, and has more than 20,000 recorded marine species. The stretch of the coastal zone is full of various high-productivity habitats, including mangroves, seagrass beds, coral reefs, seaweed forests, and tidal flat wetlands, etc., which provide various important ecological services functions. For example, mangroves can filter pollutants in the water, provide important timber and food resources for coastal communities, store large amounts of carbon sinks, and are a natural barrier against erosion and severe storms.

In recent years, China has actively promoted the restoration of coastlines such as "returning fish farms to beaches" and "returning farms to sea". In the process, nature-based solutions have received more and more attention. Nature-based solutions adhere to the restoration principle of "emphasis on nature and light on engineering", and avoids the restoration mode of artificial landscape creation through a large number of engineering measures. These solutions include protecting, restoring, and sustainably managing ecosystems, improving the resilience and adaptability of ecosystems, reducing disaster risks, and building green infrastructure, thereby simultaneously protecting biodiversity and improving human well-being. For example, by building oyster reefs to absorb wave energy, the coastline can be protected from wave erosion and storm damage, seawater can be filtered to improve water quality, and breeding habitats for economic species can be provided. In addition, some studies have shown that coral reefs are more effective than traditional breakwaters in reducing the height and energy of waves. These nature-based solutions can provide solutions for the protection of coastlines from the perspective of ecological protection.

Nature-based solutions can play an important role in the restoration of mangroves in China. In China, a large number of mangrove wetlands were converted into aquaculture ponds in the 1980s. The reduction of mangrove wetlands has severely damaged the local biodiversity, and the polluted waste generated by aquaculture has made most wetlands lose their ability to recover naturally. During the "13th Five-Year Plan" period, China began to promote the work of "returning ponds and returning wetness" and proposed to build and restore 18,800 ha of mangrove forests by 2025 on the basis of clearing and retreating ponds in nature reserves. At present, Beihai and other places are exploring the use of nature-based solutions to restore mangroves in abandoned ponds. The local staff designed a mangrove-Wutang snakehead multi-nutrient level composite ecosystem, using natural productivity and bait to proliferate economic organisms under the mangroves and implement sustainable resource harvesting to achieve the continuous improvement of the ecosystem and sustainable economic organisms. At the same time, it plays an extremely important role in purifying seawater, preventing wind and waves, maintaining biodiversity, and fixing carbon and storing carbon.

In addition to coastline restoration, nature-based solutions also play an important role in the process of marine ecology and environmental protection. For example, sustainable marine aquaculture based on integrated multi-trophic aquaculture (IMTA) can utilize cultured organisms of multi-trophic levels such as filter-feeding shellfish, macroalgae, and benthic animals to recycle the residual bait and biological waste in the system toreduce nutrient loss as much as possible, thereby increasing the capacity of the breeding environment and the sustainable production level of the entire system.

3.2.3.3 Green Mariculture

Mariculture contributes to 40% of the total global marine fishery production, while China's marine aquaculture production accounts for more than 60% of the global total output. China's mariculture industry boasts its long history, large scale, and huge species variety. There are about 70 species of marine organisms are listed in the official fishery statistics, including finfish, shrimps and crabs, molluscs, seaweed, sea cucumbers, and other species. A considerable part of the aquaculture species grow through photosynthesis or filter-feeding on plankton, which means no artificial feeding is needed during the aquaculture process; only about 15% of fish and crustaceans need to be fed.

Quality improvement, waste water treatment, volume reduction, and income increase are major strategies to China's fishery development and are also the general direction of green development for the industry. In 2020, Document No. 1 of the Central Committee of China Communist Party made an important deployment of "promoting green and healthy aquaculture". The Ministry of Agriculture and Rural Affairs immediately issued the document, "Notice on the Implementation of the 'Five Actions' for Green and Healthy Aquaculture in 2020", making specific requirements in five aspects, including promoting ecological and healthy aquaculture modes, promoting aquaculture waste water treatment modes, reduction in application of aquaculture chemicals, replacement of trash fish with formulated feed, and enhancement of genetic resources etc. In recent years, the National Aquatic Technology Promotion Station has promoted eco-friendly aquaculture technologies such as recirculating aquaculture, integrated multitrophic aquaculture, as well as rice-fish co-cultivation to the whole country. Among them, the seawater pond (or inshore) integrated multi-trophic aquaculture technology mode is based on different physiological and ecological characteristics of fish, shrimp, and shellfish, by taking advantage of the complementary characteristics of polyculture species in the water layer, feeding habits, and living habits. The three-dimensional ecological farming mode may consist of fish in the water column, shrimp on the bottom and molluscs in the bottom of the pond. In the process, an important issue to be solved in the development of green mariculture is how to balance the relationship between the growth of the aquaculture industry and the protection of the ecosystem.

3.2.3.4 Marine Aquaculture Spatial Planning

As an important way of using the sea, the development of marine aquaculture needs to meet the requirements of the national, provincial, and municipal marine functional zoning. Marine functional zoning is a unique marine spatial plan in China. Marine functional zoning is revised and supplemented every ten years or so to keep the content of the plan consistent with China's marine ecological protection goals and promote the sustainable development of marine industries including mariculture. According to the Fisheries Law revised in 2013, people's governments at all levels are responsible for strengthening the overall planning and management of water areas, standardizing the use of water areas, and determining which areas can be used for mariculture. If enterprises and individual farmers decide to use waters and tidal flats for aquaculture activities, they need to apply for aquaculture license and sea area use license from or above government at the county level. Furthermore, from 2018 to 2020, coastal cities and counties across the country have comprehensively delineated the "three zones" for aquaculture (aquaculture permitted, restricted and prohibited areas), and have successively compiled regional aquaculture plans for water areas and tidal flats (2018–2030).

However, in the case of insufficient coordination of the top-level design of fishery management in China, there are serious overlaps and conflicts between mariculture zoning and marine ecological protection red lines, and the current Fisheries Law does not make provisions for the management of marine ecological protection red line. How to collectively consider the needs of fishery development and marine protection, and formulate reasonable aquaculture zoning, is an important topic of concern to the academics and the industry [18].

3.2.3.5 Treatment of Mariculture Waste Water

The treatment of waste water is one of the key points in the development of green mariculture. The Marine Environmental Protection Law of the People's Republic of China (revised in 2017) clearly stated that "the state establishes and implements a total pollution control system in key ocean areas, determines the total discharge control index of major pollutants, and allocates discharge control quantities to major pollution sources". At the beginning of 2019, ten ministries and commissions, including the Ministry of Agriculture and Rural Affairs, jointly issued the "Several Opinions on Accelerating the Green Development of Aquaculture Industry", further proposing to "develop ecological and healthy aquaculture modes, improve water recirculating and intake/discharge treatment facilities, support ecological upgrade and transformation of waste water treatment facilities such as water ways, ponds and subsurface wetlands; furthermore, promote the treatment of aquaculture waste water, promote the introduction of aquaculture waste water pollutant discharge standards, and carry out the environmental impact assessment of aquaculture in accordance with the law".

In line with the promulgation and implementation of the above policies, China has organized experts since 2017 to revise the current "Freshwater Pond Aquaculture Water Discharge Requirements" (SC/T9101-2007) and "Marine Aquaculture Water Discharge Requirements" (SC/T9103-2007). Coastal provinces and cities are also actively conducting surveys of fishery pollution sources, formulating and implementing technical plans for aquaculture waste water treatment, and selecting typical aquaculture companies to carry out technology research and development, application and demonstration. Although some results have been achieved in the implementation of the work mentioned above, many problems have also been exposed. As the pollution discharge of aquaculture has characteristics of low pollutant concentration, large quantity of drainage, and non-point source discharge, it is difficult to meet the treatment requirements of aquaculture waste water by referring to the prevention and treatment of point source pollution and sewage treatment methods. In addition, the formulation of aquaculture waste water discharge standards has not taken the latest research results at home and abroad into consideration, and the regulations on aquaculture species, modes of operation, water quality, and nitrogen and phosphorus budgets are relatively outdated. The discharge characteristics and development trends of aquaculture waste water should be considered collectively in order to develop a more flexible, comprehensive, targeted, and practical discharge standard for aquaculture waste water.

3.2.3.6 The Growth of Recreational Fisheries

China's recreational fishery started in the 1990s, slightly later than developed countries such as in Europe and the United States, but it has developed rapidly and has become a new bright spot in the development of the modern fishery economy. The "12th Five-Year Plan for National Fishery Development" issued by the Ministry of Agriculture in 2011 included recreational fisheries in the fishery development plan for the first time and clearly listed it as one of the five major industries of modern fishery in China. During the "13th Five-Year Plan" period, China further proposed to form a modern fishery industry system featuring coordinated development of aquaculture, fishing, processing and circulation, enhanced fisheries, recreational fisheries, along with the integration of primary, secondary and tertiary industries. To objectively reflect the development of recreational fisheries across the country and lead the sustainable and healthy development of recreational fisheries, China launched nationwide monitoring of the development of recreational fisheries in 2017 and issued the "Report on the Development of China's Recreational Fishery Industry" in 2018. Following this, China's recreational fishery has begun to embark on a standardized development path.

China's recreational fisheries are divided into five categories: recreational fishing and gathering industry; tourism-oriented recreational fishery; ornamental fish industry; fishing tackle, bait, ornamental fish, fishery medicine; aquarium equipment; and others. As shown in Fig. 3.4, the output value of China's recreational fisheries in 2019 was mainly derived from tourism-oriented recreational fisheries, recreational fishing activities, and gathering industries, which were 44.62 billion yuan and 28.42 billion yuan, respectively, accounting for 47.30% and 30.13% of the national recreational fishery output value. In total, the two categories account for 77.43% of the national recreational fishery output value, while other categories account for relatively small proportions.

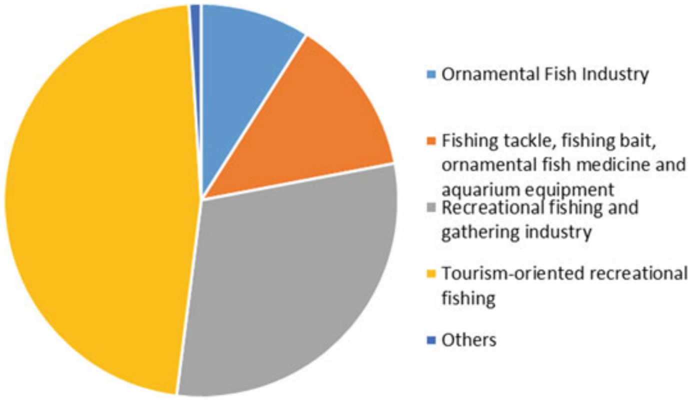

Fig. 3.4 China's national recreational fishery industry structure in 2019

According to the data of China Fishery Statistical Yearbook, since the implementation of recreational fishery monitoring statistics in 2003, the output value of recreational fishery in China and its proportion in the total fishery economic output value show an overall upward trend, with an average annual growth rate of 19.6%. In 2019, the annual output value of recreational fisheries in China reached 94.32 billion yuan, accounting for 3.8% of the total output value of China's fishery economy.

3.2.3.7 Sustainable Use of Fishery Resources

In recent years, marine fishery resources are facing increasing human and environmental pressures, and many countries, regions, and non-governmental organizations are taking action to maintain the sustainable development of marine fishery. China should give full attention to its advantages of marine environment and resources, carry out ecological farming, strengthen scientific and technological innovation, and improve the level of fishery production equipment; Implement sustainable fishery certification, reduce the impact of aquaculture on the environment and society, ensure the healthy and sustainable development of aquaculture, and restore and develop the fishery biological population with the most ecological, economic and cultural values.

(1) Traceability System for Aquatic Products

Since 2003, China has explored the establishment of a traceability system in the aquatic field. The prevention and control of cold chain food safety during the 2020 COVID-19 pandemic has further promoted the traceability management of domestic aquatic products, including extensive coverage of traceability requirements and technological progress. The establishment of a complete traceability management system is the focus of the development of sustainable fisheries. China has a long-standing unsound and unsystematic traceability quality management status, but with the development of E-commerce and the improvement of consumer awareness, some retailers have begun to establish traceable seafood supply chains through information technology.

At present, China's aquatic product traceability hardware conditions are at a relatively advanced level, but the relevant information in the traceability system has not yet been linked to sustainable development, and it is impossible to identify whether aquatic products on the market come from overfishing areas, whether they are endangered species, and whether they are derived from illegal, unreported and unregulated fishing (IUU), etc.

(2) Sustainable Fisheries Certification

In recent years, China's aquatic product production and processing industry has developed rapidly, and the output value of foreign exchange earnings from exports has ranked first in the trade of bulk agricultural products for many years. As an operable and identifiable means, a certification is a favorable tool for leveraging the coordinated development of marine protection and industrial economy through the market. Carrying out aquatic product certification can enhance its brand competitiveness in domestic and foreign markets, improve the sustainability of fishery production and the added value of products, and effectively reduce the pressure on fishery resources. At present, the domestic aquatic product standard system mainly includes the international Best Aquaculture Practices, the Aquaculture Stewardship Council, the Marine Stewardship Council, as well as domestic organic products and green products. Among them, the strict certification standards for organic products are conducive to protecting the environment and ecological diversity, giving consumers more choices, and allowing businesses with good production conditions to obtain higher benefits. Compared with organic certification, green products are less strict, more in line with the reality of China's agriculture, and are conducive to promoting fishermen to improve their breeding environment.

3.3 China's Offshore Environmental Pollution and Its Treatment

From the 1990s to 2012, the intensity of marine development has been increasing. The coastal economy has entered a development mode of resource competition, low utilization efficiency and similar main industries. The marine ecological environment quality has deteriorated comprehensively. Oil spills, pollution (including anthropogenic chemicals and microbial wastes), and eutrophication remained the major problems. However, in recent years, there has been a dramatic increase in research on macro-, micro- and nano-plastics and other forms of marine litter. By 2015, the world had produced 8.3 billion tons of new plastics and 6.3 billion tons of plastic waste. Among them, 9% of plastic waste has been recycled, 12% burned, while 79% has been piled up in landfills or abandoned in the natural environment.

Based on current production and waste management trends, it has been estimated that 12 billion tons of plastic waste will enter the landfill or natural environment by 2050. It is estimated that the total amount of large and micro plastic waste floating in the open ocean is 5.25 trillion tons, and the weight is 269,000 tons. At the end of the twentieth century, about 32,600 km^2 of the sea area under China's jurisdiction has been significantly polluted, reaching a peak of about 67,900 km^2 in 2012. Since the 18th National Congress of the Communist Party of China, with the continuous advancement of the start of ecological civilization, the pollution control and ecological restoration in coastal areas have been strengthened, and the marine ecological environment quality has stepped into an improvement period. The seriously polluted area of China's coastal waters has shown significant decrease. By 2020, the seriously polluted area has dropped to 30,100 km^2.

This chapter analyzes the marine pollution status and relative governance countermeasures focuses on marine plastic pollution, coastal eutrophication and mercury pollution. The main research includes as follows.

- Compare the policies related to solid waste management and plastic pollution prevention and control in China and the European Union. Analyze the source of marine plastic debris from the whole chain of production, including product design, consumption and waste disposal. Evaluate the marine plastic pollution prevention and control effect, as well as to optimize the estimation of plastic waste flux into the sea.
- Investigate the nutrients distribution in the Bohai Sea in the context the combined effects of land-based nutrients input/reduction, climate change, water and sediment regulation of the Yellow River. Analyze coupling effect of coastal chemical elements and ecological environment in the view of the bottom layer anoxia evolution and surface seawater chlorophyll distribution. Compare regulation of human activities and climate change on nutrient cycle in the Bohai Sea and the Baltic Sea. Put forward countermeasures and suggestions on the management and control of nutrients in coastal waters.
- Sort out the data of mercury in seawater, sediment and organism both from operational monitoring and investigation. Assess the mercury pollution in China's coastal waters. Analyze input and transfer process of mercury in the marine environment, and provide basic information to assess the effectiveness of the implementation of the Minamata Convention.

3.3.1 Eutrophication and Mitigation Actions in the China Coastal Sea

3.3.1.1 Overview of Coastal Eutrophication

As research is conducted in more habitats and using new tools and approaches, the range of effects of hypoxia driven by eutrophication that have been identified. Severe hypoxia process will lead to a large number of marine organisms to die, forming a "marine dead area". Since 1950, more than 500 sites in coastal waters have reported oxygen concentrations ≤ 2 mg L^{-1}, a threshold often used to delineate hypoxia. This oxygen loss, or deoxygenation, is one of the most important changes occurring in an ocean increasingly modified by human activities. In estuaries and other coastal systems strongly influenced by their watershed, oxygen declines have been caused by increased loadings of nutrients (nitrogen and phosphorus) and organic matter, primarily from agriculture; sewage; and the combustion of fossil fuels. Hypoxia results a wide range of biological and ecological consequences, including not only effects on marine and estuarine fisheries and ecosystems, but also impacts on regulation of global cycles of major nutrients and carbon. In the meantime, hypoxia can enhance acidification in coastal waters.

3.3.1.2 Distribution Patterns of Nutrients and Control Mechanisms in Coastal Sea

(1) Bohai Sea

Anthropogenic activities have considerably perturbed China marginal seas, in particular the Bohai Sea. Therefore, prominent impacts on the coastal ecosystem have been observed in the Bohai Sea. Nutrient concentrations generally decreased from the coastal areas to the central part of the Bohai Sea and had significant seasonal variations. Nutrients showed stratification in summer with higher values at near-bottom layers than those in the surface and were vertically mixed well in winter. The nutrient limitation was changing from nitrogen limitation to phosphorus limitation and silicon limitation.

One of the main sources of nutrients in the Bohai Sea is riverine input. The seasonal patterns of both water discharge and sediment load have been changed by the water and sediment regulation scheme (WSRS). In particular that residence time of the Yellow River water was long in the Bohai Sea, thus the WSRS has a far-reaching influence on the ecological environment of the Bohai Sea. The composition of nutrients in the Yellow River has high ratios of N/P and Si/P, and low ratio of Si/N. Strictly controlling the amount of fertilizer and improving the application methods, enhancing sewage treatment technology and vigorously promoting "green travel" might reduce nutrients emptied into the Yellow River based on the main source of nutrients. The second is other sources, including nutrient regeneration in summer sediments, atmospheric deposition and groundwater. Compared with river input, the contribution of nutrient regeneration in sediment to nutrient load in water in summer is nearly 2–3 times that of river input, indicating that the internal circulation of nutrients in the Bohai Sea is very important. although submarine groundwater discharge (SGD) had large uncertainties, nutrient fluxes transported via SGD to the Bohai Sea were higher than those from the riverine input and atmospheric deposition. The pollution of large-scale mariculture is widely concerned globally. Nutrients input to the Bohai Sea through marine aquaculture (including feeding and non-feeding marine culture) contributed < 5% of total N and P fluxes by industrial wastewater and domestic sewage.

(2) Baltic Sea

Similar to the Bohai Sea, the Baltic Sea is a semi-closed marginal sea, which only connects with the North Sea and the Atlantic Ocean through narrow channels. The residence time of seawater in different areas of the Baltic Sea is different. The distribution characteristics of nutrients in the Baltic Sea can be traced back to the early 1990s, DIN concentrations in the sub open seas of the Baltic Sea showed increase. After that, DIN concentration in each sub open seas almost stopped increasing and maintained at a high level, with a significant decrease in most of the sub open seas. The observation of DIP in some sub open seas can be traced back to the 1960s. The DIP concentration in most sub open seas increased significantly from 1960 to 1970s, and then remained at a high level. There was no obvious trend in DIP concentration in most sub open seas. However, the DIP concentration in Aland Sea continued to increase from 1990 to 2016 and that in the Bothnian Sea, Gulf of Riga, Gdansk Basin and Northern Baltic Prope also had significant increase during 2011–2016. Fleming-Lehtinen showed that DSi concentrations in northern Baltic Proper, Gulf of Finland and Bothnian Sea decreased by 30–50% from the beginning of 1970s to the end of 1990s, and then increased by 20–40%.

The total nitrogen (TN) input to the Baltic Sea included water input and atmospheric input, where the water input was a combination of river input and direct point sources input (industrial, municipal and aquaculture wastewater directly discharged into the sea in coastal areas). The total phosphorus (TP) input to the Baltic Sea mainly came from river inputs and direct point sources input. River input was mainly affected by natural and anthropogenic sources, among which anthropogenic sources included diffuse sources and point sources. In addition to natural and anthropogenic sources, some of the nutrients in the river came from non-HELCOM countries (mainly Belarus) in the upper reaches of the river, which were separately defined as trans-boundary input. Generally, the inputs of nitrogen and phosphorus to the Baltic Sea has decreased in recent decades. River input was the main way for providing DSi to coastal water.

(3) Comparative analysis of nutrients in the Bohai Sea and Baltic Sea

The DIN concentration in the Bohai Sea was very low before the 1990s, and then began to increase significantly in recent years. Since 1978, the DSi concentration in the Bohai Sea showed a trend of decrease first followed by increase. The concentrations of DIN and DIP in most of the sub open seas of Baltic Sea increased significantly before the 1990s. After that, the DIN concentration in most sub open seas and the DIP concentration in a few sub open seas decreased due to the implementation of some management measures.

The average DIN concentration level in the Bohai Sea was higher than the peak average DIN concentration in most sub open seas of Baltic Sea. The average DIP concentration was relatively the same, while the average DSi concentration in the Bohai Sea was equivalent to the intermediate level of the sub-sea areas of the Baltic Sea. Relatively higher DIN concentrations, close DIP concentrations, and intermediate DSi concentrations in Bohai Sea resulted in higher N/P ratios and lower Si/N ratios in the Bohai Sea than that in Baltic Sea. Although relevant measures have been taken to protect the Bohai Sea in China in recent decades, previous studies have shown that the total DIN input into the Bohai Sea through rivers has not decreased significantly in recent years and maintained at a high level. In addition, the amount of agricultural fertilizer, municipal sewage discharge and aquaculture area in the Bohai Rim region have been increasing, which indirectly indicated that the total amount of nitrogen input into the Bohai Sea through these channels has not been effectively controlled. Therefore, effective control of nitrogen input in Bohai is the key to improving eutrophication in Bohai.

3.3.1.3 Ecological Responses to Coastal Eutrophication

(1) Bohai Sea

The WSRS has led to that high monthly average water discharge, sediment load and nutrient transports advance to as early as 2 months earlier than before the event, such that the surface Chl-a exhibited two peaks in spring and autumn until 2002, but has exhibited only one peak in spring–summer since 2002. Along with changes in physicochemical environment, the composition pattern of the phytoplankton community changed dramatically during 1959–2015, in which diatoms accounted for 65.3–99.8% of phytoplankton abundances and phytoplankton transitioned from diatom dominated communities to communities co-dominated by diatoms and dinoflagellates. Along with eutrophication caused by human activities, the diversity of benthos has been significantly decreased. During 1959–2010, there were rapid alteration in fish community structure, the abundance of dominant species changed, and the diversity of fish species and species number density decreased.

The bottom DO in the Bohai Sea has been gradually decreasing since 1978. In terms of seasonal distribution, DO concentrations in the Bohai Sea are at a high level (~ 10 mg/L) in April and gradually decrease, to a minimum in summer, showing a seasonal hypoxia process. In general, the Bohai Sea hypoxia zone is still at a preliminary stage of development, and relevant studies are still scarce, especially for ecosystem impacts.

(2) Baltic Sea

The comprehensive assessment of eutrophication in the Baltic Sea from 2011 to 2016 shows that 97% of the sea areas were still affected by eutrophication in varying degrees, although the eutrophication in the Baltic Sea has improved. The nutrient level in the evaluation was the furthest from Good Environment Status (GES), meaning that it had the greatest impact on the comprehensive assessment results. Nutrient levels directly affected all aspects of the Marine ecosystem. The massive inputs of N and P promoted the algae growth. The massive growth of algae intensifies the water eutrophication, and the increase in the intensity and frequency of algal blooms usually leads to the decrease in the transparency of the water and the increase in the sinking organic matter. Long-term studies have shown that the transparency of water bodies in most sub open seas of Baltic Sea has been fluctuating or deteriorating continuously in recent decades, especially in the northeastern sub open sea areas. Only a few sub open seas have seen improvements in transparency. However, the reduction of nutrients inputs to the Baltic Sea is difficult to see the corresponding improvement of eutrophication in a short period of time. That is, the response has a lag.

The development of hypoxia processes in the Baltic Sea over the last 100 years has been unprecedented, with the hypoxia area growing rapidly from about 5000 km^2 to more than 80,000 km^2, an increase of more than 10 times, making the Baltic Sea the largest offshore hypoxia area in the world. The process of hypoxia in the Baltic Sea is influenced by multiple effects of physical processes, climate change and anthropogenic processes, in recent times, excessive nutrient input due to anthropogenic activities is the main factor contributing to hypoxia in the Baltic Sea. By the 1980s, anthropogenic inputs of nitrogen and phosphorus to the Baltic Sea had increased four fold and eight fold respectively. Overall, changes in the size of the Baltic Sea hypoxia zone lagged by 2 years compared to changes in DIN/DIP. The coupling between oxygen depletion processes and nitrogen and phosphorus biogeochemical processes in the Baltic Sea determines the above-mentioned distributional relationships. Overall, hypoxia has had a serious negative impact on the Baltic Sea ecosystem, including a reduction in fisheries resources, weakened nutrient removal and an intensification of the algal growth.

3.3.1.4 Mitigation Actions on Coastal Eutrophication

(1) Baltic Sea

The governance of the Baltic Sea is a multi-level control system, including global conventions (such as the Convention on biological diversity), regional conventions and organizations (such as the Helsinki Convention), the European Union, relevant national and local authorities, non-governmental organizations and the public society.

In 1974, the Baltic States acceded to the Convention for the Protection of the Baltic Marine Environment. In 2007, HELCOM launched the Baltic action plan (BSAP), which incorporates up-to-date scientific knowledge and innovative approaches to management into the enforcement of management policy and promotes the construction of target oriented multilateral cooperation models for Baltic coastal countries. Adaptation management is one of the important working principles of HELCOM.

From 2008 to 2013, HELCOM dynamically updated and improved the nutrient emission reduction plan. The European Union attaches great importance to the issue of eutrophication in the offshore waters. Several regional seas conventions contain the contents of mitigating coastal eutrophication. Overall, the Baltic Sea reversed the growth trend in nutrient input earlier than areas such as the Black Sea and Great Barrier Reefs due to proper controls.

The Baltic Sea has gained many advanced experiences in eutrophication control, including: (1) strengthening policy formulation and effective implementation of cross-regional and cross-government policies; (2) improving the management of eutrophication. Early monitoring of long time series is very important for identifying and understanding problems, formulating and implementing management policies; (3) Solve easy-to-handle problems first, which can usually lead to significant improvement in environmental conditions, for example, reducing and controlling point source pollution first; (4) Global and regional changes increasingly threaten initial gains, requiring the revision of appropriate management measures; (5) Inclusive governance measures based on stakeholder and cross-sectoral collaboration are important to governance.

(2) Bohai Sea

In China, nutrients are usually controlled and treated as pollutants. At present, there is no special plan or treatment action for Bohai eutrophication. During the 10th Five-Year Plan period, in accordance with the overall arrangement of the state's environmental protection work, the local governments of three provinces and one city around the Bohai Sea and the relevant state departments carried out environmental protection work in the Bohai Sea in various aspects in accordance with the "Bohai blue sea action plan", "the 10th Five-Year Plan for the prevention and control of water pollution in the Liao River Basin" and "the 10th Five-Year Plan for the prevention and control of water pollution in the Hai River Basin" approved by the State Council, And achieved certain progress and results. However, although there is no obvious deterioration of water quality in the Bohai Sea, the situation is still not optimistic. From the perspective of pollutant indicators, although most of the water quality indicators meet the class II sea water quality standards, inorganic nitrogen, active phosphate and petroleum are over standard in varying degrees. The plan put forward the linkage of non-point source control and prevention, and established the land pollution source control and comprehensive treatment system. Emphasize comprehensive management of secondary watershed and agricultural non-point source control to effectively solve the difficult problem of continuous increase of nitrogen and phosphorus pollutants in the Bohai Sea. The main measures to promote the reduction of nutrient emission include: (1) focus on controlling rural non-point sources in offshore land areas. (2) we have to continue to reduce the total discharge of industrial pollution sources. (3) improve the operation efficiency of urban sewage treatment facilities.

In 2018, the Ministry of Ecology, the State Development and Reform Commission and the Ministry of Natural Resources jointly issued the Bohai Sea Comprehensive

Management Struggle Action Plan, aiming at ensuring that the Bohai Sea ecological environment will not deteriorate anymore and that three-year comprehensive management will be effective through scientific planning and multiple measures. One of the key tasks of the action plan is land source pollution control action, among which many measures contribute to alleviating eutrophication in the Bohai Sea, including: (1) pollution control of rivers entering the sea. (2) Rectification of pollution sources discharging directly to the sea. (3) Prevention and control of agricultural and rural pollution. (4) Prevention and control of urban domestic pollution. (5) Total control of discharge of water pollutants.

3.3.2 Ecological Environmental Problems and Policies of Marine Plastic Debris and Microplastics

3.3.2.1 Overview of Marine Plastic Debris and Microplastics

Marine plastic pollution has become a problem almost along with the large-scale production and application of plastics. In 2004, British scholars discovered the existence of plastics in their accumulated seawater samples for many years, and most of the plastic particles in the samples need to be observed with a microscope. Therefore, plastics of this type of size are defined as "microplastics". In 2008, international experts in related fields organized a seminar and they defined the upper size limit of microplastics as 5 mm. Since 2014, UNEP has proposed that marine plastic and microplastic pollution need urgent attention, research and response in five consecutive United Nations Environment Assembly sessions. At the G20 summit in June 2019, countries agreed on the "Blue Ocean Vision" in the "Osaka Declaration", promising to achieve zero discharge of marine plastic debris by 2050. In addition, the "United Nations Decade for Promoting the Sustainable Development of Marine Science" (2021–2030) has made marine plastic pollution one of the priority issues to be solved.

3.3.2.2 Distribution, Source and Fate of Marine Plastic Debris and Microplastic

(1) Distribution of marine plastic debris and microplastic

Plastic debris in the ocean accounts for 80% of all discarded solid waste. Eriksen [19] and Sebille [20] estimated based on models that there are around 15–51 trillion plastics debris floating in the ocean, weighing about 93–236 million tons. It was found that the average size of plastic debris in the ocean tends to be miniaturized, and the quantity of microplastics continues to increase. Isobe studied the long-term changes of the abundance for microplastics in the Pacific Ocean from 1957 to 2066 with a combination of numerical simulation and transoceanic surveys, and concluded that the weight of microplastics near the marine subtropical convergence zone will increase by about two times compared with the current status.

(2) Sources and pathway of marine plastic debris and microplastics

Marine plastic debris mainly comes from land sources and sea sources. Among them, the land-based source of plastic waste includes landfills, industrial sewage outlets, sewage treatment plants, coastal recreational area, agricultural plastic sheeting, shipping, and riverine input, atmospheric deposition through runoff and wind. Sea-based source input includes plastic waste discharged into the sea from activities such as fishing, aquaculture, and shipping. Marine plastic pollution from land-based sources accounts for about 80%, and the remaining 20% of plastic pollution is based on the ocean. Half of the latter comes from fishing boat operations, such as abandoned fishing nets, fishing lines, and boats. Coasts and rivers are important ways for plastic waste to enter the sea.

In terms of microplastics pollution, primary microplastic is an important source of marine microplastics. There are several ways of loss and release of primary microplastics worldwide: tires abrasion, synthetic textiles, marine coatings, road markings, personal care products, plastic microbeads, and urban dust. The release of secondary microplastics mainly comes from improper management of plastic waste. Secondary microplastics are broken into fragments due to physical and biochemical effects and enter the marine environment. With the continuous decomposition of large plastics, the content of secondary microplastics will gradually increase.

(3) Fate of marine plastic debris and microplastic

It was estimated that 8300 million metric tons (Mt) as of virgin plastics have been produced to 2015. As of 2015, approximately 6300 Mt of plastic waste had been generated, around 9% of which had been recycled, 12% was incinerated and 79% was accumulated in landfills or the natural environment. Today, the annual output of plastics has exceeded 300 million tons and is expected to exceed 1.5 billion tons by 2050. If current production and waste management trends continues, roughly 12,000 Mt of plastic waste will be in landfills or in the natural environment by 2050. The recent research shows that in the absence of any policy measures, the amount of improperly managed plastic waste will increase from 91 million tons in 2016 to 239 million tons in 2040; the amount of plastic waste generated in the next 20 years will be doubled. The amount of plastic waste leaking into the ocean will increase nearly three times and the total amount of plastic debris in the ocean will increase more than four times.

The fate of marine plastic debris and microplastic is still undergoing research. Plastic debris will be subjected to different forces in the marine environment and degrade at different rates. Marine plastic debris may float or sink in the water column, and eventually accumulate in the deep sea or tidal flat, and may occur in the food chain.

3.3.2.3 Current Measures to Reduce Marine Plastic Debris and Microplastics

(1) International actions to address marine plastic debris and microplastics

In order to reduce the generation of marine waste, we should first ensure that no solid waste enters the environment in the process of harmless treatment such as solid waste generation, collection, transfer, cleaning and transportation to incineration and sanitary landfill, put an end to improper disposal methods such as open landfill, and implement policies such as "waste classification", Let recyclable waste plastics enter the solid waste treatment system and be recycled. Building a "circular economy" of plastics is also an effective way to prevent plastic waste from entering the sea from the source.

Legal conventions related to marine waste management have been implemented as early as the 1950s. especially marine plastics debris, was highly concerned. In May 2019, Amendment to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was endorsed, several new categories of waste plastics are added to regulate their cross-border transportation and harmless treatment.

(2) Governance and addressing marine plastic debris in EU and China

EU

In 2015, the European Commission put forward the circular economy action plan (CEAP) and then adopted the new CEAP in 2020. The CEAP aims to promote the transition from linear economy to circular economy in Europe and realize the reuse of wastes. Plastics are listed as priority materials under the circular economy. In 2018, the EU issued the CEAP, including the plastic strategy, chemical waste management, port receiving waste management, key raw material management policies and the monitoring system of circular economy progress. The plan requires that all plastic packages on the EU market should be reused or recycled by 2030. Meanwhile, rubber tire friction dust, textile and paint are listed as plastics to be treated, which are important microplastic sources. Overall, the strategy aims to tackle plastic pollution at its sources such as avoiding leakage of plastics to the environment, reducing the emission of microplastics from products, litter from single-use plastic products, fishing activities and aquaculture. This will help to reduce the amount of plastic waste ending up in the seas and coasts.

At the same time, the EU has adopted a series of goals: 10 million tons of recycled plastics will be used in new products by 2025, the recycling rate of plastic packaging waste will reach 55% by 2030, and plastic beverage bottles will contain at least 30% recycled plastics by 2030. Specific EU policies focus on seven aspects including (1) Plastic Bags; (2) Single-use plastics; (3) Plastic waste shipments; (4) Packaging waste; (5) Microplastics; (6) Bio-based, biodegradable and compostable plastics; and (7) Global action on plastics. On May 31, 2021, the Committee adopted the guidelines on single-use plastic products, as well as the implementation decision on reporting on fishing gear, and plans to take effect the ban on certain disposable plastic products on July 3, 2021. In 2019, European Chemical Agency (ECHA) proposed a wide-ranging restriction on microplastics in products to avoid or reduce their release to the environment. This proposal is expected to prevent the release of 500,000 tonnes of microplastics over 20 years. Plastic pollution is a global problem that needs efforts worldwide. The EU is trying for a global agreement on plastics that addresses plastic pollution throughout the entire plastics life-cycle, in order to minimise the mismanagement of plastics and prevent plastic wastes from entering the environment.

China

China is one of the earlier countries to issue “plastic ban order” (Emergency Notice on Immediately Stopping the Production of Disposable Foam Plastic Tableware, 2001) and “plastic restriction order” (Notice of the General Office of the State Council on Restricting the Production, Sales and Use of Plastic Shopping Bags, 2007).

China has been active in cleaning up the blue ocean. Specifically, in terms of laws and policies, although there is no law to directly control marine garbage in China, the state has formulated a series of regulations, policies and measures for the prevention and control of plastic garbage pollution for a long time, and constantly supplemented and revised them. In recent years, the state has also successively issued environmental protection policies such as The Action Plan for Prevention and Treatment of Water Pollution (2015), The Action Plan for Prevention and Treatment of Soil Pollution (2016), River Chief System (2016). Some coastal cities have also carried out the pilot work of “Bay Chief System” (2017) to prevent garbage from directly entering the river or randomly stacking at the edge of the water body, and strengthen the garbage treatment of the water body and its shoreline. Timely remove the garbage and floating objects in the water body and properly handle them.

In 2018, the Ministry of Ecological Environment adopted the action plan for 2018–2020 on comprehensively implementing the implementation plan for the reform of solid waste import management system by banning the entry of foreign waste, which effectively controlled an important source of marine plastic debris in China. At the same time, since 2018, the Ministry of ecological environment has continuously carried out actions such as the Waste Removal Action of the Yangtze River Economic Belt and the Action Plan for Comprehensive Treatment of the Bohai Sea, and carried out comprehensive treatment of the garbage in the rivers and coastal waters of the Yangtze River and the Bohai Sea, so as to reduce the plastic garbage into the sea from the source.

On June 3, 2019, General Secretary Xi Jinping made important instructions on garbage sorting work, emphasizing “cultivating good habits of garbage sorting, making efforts to improve the living environment, and contributing to the sustainable development of green development”. On July 1, 2019, Shanghai municipal domestic waste management regulations were formally implemented, and the compulsory domestic waste classification action was first implemented, by November 2020, the domestic waste classification system has been basically completed, and zero landfill of primary domestic waste is basically realized in 2020. The total amount of dry waste incineration and wet waste resource utilization has increased from 10,250 tons per day in 2018 to 26,095 tons per day in 2020. So far, the overall effect has far exceeded expectations.

On October 30, 2019, the National Development and Reform Commission officially issued Industrial Structure Adjustment Guidance Catalogue (2019 edition), it is clear that the daily chemical products containing plastic microbeads will be banned from production by December 31, 2020, and banned from sale by December 31, 2022. On January 19, 2020, the National Development and Reform Commission and Ministry of Ecology and Environment issued the Opinions on Further Strengthening Plastic Pollution Treatment, prohibited or restricted from part of the plastic products production, sale and use, application alternatives and patterns (such as plastic products, biodegradable plastic bags and biodegradable plastic sheeting, etc.), to reduce the plastic products from the source. China will strengthen the control of plastic pollution in accordance with the idea of "banning one batch, replacing one batch and standardizing one batch".

In addition to policies, China has actively participated in international intergovernmental organizations, bilateral and multilateral activities to prevent and control marine plastic debris. With the help of these policies, the recycling rate of waste plastics in China has increased in the past few years and is at peak in the global recycling and treatment of waste plastics.

(3) Challenges in prevention and control of marine plastic debris

- Internationally, there is no legally joint action to deal with and reduce marine plastic debris. And the goal of reducing the amount of marine plastic debris has not been implemented;
- Different countries have different policies on environmental protection, industrial development and international trade;
- There are still many deficiencies in the current laws and regulations;
- The recycling and classification system of plastic debris in marine fishery, water transportation, coastal and underdeveloped areas is not well-developed;
- The recycling system of waste plastics is not well-developed;
- There are widespread global conflicts in the management of plastic waste because of the misunderstandings about the nature of degradable plastics still exist, and the lack of scientific assessment of the environmental impact; and
- Part of the public is lack of scientific understanding of the pollution of marine plastics and microplastics.

3.3.3 Sources, Distributions and Trend of Mercury Pollution in Marine Environment

3.3.3.1 Sources of Mercury in the Marine Environment

The mercury and mercury and mercuric compounds in the ocean come from natural and anthropogenic sources. National or continental boundaries do not restrict mercury discharge. When mercury is released into the air, it can travel thousands of miles for long-distance migration through air circulation. Most mercury will eventually enter the aquatic ecosystem in dry precipitation or rainfall and eventually merge into the ocean.

3.3.3.2 Mercury Pollution in Coastal Waters of China

(1) Atmosphere

At present, there are two main ways to study the atmospheric mercury in near shore area: one is the long-term observation, that is, the morphological study of fixed sampling points carried out in coastal areas and islands; the other is the short-term observation, that is, the morphological study of mobile sampling points carried out with marine scientific research vessels. The concentration of GEM in China's coastal air is higher than the background value of the northern hemisphere (1.5–1.7 ng/m^3), and the concentration of GEM in coastal areas was higher than that in islands and ships. Compared with the observations of other sea areas in the world, the research results in China are also significantly higher. Although the marine GEM is affected by anthropogenic emissions, the GOM and PBM in the marine atmosphere are affected by the relatively rapid speciation transformation and sedimentation rate, and there is no significant increase. Most coastal areas in China are economically developed areas, and anthropogenic emissions have a strong impact on the concentrations of GOM and PBM in the local atmosphere. Under the synergistic effect of local anthropogenic emissions and marine atmospheric background air mass, the concentrations of various forms of mercury in the coastal area are in the middle of the background values and the observations of inland cities.

(2) Seawater

Due to the low concentration of mercury in water, it is more difficult to detect various forms of mercury. Due to the limitation of many experimental conditions, there are relatively few studies on mercury concentration and speciation analysis in seawater in China. The average concentration of THg in surface seawater in the offshore area of China's marginal sea is about 1.2–1.7 ng/L. Compared with other sea areas in the world, this value is higher than THg concentration in open sea areas and open sea waters. However, it is slightly lower than that of the Gulf and seacoast, which are greatly affected by land-based emissions. From the morphological point of view, the average DEM concentration of surface seawater in China is 27.0–63.9 pg/L, accounting for 3–6% of THg. Compared with other sea areas in the world, this value is equivalent to other open sea areas and coastal areas in the world. The DEM concentrations in the surface waters of the Yellow Sea and the South China Sea also showed a seasonal trend, with high concentrations in the warm season and low concentrations in the cold season, the trend is similar to that of other sea areas in the world. The spatial distribution trend of DEM concentration is higher in offshore area and lower in offshore area, and the DEM concentration in offshore area is similar to that in other offshore areas in the world.

(3) Sediment

The study of mercury in surface sediments and sediment cores has become an effective means to reveal the source, migration and transformation of mercury in both spatial and temporal scales. The concentration (dry weight) of THg in China's coastal sediments is mostly in the range of background concentration (20–100 μg/kg). Most of the sampling points in the Pearl River Estuary (42/54) and one sampling points in the Bohai Sea (1/29) were significantly higher than the background value (> 100 μg/kg). Compared with other sea areas in the world, THg values of marine sediments in Europe, North America, Africa and Asia are significantly lower.

From the perspective of spatial distribution, the hot spots of THg enrichment are mainly distributed in the Yellow River Estuary of the Bohai Sea, the muddy area in the middle of the Yellow Sea, the muddy area of the Yangtze River Estuary and the lower reaches of the Pearl River Estuary in the East China Sea, and the lower reaches of the Pearl River Estuary in the South China Sea, This indicates that mercury in the coastal sediments of China is mainly concentrated in the muddy areas with high organic carbon content, and mainly comes from the input of coastal human activities. From the perspective of time trend, the overall performance shows an increasing trend from the bottom to the top of the core, especially near the top of the core, which indicates that the mercury input in China's coastal waters continues to increase, especially in recent decades.

The detection data of organic mercury in coastal sediments in China are relatively few, and the existing data show that the concentration of MMHg is mostly in the range of 0.1–3.2 μg/kg, only relatively high concentrations of MMHg (15 μg/kg) was found in several estuaries. In the future, it is necessary to strengthen the study of mercury speciation in sediments.

(4) Residue in organism tissue

Seafood has become an important source of human methylmercury exposure, which poses a potential threat to human health and needs special attention. From 2007 to 2012, 11 species of mollusks (including 9 bivalves and 2 snails) were collected from the Bohai Sea. The results showed that the concentration (dry weight) of THg and MMHg ranged from 27.2 to 461.1, which were lower than the limit of MMHg in seafood in China, which is 500 μg/kg. The concentrations of THg and MMHg in molluscs did not change significantly in this period; In terms of space, there are significant regional differences; In terms of species, the percentage of MMHg in snails (57.3–65.8%) was significantly higher than that of bivalves (21.1–49.5%). MMHg in low trophic molluscs showed biomagnification effect, while inorganic mercury mainly showed growth dilution effect.

Compared with the existing data in China, the concentrations of THg and MMHg in the Bohai Sea are close to those in the other three regions, but the reports about fish in the South China Sea show relatively higher concentrations of MMHg, as high as 1811 μg/kg. Compared with other sea areas in the world, THg concentration in fish in China is relatively low.

3.3.3.3 International (Marine) Mercury Pollution Monitoring

(1) The Global Mercury Observation System

Global Mercury Observation System (GMOS) aims to establish a global mercury observing system to study and model global mercury emission scenarios, both regionally and globally, with support from network facilities. The system supports the operation of the Mercury Convention by measuring atmospheric mercury in ambient air and precipitation samples, providing comparable monitoring data on mercury concentrations in air and marine ecosystems in the northern and southern hemispheres. GMOS monitors through field and satellite platforms, with network facilities providing real-time or recent data from participating observatories. Adopting a global monitoring approach, this project locates monitoring stations worldwide, covering areas with different elevations, various sea levels, and a variety of climates. By employing data from those sites, researchers can test atmospheric mercury models from a regional and global perspective to improve the understandings of global mercury migration, deposition and emissions, and provide a viable foundation for international policy-making and implementation. However, due to the limited data from GMOS, it is still challenging to provide more time trend information at present. There are still rooms in improving emission inventories and monitoring data, projections of future mercury observation and the cost-benefits.

(2) EU environmental quality standards and mercury monitoring in water bodies and edible fish

The EU Water Framework Directive requires monitoring mercury and other substances following the EU Environmental Quality Standards (EQS, Directive 2008/105/EC). EU members may choose to use biota such as fish, mollusks and crustaceans as appropriate indicators for monitoring. Per monitoring mercury contents in fish and controlling human exposure to mercury through eating, is part of the EU's strategy for eliminating the impacts of mercury pollution. EC's Regulation 1881/2006 sets an upper limit of 0.5 mg/kg for fish and 1.0 mg/kg for some large fish. In addition, the European Food Safety Authority (EFSA) assesses methylmercury and inorganic mercury in 2012, setting the acceptable intake at 1.6 μg/kg body weight and 4 μg/kg body weight.

(3) UK monitoring of mercury emissions from water bodies

The United Kingdom (UK) occupies the major part of the British Isles archipelago, surrounded by the sea and crisscrossed internal water system. When monitoring mercury pollution in water bodies, the UK distinguishes marine water from fresh water and the estuarine and coastal water and takes different monitoring methods.

One is mercury monitoring in territorial waters, The Clean Safe Seas Environmental Monitoring Programme (CSEMP), which has been in place in the UK since 1999, collects data on mercury concentration in fish, mussels and sediments in the brine system within the territorial waters (12 nautical miles) to reflect trends in mercury emissions [21]. However, the UK Environment Agency cautions that for monitoring data, significant effects of short-term conditions, such as storms and floods, may cause resuscitation of contaminated sediments, causing interference and over covering of data trends.

The second is mercury monitoring in freshwater, estuarine and coastal waters, Unlike mercury monitoring in territorial waters, the UK adopts the EU's EQS system for monitoring freshwater, estuarine and coastal waters.

(4) Mercury monitoring in Norway

In the Norwegian Action Plan for Reducing Mercury Releases (2010), the Climate and Pollution Agency is identified as the authority responsible for monitoring mercury concentration trends in the environment. The Agency is also responsible for revealing the causation and mechanisms of mercury runoff in the river basins and investigating the mercury concentrations in fish and food chains. Long-term mercury monitoring projects take a full ecological view of mercury, including monitoring mercury loads in marine organisms, analyzing time trends in biota, mercury inputs from rivers and industry, and data from North–South air monitoring stations. In addition, there are other periodic projects to sample and monitor mercury, such as a national lake sediment monitoring programme that includes measurements of mercury every ten years and measurements of mercury and other heavy metals in mosses every five years.

However, although a significant decline in mercury emissions is recorded in Norway, the monitoring data of mercury concentrations returned from the monitoring stations (1990–2008) is stable and does not show a decrease. Nonetheless, the mercury content in fish does not decrease compared with the 1990s but shows a trend of significant increase. The Norwegian environmental authorities attribute this to the long-distance transport of mercury in the atmosphere. In other words, the import of mercury pollution from outside Norway into the country through the atmospheric circulation system is more important than the production of mercury from Norway itself. However, due to the significant uncertainty in Marine mercury circulation and bioaccumulation, the actual causes are still in the blank area to be explored.

3.3.3.4 Nternational and EU Mercury Pollution Control Practices

(1) Mercury Convention and other international conventions

Later multilateral pollution controlling agreements and conventions cover some parts of mercury governance, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, including a mercury waste processing, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade containing mercury international trade issues, and the Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention, 2001) covering the methyl mercury issues. Those international agreements and treaties expand participants' scope, trying to respond to mercury pollution as a global or regional context. Nevertheless, given the characteristics of mercury pollution, they cannot cover the entire cycle of mercury's lifespan; therefore, they cannot effectively prevent and control the pollution. Under this background, UNEP promotes a new independent mercury convention, namely the Mercury Convention.

(2) Mercury pollution control in the EU

The EU has identified mercury pollution as a global risk since 2005 and launched the Community Strategy Concerning Mercury (Mercury Strategy, COM/2005/0020) and the corresponding Directives and Action Plan to strengthen the governance of mercury pollution through law and regulation. The mercury strategy is a comprehensive plan to address mercury use and polluting issues. The core segment of the strategy is its 20 action plans, aiming at reducing mercury emissions, cutting mercury supply and demand, and protect citizens from mercury exposure. The Mercury Strategy has made international cooperation a priority, and one of the most important developments has been the active negotiation of the multilateral mercury convention (i.e., the Mercury Convention) with UNDP. The EU has played a crucial part in promoting the negotiation process. The signing of the treaty and the formation of multilateral cooperation are also important achievements of the EU in their green diplomacy.

Although existing regulations and directives relating to mercury control had generally met the requirements of the Mercury Convention, the EU introduces further measures in 2017 to go beyond the treaty's requirements and strengthen the laws by adopting Regulation 852/2017 (replacing Regulation 1102/2008). This Regulation covers the entire life cycle of mercury, reinforcing and complementing previous environmental regulations. By implementing the Directives and Regulations mentioned above, the EU has tried to create a mercury-free economy and achieved encouraging results.

(3) Mercury pollution control in the UK

The UK has reduced mercury emissions by 88% since 1990 by putting restrictions on mercury use and discharge. This decline in emissions is linked to less use of coal and the prohibition of mercury cells in the production process in the chlorine-alkali industry. The UK has legally completed the Brexit in late 2020, but no new rules on mercury control are introduced at this reporting stage. The UK still employing those EU Directives and Regulations as their guiding rules and performs those EU provisions, keeping the same practices as the EU in manufacturing, trade, storage and reporting.

(4) Mercury pollution control in Norwegian

Although Norway is not an EU member, it shares a similar idea in mercury control and governance. Based on laws and regulations, public governance is the primary means in Norway to control and manage mercury pollution. Furthermore, Norway has set higher standards than the EU to minimize mercury use and emissions. Under the Agreement on the European Economic Area, Norway shares EU legislation on chemicals. Furthermore, in its own country, based on the Product Control Act (1976) and the Pollution Control Act (1983), Norway implements a licensing system as the primary policy instrument to deal with mercury pollution.

(5) Policy analysis of mercury pollution control

The EU and major non-EU countries, such as the UK and Norway, start the mercury control process earlier than other parts of the world. They establish a relatively perfect policy framework and achieve fairly positive results during the decade's practice, providing a valuable experience for other countries. It mainly includes the following aspects:

- European countries put emphasize combining global multilateral and domestic law and regulation-based governance;
- The mercury pollution control in Europe is based on strict policies, supplemented by market-based tools and soft policies; and
- In such a progressive policy framework, the European mercury strategy includes top-level design and emphasizes the need for collaboration among various local government authorities and the need for public participation.

It should be noted that although European countries are pioneers in mercury pollution control and leaders in international governance, there are also some lessons to be learned from the development of their governance process. It mainly includes the following aspects:

- Although the rapid decline in mercury pollution reflects the positive effects of active policy interventions by Europe, it is more a result of the relocation of a large number of polluting industries and manufacturing industries to less developed countries due to globalization. While strengthening mercury pollution standards, European countries have not solved the problem of 'pollution flight' well;
- The performance of monitoring in European countries needs to be improved; and
- The EU's mercury policy has not yet been linked to major global issues, such as climate change, which have a very close relationship. On the one hand, reducing

carbon emissions from high-carbon industries, such as coal-burning and oil, and rectifying mercury pollution have clear room for policy integration.

3.4 Policy Recommendations

Recommendation 1: Improve Fisheries Resource Study and Survey, Strengthen Science-Based Governance Systems

(1) Strengthening marine fishery resource assessment, natural capital accounting and management system optimization

Effective protection of China's marine ecological resources and fishery resources requires an understanding of their value and importance. First of all, China should give priority to the development of scientific research and tools related to the development of marine and fishery resources. Through marine resource surveys, the species diversity, population number and distribution of index species, breeding period, ecosystem connectivity, and habitat fragmentation should be ascertained. Furthermore, China should promote the standardization of scientific methods and technologies to provide a basis for the scientific delineation of protected areas and the design and implementation of protection management plans. China should also conduct baseline research on marine ecosystem value accounting, strengthen cooperation between provincial governments and research institutions, and identify the marine ecological hotspots with the highest natural capital to provide the strongest protection measures.

Second, China should focus on studying the nation's marine economic activities and development plans, understanding their dependence on and interrelationships with marine capital, and correctly assessing the impact of coastal development and various activities on marine natural capital. If conditions permit, it is also possible to conduct relevant research on the economic development of coastal communities to provide a scientific basis for the subsequent sustainable development of fishery and industrial transformation.

Third, in terms of marine natural capital management, China should strengthen high-level communication and cooperation between the central and provincial governments, collaboration between different administrative departments, and international exchanges and cooperation. Priorities should be given to the creation of marine national parks, build an effective ocean protected areas network system to increase marine protected areas and the protection of key species and habitats.

(2) Build and strengthen foundational research and management institutions for climate resilient fisheries

Climate change has clear impacts on the distribution and productivity of marine fisheries resources in China, as well as on the livelihoods of its fishers and coastal communities. We recommend that China strengthen its work related to climate change and fisheries in the following ways. First, policymakers should examine how marine resource management goals must adapt to changing ecosystem dynamics as climate changes. Climate change resilience should be built into marine management approaches, including funding and investment in necessary science to identify appropriate management benchmarks, monitor changes in species abundance and distributions over time, and develop forward looking policies to minimize risks under uncertainty. This should include a national climate-fisheries adaptation strategy, integrating climate adaptation to national and local fisheries planning, priotitizing fisheries and coastal communities in national climate adaptation initiatives, and developing both medium and long-term plans for fisheries to effectively respond to climate change. Second, China should strengthen the resilience of marine ecosystems by establishing effective fisheries management today, reducing cumulative stresses placed on marine ecosystems from both climate and non-climate stressors, planning for sea level rise impacts on coastal communities and habitats, and protecting and restoring diverse habitats that are critical for species likely to remain present in the region as well as those likely to move in. Third, China should seek opportunities to build and strengthen international institutions to ensure adequate authority to manage new fish stock distributions and inclusivity of affected countries. This requires collaboration and agreement on basic science concerning fish stocks, regional agreements on management goals for changing fish stock portfolios, establishing access and resource sharing agreements that adapt to changing conditions. Such collaboration will enhance China's capacity to adapt to climate change and its ability to participate in relevant international affairs.

(3) Advancing sustainable fishery development with nature-based solutions

Nature-based solutions restore the ecological environment with natural structure and strength, maintain the balance of the ecosystem, and reduce the cost of operation and maintenance. Therefore, in the process of promoting sustainable fisheries development, China can encourage nature-based solutions from many aspects, including exploring relevant scientific foundations and technologies, designing clear indicators, standards and management mechanisms, and large-scale application of pilot results, supporting the development of long-term and profitable business models, etc. When developing and designing nature-based solutions, we should also refer to relevant principles and standards that are already available internationally, and formulate implementation plans and management systems that comply with China. For example, China's implementation plan should improve climate response capabilities and ecosystem functions (climate change adaptation or mitigation, support for ecosystem functions, etc.); set achievable and measurable goals based on science;

reflect the nature and society synergies while protecting nature and balancing other social goals; design and implement with coastal communities and stakeholders to understand their most pressing challenges and establish joint responsibilities; ensure that project results can be quantified through strong monitoring, evaluation, and reporting framework, reflecting measurability and accountability.

(4) Strengthening the protection of fishery resources in coastal trawling-prohibited zone (TPZ)

Bottom trawling can create serious damage in marine ecosystems and can cause devastating effects on benthic organisms and ecological communities. It is the most unsustainable fishing method. In 1955, China issued an order on the prohibited fishing zone line of the Bohai Sea, the Yellow Sea, and the East China Sea. It stipulated that the prohibited fishing zone line should be composed of 17 base points. Since 1981, all locomotive bottom trawl nets are prohibited from entering the TPZ. However, despite being repeatedly banned, bottom trawling has yet not been eliminated in China's coastal waters (including those within the TPZ). According to "China Fishery Statistical Yearbook", nearly 50% of China's coastal fishing output comes from poorly selective trawling operations. Therefore, it is recommended that trawling operations should be prohibited in the TPZ, while the structure of coastal fishing operations should be adjusted to gradually reduce the amount of trawling, and increase the scale of angling and gillnet fishery to a reasonable level.

Recommendation 2: Standardize and Improve Management Approach, Strengthen the Protection of Fishery Resources

(1) Continuously improving the implementation of TAC policy in China

Based on the experience of the nine pilots of quota control in coastal provinces (cities), strengthening the single species resources survey and total allowable catch assessment of major economic species in China coastal oceans [22]. Explore ways to gradually expand the total catch control to all major economic species, such as small yellow croaker, striped bass, blue-spotted horse mackerel, mackerel, conger eel, *Collichthys lucidus*, and Pacific pleated squid. Explore a new model of TAC that is suitable for China's coastal multi-species fisheries, and improve the feasibility of full implementation of the TAC in China. Based on the pilot experience, improve the catch monitoring system of coastal fisheries by integrating the supervisory power of fishery, maritime affairs and market affairs administrations, to guarantee the orderly implementation of TAC. Finally, the central and local legislation of the TAC should be strengthened to provide legal guarantee for the smooth implementation of the system nationwide.

(2) Enhancing the sustainable management of China's fish supply chain

China's aquatic products market is characterized by a wide range of producers, a wide variety of products, and a variety of marketing channels. In order to achieve the whole process of protection and management from source to table, it is suggested that China should develop unified recognition standards as soon as possible, such as Fishery Improvement Program (FIP), Aquaculture Improvement Program (AIP), Sustainable Fishery, and Sustainable Aqualculture Standards. On the basis of extensive industry and market research, absorbing the parts of the existing international standards that can be used as reference, developing standards for the characteristics of different fish species for domestic sales and export sales, and eventually publishing and promoting the application of the standards by authoritative institutions, and developing regulatory measures for the new standards on the basis of the existing regulatory system to effectively guarantee a high quality implementation. On the other hand, the traceability management of Chinese aquatic products should also be increased. In this process, we should not only learn from international advanced experience, but also make use of platforms such as GDST for international benchmarking to promote sustainable development of the industry with traceability management.

(3) Scientific and standardized recreational fisheries management to promote the sustainable and healthy development of recreational fisheries

In recent years, with policies to reduce China's active fishing vessels and marine catch and relocate fishermen, while higher incomes among China's urban and rural residents alike are shifting preferences for culture, tourism, and leisure, China's recreational fisheries have developed rapidly and become a new highlight in the modern fishing economy. The growth in recreational fishing takes advantage of China's rural revitalization strategy. However, it reveals several problems, such as poor understanding of the industry and necessary management responses, an unsound management system without needed laws and regulations, and potential impacts on the natural environment. There is a need to strengthen management institutions by demonstrating the feasibility of TAC and area-based management systems in recreational fishing, implementing science-based and standardized management systems, strengthening monitoring, catch and effort reporting, and stock assessments, and increasing resource and environmental protections. Policymakers also should seek to cultivate the knowledge of recreational fishing practitioners, promote the sustainable development of recreational fisheries, and enable fishermen to obtain sustainable economic benefits while participating in protection of fishery resources.

(4) Exploring the fishery resource protection mode of community participation and joint management

In the past, the protection of fishery resources was mostly promoted through a top-down approach, which required high government resources and had limited management effectiveness. It is recommended to integrate community and social resources and explore a common management model for fishery resource protection. For example, give full play to the enthusiasm of the local community, organize training, publicity, and other activities to popularize in-depth knowledge of the ecological functions, environmental economic value, and other knowledge, obtain the recognition and support of the local residents, and guide the local residents to assist in ecological resources (such as the location of major fishing grounds, the distribution of important local natural resources, etc.) and cultural research, and carry out community-participated resource protection work through their production and life. Experience may be drawn from the river keeper model for public welfare litigation, for which citizen science helps protecting coastal areas and reporting violations. Another example is the introduction of local communities, enterprises, and fisheries organizations, in establishing protected area observer monitoring networks, encouraging local fishery practitioners to participate in monitoring and observation, gradually expanding the number of participants in protection work, improving the quality of protection personnel, and expanding protection projects from point to point, enlarge the scope of influence, strengthen the ecological environment supervision and management capabilities of marine protected areas, and achieve the goals of marine ecological environment and resource protection. On this basis, people with certain experience and willingness to support the work of protected areas and sustainable industrial transformation can be organized to form a network of leaders, enhancing the sense of belonging of local residents, and driving their support and participation in conservation work. In addition, under the premise of orderly management and environmental protection, it is necessary to cultivate the quality of recreational fisheries practitioners, promote the sustainable development of recreational fisheries, and enable fishermen to obtain sustainable economic benefits while participating in the protection of fishery resources.

(5) Promoting sustainable fishery development by green finance

At present, China has incorporated marine protection into the green financial system. For example, the Green Industry Catalog issued by the National Development and Reform Commission in 2019 has listed marine eco-friendly projects and technologies (seawater pollution control and marine ecosystem restoration) as key support objects. In the context of the rapid development of global green finance, China's sustainable fishery development also needs to use green finance tools to innovate models to provide more financial incentives for naturally active fishery projects. For example, develop fishery financial institutions, issuing special loans without a mortgage for sustainable fishery production, or subsidizing fishery loan interest from financial institutions; establishing a fishery guarantee insurance system to solve the problem of insufficient guarantees for fishery producers' loans; strengthen financial institutions reputational risk supervision, by reminding them of potential reputational risks that may be caused by illegal fisheries and providing technical guidelines; learn from international protection experiences, using innovative mechanisms to absorb social capital into sustainable ocean projects, promote green financial tools, and expand funding sources.

Recommendation 3: Establish and Improve the Marine Environmental Protection Pattern, Promote the Formation of a Joint Prevention and Control Mechanism for Ecological Environmental Protection in Watersheds—Estuaries—Nearshore Waters

Establish a sound marine environmental protection pattern. To deepen the organization and implementation of the fight against pollution as an opportunity to further improve the central coordination, provincial responsibility, cities and counties to implement the marine ecological environmental protection mechanism, clearly refine the division of powers between the central and local, departments and departments, the clear implementation of the main responsibility of the coastal local party committees and governments and industry departments in charge of the permanent supervision of the responsibility, speed up the establishment of a comprehensive coordination mechanism of departmental coordination, and further improve the joint management, each responsible for the big environmental protection pattern, the full implementation of the marine ecological environmental protection target responsibility system and assessment system, and effective interface with the central ecological environmental protection inspectors.

Build a watershed-estuary-nearshore sea pollution prevention and control linkage mechanism. The Ministry of Ecology and Environment, the Bureau of watershed and marine areas, provincial ecological and environmental departments and other industries and fields in charge of the functions, in accordance with the principle of land and sea integration, to explore the establishment of coastal, watershed and marine areas in concert with the integrated management system, to promote estuaries, watersheds, nearshore marine environmental management of the integrated interface, to promote the formation of watersheds-estuaries-nearshore marine ecological environmental protection joint prevention and control mechanism. The implementation of the "14th Five-Year Plan" on the comprehensive management of key sea areas, to further focus on the key, and make great efforts to solve the outstanding environmental problems and institutional shortcomings of key bays and estuaries.

Recommendation 4: Promote the Synergy Between Marine Pollution Reduction, Climate Change, and Improve the Quality of Marine Ecosystem

Promote the synergy between marine pollution reduction and climate change. Strengthen the integrated management of land and sea pollution, further reduce the nitrogen and phosphorus pollutants from rivers into the sea, continuously reduce the eutrophication level of the coastal waters, alleviate the ecological deterioration under climate change, including marine acidification, hypoxia, red tide and green tide. Improve the quality and stability of marine ecosystems and their resilience in adapting to climate change.

Promote multi-sectoral linkage and integrated management of oxygen-deficient areas. The Ministry of Ecology and Environment will take the lead and set up a joint working group with the Ministry of Rural Affairs and Agriculture, the Ministry of Water Resources, the Ministry of Natural Resources, the Ministry of Science and Technology and other ministries and local governments to explore the introduction of a national action plan, gradually improve the institutional system, and combine the revision of laws and regulations to supplement the comprehensive control and management of oxygen-deficient areas to ensure that the comprehensive management of oxygen-deficient areas achieves long-term effectiveness. Integrate the reduction of pollutants and the comprehensive management of oxygen deficiency zones, and make the comprehensive management of oxygen deficiency zones one of the work objectives in the 14th Five-Year Plan to fight the battle of pollution prevention and control. Strengthen the integration of land and sea, as one to promote land-based emissions, mariculture, agricultural sources, atmospheric deposition and other ways of pollutant emissions reduction. Consider the negative feedback effect of climate change on pollutant emission reduction and oxygen deficiency zone management, strengthen the synergistic effect of pollution reduction and disaster prevention and climate resilience improvement.

Strengthen the protection and restoration of coastal ecosystems. Promote the synergy between marine and coastal zone ecological protection and restoration and adaptation to climate change, incorporate climate adaptation goals into marine ecological environmental protection planning; promote the construction of marine ecological reserves, implement a regulatory system for marine ecological protection red lines, carry out monitoring and evaluation of the effectiveness of protection and adaptation of coastal climate fragile ecosystems such as mangroves, sea grass beds, salt marshes, coral reefs, sand dunes and islands; carry out coastal ecosystem restoration and enhance the capacity of wetlands for water purification, carbon sequestration and sink, etc., improve the quality, stability and climate resilience of marine ecosystems.

Recommendation 5: Improve the Ecological Environment Monitoring System, Strengthen the Source of Control

Improve the integration of land and sea ecological and environmental monitoring system. In accordance with the principle of land-sea integration and unified layout, optimize the construction of a full-coverage, refined marine ecological environment monitoring network, strengthen grid monitoring and dynamic real-time surveillance monitoring, online real-time monitoring of the main rivers into the sea, land-based sources into the sea outfalls, etc., to provide data support for the source control of marine pollution.

Strengthen the analysis and monitoring of mercury pollutants and traceability capacity building. It is recommended to accelerate the development of monitoring methods for the morphological analysis of mercury in the marine environment, promote the development and application of relevant standard substances, and build a perfect system of standards for the morphological analysis and evaluation of mercury; strengthen training on relevant analytical techniques and quality control technologies, enhance the capacity building of morphological analysis in operational monitoring institutions. Build a full-source database including the list and isotope "fingerprint spectrum" of relevant mercury emission point sources around China's offshore area, improve the ability of fine traceability, build a control system of pollution sources and their entry routes to the sea.

Strengthen the source control of marine plastic pollution and microplastics, improve waste management and disposal capacity. Strengthen technological innovation, improve the capacity of plastic waste reduction, harmless and resource disposal, accelerate the construction of waste recycling and management infrastructure; develop a comprehensive action plan for the prevention and control of marine litter and marine microplastics pollution at the national level, build a "source and sink" double interception of marine plastic litter control and prevention mechanism from the source, prevent plastic garbage from land-based sources from entering the sea. Efforts will be made to move forward with the pilot project to achieve zero plastic discharge in coastal areas, with upstream/downstream coordination, waste recycling infrastructure, and public awareness campaign; link zero plastic goals to broader carbon neutrality target.

Recommendation 6: Establish and Improve the Joint Scientific and Technological Research Mechanism to Enhance the Scientific Knowledge of Marine Pollution Problems

Establish and improve the joint science and technology research mechanism. Strengthen the major national science and technology projects on key sea areas to fight the battle of pollution prevention and control of science and technology support role. Marine-related universities, institutes jointly carry out scientific and technological research to accelerate the solution of bottleneck technology and difficult issues. Strengthen marine pollution regulation and governance theory and applied technology research, increase investment in the arranging of talent teams and capacity building, actively promote the transfer of scientific and technological achievements and pilot demonstrations, focus on solving and tackling marine pollution management and protection of major issues and technical difficulties. Strengthen the application of scientific and technological innovation and the transformation of results to enhance the modernization of marine ecological and environmental governance capabilities.

Strengthen the scientific and technological support for marine pollutant control. Conduct research on key technologies and major issues such as pollution source analysis in near shore waters, total nitrogen reduction in watersheds, water quality evaluation in estuaries, and protection of key marine species, response to climate change, and marine ecological protection and restoration. Based on the three-dimensional monitoring data of mercury and plastics/microplastics in different environmental media, we will carry out research on the transport paths and environmental behavior of typical and new pollutants such as mercury, plastics/microplastics, assess the impact of pollutants and their transformation products on marine ecosystems, and improve the scientific knowledge of mercury and plastics/microplastics pollution.

Regularly implement special surveys of marine pollutant baselines. Through regular special surveys, identify the types, levels and distribution of pollutants in China's marine environment, identify the bottom line, assess the effectiveness of marine pollution control, prepare and regularly update the priority control list of new marine pollutants, optimize and improve the marine environmental quality monitoring network.

Recommendation 7: Enrich the Development of Global Marine Public Goods and Participate Deeply in Global Marine Environmental Governance

Promote China's governance experience and strive to provide global public goods. Benchmark the international level of marine ecological and environmental governance in the Great Bay, build the Guangdong-Hong Kong-Macao Greater Bay Area into a pioneering demonstration area for the protection and construction of "beautiful bays", show the world the successful cases of China's comprehensive marine ecological and environmental governance and green and high-quality development in the region, and take the lead in promoting China's marine ecological and environmental management experience in regions along the "Silk Road" and the Beibu Gulf region. We will make the enrichment and development of global public goods an important strategic goal of China's marine ecological and environmental protection work in the 14th Five-Year Plan and even in the future period, and realize the profound transformation from expanding from the jurisdictional waters to the global oceans, and from concentrating on solving our own problems to deeply participating in global marine environmental governance. We will also actively explore the provision of global public goods in key areas such as marine litter and microplastic management, ocean hypoxia and acidification, polar environment and climate change.

Promote the development of the global marine environmental governance system toward a more just and reasonable direction. Under the guidance of the concept of marine community of destiny, we will deeply participate in global marine environmental governance actions and enhance our ability to comply with international conventions. Make full use of the UN General Assembly, the United Nations Environment Assembly, the Conference of Signatories to United Nations Convention on the Law of the Sea, the Informal Consultative Process on the Law of the

Sea and other platforms to put forward China's proposal foe win–win cooperation, lead the direction of the development of global marine environmental governance rules. It has promoted the building of the Blue Partnership, active participation in the international governance of the polar regions, and the promotion of marine cooperation with European countries. In the South China Sea, promote cooperation in the marine field to address climate change, marine plastic debris and other low-sensitive areas, form a benign pattern driven by overall cooperation and bilateral cooperation with sustained and tenacious efforts. Organize a high-end summit on marine ecological and environmental protection, actively play the role of home diplomacy, contribute China's wisdom, propose Chinese solutions, and demonstrate our image as a responsible power and show our responsibility.

3.5 Future Ocean Research Roadmap for CCICED

3.5.1 Ocean in the Framework of the CCICED

The SPS for Ocean Governance and Ecological Civilization, in its first phase (2017–2020), focused its efforts on the central theme and concept of an integrated ecosystem-based marine management. In the context of this work the SPS initiated work on a number of interlinked and relevant issues: integrated ocean management, marine living resources and biodiversity, marine pollution (plastics in particular), green maritime operations, renewable energy systems and mineral resource extraction. Climate change, technology, ocean economy, and gender issues were a common thread through the various themes.

The work of the SPS clearly demonstrated that now is the time for China and the world at large to ensure that the ocean environment plays a critical role in the national and international efforts toward developing an ecological civilization and securing our own future. **It also identified that there is a continued need to focus on ocean governance issues and, in particular, to further explore into specific issues to provide a clear path forward**.

3.5.2 International Framing of Future CCICED Ocean Efforts

Over a period now there has been a rising societal awareness and understanding of the overarching global importance of the ocean system as basis for civilization. As a result, there have been and continues to be several key global efforts and initiatives which provides a clear framework for both global, regional and national efforts. These processes could and should provide a solid basis for policy recommendations framing national and international ocean actions and engagement by China. While there are many relevant ongoing overarching and all-encompassing ocean undertakings, three key initiatives are highlighted here, noting their relevance in guiding development of future ocean policies.

The **UN Sustainable Development Goals** [23] are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals. SDG 14 aims to sustainably manage and protect marine and coastal ecosystems from pollution, as well as address the impacts of ocean acidification. Enhancing conservation and the sustainable use of ocean-based resources through international law is also aimed to help mitigate some of the challenges facing the global oceans.

The **High Level Panel for a Sustainable Ocean Economy** [24], a unique group of world leaders from around the globe, delivered its report at the end of 2020, putting forth a transformative set of recommendations and actions to advance a sustainable ocean economy, prioritizing a healthy ocean alongside sustainable production to benefit people everywhere. The Panel emphasized that sound management of marine resources will allow the oceans to sustainably yield greater benefits for society, but also noted that while investments in protection of the marine environment and the development of ocean industries often have significant economic benefits; it will require incentives and a good framework. The report identifies five key areas of transformation:

- **Ocean Wealth**, stressing the need to ensure that the ocean can continue to sustainably produce food, energy, tourism, transport and others for future generations.
- **Ocean Health**, underscoring that the global community must act urgently to restore and protect coastal and marine ecosystems, reduce pollution and take a precautionary approach to economic activity on the ocean floor.
- **Ocean Equity**, where a sustainable ocean economy puts people at its centre, facilitates the equitable distribution of ocean wealth and ensures equality of opportunity for all.
- **Ocean Knowledge**, in which it is it stressed that we need to build literacy and skills, and share and apply knowledge of how ocean ecosystems work, and how they respond to stressors to inform decision-making and to guide the sustainable development of ocean industries.
- **Ocean Finance**, ensuring that access to finance is equitable and supports sustainability, recognising the needs of developing countries, and noting that public sector finance can help unlock private sector financing.

The **UN Decade of Ocean Science for Sustainable Development 2021–2030** [25] (the Ocean Decade), fundamental for reaching the SDG 14, aims to provide an international framework for continued focus on research and innovation in ensuring better use of the oceans and ocean resources. The UN General Assembly mandated UNESCO's Intergovernmental Oceanographic Commission (IOC—UNESCO) to coordinate the preparations and implementation of the Ocean Decade, procuring the following societal benefits:

- **A clean Ocean** whereby sources of pollution are identified, quantified and reduced, and pollutants removed from the Ocean;
- **A healthy and resilient Ocean** whereby marine ecosystems are mapped and protected, multiple impacts (including climate change) are measured and reduced, and provision of ocean ecosystem services is maintained;
- **A predicted Ocean** whereby society has the capacity to understand current and future ocean conditions, forecast their change and impact on human wellbeing and livelihoods;
- **A safe Ocean** whereby human communities are protected from ocean hazards and where safety of operations at sea and on the coast is ensured;
- **A sustainably harvested and productive Ocean** ensuring the provision of food supply and alternative livelihoods;
- **A transparent and accessible Ocean** whereby all nations, stakeholders and citizens have access to Ocean data and information, technologies, and have the capacities to inform their decisions;
- **An inspiring and engaging ocean** where society understands and values the ocean.

3.5.3 Identifying and Prioritizing Ocean Issues for the Future

The SPS for Ocean Governance and Ecological Civilization, in the first phase (2019–2020) of its work addressed several key aspects and provided a suite of policy recommendations in key areas. The SPS also emphasized that ocean studies need to continue within the framework of CCICED to fully reflect the importance of the ocean to society, and in particular, to China's national strategy of vitalizing blue economy and reaching carbon neutrality.

Subsequently, in the short time-span of its second phase (2021?) during the COVID-19 pandemic the Ocean SPS has focused on the two most pressing issues that have the greatest impact on the coastal marine ecosystems in China, namely Loss of Marine Living Resource and Biodiversity from Overfishing, and Marine Pollution. In addition, the Ocean SPS also developed a seamap for "ocean into the future"—in essence pointing out directions for the CCICED to focus its work in areas where China should pay special attention with regard to ocean issues in the future. As part of this effort the SPS team engaged with stake holders through a suite of scoping and dialogue meetings, where relevant experts from other CCICED SPSs and externally have been invited to discuss and suggest what and how ocean issues can and should be taken further in the next five-year period of CCICED.

3.5.4 Seamap for the Ocean Future

The Seamap for Future Ocean Work in the CCICED has been organised around the 7 societal needs identified as the motivation for the Ocean Decade, preluded by an identification of ocean actions may contribute to select key overarching policy areas in the current priorities of the Chinese government. **The list of topics included under the various policy areas is not exhaustive, but rather reflects topics that have been flagged during discussions with various stakeholders. The descriptions provided for the different topics are neither comprehensive nor detailed, but are rather provided to give an indication of potential directions for future policy relevant discussions**.

3.5.4.1 Ocean Contributing to Key Overarching Policy Areas

POLICY AREA 1: Policy Actions Utilizing Ocean's Role as Tool for Carbon Neutrality Goal

The ocean plays a fundamental role in mitigating climate change by serving as a major heat and carbon sink. Coastal ecosystems like mangroves, salt marshes, seagrass beds and tidal flats play a vital role in carbon storage and sequestration. Per unit of area, they sequester carbon faster and far more efficiently than terrestrial forests. These ecosystems are also vitally important to coastal and island communities around the world through the many important ecosystem services they provide. Developing active policy actions utilizing this knowledge will be an important contribution towards reaching China's aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. To this end it will also be important to educate the public and raise awareness about the ocean's role as a tool for the carbon neutrality goal.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Climate*, *SPS Green Technology*.

POLICY AREA 2: Policy Actions Utilizing Ocean's Role as Climate Regulator

Looking to *quantify* the effect of measures' contribution to Paris agreement could be a useful contribution to lay the foundation for future policy actions, for example looking at the effects of specific Marine Protected Areas (MPA) as case studies. For this purpose, it could be relevant to use the approach taken by the High Level

Panel for a Sustainable Ocean Economy in their report *The Ocean as a Solution to Climate Change: Five Opportunities for Action* [26] as a starting point for similar approach in selected MPAs in China. The five opportunities in this case being ocean-based renewable energy (primarily wind); ocean-based transport ("green shipping"); coastal and marine ecosystems; fisheries, aquaculture and dietary shifts (from meat to seafood); and carbon storage in seabed.

In conducting such a case-study, it could be relevant to consider what and how the five identified opportunities above can be implemented domestically and how this can give China an opportunity to help with equity in developing countries.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Climate*, *SPS Green Technology, SPS Biodiversity*.

3.5.4.2 A Clean Ocean

Coastal marine pollution is one of the main environmental challenges of recent decades, so its prevention and control is a key objective. Even though the oceans are vast and seemingly able to digest any amount of input, the cumulative effect of various types of pollution has tangible effects on the marine environment. The most challenging ocean pollutants include agricultural fertilizers; untreated waste water; invasive species; and micro- and macro-plastics. The relationship between upstream pressures and downstream effects highlights the importance of coordinating efforts on the management of freshwater and oceans. A "Source to Sea Approach" is crucial to addressing land-based activities and pollution.

POLICY AREA 3: Policy Actions to Reduce Terrestrial Transportation of Pollutants to the Sea—Connecting Land, River and Ocean Management to Support a Clean Ocean

Over the past two centuries, with the increase of global population, human needs are also increasing, in order to meet the requirements of necessities of life, industry and agriculture are developing rapidly, and a large number of industrial, agricultural wastes and domestic garbage are discharged into the environment. Although production and emissions are largely land-based, the marine environment is the ultimate recipient of man-made pollution. In addition to the well-known problem of eutrophication caused by excessive input of terrestrial nutrients, the growing global pollution of plastics is another example of this land sea interaction.

Developing active policy actions to counter these ocean related challenges will be important to safeguard both human health and ocean health.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS River-basin*, *SPS Green Urbanization, SPS Green transformation.*

POLICY AREA 4: Global Control of Plastic and Micro-plastic Pollution

Micro- and nanoplastics are persistent in the marine ecosystem and due to their micron sized particle nature; these fragments are mistaken as food and ingested by a range of marine biota and ultimately get transferred to higher tropic levels. At the same time, a large number of studies have shown that marine plastic and microplastic pollution directly or indirectly affects the safety of marine biodiversity, fisheries resources, tourism and shipping. Marine litter and microplastic pollution have become one of the world's high-level environmental issues with far-reaching impact. It involves the management of the marine ecological environment, as well as the economic behavior of terrestrial plastics and waste management. Marine litter and microplastics not only come from land-based waste management systems and riverine input, but also come from a wide range of marine sources include discarded fishing gear, mariculture, and surreptitious discharge at sea.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS River-basin*, *SPS Green Urbanization, SPS Green transformation.*

POLICY AREA 5: Policy Actions to Combat Accumulation of Legacy Infrastructure and Ghost Gear

Decommissioned and abandoned oil and gas infrastructure (legacy infrastructure) can pose threats to local environment, as can other upcoming ocean infrastructures such as windfarms, seabed mining etc. Strong regulatory foundation for end-of-life handling of such infrastructure is required to minimize impacts on the ocean environment and ecosystems. Derelict fishing gear ("ghost gear") is any discarded, lost, or abandoned, fishing gear in the marine environment. This gear continues to fish and trap animals, entangle and potentially kill marine life and smother habitat. Derelict fishing gear is one of the main types of debris impacting the marine environment today. Developing active policy actions to minimize potential negative impacts of legacy activities on the ocean environment will be important.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Green Finance, SPS BRI*.

3.5.4.3 A Healthy and Resilient Ocean

For oceans, seas and marine resources to successfully contribute to human well-being, ecosystem integrity, with properly functioning biogeochemical and physical processes, is required. Marine ecosystem degradation has greatly accelerated during the last five decades due to the multitude of stressors affecting the ocean. All nations will benefit in a healthy and resilient ocean and by preserving its capacity to deliver food, income, support transportation and many other elements of sustainable development.

POLICY AREA 6: Policy Actions Promoting a Blue Economy Supporting a Healthy Ocean

Both ships and ports contribute heavily to CO_2 emissions and to the larger climate issue, while they also add on additional pollution challenges. Pollution from ships and platforms include release of oil, fuel, plastic, and human waste. Ships also cause noise pollution, disrupting the balance of life for marine animals. The fisheries have the potential to impact the marine environment in several ways in addition to pollution, including overfishing, habitat destruction and by-catch. Both shipping and the fishery industry have the potential to be pathways for the introduction of non-native species. Ports contribute to local water pollution, including widespread contamination of sediments. The emerging seabed mining industry has the potential to become a major source of pollution. Sulfide deposits created when these substances are drilled can have environmental impacts that are not fully understood. Material leaks and corrosion of equipment only exacerbate the problem.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Green Technology, SPS BRI, SPS Green Finance.*

POLICY AREA 7: Policy Actions Safeguarding the Ocean's Continued/Growing Role as Major Source of Food

The ocean plays an important role in global food provision and has the potential to play a much more significant role. The potential for increased production and consumption of food from the sea will depend on physical factors, policy, technology and institutions. Ocean, climate and biodiversity are connected issues where core issue is food,—the one issue cannot be seen independent of the others. Opportunities lie in promoting policies that take these aspects into account both nationally and internationally. It seems particularly relevant to consider how one within this policy area could look at opportunities to build policies that would encourage safeguarding the ocean's food value in the context of investment initiatives in the international sphere, such as along the Ocean BRI.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Biodiversity.*

POLICY AREA 8: Policy Actions to Enhance and Build the Foundation for Integrated Approach to Ocean Management

Integrated Ocean Management (IOM) is considered an appropriate approach for ensuring protection and the sustainable use of coasts and oceans, taking sufficiently into account knowledge and the particularities of the ecosystems to be managed. A fully integrated ocean management strikes the balance between environment, economy and society, and between short-term economic gains and long-term prosperity of the ecosystem services.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Biodiversity, SPS River-basin.*

POLICY AREA 9: Policy Actions to Contribute to a Sustained and Healthy Global Ocean System into the Future

While there is general agreement in international policy that an ecosystem approach is needed to improve ocean governance, its application in practice is still limited. This is due in large part to the considerable practical difficulties of implementation, including the availability of suitable.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS BRI*.

POLICY AREA 10: Policy Actions Looking at How to Account for the Value of a Healthy Ocean

The ocean and coastal ecosystems are extremely important in terms of ecosystem services and economic values. Accounting for these values is one approach to tally the costs and savings associated with decisions we take that affect ocean health. There is a need to balance a number of components, such as market and non-market values, living and non-living resources and uses now and in the future.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Green Finance, SPS Green Supply Chain.*

3.5.4.4 A Predicted Ocean

Understanding the relationships between the ocean systems and human activities that take place in or impact on it, giving us a better foundation for predicting its future provide important knowledge to inform decisions and actions that shape ocean sustainability. Sustained ocean observations are vital to enable a predicted ocean. New technologies are required to enable ocean observation under various ocean environment such as the deep ocean and the ice zone. Such information is increasingly needed by nations and the ocean business community operating within or beyond national jurisdictions.

POLICY AREA 11: Policy Actions to Maintain/Increase China's Contribution to Ocean Knowledge Supporting Ocean Management

The vast volume of the ocean and its complex coastlines are neither fully observed nor adequately understood. In particular, the deep sea is a frontier of ocean sciences. Sustained and systematic ocean observations are needed to document ocean change, initialize ocean system models and provide critical information for improved ocean understanding and through this the basis for managing the ocean for the future.

3.5.4.5 A Safe Ocean

The rush for coastal recreation and economic expansion in the maritime domain has increased access to the sea to a multitude of users, producing newly built infrastructures that are increasingly vulnerable to ocean extreme events. Some of the hazards include movement of barrier islands, sea level rise, hurricanes, storms, earthquakes, flooding, erosion, pollution and human development along the coast. They can have lasting and damaging effects on the coastal landscape, causing long-term coastal erosion, and on marine ecosystems. There is a pressing need to focus on implementing adaptation measures to strengthen the resilience of vulnerable coastal communities, their infrastructure and service-providing ecosystems.

POLICY AREA 12: Policy Actions to Reduce Ocean Hazards

Reducing the risks from tsunamis, storm surges, harmful algal blooms and other coastal hazards need to focus on implementing adaptation measures to strengthen the resilience of vulnerable coastal communities, their infrastructure and service-providing ecosystems.

3.5.4.6 A Sustainably Harvested and Productive Ocean

The ocean is a vital source of nourishment, supporting directly the livelihood of about 500 million people. Ocean economies are among the most rapidly growing and promising in the world, providing benefits to many sectors of great economic value, such as fisheries, biotechnologies, energy production, tourism and transport, and many others. Safe and sustainable economic operations in the ocean will help policymakers and stakeholders in implementing a truly sustainable blue economy.

POLICY AREA 13: Policy Actions to Build Sustainability in the Domestic and Distant Water Fisheries

Overfishing results in the decrease of biodiversity. Decline of top biological communities (e.g., fish) results in an ecological degradation. Healthy fishery resources will be an important indicator for the health of marine ecosystems, and the conditions supporting the healthy structure of fishery resources include moderate fishing intensity, good larval and juvenile habitats etc. In China, ecosystem-based fisheries management has appeared in a series of systems and measures, such as the summer moratorium, "dual control" of the number and power of fishing boats, enhancement release, sea ranch construction, "zero growth" in marine catch fisheries and "total output control", as well as the construction of aquatic genetic resources reserves, etc.

The following CCICED Special Policy Studies are particularly relevant in the context of this policy area: *SPS Green Finance, SPS Green Supply Chain, SPS Climate.*

3.5.4.7 A Transparent and Accessible Ocean

A healthy, safe, sustainable ocean very much depends on global capacity building and resource-sharing between countries. There is an enormous need for more ocean information at the scientific, governmental, private sectors, and public levels. New technologies and the digital revolution are transforming the ocean sciences.

POLICY AREA 14: Policy Actions to Promote Data Access and Use

Data and information play an essential role in connecting knowledge generators and end users, but many challenges and disparities still exist in the access, sharing and use of ocean data across regions.

3.5.4.8 An Inspiring and Engaging Ocean

Open access to ocean information and ocean literacy for all should capacitate all citizens and stakeholders to have a more responsible and informed behaviour towards the ocean and its resources, be key in raising ocean awareness and promote better solutions.

POLICY AREA 15: Policy Actions to Promote the Public as Ocean Ambassadors

Empowering ordinary people to understand the role of the ocean in our society and thereby themselves becoming ambassadors bringing knowledge out to others, will be important in order to raise general awareness as support for implementing actions.

References

1. Dong JH. China fisheries statistics yearbook. China Agricultural Press; 2013.
2. Cheng QT. Systematic retrieval of Chinese fish. Science Press; 1987.
3. Lu JW, Luo BZ, Lan YL, et al. Study on the structural characteristics and succession of China's offshore fishery resources. J Mar Sci. 1995;36:195–211.
4. Cai RS, Chen JL, Tan HJ. Variations of the sea surface temperature in the offshore area of China and their relationship with the East Asian monsoon under the global warming. Clim Environ Res. 2011;16(1):5549–51.
5. Cai F, Su XZ, Liu JH. Problems and countermeasures of China's coastal erosion under the background of global climate change. 2008;28:1093–193.
6. He XJ, Zhang JT, Ji TY, et al. Study on the sea level rising in the China coast and its adaptation strategy. Mar Forecasts. 2012;29:84–91.
7. Hanson AJ. The ocean and China's drive for an ecological civilization. In: The future of ocean governance and capacity development. Brill Nijhoff; 2019. p. 59–66.
8. Ministry of Agriculture of the People's Republic of China. Ecological priority of fish culture and water protection—a summary of sustainable development of fisheries since the 18th party congress. http://www.moa.gov.cn/ztzl/xysjd/201710/t201710_550, 10 Aug 2017.
9. Xinhuanet. The development environment, guidelines and main objectives of the tenth five-year plan and the long-term goal of 2035. http://www.xinhuanet.com/politics/2021-03/05/c_112711, 15 Mar 2021.
10. The Ministry of Agriculture and Rural Affairs of the People's Republic of China. The Ministry of Agriculture held a press conference on fishery law enforcement and supervision. http://www.cjyzbgs.moa.gov.cn/gdxw/201904/T20190428_622038, 05 Jan 2018.
11. CWR. 2019 state of ecology and environment report review. 2019 State of Ecology and Environment Report Review—China Water Risk, 18 July 2020
12. State Council. National marine main functional area planning. http://www.gov.cn/zhengce/content/2015-08/20/content_10107.htm, 20 Aug 2015.
13. Ministry of Ecology and Environment. China biodiversity conservation strategy and action plan. http://www.mee.gov.cn/GKML/HBB/BWJ/201009/T20100921_194841, 17 Sept 2010.
14. Li Y, Fluharty DL. Marine protected area networks in China: challenges and prospects. Mar Policy. 2017;85:8–16.

15. The Central People's Government of the People's Republic of China. Some opinions on establishing the Bohai Sea marine ecological red line system. http://www.gov.cn/gzdt/2012-10/17/content_2245965.htm, 17 Oct 2012.
16. Lu WH, Liu J, Xiang XQ, et al. A comparison of marine spatial planning approaches in China: marine functional zoning and the marine ecological red line. Mar Policy. 2015;62:94–101.
17. The Central People's Government of the People's Republic of China. The state oceanic administration has comprehensively established and implemented the marine ecological red line system-firmly holding the fundamental bottom line of marine ecological security. http://www.gov.cn/xinwen/2016-06/16/content_5082772.htm, 16 June 2016.
18. Liu H, Jiang ZJ, Yu LJ, et al. Spatial management of mariculture. Science Press; 2021.
19. Eriksen M, Lebreton LCM, Carson HS, et al. Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS ONE. 2014;9(12).
20. Van Sebille E, Wilcox C, Lebreton L, et al. A global inventory of small floating plastic debris. Environ Res Lett. 2015;10(12): 124006.
21. DOME: date portals. https://www.ices.dk/data/data-portals/Pages/DOME.aspx.
22. Legal Times. Illegal operation of trawl in fishing line. 2015. http://fzsb.hinews.cn/html/2015-08/12/content_4_6.htm.
23. UN. The 17 goals. https://sdgs.un.org/goals.
24. Oceanpanel. Towards a sustainable ocean economy. https://www.oceanpanel.org/.
25. Oceandecade. The science we need for the ocean we want. https://www.oceandecade.org/.
26. Oceanpanel. The ocean as a solution to climate change. http://live-oceanpanel.pantheonsite.io/sites/default/files/2019-10/19_4PAGER_HLP_web.pdf, 19 Oct 2019.