# The China Council for International Cooperation on Environment and Development (CCIED)

# Special Policy Study on Global Ocean Governance and Ecological Civilization

## Topic 4: Green Maritime Operations

**2020 Annual Conference of The China Council for International Cooperation on Environment and Development**

**Mar 2020**

# Research/Project Team Members

Team Leaders*:

| | |
|---|---|
| WINTHER, Jan-Gunnar | Director of the Norwegian Polar Institute |
| SU Jilan | Academician of the Chinese Academy of Sciences, Second Institute of Oceanology,Ministry of Natural Resources of the PRC |

Core Members*:

| | |
|---|---|
| SVENSSON, Lisa | UNEP |
| DEGRANIAN, Nishan | World Economic Forum |
| MIMIKAKIS, John | Environment Defense Fund |
| LIU Hui | Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences |
| WANG Juying | National Marine Environmental Monitoring Center |
| SUN Song | Institute of Oceanology, Chinese Academy of Sciences |
| DAI Minhan | Xiamen University |
| HAN Baoxin | South China Institute of Environmental Sciences, Ministry of Ecology and Environment |

Coordinators:

| | |
|---|---|
| NJÅSTAD, Birgit | The Norwegian Polar Institute |
| LIU Hui | Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences |

Green Maritime Operations Taskforce:

| | |
|---|---|
| WINTHER, Jan-Gunnar | The Norwegian Polar Institute |
| XU Honglei | Transport Planning and Research Institute, MOT |
| NJÅSTAD, Birgit | The Norwegian Polar Institute |
| HENRIKSEN, Strula | United Nations Global Compact |
| ESKELUND, Jens | A.P. Moller–Maersk (China) |
| CAI Meijiang | China COSCO Shipping |
| ZHANG Shuang | Dalian Maritime University |
| ZHANG Kunkun | Zhejiang Maritime Safety Administration |
| MAO Ning | Transport Planning and Research Institute, MOT |
| ZHENG Chaohui | Transport Planning and Research Institute, MOT |
| ZHANG Ning | Transport Planning and Research Institute, MOT |

# Table of Content

## Executive Summary

Ocean, the largest ecosystem on earth, is closely connected to the livelihood and prosperity of mankind. As a major maritime nation, China boasts a coastline of 18,000 kilometers and coastal waters accounting for nearly one third of its total territory, which provides an abundance of marine resources and ecosystem services as the foundation of socioeconomic growth. Since the reform and opening-up, ocean economy in China soared from 6 billion RMB to over 1 trillion RMB in 2003 with the guidance of "*Implementation of Ocean Development*" and "*Ocean Industry Development*" policies. The annual growth rate of ocean economy reached 12.8% between 2002 and 2012, higher than national GDP by 2.4%. The yearly climb from 2012 to 2018 was also over 7%, accounting for almost 10% of China's GDP, making the ocean economy an indispensable contributor to the Chinese economy. However, intensifying maritime operations featuring extensive growth have resulted in environmental challenges such as land reclamation, which is threatening the vulnerable ecosystem of Chinese coasts. An article on *Science* points out that since urbanization and economy started to take off in the 21st century, 40,000 hectares of coastal wetlands have been developed each year (Ma ZJ, 2014). Land-based pollution aside, the environmental impact of maritime transportation, oil and gas exploration and fisheries should also be addressed. The risk of marine pollution is further exacerbated by inadequate port and ship infrastructure, vessel GHG emissions as well as the offshore development, transport and storage of oil, gas and chemical products.

In 2015, the United Nations published '*Transforming our World: The 2030 Agenda for Sustainable Development'*, which listed *"conserve and sustainably use the oceans, seas and marine resources for sustainable development"* as one of the 17 goals for sustainable humanity. The green maritime operation is an effective way to sustainability. To protect maritime ecosystems, some international organizations and industrialized countries already started green maritime operation practices, such as emissions control areas, green ports and fleets, emergency response, pollution prevention and control for fishing vessels and harbors, which could be translated to valuable experience for China. While respecting and protecting oceans, China should restrict development activities within carrying capacity of marine and improve ocean health for marine ecosystem restoration.

Recently, China has been advancing the Ecological Civilization Construction, and announced "three major battles" for the whole society, taking "the battle against pollution" as one of them. In order to promote green maritime operations for the purpose of ecological protection and sustainable development of China's seas, this report puts forward the following policy recommendations.

**1. Establish Emission Control Area (ECA) under the framework of the MARPOL Convention**

Expand the geographical scope of emission control area, and tighten emission standards. Meanwhile, cooperate with neighboring countries in the application of IMO-designated cross-national ECA.

**2. Implement special protection for the Bohai Sea**

Further improve laws and regulations on environmental protection for the Bohai Sea, such as introducing '*the Bohai Sea Protection Law'*. Establish Bohai Sea committee dedicated to Bohai issues such as ecological protection, pollution prevention and sustainable utilization. Delineate a special control area around the Bohai Sea where tighter emission controls apply. Apply to IMO for the recognition of the Bohai Sea as a particularly sensitive sea area.

**3. Carry out Green Port Action Plan**

Promote integrated growth and synergetic planning between port and urban-rural development. Optimize cargo handling systems by improving railway connections, sea-rail and water-water transfers as well as landscape construction. Remediate old ports by upgrading the infrastructure for receiving and treating ship-sourced pollutants. Promote new and clean energies as well as operations geared towards "*zero emission"*.

**4. Enhance vessel cleanliness**

Reward greener vessels through incentive programs. Establish lifecycle-based evaluation standards, encourage Chinese ship-owners to join international programs and reduce emissions voluntarily. China should formulate its own incentive policies based on advanced experience at home and abroad. Scrap outdated ships and revise *the Old Vessel Management Regulations* to tighten the age threshold. Set up a funding pool to subsidize scrapped vessels, diesel engines, exhaust cleaning systems and emission control technologies. Draft an emission inventory for ship-sourced pollutants and evaluate the current port pollution, providing data support to precision pollution control of vessels.

**5. Improve GHG reduction mechanisms**

Establish a measurement, report and verification (MRV) mechanism for ship-sourced GHG emissions. Formulate standards and guidelines for emission verification as well as planning on vessel energy efficiency and statistical analyses. Incorporate coastal shipping into emissions trade system, which will lay a solid foundation for Chinese shipping to participate in international carbon trade systems.

**6. Strengthen maritime risk control focusing on chemical emergency response and emergency response integration**

Enhance risk prevention of both land-based and marine pollution. Improve law enforcement, reduce latent risks and nib accidents in the bud. In the coastal waters with high risk of hazardous chemicals, relying on the existing ship oil spill emergency equipment storehouse, supplement the emergency equipment and materials of hazardous chemicals, and continuously improve the capacity of hazardous chemical pollution accidents. Establish an inter-departmental emergency information system for more effective coordination, information exchange and decision making. Actively participate in international cooperation and accumulate more resources for China while contributing to global emergency response to pollution accidents at sea.

**7. Improve environmental requirements for fishing vessels/ports**

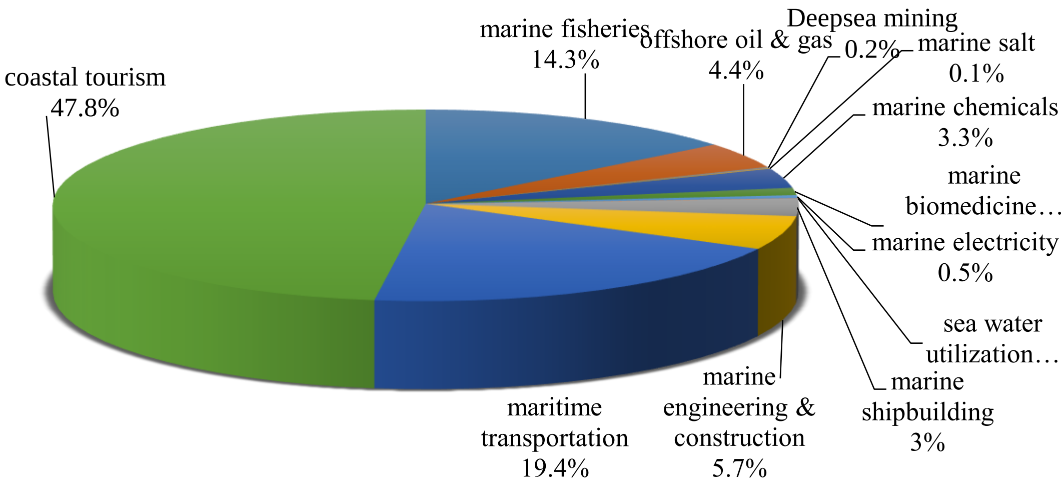
Conduct specialized actions to improve the environmental quality of fishing vessels and harbors. Invest in environmental facilities and increase the protection level of fishing vessels and harbors. Tighten emission controls by extending the scope of atmospheric pollutants to fishing vessels, which shall apply the same standards as commercial vessels and harbors. Strengthen supervision of fishing vessels via safety inspection and screenings against potential hazards, further lowering risks of accidents.

**8. Engage in and explore potential for arctic green shipping**

Strengthen cooperation with Russia and Nordic countries on the utilization of the Arctic routes. Advance research on Arctic navigation. Build northeastern China into an important hub connecting China to Arctic routes, opening up new directions for deeper economic and trade cooperation between China and Europe via the *Ice Silk Road*.

# 1.Introductioon

As a major maritime nation, China boasts a coastline of 18,000 kilometers and coastal waters accounting for nearly one third of its total territory, which provides an abundance of marine resources and ecosystem services as the foundation of socioeconomic growth. In the 21st century known as the ocean century, China strategizes to become a maritime power. In 2018, ocean economy in China soared from 6 billion RMB at the start of the reform and opening-up policy to 8341.5 billion RMB. The major ocean industries contributed 3360.9 billion RMB, in which coastal tourism, maritime transportation, marine fisheries and offshore oil/gas industry contributing 47.8%, 19.4%, 14.3% and 4.4% respectively as pillars in added value (Ministry of Natural Resources, 2019). China, occupying 7 seats in the world's top 10 ports by cargo throughput, totaled a throughput of 9.463 billion tons. China owns 225,1 ocean-going vessels, registering a total load capacity of 53.15 million tons, 1.06 million TEU container slots and a fleet size ranking the second in the world. Furthermore, the 863,900 fishing vessels in China totaled 10.80 million tons, marine fisheries 480.1 billion RMB by added value and offshore oil and gas industry 48.07 million tons and 15.4 billion cubic meters respectively, leading the world in the maritime realm.




**Graph 1-1 major sectors of Chinese ocean economy by added value in 2018**

However, the booming ocean economy featuring substandard operations and extensive growth exacerbated environmental problems. Eutrophication is deteriorating and so are ecological disasters. Port engineering claim large swathes of land from sea, causing adverse impacts on the ecological functions of coastal waters. Land-based pollution further threatens the ocean ecology, so is the inadequacy of environmental facilities at ports and on vessels as well as the worsening air and water pollutions *(Dongsheng Chen, 2017)*. Ship-sourced GHG emissions remain significant. The massive scale of maritime transportation and coastal storage of hazardous chemicals such as petroleum products cause marine pollution risks to rise.

The Chinese government has put forward a series of new philosophies and strategies around the Ecological Civilization Construction, in which unprecedented commitment to pollution control, policy introduction, supervision and law enforcement as well as environmental improvement have been made. Increasing environmental protection and sustainability has become an important ingredient in China's ecological civilization. On April 23rd, Chinese president Xi Jinping, while meeting with the head of foreign delegation at the 70$^{th}$ founding anniversary of the PLA Navy in Qingdao stated, "*The blue planet inhabited by humans is not divided into isolated islands by the ocean but rather is connected into a community of shared future where peoples of all countries are closely related.*" Building an ocean community of shared future demonstrates China's determination to fully integrate its marine development into the global trajectory. The proposal is the China program for global governance of a peaceful, secure, open, prosperous and beautiful ocean.

In order to address increasingly severe challenges of marine ecology, major maritime actors such as the U.S. and Japan are promoting green operations through policies and legal framework to coordinate and regulate marine activities, sustainable utilization of marine resources and the marine environment protection *(Izabela Kotowska, 2019)*. Build an ecosystem-based concept and position the marine ecosystem health as the foundation of sustainable development *(Eva Chatzinikolaou, 2018)*. Update development concept and production technologies. Develop ocean renewable energies, increase cooperation with other countries and relevant organizations to address the global challenges *(Jordi Perdiguero, 2019)*. This report aims at policy recommendations for the greening of future maritime operations with the basis of an overview of port and vessel pollution prevention and control in China and abroad. It starts with developments in China's ports and shipping industry with a focus on the size of ports and fleets as well as the present situation of pollution prevention and control, which is followed by analyses on problems and sources of marine pollution, existing policies and the requirements. Drawing from international experience, the report concludes with policy recommendations for the next phase of green maritime operations.

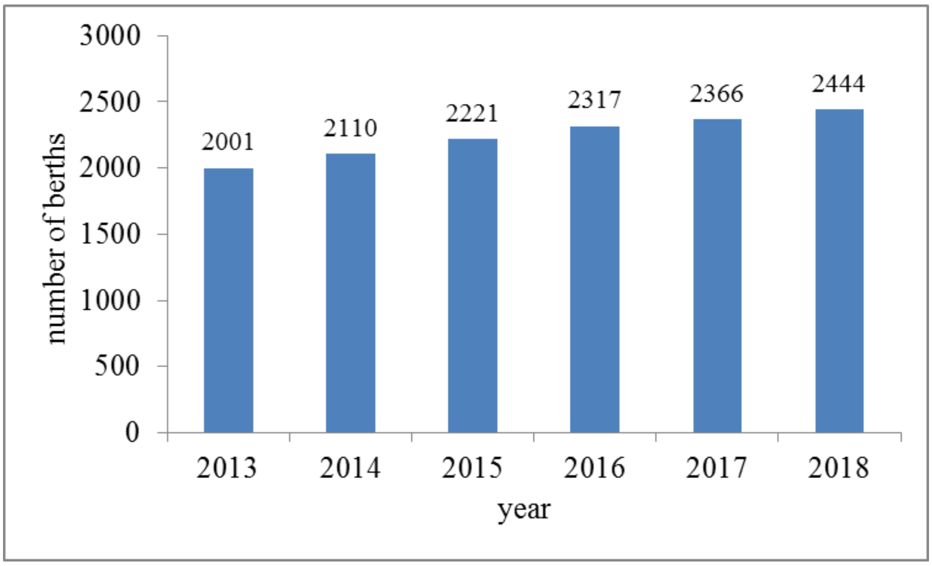
## 2. Present Situation and Developments

## 2.1 Maritime Transport

As a major player in the port and shipping industry, China has observed that specialization, upsizing and deep-water have been become the trends. There are 5 major port clusters in China, namely around the Bohai Sea, the Yangtze River Delta, the southeastern coast, the Pearl River Delta and the southwestern coast, covering 8 transportation systems for coal, oil, iron ore, containers, grain, commercial vehicles, land island ro-ro and passengers *(Yingming Chen,2019).*


**Graph 2-1 Distribution of coastal ports in China**

The scale of Chinese ports has ranked the first in the world for many years. By the end of 2018, a total of 23,919 berths for production including 5,734 coastal ports had been registered in China and the number of deep-water berths above 10,000-ton had grown from zero to 2,444, including 2,007 coastal ports.




**Graph 2-2 Number of Chinese berths above 10-thousand-tons in 2013-2018**

In 2018, the total port cargo throughput in China reached 14.35 billion tons, in which 9.463 billion tons came from coastal ports (*2018 Statistical Communique on the Development of Communicate and Transportation Industry*). At present, China holds seven of the world's top ten ports by cargo throughput. Ningbo Zhoushan Port, the largest port in the world, registers a throughput over 1 billion tons and container throughput around 144.79 million TEU.

**Table 2-1 Top 10 Ports by Cargo Throughput in 2018**

| Rank | Port | Country/Region | Throughput (million tons) |
|---|---|---|---|
| 1 | Ningbo Zhoushan | China | 1084.4 |
| 2 | Shanghai | China | 730.5 |
| 3 | Tangshan | China | 637.1 |
| 4 | Singapore | Singapore | 630.2 |
| 5 | Guangzhou | China | 594.0 |
| 6 | Qingdao | China | 542.5 |
| 7 | Suzhou | China | 532.3 |
| 8 | Port Hedland | Australia | 517.8 |
| 9 | Tianjin | China | 507.7 |
| 10 | Rotterdam | The Netherlands | 469 |

*Resource: 2018 National Transportation Concise Statistics*

Vessels for maritime transportation in China are increasing in size and specialization whereas the fleet scale is decreasing. By the end of 2018, there were 137,000 cargo vessels, down by 5.5% year-on-year as well as 10,379 coastal vessels totaling a payload of 68.86 million tons, 20,600 passenger capacity and 1.06 million TEU container slots *(2018 Statistical Communique on the Development of Communicate and Transportation Industry).*

**Table 2-2 Chinese coastal vessel structure in 2018**

| Index | Unit | Quantity | Compared to previous year(%) |
|---|---|---|---|
| **Costal vessels** | | | |
| **Cargo** | | 10,379 | 0.6 |
| **Net payload** | million ton | 68.8506 | -2.3 |
| **Passenger capacity** | thousand | 226.8 | 1.4 |
| **Container slots** | thousand TEU | 566.2 | 12.9 |
| **Seagoing vessels** | | | |
| **Cargo** | | 2,251 | -2.4 |
| **Net payload** | million ton | 53.1473 | -2.6 |
| **Passenger capacity** | thousand | 20.6 | -1.0 |
| **Container slots** | million TEU | 1.0634 | -20.4 |

In 2018, China (mainland) surpassed Japan and rose to the second place for fleet size with an average ship age 3 years lower than the world average and an international maritime transport accounting for one third of the world's total. China has international transport routes with more than 100 countries and regions and a maritime service network spanning the globe. Having been elected as a Class-A member state of the International Maritime Organization for over ten years consecutively, the status of China in global shipping has made a great leap *(Xiaoming Liu,2019)*.

**Table 2-3 Top 10 Country (region) by fleet size in 2018**

| Rank | Country or Territory | Fleet total tonnage (million DWT) | Share in World Fleet (%) | World Percentage by Vessel Type (%) | | | National flag as a percentage of total (%) | Foreign flag as a percentage of total (%) |
|---|---|---|---|---|---|---|---|---|
| | | | | Oil tankers | Dry bulk carriers | Container ships | | |
| 1 | Greece | 380.3 | 20.3 | 24.2 | 25.6 | 9.8 | 17.3 | 82.7 |
| 2 | Mainland China | 270.2 | 14.4 | 8.6 | 21.8 | 15.1 | 31.7 | 68.3 |
| 3 | Japan | 241.9 | 12.9 | 8.0 | 20.6 | 7.5 | 14.8 | 85.2 |
| 4 | Germany | 95.5 | 5.1 | 1.8 | 3.3 | 18.4 | 8.7 | 91.3 |
| 5 | South Korea | 79.5 | 4.2 | 3.5 | 6.1 | 2.7 | 14.3 | 85.7 |
| 6 | Norway | 74.9 | 4.0 | 6.0 | 2.8 | 1.6 | 22.2 | 77.8 |
| 7 | The U.S.A | 59.5 | 3.2 | 4.8 | 2.8 | 1.2 | 8.4 | 91.6 |
| 8 | Singapore | 54.8 | 2.9 | 4.5 | 1.9 | 3.3 | 49.3 | 50.7 |
| 9 | China Taiwan | 51.5 | 2.7 | 1.1 | 4.0 | 4.8 | 10.6 | 89.4 |
| 10 | Italy | 48.0 | 2.6 | 2.4 | 1.5 | 6.0 | 24.2 | 75.8 |

*Notes: Propelled commercial vessels of 1,000 gross tons and above.*
*Source: 2018 China Shipping Development Report*

By the end of 2018, China had a total of 1.575 million registered seafarers, ranking the first in the world with an annual increase of 6.2%, of which 239,000 were female crew members accounting for 15.2% of the total. The number of international seafarers was 545,877, increasing 4.1% year-on-year. Among them, 300,000 held valid Certificates of Competence and 34,000 were female. There were 192,000 registered coastwise seafarers, which increased 3.9% compared to the previous year and 5,896 were female. 146,000 seafarers had been dispatched overseas, rising by 5.1% in one year. Statistics show that a total of 3,671 women were recruited in nautical majors from 2016 to 2018 and gender curve is climbing every year (*2018 Chinese Seafarer Development Report).*

**Table 2-4 Number of registered seafarers in China in 2014-2018**

| **Type** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|
| Intercoastal Seafarers | 447,054 | 470,512 | 497,197 | 524,498 | 545,877 |
| Coastwise Seafarers | 161,413 | 168,478 | 175,764 | 184,524 | 191,780 |

In recent years, China has been accelerating port transformation, the integrated port-city reform and development as well as the advancement of greener, smarter, and safer ports. In November 2019, the Ministry of Transport proposed the goal of building world-class ports and green ports was regarded as one of the most important directions. Moving forward, Chinese ports will optimize the provision of comprehensive services and supply chains as well as multi-model transportation. In the meantime, speed up the construction of green ports, strengthen pollution prevention and control, build clean and low-carbon energy systems and level up resource conservation, recycling and ecological protection. Promote integrated port-city development as a contribution to the '*Belt and Road Initiative'*. Ultimately, establish a pollution prevention and treatment system with proper facilities, management and operations, making strides into resource conservation with major ports among the greenest in the world *(Guiding Opinions on Constructing World-class Ports, 2019).*

Committed to mechanism building, fleet optimization as well as upgrading shipboard equipment and technologies (*Guiding Opinions on Promoting Quality Development of Maritime Transport Industry, 2020),* China will concentrate on the lifecycle-based management of ships while integrating resource conservation, energy saving and environmental protection throughout processes from ship design and construction to utilization and disassembly, thus creating world-class green fleets by vigorously promoting new and clean energies and eliminating energy-intensive old ships. In addition, China will adjust the transportation structure by shifting long-haul commodities from road to railway and waterborne transport. Encourage river-sea, sea-rail and other forms of multi-model transport. Improve port planning and resource integration by more railway and road links for cargo handling. Supervise maritime transport and port operations. Prevent and control pollution from vessels and ports and accelerate the progress of setting up emission control areas (*Jianzhong He, 2018).*

## 2.2 Marine Fisheries

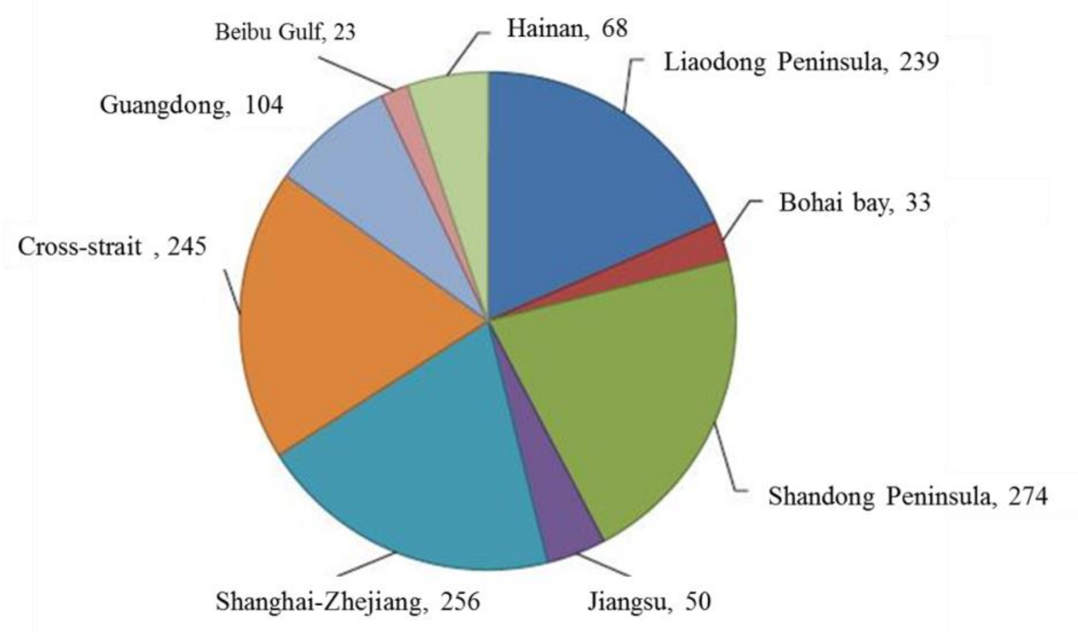
Marine fisheries, pillar of ocean economy, has been on the decline whereas shares of marine aquaculture and deep-sea fishing on the rise. By the end of 2017, there were 233 state-level ocean farms with a total area exceeding 850 square kilometers. The production of deep-sea fishing registered 2.086 million tons, growing by 4.97%. In 2018, the added value of marine fisheries reached 480.1 billion RMB, contributing 14.3% to major ocean industries *(Annual Report on the Development of China's Marine Economy, 2018).*

Fishing harbors provide essential infrastructure for the safety of fisheries and a vital base for developing marine biological resources. Statistics show that by the end of 2017, China, with its long coastline and numerous fishing harbors and vessels, had 1,292 fishing harbors and most were located along the coast, accounting for over 82% of the total. From 1998 to 2005, the Chinese government invested nearly 4 billion RMB in developing 148 fishing harbors, where 66 were central ports and 82 tier-one ports *(Quan Lu, 2018).*

**Table 2-5 Fishing harbor Classification Standards**

| **Type** | **Unloading volume (thousand tons)** | **Effective sheltered waters(thousand sqm)** | **Qualified for mooring, sheltering and supplying** | **Scope of services** | **Quantity** |
|---|---|---|---|---|---|
| **Central** | 80 | 400 | 800 | Inter-provincial (regional/ municipal) vessels | 66 |
| **Tier-1** | 40 | 200 | 400 | Provinces or neighboring provinces (regions/cities) | 82 |
| **Tier-2** | 20 | 100 | 200 | Pre-production in provinces (regions/cities) | 276 |
| **Tier-3** | | | 50 | Counties (cities) | 293 |
| **Others** | | | | Mooring or anchoring locations | 575 |

By the end of 2018, China had 863,900 fishing vessels with a total tonnage of 10.805 million tons, among which 556,200 were motorized totaling 10.4144 million tonnage and over 2,600 were sea-going vessels, attributing to a world-leading fleet and far sea fisheries *(China Fishery Statistical Yearbook, 2019)*. The thriving far sea fisheries have expanded its operating scope from near sea to public waters. Operators already have fleets in Pacific Ocean, Atlantic Ocean, Indian Ocean and waters in more than 40 neighboring countries as well as public waters in South Antarctica *(Ning Wang, 2020).*




**Graph 2-3 Distribution of fishing harbors in China**

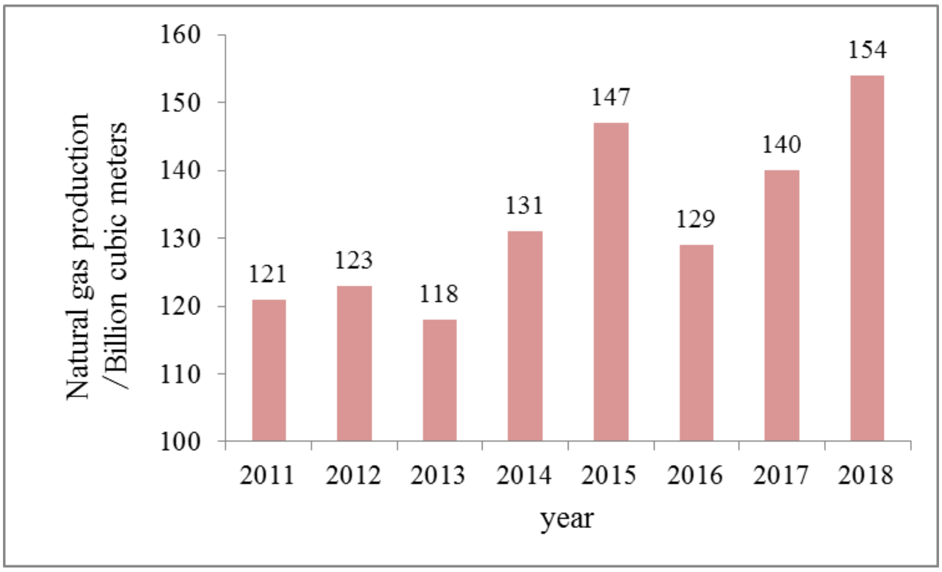
Since reform and opening up, China has rose to prominence into one of the largest aqua producer, trader and player in far-sea fisheries in the world, according to the rapid development of Chinese marine fisheries. Meanwhile, safety concerns of production, ecology and quality are increasing. Prioritizing ecology while combining protection and science-based utilization will be the inevitable choice for the Chinese marine fisheries.

Moving forward, China will significantly curb the intensity and quantity of fishing, balancing fishing capacity with allowable catch. Firstly, tighten regulations on fishing vessels. Continue *the Double Controls* on both quantity and power of vessels. Implement pilot programs on limiting the total volume of marine fishing resources as well catch quotas. Strengthen the management on fishing permits. Secondly, provide guidance on environmentally friendly operations. Phase out energy-intensive and ecologically damaging operations such as bottom trawling. Encourage flexible scientific equipment and methods as well as adjust the structure of fishing operations. In addition, accelerate the retrofitting of fishing vessels by improving its environmental protection level, hygiene conditions and catch processing capacity. Increase utilization and reduce waste, thus upgrading the overall quality and profitability of fisheries. To protect marine fishing resources, China has tightened the grip on the number of deep-sea fishing businesses and size of seagoing fleets and proposed the targets of *limiting deep-sea fishing vessels within 3,000 by 2020* and *zero-growth* of deep-sea fishing operators.

## 2.3 Status and Trends of Offshore Oil and Gas Development

China's offshore oil and gas resources are mostly located in four major production bases, namely the Bohai Sea, the East China Sea and two production bases in the South China Sea. Among them, the South China Sea is China’s largest sea with the country’s most marine oil and gas reserves. It holds nearly 7 billion barrels of proven reserves and a daily production of 2.5 million barrels. In recent years, with a greater emphasis on offshore oil and gas development, China saw further growth in its reserves *(C. Zhao, 2019)*. In 2018, under the influence of international and domestic demand and industrial restructuring, China's offshore crude oil production totaled 48.07 million tones and offshore natural gas production topped 15.4 billion cubic meters. The offshore oil and gas industry has created an annual added value of 147.7 billion RMB, a 3.3% increase over last year. Meanwhile, China has also improved its capabilities in deep water oil and gas exploration and development. The gas hydrate production test in the South China Sea was successful, making China one of the world's leading countries with marine gas hydrate production technology *(Annual Report on the Development of China's Marine Economy 2018).*


**Graph 2-4 Marine crude oil production in 2014-2018**




**Graph 2-5 Marine natural gas production in 2014-2018**

Globally, offshore oil and gas development is trending towards deep water and Polar Regions. Deep water investments account for about one third of total offshore investments. A quarter of offshore projects worldwide are in deep water, and three-quarters of the top 50 mega projects in the world are deep water projects. China's deep water oil and gas exploration and development is also picking up speed and heading towards reservoirs at water depths of more than 1,500 meters, low-grade resources such as ultra-low permeability oil, thickened oil and tight oil, as well as unconventional resources like shale oil and shale gas.

China's offshore oil and gas development will also be more focused on protecting marine ecology. In June 2019, China National Offshore Oil Corporation (hereinafter as "CNOOC"), the largest offshore oil producer in China, issued a *Green Development Action Plan*, which strategized the framework for CNOOC's green growth from three aspects: green development of oilfields, clean energy supply and low-carbon development. To a certain extent, the Action Plan is an epitome of Chinese offshore oil industry's progress towards a green growth. The green development of oilfields encompasses a range of measures, including establishing an environmentally-friendly lifecycle management, establishing a long-term mechanism for the coexistence of oil & gas development and marine conservation, improving the multipurpose utilization of by-products during oil & gas development, improving environmental friendliness and controlling waste discharge during oil and gas production, and gradually improving capabilities in environmental risk classification, prevention and control. The clean energy plan adheres to furthering the offshore exploration and development with additional efforts to promote the development of clean energy and related technologies. These efforts include speeding up unconventional natural gas development, stepping up the exploration in the peripheral blocks, increasing the supply of liquefied natural gas (LNG), boosting the construction and expansion of LNG terminals and the construction of onshore natural gas pipeline networks and end-use facilities. The low-carbon development plan calls for energy efficiency, digitalization and carbon reduction throughout the production process in the whole industry chain, active response to the global call for actions to tackle climate change, greenhouse gas emission control, pollution control and emission reduction during production, strict control on the monitoring and treatment of flue gas, wastewater and solid waste, greater development of energy-saving and emission-reducing industries, and commitment to environmental and social responsibility.

## 3. Challenges of green maritime operations in China

### 3.1 Maritime operations are under increasing pressure from international environmental protection

Green maritime operations are an effective approach to achieving the 2030 global Sustainable Development Goals (SDGs). In 2015, 193 member states of the United Nations reached consensus on sustainable development and adopted the outcome document titled *Transforming Our World: The 2030 Agenda for Sustainable Development*, which is a framework document that guides the international community's development. The Agenda lays out 17 SDGs (UN, 2015) for mankind. One of these goals is to conserve and sustainably use the oceans, seas and marine resources for sustainable development. Other SDGs such as to end hunger, to ensure sustainable and modern energy, to adopt sustainable production patterns, and to combat climate change and its impacts, are all closely related to oceans.

In the context of sustainable development, maritime operations such as maritime transport, marine fisheries, and offshore oil and gas exploitation are being promoted for a quicker transition towards green development. As an example, global shipping is an important pillar in world economic and trade development, Greening of which can contribute significantly to the progress towards SDGs. As former UN Secretary-General Ban Ki-moon said in his speech at the opening session of 2016 Global Sustainable Transport Conference, "*The 2030 Agenda for Sustainable Development is a roadmap for people, planet, peace and prosperity through global partnership… Sustainable transport systems is essential to achieving the Sustainable Development Goals*." Unsustainable transportation will bring many problems such as the increase of greenhouse gas emissions, road accidents, low productivity, air pollution, and so on. Attention to ecological environment has become the new style of the international shipping industry. The Review of Maritime Transport by the United Nations Conference on Trade and Development (UNCTAD) pointed out that a number of international developments continued to contribute to the implementation of the 2030 Agenda for Sustainable Development *(UNCTAD, 2019)*. For instance, the discharge of untreated ballast water from ships is considered one of the greatest threats to biodiversity of the world's oceans. In view of this, the International Convention for the Control and Management of Ships' Ballast Water and Sediments as a result of lengthy negotiations entered into force. In 2018, focusing on reduction of air pollution and greenhouse gas emissions, States party to *the International Convention for the Prevention of Pollution from Ships (MARPOL)* discussed and decided on the implementation of the 2020 sulphur limit and initial GHG reduction strategy. These new environmentally driven regulations in international shipping are constantly being complemented and improved, making international shipping cleaner. They are expected to bring significant benefits for human health and the environment, but also raise fresh challenges for the shipping industry (UNCTAD, 2019).

In addition, rule-making on the environmental protection during submarine mineral resources development has been advanced. In Part 1 and Part 2 of the 24th Annual Session of the International Seabed Authority (ISA) in 2018, ISA reviewed the

Draft Regulations on Exploitation of Mineral Resources in the Area. It was emphasized that the Draft Regulations must be in line with relevant provisions in *the United Nations Convention on the Law of the Sea* and *Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea on 10 December 1982*, and that policies regarding activities in the international sea-bed area must take necessary measures to ensure effective environmental protection against possible harmful impacts of such activities.

## 3.2 Vulnerable marine ecology demanding higher requirements for green maritime operations

China is a major maritime power with a long coastline and diverse marine ecosystems. However, as a result of over-exploitation and improper operating model, the marine environment has deteriorated markedly. Large areas of offshore waters fail to reach clean seawater standard, covering a total area of up to 177,000 square kilometers since 2000. Widespread eutrophication occurred in coastal provinces. Coastal marshes which are home to important flora and fauna have shrunk by half since the founding of the People's Republic of China. These are the pressing issues to be addressed in marine governance. Monitoring data show that in 2018, 33,270 square kilometers out of all the waters under China's jurisdiction are areas with water quality inferior to the standard specified in the national Sea Water Quality Standard; a total area of 21,560 square kilometers in the Bohai Sea did not meet Class 1 sea water quality standard, a 2,820 square kilometers increase over the previous year; 56,680 square kilometers of sea surface is eutrophic, with Liaodong Bay, Bohai Bay, Yangtze River estuary, Hangzhou Bay, and Pearl River estuary highly eutrophicated; among the marine ecosystems under monitoring, such as estuaries, bays, mudflats, coral reefs and mangroves, 71.4% are in sub-health condition and 4.8% are unhealthy (Ministry of Ecology and Environment, 2019). Reclamation, pollutant discharges into oceans, and marine accidents with an environmental impact are the "side effects" of maritime operations and are the main driving factors to marine environmental problems.

China fully participates in the formulation and implementation of marine governance mechanisms and related rules within the UN framework, implements the SDGs on oceans, defines the construction of marine eco-civilization as a common social goal, and adopts multiple measures to stimulate green maritime operations among different industries. China attaches great importance to the implementation of *UN 2030 Agenda for Sustainable Development*. By integrating it into the country's mid- and long-term development plans such as the 13th Five-year Plan, China has yielded results in multiple sustainable development goals. In building the legal framework on marine conservation, amendments were made to related laws and regulations such as the *Marine Environmental Protection Law, Fisheries Law, Law on the Administration of the Use of Sea Areas, and Regulations on the Prevention of Vessel-induced Sea Pollution,* which are the legal manifestation of the country's green and ecological development ideas. Meanwhile, China's major campaigns such as the construction of ecological civilization and the fight against pollution have also extended offshore. Supervision and monitoring in this regard have also been strengthened. Central

Environmental Protection Supervision and Inspection has established whose work includes marine environment management. The Standing Committee of the National People's Congress conducts law enforcement inspections regarding the Marine Environmental Protection Law on a regular basis. Moreover, designated departments which formulated assessment criteria for special campaigns such as water pollution and air pollution prevention and control would also evaluate the implementation and performance of such campaigns in different provinces and cities.

## 3.3 Large-scale and high intensity of maritime operation with outstanding local pollution

China's maritime operations have maintained the development momentum, featured by its large scale and high intensity compared with other countries. In terms of maritime transport, China is considered to have the highest connectivity with the rest of the world in global maritime trade, with world leading numbers of liner shipping and container-carrying capacity. Statistics show that maritime imports into China accounted for about a quarter of global maritime trade (UNCTAD, 2019). In addition to over 10,000 coasting liners and more than 2,000 Chinese oceangoing vessels that have long been active in Chinese waters, a large number of passing vessels also sail through Chinese waters where major East Asian sea lanes run through. According to incomplete statistics, at least 18,000 ships were recorded active in East Asia (including coastal areas of China, and South Korean and Japanese waters) (H. Liu et al., 2016). Similar to maritime transport, Chinese commercial ports, fishing harbors, and fishing fleets are also developing on a large scale and operating intensively. Meanwhile, China is also a major offshore oil and gas producer with constant intensive development. Led by the government, initiated by businesses and participated by the market, a number of actions against port pollution have been taken in the past decade, including transformation to new energy for port machinery and vehicles, building rainwater and sewage collecting and recycling facilities, adoption of noise reduction technologies, etc. However, due to limits in development and mindset, during the planning, design, construction and operation of some old ports, very little consideration was given to environmental protection and ecological conservation. As a result, there are very limited environmental protection facilities and equipment. Compared to commercial ports and vessels, pollution prevention and control in fishing harbors and fleets started late with comparatively lower environmental standards. There is a lack of pollutant collection and treatment facilities in most fishing harbors and fishing vessels, leading to a common practice of releasing pollutants and wastes into the sea without treatment.

Substantial pollutant discharges into the sea as a result of large-scale and intensive maritime operations have become non-negligible. High concentrations of pollution in some areas are posing a significant threat to the local environmental. According to data from the Ministry of Ecology and Environment, in 2018 cargo ships emitted 588,000 tons of sulfur dioxide, 89,000 tons of hydrocarbons, 1.511 million tons of nitrogen oxides, and 109,000 tons of particulate matter, with nitrogen oxides and particulate matter emissions accounting for 13.4% and 12.3% of mobile source emissions respectively (China Mobile Source Environmental Management Annual Report, 2019).

In some coastal cities, vessels have become a more major source of air pollution. In Shenzhen, sulfur dioxide emissions from vessels account for 59% of all human induced emissions, while nitrogen oxides emissions and $PM_{2.5}$ accounting for 17% and about 7% respectively. Similarly, ship-source polluting discharges of sewage, oily water, chemical tank washings and ballast water are also a widespread problem in China.

What's more, since the beginning of the 20st century China has embraced a rapid development of cities and ports. During this time, land reclamation was widely adopted to gain more space for development. For example, between 2003 and 2011, Lianyungang port has reclaimed an area of approximately 15.2 square kilometers, and Ningbo port has reclaimed approximately 2.7 square kilometers of land (Y. Hu, 2018). Reclamation activities in inshore areas may change local hydrodynamic conditions and local erosion and deposition patterns, thus alternating the natural state of the shoreline and even encroaching coastal marshes and causing suitable habitats for rare species to dwindle. Some fast-growing ports, though crucial in sustaining the city's social and economic development, have seen more and more conflicts between port development and the demand for urban space and ecological environment.

## 3.4 Increasing oil and gas exploitation and transportation giving rise to higher risks for pollution accidents

Fast economic development in China in recent years boosted a continuing increase in the demand for oil products and chemical products. According to statistics, in 2018 the petroleum and chemical industry saw further increase in its proportion in the total industrial economy. When chemical industry's sales revenue hit a record high of 6.89%, sales revenue of two mentioned industry rose from last year's 11.8% to 12.1% in 2018, and was expected to increase by approximately 8% in 2919 *(Report of China Petroleum and Chemical Industry Performance in 2018, 2019)*. China's imports of oil products and liquid chemicals are mainly done by marine shipping. In 2005 China had only 35 liquid chemicals berths of 10,000-DWT and above. By 2018 the number has increased to 217. A constantly high number of vessels carrying dangerous chemicals shipping inward and outward Chinese ports, which reached 120% increase over 2010 to 686.7 million in 2018 according to statistics from the Maritime Safety Administration of China (including 10,226 in Yangtze River). There is also a clear trend towards scaling up for ships. In 2010, the carriers for bulk liquid chemicals were mostly vessels of 1,000 to 3,000 DWT. By 2018, the main carriers were of 2,000 to 5,000 DWT, with 110 times more bulk liquid chemical vessels of over 50,000 DWT. All of the factors mentioned above, coupled with the large number of cargo ships passing Chinese waters each year, contributed to increasingly high risks of chemical-leaking. Improvement in administration brought down the total number of ship-source pollution accidents, but severe pollution accidents still occur from time to time. The oil spill from Sanchi in 2018, for instance, caused significant negative impacts on the marine environment.

Recent development in offshore oil and gas industry in China ensured a steadily high oil and natural gas production. Due to long-term exposure to marine environment, offshore oil platforms are susceptible to damage or collision with passing ships, and thus leading to severe oil spills. One example is the *19-3"* oil spill incident in Penglai in 2011 caused by offshore drilling operations. Submarine pipelines are the fasted, most economical and reliable means of oil and gas transportation, but corrosions and scrapings during their service may also lead to oil leakage. In the event of leakages in coastal oil storage, serious pollution to the surroundings waters is highly likely. The oil spill occurred on July 16th 2010 was the result of leakage in coastal oil storage tanks. According to *the Medium-and Long-term Plan for National Oil Reserve*, by 2020 China will work on the 2nd and 3rd phases of its oil reserve project to reach a total reserve equivalent to 100 days of net oil imports, with a number of national oil reserve bases along the coastal region. To conclude, large-scale offshore oil extraction, submarine pipeline transportation and coastal oil storages have put China under constantly high risk of marine pollution.

# 4. Chinese Practice on Green Maritime Operations

For a major marine country such as China, the environmental security of its blue territory is an important chapter in the construction of ecological civilization. In recent years, China has gradually established a legal framework for the conservation of marine environments to strengthen supervision and management, prevent and control marine pollution as well as protect ecological resources in oceans and seas. In particular, China assumes its responsibilities as a major country for the green development of shipping industry by actively implementing international conventions and launching a series of measures on pollution prevention and treatment including designating domestic emission control areas, promoting shore-based power for berthing vessels, building facilities to receive ship pollutants, strictly controlling discharge of ship-sourced water pollutants, continuously strengthening the emergency response capacity building for at-sea oil spills, promoting port greening etc., which have significantly enhanced the greening level of the shipping industry.

## 4.1 Control of vessel-sourced atmospheric pollution

Ship emissions have become one of the major culprits of atmospheric pollution in certain coastal regions. According to the 2016 Hong Kong Air Pollutant Emission Inventory released by the Environmental Protection Agency of the Hong Kong Special Administrative Region Government, the share of sulphur dioxide, nitrogen oxides, respirable particulate matter and fine particulate matter emissions by water transport reached 49%, 37%, 38% and 44% respectively, making it one of the biggest emission sources in the city *(Ma Dong et al. 2019).* To improve the air quality in coastal and riverfront regions, in particular in port cities, and to promote energy conservation and green operations of the shipping industry, the Chinese government has launched a series of measures including establishing emission control areas, tightening standards on vessel engines, promoting shore power and LNG vessels, advancing the task on pollution control in the transportation industry.

In December 2015, three Domestic Emission Control Areas (DECAs) against ship-sourced air pollutants were set up in the Pearl Delta Region, Yangtze Delta Region and Bohai Rim (Beijing-Tianjin-Hebei) waters to control sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM) from sailing, mooring, and other ship operations.

As DECAs entered into force on Jan 1$^{st}$, 2016, China officially became the first developing country to have set up emission control areas against ship-sourced atmospheric pollutions as well as the first Asian country to adopt low-sulfur fuel oil within control areas. In December 2018, the Ministry of Transport adjusted the scope of DECAs, expanded the geographical scope to coastal areas in the entire country, and also tightened emission standards of SOx, NOx, PM, and volatile organic compounds (VOCs), and specified requirements for shore power usage. It is estimated that by the end of 2018, SOx emission in DECAs decreased by 160,000 tons compared with 2015 and PM by 17,000 tons. Monitored results also showed significant improvement of air quality in surrounding areas.

In addition, the adoption of shore power and new energy vessels such as LNG ships are effective means to reduce ship-induced atmospheric pollution. Pursuant to the *Air Pollution Prevention and Control Law of China,* newly built terminals shall plan, design and built shore-based power supply facilities. Existing terminal shall gradually retrofit with shore-based power supply facilities. Shore power shall be prioritized for vessels at berth. New seagoing and coastal vessels shall be equipped with qualified power receiving facilities. To accelerate the adoption of LNG application in the waterborne transport industry, *the Ministry of Transport* published 2 batches of demonstration projects from 2014 to 2016, covering 24 sectors within water transport industry. At present, relevant departments are resolving the difficulties associated with the construction and maintenance of LNG bunkering stations. Incomplete statistics show that by June 2019, China had already built 3,700 shore power facilities covering more than 6,000 berths and 284 LNG-fueled vessels.

Despite China's various measures on reinforcing air pollution control, a gap remains from developed countries. The ECAs in China are domestic and unilateral areas that apply only to inland waterways and Chinese waters while IMO ECAs can extend to exclusive economic zones. In terms of efficacy, Chinese ECA policies can not to mandate foreign vessels to retrofit based on emission control requirements. Besides, the requirements of pollution control also fall behind. Constraint by factors including construction and utility costs, safety and user willingness, the number of vessels equipped with receiving facilities remains small and the adoption of shore power and LNG ships slow. Furthermore, China has not yet established a monitoring system for port and ship atmospheric pollutions. The formulation of a pollutant inventory is still at a preliminary stage where a proper mechanism for compilation is absent. The precision supervision of port and vessel pollution faces a dearth of scientific guidance.

## 4.2 Prevention of ship-sourced water pollution

Water pollution constitutes another daunting challenge aside atmospheric pollution. *The Water Pollution Prevention and Control Law of China* revised in 2017 stipulated requirements for prevention and control of water pollution caused by ports and ships as well as specific restrictions on vessel-sourced water pollutants. Implemented on July 1st, 2018, *Discharge Standards for Water Pollutants from Ships (GB 3552-2018)* imposes similar as or even more stringent rules on the discharge of ship-sourced pollutants including oily water, domestic sewage and solid waste compared to *the MARPOL Convention.* While endorsing receiving facilities at terminals and shipyards for pollutants such as oily water, tank wash-water, domestic sewage and solid waste as well as for transferring and treating pollutants between ships, ports and cities, relevant departments of the Chinese government issued a myriad of measures to boost the development of pollutant receiving facilities from 2016 to 2018. By the end of 2018, 49 coastal ports (mainly major coastal ports and important regional ports) have issued corresponding plans, 47 of which have already completed the construction. Only *Zhanjiang Port* and *Chaozhou Port* in Guangdong Province have not yet completed the construction.

Since Jan 22, 2019, *International Convention for the Control and Management of Ship's Ballast Water and Sediments (hereinafter as the Ballast Water Convention)* entered into force for China. To guide ship-making, shipping operators and supporting businesses in the implementation of the convention, the Chinese authorities published the *Measures for Supervision and Management of Ship* Ballast *Water and Sediment.* Some ports in China has started to research on the receiving facilities for ballast water such as research on receiving ballast water from barges by *Shenzhen Yantian Port* and on mobile receiving facilities for ballast water by *Shanghai Yangshan Port*. Moreover, to minimize the impact of anti-fouling system on marine environment, the Chinese government inspects the anti-fouling systems of incoming Chinese and foreign ships by measures including documentation review and spot checks.

Increasing efforts as have been made by China on preventing and controlling ship-sourced pollution, outstanding problems persist. For example, the share of aged vessels is high in coastal cargo transport and sewage treatment facilities of some coastal and seagoing ships remain suboptimal. The receiving facilities of some ports and terminals are not yet included in the overall municipal infrastructure planning. Besides, although the *Ballast Water Convention* has officially entered into force for China, the ballast water treatment technology is still in its infancy and the potential biological invasion caused by ballast water still exists. Meanwhile, factors such as vessel type, route distance, ballast tanks and piping erosion give rise to risks of secondary pollution *(Liu Minghui et al, 2019)*. Besides, in terms of pollution superintendence, lacking precise statistics on ship-sourced pollution is posting difficulties to the scientific management of ships and ports.

Compared to commercial vessels and ports, environmental requirements for their counterparts in fisheries are relatively slack and sub-standard. Due to insufficient investment and legacy issues, pollution prevention of fishing harbors and vessels started relatively late and many problems still persist. First, supporting facilities and cleaning at fishing harbors are mostly undertaken by operating companies or third parties. Current laws and regulations are rather generic on environment protection facilities, which lack practicality without specific requirements on recovery form, receiving facility setup and equipment quantity. Second, most state-level central fishing harbors are under-equipped in terms of oil and sewage collection and treatment facilities; some ports commission private clearance companies for reception and transfer, but it is lacking scale and proper management. Regarding the method of oil pollution recovery, it primarily depends on the initiative of fishermen, leading to uncertainties in complete recovery. Third, fishing harbors do not have special vessels to receive and store domestic sewage and ship waste, which are usually discharged directly into fishing harbors at times of fishing season or storms when the number of incoming vessels soar. Therefore, the peak of boat returning often coincides with it of illegal pollutant discharge and floating garbage salvage. Fourth, with the continuous expansion of fishing harbor functions, aqua-product production and processing, catering and entertainment sectors around fishing harbors are sprawling, and such port-based activities also discharges pollutants into surrounding waters, complicating the components of pollutants.

## 4.3 Strengthen capacity building on emergency response

Accidents in operations such as marine oil-gas exploration and lightering or coastal storage and processing, if handled improperly, could cause marine pollutants, in particular the spill of oil and other hazardous chemicals poses a serious threat to the marine ecology *(Yang Qin, 2015)*.

Lately, China has endeavored to build and improve its emergency response system at national and local levels. Measures including upgrading the storage and management mechanism for emergency resources as well as emergency rescue teams have increased its capacity in responding to oil spillage at sea. At the state level, the interdepartmental joint conference mechanism on major oil spill emergency response led by the Ministry of Transport in 2010 coordinates the resources of its 23 members including government agencies, petrochemical and shipping operators. By the end of 2018, the government investment had contributed to the completion of 24 state-level oil spill emergency response warehouses along the coast, among which there were three 1,000-ton, thirteen 500-ton and eight 200-ton warehouses, accomplishing the target of 1,000-ton one-time oil clean-up capacity within 50 nautical miles from the coast.

The Ministry of Transport and the National Development and Reform Commission issued the *National Major Maritime Oil Spill Emergency Capacity Construction Plan* in December 2016, proposing the following targets on capacity building: The oil spill clean-up capacity of waters within 50 nautical miles from the coast to reach 1,000 tons; The capacity of high risk waters within 50 nautical miles to reach 10,000 tons; The capacity of coastal provinces (autonomous regions and municipalities included) on cleaning- up shoreline oil spill and receiving recycled materials to reach 10,000 tons. The *National Emergency Plan for Major Marine Oil Spill Emergency Disposal* issued in 2018 clarified the procedures for handling major marine oil spills, under the guidance of which the *Sanchi* explosion and spill accident was successfully coordinated and organized. At the local level, *Regulations on the Prevention and Control of Marine Environment Pollution by Ships* require that local governments at or above the municipal level in coastal areas to produce corresponding emergency capacity building plans for the prevention and control of marine pollution from ships and related operations, and to include the planning as well as its implementation into the performance review of the *Water Pollution Prevention Action Plan*. China has established a system for oil spill contingency management and vessel pollution monitoring headed by maritime authorities.

Notwithstanding years of undertaking, China's emergency response capacity at sea still witnesses certain deficiencies. First, weak capacity in response to leakage of hazardous chemicals is severely challenged by the current sea transport industry, which is massive in size and variety. Second, lack of an information sharing and decision support platform is hindering communications and coordination and associated cost effectiveness. Third, international cooperation is needed when addressing major pollution at sea involving multiple countries and regions where one country alone can't cope effectively. An international mechanism should be established for resource sharing and collaboration in responding to emergencies.

## 4.4 Port optimization

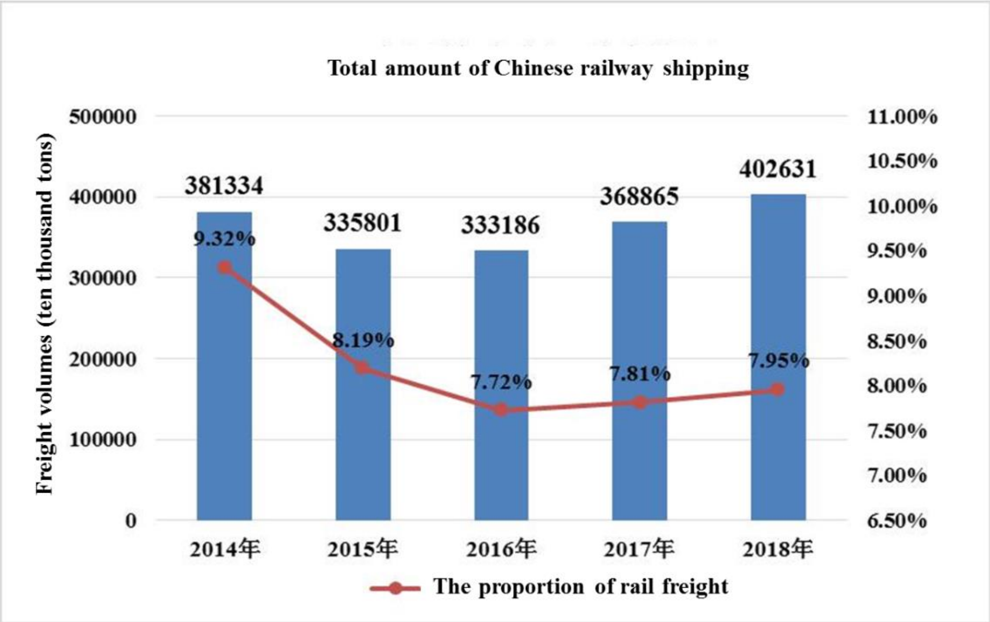
The development of a port is closely related to the development of the city. On the one hand, port development can boost economic growth in the hinterland and the city, and improve local industrial structure; on the other hand, such economic growth can in turn ensure the materials, products and other resources needed for the port's further development and support its freight and maritime transport (Jean-Baptiste,2020). But port construction and operations will inevitably have direct or indirect impact on the resources and ecological environment (P. X. Wen, 2015). The co-development of cities and ports caused conflicts between urban expansion and port growth in aspects such as port operation affected areas, cargo collecting and distributing, environmental pollution and land use, leading to intense port-city relations (D. J. Hai, 2019). The Chinese government has introduced policies to promote an in-depth and integrated port-city development, which links port and urban-rural construction, incorporates port development into industrial development framework, coordinates urban water front landscape and coastal port operation, and integrates port pollution control into urban environmental protection system. Alternatively, by revising port master plans, functions with great environmental impact such as cargo shipping are transferred to regions with bigger environmental capacity and local resources. For instance, in the revised master plan of Yantai Port, Zhifu Bay port zone, which is closer to Yantai central downtown and relatively more polluted, had the dry bulk shipping function transferred to the Western port zone far from downtown. In revising the master plan of Ningbo Zhoushan Port, cargos apt to cause pollution which used to be handled at Yongjiang port zone in urban area were phased out, in order to bring back a clean shoreline to the city. The Shenjiamen port zone in Zhoushan has also phased out shipbuilding and dry bulk shipping functions which were near human settlements.

Environmental assessment, inspection and follow-up evaluation of port planning are crucial in preventing and mitigating adverse environmental impacts. Environmental assessments help to optimize the function and spatial layout of port planning, eliminate potential pollution and damage to the environment, and promote green development in the industry. Inspections and follow-up evaluations offer analysis on the actual environmental impact following the implementation of the planning, evaluate the effectiveness of the measures taken to prevent or mitigate the adverse environmental impacts, provides solutions to the environmental problems caused by what's previously done, and proposes measures to optimize the following practices. By the end of 2016, 25 major Chinese sea ports had undergone environmental assessment. The Ministry of Ecology and Environment had carried out environmental impact inspections on Yancheng Port, Beibuwan Port and Zhanjiang Port; follow-up evaluations on Tianjin Port and Guangzhou Port are on-going.

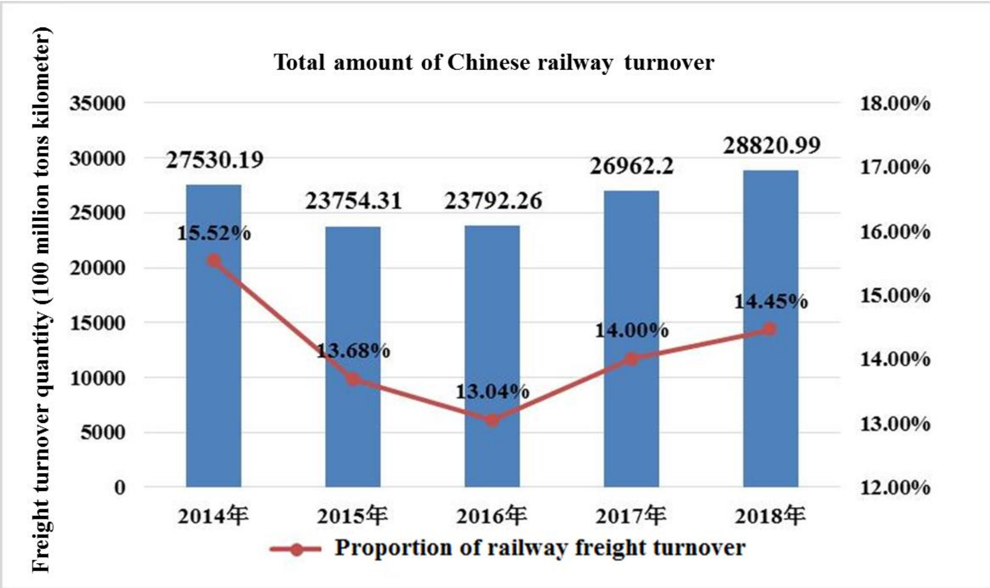
China has made a lot of useful attempts to build eco-friendly ports. However, improving port-city relations still have a long way to go due to various limitations, such as the large number of coastal ports and the uneven development, lack of pollution prevention and control facilities in ports developed during early years, insufficient port reception facilities, and large numbers of substandard construction machineries and port operation machineries.

## 4.5 Improve environment friendly port collection and distribution system

In recent years, China worked actively towards a structural adjustment in port transportation. Efforts were made to develop multimodal transport, and utilize relatively cleaner water and rail transport for cargo distribution, which has lower energy consumption and pollution emissions. Since 2017, China focused on transport restructuring and has seen a rebound in rail freight volume and turnover. In 2018, the Chinese government issued the Three-year Action Plan for Promoting Transport Restructuring (2018-2020), followed by supporting policies and financial subsidies from local governments regarding the restructuring and multimodal transport. The proportion of rail freight grew from 7.72% in 2016 to 7.95% in 2018 in terms of volume, and increased from 13.04% in 2016 to 14.45% in 2018 in terms of turnover.




**Graph 4-1 Chinese railway shipping and developments in 2013-2018**




**Graph 4-2 Chinese railway freight total turnover and developments in 2013-2018**

China is also actively exploring the transition to a green and low-carbon transportation. By strengthening top-level design, focusing on key links and establishing long-term mechanisms, China aims to accelerate the construction of a green transportation system (Z. Z. Ji, 2016). The Chinese government proposed to implement green shipping and port initiatives in 2011, and the Ministry of Transportation proposed to start demonstration projects of eco-friendly ports in 2012. Currently, the Chinese green port model is characterized by lower resource consumption, lower pollution, good growth and strong scale effect (S. Q. Lv, 2018). The Guangzhou Port, for example, has stepped up air and water pollution prevention and control, and advanced its green port development by optimizing the port layout, integrating shoreline resources, utilizing green energy and shore power, deploying practical cargo collecting and distributing, and upgrading equipment and facilities. The Xiamen Port has completed the “oil-to-electricity” and “oil-to-gas” energy transformation of machineries for port operations. Environmental initiatives such as shore power transformation, recycling and treatment of oily water and garbage from ships were also undertaken.

So far China's transport restructuring has achieved interim results, but difficulties and problems still pertain during implementation. Financial support is needed to construct railways for cargo distribution from ports; difficulties in coordinating railway with other transportation industries are and inadequate supervision of road transport industry are also hurdling the process of promoting the “road-to-rail” and “rail-to-water” transformation.

## 4.6 International Cooperation on Green Maritime Operations

Compared with the traditional route, the Arctic Northeast Channel known as green route greatly shortened the voyage and reduced operating costs and carbon emissions. In recent years, China has accelerated its pace in developing the Arctic routes. The white paper entitled '*China's Arctic Policy'* points out that China is an active participant, builder and contributor to Arctic affairs. China is willing to work with all relevant parties to proactively address the challenges brought about by changes in the Arctic region, to jointly study, protect, and utilize the Arctic while participating in the Arctic governance. China COSCO Shipping Group is actively engaged in activities in the Arctic Northeast Channel. In August 2013, the *Yongsheng* ship, loaded with the first batch of Arctic sailing materials, successfully docked at Rotterdam port after 27 days on September 10, becoming the first Chinese merchant ship to reach Europe via the Arctic Northeast Passage. Since 2013, a total of 22 Arctic Northeast waterway voyages have been completed, saving an accumulative mileage of 93,350 nautical miles and voyage time 7,332 hours. Preliminary estimation shows that 8,948 tons of fuel consumption and 27,833 tons of carbon dioxide emissions have been avoided due to the North Pole route, amounting to a total cost saving exceeding RMB 90 million, which also generated great socioeconomic benefits *(Han Guomin, 2019)*.

Furthermore, China has introduced various measures on curbing GHG emissions. Since 1980s, the Chinese administration has formulated a series of laws, regulations and technical guidelines on the control of $CO_2$ emissions in the shipping industry, providing policy and legal framework for China to further its capacity in addressing climate change. In 2012, the Ministry of Transport published the *Limits and Verification Methods of Fuel Consumption for Commercial Ships*, which defined the methodologies of the determination the fuel consumption limits, calculation formulates and verification for fuel consumption index of commercial ships. In 2018, the Maritime Safety Administration of China issued *Measures for the Administration of Ship Energy Data Collection*, mandating marine vessels to report energy consumption data to the maritime administration when processing departure reports or port clearance formalities. Setting limits as well as a data collection system for the fuel consumption of commercial vessels are the specific actions taken by China to adapt to the international requirements of GHG emission reduction.

China actively participates in the formulation of GHG reduction strategies, contributing Chinese wisdom in the drafting of preliminary IMO GHG reduction strategies. For instance, for the preliminary emission reduction strategy agreed upon at the 72th MEPC, China adheres to the principle of *Common but Differentiated Responsibilities*, communicates closely with developing countries and deliberates with the United States, the European Union and small island states, driving the IMO Secretariat and working groups to coordinate developed countries to accommodate requirements and concerns of developing countries

Additionally, China is exploring into the establishment of a carbon emission trading market. The implementation of the IMO GHG emission reduction strategy emphasizes the role of market in reducing emission of the shipping industry. After years of development, Europe and the United States have accumulated valuable experience in market-driven emission reduction. Carbon trading system in China was officially launched at the end of 2017, before which only operational vessels with annual emissions of more than 10,000 tons in certain pilot regions were included in carbon trade. Compared with developed countries such as the European Union, China's carbon market trading mechanism is still in its infancy. The legal system and market environments also need to incorporate GHG emission trade system in order to response to the mandate of the IMO GHG reduction strategy.

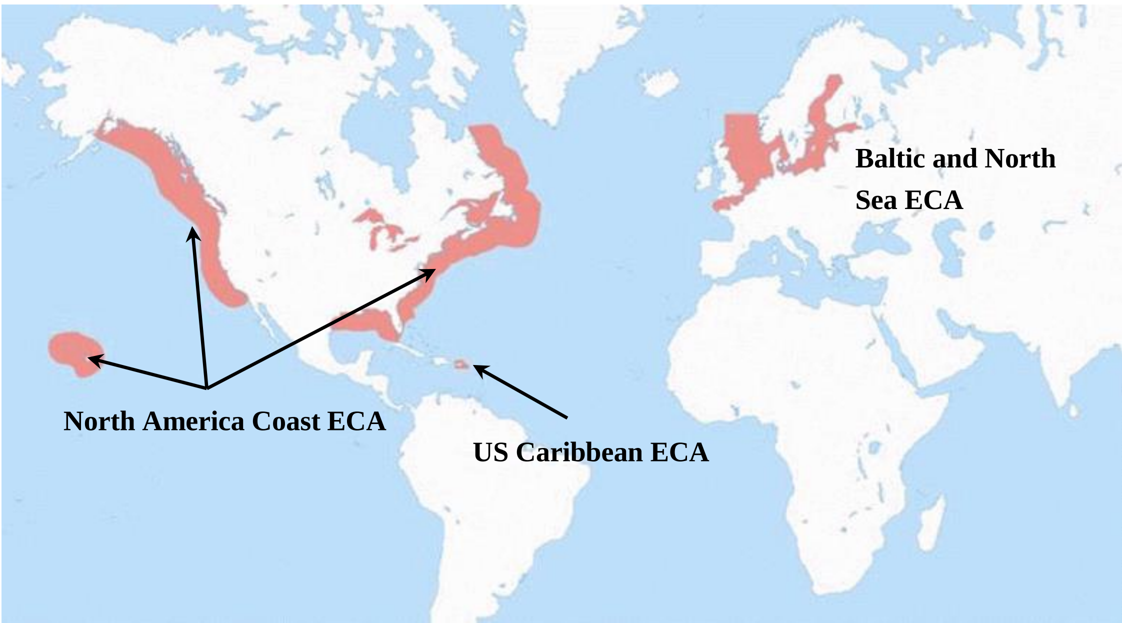
## 5.International Experience on Green Maritime Operations

*'The UN 2030 Agenda for Sustainable Development'* lists *"conserve and sustainably use the oceans, seas and marine resources for sustainable development"* as one of the important goals of achieving sustainability by 2030. Green maritime operations are the inevitable course to the conservation of marine ecology and sustainability. Some forerunners have provided valuable experience for other countries on the practice of green maritime operations.

### 5.1 Emission Control Areas

Emission Control Area (hereinafter as ECA) is a policy officially introduced by *the International Convention for the Prevention of Pollution from Ships (the MARPOL Convention)* that aims to further reduce the emission of atmospheric pollutants by the implementation of more stringent requirements. Measures in ECAs mainly include that vessels shall switch to super-low sulfur fuel oil (lower than 0.1%m/m) and that vessels built or retrofitted after certain date shall install diesel engines fulfilling the Tier III NOx emission standards.

At present, four ECAs i.e. the Baltic Sea, North Sea, North American Seas, and US Caribbean Emission Control Area have been included in *the MARPOL Convention (graph 5-1)*. These four ECAs have implemented the super-low sulfur requirements and announced the data for Tier III diesel engines. Once approved by IMO as amendments to *the MARPOL Convention Annex VI*, ECAs become binding to all vessels in the jurisdictions of contracting parties, thus ensuring ships entering ECAs comply with more strict pollution controls. ECAs have achieved significant reduction of atmosphere pollutants, accumulated tremendous experience in enforcement and supervision, and motivated the shipping industry to operate more responsibly. As a result, more regions in the world are considering setting up ECAs to improve air quality. For example, driven by the Commission for Environmental Protection founded by Canada, the U.S. and Mexico, Mexico is now ready for its ECA application. IMO's Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), the European Commission and France have conducted feasibility studies on establishing an ECA in the Mediterranean Sea and partial results were published at the 74th conference of the Marine Environment Protection Committee MEPC in 2019.




**Graph 5-1 IMO-designated ECAs**

## 5.2 Construction of green ports

At the global scale, major ports around the world are also the most active advocates of green ports. Industrialized players such as the EU, the U.S., Japan and South Korea have already made tremendous progress. Port of Long Beach, the second largest port in the U.S., launched *"the Green Port Policy"* encompassing over 40 initiatives in 7 aspects including water quality improvement, clean air action, land and marine wildlife and habitat protection, traffic pressure reduction, sustainability and community engagement. The Port of Long Beach and the Port of Los Angeles joined to improve air quality by adopting the *Clean Air Action Plan (CAAP, first published in 2006 and updated in 2010 and 2017)*, which includes air quality monitoring, emission inventory management, rail-to-terminal development, green berth recognitions and so on. In ten years, emission reduction of PM, NOx, SOx and GHG dropped by 87%, 56%, 97% and 18% respectively, amounting to a milestone in air quality improvement in the Los Angeles metropolitan area.

The Port of Tokyo is an early practitioner of port landscape improvement. The Bureau of Port and Harbor of Tokyo announced the plan for parks around port areas, connecting various green spaces from spots, strips to areas, forming an inter-connected green network. Tokyo prioritizes the coastline and seafront landscape with a strong focus on coastline view and seashore restoration, adorning port areas and connecting operating terminals with green parks. *The BwN Wadden Sea Harbors* in the Netherlands takes one step closer to nature, proposing the concept of *Building with Nature* for the harmonious symphony between harbors and nature. The green planning principles ecosystem and environmental protection, addresses the rough transition between land and water and encourages salt marsh, creating more vibrant habitats for wildlife.

**Table 5-1 Green Practice Across the Global**

| Port/Region | Measures |
|---|---|
| Port of Long Beach | 1） Protect, maintain and restore aquatic ecosystem and marine habitats.<br>2）Reduce the harmful emissions of port operations.<br>3）Improve water quality in and around Port of Long Beach.<br>4）Dredge, dispose or reuse contaminated soil and sediments in the port area.<br>5）Community engagement and education on port operations and environmental programs.<br>6）Implement the sustainable green port concept throughout the port design, construction, operations and management practice. |
| Rotterdam | 1） Carbon footprint reduction is a part of the main strategy to transition the port into a center of renewable energies.<br>2） Improve punctuality and reduce out-of-port berthing time of vessels through a digitalization program. |
| Baltic Sea | 1）Invest in energy-saving lighting and equipment as well as resources such as solar panels or biomass too reduce the energy consumption of port areas.<br>2）Reduce emissions and noise by using clean fuels, electrification of port operations, ecological driving and modernization of port infrastructure. |
| Sydney | 1）Fully implement "*Green Port Guidelines*" ranging from water and air quality, noise control, biological conservation, waste disposal, dangerous goods management to environmental education and trainings.<br>2） The draconian legal measures have protected the ecological environment of ports. Effective results have been achieved on green construction, serving as positive examples for the global community. |
| Tokyo | 1）The green planning measures introduced by the Bureau of Port and Harbour of Tokyo secured large swathes of green space in port parks, ensuring the greenness and scientific soundness in land utilization.<br>2）Dedicated to beach and shore restoration as well as the greening of ports.<br>3）Improve the environments in the coastal area by focusing on the greening and protection of waterfront landscape and facilities such as aquapark, natural landscape and wildlife habitats. |
| Sweden | The environmentally differentiated fairway due policy has been in place for a fairly long time and was revised in 2018. Vessels with higher scores can have more cuts on fairway dues. |

In addition, railway and waterway take up a large share in the port distribution system of developed countries. Hamburg Port has a railway line of over 300 kilometers dispatching more than 200 trains, accounting for one third of the port throughput.

Rotterdam Port divides the mode of transport based on distance where inland waterways and road transport applies for transport radius within 800 kilometers and railway for over 1,200-1,600 kilometers. It is planned that by 2025, road transport in Rotterdam Port will be down to 35% from the current 44%, water transport up to 45% from 43% and railway up from 13% to 20%. Being the second largest in Europe, the Port of Antwerp boasts around 1,000 kilometers of railway lines, 26 railway stations, 250 freight trains a day and an annual transport volume of 21 million tons, taking up 50% of railway capacity in Belgium. By 2030, the share of Antwerp railway transport will increase from 8% to 20% (container railway transport from 7% to 15%) and road transport decrease from 52% to 40% *(Zhaoxin Wu et. al, 2019)*.

## 5.3 Building green fleets

Granting certificates with corresponding rewards or port due reductions is the main measure used by the international community to incentive cleaner ships, among which the Environmental Ship Index (ESI), Clean Shipping Index (CSI) and Green Award (GA) are adopted at a wider scope. Beginning in Rotterdam in 1994, Green Award evolved into an independent organization in 2000 and gradually expanded to Europe and the rest of the world. Ships with *the Green Award* are entitled to a variety of benefits ranging from port tax discounts in 12 countries to free yearly VIP services provided from various companies. In 2007, Gothenburg and Sweden launched *the Clean Ship Index* (CSI), covering 5 pollutions ranging from NOx, SOx and PM, $CO_2$, chemical substances, wastewater and solid waste. By the end of 2017, 30 cargo owners (including *Volvo, Volkswagen, H&M, Philips, Stora Enso* and *Tetra Laval*) and 74 shipping companies joined the program and the number of CSI-certified vessels exceeded 2,250. In 2010, partnering with ports including Le Havre, Bremen, Hamburg, Antwerp, Amsterdam and Rotterdam, *World Ports Sustainability Program (hereinafter as WPSP)* established the Environmental Ship Index (ESI), offering discounts on port dues and tonne charges to ships emitting less SOx, Nox and $CO_2$ than the current average IMO standards. Ship owners can register environmental performance of their vessels on ESI website and obtain their ESI scores and certifications as the documents for reductions on port due and tonne charge. By the end of 2017, 6,860 ships had ESI scores, accounting for 7% of the world’s total oceangoing commercial vessels and around 50 ports had participated in the index system.

Contrasting emission controls on atmospheric pollutants such as SOx, the GHG reductions in the shipping industry is more influenced by the global progress on climate change negotiations. For a long time, such negotiations were carried out within the United Nations Framework Convention on Climate Change (UNFCCC) and IMO frameworks with the latter gradually growing into the main battlefield for maritime shipping to cope with climate change. *The Initial IMO Strategy on GHG Reduction* adopted by 2018 included vision, ambition, guiding principles as well as measures in short, medium and long terms, which is due to be revised in 2023 based on further empirical analysis and research. Utilizing emissions trading system as a means to cut GHG emissions, the European Union is the first region to have established a cross-border emissions trading system (EU-ETS) and to have considered the inclusion of maritime transport sector in the system (pre-requisite being that the IMO members fail to reach a consensus on the target of sectoral emission reduction by 2021). Regardless of the controversies within the shipping industry on the unilateral actions by the EU, such a measure undoubtedly will be translated into higher operating costs for shippers and a considerable impact on the progress of GHG reduction negotiations to a large extent.

Artic routes can reduce the voyage distance, cost and emissions significantly and have attracted widespread attention in recent years. Russia and Nordic countries are actively exploring Arctic navigation routes. In 2008, a cargo ship named *the MV Camilla Desgagnes* departed from Montreal, eastern Canada and successfully crossed the Northwest Passage. On August 14, 2010, a tanker named *Baltica* owned by *Sovcomflot*, the Russian state-owned shipping giant, voyaged through the Arctic Northeast Fairway to Zhejiang, China. In September 2010, *Nordic Barents*, a Danish cargo ship set sail from the Port of Kirkenes, carrying more than 40,000 tons of iron ore, arrived in Qingdao Port China through the Arctic Passage. As anthropogenic activities in the Artic region increases, so is “environmental footprints”. Countries in Europe and North America have expressed concerns about the aggregating environmental stress in the region and numerous research and action plans have been introduced such as *the EU Arctic Policy* and the U.S. Arctic Research Commission.

## 5.4 Pollution accident response mechanisms at sea

Since the last century, developed countries have built robust capabilities, which is comprised of public and private sectors, and a well-established management system against oil spill accidents. In the U.S., the system consists of 3 levels (national, state and local). National Response Center composed by 16 government agencies is responsible for state-level planning and coordination, states for their own prevention strategies as well as state-wide mobilization and support, whereas local authorities for specific guidance and clean-up actions on the ground. In general, the government mainly assumes management functions, and numerous cleanup companies are the backbone in providing professional services after accidents. Developed countries are exploring into the possibility of established a global responding network. The Global Response Network (GRN) initiated by Oil Spill Response Limited is a consortium joined by a large number of oil spill response organizations, offering services in most areas in North and South America, Asia, Europe and Oceania.

The at-sea leaking of hazardous chemicals is another major issue for costal nations. As the authority to enforce regulations pertaining to hazardous chemical materials carried by vessel, the United States Coast Guard has developed the Chemical Hazard Response Information System (CHRIS). The United States Environmental Protection Agency set up National Risk Management Research Laboratory (NRMRL), providing technical support to government emergency responses in areas including hazard identification and assessment, risk management, supplies and resources, command and control coordination, early warning, procedure development, equipment, training, drills, public education and fund management. By revising the Act on Prevention of Marine Pollution and Maritime Disaster and its implementing rules, Japan mandates vessels carrying over 150 tons of liquid chemicals in certain waters must be equipped with materials and qualified personnel for HNS incidents. Major ports in countries such as Germany and the Netherlands have established online management systems for storage and transportation of hazardous chemicals with databases for ships and warehouses and a dynamic ship-tracking system. The Maritime and Coastguard Agency in UK organizes specialized agencies and laboratories for technical research on risk assessment, personnel training and drills, improving the prevention and control capabilities against hazardous chemical risks at ports and terminals.

## 5.5 Controlling pollution of fishing vessels/harbors

Aqua products are the major food sources in many countries and regions with a large impact on environment, society, economy and livelihood. Pollution prevention and control of fishing vessels and harbors are important components of the 'blue economy'. While assisting fishery development in the world, the Food and Agriculture Organization (FAO) endeavors to promote a greener fisheries. In 2010, FAO published the *Fishing Harbor Planning, Construction and Management*, which pointed out that "*In today's world of increased environmental awareness, a fishing harbor must be planned, designed and managed in harmony with both the physical and biological coastal environments*" and included sections on renewable energy and waste disposal *(Fishing Harbor Planning, Construction and Management,2010)*. Over the years, countries have conducted various practices. EU's efforts in energy conservation, decarbonization, renewable development and utilization for blue fishing harbors are regarded as important measures and cushions for the mankind to address climate change. Japan implemented 9 construction projects of fishing harbors with the latest one including measures to restore infrastructure and build centralized drainage facilities at legacy ports. New York stepped up the monitoring and treating facilities for major pollutants at fishing harbors. In 2019, the first Blue Growth Forum for best practices for fishing harbors convened in Spain. Participated by 25 experts from more than 10 countries including China, the Forum reviewed major fishing harbors and *green ports* in the world, introduced case studies and experience sharing, deliberated on the challenges, limiting factors, models and policy recommendations in balancing environmental and socioeconomic benefits of sustainable fishing harbors and exchanged opinions on the demand and practice of the development and management of blue fishing harbors.

## 5.6 Summary

The successful experience accumulated by developed countries offers valuable reference to China, compared to which the industrialized counterparts have a stronger focus on port landscape, port-city integration, new and clean energies and stricter emission standards and more experience in utilizing the market mechanism in controlling emissions. Pioneering experience across the globe shows that China can further the width and depth of green maritime operations by adopting measures such as financial rewards, preferential taxes and market-based solutions to boost the green development and transition from reducing pollution to realizing economic benefits.

Ports can be cleaner, and more attention is needed on the harmony between ports, cities and ecosystems. With national requirements of environmental protection as the baseline, more stringent requirements can be imposed in certain waters including controls on ship-sourced atmospheric and water pollution. Pollution accident response capabilities need to expand from oil spills to include leakage of chemical substances. Fishing harbors and vessels have sizable potential for greener development; hence higher environmental requirements and infrastructure are needed along for the sustainable development of oceans and seas.

## 6. Policy Recommendations

The economic miracle in China started along the coast. Forty years into reform and opening-up, China regards the development of coastal economy as an important part of the national development strategy and a major measure to revitalize the economy. Today, coastal regions in China have risen to booming centers of high urbanization rate and population density. However, the extensive growth model and unsound operations have placed the ocean, the underlying cornerstone of coastal and ocean economies, under great pressure of ecological destruction and land-based pollution. Pollutants from ports, ships, oil extraction, fisheries and other sources enter the marine environment, destroying water quality and marine ecosystem as well as damaging marine fisheries, coastal tourism and public health. The report hereby proposes the following policy recommendations on maritime operations for the harmonious coexistence between man and ocean as well as the protection of marine environment.

### 6.1 Establish MARPOL-approved ECAs.

DECA policies in China have entered the second phase, which is preceded by the first phase productive in controlling ship-sourced atmospheric pollution. However, there remains to be several differences between DECAs and IMO-approved international ECAs. In terms of geographical scope, DECAs apply to inland and Chinese territorial waters whereas the international ECAs may have larger coverage, even exclusive economic zones as shown by precedence. According to '*the United Nations Convention on the Law of the Sea*', control requirements should not be implemented to foreign ships, which can be complied only by ship structure modification. When pollution control policies are brought into MARPOL framework, they are applied to all the ships registered in party countries. China shall actively apply for designating international ECAs within the MARPOL framework, strengthening the control on vessel pollution.

**a. Expand scope of ECAs and impose more stringent requirements.** The DECAs are mainly within the territorial waters of China. Relevant research indicates that the extension of control area scope to 100 kilometers off the coastline or more can substantially improve air quality in coastal regions (*Tsinghua University, 2019).* Moreover, emission standards of DECAs are slightly lower than international ECAs. For instance, the sulphur content limit of the latter is 0.1% m/m whereas the former 0.5% m/m. The waters around Hainan will reach 0.1% m/m by 2022. Engines of vessels entering international ECAs must comply the MARPOL Tier-III whereas DECAs only benchmark against Tier-II. Vessel built after 2022 or those with retrofitted engines are required to implement the Tier-III standards. China shall conduct assessment on current DECA as well as forecasting on regulations of wider scope and stricter controls as a part of preparations for the international ECA applications.

**b. Cooperate with neighboring countries in establishing IMO ECAs.**

Confronted with borderless atmospheric pollution, China, Japan and South Korea need to jointly shoulder the responsibilities of improving air quality in the region. As important players of northeast Asia, the three countries govern neighboring waters where the same fleets berth and pass through. Establishing one ECA covering waters of the three Asian giants can minimize ship-sourced pollutant emissions as well as the impact on their shipping industries. Enhance regional communication and consultation and strive to apply for an IMO-approved ECA with South Korea, Japan and other neighboring countries, thus magnifying the effectiveness of emission control via a collaborative approach towards atmospheric pollution in the region.

## 6.2 Implement special protection for the Bohai Sea

As a semi-enclosed inland sea with limited self-cleaning capacity, the Bohai area is one of the most ecologically vulnerable waters in China (*Rong Zeng et.al, 2015).* Also, as an essential ecological zone in northern and northeastern China, the Bohai Sea offers unique ecological services that are vital to the ecological balance and security in the region (*Anniing Suo et.al, 2011).* Being one of the 4 largest fish farms in China, *the Bohai Bay Fish Farm* is the center of sprawling and foraging for many rare marine species as well as economics fish and prawns. The wetlands of Yellow Sea and Bohai coastal areas are known as world’s natural heritage for having the largest mudflats in the world and the hub for bird migration from East Asia to Australia. In recent years, the increasing intensity of industrial, transport, fishing and marine oil exploration activities along the coast is taking a toll on the productivity of the Bohai Sea, which has witnessed issues such as declining biodiversity and water quality. Its marine ecosystem is under grave threat *(Debin Song, 2017).* More draconian measures are needed in addressing the pollution prevention and ecosystem restoration of the Bohai Sea.

**a. Further improve laws and regulations on environmental protection for the Bohai Sea.** Propose the State Council to introduce a specialized *Bohai Sea Protection Law* or *Bohai Sea Protection Regulations*. Strengthen the management of *Bohai* waters through legislation. Regulate resource utilization, ecological conservation as well as pollution prevention and treatment.

**b. Set up Bohai Sea committee for holistic management.** The State Council can lead relevant departments along with the three provinces and one city along the Bohai rim to form a committee for the management of the Bohai waters, ameliorating the coordination between various authorities. The committee can draft an overall planning for the development and protection of the area, integrate environmental funds related to the Bohai Sea, improve the ecological compensation system and adopt a uniform approach in ecological conservation, pollution prevention and treatment as well as sustainable resource utilization.

**c. Delineate a special control area in the Bohai region.** The delineation of Bohai as a special area of stricter emission standards where the intensity of maritime development and land-based pollutants entering the sea are contained. In terms of vessel pollution control, apply to IMO for the Bohai Sea to be recognized as a Particularly Sensitive Sea Area *(MEPC, 2005)*. Reduce vessel pollution and potential risks through ships’ routing system, area to avoid by ships, speed limits and emission limits etc.

## 6.3 Carry out Green Port Action Plan

While booming Chinese ports have brought prosperity to regional economies, it comes with the price on the increasingly daunting ecological impacts and pollution. Inadequate facilities and unclean operations at ports have made them one of the major pollution sources in some coastal cities. Large scales of reclamation have caused severe destruction to ecological environment. Ports compete with cities on limited resources such as land, shoreline and water bodies, which results in rising port-city tension *(Zhaonan Shen et.al, 2018).* An action plan for green ports is necessary for addressing ecological impacts, port cleanliness and integrated port-city development.

**a. Promote Integrated development of port and city.** While the integrated transportation system is being developed during the spatial planning of China, seize the opportunity to strengthen planning coherence of port and city. Port planning shall avoid occupying the ecological redlines, basic farmlands and urban development boundaries, as well as reserve coastal wetlands and other ecological spaces for cities. Urban-rural development shall fully accommodate the need of ports by providing the necessary land and shoreline resources and incorporating infrastructure for receiving, transferring and treating pollutants. The port collecting and dispatching system shall balance efficiency, energy conservation and environmental protection. Accelerate the railway construction, in particular for sea-rail and water-water transfers, reducing pollution arising from cargo collection and distribution at ports. For landscape construction, draw lessons from international experience and focus on port landscape design. Create characteristic port landscape for aesthetics pleasantry and tourism.

**b. Clean port operations targeting "zero emission".**

Carry out environmental renovation of legacy ports and address the shortage and backwardness of pollution prevention as fast as possible, which were restricted by early environmental protection concepts, policies and technologies. Improve port facilities for receiving vessel pollutants, in particular wastewater from washing chemical tanks and ballast water to meet the requirements of incoming vessels. Promote electricity, LNG and other clean energies. Phase out engineering and port machinery uncompliant with emission restrictions. Machinery newly installed or replaced shall use clean energies and incoming ships shift to shore power pursuant to relevant laws and regulations.

## 6.4 Enhance vessel cleanliness

China, located at the navigational center of Eastern Asia with the second largest fleet for maritime transport in the world, embraces a large number of vessels in its waters, which results in significant pollution from vessels. The share of old ships in China remains high. Statistics show that by June 2019, old (above 12 years) and special-surveyed (above 26 years) vessels accounted for 42.96% and 0.70%, in which the percentages of oil tankers were 37.56% and 0.69% respectively *(Half-Year Coastal Freight Vessel Transport Capacity Analysis Report, 2019).* The old transport ships have poor technical conditions, backward environmental protection facilities and relatively high pollution risks. In addition, due to various reasons such as insufficient attention to ship pollution in the early stage, the discharge base of pollutants from ships is not clear, so it is difficult to accurately control the pollution from ships. Therefore, a basket of comprehensive measures is in need for improving the pollution control and cleanliness of vessels.

**a. Green vessel reward programs.** Establish a green vessel evaluation system based on systematic standards encompassing the whole lifecycle from design, building, operations to dissembling. Encourage Chinese shipping companies to join international green vessel incentive programs and conduct energy conservation and reduce emissions on a voluntary basis. Formulate reward policies for green vessels in China. Incentivize shipbuilding activities compliant with new international regulations, conventions and standards. Offer financial rewards such as subsidies and tax breaks to vessels fulfilling green standards as well as preferential policies such as priority pass in custom clearance, berthing and departures, thus raising the environmental awareness of vessel operators.

**b. Accelerate the phasing out of old transport vessels.** Revise *the Provisions on the Administration of Old Transport Vessels* and update requirements pertaining to ship age. Lower the age threshold for mandatory scrapping through legislation. Set up a fund for subsidizing vessel scrapping and break-up as well as retrofitting for energy saving and environmental protection. Encourage old ships below the legally required age of scrapping to retire or upgrade in advance, improving the transport structure together with fleet environmental performance. Accelerate the implementation of clean diesel engine action plan. Promote the installation of desulfurizing towers and selective catalytic reduction (SCR) systems, increasing the technical level of ship emission control.

**c. Establish pollutant monitoring and emission inventory systems.** Speed up research and adoption of monitoring technologies on ship emissions. Utilize remote sensing technologies in key fairways in research on vessel emission monitoring technologies, increasing the scope of supervision. Build a data monitoring and sharing platform for vessel ownership and activity levels. Compile national and local inventories of ship pollutants for an accurate assessment of current ship and port pollution, providing data support to the precision control of ship and port pollution.

## 6.5 Improve GHG reduction mechanisms

The 72nd MEPC in 2018 passed the *Initial IMO strategy on reduction of GHG emissions from ships*, which is the first time that the water transport industry has set a GHG emission reduction target for addressing climate change, amounting to an overall plan for the global industry to cope with climate challenge as well as an important milestone in the IMO trajectory to curb GHG emissions. Given that the foundation of monitoring and management of vessel energy efficiency in China remains weak and the fact that the water transport industry is not yet included in the carbon trading system, it is necessary that a reduction mechanism for vessel-sourced GHG be established to fulfill the requirements of global shipping industry for greenhouse gas emission reduction..

**a. Build the monitoring, reporting and verification (MRV) system for GHG emissions in the shipping industry.** Conduct targeted research on relevant MRV methodologies and reference on the experience of IMO and the EU in formulating the verification regulations and guidelines. Establish a management system for vessel energy efficiency and a platform for information sharing. Define the specific steps and tasks involved in the carbon verification for shipping companies, laying a solid foundation for the Chinese shipping industry to participate in the global emissions trading scheme.

**b. Include coastal shipping into carbon emissions trading system.** Despite the fact that China has preliminarily established a market for emissions trading, the shipping industry is not yet included in the system. While improving the MRV mechanism for GHG emissions in the shipping industry, it is high time to formulate the technical roadmap for the Chinese shipping industry to implement the emissions trading scheme along with supporting regulations and guidelines. The inclusion of coastal shipping into the carbon trading system will be another leap for the current Chinese carbon trading system as well as for China's readiness to join international carbon trading systems.

## 6.6 Strengthen maritime risk control focusing on chemical emergency response and emergency response integration

The rapid growth of China is accompanied by increasing intensity of marine development. Statistics show that the production of marine crude oil in 2018 was 48.07 million tons and natural gas 15.4 billion cubic meters, remaining at high levels for many years (*Ministry of Natural Resources, 2019).* According to statistics on oil spill accidents from the International Tanker Owners Pollution Federation (ITOPF), regardless of the recent declining frequency of maritime oil spill, major oil spill accidents caused by ships still occur from time to time. The *Sanchi* accident at the mouth of Yangtze River in 2018 caused disastrous impacts to the surrounding marine and atmospheric environment. Pollution risks associated with marine oil exploration, storage and transport cannot go neglected. Additionally, years into capacity building, China's capabilities in preventing and controlling oil spill accidents have taken roots but its capacity in dealing with hazardous chemicals leakage accident remains to be improved.

**a. Strengthen risk prevention.** Further strengthen the risk prevention of land-based environmental emergencies. Major coastal companies engaged in handling of hazardous chemicals, heavy metals, industrial waste and nuclear power should build libraries for hazardous chemicals and conduct marine pollution risk assessment. Perform regular risk-based safety inspections on offshore oil platforms, oil and gas pipelines and inland terminals. Enhance law enforcement and supervision, reduce potential accidents and eliminate pollution accidents from the source.

**b. Improve emergency response capabilities against pollution of hazardous chemicals.** In the coastal waters with high risks of hazardous chemicals, relying on the existing ship oil spill emergency equipment storehouse, supplement the emergency equipment and materials for hazardous chemicals, and continuously improve the capacity of hazardous chemical pollution accidents. For hazardous chemicals carried by vessels in bulk and of higher risks, shore up research and development for shipboard technologies and equipment, level up relevant standards and systems, improving the technological robustness on responding to accidents involving hazardous chemical products.

**c. Build an inter-departmental maritime emergency management system.** With the support of the inter-ministerial joint conference system for major maritime oil spill emergency, coordinate emergency resources among member organizations and establish an inter-departmental system for maritime emergency response, achieving the uniform management and information sharing for more efficient and scientific decision making.

**d. Participate international cooperation.** In the short term, fully utilize regional cooperative frameworks such as Northwest Pacific Action Plan (NOWPAP), the Coordinating Body on the Seas of East Asia (COBSEA), APEC Port Service Network (APSN) and increase cooperation with Japan, South Korea, Russia and other neighboring countries on emergency response. Coordinate emergency resources and improve capabilities in addressing marine pollution incidents. In the long term, the government should further cooperation with ASEAN and countries along '*the Belt and Road Initiative'*, broaden the scope of international communications on emergency response. Encourage qualified businesses to participate in Global Response Network (GRN) where resources can be marshalled at the global scale. Meanwhile, contribute more Chinese efforts to the global community in addressing marine pollution accidents.

## 6.7 Improve environmental requirements for fishing vessels/harbors

China has a large number of fishing harbors and vessels. Constraint by concepts, policies and technologies in the early stage, fishing harbors and vessels lack environmental facilities and standards and cause severe pollution in the marine environment. Therefore, relevant requirements on environmental protection need to be improved for fishing vessels and harbors.

**a. Make up the shortage of environmental protection facilities.** Draw lessons from developed countries and regions such as the EU, the U.S. and Japan. Conduct specialized programs on the upgrading of environmental facilities for fishing vessels and harbors. Increase investment and build facilities in accordance with relevant standards for fishing ships and harbors. Maintain and repair old environment protection facilities, encourage old vessels to retrofit and improve the overall environmental standards for fishing ships and harbors.

**b. Tighten the emission standards.** Include fishing vessels into the monitoring program of atmospheric pollutants from ships. Levy the same emission standards for fishing ships/harbors as merchant ships/harbors. Raise environmental requirements and strictly control the pollution emissions from fishing vessels and harbors.

**c. Strengthen fishing boat supervision.** Conduct safety inspection and risk screening on fishing vessels. Lower the inherent risks of safety accidents. Strengthen supervision on fishing boats and regulate their activities at sea, reducing the risks of collision between fishing and merchant ships.

## 6.8 Engage in and explore potential for arctic green shipping

Global warming and melting of ice in the Arctic have enabled new regional and global trading routes, and ships voyaging between China, Russia and Europe via the Arctic Channel are increasing year by year. This route through Eurasian and North American waterways, is expected to become a major corridor for international trade. The Arctic route shortens the distance between Chinese and European ports by one third compared to it via the Suez Canal, producing significant benefits of energy conservation and emission reduction.

Suggest to strenghen cooperation with Russia and Nordic countries on the utilization of the Arctic routes. Advance research on Arctic navigation. Build northeastern China into an important hub connecting China to Arctic routes, opening up new directions for deeper economic and trade cooperation between China and Europe via the *Ice Silk Road*.

## Main references


陈英明.中国港口现状及未来走势，中国水运，2019（6）：7.

大连海事大学, 欧盟海运排放交易单边行动的影响及应对研究, 交通运输部战略规划政策项目.

国际船舶排放控制区现状梳理. The International Council on Clean Transportation (ICCT), 2018.12.

国家海洋局生态环境保护司, 坚持绿色发展 保护海洋生态[J], 中国海洋报, 2015, 11,18(001).

海德俊,王玉,段征宇,杨东援.特大港口城市的港城矛盾及疏港模式分析[J].综合运输,2019,41(04):108-114.

韩国敏.中国商船开辟极地航线实践与展望[J].世界海运，2019，42(02):1-5.

胡怡. 我国内河及沿海港口总体规划环境影响评价对比分析[J].环境影响评价.2018.40（2）：41—45.

《交通运输部 发展改革委 财政部 自然资源部 生态环境部 应急部 海关总署 市场监管总局 国家铁路集团 关于建设世界一流港口的指导意见》 http://www.gov.cn/xinwen/2019-11/13/content_5451577.htm

季则舟,杨兴宴,尤再进,侯伟.中国沿海港口建设状况及发展趋势[J].中国科学院院刊,2016,31(10):1211-1217.

交通运输行业发展统计公报（2018 年).交通运输部. http://xxgk.mot.gov.cn/jigou/zhghs/201904/t20190412_3186720.html

交通运输部.2019 年上半年国内沿海货运船舶运力分析报告.http://xxgk.mot.gov.cn/jigou/syj/201909/t20190919_3272749.html

李帅.论韩国渔船渔港管理与船员培训[J], 南方农机，2019, 50(2):67.

梁华罡.中国海洋经济绿色发展水平综合测度与时空演化研究[J], 海洋开发与管理, 2019(5):73-83.

刘慧, 蓝色渔港最佳实践研讨会, 西班牙.

刘铭辉等. 船舶压载水处理方法研究进展[J].资源节约与环保.2019.2:69-72.

刘小明：奋力开创航运业高质量发展新局面. http://scitech.people.com.cn/n1/2019/0711/c1007-31228323.html

刘子飞. 国外渔港发展经验与借鉴—以纽约港和普利茅斯港为例[J].世界农业.2020.1:91-97.

鹿红, 我国海洋生态文明建设研究[D], 大连海事大学, 2018 年 3 月.

吕淑琪.中国绿色港口建设存在的问题和建议[J].环境科学与管理,2018,43(12):15-19.

马冬,肖寒,田苗,谢琼.中国船舶港口绿色发展现状与建议[J]. 世界环境.2019.4:22—25.

农业农村部.中国渔业统计年鉴（2019）.

清华大学.中国船舶排放环境影响评估研究.2019.2.

宋德彬,高志强,徐福祥,郑翔宇,张华,胡晓珂,黄国培,章海波.渤海生态系统健康评价及对策研究[J].海洋科学,2017,41(5):17-26.

沈兆楠,李南.基于元分析的港城关系评价：2007-2016[J].华北理工大学学报：社会科学版,2018,18(1):27-30.

索安宁,于永海,苗丽娟.渤海海域生态系统功能服务价值评估[J].海洋经济,2011,1(4):42-47.

生态环境部.2018 年中国海洋生态环境状况公报.

王刚, 雷鹏, 王占行等.日本渔港建设、管理情况及对我国渔港建设的建议[J], 中国水产, 2015(9):19-24.

王琪, 李简.我国海洋社会组织参与全球海洋治理初探[J], 中国国土资源经济, 2019 ,32(9):32-38.

温培祥.我国港口防污染应加速步入正轨[J].中国港口,2015(11):19-21.

吴兆新，赵红森，刘钦义.国外港口海铁联运发展经验与启示[J].铁道货运,2019,37(3):49-53.

赵聪蛟, 赵斌, 周燕.基于海洋生态文明及绿色发展的海洋环境实施监测[J]. 海洋开发与管理, 2017,5:91-97.

曾容,路文海,杨翼,刘捷.渤海生态环境问题与管理对策分析[J].海洋开发与管理,2015,32(5):91-96.

自然资源部. 2018 年中国海洋经济统计公报,2019.

中国石油和化学工业联合会. 2018 年中国石油和化学工业经济运行报告,2019.

Bing Qiao, Weijian He, Yujun Tian, et al. Ship emission reduction effect evaluation of air pollution control countermeasures[J]. Transportation Research Procedia, 2017, 25:3606-3618.

Dongsheng Chen, Xiaotong Wang, Peter Nelson, et al. Ship emission inventory and its impact on the $PM_{2.5}$ air pollution in Qingdao Port, North China[J]. Atmospheric environment (Oxford, England : 1994), 2017, 166:351-361.

Eva Chatzinikolaou, Manolis Mandalakis, Panagiotis Damianidis, et al. Spatio-temporal benthic biodiversity patterns and pollution pressure in three Mediterranean touristic ports[J]. Science of the Total Environment, 2018, 624:648-660.

FAO. Fishing harbor planning construction and management,2010

Izabela Kotowska, Daria Kubowicz. The role of ports in reduction of road transport pollution in port cities[J]. Transportation Research Procedia, 2019, 39:212-220.

Jean-Baptiste Bahers,Audrey Tanguy,Stephanie Pincetl. Metabolic relationships between cities and hinterland: a political-industrial ecology of energy metabolism of Saint-Nazaire metropolitan and port area (France)[J]. Ecological Economics,2020,167.

Jordi Perdiguero, Alex Sanz. Cruise activity and pollution: The case of Barcelona[J]. Transportation Research Part D, 2019.

Ma Z J, Melville D S, Liu J G, et al. Rethinking China's new great wall[J]. Science, 2014, 346: 912-914.

MEPC. Initial IMO strategy on reduction of GHG emissions from ships[S].2018.

MEPC.Revised guidelines for the identification and designation of Particularly Sensitive Sea Areas:A.982(24)[S].2005.

Sayka Jahan, Vladimir Strezov. Comparison of pollution indices for the assessment of heavy metals in the sediments of seaports of NSW, Australia[J]. Marine Pollution Bulletin, 2018, 128:295-306.

UN. Transforming our world: the 2030 Agenda for Sustainable Development。 https://sustainabledevelopment.un.org/post2015/transformingourworld