# NATIONAL REPORT OF CHINA
# on the Transboundary Diagnostic Analysis
# (TDA)

**South China Institute of Environmental Sciences, MEE**

**Guangzhou, China**

**January, 2026**

# TABLE OF CONTENTS

# List of National Authors

**Project Director**

Yunjun Yu, Senior Engineer, SCIES, yuyunjun@scies.org

**Report Authors（Sorted by the pinyin initials of the last name）**

Qinghua Chen, Professor of Engineering, SCIES, chenqinghua@scies.org

Zhonghan Chen, Senior Engineer, SCIES, chenzhonghan@scies.org

Yan Liao, Professor of Engineering, SCIES, liaoyan@scies.org

Qiuyan Li, Engineer, SCIES, liqiuyan@scies.org

Qiaoyun Lin, Engineer, SCIES, linqiaoyun@scies.org

Shuaishuai Liu, Engineer, SCIES, liushuaishuai@scies.org

Siqi Su, Engineer, SCIES, susiqi@scies.org

Haozhi Sui, Research Assistant, SCIES, suihaozhi@scies.org

Yu Xing, Engineer, SCIES, xingyu@scies.org

Mengmeng Zhao, Engineer, SCIES, zhaomengmeng@scies.org

Xiao Zhao, Professor of Engineering, SCIES, zhaoxiao@scies.org

Chao Zhong, Engineer, SCIES, zhongchao@scies.org

Yi Zhong, Senior Engineer, SCIES, zhongyi@scies.org

Guanhua Zou, Engineer, SCIES, zouguanhua@scies.org

# Contributing Institutions

South China Institute of Environmental Sciences, MEE

# List of Acronyms

AI: Artificial Intelligence

GCA: Global Center on Adaptation

GDP: Gross Domestic Product

GEF: Global Environmental Fund

IUCN: International Union for Conservation of Nature

MEE: Ministry of Ecology and Environment of the People's Republic of China

NGO: Non-Governmental Organizations

UNEP: United Nations Environment Programme

SAP: Strategic Action Programme

SCIES: South China Institute of Environmental Sciences

SDGs: Sustainable Development Goals

TDA: Transboundary Diagnostic Analysis

UNOPS: United Nations Office for Project Services

# Table of Contents with Chapter Authors listed

**1 Introduction**

（1）Siqi Su performed the analysis of the chapter about introduction, including the aim of the report, major water related problem, biogeophysical setting and assessment methodology.

（2）Xiangbin Pei designed the overall framework, objectives and direction of the chapter; provided professional guidance and advice.

**2 Socioeconomics and Climate-related threats**

（1）Guanhua Zou collected and analyzed data, conducted literature review, interpreted results, and drafted the report.

（2）Yunjun Yu performed the role of planing, organizing, scheduling and managing the overall project and coordinating the work of all participants.

（3）Xiangbin Pei designed the overall framework, objectives and direction of the project; provided professional guidance and advice.

**3 Land-Based Pollution**

（1）ZHAO XIAO conceived the study and performed the marine litter analysis.

（2）LI QIUYAN subject secretary and performed the blue economy analysis.

（3）ZHANG YUMING performed the eutrophication status analysis.

（4）LIN QIAOYUN performed the aquaculture analysis.

（5）LIU SHUAISHUAI performed the agricultural pollution analysis.

（6）CHEN ZHONGHAN performed the water quality model analysis.

**4 Ecosystems**

（1）Xiangbin Pei conceived the study.

（2）Chao Zhong performed the analysis involving seagrass.

（3）Yu Xing performed the analysis involving costal wetland.

（4）Guanhua Zou performed the analysis involving mangrove.

（5）Mengmeng Zhao performed the analysis involving seagrass.

**5 Governance**

（1）Yi Zhong collected and analyzed data, conducted literature review, interpreted results, and drafted the report.

（2）Yunjun Yu performed the role of planing, organizing, scheduling and

managing the overall project and coordinating the work of all participants.

（3）Xiangbin Pei designed the overall framework, objectives and direction of the project; provided professional guidance and advice.

**6 Conclusion of the National TDA Report**

（1）Naiwen Zhang performed the analysis of the chapter about conclusion of the TDA report, including the working grop general situation, key finding, target audience and environmental assessments.

（2）Xiangbin Pei designed the overall framework, objectives and direction of the chapter; provided professional guidance and advice.

# Executive summary

The South China Sea is a semi-enclosed sea bordered by China and relevant ASEAN countries, featuring numerous islands and possessing an unique ecosystem with rich biodiversity. In recent years, the ecological environment of the South China Sea has been facing challenges such as climate change, environmental pollution, and biodiversity loss. These three aspects are interwoven and mutually influential. Climate change has become a significant driver of changes in the marine ecological environment, like sea temperatures rising and acidification. Marine pollution threatens marine ecosystems and human health, for instance, nutrients entering the ocean via riverine input and atmospheric deposition lead to seawater eutrophication. Coastal habitat destruction and overfishing have resulted in the reduction of marine biological resources and biodiversity loss. The degradation of marine ecosystem quality caused by climate change, marine pollution, and biodiversity loss has become a major challenge for sustainable development in the region. To systematically address these three challenges, relevant coastal countries need to jointly adopt comprehensive governance measures.

This report is based on governmental publishing data and relevant literatures from China with both quantitative and qualitative analyses. It assesses the socio-economic conditions and climate change pressures, land-based pollution, ecosystem and marine environmental governance in the study region. The report also identifies priority issues and recommends priority actions, thereby supporting regional TDA/SAP efforts and providing policy recommendations on ecological and environmental protection issues in the South China Sea which national concerned and as well as on regional international cooperation.

# 1 Introduction

## 1.1 Aim of national report

As a participating country, the purposes of this report are threefold: first, to investigate and study the current status and trends of the eco-environmental quality of the coastal water and related watersheds of coastal provinces in South China, analyze existing environmental problems and their causes, summarize successful experiences, identify priority environmental issues and their solution strategies, thereby providing support for the regional TDA/SAP. Second, to provide technical support and scientific basis for China's implementation of the United Nations initiative in the South China Sea region to achieve Sustainable Development Goal 14 (Sustainable Development Goal 14, abbreviated as "SGD 14", which aims to protect and sustainably utilize the oceans and marine resources to promote sustainable development), and the fulfillment of international conventions like the Convention on Biological Diversity in the South China Sea region. Third, to provide relevant policy recommendations about ecological and environmental protection of the South China Sea and regional cooperation.

## 1.2 Biogeophysical Setting

### 1.2.1 Geomorphology and Geology

The South Sea of China refers to the vast sea area located in the southeast of China. It is situated between the Chinese mainland, the Indochina Peninsula, Borneo, Palawan, Luzon, and Taiwan Island of China. It is surrounded by islands including Sumatra, Bangka, Borneo, Palawan, Mindoro, Luzon, Taiwan, Hainan, and the Indochina Peninsula. The South Sea of China covers an area of approximately 3.5 million square kilometers, with a width of about 1,667 km from east to west and a length of about 2,693 km from north to south. Its average depth is 1,212 meters (Huang et al., 2000).

The South Sea of China is one of the largest marginal seas in the western Pacific, overall rhombus-shaped with its long axis trending NE-SW. Its geological structure is mainly controlled by four sets of faults: the N-E trending

faults in the northern and southern parts of the basin, the N-S trending faults on the eastern and western sides, the nearly E-W trending faults in the central part of the basin, and the N-W trending faults cutting across the NE-trending faults. Among these, the N-E trending faults have a particularly significant influence on the tectonic framework of the South China Sea (South China Sea Institute of Oceanology, Chinese Academy of Sciences, 1985). In terms of plate tectonics, the South Sea of China is itself part of the Eurasian Plate which is located at the inersection area of the Eurasian Plate, the Pacific Plate, and the Indian Ocean Plate (South China Sea Institute of Oceanology, Chinese Academy of Sciences, 1983). The continental shelf of the South China Sea is broad and gentle in the north and south, and relatively narrow in the east and west. The northern continental shelf develops four levels of submarine terraces at depths of 25-30 m, 35-40 m, 80-90 m, and 110-120 m. Except for the eastern part, the continental slope of the South Sea of China is broadly and step-like undulating, developing multiple submarine steps; the Dongsha, Zhongsha, Xisha, and Nansha Islands are located on the bases of these steps. The slope topography is complex, featuring both mountainous seamounts and deep-slope troughs, trenches, and submarine canyons. The central basin of the South Sea of China belongs to a broad, flat abyssal plain, with overall terrain higher in the north and lower in the south, dotted with seaknolls and seamounts.

### 1.2.2 Climatology

The South Sea of China belongs to the typical East Asian monsoon climate system, characterized by a semi-annual cycle with significant differences between winter and summer and very short transitional seasons. The winter monsoon features northeast monsoon with an average speed of 9 m/s. The summer monsoon is a weak southwest monsoon with an average speed of 6 m/s (Wang, 2022). The northeastern part of the South Sea of China is a frequent activity area for typhoons and tropical depressions, with the highest frequency of severe typhoons, typhoons, and tropical depressions all occurring in August each year. The Western Pacific subtropical high is one of the important weather systems affecting the northeastern South China Sea, during

the process of intensifying westward extension, it can also bring heavy rainfall to the northern part of the South China Sea. (Feng，2024).

The South China Sea predominantly lies within the tropical zone, with an annual mean sea surface temperature consistently ranging between 26°C and 29°C. Due to solar radiation variations with latitude, this temperature decreases as latitude increases. The uneven distribution of land and sea causes a more pronounced temperature gradient in straits and coastal waters than in open seas, with the southern Taiwan Strait exhibiting the steepest gradient. The combined effects of solar radiation, land-sea distribution, ocean currents, coastal currents, and monsoon patterns result in the South China Sea's annual mean sea surface temperature isotherms generally following a southwest-northeast orientation. (Zhanglei, 2017).

Regarding precipitation, annual precipitation in the South China Sea ranges from 1000 to 2000 mm, with clear regional differences. The northern part of the sea has distinct dry and wet seasons. The dry season is from November to March, with less precipitation, about 600 mm less than evaporation. The wet season is from May to October, with precipitation exceeding evaporation by about 800 mm. The southern part of the sea does not have a true "dry season" because precipitation exceeds evaporation in all months of the year, especially from October to January, which can be considered as a true rainy season, with precipitation about 750 mm more than evaporation. Annual precipitation in the Nansha Islands can reach 2200 mm, with up to 170 rainy days per year (Guangxi Zhuang Autonomous Region Oceanic Administration, 2017).

### 1.2.3 Biogeography

The coastal area of southern China encompasses the coastal area of six sub-national geographic region: Guangdong, Guangxi, Hainan, Hong Kong, Macao and Taiwan located in the northern part of the South China Sea. It is a key transportation hub between the Western Pacific and the Indian Ocean. The marine biota of this area exhibits typical tropical-subtropical characteristics, with superior marine resource endowments, rich fishery resources, high

species diversity, and serves as an important distribution area for typical marine ecosystems such as coral reefs, mangroves, and seagrass beds. These marine ecosystems not only provide habitats for numerous creatures but also functionally constitute ecological corridors to connect different habitats, playing crucial roles in maintaining biodiversity and facilitating material cycling and energy flow. In terms of marine economic development, leveraging its geographic location and resource advantages, the coastal area of southern China has formed a diversified industrial system represented by marine fishery, coastal tourism, and marine transportation. The marine economy continues to develop healthily, providing important support for regional social progress.

**Mangrove Ecosystems:** To protect mangroves, China has established numerous reserves in mangrove dense distribution areas along the costal area in southern China, including the Hainan Dongzhaigang National Nature Reserve, Guangxi Shankou Mangrove Ecological National Nature Reserve, Guangxi Beilun River Estuary National Nature Reserve, Guangdong Neilingding Futian National Nature Reserve, Guangdong Zhanjiang Mangrove National Nature Reserve, etc.

**Seagrass Bed Ecosystems:** China has established two seagrass reserves along the coastal area of southern China: the Hainan Lingshui Xincun Port and Li'an Port Seagrass Special Reserve and the Guangdong Zhanjiang Leizhou Seagrass County-level Nature Reserve. Additionally, the Hepu Dugong National Nature Reserve in Guangxi also focuses on seagrass bed conservation.

**Coral Reef Ecosystems:** China has established several coral reef ecosystem reserves along the coastal area of southern China, including the Hainan Sanya Coral Reef National Nature Reserve, Guangdong Xuwen Coral Reef National Nature Reserve, Guangxi Weizhou Island Coral Reef National Marine Park, and Guangdong Nan'ao Qing'ao Bay National Marine Park.

**Important Species:** There are abundant marine species in the coastal area of southern China with high ecological value. The area hosts 21 endemic marine

species, including 8 bird species such as *Gorsachius Magnificus,* 5 reptile species such as the *Dibamus Bogadeki*, 4 mammal species such as *Dugong Dugon*, and 4 amphibious animals such as *Buergeria Oxycephala*. It also hosts 33 endangered species, including 18 bird species such as *Platalea Minor* and *Larus Saundersi,* 9 reptiles such as *Eretmochelys Imbricata* and *Dermochelys Coriacea*, and 6 mammal species such as *Dugong Dugon* and *Neophocaena Asiaeorientalis.*

## 1.3 Assessment methodology

### 1.3.1 Establishment of Working Groups

SCIES established a TDA working group, with subgroups for socioeconomic and climate change stressors, land-based pollution, coastal habitats and biodiversity, and comprehensive marine ecological environment governance..

### 1.3.2 Evidence-based Assessment

**Data Collection:** primarily collecting and collating public government data and published literature, supplemented by field investigations and expert consultation.

**Technical Methods:** the report employs analytical methods such as inductive summarization, quantitative analysis, and qualitative description. By using quantitative and qualitative indicators, to ensure the accessibility of the underlying data on which the assessment is based. This process guarantees the credibility of the analysis and the recommendations. Furthermore, data are presented in forms such as charts and graphs, with supporting data and sources provided in the report appendices.

### 1.3.3 Peer Review

Data collected and preliminary conclusions in the TDA report were discussed with multiple stakeholders and consulted with experts. Through professional demonstration and exchange of opinions, the report was refined by incorporating diverse professional viewpoints.

### 1.3.4 Conceptual framework

**Drivers:** Focus on human activities such as population growth, economic development, and urbanization, as well as natural factors like global warming, to identify core drivers triggering regional environmental changes.

**Pressures:** Based on driver analysis, identify direct pressures on the marine ecological environment, including land-based pollutant discharge (domestic sewage, industrial wastewater, agricultural non-point sources), mariculture activities, marine litter input, habitat encroachment, and seawater temperature rising.

**State:** Assess the environmental and ecological status and changes in the northern part of the South China Sea under pressure, including key indicators such as seawater quality (eutrophication, acidification), ecosystem structure (area and quality of mangroves and seagrass beds), and biodiversity (population dynamics of rare species).

**Impacts:** Analyze the impacts of changes in the ecological environment state on marine ecosystem service functions, human well-being (resident health, economic benefits, public safety), and transboundary ecological environment.

**Responses:** Based on the preceding analysis, propose targeted recommendations about governance measures, policy optimization, technology research and development and regional cooperation .

### 1.3.5 Report Development Process

- February 2025: The working group started the TDA report drafting work.
- August 2025: The working group held multiple meetings to discuss and formed the first draft of the TDA report.
- August 4, 2025: The working group organized an expert consultation meeting for the TDA report, inviting 7 special experts to participate and provide suggestions on the report.
- August to November 2025: The working group conducted multiple rounds

of peer review for each chapter.

- December, 2025: The project coordination working group convened a TDA report review meeting to jointly provide recommendations on the report.
- January 2026: The working group revised and formed this version of the TDA report based on opinions of the project coordination working group.

## 1.4 Subnational Geographic Divisions

The coastal area of southern China starts from Raoping county in Guangdong province to the Beilun Estuary in the Guangxi Zhuang Autonomous Region, with a coastal line length of 6,888 km, including 403 km of coastal line in Hong Kong and Macao. The project implementation area includes 3 administrative districts: Guangdong Province, Guangxi Zhuang Autonomous Region and Hainan Province, and the adjacent coastal waters under their jurisdiction.

Since most relevant statistical data are aggregated from county to city, then from city to province/autonomous region, the project implementation area is divided into three subnational regions: Guangdong, Guangxi and Hainan.

**(1) Guangdong**

The Guangdong subnational region has 14 coastal cities and many offshore islands, including the Dongsha Islands. The 14 coastal cities from east to west are: Chaozhou, Shantou, Jieyang, Shanwei, Huizhou, Shenzhen, Dongguan, Guangzhou, Zhongshan, Zhuhai, Jiangmen, Yangjiang, Maoming, and Zhanjiang, among which Guangzhou and Shenzhen are first-tier cities in China. There are 52 rivers flowing independently into the sea in the Guangdong subnational region, with 6 major rivers discharging into the South China Sea.

The Pearl River is mainly formed by the confluence of the West River, North River, and East River, forming eight outlets in the Pearl River Delta; Han River and Rong River flow into the South China Sea via Shantou city; Moyang River flow into the South China Sea via Yangjiang city; Jian River flow into the South China Sea via Maoming city; Jiuzhou River flow into the South China Sea via Zhanjiang city.

**(2) Guangxi**

Guangxi's three coastal cities from east to west are Beihai, Qinzhou, and Fangchenggang. The Nanliu River is the largest river in Guangxi by basin area, flowing into the Lianzhou Bay of the Beibu Gulf in Hepu County, Beihai City. Qinzhou City has three major rivers: Dafeng River, Qin River, and Maoling River. The Dafeng River originates in Qinzhou and flows into the Beibu Gulf at Xiniujiao Town, Qinzhou. The Qin River and Maoling River both discharge into the Qinzhou Bay of the Beibu Gulf from Qinzhou City. Fangchenggang City has the Fangcheng River and Beilun River. The Fangcheng River eventually flows into the West Bay of Fangchenggang Port. The Beilun River is a border river between China and Vietnam, ultimately discharging into the South China Sea at Fangchenggang City.

**(3) Hainan**

The Hainan subnational region mainly focus on the main island of Hainan (China's second largest island), Zhongsha Islands, Xisha Islands, Nansha Islands and adjacent sea area under the administration of Hainan Province are not included. Hainan has 13 coastal cities/counties: Haikou, Sanya, Sansha, Danzhou, Qionghai, Wenchang, Wanning, Dongfang, Ledong, Chengmai, Lingao, Lingshui and Changjiang. The Nandu River is the largest river on Hainan Island, flowing through Danzhou, Chengmai and other cities/counties before entering the Qiongzhou Strait at Meilan District, Haikou City. The Changhua River is the second largest river on Hainan Island, traversing the central-western part of the island and flowing into the Changhua Port of the South China Sea from Dongfang City. The Wanquan River is located in eastern Hainan Island and is the third largest river, flowing into the South China Sea at Qionghai City. Additionally, Hainan has the Zhubi River, Lingshui River, and many other small rivers flowing into the South China Sea.

# Chapter References


[1] Huang Z，Guo Z, et al. National Report Of China on the Formulation of a Transboundary Diagnostic Analysis [R]: South China Institute of Environmental Sciences, 2000.

[2] Feng J, An X, Sheng L, et al. Mechanisms of Upper-Level Divergence Superimposed on Low-Level Disturbance Causing Heavy Rainfall Over the Northern South China Sea in Autumn: Case Study [J]. Journal of Geophysical Research: Atmospheres, 2024, 129(22): e2024JD041460.

[3] Wang D. Ocean Circulation and Air-Sea Interaction in the South China Sea [M]. Springer Nature Singapore，2022

[4] China Nanhai Net. The natural environment of Nanhai [EB/OL]. [4]. (2017-02-021) [2025-11-15]. http://hyj.gxzf.gov.cn/hykp_66917/hydl/t3474537.shtml

[5] South China Sea Institute of Oceanology, Chinese Academy of Sciences. Comprehensive Survey and Research Report on the South China Sea Area (1) [M]. Science Press, 1983.

[6] South China Sea Institute of Oceanology, Chinese Academy of Sciences. Comprehensive Survey and Research Report on the South China Sea Area (2) [M]. Science Press, 1985.

[7] Zhang L, Ren G, Baole E, et al. Characteristics and Long-term Changes of Surface Temperature Climatology in the South China Sea Based on Satellite Observations [J]. Advances in Climate Change Research, 2017,13(03):189-197.

# 2 Socioeconomics and Climate-related threats

## 2.1 Socioeconomics and Climate Status

### 2.1.1 Demographcis

As of the end of 2024, Guangdong, Guangxi and Hainan (hereinafter referred to as "the three South China Sea provinces/regions") had a total population of approximately 188.4 million. Specifically, Guangdong had 127.8 million people, Guangxi 50.13 million and Hainan 10.48 million, accounting for 9.05%, 3.55% and 0.74% of China’ s total population respectively.

### 2.1.2 Human Wellbeing

#### 2.1.2.1 Human Development Index

From 1990 to 2023, the Human Development Index (HDI) of Guangdong, Guangxi, Hainan and China as a whole registered a steady year-on-year increase. Specifically, Guangdong’ s HDI rose from 0.537 in 1990 to 0.823 in 2023; Guangxi’ s HDI from 0.450 to 0.760; Hainan’ s HDI from 0.503 to 0.790; and China’ s national HDI, from 0.482 to 0.797.

This reflects the sustained progress made by the three South China Sea provinces/regions and China in human development, with the outcomes of social development gradually coming to fruition.

#### 2.1.2.2 Residents' Income and Consumption

In 2024, China’ s national per capita disposable income stood at 41,314 yuan, while those of Guangdong, Guangxi and Hainan reached 51,474 yuan, 31,125 yuan and 34,829 yuan respectively.

Among consumption, food, tobacco and alcohol (29.8%) and housing (22.2%) together accounted for over 50%, making the main components of residents’ consumption. Transportation and communication (14.1%), education, culture and recreation (11.3%), and healthcare (9.0%) took up relatively high proportions, reflecting the upgrading of residents’ demands for quality of life,

health and education.

#### 2.1.2.3 Education

From 2020 to 2024, the number of regular institutions of higher education, enrolled students, and full-time teachers in the three South China Sea provinces/regions all maintained a growth trend. This indicates that the higher education sector of these three provinces/regions is in a phase of steady expansion in terms of scale, with Guangdong taking the lead.

### 2.1.3 Economic Activities

#### 2.1.3.1 Gross Domestic Product

In 2024, China's Gross Domestic Product (GDP) reached 134908.35 billion yuan. The GDP of Guangdong, Guangxi and Hainan stood at 14163.38 billion yuan, 2864.94 billion yuan and 793.57 billion yuan respectively, accounting for 10.50%, 2.12% and 0.59% of China’s GDP.

#### 2.1.3.2 The operation status of the marine economy in the South China Sea

According to data from the past five years (South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China, 2025), the Marine Gross Domestic Product (MGDP) of the South China Sea grew from 1.85942 trillion yuan in 2020 to 2.53104 trillion yuan in 2024, with its share of the regional GDP rising from 13.4% to 14.2%. In 2024, the added value of the marine industries in the region surpassed the 1-trillion-yuan threshold, hitting 1.00684 trillion yuan, which accounted for 39.7% of China’s total MGDP. The nominal growth rate of the South China Sea’s MGDP stood at 5.4% in 2024, outpacing the regional economic growth rate of 4.6%.

In terms of marine industries, marine tourism ranked first with a 42.7% share, boasting strong growth momentum and emerging as a key pillar of the marine economy. Marine transportation (14.3%) and marine fishery (13.3%) also occupied important positions, serving as core components of the marine economy.

#### 2.1.3.3 Agriculture

In 2023, China's national grain planting area reached 118,970 thousand hectares, with a total output of 695,410 thousand tons and a gross output value of approximately 15850.72 billion yuan.

At the provincial level, the grain planting areas in Guangdong, Guangxi and Hainan were 2,229.51 thousand hectares, 2,834.7 thousand hectares and 273.59 thousand hectares respectively, with corresponding outputs of 12,851.9 thousand tons, 13,953.6 thousand tons and 1,470.2 thousand tons.

#### 2.1.3.4 Industry

The industrial production of the three South China Sea provinces/regions presents distinct development characteristics and scales. As a major industrial province, Guangdong boasts prominent advantages in the electronic information industry, has a solid foundation in heavy industries such as steel and chemicals, and maintains high output in its traditional home appliance industry. Guangxi is dominated by resource-based industries and serves as a major national sugar production base. Hainan’s industrial production scale is relatively small compared with Guangdong and Guangxi, with chemical fertilizers as its relatively prominent product category in terms of output.

### 2.1.4 Climate-related threats

#### 2.1.4.1 Ocean Acidification

Since the 20th century, the ocean has absorbed nearly one-third of the $CO_2$ produced by human activities (Sabine et al, 2004). The surface seawater in the northern South China Sea has undergone significant acidification, with the pH of the seawater decreasing by approximately 0.1 pH at a rate of 0.0102 (±0.0017) pH per decade since the 1920s (Kang et al, 2021).

#### 2.1.4.2 Ocean Warming

Over the past century, the sea surface temperature (SST) in the South China Sea has risen amid global warming, with a warming range of approximately 0.7-1.2°C, and the warming rate is still accelerating. In addition, both the

frequency and duration of marine heatwave events in the South China Sea have increased significantly over the past four decades (Climate Change Center of China Meteorological Administration, 2025). Between 2010 and 2019, the occurrence probability of extreme marine heatwaves was more than four times that of the 1980s (Tan et al, 2022).

#### 2.1.4.3 Sea Level Rise

Global climate warming has led to sea level rise. The sea level rise rate along China's coasts was 4.0 mm/year from 1993 to 2024 (Climate Change Center of China Meteorological Administration, 2025). Over the similar time period, the South China Sea region also registered a sea level rise rate of 3.5 mm/year, and projections indicate that sea levels along the South China Sea coasts will rise by 80-190 mm over the next 30 years. (Ministry of Natural Resources of the People's Republic of China, 2024).

#### 2.1.4.4 Coastal Erosion

Coastal erosion disaster refers to the phenomenon of coastline retreat toward the land and coastal land loss caused by a combination of natural dynamics and human activities. In 2022, erosion occurred in the sandy monitored coastal segments of the three South China Sea provinces/regions, where the maximum annual erosion depth reached over 10 meters in some segments, with beach down-cutting issues also observed in certain areas (South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China, 2023).

## 2.2 Discussion and Conclusion

### 2.2.1 Risk assessment from socioeconomic trends

#### 2.2.1.1 Urban Sustainable Development Risks

Climate change exerts multifaceted impacts on urban development. It not only affects the natural environment of cities, but also imposes significant shocks on urban infrastructure, economic development, and residents' livelihoods. For instance, frequent heavy rainfall exacerbates urban waterlogging, damages underground pipe networks, and impairs the normal

operation of water supply and drainage systems (Fan, 2024). In addition, climate change has compelled cities to place greater emphasis on resilience building to enhance cities' disaster resistance capacity (Zhao et al, 2025), requiring that climate change factors be fully considered in urban planning and construction processes, which in turn increases the costs of urban development.

#### 2.2.1.2 Risks of Sustainable Development of the Blue Economy

Climate change-induced marine environmental changes are prone to directly impact the blue economy centered on marine industries, significantly elevating their development risks. Specifically, variations in sea surface temperature and sea level have altered the distribution pattern of some economic fish resources in the South China Sea (Xiong et al, 2024); ocean acidification has intensified the survival pressure on shellfish and other organisms, reducing their growth rate and survival rate; extreme climate events such as strong typhoons have frequently damaged industrial infrastructure and caused shocks to industrial chains. In 2023, three typhoon storm surge disasters in the three southern coastal provinces directly resulted in economic losses of 315.6389 million yuan (South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China, 2024).

### 2.2.2 Risk assessment from climate- and environment-related threats

#### 2.2.2.1 Risk of Ocean Warming

Ocean warming is a core manifestation of global climate change in the marine realm. The continuous accumulation of ocean heat and its uneven regional distribution trigger a series of cascading risks, such as accelerating sea level rise and ocean acidification (Tan et al, 2025), disrupting the survival and spawning rhythms of marine organisms, and impairing biodiversity (Wernberg et al, 2025); they also disrupt the distribution of fishing grounds and reduce the stability of fishery resources (Dong, 2025). In addition, ocean warming is recognized as the primary cause of ocean deoxygenation. Over the past 50 years, the global open oceans are estimated to have lost 2% of their oxygen (Breitburg et al, 2018).

#### 2.2.2.2 Risk of Ocean Acidification

Ocean acidification is one of the major environmental challenges currently facing marine ecosystems, which may lead to hindrance in the growth and development of marine organisms, a decline in marine biodiversity, and degradation ecosystem functions.

Ocean acidification affects the photosynthesis of marine phytoplankton. It alters the distribution and composition of inorganic carbon in seawater, thereby impacting the photosynthetic carbon fixation of phytoplankton, which may lead to a reduction in phytoplankton productivity (Dai et al, 2025). Meanwhile, it may also increase the occurrence of harmful algal blooms and raise the probability of red tide events (Ma, 2018).

Ocean acidification disrupts the behavioral activities of marine organisms. It impairs the nervous systems of marine organisms, reduces their sensitivity to environmental changes, and even causes them to lack escape behaviors in critical situations (Sun et al, 2023). If the acidification level exceeds the tolerance range of fish, it will also lead to abnormal physiological states or even death (Liu et al, 2012).

Ocean acidification reshapes the pattern of fishery resources. It inhibits the physiological functions of fish, especially calcification-dependent species such as sea bream and flounder, which grow slowly in acidic seawater, experience population declines, or migrate to areas with lower acidity (Liu et al, 2024). In addition, studies have indicated that compared with 2015, future ocean acidification may cause a 11.65%-26.80% decrease in crab resources in marine areas by 2100 (Chen, 2020).

#### 2.2.2.3 Risk of Sea Level Rise

Sea level rise has exacerbated coastal erosion, seawater intrusion, and soil salinization, while impairing the protective functions of coastal flood control and drainage infrastructure. From 1980 to 2023, sea levels along China's coasts generally exhibited an accelerated rising trend (Climate Change Center of China Meteorological Administration, 2024), placing increasing pressure on

coastal flood control and drainage infrastructure. The rate of coastline erosion has accelerated in many areas along the northern South China Sea coast; the average erosion rates in multiple locations in Guangxi and Hainan were higher than in previous years, with the maximum erosion distance reaching 16.7 meters (South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China, 2024). In addition, it has been found that driven by factors such as sea level rise and tidal current erosion, the area of Luodousha Island in Zhanjiang, shrank by nearly half between 1973 and 2020 (Nanfang Daily, 2024).

#### 2.2.2.4 The Risk of Extreme Weather and Climate Events

Amid the backdrop of global warming and sea level rise, extreme weather and climate events such as storm surges, cold waves, and heavy rainfall have become more frequent. In 2023, three typhoon-induced storm surge disasters occurred in the South China Sea region, causing direct economic losses of 315.6389 million yuan (South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China, 2024). At the end of 2023, Guangdong experienced a severe cold wave process, which was the second strongest cold air event to impact Guangdong in December since 1978 (Guangdong Meteorological Bureau et al, 2024). In 2024, the cumulative precipitation during the pre-flood season in South China was 40% above the normal level, with the Pearl River Basin seeing its highest precipitation on record (China Meteorological Administration, 2024). In 2024, the number of average summer days in Guangdong reached 233, marking the longest summer in the province since the start of meteorological records (Guangdong Weather, 2025). The frequent occurrence of extreme weather and climate events poses severe challenges to ecological security protection, disaster risk prevention and control, and the sustainable economic and social development of the South China Sea.

### 2.2.3 Mitigating socioeconomic vulnerability from climate-mediated environmental change- current actions and gaps

Through systematic planning and multi-dimensional policy interventions, China has undertaken targeted efforts to address marine environmental changes in such key areas as ecological protection and restoration, disaster prevention and control, and institutional innovation. However, the issue of climate change is complex, and it will be necessary to continuously deepen marine climate governance in the future.

#### 2.2.3.1 Current Actions

Firstly, systematically carry out marine ecological restoration to mitigate the economic impacts of marine environmental changes. China has orderly implemented major marine ecological protection and restoration projects. From 2016 to 2023, central fiscal funds have cumulatively invested 25.258 billion yuan to support 175 major marine ecological protection and restoration projects, driving the nationwide remediation and restoration of nearly 1,680 kilometers of coastline and over 750,000 mu of coastal wetlands (State Council Information Office, 2024). Among these efforts, the restored area of mangrove forests and the construction mileage of ecological seawalls have steadily increased; which built a multi-layered defense system against coastal erosion, significantly enhancing disaster resilience and adaptability to sea level rise, and reducing disaster losses. Coastal wetland restoration has simultaneously improved ecological carbon sequestration capacity, providing support for the exploration of blue carbon trading and the green and low-carbon transition of coastal areas. Meanwhile, the implementation of these projects has boosted the development of related industries and spawned new economic growth drivers.

Secondly, strengthen the comprehensive prevention and control of marine disasters to avert coastal economic losses caused by marine disaster risks. China has actively improved the marine disaster observation, early warning and assessment system, achieving full-coverage large-scale monitoring of

major marine ecosystem types, with the number of offshore ecological trend monitoring stations exceeding 1,600 (State Council Information Office, 2024). It has also carried out the construction of coastal shelterbelts and disaster prevention and mitigation facilities, and regularly released marine climate prediction products and marine ecological early warning and monitoring bulletins, among other outputs (Ministry of Ecology and Environment of the People's Republic of China, 2024). The development of comprehensive marine disaster prevention and control has ensured the stable operation of industrial clusters related to the marine economy and enhanced the regional economic resilience to risks.

Third, enhance capacity to adapt to climate change and strengthens economic resilience amid climate change impacts. China strengthens the guidance role of strategic planning, by formulating and implementing the National Strategy for Climate Change Adaptation 2035. China enhances the assessment of climate change impacts and risks, issues the Technical Guidelines for the Assessment of Climate Change Impacts and Risks (Trial Implementation), and compiles and develops the China Dataset of Climate Change and Its Impact and Risk Indicators (2025). China advances targeted adaptation in key sectors， with rolling out the National Action Plan for Climate Change Adaptation in Health (2024–2030) to boost climate resilience in health and public health; refines the climate change monitoring, assessment and early warning system, with the release of the China Action Plan for Early Warning for Climate Change Adaptation (2025–2027) (Ministry of Ecology and Environment of the People's Republic of China, 2025); and provides support for the development of climate-resilient cities (Ministry of Ecology and Environment of the People's Republic of China et al, 2022). Coastal cities such as Shenzhen actively carry out pilot practices, building more resilient urban systems by improving basic support capacity and promoting sponge city construction, among other measures (Shenzhen Municipal Ecology and Environment Bureau et al, 2024). China’s steadily improved capacity to adapt to climate change has provided strong support for addressing economic uncertainties caused by climate risks and advancing the optimization and

upgrading of industrial structures in coastal areas.

#### 2.2.3.2 Gaps

First, the technical support capacity for marine ecological restoration needs to be enhanced. There is insufficient understanding and grasp of the evolutionary laws and damage mechanisms of ecosystems in different sea areas; research on the coordination mechanism between ecological restoration and disaster defense is inadequate; the evaluation of restoration effectiveness needs further research; funding is dominated by central fiscal allocations, and market-oriented incentive mechanisms for social capital participation await further development.

Second, the understanding of and response measures to climate change urgently need to be upgraded. There is an urgent need to deepen the understanding of the complexity, extensive coverage and far-reaching nature of climate change’s direct and indirect threats to natural ecosystems and economic and social systems. Relevant theoretical and technological research are relatively weak, and the supply of knowledge and experience remains insufficient (Ministry of Ecology and Environment of the People's Republic of China et al, 2022).

### 2.2.4 Priority Action Recommendations

#### 2.2.4.1 Strengthening the research and development of marine ecological restoration technologies

Strengthen the underpinning role of basic research, conduct systematic research focusing on the evolutionary laws and damage mechanisms of ecosystems in different sea areas, and develop a collaborative working model for ecological restoration and disaster prevention. Improve the ecological restoration effectiveness evaluation system, and refine evaluation indicators, standards, and processes. Improve market-oriented incentive policies, optimize the environment for social capital participation, and expand investment and financing channels.

#### 2.2.4.2 Strengthen Basic Research and Technological R&D for Climate Change Adaptation

Carry out systematic basic research on climate change adaptation, and strengthen research on major issues such as climate change monitoring and early warning, impact analysis and risk assessment, and vulnerability and adaptive capacity assessment; intensify development of key technologies for climate change adaptation, and promote the integrated innovation of adaptation technologies (Ministry of Ecology and Environment of the People's Republic of China et al, 2022).

## 2.3 Methodology and analysis

### 2.3.1 Workgroup Formation

Establish a Working Group Under the "1+N" Model. Designate 1 seasoned overall coordinator to oversee the overall work, and assign N specialized leaders for specific fields such as data collection, technical analysis, and report writing. Develop a TDA Specialized Personnel Responsibility Allocation Schedule to clearly define the specific duties of each member.

### 2.3.2 Data Collection and Processing

Data collection will be mainly based on publicly available government statistical data, supplemented by data from academic databases, online libraries, and authoritative internet information platforms. Meanwhile, relevant data for the report will be obtained through interviews, exchanges, and consultations with relevant stakeholders and authoritative experts in the field. The collected data and preliminary analysis conclusions will be discussed with multi-stakeholders, and final data outcomes will be formed through professional demonstration and opinion exchange.

### 2.3.3 Report Compilation

Each specialized leader will draft the content of the corresponding chapters in accordance with their division of labor, based on the collected data and analysis results. The overall coordinator will integrate the draft report to check

for content coherence and consistency; organize internal review meetings, invite experts to evaluate the report, and solicit revision suggestions.

### 2.3.4 Outcome

The report was revised and improved in accordance with the review comments, and the final draft was formed after confirmation by multiple parties including government departments and industry experts.

# Chapter References


[1] Breitburg D, Levin A L, Oschlies A, et al. Declining oxygen in the global ocean and coastal waters[J]. Science, 2018, 359(6371): eaam7240.

[2] CityPopulation.de. Population Statistics in Maps and Charts for all Countries in Asia [EB/OL]. (2023-01-31)[2025-07-28]. https://www.citypopulation.de/en/asia/.

[3] Dai R, Wen Z, Hong H, et al. Eukaryotic phytoplankton drive a decrease in primary production in response to elevated CO2 in the tropical and subtropical oceans [J]. Proceedings of the National Academy of Sciences, 2025, 122(11): e2423680122.

[4] Global Data Lab. IWI Downloads [EB/OL]. (No release date))[2025-07-28]. https://globaldatalab.org/mygdl/downloads/iwi/.

[5] Hong Kong Census and Statistics Department. Hong Kong Statistical Yearbook 2023[R], 2023.

[6] Tan H, Cai R, Wu R. Summer marine heatwaves in the South China Sea: Trend, variability and possible causes[J]. Advances in Climate Change Research, 2022, 13(3): 323-332.

[7] Kang, H., Chen, X., Deng, W, et al. Skeletal Growth Response of Porites Coral to Long-Term Ocean Warming and Acidification in the South China Sea[J].Journal of Geophysical Research: Biogeosciences,2021,126(10):

[8] IPCC. Climate Change 2014:Synthesis Report. Contribution of Working Groups I,II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate - Change[R/OL]. Geneva, Switzerland: IPCC, (2015-12-17)[2025-07-28]. http://www.ipcc.ch/pdf/assessmentreport/ar5/syr/SYR_AR5_FINAL_full.pdf.

[9] Sabine C L, Feely R A, Grube N, Key R M, Lee K, Bullister J L, Wanninkhof R, Wong C S, Wallace D W R, Tilbrook B, Millero F J, Peng T-H, Kozyr A, Ono T, Rios A F. The oceanic sink for anthropogenic CO2[J]. Science, 2004,305:367-371.

[10] Sarma S S V V ,Bhaskar U S V T .Ventilation of Oxygen to Oxygen Minimum Zone Due to Anticyclonic Eddies in the Bay of Bengal[J]. Journal of Geophysical Research: Biogeosciences, 2018, 123(7): 2145-2153.

[11] Tan Z ,Schuckmann V K ,Speich S , et al.Observed large-scale and deep-reaching compound ocean state changes over the past 60 years[J].Nature Climate Change,2025,(prepublish):1-11.

[12] Wernberg T ,Thomsen S M ,Burrows T M , et al.Marine heatwaves as hot spots of climate change and impacts on biodiversity and ecosystem services[J].Nature Reviews Biodiversity,2025,1(7):1-19.

[13] Xiong P, Cai Y, Jiang P, et al. Impact of climate change on the distribution of Trachurus japonicus in the Northern South China Sea [J]. Ecological Indicators, 2024, 160: 111758.

[14] Chen X，Wei G，Deng W，Zou J, et al.. Reef Water pH Variation and Its Implications for Ocean Acidification [J]. Tropical Geography ( in Chinese )，2016，36（1）：41-47.

[15] Chen P. The influence of Ocean acidification to the global fisheries and regional fisheries resources (East Bering Sea) [D]. Shanghai Ocean University, 2020.

[16] Chen Y, Chao Q. 100 Questions on Carbon Peaking and Carbon Neutrality[J]. State-owned Enterprise Management (in Chinese), 2021, (16): 12.

[17] Dong Z. Research progress on marine fishery resources and their biological responses in the context of ocean warming: a review [J]. JOURNAL OF Dalian Ocean University (in Chinese), 2024, 39(05): 729 - 738.

[18] Fan L. Innovation Paths of Urban Resilient Governance Model Under the Background of Frequent Extreme Weather[J]. National Governance (in Chinese), 2024, (01): 73-76.

[19] Guangdong Meteorological Bureau, Hong Kong Observatory, Macao Meteorological and Geophysical Bureau. 2023 Climate Monitoring Bulletin of the Guangdong-Hong Kong-Macao Greater Bay Area[R]. 2024.

[20] Guangdong Provincial Bureau of Statistics, Survey Office of the National Bureau of Statistics in Guangdong. Guangdong Statistical Yearbook 2023[R]. 2024.

[21] Guangdong Weather. Top 10 Weather and Climate Events in Guangdong in 2024[EB/OL]. (2025-03-20) [2025-11-31].

https://mp.weixin.qq.com/s/yBynrEaKlMEegR7hr3nP8w.

[22] Guangxi Zhuang Autonomous Region Bureau of Statistics, Survey Office of the National Bureau of Statistics in Guangxi. Guangxi Zhuang Autonomous Region Statistical Yearbook 2023[R]. 2024.

[23] National Bureau of Statistics of China. National Data [EB/OL]. (No release date) [2025-07-28]. https://data.stats.gov.cn/index.htm.

[24] National Bureau of Statistics of China. Statistical Communique of the People's Republic of China on National Economic and Social Development in 2024[R]. 2025.

[25] Hainan Provincial Bureau of Statistics, Survey Office of the National Bureau of Statistics in Hainan. Hainan Statistical Yearbook 2023[R]. 2024.

[26] Liu H，Zhang Z，Guan S, et al. A review of comprehensive effect of ocean acidification on marine fishes[J]. Acta Ecologica Sinica (in Chinese), 2012, 32( 10) : 3233-3239.

[27] Liu Y, Zhang S, Sun S, et al. Impacts of Climate Change on Coastal Fisheries and Corresponding Suggestions[J]. China Fisheries (in Chinese), 2024, (12): 46-47.

[28] Ma S. Studies on responses of phytoplankton and community structure to ocean acidification [D]. Shanghai Ocean University, 2018.

[29] Sun P, Yang J, Qin Y, et al. Research Progress on the Impacts of Ocean Acidification on Marine Organisms[J]. South-Central Agricultural Science and Technology (in Chinese), 2023, 44(09): 231-236.

[30] Tian S, Liu X, Hua C, et al. Status and Management Challenges of Fishery Resources in the South China Sea[J]. Journal of Shanghai Ocean University (in Chinese), 2024, 33(03): 786-798.

[31] Zhang J, Su F, Wang W. Research Progress on Geography of Resources and Environment in the South China Sea[J]. Progress in Geography(in Chinese), 2018, 37(11): 1443-1453.

[32] Zhao L, Zhang C, Song J, et al. Research Progress and Prospects of Resilient Cities from the Perspective of Climate Change Cascade Effects ［J］.Journal of Catastrophology (in Chinese), 2025, 40(4) : 97-104.

[33] China Environment. Promoting Sustainable Blue Economy Transition Toward Carbon Neutrality——Focus on the Series Reports of the 2023

Annual Session of the China Council for International Cooperation on Environment and Development [EB/OL]. (2023-08-30) [2025-07-28]. https://lyj.gd.gov.cn/gkmlpt/content/4/4471/mpost_4471542.html#1988.

[34] Ministry of Ecology and Environment of the People's Republic of China. Progress Report on Climate Change Adaptation in China (2024). 2024.

[35] Ministry of Ecology and Environment of the People's Republic of China. China's Nationally Determined Contribution Report 2035 [R]. 2025.

[36] Ministry of Ecology and Environment of the People's Republic of China, National Development and Reform Commission of the People's Republic of China, Ministry of Science and Technology of the People's Republic of China et al. National Strategy for Climate Change Adaptation 2035 [R]. 2022.

[37] Ministry of Natural Resources of the People's Republic of China. 2023 China Sea Level Bulletin[R]. 2024.

[38] South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China. 2022 Marine Disaster Bulletin of the South China Sea Region[R]. 2023.

[39] South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China. 2023 Marine Disaster Bulletin of the South China Sea Region[R]. 2024.

[40] South China Sea Bureau of the Ministry of Natural Resources of the People's Republic of China. 2024 Marine Economic Operation Report of the South China Sea Area[R]. 2025.

[41] China Meteorological Administration. 2024 China Climate Bulletin[R]. 2025.

[42] Climate Change Center of China Meteorological Administration. China Climate Change Blue Book 2024[R]. 2024.

# 3 Land-Based Pollution

## 3.1 Key land-based pollution issues of concern

Marine plastic pollution, eutrophication, overfishing, as well as climate-driven sea temperature rise and ocean acidification are key factors adversely affecting the health of coastal and marine ecosystems. Accordingly, the United Nations Environment Programme has selected two indicators—marine plastic pollution and eutrophication—to assess progress toward the SDG 14.1 target of the 2030 Agenda for Sustainable Development. To assist countries in fulfilling their SDG commitments, this project primarily focuses on marine pollution issues, specifically seawater eutrophication and marine plastic pollution.

## 3.2 Environmental Quality and Pollution Status

### 3.2.1 Status and Trends of Seawater Quality

**Water quality.** Since 2010, China has comprehensively strengthened marine ecological and environmental protection, leading to a significant improvement in the water quality of the coastal areas in the northern South China Sea. In 2023, the sea area failing to meet the Category I seawater quality standards in the coastal northern South China Sea was 6,900 square kilometers, representing a 77% reduction compared to 2009. The non-excellent water quality areas were mainly distributed in coastal regions such as the Pearl River Estuary, with the exceedance of water quality indicators being inorganic nitrogen and active phosphate.

**Status of Seawater Eutrophication.** In 2023, the area of coastal waters in the northern South China Sea exhibiting eutrophic conditions measured 3,410 square kilometers. Areas characterized by severe eutrophication were predominantly concentrated in the coastal waters adjacent to the Pearl River Estuary (Ministry of Ecology and Environment, 2018-2023).

**Trends in Seawater Eutrophication.** According to the Annual Bulletin of China's Marine Ecological and Environmental Status, the area exhibiting

eutrophic conditions in the coastal waters of the northern South China Sea displayed a fluctuating trend from 2017 to 2023. The peak value was recorded in 2018, after which the extent of eutrophication generally followed a declining trajectory (Figure 3.2-1). (Figure 3.2-1). From 2020 to 2024, nutrient concentrations (specifically inorganic nitrogen and active phosphate) in the coastal waters of the three Southern Maritime Provinces demonstrated significant spatial variation. The order of concentration levels was as follows: for inorganic nitrogen, Guangdong > Guangxi > Hainan; for active phosphate, Guangdong > Guangxi > Hainan.

Imbalance in the N/P Ratio induced by eutrophication is a primary driver of marine ecosystem degradation. The N/P Ratio in the South China Sea varies across regions and under different environmental conditions. On the northern continental shelf of the South China Sea, the concentration of dissolved inorganic nitrogen in the water column exhibited an increasing trend from 1989 to 2004, with the N/P Ratio rising from approximately 10 to around 16. In Zhanjiang Bay, the N/P Ratio has remained at a relatively low level (<16) for many years. In the coastal waters of the three Southern Maritime Provinces, data from 2020 to 2024 indicate that Guangdong had a N/P Ratio ranging from 20.7 to 23.8, suggesting phosphorus limitation; Guangxi exhibited a ratio between 9.0 and 10.8, indicating nitrogen limitation; and Hainan showed a ratio of 6.5 to 9.0, also reflecting nitrogen limitation.

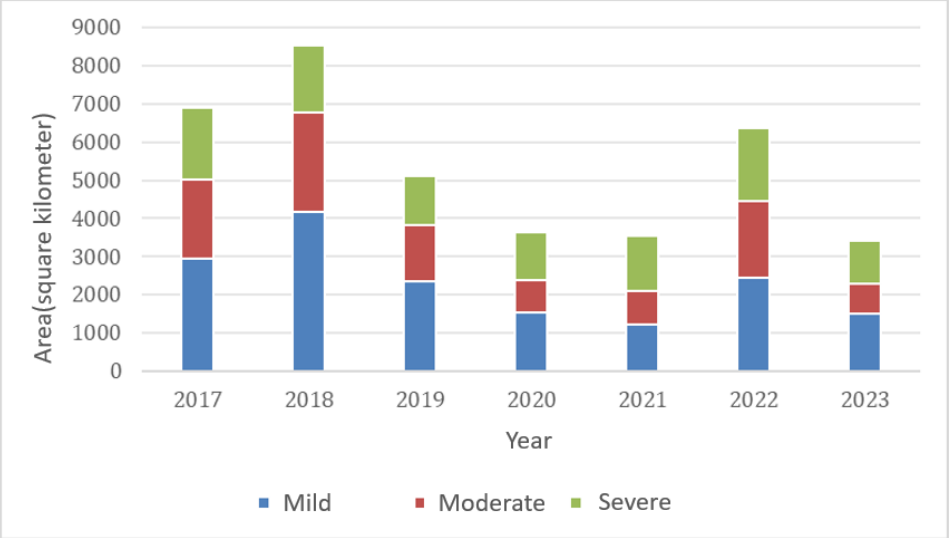


**Figure 3.2-1 The Area of Coastal Waters in the Northern South China Sea Exhibiting Eutrophic Conditions (2017-2023)**

**Table 3.2-1 Nutrient Variations in the Coastal Waters of the Three Southern Maritime Provinces (2020-2024)**

| Year | Inorganic Nitrogen (mg/L) | | | Active Phosphate (mg/L) | | | N/P Ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | Guangdong | Guangxi | Hainan | Guangdong | Guangxi | Hainan | Guangdong | Guangxi | Hainan |
| 2020 | 0.290 | 0.083 | 0.054 | 0.014 | 0.009 | 0.006 | 20.7 | 9.2 | 9.0 |
| 2021 | 0.272 | 0.092 | 0.042 | 0.013 | 0.010 | 0.006 | 20.9 | 9.2 | 7.0 |
| 2022 | 0.290 | 0.081 | 0.038 | 0.014 | 0.009 | 0.004 | 20.7 | 9.0 | 9.5 |
| 2023 | 0.251 | 0.130 | 0.039 | 0.011 | 0.012 | 0.006 | 22.8 | 10.8 | 6.5 |
| 2024 | 0.286 | 0.104 | 0.028 | 0.012 | 0.011 | 0.004 | 23.8 | 9.5 | 7.0 |

## 3.2.2 Status and Trends of Nutrient Pollution Sources

### 3.2.2.1 Status and Trends of Wastewater (Domestic and Industrial) Discharge

Since 2010, the direct discharge of nitrogen and phosphorus (specifically ammonia nitrogen and total phosphorus) into the South China Sea from China has shown a significant declining trend. In 2023, the total wastewater discharge from 146 direct discharge pollution sources (domestic and industrial) in the three Southern Maritime Provinces was approximately 1,609.88 million tons. The discharges of ammonia nitrogen and total phosphorus were 1,355 tons and 267 tons, respectively, representing decreases of 74.5% and 40.9% compared with 2010 levels.

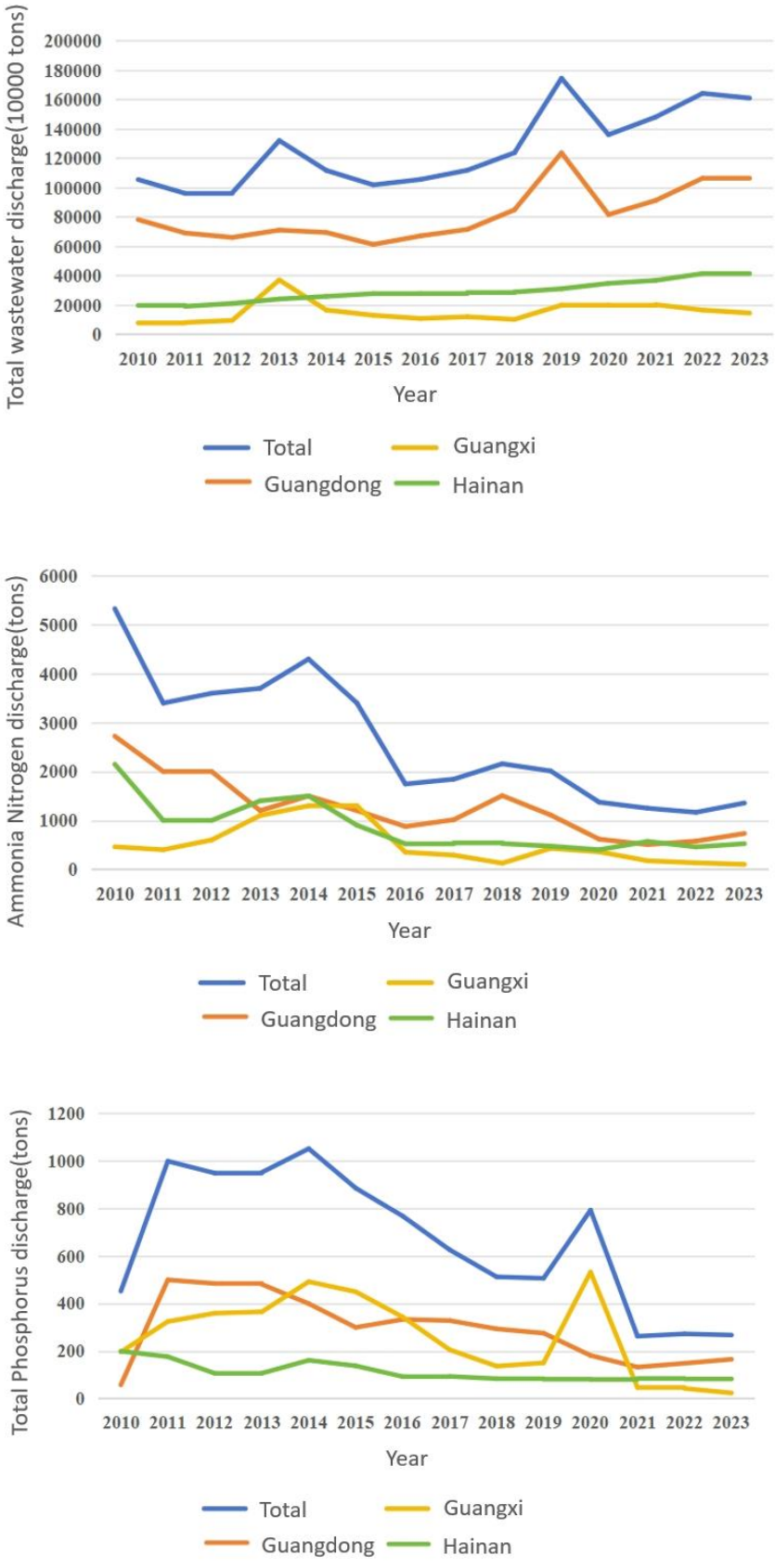


**Figure 3.2-2 Direct Discharge Wastewater Volume in the South China Sea (2010-2023)**

### 3.2.2.2 Mariculture Pollution and Trends

**(1) Mariculture Area**

According to the successive *China Fishery Statistical Yearbooks*, the mariculture areas of Guangdong, Guangxi, and Hainan in 2023 were 172,133 hectares, 69,075 hectares, and 14,673 hectares, respectively. These areas accounted for 36.1%, 31.9%, and 34.2% of their respective total aquaculture areas, with Guangdong having a slightly higher proportion. The total mariculture area in the three Southern Maritime Provinces shew fluctuating changes from 2008 to 2023 (Figure 3.2-3). Specifically, Guangdong's mariculture area in 2023 decreased by 9.3% compared with its 2008 level.

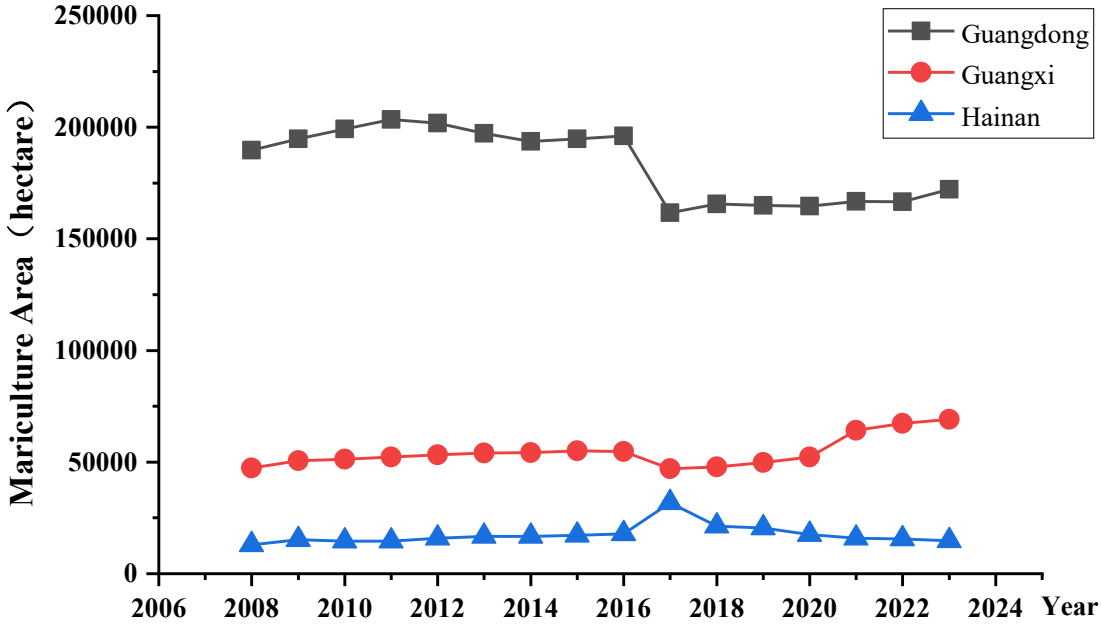


**Figure 3.2-3 Historical Trend in Mariculture Area in the Three Southern Maritime Provinces**

**(2) Mariculture Output**

According to the *2024 China Fishery Statistical Yearbook*, in 2023, Guangdong recorded the highest aquaculture output, followed by Guangxi, with Hainan having the lowest (Table 3.2-2). Compared with 2022, the total aquaculture output of the three Southern Maritime Provinces increased, with rises observed in both mariculture and freshwater aquaculture sectors.

**Table 3.2-2 Aquaculture Output in the Three Southern Maritime Provinces for 2022, 2023**

| Provinces (Regions) | 2023 Output (tons) | | | 2022 Output (tons) | | |
|---|---|---|---|---|---|---|
| | Aquaculture | Mariculture | Freshwater Aquaculture | Aquaculture | Mariculture | Freshwater Aquaculture |
| Guangdong | 7957083 | 3572835 | 4384248 | 7677336 | 3396736 | 4280600 |
| Guangxi | 3214282 | 1732371 | 1481911 | 3078015 | 1656464 | 1421551 |
| Hainan | 739147 | 286867 | 452280 | 673384 | 262605 | 410779 |

### (3) Aquaculture Pollutant Discharge

The discharge of pollutants from mariculture is closely related to factors such as farming zoning, species, and discharge periods. Since 2010, China has continuously advanced the management of mariculture pollution. The three Southern Maritime Provinces had formulated Aquaculture Waters and Tidal Flat Zoning Plans and issued Aquaculture Effluent Discharge Standards. As a result, pollutant discharges from mariculture have been brought under effective control.

### 3.2.2.3 Agricultural Non-Point Source Pollution (fertilizer consumption)

The total fertilizer consumption in t the three Southern Maritime Provinces of China, ranked from largest to smallest, is as follows: Guangxi, Guangdong, and Hainan, with consumption amounts of 28.052 million tons, 26.132 million tons, and 5.124 million tons, accounting for 47.3%, 44.1%, and 8.6% of the total respectively. In 2022, the fertilizer consumption amounts in Guangdong, Guangxi, and Hainan were 2.087 million tons, 2.492 million tons, and 455,000 tons, respectively. From 2012 to 2022, the total fertilizer consumption in the three Southern Maritime Provinces generally shew an initial increase followed by a decline (Figure 3.2-4).

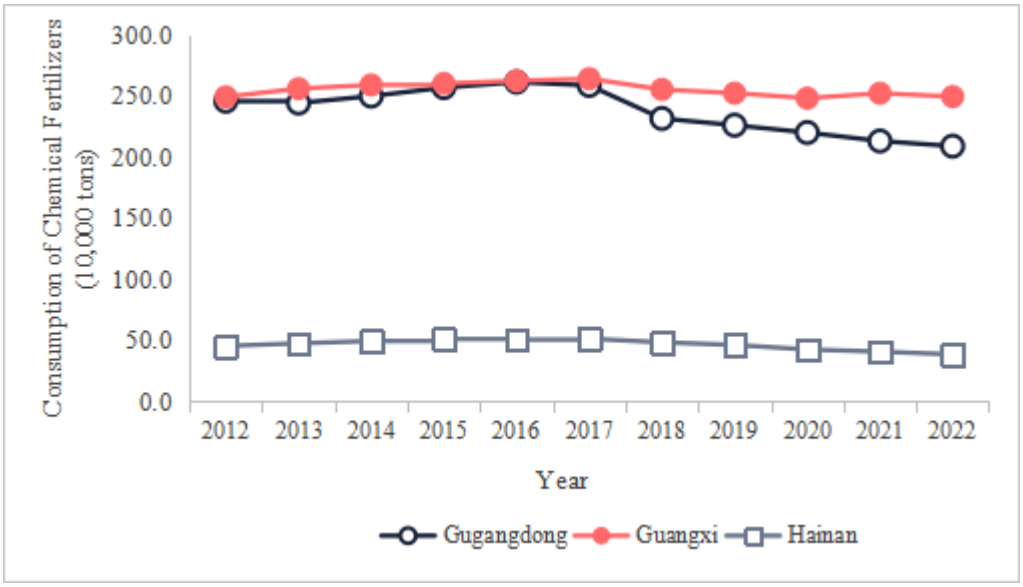


**Figure 3.2-4 Changes in fertilizer consumption in the three Southern Maritime Provinces (2012-2022)**

## 3.2.3 Status and Trends of Marine Litter and Microplastics

### 3.2.3.1 Status of Marine Litter and Microplastics.

China has included marine litter in its routine monitoring of marine ecological environment, systematically conducting regular monitoring of marine litter (including floating marine litter, beach litter, and seafloor litter in approximately 60 coastal near-shore areas nationwide). Since 2016, China has further carried out monitoring of marine microplastics. According to the *2024 China Eco-Environmental Status Bulletin*, the national average abundance of beach litter reached 59,710 items/km², with an average density of 491 kilograms/km²; plastic litter constituted the predominant category by quantity, accounting for 85.6% of the total. The national average abundance of seafloor litter was 5,051 items/km², with an average density of 5.2 kilograms/km²; plastic litter was the most numerous, accounting for 94.5%. Regarding microplastics, according to the *2024 Guangdong Eco-Environmental Status Bulletin*, the densities of floating microplastics in the Pearl River Estuary and Daya Bay were 1.36 and 1.12 items /m³ respectively. The main types were fragments, particles, fibers and foams, and the main components were polyethylene, polypropylene and polystyrene.

### 3.2.3.2 Trends of Marine Litter

According to the annual *China Marine Ecol-Environment Status Bulletins*, since 2020, the average abundance of beach and seafloor litter in China has generally shown a downward trend. By 2024, the average abundance of beach and seafloor litter had decreased by 72.4% and 31.3% respectively compared to 2020.

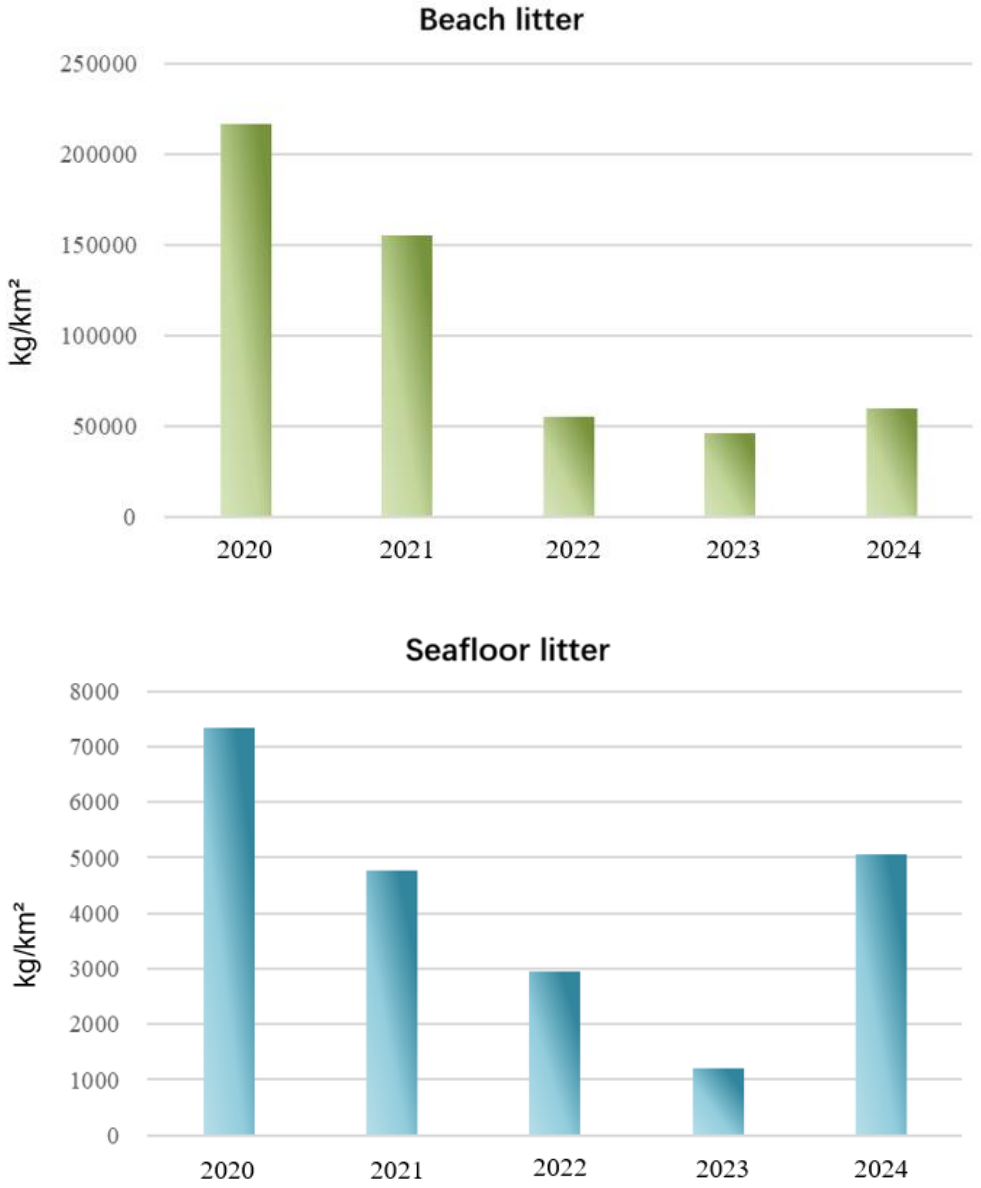


**Figure 3.2-5 Changes in the Average Number of Marine Litter in China's Coastal Waters (2019~2023)**

### 3.2.4 Key governance areas

**The definition and division criteria for key governance areas:** Coastal regions where water quality fails to meet excellent standards, exhibit

eutrophication or ecosystem degradation, and hold significant socio-economic and ecological security importance are designated as key governance areas.

The Pearl River Estuary, as the primary river discharge outlet on the northern continental shelf of the South China Sea, is recognized as one of the world's most hydrosedimentologically complex estuarine systems. The adjacent waters of the Pearl River Estuary constitute a critical strategic zone for high-quality development along China's coastal regions, a vital functional area for public access and recreational use of coastal waters, and a key ecological region for the conservation of marine biodiversity and the maintenance of ecosystem health. Moreover, this area serves as a core focal point for the integrated land–sea coordination in ecological environmental management.

The *Bulletin on the Eco-Environmental Quality of China's Coastal Waters (2016-2020)* indicates that some nearshore waters of the Pearl River Estuary have experienced moderate or severe eutrophication. The Guangdong Province Environmental Quality Bulletin indicates that the ecosystem of the Pearl River Estuary is in a sub-healthy state, with some waters showing hypoxia, and a toxic red tide occurred in the Pearl River Estuary in 2020.

China has intensified its efforts to combat pollution in the Pearl River Estuary. In February 2022, China issued *Action Plan for Comprehensive Management and Control of Key Sea Areas,* which emphasizes a focused approach targeting six coastal cities—Shenzhen, Dongguan, Guangzhou, Zhongshan, Zhuhai, and Jiangmen in Guangdong Province—along with their administered maritime zones. The initiative aims to steadily improve the water quality of coastal waters and enhance the environmental conditions of recreational coastal areas. It also seeks to protect important marine species and their habitats, thereby contributing to the development of a beautiful, livable, and economically vibrant bay area that is conducive to tourism and business activities.

Accordingly, the Pearl River Estuary has been designated as key governance area along the northern coastal waters of the South China Sea.

## 3.3 Discussion and conclusion

### 3.3.1 Priority Transboundary Pollution Issues

Land-Based nutrient input leading to eutrophication: Eutrophication is a common problem in most coastal countries of the South China Sea and the Gulf of Thailand, and it is also a concern of this project with the possibility of transboundary pollution. The impacts on maritime countries are confined to nearshore areas and remain localized, posing no significant transboundary contamination risks. However, the cumulative effects of eutrophication result in algal blooms in estuaries and coastal lagoons, which threaten critical fish spawning and nursery habitats. This, in turn, indirectly affects regional fish stocks and biodiversity.

**Marine Litter and Microplastics:** In recent years, the problem of marine litter and microplastics has become increasingly prominent, emerging as a global environmental challenge. Due to such intrinsic properties as slow degradability and pronounced capacity for long-range transport, plastic litter has become widely distributed throughout the global marine ecosystem—from coastal regions to the open ocean, from equatorial to polar latitudes, and from surface waters to the deep-sea.

### 3.3.2 Environmental and Social Impacts of Land-based Pollution

**The Impact of Land-Based Nutrient Input.** Seawater eutrophication caused by land-based nutrient input can promote the explosive reproduction of planktonic algae (such as dinoflagellates and diatoms), leading to red tides. In 2023, seven red tide events were recorded in the coastal waters of the northern South China Sea, with a cumulative affected area of 24 square kilometers. The occurrence and cumulative area of red tide detected in the coastal waters of the northern South China Sea from 2017 to 2023 are presented in the figure below. Since 2021, both the occurrence and cumulative area of red tides in this region have shown a notable decline.

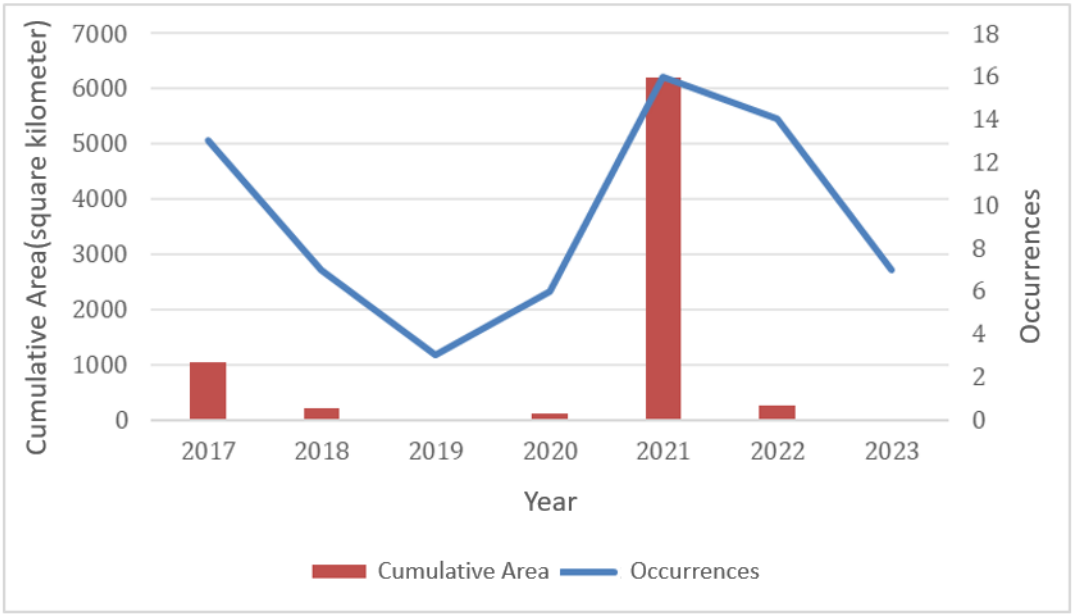


**Figure 3.3-1 Occurrence Frequency and Cumulative Area of Red Tides in Coastal Waters of the Northern South China Sea (2017-2023)**

**The Impact of Marine Litter and Microplastics.** Large marine litter can damage the landscape, affect navigation safety, and directly entangle or kill marine organisms. Due to their microscopic size, microplastics are easily ingested by marine organisms and act as "pollution vectors," adsorbing and accumulating persistent organic pollutants and heavy metals from aquatic environments. These toxic substances subsequently infiltrate the food chain, indirectly threatening human health.

### 3.3.3 Risk Assessment

**Environmental Risks from Land-Based Nutrient Input:** Persistent high inputs of land-based nutrients lead to excessive levels of nitrogen, phosphorus, and other nutrients in seawater, resulting in structural imbalances in nutrient composition in localized marine areas. This elevated nutrient loading causes issues such as hypoxia and reduced water transparency, triggering explosive algal blooms (e.g., red tides and green tides) and altering the structure and function of ecosystems. According to the *Guangdong Provincial Marine Disaster Bulletin*, during the period from 2020 to 2022, the Pearl River Estuary experienced four, eight, and two occurrences of red tide, respectively. This issue is predominantly confined to relatively enclosed environments such as

estuaries, where the natural capacity to assimilate nutrients and biodegradable organic matter is typically limited. However, with accelerating urbanization in coastal regions, alongside the increase in municipal waste as well as agricultural and industrial activities, nutrient loading is likely to escalate. This trend presents a major risk factor that may compromise the quality of coastal ecological environments.

**Environmental Risks of Marine Plastic Pollution:** Marine plastic litter poses a direct threat to marine organisms. For instance, *Mytilus galloprovincialis* and *Carcinus maenas* can ingest microplastic particles—specifically polyethylene (<80μm) and polystyrene (10μm), respectively—through their gills during respiration. Once internalized, these microplastics can cause intestinal damage (Von M N et al., 2012). Furthermore, plastic pollution may indirectly impact human health through the "ocean–food–human" chain. The trophic transfer of microplastics has been documented, demonstrating their ability to move from lower to higher trophic levels. This process can lead to disruption of food web dynamics and imbalance in ecological niches (Desforges et al., 2014). The intensification of marine plastic litter and microplastic problems may bring greater socio-economic risks to society. The development of the tourism industry may be severely affected, further lowering the socio-economic level and environmental quality of coastal areas.

## 3.3.4 Current Management Measures

### 3.3.4.1 Governance Measures for Land-Based Nutrients

**------ Implementing the Beautiful Bays Initiative:** Since 2020, China has been promoting the construction of beautiful bays, treating them as fundamental units for marine ecological and environmental protection. Guided by a systematic approach, the country has strengthened integrated land-sea coordination and implemented tailored measures for each bay to synergistically advance pollution prevention and control on land and at sea, ecological conservation and restoration, as well as coastal environmental improvement.

**------ Implementation of the Comprehensive Management Action Plan for the Pearl River Estuary Waters:** Since 2022, China has launched a comprehensive management action in the Pearl River Estuary waters, setting explicit water quality improvement targets for the area. These efforts advance coordinated governance across the Pearl River Basin and ensure a reduction in the discharge of major pollutants into the sea.

**------Promoting Agricultural Non-Point Source Pollution Control:** The systematic enhancement of fertilizer application management has been instituted, with the explicit objective of achieving zero growth in fertilizer usage and implementing initiatives for reducing application rates while improving efficiency. Technological extension and innovative models are being pursued, including soil testing and formulated fertilization practices, high-efficiency fertilization techniques, and the adoption of novel fertilizers. Specific measures encompass substituting chemical fertilizers with organic alternatives, controlling nitrogen fertilizer application, and optimizing the nitrogen-phosphorus-potassium nutrient ratio. Dedicated subsidy programs—such as those supporting green crop-livestock recycling systems and soil testing-based fertilization—have been established to foster the advancement of green agriculture.

#### 3.3.4.2 Governance Measures for Marine Litter

**------Establishing a Marine Litter Pollution Prevention System:** In October 2023, China amended the *Marine Environment Protection Law of the People's Republic of China* , comprehensively strengthening systematic governance and taking multiple measures at various stages to curb the amount of marine litter entering the sea. By intercepting, collecting, and retrieving litter already entering marine areas, followed by land-based treatment, a closed-loop management system for integrated land-sea coordination in marine litter governance was established. The law designates competent authorities at or above the county level in coastal regions to oversee marine litter pollution prevention within their jurisdictional waters. These authorities are mandated to develop monitoring and cleanup mechanisms, coordinate the planning and

construction of land-based facilities for receiving, transferring, and processing marine litter, demarcate control zones, and establish a comprehensive system for monitoring, intercepting, collecting, retrieving, transporting, and treating marine litter, with responsibility for its implementation.

**------ Implementing the Marine Litter Cleanup Action:** China organizing coastal cities to carry out a systematic three-year comprehensive marine litter cleanup action targeting 65 bays adjacent to urban built-up areas. The plan set goals such as ensuring that litter on the beaches within these 65 bays is promptly and effectively cleared by 2025, and significantly reducing the density of floating marine litter. By 2027, the density of marine litter in these bays is expected to drop significantly, reaching a consistently clean level. Six key tasks have been identified, including establishing a system, intercepting litter on land, treating it at sea, timely clearance, standardized disposal, and regular management.

**------Strengthening Plastic Pollution Control:** In January 2020, China's National Development and Reform Commission and Ministry of Ecology and Environment issued the Guideline *on Further Strengthening Plastic Pollution Control*. This policy outlines a phased approach to prohibit or restrict the production, sale, and use of specific plastic products, promotes alternative products, standardizes plastic litter recycling and recovery, and establishes a comprehensive management system covering the entire lifecycle of plastic products—from production and distribution to use, recycling, and disposal—to control plastic pollution. Addressing the issue of abandoned fishing gear, China has introduced fisheries and gear standards (e.g., mandating biodegradable materials and prohibiting fragile, low-quality gear) and requires fishers to use gear fixation devices (such as anti-loss ropes) during operations to reduce accidental loss. Additionally, policy incentives (e.g., subsidies) are provided to encourage the adoption of environmentally friendly fishing gear and reduce the use of non-degradable materials.

**------Promote a "Zero-Waste City" Construction:** Since 2018, China has launched pilot projects for building zero-waste city , advancing the construction

of such cities in 113 prefecture-level and higher administrative regions, as well as eight special areas. The initiative has focused on significantly reducing waste at the source, promoting resource utilization, ensuring safe disposal, and resolutely curbing illegal transfer and dumping. Six provinces, including Shandong, have incorporated the development of zero-waste city into local legislation. Hainan has further advanced the construction of zero-waste city across the entire province, proposing the goal of building a zero-waste city. Over the next five years, China will comprehensively promote the construction of zero-waste city in around 200 cities, support deepened cooperation and joint construction in major strategic regions, establish a zero-waste index indicator system, and facilitate the transition from "constructing" to "completing" the zero-waste city.

### 3.3.5 Gaps and Priority Challenges

#### 3.3.5.1 Gaps

**(1) The water quality standards system for coastal and marine ecosystems requires further improvement.** First, there is a lack of tropical water quality standards. Sensitive ecosystems such as coral reefs and seagrass beds cannot be adequately protected under the current water quality standards. Second, the existing surface water and seawater standards are insufficiently applicable in estuarine areas. The results of water quality assessments fail to objectively reflect the current status and trends of water environmental quality in estuarine regions.

**(2) Lack wastewater treatment technologies that synergize pollution control and carbon reduction.** Against the backdrop of climate change, there is a need to develop wastewater treatment processes that synergize pollution reduction and carbon mitigation while lowering the total nitrogen emissions from wastewater treatment plants. Approximately 80% of China’s existing municipal domestic wastewater treatment plants employ the "activated sludge method" and its improved variants (e.g., $A^2/O$, MBR), which rely heavily on energy-intensive processes such as aeration oxygenation and mixing. Moreover, these processes are prone to emitting nitrous oxide ($N_2O$), a potent

greenhouse gas, during denitrification. If efforts focus solely on "carbon reduction" by reducing aeration intensity, the removal rates of COD and $NH_3$-N may decline, compromising the fundamental goal of "pollution reduction." Conversely, if strict "pollution reduction" standards are maintained, it becomes difficult to overcome the bottlenecks of high energy consumption and carbon emissions.

#### 3.3.5.2 Priority Challenges

**(1) Urban Domestic Wastewater Treatment:** Total nitrogen (TN) in domestic wastewater is a key pollutant contributing to water eutrophication (e.g., red tides and cyanobacterial blooms). Its management involves multiple stages, including wastewater collection, treatment processes, and operational management. The priority challenges are the following: Firstly wastewater originates from diverse sources (residential, commercial, and small-scale industrial activities), leading to significant fluctuations in water quality and flow rates over time and across seasons. Secondly, Biological nitrogen removal technologies face economic inefficiencies due to challenges such as insufficient carbon sources, temperature fluctuations causing operational "shocks," and difficulties in achieving precise dissolved oxygen control.

**(2) Mariculture Pollution Control:** Mariculture pollution control is a systematic project involving ecology, technology, economy, and policy. It faces challenges such as the "conflict between the openness of the marine environment and the enclosed nature of pollution control" and the "tension between short-term economic benefits and long-term ecological protection." First, dispersed aquaculture makes centralized treatment difficult. Pollutants from decentralized farming models such as cage and mudflat aquaculture (e.g., residual feed and feces) disperse with water currents and cannot be collected for centralized treatment. For industrialized aquaculture, the cost of treating wastewater to meet discharge standards is high, making it unaffordable for small and medium-scale farmers. Second, high-salinity environments constrain treatment efficiency. Conventional microbial treatment technologies (e.g., activated sludge methods) are significantly less effective in high-salinity seawater environments. This necessitates the screening of salt-tolerant

microbial strains or the development of specialized processes, leading to substantially increased costs. Third, resource utilization is challenging. Unlike livestock and poultry waste, marine aquaculture waste (e.g., residual feed and shellfish excreta) contains high salt content. Direct use as fertilizer can cause soil salinization, leaving limited pathways for resource utilization and resulting in low economic value.

### 3.3.6 Priority Action Recommendations

#### 3.3.6.1 Priority Action Recommendations for Urban Domestic Wastewater Treatment

**Enhancing Nutrient control by improving Municipal Wastewater Treatment.** Continuous efforts are being made to address deficiencies in the collection pipe networks for urban domestic sewage, with ongoing upgrades of aging pipelines and the implementation of separate stormwater and sewage systems. Support will be provided for the research and development of economically feasible technologies that synergize pollution reduction and carbon mitigation while removing nutrients such as total nitrogen. Pilot demonstration projects aimed at enhancing the quality and efficiency of urban domestic sewage treatment plants will be steadily advanced based on local conditions. In sparsely populated, relatively decentralized areas, urban renewal zones, and newly developed districts, support will be extended for the development of integrated facilities and the construction of decentralized treatment systems along with their supporting pipe networks. This will enable on-site sewage collection, treatment, and reuse.

**Comprehensive Management of Urban Non-Point Source Pollution.** Urban non-point source pollution is characterized by its dispersed, random, and complex nature. Following the stepwise control approach of "source-migration-sink" and integrating the concept of sponge city development, comprehensive management of urban non-point source pollution is being explored. First, while ensuring urban drainage and flood control safety, decentralized source control measures are implemented through the construction of sunken green spaces, buffer zones, permeable

pavements, vegetated swales, micro-wetlands, and ecological revetments. Second, suitable rainwater runoff purification devices are adopted to enhance mid-path flow control. These include roadside vegetated swales, green spaces, rainwater sedimentation tanks, sedimentation and purification systems for combined sewer overflows, various rainwater retention basins in separated sewer systems, and oxidation ponds. These measures effectively reduce soil erosion and decrease pollutant loads in stormwater runoff. Third, natural urban depressions, ponds, and park water features are repurposed as rainwater retention basins. Natural channels and constructed wetlands are utilized to establish forest and grass buffer zones. Additionally, vegetation planting is employed to intercept pollutants in rainwater entering rivers, providing final filtration and purification treatment for runoff before it enters water bodies.

#### 3.3.6.2 Priority Action Recommendations for Mariculture Pollution Control

**Promote various green and ecological aquaculture models based on local conditions.** Encourage the development of ecological fisheries, promote new environmentally friendly floating buoys made of novel materials, support the eco-friendly modification of aquaculture gear, and ensure the centralized shore-based disposal of decommissioned and obsolete facilities. For open mariculture systems such as net-pen and raft culture, rationally determine the scale and density of aquaculture based on environmental carrying capacity, and scientifically administer feed and chemicals. Promote the orderly clearance of activities in no-aquaculture zones and accelerate the transformation and upgrading of the marine fisheries industry.

**Enhance mariculture effluent treatment technologies.** For industrial aquaculture, promote and apply Recirculating Aquaculture System technologies and construct supporting effluent treatment facilities. For pond aquaculture, build ecological purification channels, ecological ponds, and similar structures tailored to local conditions to fully reduce pollutants such as nitrogen and phosphorus from aquaculture effluent and pond sludge, while strictly implementing effluent management requirements.

#### 3.3.6.3 Priority Action Recommendations for Agricultural Non-Point Source Pollution Control

**Advance Agricultural Non-Point Source Pollution Control in Crop Farming.** Select areas with prominent non-point source pollution from crop farming, implement fertilizer and pesticide reduction and efficiency increase, carry out precision fertilization by region and crop, strengthen agricultural water-saving and emission reduction, and reduce nitrogen and phosphorus loss from farmland. Explore end-of-pipe emission reduction models and promote the construction of nitrogen and phosphorus ecological interception systems. Continue advancing pesticide reduction and harm control, improve pesticide utilization efficiency, and effectively mitigate the impact of pesticides on the water environment.

**Advance Livestock and Poultry Farming Pollution Control.** Select areas with prominent livestock and poultry farming pollution (major livestock counties and large-scale farms), carry out the resource utilization of livestock and poultry farming waste, promote the resource utilization of livestock and poultry farming waste through the entire process of source reduction, process control, and end-use, and build sustainable development models combining farming and breeding, and agricultural-pastoral cycles.

#### 3.3.6.4 Priority Action Recommendations for Marine Plastic Pollution Control

**Facilitate high-value resource utilization pathways for marine plastic litter and promote the scaling of the recycling industry chain**. Encourage enterprises to develop high-value-added products and recycle plastic litter at prices higher than market rates, thereby activating market participation incentives. Promote financial institutions to include marine plastic litter recycling projects in their green credit catalogs and encourage efforts related to the recycling and utilization of marine plastic litter.

#### 3.3.6.5 Recommendations for Regional International Cooperation

Develop regional technical guidelines for land-based pollution prevention and control. Establish a regional information exchange mechanism for land-based

pollution management, share experiences and practical cases in land-based pollution control, and organize technical exchange and training activities to enhance regional capacity in land-based pollution prevention and control.

## 3.4 Methodology and Analysis

### 3.4.1 Data Sources

China regularly discloses fundamental environmental data on government websites, including information on pollution sources, water quality, and ecological conditions. This report is based on government-published documents such as the Bulletin on Environmental Conditions, the Census Bulletin on Pollution Sources, and the Environmental Statistics Yearbook, supplemented by relevant published research papers.

### 3.4.2 Technical Standards

China has established a comprehensive system of marine-related environmental technical standards, covering environmental survey and monitoring, environmental quality standards, technical specifications for assessment, wastewater discharge standards, and more. This report primarily references standard specifications in areas such as seawater and surface water environmental quality, survey monitoring and assessment, wastewater and tailwater discharge, and marine litter monitoring and evaluation.

### 3.4.3 Report Compilation

Tasks were assigned based on the activities outlined in the project task document. Each activity lead drafted the corresponding chapter according to their assigned responsibilities, incorporating relevant data and analysis results. The thematic lead consolidated the report, ensuring data reliability and content coherence. Experts were invited to review the report and provide feedback for revisions.

### 3.4.4 Output

The report was revised and refined based on the review feedback. After

confirmation by multiple stakeholders, including government departments and industry experts, the final version was produced.

## Chapter References


[1] National Bureau of Statistics, Ministry of Ecology and Environment. China Statistical Yearbook on Environment [M/OL]. Beijing: China Statistics Press, 2012-2022.

[2] Ministry of Ecology and Environment. Bulletin on China's Marine Ecological and Environmental Status [R]. Beijing: Ministry of Ecology and Environment of the People's Republic of China, 2018-2023.

[3] Lv, Y., Yuan, J., Li, Q., Zhang, Y., Lv, X., & Su, C. Impacts of land-based human activities on coastal marine ecosystems [J]. Acta Ecologica Sinica, 2016, 36(5): 1183-1191.

[4] Wang, X. Research status and control measures of the impact of microplastics on the marine environment and fishery production [J]. Journal of Fisheries Research, 2021, 43(01): 89-97.

[5] Zhao, L., Wang, Y., Luan, S., Yang, Y., Wu, S., Wang, Z., & Li, L. Changes in water resources and eco-environmental pattern in the Guangdong-Hong Kong-Macao Greater Bay Area over the past 40 years [J]. Geology in China, 2025, 52(1): 215-231.

[6] Desforges J, Galbraith M, Ross P S, et al. Ingestion of microplastics by zooplankton in the northeast pacific ocean [J]. Archives of Environmental Contamination and Toxicology, 2015, 69(3): 320-333.

[7] Mommsen T P , Vijayan M M , Moon T W. Cortisol in teleosts: dynamics, mechanism of action, and metabolic regulation [J]. Reviews in Fish Biology and Fisheries, 1999, 9(3):211-268.

[8] Von M N, Burkhardt-Holm P, Köhler A. Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure [J]. Environmental Science & Technology, 2012, 46(20): 11327-11335.

# 4 Ecosystems

This chapter provides scientific support for marine ecological protection, resource utilization, and management decision by systematically reviewing the current status of key coastal wetland ecosystems, identifying coastal key biodiversity areas, and analyzing the key issues and changing trends in coastal wetlands. Within the working framework of SCS SAP Project, the key coastal wetland habitats addressed in this chapter primarily include mangroves, seagrass beds, and other significant coastal wetlands. Other significant coastal wetlands" refer to near-shore and coastal wetlands other than mangroves, seagrass beds, and coral reefs, primarily including estuarine waters and shallow marine waters.

## 4.1 Ecosystem Status

### 4.1.1 Mangroves Forests

#### 4.1.1.1 Status and Distribution

According to the latest reports, China's mangrove area has reached 30,300 hectares (Xinhua News Agency, 2025). Among these, Guangdong has 11,454.104 hectares (Department of Natural Resources of Guangdong Province, 2024) with 27 species distributed (Forestry Bureau of Guangdong Province, 2023). Guangxi has 10,605.3 hectares (Forestry Bureau of Guangxi Zhuang Autonomous Region, 2025) with 20 species distributed (Forestry Bureau of Guangxi Zhuang Autonomous Region, 2021). Hainan has 6,165.01 hectares (People's Government of Hainan Province, 2025) with 37 native mangrove plant species distributed (General Office of the People's Government of Hainan Province, 2025).

**Table 4.1-1 Distribution Overview of Mangroves in South China**

| Province (Autonomous Region) | Key Distribution Areas |
|---|---|
| Guangdong | Leizhou Peninsula, Shuidong Bay, Chengcun Bay, Zhenhai Bay, Qi'ao Island, Kaozhouyang, and others |
| Guangxi | Tieshan Port, Yingluo Port, Zhenzhu Bay, Lianzhou Bay, Maowei Sea, and others |
| Hainan | Dongzhai Port, Xinying Bay, Qinglan Port, Qingmei Port, Tielu Port, and others. |

#### 4.1.1.2 Trends

In recent years, China has strengthened mangrove protection efforts, enforced stricter regulations on land use, and implemented conservation and restoration projects, leading to an increase in mangrove area in the coastal regions of the South China Sea. The detailed trends are shown in the table below.

**Table 4.1-2 Changes in Mangrove Area in South China**

| Province (Autonomous Region) | Year | Area | Source |
|---|---|---|---|
| Guangdong | 2008 | 9084 ha | SCS Project Phase I Report, 2008 |
| | 2020-2023 | increased from 10,513.8 ha to 11,454.104 ha | Department of Natural Resources of Guangdong Province, 2024 |
| Guangxi | 2008 | 8375 ha | SCS Project Phase I Report, 2008 |
| | 2011 | 8780.73 ha | Forestry Bureau of Guangxi Zhuang Autonomous Region, 2021 |
| | 2024 | 10605.3 ha | Forestry Bureau of Guangxi Zhuang Autonomous Region, 2025 |
| Hainan | 2008 | 3930 ha | SCS Project Phase I Report, 2008 |
| | 2017 | 4278 ha | Liao et al, 2022 |
| | 2024 | 7638.73 ha | People's Government of Hainan Province, 2025 |

#### 4.1.1.3 Key Mangrove Areas

Strategic Action Programme for the South China Sea and Gulf of Thailand Project (abbreviated as the “SCS Phase Ⅱ Project”) selected five representative mangrove areas as demonstration areas for investigation and research: the Dongzhai Port Mangrove Demonstration Area, the Shankou Mangrove Demonstration Area, the Zhanjiang Mangrove Demonstration Area, the Yangjiang Mangrove Demonstration Area, and the Huidong Mangrove Demonstration Area.

### 4.1.2 Seagrass Beds

#### 4.1.2.1 Current Area and Distribution

The total area of seagrass beds along the South China coast is 8,933.69 hectares, with Hainan accounting for 6,727.73 hectares (Zhou Yi et al., 2023), Guangxi for 665.46 hectares (Zhou Yi et al., 2023), and Guangdong for 1,540.5 hectares (Zhong Chao et al., 2024).

The distribution of seagrass species in South China coast is shown in Table 4.3-1, with Hainan having 12 species, and both Guangxi and Guangdong having 5 species each.

**Table 4.1-3 Seagrass Species in South China coast**

| Seagrass Species | Hainan | Guangxi | Guangdong |
|---|---|---|---|
| *Thalassia hemprichii (Ehrenb.) Asch.* | √ | | |
| *Enhalus acoroides (L.f.) Steud.* | √ | | |
| *Cymodocea rotundata Asch. & Schweinf.* | √ | | |
| *Cymodocea serrulata (R.Br.) Asch. & Magnus* | √ | | |
| *Halodule uninervis (Forssk.) Asch.* | √ | √ | √ |
| *Halodule pinifolia (Miki) Hartog* | √ | | |
| *Syringodium isoetifolium (Asch.) Dandy* | √ | | |
| *Halophila ovalis (R.Br.) Hook.f.* | √ | √ | √ |
| *Halophila minor (Zoll.) Hartog* | √ | | |
| *Halophila beccarii Asch.* | √ | √ | √ |
| *Zostera japonicaSteud.* | √ | √ | √ |
| *Ruppia brevipedunculata (C.A.Mey.) Grande* | √ | √ | √ |

#### 4.1.2.2 Trends

The "Bulletin of Marine Ecology and Environment Status of China" showed that in recent years, the seagrass beds in Hepu, Guangxi and the east coast of Hainan had overall exhibited a recovery trend, with their area remaining relatively stable.

Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand (abbreviated as the “SCS Phase Ⅰ Project”) and SCS Phase Ⅱ Project, conducted approximately 20 years apart, carried out investigations of the Xincun seagrass bed and Li'an seagrass bed in Hainan, the Hepu seagrass bed in Guangxi, and the Liusha Bay seagrass bed in Guangdong. The survey results are shown in table 4.1-4.

**Table 4.1-4 Comparison of Historical Seagrass Bed Data**

| Seagrass Bed | Survey Date | Area(ha) | Biomass(g/m$^2$) | Density (shoots/m$^2$) | Number of Species | Species |
|---|---|---|---|---|---|---|
| Xincun | 2002 | 200 | 1134.4 | 1209 | 4 | *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halodule uninervis* |
| | 2021(Hainan Academy of Forestry, 2021) | 301 | 23.47 | 775.11 | 5 | *E. acoroides, T. hemprichii, C. rotundata, H. uninervis, Halophila ovalis* |
| Li'an | 2002 | 320 | 577.0 | 1200 | 5 | *E. acoroides, T. hemprichii, C. rotundata, H. uninervis, H. ovalis* |
| | 2021 | 114 | 50.54 | 248 | 4 | *E. acoroides, T. hemprichii, C. rotundata, H. ovalis* |
| Hepu | 2003 | 540 | 25.5 | 1385 | 4 | *H. ovalis, H. uninervis, Zostera japonica, Halophila beccarii* |
| | 2023(Guangxi Zhuang Autonomous Region Marine Environment Monitoring Center Station, 2023) | 48.08 | 25.0 | 4005 | 2 | *H. ovalis, H. beccarii* |
| Liusha Bay | 2002 | 900 | 22.3 | 5958 | 2 | *H. ovalis, H. uninervis* |
| | 2020(Yang Xi et al., 2023) | 710.44 | 28.42 | 973.1 | 4 | *H. ovalis, Halophila minor, H. beccarii, H. uninervis* |

#### 4.1.2.3 Key Seagrass Bed Areas

The SCS Phase Ⅱ Project selected five seagrass demonstration areas for investigation and research, including the Xincun seagrass bed in Hainan, Li'an seagrass bed in Hainan, Hepu seagrass bed in Guangxi, Liusha Bay seagrass bed in Guangdong, and Yifengxi seagrass bed in Guangdong.

### 4.1.3 Other Significant Coastal Wetlands

#### 4.1.3.1 Trends

The coastal wetlands of South China contain typical ecosystems such as coastal salt marshes, sandy coasts, and muddy coasts. Among these, the total area of coastal salt marshes is approximately 2,710 hectares, dominated primarily by native species such as *Phragmites australis*, *Cyperus*, and *Cyperus malaccensis*, as well as the invasive alien species *Spartina alterniflora*. The areas of sandy coasts and muddy coasts are approximately 55,280 hectares and 137,570 hectares, respectively (South China Sea Bureau of the Ministry of Natural Resources, 2024). Since 2012, with the slowdown in reclamation and urbanization, some coastal wetland areas have begun to recover. For instance, by 2020, the salt marsh area in Guangxi had increased by 687.99% (6,800 hectares) compared to 1990 (Cui Lijuan et al., 2022), fully demonstrating the critical role of policy adjustments in the process of wetland conservation and restoration (Wang, et al., 2021).

#### 4.1.3.2 Wetland Demonstration Area

The SCS Phase Ⅱ Project selected five coastal wetland demonstration areas for investigation and research, including the estuarine waters of Danzhou (Xinying Bay) in Hainan, the Beilun Estuary in Guangxi, the estuarine waters of Maowei Sea in Guangxi, the Pearl River Estuary, and the shallow marine waters of Dahu in Guangdong.

## 4.2 Coastal Key Biodiversity Areas

China has established a natural protected area system with national parks as the core, nature reserves as the foundation, and natural parks as supplements. The coastal key biodiversity areas in South China presented in this section are the major protected areas in the waters surrounding the demonstration areas, as shown in Table 4.2-1.

**Table 4.2-1 Key species and transboundary significance of coastal key biodiversity areas in South China**

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Protection Target / Key Species | Transboundary Significance |
|---|---|---|---|---|---|
| 1 | Hainan | Coastal waters of northeastern Hainan Island | National Nature Reserve in Dongzhai Port of Hainan | Mangrove ecosystem; key organisms including 38 mangrove plant species (including introduced species), 217 bird species, 13 amphibian and reptile species, 208 insect species, 174 fish species, and 221 macrobenthic species. | The migration sites of the *Limosa limosa*, *Anas clypeata*, *Charadrius mongolus*, *Charadrius leschenaultii*, *Tringa nebularia*, *Tringa totanus*, and other species, serve as crucial nodes along the East Asian–Australasian flyway |
| 2 | | | Mangrove Provincial Nature Reserve in Qinglan Port of Hainan | Mangrove ecosystem; key organisms including 36 mangrove plant species, 112 bird species, 25 insect species, 300 fish species, and 218 macrobenthic species. | A secure migratory corridor for migratory birds such as *Platalea minor*, *Platalea leucorodia*, *Tringa guttifer*, and *Egretta eulophotes*. |
| 3 | | Coastal waters of northwestern Hainan Island | Mangrove Municipal Nature Reserve in Xinying Bay of Danzhou | Mangrove ecosystem; key organisms including 26 mangrove plant species, 2 seagrass species, 28 fish species, 13 amphibian species, 175 bird species, 15 mammal species, among others. | An important wintering ground for protected birds such as *Platalea minor*, *Eurynorhynchus pygmeus*, *Tringa guttifer*, and *Plegadis falcinellus*. Tens of thousands of waterbirds winter here annually. |
| 4 | | Coastal waters of southern Hainan Island | Mangrove Municipal Nature Reserve in Tielu Port | Mangrove ecosystem; key organisms including 104 mollusk species, 16 crab species, 50 fish species, and 122 bird species, among others. | Located on the East Asian-Australasian flyway, it provides vital support for the migration of numerous waterbirds each year, including supply, rest, refuge, and transit (Sanya Daily Digital, 2024). |
| 5 | | | Special Marine Protected Areas for Seagrass in Xincun Port and Li'an Port of Lingshui | Mangrove ecosystem and seagrass bed ecosystem, supporting 14 mangrove plant species and 5 seagrass species. | The migratory corridor of birds including *Egretta garzeta*, *Spatula querquedula*, *Himantopus himantopus*, and *Platalea leucorodia*. |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Protection Target / Key Species | Transboundary Significance |
|---|---|---|---|---|---|
| 6 | Guangxi | Surrounding waters of Beihai | Dugong National Nature Reserve in Hepu of Guangxi | Dugongs, *Sousa chinensis*, and their marine ecosystems; additionally, the area supports 11 mangrove plant species and 4 seagrass species. | The area has a population of over 50 *Sousa chinensis* and also serves as a migratory bird flyway. |
| 7 | | | Mangrove Ecological National Nature Reserve in Shankou of Guangxi | Mangrove ecosystem; key organisms including 16 mangrove plant species, 251 macrobenthic species, 137 fish species, and 253 bird species, among others. | The protected area is located along the East Asian–Australasian flyway, serving as a critical stopover site and habitat for migratory birds, with tens of thousands of birds resting and foraging here annually. It was listed as a Wetland of International Importance in 2002 and serves as a key platform for international ecological cooperation. |
| 8 | | | National Coastal Wetland Park in Beihai of Guangxi | Wetland ecosystem and migratory bird flyway; key organisms including 19 mangrove plant species, 239 bird species, 208 benthic species, and *Chelonia mydas*, among others (Xinhua News Agency, 2025). | Located on the East Asian-Australasian flyway, it serves as an excellent "staging and refueling station" for migratory birds, as well as an important wintering ground, stopover site, and breeding ground for coastal bird species. |
| 9 | | Coastal waters of Qinzhou | Mangrove Nature Reserve in Maowei Sea of Guangxi | Mangrove ecosystem and waterbird habitat, including 14 mangrove plant species such as *Bruguiera gymnorhiza*, and endangered birds such as *Platalea minor* and *Eurynorhynchus pygmeus*. | Serving as a critical node along the East Asian–Australasian flyway, it holds global significance for the conservation of transnational migratory species such as *Platalea minor* (Southern Daily Online, 2024). |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Protection Target / Key Species | Transboundary Significance |
|---|---|---|---|---|---|
| 10 | | Coastal waters of Fangchenggang | National Nature Reserve in Beilun Estuary of Guangxi | Mangrove ecosystem; key organisms including 16 mangrove plant species, 251 macrobenthic species, 137 fish species, and 253 bird species, among others. | The protected area is situated at the convergence of the East Asian coastal route and the Central Siberia-Central China avian migration flyways, serving as a critical migratory corridor and habitat for migratory birds. It represents China's only border mangrove forest and plays a vital role in maintaining ecological stability and marine environmental security in the border region. |
| 11 | Guangdo-ng | Pearl River Estuary and its surrounding waters | Pearl River Estuary Chinese White Dolphin National Nature Reserve | *Sousa chinensis*, *Neophocaena phocaenoides*, other marine organisms and their habitats, mangroves, estuarine wetlands, other marine biological resources (CCTV Science and Education Channel, 2024). | As the world's largest habitat for *Sousa chinensis*, it holds significant importance for maintaining the species' gene pool and ecological balance. |
| 12 | | | Guangdong Neilingding Futian National Nature Reserve | The primary protection targets are macaques, birds, and the mangrove wetland ecosystem, including animals such as *Platalea minor*, along with 821 species of vascular plants (Guangdong Forestry Website, 2024). | Together with Hong Kong's Mai Po Wetlands, it forms a critical node along the East Asian-Australasian flyway (Zhang Chenmu, 2021). |
| 13 | | | Qi'ao-Dangan Island Provincial Nature Reserve in Zhuhai of Guangdong | Mangrove wetlands, macaques, birds, and island ecosystem; key organisms including plants such as *Kandelia candel*, *Ceratopteris thalictroides*, and *Cinnamomum camphora*, and animals such as macaques, *Viverricula indica*, and *Leiolepis reevesii* (Zhuhai Municipal Ecology and Environment Bureau, 2025). | It serves as a critical node on global migratory bird flyways and collaborates with Hong Kong's Mai Po Wetlands on coordinated conservation, jointly building an ecological corridor in the Guangdong-Hong Kong-Macao Greater Bay Area (Civilization Zhuhai, 2023). |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Protection Target / Key Species | Transboundary Significance |
|---|---|---|---|---|---|
| 14 | | Coastal waters of Leizhou Peninsula | Zhanjiang Mangrove National Nature Reserve in Guangdong | Mangrove ecosystem; key organisms including 27 mangrove plant species, 208 macrobenthic species, 139 fish species, 19 shrimp species, 314 bird species, among others. | Located within the East Asian–Australasian waterbird flyway, it serves as a crucial habitat for waterbirds. |
| 15 | | | Leizhou Seagrass Nature Reserve | Seagrass including *H. ovalis*, *H. minor*, *H. beccarii*, and *H. uninervis*, macrobenthos including *Gafrarium tumidum Batillaria zonalis*. | Migratory corridor for birds such as *Eurynorhynchus pygmeus*, *Platalea minor*, and *Calidris tenuirostris*. |
| 16 | | Surrounding waters of Nan'ao Island | Qing'ao Bay National Marine Park in Nan'ao of Guangdong | Coral reef and other marine ecosystems, along with rare marine species habitats, including animals such as *Sousa chinensis*, as well as fish, shellfish, and algae (Shantou Media Covergence Group, 2023). | It serves as a critical node on global migratory bird flyways. |
| 17 | | Daya Bay | Mangrove Municipal Nature Reserve in Huidong | Mangrove ecosystem; key organisms including 13 higher plant species, 129 fish species, 6 amphibian species, 21 reptiles species, 115 bird species, 5 mammal species, among others. | Serving as a key node along the East Asian-Australasian flyway, it attracts rare waterbirds such as *Platalea minor* for wintering from December to April each year. |
| 18 | | Honghai Bay | Birds Provincial Nature Reserve in Haifeng of Guangdong | The primary protection targets are birds and their habitats, with the key bird species comprising 243 species across 17 orders and 52 families. | It serves as a critical staging site along global migratory bird flyways. |
| 19 | | Coastal waters of Yangjiang | Hailing Island National Marine Park in Guangdong | Island ecosystem; key organisms including 98 mollusk species, 134 fish species, 39 shrimp and crab species, as well as *Sousa chinensis*, Chinese bahaba, *Balaenoptera edeni*, *Eretmochelys imbricata*, *Chelonia mydas*, among others. | Hailing Island is situated on the East Asian–Australasian flyway, serving as a vital stopover site and wintering ground for migratory birds. |

**Table 4.2-2 Key endemic, endangered, threatened, and migratory species in the coastal key biodiversity areas of South China.**

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Key Endemic Species | Key Endangered, Threatened, and Protected species | Key Migratory Species | Biodiversity Trends |
|---|---|---|---|---|---|---|---|
| 1 | Hainan | Coastal waters of northeastern Hainan Island | National Nature Reserve in Dongzhai Port of Hainan | NA | *Hernandia nymphaeifolia*, *Nypa fruticans*, *Rhizophora apiculata*, *Xylocarpus granatum*, *Platalea minor*, *Emberiza aureola*, among others. | *Himantopus himantopus*, *Tringa nebularia*, *Ardea alba*, *Limosa limosa*, *Spatula querquedula*, among others | Increase |
| 2 | | | Mangrove Provincial Nature Reserve in Qinglan Port of Hainan | NA | *Sonneratia paracaseolaris*, *Sonneratia hainanensis*, *Platalea minor*, *Enrynorhynchus pygmeus*, *Egretta eulophotes*, *Tachypleus tridentatus*, *Hoplobatrachus rugulosus*, *Lepus hainanus*, among others. | NA | Increase |
| 3 | | Coastal waters of northwestern Hainan Island | Mangrove Municipal Nature Reserve in Xinying Bay of Danzhou | *Murraya microphylla*, *Tinospora hainanensis* | *Eurynorhynchus pygmeus*, among others (Danzhou Municipal Bureau of Natural Resources and Planning, 2024)。 | NA | Increase |
| 4 | | Coastal waters of southern Hainan Island | Mangrove Municipal Nature Reserve in Tielu Port | NA | *Lumnitzera littorea*, *Platalea minor*, *Calidris pygmaea*, among others. | NA | Increase |
| 5 | | | Special Marine Protected Areas for | NA | *Lumnitzera littorea*, *Chelonia mydas* | *Egretta garzeta*, *Spatula querquedula*, | NA |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Key Endemic Species | Key Endangered, Threatened, and Protected species | Key Migratory Species | Biodiversity Trends |
|---|---|---|---|---|---|---|---|
| | | | Seagrass in Xincun Port and Li'an Port of Lingshui | | | *Himantopus himantopus*, *Platalea leucorodia*, among others | |
| 6 | Guangxi | Surrounding waters of Beihai | Dugong National Nature Reserve in Hepu of Guangxi | NA | *Sousa chinensis*, *Neophocaena phocaenoides, Chelonia mydas* | National First-Class Protected Animals such as *Platalea minor*, *Egretta eulophotes*, *Tringa guttifer*, *Larus saundersi* and National Second-Class Protected Animals such as *Platalea leucorodia*, *Numenius arquata*, *Merops philippinus*, *Calidris tenuirostris*, among others. | The dugong population within the protected area shows a declining trend (Guangxi Zhuang Autonomous Region Forestry Survey and management station of Dugong National Nature Reserve in Hepu of Guangxi, 2016). |
| 7 | | | Mangrove Ecological National Nature Reserve in Shankou of Guangxi | NA | *Acanthus ebracteatus*, *Acrostichum speciosum*, *Platalea minor*, *Egretta eulophotes*, *Vanellus cinereus*, among others | *Sterna albifrons*, *Chroicocephalus ridibundus*, among others | NA |
| 8 | | | National Coastal Wetland Park in Beihai of Guangxi | NA | *Tachypleus tridentatus*, *Eurynorhynchus pygmeusr* (Guangxi Beihai Coastal National Wetland Park Management Office, | *Egretta eulophotes*, *Platalea minor*, *Ciconia nigra*, *Larus saundersi*, among others, along with large numbers of migratory shorebirds | Showing a stable recovery trend but still facing pressures. |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Key Endemic Species | Key Endangered, Threatened, and Protected species | Key Migratory Species | Biodiversity Trends |
|---|---|---|---|---|---|---|---|
| | | | | | 2025) | | |
| 9 | | Coastal waters of Qinzhou | Mangrove Nature Reserve in Maowei Sea of Guangxi | NA | *Sousa chinensis*, *Ciconia nigra, Egretta eulophotes* | *Egretta garzetta*, *Ardea cinerea*, *Ardeola bacchus*, *Nycticorax nycticorax*, and other Ardeidae species (Qinzhou Release, 2025) | Gradual recovery under effective conservation, but still under pressure. |
| 10 | | Coastal waters of Fangchenggang | National Nature Reserve in Beilun Estuary of Guangxi | NA | *Eurynorhynchus pygmeus*, *Aythya baeri*, *Emberiza aureola*, *Platalea minor*, *Numenius madagascariensis*, *Tringa guttifer*, *Calidris tenuirostris*, among others (Chen Qinrong, 2025) | *Eurynorhynchus pygmeus*, *Larus saundersi*, *Calidris tenuirostris*, *Recurvirostra avosetta*, *Limosa lapponica*, *Egretta eulophotes*, *Platalea minor*, among others | Showing a stable recovery trend but still facing pressures. |
| 11 | Guangdo-ng | Pearl River Estuary and its surrounding waters | Pearl River Estuary Chinese White Dolphin National Nature Reserve | NA | *Sousa chinensis*, *Neophocaena*, among others (Forestry Administration of Guangdong Province, 2025) | NA | Gradual recovery under effective conservation, but still under pressure. |
| 12 | | | Guangdong Neilingding Futian National Nature Reserve | NA | *Platalea minor*, *Manis pentadactyla*, macaques, among others (Forestry Administration of Guangdong Province, 2025) | *Egretta eulophotes*, *Pelecanus crispus*, *Larus saundersi*, *Phalacrocorax pelagicus*, *Platalea leucorodia*, and other bird species | Showing a stable recovery trend but still facing pressures. (Ye Kasi, 2023) |
| 13 | | Coastal waters of | Zhanjiang Mangrove | NA | *Lumnitzera racemosa*, | *Eurynorhynchus* | NA |

| No. | Province (Autono-mous Region) | Key Biodiversity Areas | Demonstration Area | Key Endemic Species | Key Endangered, Threatened, and Protected species | Key Migratory Species | Biodiversity Trends |
|---|---|---|---|---|---|---|---|
| | | Leizhou Peninsula | National Nature Reserve in Guangdong | | *Ceriops tagal*, *Eurynorhynchus pygmeus*, *Aquila heliaca*, *Platalea minor*, *Hydroprogne caspia*, *Tringa guttifer*, *Thalasseus bernsteini*, among others | *pygmeus*, *Platalea minor*, *Thalasseus bernsteini*, *Larus saundersi*, *Platalea leucorodia*, *Egretta eulophotes*, among others | |
| 14 | | | Leizhou Seagrass Nature Reserve | NA | NA | *Eurynorhynchus pygmeus*, *Platalea minor* and *Calidris tenuirostris* | NA |
| 15 | | Surrounding waters of Nan'ao Island | Qing'ao Bay National Marine Park in Nan'ao of Guangdong | NA | *Sousa chinensis*, *Chelonia mydas*, among others (Yi Luya, 2025) | NA | NA |
| 16 | | Daya Bay | Mangrove Municipal Nature Reserve in Huidong | NA | Lumnitzera racemosa, *Heritiera littoralis* | *Egretta garzetta*, among others | NA |
| 17 | | Honghai Bay | Birds Provincial Nature Reserve in Haifeng of Guangdong | NA | *Platalea minor*, *Ciconia boyciana*, among others (Forestry Administration of Guangdong Province, 2025) | *Platalea minor*, *Plegadis falcinellus*, among others (People's Daily, 2022) | Showing a stable recovery trend |
| 18 | | Coastal waters of Yangjiang | Hailing Island National Marine Park in Guangdong | NA | *Sousa chinensis*, Chinese bahaba, *Balaenoptera edeni*, *Eretmochelys imbricata*, *Chelonia mydas*, *Tachypleus tridentatus*, among others | Shorebirds and other migratory bird species | NA |

## 4.3 Discussion and Conclusion

### 4.3.1 Priority Transboundary Biodiversity Issues

Priority transboundary biodiversity issues are critical to the stability and sustainability of coastal habitat ecosystem diversity.

### 4.3.2 Risk Assessment (Analysis of Risk Factors)

This section focuses on analyzing the key risk factors for coastal habitats.

**First, global climate change.** Global climate change is one of the most severe threats facing mangroves and seagrass beds (Waycott et al., 2009). Studies have found that temperatures above 36°C can damage Enhalus acoroides and accelerate the decline of tropical seagrass beds (Zhang et al., 2023). Typhoons and storm surges can scour seagrass, exacerbating the degradation of seagrass beds in Guangdong and Guangxi (Wu Yuanjia and Zhang Hongke, 2018; Jiang et al., 2020). Additionally, the sea-level rise rate of 3.5 mm/year along the South China Sea coast will submerge tidal flats and impact the survival of mangroves.

**Second, destructive intertidal harvesting activities.** For a long time, clam digging and sandworm harvesting in seagrass beds along the coastal areas of South China have adversely affected seagrasses (Qiu Guanglong et al., 2020). In multiple seagrass beds, including those in Yifengxi, Tangjia Bay, Xiachuan Island, Shuidong Bay, and Zhanjiang in Guangdong, trampling and direct uprooting of seagrass roots by people digging for clams, sandworms, or seaweed (such as *Eucheuma*) have led to seagrass burial or destruction.

**Third, invasive alien species and harmful organism threats**. *Spartina alterniflora*, an invasive alien species in coastal wetlands, has encroached upon coastal areas of Guangdong and Guangxi, displacing native habitats and leading to the degradation and succession of seagrass beds (Lan Wenlu et al., 2013). Mangroves face threats from the spread of climbing vines and pest infestations. In May 2019, *Oligochroa cantonella* infestation was detected in

Gangdong Bay, Fangchenggang City, affecting 10 hectares of mangroves (Forestry Department of Guangxi Zhuang Autonomous Region, 2021).

### 4.3.3 Regulatory and Institutional Development Status

China has carried out regulatory and institutional development by strengthening legislative protection for coastal wetland ecosystems, progressively improving the construction of the protected area system, and conducting integrated planning for the conservation and restoration of key ecosystems in offshore and coastal zones. First, strengthening legislative protection for habitats. At the national level, the Wetland Conservation Law was enacted and implemented in 2021. The three coastal provinces (autonomous regions) of South China—Guangdong, Guangxi, and Hainan—have also successively introduced provincial-level wetland protection regulations and formulated multiple specific local regulations for typical ecosystems such as mangroves and coral reefs, forming a relatively comprehensive legal system for habitat conservation. Second, gradually improving the construction of the protected area system. Since the systematic deployment at the national level in 2019, China has been accelerating the establishment of a protected area system with national parks as its main component. The three provinces (autonomous regions) of Guangdong, Guangxi, and Hainan have actively implemented national requirements by establishing various types of nature reserves, wetland parks, and marine parks, while advancing integration and optimization efforts to continuously strengthen the systematic protection of wildlife habitats. Third, advancing the ecological conservation and restoration of offshore and coastal areas in a coordinated manner. In recent years, the state has intensively issued a series of top-level plans and special action initiatives addressing coastal zones, biodiversity, mangroves, and *Spartina alterniflora* control. Building on this, the three southern provinces (autonomous region) have closely aligned with local realities to formulate and implement corresponding conservation and restoration plans and technical guidelines, coordinate key tasks such as mangrove restoration, seagrass bed protection, and invasive species control, and systematically advance the ecological rehabilitation of offshore and

coastal areas.

### 4.3.4 Gaps and Challenges

#### 4.3.4.1 Gaps

**First, monitoring capacity requires improvement.** The South China Sea boasts diverse ecosystems, yet China has currently established only two seagrass bed ecosystem monitoring areas, two salt marsh ecosystem monitoring areas, and one estuary ecosystem monitoring area, indicating insufficient monitoring coverage—for instance, Guangdong lacks fixed monitoring areas.

**Second, the intensity, breadth, and depth of publicity and education are insufficient**. Science outreach targeting key areas and critical groups has not been sufficiently in-depth, resulting in inadequate public awareness regarding coastal habitats and biodiversity conservation.

**Third, knowledge gaps persist**. In the context of seagrass beds, while there is relatively extensive research on specific species such as *Posidonia oceanica*, the understanding of factors influencing carbon sequestration in other seagrasses—such as water depth, light availability, and bioturbation—remains relatively limited (Nordlund et al., 2018). Regarding mangroves, research on the relational mechanisms between mangroves and surrounding biodiversity, habitat connectivity, and fishery resources is inadequate. In coastal wetlands, this is primarily reflected in an insufficient understanding of the complexity of ecological functions and inadequate comprehension of biodiversity and species interactions.

**Fourth, there is a shortage of methods and techniques for coastal ecological restoration**. In mangrove afforestation, restoration efforts must consider long-term impacts. Currently, some mangrove restoration projects convert non-forest ecosystems, such as tidal flats and tidal creeks, into mangroves (Ouyang, 2024), relying on land reclamation and elevation-raising methods to enhance mudflat levels and create mangrove habitats. This may

cause secondary damage, including destruction of intertidal environments and displacement of bird foraging grounds (Choi et al., 2022). In seagrass ecological restoration, the success rate of rehabilitation is low, and there is a failure to integrate related elements such as mangroves and oyster reefs. Isolated restoration approaches overlook the broader ecosystem context, indicating a need for further technological innovation (Zhang Mingliang, 2022).

#### 4.3.4.2 Challenges

Priority challenges in mangrove conservation: 1)Policies and measures for ecological compensation, such as restoring fishponds to mangroves, require further refinement to balance economic, social, and environmental benefits. 2)Mangrove ecological restoration should transition from the previous single-species vegetation restoration approach to holistic restoration at the ecosystem and regional scales. 3)The ecological health of existing mangroves urgently needs attention, including issues like invasive vine overgrowth, spread of non-native mangrove species, degradation of native community structure, and habitat destruction. 4)The value-realization mechanism for mangrove ecological products needs improvement to achieve sustainable development in mangrove-associated communities.

Priority challenges in seagrass bed Conservation: 1)Enhance public awareness of the ecological significance of seagrasses. 2)Strengthen baseline surveying and monitoring of seagrass bed resources to obtain updated information on their status and conditions, documenting characteristics of diverse seagrass communities. 3)Analyze human activities threatening seagrass beds and develop tailored conservation and management measures based on local conditions. 4)Conduct related research on seagrass bed community structure and ecological functions (e.g., food security and blue carbon). 5)Implement seagrass conservation initiatives in the context of climate change, restore seagrass bed communities, and enhance ecosystem resilience and stability.

Priority challenges in other coastal wetland conservation: 1)Overdevelopment threatening wetland ecological security. Salt marshes possess significant

carbon capture and storage potential, but port construction, tidal flat reclamation for aquaculture, and urban expansion have led to their degradation or loss (Feng et al., 2024). 2)Invasive plants posing threats to biological and ecological security. For instance, Spartina species, among the most invasive plants, have become the most damaging invasive plant in China's coastal mudflats and one of the most critical factors driving dynamic changes in China's coastal wetlands.

### 4.3.5 Recommended priority actions including regional cooperation

#### 4.3.5.1 Priority Actions for Mangrove Habitat Conservation

1)Scientifically plan ecological restoration areas, optimize restoration technical models, focus on ecosystem integrity, and enhance mangrove ecological functions and biodiversity. 2)Establish a mechanism of restoration effectiveness evaluation and strengthen post-restoration management and maintenance efforts. 3)Enhance invasive species monitoring, early warning, and dynamic surveillance. 4)Accelerate the pace of value realization of ecological products.

#### 4.3.5.2 Priority Actions for Seagrass Habitat Conservation

1)Strengthen research on seagrass bed ecosystems, including carbon sequestration, climate change responses, and interactions with adjacent ecosystems. 2)Enhance seagrass survey and monitoring capabilities. 3)Establish a robust regulatory system for seagrass conservation. 4)Develop key technologies for seagrass bed ecological restoration. 5)Actively conduct public awareness campaigns and science outreach on seagrass bed conservation.

#### 4.3.5.3 Priority Actions for Estuarine Wetland Conservation

1)Investigate the structure and function of estuarine and delta wetland ecosystems, focusing on changes in coastal wetland distribution, area, and functionality under influences such as climate change, hydrological dynamics, and sediment deposition in estuaries and coasts. Ecological restoration should shift from primarily focusing on area expansion to emphasizing the

improvement of wetland quality and resilience (He et al., 2025), providing technical support for sustainable development of coastal cities. 2)Conduct assessments of wetland ecological restoration effectiveness and strengthen supervision of wetland ecological conservation and restoration. 3)Promote the control of invasive species such as *Spartina alterniflora*.

#### 4.3.5.4 Priority Actions for Marine Biodiversity Conservation

1) Enhance marine ecosystem resilience, implement integrated conservation of adjacent ecosystems across large spatial scales, and define water quality targets and priority actions. 2)Improve the spatial network for marine biodiversity conservation, strictly enforce ecological red lines, and construct ecological corridors. 3)Optimize marine ecosystem restoration projects by prioritizing natural recovery and rehabilitate typical marine ecosystems. 4)Strengthen the protection of endangered species and the restoration of their habitats, enhance survey and monitoring of endangered species, restore habitats, and promote transboundary conservation efforts. 5)Establish a synergistic framework integrating climate change and biodiversity conservation and develop coordinated systems to address both challenges. 6)Enhance the development and demonstration of coastal ecosystem carbon stabilization and sequestration support systems, conserve and restore coastal wetlands, strengthen their carbon sequestration capacity, establish a monitoring and accounting system for marine carbon sinks, and promote demonstration projects.

#### 4.3.5.5 Recommendations for Regional Cooperation in the South China Sea

**Develop a regionally coordinated marine ecosystem conservation and management strategy**. Enhance cooperative exchanges on marine ecosystem conservation among countries and regions surrounding the South China Sea, establish a regional alliance for South China Sea ecosystem conservation, achieve sustainable management of its ecosystems, and strengthen transboundary conservation and collaborative efforts for migratory marine endangered species.

**Establish a regional database of marine organisms and their habitats in the South China Sea**. Develop a database of key species information and their critical habitats, create a survey and monitoring network for marine organisms and their habitats in the South China Sea region, further improve the regional marine protected area system, and form multiple functionally synergistic networks of protected areas.

**Establish a communication platform for rare and endangered protected species in the South China Sea, and promote the conservation and international cooperation of coastal ecosystems and these species**. Conduct investigations and research on the population size, structure, distribution, dynamics and trends, and ecological habits of rare and endangered protected species across various sea areas of the South China Sea. Systematically assess the suitability of habitats and identify conservation gaps for these species, and propose coastal ecological restoration plans and conservation strategies for rare and endangered species.

## 4.4 Methodology and analyses

By synthesizing and analyzing the content of recent Bulletin of Marine Ecology and Environment Status of China and investigation findings from scientific publications, this report outlines the fundamental status and recent changing trends of mangrove, coastal wetland, and seagrass bed ecosystems along the coast of South China. Building on the achievements of the demonstration areas under the SCS Phase Ⅱ Project, it summarizes the key challenges currently facing these ecosystems and elaborates on both the direct causes and underlying drivers.

A partial synthesis and analysis has reviewed plans across multiple tiers of China's governance system—national, local, and protected-area levels—covering various planning periods such as the 14th Five-Year Plan (2021–2025), the 2021–2035 period, and the 2020–2025 period. It summarizes priority challenges facing China's marine ecosystems and marine biodiversity, and synthesizes recommended priority actions.

# Chapter References

[1] Choi C, Xiao H, Jia M, et al. A. An emerging coastal wetland manag ement dilemma between mangrove expansion and shorebird conservation [J]. Conservation Biology, 2022, 00, e13905.

[2] FENG Xinhua, LI Yan, LIN Xinle. Protect China's coastal salt marshes [J]. Science, 2024, 386: 629-630.

[3] HE Q, LI Z, Daleo P, et al. Coastal wetland resilience through local, regional and global conservation[J]. Nat. Rev. Biodivers. 2025, 1, 50-67.

[4] IUCN. The IUCN Red List of Threatened Species, Version 2021-3. htt ps://www.iucnredlist.org. 2022. [2025-08-13].

[5] Jiang Z, Cui L, Liu S, Zhao C, Wu Y, Chen Q, Yu S, Li J, He J, Fa ng Y, Premarathne Maha Ranvilage C I, Huang X. Historical changes in seagrass beds in a rapidly urbanizing area of Guangdong Province: Imp lications for conservation and management[J]. Global Ecology and Conse rvation, 2020, 22: e01035.

[6] Lin M, Turvey S T, Han C, Huang X, Mazaris A D, Liu M, Ma H, Ya ng Z, Tang X, Li S. Functional extinction of dugongs in China [J]. Royal Society Open Science, 2022, 9(8): 211994.

[7] Nordlund L M, Koch E W, Barbier E B, Creed J C. Seagrass ecosyst em services and their variability across genera and geographical regions [J]. PLoS One, 2016, 11(10): e0163091.

[8] Nordlund L M, Unsworth R K F, Gullström M, Cullen-Unsworth L C. Global significance of seagrass fishery activity [J]. Fish and Fisheries, 20 18, 19(3): 399-412.

[9] Ouyang，X.，Guo, F., Lee，S.Y, Yang, Z. Mangrove restoration in Chi na's tidal ecosystems. Science 385,836-836(2024).

[10] Ramsar Information Sheet. China Guangdong Haifeng Wetlands[R]. (2017-08-03)[2025-07-11].https://rsis.ramsar.org/ris/1727.

[11] Unsworth R K F, Mckenzie L J, Nordlund L M, Cullen-Unsworth L C. A changing climate for seagrass conservation? [J]. Current Biology, 2018, 28(21): R1229-R1232.

[12] Wang X, Xiao X, Xu X, et al. Rebound in China's coastal wetlands following conservation and restoration[J]. Nat Sustain 4, 2021:1076–1083.

[13] Waycott M, Duarte C M, Carruthers T J B, Orth R J, Dennison W C, Olyarnik S, Calladine A, Fourqurean J W, Heck K L, Hughes A R, Kendrick G A, Kenworthy W J, Short F T, Williams S L. Accelerating loss of seagrasses across the globe threatens coastal ecosystems [J]. Proceedings of the National Academy of Sciences of the United States of America, 2009, 106(30): 12377-12381.

[14] Zhang M, Li H, Zhang L, Liu J. Heat stress, especially when coupled with high light, accelerates the decline of tropical seagrass (Enhalus acoroides) meadows [J]. Marine Pollution Bulletin, 2023, 192: 115043.

[15] CHEN Qinrong, WEI Lu, LIN Jinlin. China Southern Power Grid Weaves an Ecological Protection Network for Guangxi Biodiversity [N]. China News Network. (2025-05-22)[2025-09-17]. https://www.163.com/dy/article/K06PUCPG0514R9OJ.html.

[16] CUI L J, LI W, DOU Z G, et al. Changes and driving forces of the tidal flat wetlands in coastal China during the past 30 years. Acta Ecologica Sinica, 2022, 42(18): 7297-7307.

[17] Danzhou Natural Resources and Planning Bureau. Ecological Danzhou, Green Progress[N]. (2024-05-17)[2025-09-17].https://www.danzhou.gov.cn/danzhou/zfxxgkzl/bm/gtj/gkml/202405/t20240517_3664945.html.

[18] Guangming Daily. China Achieves "One Red Line" Control of Important Ecological Space by Defining Red Line Area of Ecological Protection Exceeding 3.15 Million Square Kilometers[N]. (2025-08-16)[2025-08-21].https://epaper.gmw.cn/gmrb/html/2025-08/16/nw.D110000gmrb_20250816_2-02.htm.

[19] Guangming Daily. China Achieves "One Red Line" Control of Important Ecological Space by Defining Red Line Area of Ecological Protection Exceeding 3.15 Million Square Kilometers[N].(2025-08-16)[2025-08-21]. https://epaper.gmw.cn/gmrb/html/2025-08/16/nw.D110000gmrb_20250816_2-02.htm.

[20] The Guangdong Communist Youth League. It first appeared in Zhanjiang![N]. (2023-12-09)[2025-09-05]. https://mp.weixin.qq.com/s?__biz=MzA5MzUwNjUzMA==&mid=2650786306&idx=1&sn=62d7e74b3a36275577578a8289ab6f9b&chksm=8857b48fbf203d99af546dfa925930b9436c2d3945001c5b14bd55120d3a022080003974c460&scene=27.

[21] Guangdong Provincial Forestry Bureau. Introduction to Mangrove National Nature Reserve in Zhanjiang, Guangdong[EB/OL]. (No release date) [2025-09-18]. https://lyj.gd.gov.cn/bhq/html/protection_zone/hongshulin.html.

[22] Guangdong Provincial Forestry Bureau. Go! Follow Shenzhen-Zhongshan Channel to check in the green and beautiful protected area of the Bay Area[N].(2024-07-04)[2025-09-17].http://www.kaiping.gov.cn/kplyj/xxdt/ywsd/content/post_3124493.html.

[23] Guangdong Provincial Forestry Bureau. Introduction to the National Nature Reserve of Lingding-Futian in Guangdong Province[EB/OL]. [2025-09-17].https://lyj.gd.gov.cn/bhq/html/protection_zone/futian.html.

[24] Guangdong Provincial Forestry Bureau. Wetland Protection Plan of Guangdong Province (2023—2035)[R].2024.

[25] Guangdong Provincial Forestry Bureau. Rare and endangered bird Oriental white stork appears in Shantou, Guangdong[N]. (2024-02-05)[2025-09-17].https://www.forestry.gov.cn/c/www/dfdt/541494.jhtml.

[26] Guangdong Forestry Bureau. Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve[EB/OL].[2025-09-17].https://lyj.gd.gov.cn/bhq/html/protection_zone/zhujiangkou.html.

[27] Guangdong Provincial Department of Ecology and Environment, Guangdong Provincial Development and Reform Commission, Guangdong Pro

vincial Department of Science and Technology, Guangdong Provincial Department of Natural Resources, Guangdong Provincial Department of Water Resources, Guangdong Provincial Department of Agriculture and Rural Affairs, Guangdong Provincial Forestry Bureau. Guangdong Biodiversity Conservation Strategy and Action Plan (2023—2030) (Yue Huan [2024] No.2)[EB/OL]. 2024-5-12.

[28] Department of Natural Resources of Guangdong Province. Summary Table of Land Use Classification Area of 2023 Land Change Survey in Guangdong Province[EB/OL]. (2024-11-27)[2025-09-18]. https://nr.gd.gov.cn/zwgknew/sjfb/tjsj/content/post_4519822.html.

[29] Beihai National Wetland Park Management Office, Guangxi. 6.20 International Day for the Conservation of the Limulus: Scientific Innovation, Creating a "Limulus" for the Limulus[EB/OL]. (2025-06-19)[2025-10-14]. https://mp.weixin.qq.com/s/kGvBXZs_9iAwaM3ibm8vww.

[30] Guangxi Shankou Mangrove Ecological Nature Reserve Management Center, Guangxi Mangrove Research Center. Guangxi Shankou Mangrove Ecological National Nature Reserve Management Plan (2021—2030)[R]. 2021.

[31] Marine Environment Monitoring Center Station of Guangxi Zhuang Autonomous Region. 2023 Report on Health Monitoring and Evaluation of Mangrove Ecosystem in Guangxi[R]. 2023.

[32] Relevant information from the Guangxi Zhuang Autonomous Region Marine Environment Monitoring Center Station, 2023.

[33] Guangxi Zhuang Autonomous Region Forestry Bureau. Guangxi Mangrove Resources Protection Plan (2020—2030)[R]. 2021.

[34] Guangxi Zhuang Autonomous Region Forestry Bureau. 2024 Guangxi Land Greening Status Bulletin[R]. 2025.

[35] Guangzhou Linmao Nature Technology Co., Ltd. and Haifeng Provincial Nature Reserve Management Office of Guangdong Province. Annual

Report on Monitoring and Investigation of Important Wetland Resources in Haifeng[R]. 2023-12.

[36] National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs. Announcement of the National Forestry and Grassland Administration and the Ministry of Agriculture and Rural Affairs (No.3, 2021) (List of National Key Protected Wild Animals)[EB/OL]. (2021-02-05)[2025-08-12]. https://www.forestry.gov.cn/main/5461/20210205/122418860831352.html.

[37] National Forestry and Grassland Administration. 20 rare birds Spoon-billed Sandpiper appear in Zhanjiang, Guangdong province[N]. (2025-04-07)[2025-09-05]. https://www.forestry.gov.cn/lyj/1/dzwzbh/20250407/619229.html.

[38] National Forestry and Grassland Administration[N]. (2024-11-12) [2025-09-05]. https://www.forestry.gov.cn/c/www/sddfdt/595022.jhtml.

[39] Central South Survey and Planning Design Institute of National Forestry and Grassland Administration. Master Plan for Hongshulin Municipal Nature Reserve in Huidong County (2019—2028)[R]. 2019.

[40] General Administration of Quality Supervision, Inspection and Quarantine, National Standardization Administration. Wetland Classification: GB/T 24708-2009[S]. Beijing: China Standards Press, 2009: 1-5.

[41] Hainan Dongzhai Port National Nature Reserve Administration. Hainan Dongzhai Port National Nature Reserve Ecological Environment Protection Effectiveness Self-evaluation Report[R]. 2023.

[42] Hainan Daily. Hainan Danzhou: Spoon-billed Sandpiper Focus on Feeding[N]. (2023-11-29)[2025-07-11]. https://www.hi.chinanews.com.cn/hnnew/2023-11-29/694393.html.

[43] Special Plan for the Protection of Mangrove Resources in Hainan Province (2024—2035)[R]. 2025.

[44] Hainan Academy of Forestry Sciences (Hainan Mangrove Research Institute). 2021 Survey Report on Seagrass and Mangroves in Xincun in Lingshui and Li'an, Hainan[R]. 2021.

[45] Hainan Academy of Forestry Science. Report on the Scope and Functional Area of the Municipal Nature Reserve of Xinyingwan Mangrove in Danzhou, Hainan[R]. 2022.

[46] General Office of Hainan Provincial People's Government. Special Plan for the Protection of Mangrove Resources in Hainan Province (2024—2035)[R]. 2025.

[47] HUANG Xiaoping, JIANG Zhijian, ZHANG Jingping, et al. Newly discovered seagrass beds in the coastal seas of Guangdong Province[J]. Journal of Tropical Oceanography, 2010, 29(1): 132-135.

[48] Huidong Media. The only one in the province! Huidong Marine Ecological Protection and Restoration Selected as a National Typical Case[EB/OL]. (2024-12-12)[2025-09-18]. https://news.qq.com/rain/a/20241212A061LO00.

[49] LAN Wen-lu, LI Ming-min, QIN Qiu-rong. Community Succession and Preventive Countermeasures of Small Seagrass Bed in Ronggenshan of Hepu Guangxi[J]. Guangxi Science, 2013, 20(2): 176-10, 182.

[50] LI Yinghong, HUANG Xiaoping, XU Zhanzhou, et al. Threat and protection measurement of Hepu seagrass beds in Guangxi[J]. Marine Environmental Science, 2007, (06): 587-590.

[51] The People's Government of Lingshui Li Autonomous County. Mangrove Welcomes Rare Guest: White Spoonbill Appears in Lingshui for the First Time[N]. (2023-10-23)[2025-09-05]. https://lingshui.hainan.gov.cn/mlls_57671/stls/202310/t20231023_3513394.html.

[52] MU Jinggu. International Law Governance of Marine Microplastic Pollution From the Perspective of Biodiversity Conservation[D]. Harbin Engineering University, 2023.

[53] Southern Metropolis Daily. The "Graceful Shadow" of Hechangwei! Birds in the Coastal Wetland of Shantou Dance into a Painting[N]. (2024-12-07)[2025-09-05]. https://baijiahao.baidu.com/s?id=1817741891815240109&wfr=spider&for=pc.

[54] Southern Rural News. Mangrove Forest in Zhanjiang: Protecting the National Treasure of Ecology and Painting a New Chapter of Green Beauty[EB/OL]. (2025-03-29)[2025-09-18]. https://www.forestry.gov.cn/lyj/1/dfdt/20250329/617604.html.

[55] Southern Daily Online. Guangdong, Guangxi and Hainan sign agreement to strengthen cooperation in mangrove protection[N]. https://www.gd.gov.cn/gdywdt/bmdt/content/post_4406742.html. (2024-04-15) [2025-09-17].

[56] Qinzhou Release. Birds Know the Best about the Ecology[EB/OL]. (2025-04-09)[2025-10-14] https://mp.weixin.qq.com/s/Z8PQPofmxmcF0HLWkPyz0Q.

[57] PAN Delu, ZHANG Si, QIN Dahe, et al. Current Structural Status and Optimized Protection Strategies for Coastal Blue-Carbon Ecosystems in China[J]. Engineering Science, 2024, 26 (06): 233-245.

[58] QIU Guanglong, SU Zhinan, FAN Hangqing, et al. Biological and ecological characteristics of intertidal seagrass Halophila beccarii and its conservation countermeasures[J]. Marine Environmental Science, 2020, 39(01): 121-126.

[59] People's Daily. The wild bird population in Dongfeng, Guangdong has been increasing year by year [N]. Guangdong Provincial Forestry Bureau official website. (2025-07-05)[2025-09-17]. https://lyj.gd.gov.cn/news/special/swdyxbh/content/post_4739970.html.

[60] Sanya Daily Digital Edition, Centenarian Tree Sings Ecological Ode[EB/OL]. (2024-08-16)[2025-10-09]. https://www.sanya.gov.cn/sanyasite/syyw/202408/4ab69cb5df7d4fbd80f2a50b04130ad6.shtml.

[61] Shantou Rongmei Group.116 bird species, 1,308 marine species... This is the hidden 'treasure' of Shantou[N]. Shantou Release. (2023-05-23)

[2025-09-17].https://mp.weixin.qq.com/s?__biz=MzIyODI1Mjc3NQ==&mid=2247653311&idx=3&sn=a3ec07a4930616c4fc179c536286827b&chksm=e8581ab7df2f93a14c770c5fb841cd6c3393a5d6f224768f2209443d7bc1edb2ec3d87338f56.

[62] Biodiversity Knowledge Platform,Huidong Mangrove Nature Reserve[EB/OL]. (No release date)[2025-09-18]. https://wiki.biodiversity.cern.ac.cn/index.php.

[63] WANG Daoru, WU Zhongjie, CHEN Chunhua, et al. Distribution of sea-grass resources and existing threat in Hainan Island[J]. Marine Environmental Science, 2012, 31(01): 34-38.

[64] Zhuhai, the civilized city. The first batch of the whole country![N]. (2023-12-24)[2025-09-17].https://mp.weixin.qq.com/s?__biz=MzA4NTEyMDYxNA==&mid=2650890400&idx=2&sn=a636431dee2c04af51f7f479e732f8ba&chksm=842903a9b35e8abf0ee26f534d1b031440f0c52a3170b052216d026513a8a2580aa1a419b0ac&scene=27.

[65] WU Yuanjia, ZHANG Hongke. Changes of Seagrass Bed in Heping County of Guangxi and Its Protection Countermeasures[J]. China Science and Technology Information, 2018, (22): 68-69.

[66] WU Zhongjie, CHEN Shiquan, CAI Zefu, et al. Analysis of distribution change and restoration suggestion of the seagrass beds in Hainan Island[J]. Marine Environmental Science, 2021, 40(04): 542-549.

[67] Xinhua News Agency. Beihai, Guangxi: Various species inhabit the coastal wetland park[EB/OL]. https://www.toutiao.com/article/7479679779772318260/.2025-03-09.[2025-09-17].

[68] China National Radio. The construction of national parks has achieved remarkable results. The construction of the system of protected areas has entered a new stage[N]. (2025-07-31)[2025-08-14].https://news.qq.com/rain/a/20250731A06RJB00.

[69] CCTV Science and Education. After three years of filming and hundreds of sea voyages, the documentary "Chinese White Dolphin" is finally

here![EB/OL]. (2024-05-21)[2025-09-17]. https://baijiahao.baidu.com/s?id=1799637881724674470&wfr=spider&for=pc.

[70] CCTV News. Over 60,000 birds of more than 40 species have been observed in the He Pu Dugong National Nature Reserve in Guangxi[N]. (2022-11-22)[2025-09-05]. https://gx.cri.cn/n/20221122/341430e6-3046-a83d-8413-3af2f0ec3cfa.html.

[71] YANG Xi, et al. Ecological investigation of the seagrass bed in Nanhai District[M]. Maritime Press, 2023.

[72] Yangjiang Municipal People's Government. Yangjiang City has successfully applied for the 2025 Marine Ecological Protection and Restoration Project, which will receive 300 million yuan in national funding[EB/OL]. (2024-10-25)[2025-09-18]. http://www.yangjiang.gov.cn/zfxxgkml/yjsczj/gzdt/hyhd/content/post_819428.html.

[73] CAO Mazhi. From Counting Birds at a Glance to Counting Them Carefully: The Ecological Transformation Behind Two Bird Photographs in Danzhou Bay [N]. Hainan Daily. (2023-11-16)[2025-07-11]. https://yangpu.hainan.gov.cn/ yangpu/zwdt/202311/ff9b5197dea54e4388f205a81ae950f7.shtml.

[74] YE Kasi, LIN Jing. This year's first batch of southward migratory birds arrives in Guangdong! Among them is the rare and endangered Chinese Crested Tern [N]. Guangzhou Daily.2023-10-13.[2025-09-17].

[75] YI Luya, CHEN Jizhong, CHEN Yeqin. Shantou Qing'ao Bay: "Green Shield" Protection, Island Turned into Rare Animal Paradise[N]. (2022-05-17) [2025-09-17]. https://travel.sohu.com/a/547848313_120046696.

[76] Zhanjiang Municipal Bureau of Natural Resources, Institute of Tropical Forestry, Chinese Academy of Forestry Sciences. Zhanjiang Mangrove Conservation and Restoration Plan (2021—2025)[R]. 2022.

[77] Zhanjiang Evening News. Thousand Endangered Great Sandpipers Visit Zhanjiang, Ecological Beauty in the Lens[N]. (2025-04-02)[2025-09-05]. https://www.gdzjdaily.com.cn/p/2916970.html.

[78] ZHANG Chenmu, CHEN Yuzhu. Shenzhen Futian Mangrove Nature Reserve Restores Fish Pond Habitats to Welcome Migratory Birds [N]. Shenzhen Evening News. (2021-07-23)[2025-09-17]. http://sz.people.com.cn/n2/2021/0723/c202846-34833812.html.

[79] ZHANG Jian, LI Jiarui, YANG Lu, et al. Current situation，problems and management countermeasures of coastal wetlands in China[J]. Environment and Sustainable Development, 2019,44(05):127-129.

[80] ZHANG Mingliang. Research advancement on degradation mechanism and ecological restoration technology of coastal salt-marsh: a review[J]. Journal of Dalian Fisheries University, 2022, 37(4): 539-549.

[81] China Green Times. Hainan protects and restores mangroves to promote harmonious coexistence between man and nature[EB/OL]. (2025-04-22)[2025-09-25]. https://www.forestry.gov.cn/c/www/dfdt/621915.jhtml.

[82] China Daily. Exploring the "Green Great Wall" along the Coastline of Huizhou Huizhou[EB/OL]. (2025-06-16)[2025-09-18]. https://lyj.gd.gov.cn/lmgd/gdxd/content/post_4725275.html.

[83] China. From "Returning Ponds to Forests" to "Carbon Sequestration and Green Bay": The Ecological Reversal Path of Dongzhai Port Mangrove[EB/OL]. (2025-06-11)[2025-09-18]. http://photo.china.com.cn/2025-06/11/content_117920665.shtml.

[84] Ministry of Ecology and Environment of the People's Republic of China. China Marine Ecological Environment Status Bulletin[R]. 2022.

[85] Ministry of Ecology and Environment of the People's Republic of China. China Marine Ecological Environment Status Bulletin[R]. 2023.

[86] Ministry of Ecology and Environment of the People's Republic of China. China Marine Ecological Environment Status Bulletin[R]. 2024.

[87] ZHONG Chao, LIAO Yaqin, LIU Weijie, et al. Status, threats and conservation suggestions on seagrass beds in Guangdong. Biodiversity Science, 2024, 32(2): 1-18.

[88] ZHONG Chao, SUN Kaifeng, LIAO Yan, et al. Distribution status of seagrass and its relationship with different habitat types in Liusha bay of Guangdong province[J]. Marine Environmental Science, 2019, 38(04): 521-527.

[89] ZHOU Yi, JIANG Zhijian, QIU Guanglong, et al. Distribution Status, Degradation reasons and protection countermeasures of Seagrass resources in China [J]. Oceanologia et Limnologia Sinica, 2023, 54(5): 1248-1257.

[90] ZHU Wenjun, MO Rongxiong, YANG Zhenbei. Special Investigation of Coastal Wetland Resources in Beilun River Estuary and Analysis of Data Fusion of the Third National Land Survey[J]. Nanfang Ziran Ziyuan, 2022, (10): 34-39.

[91] Zhuhai Municipal Ecology and Environment Bureau.[Case of Biodiversity Conservation Practice ③]Biodiversity Survey and Monitoring Results of Qi'ao-Dangan Island Provincial Nature Reserve in Zhuhai, Guangdong [N].(2025-05-23)[2025-09-17].https://mp.weixin.qq.com/s?__biz=MzAwMjQyNTE1OQ==&mid=2652244689&idx=2&sn=6e732ea06e7cbc8a426781c647496166&chksm=80b8c559dbbf6d12d741d7e4059c94362030de5602102d521f62b08cf5c5c10fc5be52a6b8e5&scene=27.

[92] Department of Territorial Space Ecological Restoration, Ministry of Natural Resources. Typical Cases of Marine Ecological Protection and Restoration in 2025 | Beautifying the Coastal "Double Eyes", Revitalizing Traditional Culture-Marine Ecological Protection and Restoration Case in Lingshui Li Autonomous County, Hainan Province[N]. (2025-06-16)[2025-09-05]. https://lr.hainan.gov.cn/ywdt_312/zwdt/202506/t20250616_3880367.html.

[93] South China Sea Bureau, Ministry of Natural Resources. A Visual Guide to the 2023 South China Sea Marine Ecological Protection and Restoration Bulletin [R]. (2024-08-20)[2025-07-11]. https://scs.mnr.gov.cn/scsb/tpxw/202408/eed5d159d7724cc38479e9c8ab7672e4.shtml.

# 5 Governance

## 5.1 Current status

### 5.1.1 Economic and Policy Drivers

#### 5.1.1.1 Economic performance

Over the past 25 years (2000–2024), China's economy has maintained a sustained and rapid growth trend with both the national and the GDP of Guangdong, Guangxi Zhuang Autonomous Region, and Hainan Province, as well as the per capita GDP, all continuous positive growth. The World Bank's data for 2025 shows that the poverty rate in China ( on the 2017 purchasing power parity, i.e., $2.15 per day) was 0% in 2021.

#### 5.1.1.2 National budget appropriation

China insists on the leading position of government in ocean environmental protection, and plays a key role in system design, scientific planning, regulatory services and risk prevention and. It has established a working mechanism for ocean environmental protection under the overall coordination of the central government, overall responsibility of provinces, and implementation of cities and counties.

The budgetary appropriations at the national level mainly consist of central ecological environmental protection transfer payments, which are used to support funds for environmental and restoration, specifically including: key ecological protection and restoration funds, marine ecological protection and restoration funds, water pollution prevention and control funds, soil prevention and control funds, rural environmental improvement funds. Among them, marine ecological and restoration funds refer to special funds arranged by the central finance through the general public budget, which are used to support the marine ecological protection and restoration of key areas that play an important in ensuring ecological security and have a wide range of ecological benefits. For specific related special types. In addition, the Marine Environmental Protection Law also stipulates that the State Council and the local people's governments at or above the county level along coast should

incorporate marine environmental protection work into the national economic and social development plan, and according to the principle of division of powers and expenditure responsibilities, marine environmental protection work should included in the budget of the government at the same level. The central government has allocated over 4.8 billion yuan in special funds for marine ecological protection and restoration from 2020 to 2024.

#### 5.1.1.3 Local budget appropriation

From 2020 to 2023, Guangdong Province has allocated over 3 billion yuan in special funds for marine protection and restoration, supporting key tasks such as ecological restoration of coastlines, mangrove planting and restoration, remediation of key bays, and prevention and control of in nearshore waters. Among these, 1.205 billion yuan has been invested to support ecological of coastlines in Zhanjiang, Zhuhai, Jiangmen, Zhongshan, and Shantou; 1.58 billion yuan has been allocated mangrove restoration, used to support the restoration of mangroves in coastal cities and counties; and 0.485 billion yuan has been committed to prevention and control of pollution in nearshore waters, used for the remediation of pollution from aquaculture in nearshore waters and the management of pollution from land-based sources entering sea.

### 5.1.2 Institutional setting

In the reform of State Council institutions in 2018, the responsibilities of marine environmental protection were incorporated into those of the Ministry of Ecology and Environment, and those of marine protection, restoration, development, and utilization, into those of the Ministry of Natural Resources. Transportation, maritime affairs, fisheries, and forestry and grassland departments all participate in marine eco-environmental protection in accordance with their respective functions, which strengthens collaboration between land and sea pollution prevention and control and ensures uniformity. Over the years, a working mechanism for marine eco-environmental protection based on coordination among different departments and between central and local governments has been established, and a comprehensive system for collaborative governance of coastal areas, river basins, and sea areas is in

place.

### 5.1.3 Legal and Policy setting

#### 5.1.3.1 Internatal legal frameworks for marine ecological protection

China has successively joined the UNCLOS, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the International Convention for the Prevention of Pollution from Ships, and Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat. China has established a policy system around the protection of marine ecological environment and conservation of resources.

#### 5.1.3.2 Legal and policy framework of the country and coastal provinces

China attaches great importance to the construction of environmental protection legal system, and has already formed the environmental legal system with the Constitution of the People's of China as the basis and the Environmental Protection Law of the People's Republic of China as the main body. In view of the protection objects of marine ecological environment, China has and promulgated the Marine Environmental Protection Law of the People's Republic of China. In addition, China has formulated and promulgated a series of laws and regulations to the protection of marine ecological environment, such as the Law of the People’s Republic of China on Prevention and Control of Water Pollution, the Wetland Protection Law of the People' Republic of China, and the Fisheries Law of the People's Republic of China.

China attaches great importance to institutional protection of the marine eco-environment. It has established standards and exercised regulation for the exploitation and utilization of marine resources and implemented an institutional framework for marine eco-environmental protection based on standard practice and in accordance with the law.In terms of pollution prevention and control, China has implemented a filing system for sea-entering sewage discharge outlets. It utilizes a permit system for marine dumping, and carries out environmental impact assessment before approving projects that could impact the marine eco-environment, while ensuring an emergency

response system is in place as a backup for worst-case scenarios. With regard to protection and restoration, it has established the systems of marine eco-environmental red lines, protected areas, and natural shoreline control. In terms of supervision and management, it has established systems for territorial space use control and eco-environmental zoning control, for central environmental protection inspection and state natural resources inspection, for enforcing responsibility for meeting targets, and for assessment, evaluation, monitoring, and investigation. In relation to green development, it has established systems for compensating marine eco-environmental protection, managing fishing quotas and permits, and regulating the paid use of sea areas.

According to the Marine Environmental Protection Law, the national marine environmental protection planning should be formulated and implemented by the State Department of Ecology and Environment in conjunction with departments/local governments, including the stages of planning preparation, examination and approval, implementation, monitoring and assessment, which constitutes a complete policy cycle and effectively improves the quality of the marine.

### 5.1.4 Civil society, stakeholders and participation

The Chinese government formulated and implemented the Interim Regulations on the Procedures for Major Administrative Decisions, which mandates effective participation of stakeholders and the public in the process making and adjusting major administrative decisions.

All walks of life, mainly including enterprises, NGOs, associations, research institutions, and universities, actively participate in marine environmental protection, pollution control, and climate change.

In addition, local governments actively explore community co-management approaches to promote the participation of stakeholders. For example, Hainan Dongzhaigang National Nature Reserve has set a precedent for community

co-management. The community, tourism companies, and the reserve jointly formulated the "Dongzhaigang Community CoManagement Plan", which jointly stops illegal activities such as electrofishing, bird hunting, and cutting down mangrove trees within the protected area, and formulates village rules regulations to control and gradually reduce the community's use of small-mesh fishing gear.

### 5.1.5 Publicity and public awareness

#### 5.1.5.1 The Offering of Marine-related Courses in Universities

China has 33 universities offering marine science majors, 21 universities offering marine technology majors, 18 universities offering marine resources and environment majors, and10 universities offering marine fishery science and technology majors.

#### 5.1.5.2 Marine science popularization

China has developed a variety of education and scientific outreach initiatives aimed at promoting marine culture.China hosts yearly themed activities celebrating World Oceans Day (also China’ s National Ocean Awareness Day), Earth Day, World Environment Day, and World Wetlands Day. More than 160 ocean awareness promotion centers have been established across the country. Since 2017 and for seven years in a row, China has hosted the National Beach Cleanup activities, look to unite the collective efforts of all people across the country as they care for and protect the sea.The National Marine Knowledge Competition has been held for the past 14 years, attracting six million participants from the public and students from over a thousand universities and colleges.

#### 5.1.5.3 Green and low-carbon lifestyle

A number of initiatives have been introduced to encourage voluntary public action in maintaining the wellbeing of the oceans. These include practicing responsible tourism, refraining from purchasing endangered marine life products, avoiding disturbance to marine creatures, and not throwing plastic waste in the sea.

### 5.1.6 Governance performance and effectiveness

Integrated land-sea efforts to improve the water quality of the nearshore. Implementation the comprehensive governance of Pearl River Estuary key sea areas, total nitrogen management of key seagoing rivers, management of marine pollution, Supervision and Administration of sea-entering sewage discharge outlets, Promote the cleaning and rectification of marine litter and its resource utilization. In 2023, the proportion of sea areas with good to excellent water quality in Guangdong, Guangxi, and Hainan offshore waters accounted for 92.3%, 94.5% and 99.66% on average, generally showing a stable and improving trend.

Improving the marine protected areas system. China has established 352 marine protected areas, which protect about 93,300 sq km of sea areas. These areas focus on the protection of rare and endangered marine species such as the Chinese white dolphin, typical ecosystems such as mangrove forests and coral reefs. The marine protected areas have enabled the populations of rare marine species to recover gradually. Continuous monitoring and surveying from 2017 to 2021 showed that the population of white dolphins at the Pearl River mouth stood at about 2,600 by the end of the five-year monitoring period, representing stable population growth.

Implementing major marine eco-environmental conservation and restoration projects. Since the 14th Five-Year Plan, the central government has supported 62 marine ecological conservation and restoration projects, renovating about 40 kilometers of coastline and about 31,000 hectares of coastal wetlands. The area of mangrove forests has increased to 30300 hectares, up by about 7,200 hectares from the beginning of the century. The International Mangrove Center has been established inzhen. China is one of the few countries in the world where the area of mangrove forests has increased. (The China Climate Change Policy and Action 205 Annual Report)

Conserve biological resources.China's summer Marine fishing moratorium system is an important marine fishery resource conservation system stipulated

by the Fisheries Law. Since its implementation in 1995, the summer fishing moratorium has been adjusted and improved for many times. The fishing moratorium been extended and its scope expanded. It has effectively controlled the intensity of marine fishing and protected and restored fishery resources. It has promoted the sustainable and healthy development of marine fisheries With the continuous implementation of a series of measures, the conservation of fishery resources in China's offshore waters has achieved the desired results. From 2018 to 023, China's offshore fishing yield remained stable at about 9.5 million tons, and the number of precious endangered aquatic wildlife species such as the Chinese whiteolphin and sea turtles also showed an upward trend.

## 5.2 Discussion and conclusions

### 5.2.1 Analysis of deficiencies

#### 5.2.1.1 Lack of scientific knowledge about marine environmental ecology

The systematic research on typical marine ecosystems such as coral reefs, mangroves, and seagrass beds has been lacking for a long time, and scientific cognition of their ecological functions, species groups and community succession rules, the coupling mechanism of biodiversity and spatial heterogeneity is insufficient (Huang et al., 2024). In addition, climate change, environmental pollution and biodiversity issues are intertwined. To systematically address these three major challenges, it is necessary to enhance the scientific knowledge and technology of synergistic enhancement of pollution reduction and carbon reduction, and synergistic enhancement of biodiversity conservation and climate change response.

#### 5.2.1.2 Lack of participation from coastal communities

The knowledge of marine ecological environment is highly specialized, and the existing knowledge dissemination mostly fails to be based on the knowledge base and the level of acceptance of the in the community, resulting in insufficient effectiveness of knowledge dissemination and lack of participation of the residents in coastal communities.

The above deficiencies may put at risk the expected effectiveness of environmental governance and climate change work.

### 5.2.2 Current governance capacity to respond to climate and major environmental changes

#### 5.2.2.1 Building a modern marine ecological environment governance system

Maintain the government's leading role in protecting the marine ecological environment, play a crucial part in system design, scientific planning regulatory services, and risk prevention, and establish a working mechanism for marine ecological environment protection that centralizes the coordination by the central government, assumes overall responsibility by the province, and by the city and county. Activate the participation of business entities, transaction elements, and social capital in marine ecological environment protection, create a sustainable model for marine environmental protection and ecological, and strive to build a modern governance system for marine ecological environment with the participation of the Party committee leadership, government dominance, enterprise main body, social organizations, and the public.

#### 5.2.2.2 Steadily promote carbon peaking and carbon neutrality

China has set up a national leading group headed by Premier of the State Council and with officials from 30 ministries and commissions as members. Its remit is responding to climate change, conserving energy, and reducing emissions. China has issued the Interim Regulations on the Management of Carbon Emissions Trading, as well as the Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy, and the Action Plan for Carbon Dioxide Peaking Before 2030, and Opinions on Advancing Green and Low Carbon Transformation and Strengthening the Construction of the National Carbon Market. Relevant departments have formulated implementation plans and supporting policies in specific fields and industries. Comprehensive policies have been introduced to promote climate investment and financing, advance the establishment of a climate investment and financing standard system in a

coordinated manner, strengthen the guiding mechanisms for market capital, and support climate change response. The national carbon emission trading market has been incorporated into the steel, cement, and aluminum smelting industries, covering more than 60% of the total dioxide emissions in China, making it the largest carbon market in the world in terms of emissions covered. Carbon emissions control targets are set for each province according to their conditions, and the achievement of these targets is incorporated into the comprehensive performance review of principal leading officials and leadership teams of provinces, autonomous regions and municipalities directly under the central government, which serve as an important basis for the appointment, removal, reward, and punishment of officials.

#### 5.2.2.3 The main work of marine fields to deal with climate change

In the field of ocean action on climate change, marine carbon sink investigation and the establishment of accounting standards system have been carried out, including monitoring, investigation, measurement and carbon sinks technology methods of marine carbon sinks such as mangrove, seagrass bed, salt marsh. Launch the national voluntary greenhouse gas emission reduction trading mechanism market, and the methodological standards of voluntary reduction of greenhouse gas such as mangrove planting and grid-connected offshore power have been issued. It supports the development of ecosystem carbon sinks and marine renewable energy. The national sea level change monitoring, influence investigation and evaluation have been organized and out, the reclamation of land has been strictly controlled, the protection of coastal wetlands has been strengthened, and the ability of key coastal areas to resist climate change risks has improved.

### 5.2.3 Strategies to enhance government responses to climate change and achieve sustainability of the coastal and marine environments

#### 5.2.3.1 Strategies to strengthen the protection of marine ecological environment

（1）Establish a land-sea integrated marine pollution prevention mechanism. Fully implement precise, scientific, and lawful pollution control, pay more attention to source, strengthen the synergy of pollution reduction and carbon reduction, multi-pollutant control, regional governance, and river basin and sea area governance, and continue to deepen the of pollution prevention and control, control sea water eutrophication, and systematically improve the ecological environment quality of nearshore sea areas.

（2）Implement ecosystem-based management approaches to strengthen the protection and restoration of marine ecosystems. Carry out major marine ecological restoration projects, strengthen the protection and of typical marine ecosystems such as coastlines, sandy beaches, coastal wetlands, coral reefs, mangroves, and seagrass beds, and promote the construction of bays, beautiful shores, and harmonious islands.

（3）Enhance the capacity building and digital transformation of marine ecological environment governance and supervision. Deepen the integration of new generation information technologies such as big data Internet of Things, and artificial intelligence with marine ecological environment protection, build an intelligent sensing, precise early warning, and collaborative efficient marine ecological environment digital governance system, and improve the level intelligence in the fields of maritime development activities supervision, marine litter governance, marine ecological environment risk prevention and control, and marine biodiversity observation and protection.

（4）Promote the construction of marine volunteer service system, enhance the public's marine ecological civilization education and publicity services, and accelerate the formation of a nationwide awareness of marine ecology. Give full play to the bridge and bond role of industry associations and mass organizations, and carry out a wide range of public participation activities such as protecting the sea and cleaning the beach. Deepen the opening of environmental protection facilities and publicity and education venues, enhance the public's marine ecological civilization education and publicity

services, and improve the public's supervision and reporting feedback mechanism.

#### 5.2.3.2 Strategies to enhance the ocean's response to climate change

Coordinating land and sea to reduce pollution and carbon emissions and enhance synergistic effects. Strengthen the pollution control that coordinates land and sea promote the reduction of source emissions in marine oil and gas exploration and development as well as maritime transportation industry, and promote the synergistic enhancement of marine pollution reduction and climate response. Promote the development of offshore wind power and offshore photovoltaic, focus on the large-scale utilization of marine energy, and actively build a and reliable offshore new energy system.

Protect and enhance the blue carbon ecosystem. Continue to improve the construction of marine nature reserves, promote the integrated protection, restoration, and climate change adaptation capacity enhancement typical coastal ecosystems, fully protect the natural coastline, carry out the return of sea and beach from reclamation, shoreline and beach restoration, estuary and bay ecological restoration,angrove,seagrass bed,and salt marsh protection and restoration. Maintain the important ecological corridors of the coastal zone and protect biodiversity.

### 5.2.4 Recommended priority actions including regional cooperation

#### 5.2.4.1 Improve the standards, monitoring, evaluation and assessment systems for marine ecological environment

Further improve the technical standard system for monitoring and evaluation of marine ecological environment, and promote the revision of seawater quality,iments quality, and biological quality standards. Develop technical guidelines for the derivation of marine environmental benchmarks and seawater quality benchmarks. Improve technical standards and specifications for the protection of marine, ecological protection and restoration supervision.

#### 5.2.4.2 Enhance the capacity of marine environmental monitoring and research and data integration

Jointly carry out monitoring and scientific research on typical marine ecosystems and key species across disciplinary boundaries. Establish a sharing mechanism for relevant marine environmental data, as data on hydrology, marine physics, marine chemistry, marine biology, coastal habitats, and sediments, to provide a basis for comprehensive management and intelligent decision-making the marine ecological environment.

#### 5.2.4.3 Promote public participation and raise residents' awareness of marine environmental protection

To build a collaborative governance network, forming the synergy of government, enterprises, and community organizations. Enhance the effectiveness and acceptance of the dissemination marine environmental protection knowledge, and improve the awareness of marine environmental protection among community residents. Lower the threshold for participation, provide diverse, interesting, and sustainable ways of participation, and public participation.

#### 5.2.4.4 Strengthen regional cooperation and establish a mechanism for the exchange of technology and information

Strengthen regional cooperation in marine environmental protection in the South China Sea, establish relevant technical guidelines and information exchange mechanisms at the regional level. Share green protection technology standards and best practices, establish a database of regional technical guidelines and best practice cases, enhance the ability of countries to fulfill international conventions and international commitments, and jointly respond regional marine environmental challenges.

### 5.2.5 Methodology and Analysis

#### 5.2.5.1 Source of Data

In accordance with the requirements of the guidelines, Section 5.1 conducts a status analysis covering aspects such as economic policy driving forces,

institutional setting, current status of legal and policies setting, and governance effectiveness. This analysis is carried out by collecting data from the World Bank website and the official websites of relevant authorities, while also referencing and citing materials including the white paper *Marine Eco-Environmental Protection in China*, as well as existing national and provincial planning and policy documents.

#### 5.2.5.2 Analysis Methods

The report adopts analytical methods such as inductive summarization and qualitative description.

#### 5.2.5.3 Peer Review

The report was revised and improved after seeking professional advice from industry experts.

# Chapter References


[1] Duarte CM. The future of seagrass meadows[J]. Environmental Conse rvation. 2002;29(2):192-206.

[2] Lin Mingli,Turvey Samuel T.,Han Chouting,et al, Functional extinction of dugongs in China[J]Royal society open science, 2022, 9:211994.

[3] Nordlund LM, Unsworth RKF, Gullström M, Cullen-Unsworth LC.Global significance of seagrass fishery activity[J]. Fish Fish, 2018,19:399–41 2.

[4] Robert J. Orth, Tim J. B. Carruthers, William C. Dennison, Carlos M. Duarte, James W. Fourqurean, Kenneth L. Heck, A. Randall Hughes, Gary A. Kendrick, W. Judson Kenworthy, Suzanne Olyarnik, Frederi ck T. Short, Michelle Waycott, Susan L. Williams, A Global Crisis for Seagrass Ecosystems[J], BioScience,2006, 56(12):987–996.

[5] World Bank. World Development Indicators (WDI) Data Base[DB/OL]. 2025.https://databank.worldbank.org/source/world-development-indicator s

[6] World Bank. Private Participation in Infrastructure (PPI) Database: Chi na Country Snapshot[DB/OL]. 2025. https://pip.worldbank.org/country-p rofiles/CHN

[7] Development of the Basel Convention and practice of China's implem entation[J]. *Environment and Sustainable Development, 45*(5), 27–29.

[8] https://data.stats.gov.cn/easyquery.htm?cn=C01
National Bureau of Statistics of China. (n.d.). Annual data [Data set]. National Data.

[9] The State Council Information Office of the People’s Republic of Chin a. (2021). *Responding to Climate Change: China’s Policies and Actio ns*.

[10] The State Council Information Office of the People’s Republic of Chi na. (2024). Marine Eco-Environmental Protection in China.

[11] Huang, L., Lin, Q., Tan, Y., et al. (2024). Considerations on the rest oration, reconstruction, and conservation of characteristic tropical mari ne ecosystems[J]. Journal of Tropical Oceanography, 43(6), 1–12.

[12] Ministry of Ecology and Environment of the People’s Republic of Chi na, et al. (2022). National climate change adaptation strategy 2035 [Report]. Ministry of Ecology and Environment.
[13] The World Bank. (2023). *Gross domestic product, quarterly (2005-20 23)* [Data set]. World Development Indicators..

# 6 Conclusion of the National TDA Report

## 6.1 TDA working group general situation

SICES（MEE） has established a national TDA working group which includes sub-groups responsible for socio-economic and climate change stress, land-based pollution, coastal habitats and biodiversity, and comprehensive management of marine ecological environment under the SCS SAP project.

The working group systematically collected multiple sources of information, including government open data, statistical yearbooks, environmental bulletins, and authoritative academic literature, in accordance with the TDA technical guidelines and national TDA outline formulated by the PCA. The data analysis was strictly based on a series of technical standards and specifications for marine environmental monitoring, water quality assessment, pollution discharge, and other active national standards and regulations. By combining quantitative and qualitative analysis, the current situation of the four core areas of socio-economic and climate-related threats, land-based pollution, ecosystem and marine environmental governance was comprehensively evaluated. Ecological and environmental problems were identified, ecological and environmental risks were assessed, the main causes of environmental risks were analyzed, and priority action recommendations were proposed. This TDA could provide inputs for updating the SAP and offer policy recommendations for deepening international cooperation on ecological environment protection in the South China Sea.

## 6.2 Key findings

1. Climate change poses systemic stress and challenges to marine ecosystems. Over recent decades, the sea level and surface temperature in the South China Sea have significantly risen, and the frequency of ocean heat waves has increased, leading to ecological challenges such as coral bleaching and changes in the pattern of fishery resources, together with direct economic losses caused by intensified coastal erosion and storm surge disasters. To

alleviate the socio-economic impact of climate stress, China has taken measures such as systematically carrying out marine ecological restoration, strengthening comprehensive prevention and control of marine disasters, and improving the work system for adapting to climate change, enhancing regional economic resilience and providing strong support for the sustainable development of the blue economy in the South China Sea. However, the issue of climate change is complex and the task of addressing it remains arduous.
Suggestions need to further focus on key areas, strengthen research and development of marine ecological restoration technologies, enhance basic research and technology development for adapting to climate change, in order to ensure high-quality regional development.

2. The issue of coastal eutrophication caused by land-based pollution requires continuous attention. From 2017 to 2023, the areas exhibiting eutrophic conditions in the coastal waters of the northern South China Sea demonstrate fluctuating changes, with the highest value occurring in 2018. Subsequently, under the efforts of comprehensively implementing water pollution prevention and control and comprehensive management of key sea areas in China, the overall area of eutrophicated coastal waters in the northern South China Sea has shown a downward trend. It should be emphasized that eutrophication caused by land-based pollution is mainly concentrated in estuarine areas and will not cause transboundary pollution problems.
Suggestions need to further focus on nutrient reduction and strengthening the control of land-based pollution.

3. Marine litter pollution requires continuous attention. Since 2020, the average abundance of beach litter and seafloor litter in China has shown a clear overall downward trend.
Suggestions need to further focus on source reduction of plastic litter at the regional level, enhancing information exchange among countries on the management of domestic plastic litter, agricultural plastic waste, fishery plastic litter, etc. Sharing experiences and practical cases in the whole-chain management of plastic litter, and developing pathways for high-value resource utilization of marine litter to promote the industrialization and scaling of

recycling supply chains.

4. As a hotspot for biodiversity in China, the degradation trend of marine ecosystems along the South China coast has been largely contained in recent years. The area of mangroves and coastal wetlands has been steadily increasing. For typical marine ecosystems under long-term monitoring—such as mangroves, seagrass beds, and coastal wetlands—all monitoring indicators have shown a stable and positive trend or are stable with a tendency toward improvement. For instance, the mangrove area in the coastal provinces/regions of Guangdong, Guangxi, and Hainan has increased by 2,370 hectares, 2,230 hectares, and 3,709 hectares respectively compared to 2008. The seagrass density along the east coast of Hainan has risen from 358 shoots/m² in 2022 to 575 shoots/m². These achievements are attributed to China's active efforts in marine ecological conservation and restoration, including strengthening legislative protection for habitats, progressively improving the protected area system, and undertaking integrated planning for the conservation and restoration of key ecosystems in nearshore and coastal zones. While China places high importance on marine environmental protection, balancing conservation with development remains a perennial challenge. Although direct destruction of critical habitats by human activities such as marine engineering no longer occurs, inputs of land-based pollutants, pressures from excessive aquaculture, and destructive fishing practices continue to pose significant threats to marine ecosystems. Additionally, global climate change and invasive alien species represent major risks facing marine ecosystems.

It is recommended to:

1) Strengthen scientific research (e.g., research on fundamental ecosystem science, key ecological restoration technologies, and carbon sequestration and climate change responses);

2) Enhance conservation regulatory capacity (e.g., improve monitoring capabilities and refine the mechanisms for evaluating restoration

effectiveness);

3) Continuously advance marine ecological conservation and restoration, while bolstering the prevention and control of invasive alien species (e.g., controlling Spartina alterniflora)

5. In recent years, China has continuously improved the legal and regulatory system and institutional framework for marine ecological and environmental protection, effectively fulfilling responsibilities and obligations under international conventions. Centered on the Marine Environmental Protection Law, China has formulated over seven administrative regulations including the Regulations on the Control of Marine Dumping, over ten departmental regulations, and more than 100 normative documents, and issued over 200 technical standards and specifications. Work related to marine ecological and environmental protection, pollution control, and climate change has seen full participation and support from social institutions and stakeholders, with diverse public awareness and science education activities on marine culture conducted. More than 30 enterprises, NGOs, associations, research institutions, and universities have shown long-term attention and support for above work. The data shows that through sustained investment and unremitting efforts, the overall quality of China's marine ecological environment has improved, and significant results have been achieved in marine ecological and environmental protection.The central government has allocated over 4.8 billion yuan in special funds for marine ecological protection and restoration from 2020 to 2024. 352 marine-related protected areas have been established, protecting approximately 93,300 square kilometers of sea area, and populations of rare marine species are gradually recovering. In 2023, the average annual proportion of coastal waters with good/excellent water quality in Guangdong, Guangxi, and Hainan was 92.3%, 94.5%, and 99.66% respectively.

Suggestions need to further focus on further improve regulations and standards, enhance marine ecological environment monitoring and scientific research capabilities, promote public participation and raise awareness of

marine ecological and environmental protection among community residents, strengthen regional cooperation for marine environmental protection in the South China Sea, establishing relevant technical guidelines and information exchange mechanisms at the regional level.

## 6.3 Key areas of ecological environment protection

### 6.3.1 Areas of concern under climate change stress

1. Pearl River Delta and coastal lowland urban agglomeration. As highly economic and population intensive areas in China, these ares faces extreme risks of sea level rise and storm surge simultaneously. The infrastructure, water supply system and millions of people of megacities in the Pearl River Delta region are directly exposed to the threat of inundation and salt tide, which is an area of special concern for socio-economic and climate stress.

2. Beibu Gulf Coast area. As an area with frequent typhoons and storm surges, the Beibu Gulf has become a potential area with high climate vulnerability in the blue economy, under the background of intensified ocean heat waves and frequent extreme weather, and its coastal aquaculture, shipping logistics, coastal tourism and other marine economic industries are under great pressure.

### 6.3.2 Key governance areas of land-based pollution

The Pearl River Estuary. As key governance area clearly identified in the report, the Pearl River Estuary bears the input of continuous nutrients and pollutants from the Pearl River Basin, resulting in moderate to severe eutrophication in some coastal waters , an ecosystem in a sub-healthy state , and hypoxia in some water bodies . Its pollution impact range may extend to the adjacent waters of the Pearl River Estuary with the coastal current in the flood season.

### 6.3.3 Key areas of ecosystem

1. Hainan costal areas, especially the northeastern, northwestern and southern coastal waters of Hainan Island. The main protected areas include

National Nature Reserve in Dongzhai Port of Hainan, Mangrove Provincial Nature Reserve in Qinglan Port of Hainan, Mangrove Municipal Nature Reserve in Tielu Port, Special Marine Protected Areas for Seagrass in Xincun Port and Li'an Port of Lingshui, etc.

2. Guangxi coastal areas, especially the coastal waters of Beihai , Qinzhou and Fangchenggang. The main protected areas include Dugong National Nature Reserve in Hepu of Guangxi, Mangrove Ecological National Nature Reserve in Shankou of Guangxi , National Coastal Wetland Park in Beihai of Guangxi, National Nature Reserve in Beilun Estuary of Guangxi, etc.

3. Guangdong coastal areas, especially the Pearl River Estuary and its surrounding waters, the coastal waters of Leizhou Peninsula, the surrounding waters of Nan'ao Island, the coastal waters of Yangjiang, and the Daya Bay and Honghai bay. The main protected areas include the Pearl River Estuary Chinese White Dolphin National Nature Reserve, Guangdong Neilingding Futian National Nature Reserve, Guangdong Zhanjiang Mangrove National Nature Reserve, Leizhou Seagrass Nature Reserve, Guangdong Nan'ao qing'ao Bay National Marine Park, Guangdong Hailing Island National Marine Park, etc.

## 6.4 Target audience

As an important output of the project of "implementing the strategic action plan for the South China Sea and the Gulf of Thailand", the core purpose of this report is to systematically assess the regional environmental status, identify priority issues and propose priority actions. Provide input for updating the strategic action plan for the South China Sea and make policy recommendations for international cooperation in marine environmental protection in the South China Sea region. The target audience includes:

1. Relevant national and provincial administrative departments
2. International organizations and multilateral cooperation institutions
3. Scientific research institutions and academia
4. Industry (such as fishery, tourism and environmental protection

industry)

5. NGOs and the public

## 6.5Future indicator-based environmental assessments

Due to the stability and sustainability of marine ecosystem diversity are intertwined by climate change, environmental pollution and biodiversity factors, DPSIR (Drivers-Pressures-State-Impacts-Responses) model can be used as a framework to analyze and evaluate the causal chain and interaction mechanism of regional ecological and environmental problems in the South China Sea, and provide support for priority problem identification and action plan formulation. Therefore, it is suggested that the relevant indicators corresponding to pressure, state and response should be used in the future regional marine ecological environment assessment indicators.

| Pressrure and other related indicators | |
|---|---|
| Total nitrogen and phosphorus input from agriculture, sewage and atmospheric nitrogen | Domestic and industrial wastewater discharge, mariculture tail water discharge, agricultural fertilizer application<br><br>Chlorophyll-a |
| Ocean Warming | Annual mean sea surface temperature |
| Aquaculture | Risk assessment of the impact of pollution load and biodiversity |
| Population pressure/urbanization | Proportion of artificial coastline/retention rate of natural coastline |
| State and other related indicators | |
| Eutrophication status | The area of eutrophic sea areas.<br><br>Frequency and area of red tide occurrence |
| Overall level of marine debris | The average number and density of floating/beach/seabed debris. |
| Pollution in hotspot areas | Specific water quality indicators and their temporal trends |
| Endangered species | The distribution of species on the Red List of Endangered Species |
| Coastal habitat | Trends in the scope and condition of key habitats<br><br>Mangrove area<br>Seagrass meadows area<br>Coastal wetland area |

| Responses and other related indicators | |
|---|---|
| Policy measures to reduce input from land-based sources | Adopting measures such as urban domestic sewage treatment, comprehensive treatment of urban non-point source pollution, treatment of marine aquaculture pollution, treatment of agricultural non-point source pollution, and ecosystem restoration to reduce the influx of nutrients into large quantities. Governance investment |
| Incentives to reduce marine litter from the source | Establish a system for preventing and controlling marine garbage pollution, improve plastic recycling rates, promote clean beach initiatives, and encourage public participation |
| Key marine habitat protection and restoration | National park area/ecological red line area<br><br>Area and quantity of mangrove protected areas, area of mangrove ecological restoration<br>Area and quantity of seagrass meadows protected areas, area of mangrove ecological restoration.<br>Area and quantity of important coastal wetlands (excluding mangroves and seagrass beds) (including wetland parks and important wetlands at all levels) |
| Space partition management and control | Implement ecological environment functional zoning management |