Climate Change Impacts on Marine Ecosystems in NEAMPAN Sites in China: Challenges and Responses

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ABBREVIATIONS

- GEF: Global Environment Facility
- GMSL: Global Mean Sea Level
- MEE: Ministry of Ecology and Environment
- MNR: Ministry of Natural Resources
- MPAs: Marine Protected Areas
- NDRC: National Development and Reform Commission
- NEAMPAN: Northeast Asia Marine Protected Area Network
- OBCA: Ocean-Based Climate Action
- SOA: State Oceanic Administration
- SSP: Shared Socioeconomic Pathway
- SST: Sea Surface Temperature

EXECUTIVE SUMMARY

Climate change is exerting profound and multidimensional impacts on China's marine ecosystems and protected area networks, fundamentally altering the ecological patterns within China's jurisdictional waters. Scientific investigations reveal that rising sea surface temperatures, intensifying ocean acidification, and accelerating sea level rise have collectively caused significant disturbances to China's coastal and marine ecosystems. Our focused study on the 100-km coastal buffer zone, employing advanced analytical tools including R software and QGIS, has demonstrated distinct spatial variations in key environmental parameters across the Yellow-Bohai Sea, East China Sea, and South China Sea. Particularly concerning is the accelerated warming trend in the Yellow-Bohai Sea (0.008 °C/year), which has reduced oxygen solubility and created hypoxic conditions detrimental to high-oxygen-demand marine organisms. Concurrently, the projected decline in salinity, especially pronounced in the Yellow-Bohai Sea, threatens sensitive seagrass ecosystems that play a vital role in maintaining marine ecological balance. The compounding effects of warming waters are further exacerbating ocean acidification, with the South China Sea experiencing the most rapid decline in pH, thereby placing its coral reef ecosystems under severe stress. These interconnected changes are differentially, yet substantially, impacting critical marine habitats, including coral reefs and mangrove forests.

The escalating climate crisis poses equally significant challenges to China's Marine Protected Areas (MPAs) and the broader North-East Asia Marine Protected Area Network (NEAMPAN). Climate projections indicate that under both SSP1-1.9 and SSP5-8.5 scenarios, global mean sea level will rise by 0.15-0.23 m and 0.20-0.30 m, respectively, by 2050, with more severe increases of 0.28-0.55 m and 0.63-1.02 m anticipated by 2100. These changes threaten all six NEAMPAN sites in China, including ecologically significant areas such as the Changyi National Marine Ecology Special Protected Area, the Nanji Islands National Marine Nature Reserve, and the Sanya Coral Reef National Nature Reserve, with extensive inundation expected by end of the century. In response to these threats, China has implemented a comprehensive suite of conservation measures that span policy innovation, ecological restoration, and expansion of protected areas. Notable examples include the establishment of specialized management bodies, such as the Changyi Marine Ecology Special Reserve Management Committee, enhancement of institutional frameworks in the Beilun Estuary Reserve, and the development of sophisticated three-tier management systems in the Shankou Mangrove Reserve.

To address these challenges systematically, our research proposes an integrated strategy for enhancing climate resilience in marine protected areas. The framework emphasizes the development of ecosystem-based adaptive management approaches that fully incorporate climate considerations into conservation planning, while simultaneously strengthening regional cooperation through enhanced data sharing and joint monitoring initiatives under the NEAMPAN framework. The strategy further advocates for expanded application of nature-based solutions to improve ecosystem adaptability and

the establishment of diversified financing mechanisms to ensure long-term conservation sustainability. These coordinated measures are designed to collectively enhance the climate adaptation capacity of China's marine protected area network, thereby contributing significantly to the maintenance of regional marine ecological security and the advancement of sustainable ocean governance. The findings and recommendations presented in this report provide a comprehensive assessment of climate impacts on China's marine ecosystems and a practical roadmap for strengthening marine-based climate action, ensuring the long-term ecological integrity of the region's marine environments.

Chapter 1. Introduction

China's marine ecosystems are among the most diverse and productive in the world. They support rich biodiversity and provide essential ecological services, including carbon sequestration, coastal protection, and habitats for a variety of marine species. These ecosystems, such as coral reefs, mangroves, seagrass beds, and coastal wetlands, are not only vital for environmental health but also support the region’s economic, cultural, and social well-being. However, these ecosystems face increasing threats from climate change, including rising sea temperatures, ocean acidification, and sea level rise. These changes are altering the structure and functioning of marine ecosystems, resulting in habitat degradation, species migration, and biodiversity loss. Coastal ecosystems, in particular, are subject to multiple stressors from both climate change and human activities such as overfishing, pollution, and coastal development.

The current acceleration of global climate change presents complex and severe challenges to China's marine ecosystems. Rising temperatures, acidification, and sea level rise are now major factors threatening their stability and sustainability. Warming oceans disrupt the thermal balance that marine organisms have long adapted to, resulting in increased survival pressures and shifting species distributions. Coral reefs exemplify this vulnerability. When temperatures exceed thresholds, the symbiotic relationship between corals and algae breaks down, resulting in bleaching (Tolleter et al., 2013). This not only seriously threatens coral survival but also causes biodiversity loss and disrupts the functioning of ecosystems.

Ocean acidification, characterized by fluctuations in seawater chemistry, interferes with physiological and ecological processes. Calcium carbonate-dependent organisms, such as shellfish and corals, experience inhibited calcification, which affects their survival and reproduction. Sea-level rise directly increases the risk of inundation risk in low-lying coastal areas. As a result, habitats such as coastal wetlands and mangroves shrink and deteriorate, threatening the species that depend on them (Liu et al., 2020).

At the same time, human activities further exacerbate these pressures. Overfishing has disrupted the marine population structure and ecological balance of aquatic biological resources, leading to the risk of population collapse of many essential fishery resources and threatening the integrity of the marine food chains. The massive discharge of industrial wastewater, domestic sewage, and agricultural non-point source pollution has deteriorated seawater quality. Harmful substances accumulate in aquatic organisms, affecting their growth, reproduction, and survival. Large-scale coastal development activities, such as land reclamation, port construction, and coastal engineering projects, alter coastal geomorphology and hydrodynamics, damaging natural ecosystem structure and functions and further compressing available habitats.

Despite these complex and severe challenges, China is committed to prioritizing ecological protection alongside green development. The government has implemented a series of comprehensive and targeted measures to address the impact of climate change on marine ecosystems. A robust and forward-looking policy framework has been established, beginning with the *National Plan for China's Response to Climate Change*, which clearly defined the basic strategic framework for climate change response, laying the foundation for subsequent policymaking and action implementation. A series of marine spatial plans and special policies have followed, aiming to regulate the rational use and adequate protection of marine areas and islands and foster integrated land-sea governance. Key legislation, such as the *National Plan for Responding to Climate Change and the Marine Environmental Protection Law,* further clarifies the objectives, tasks, and management norms in key areas, including greenhouse gas reduction, marine ecological protection, and pollution prevention. During the 14th Five-Year Plan period, several dedicated marine ecological protection and restoration plans have provided additional policy support to enhance the marine ecological environment and promote its sustainable development.

In addition, China has made significant efforts to enhance the development and management of Marine Protected Areas (MPAs). According to management objectives and effectiveness, it is classified into three categories: National Parks, Nature Reserves, and Nature Parks, based on their natural attributes, ecological value, and protection intensity.

1. **National Park:** A specially designated area established and administered by the state with the primary objective of protecting nationally representative natural ecosystems, achieving both scientific conservation and sustainable utilization of natural resources.
2. **Nature Reserve:** A legally demarcated terrestrial, aquatic, or marine area granted special protection and management to preserve representative natural ecosystems, concentrated habitats of rare and endangered wildlife species, or sites of significant natural heritage value.
3. **Natural Park:** An area designated for the long-term protection and sustainable use of natural ecosystems, geological features, and landscapes possessing exceptional ecological, aesthetic, cultural, or scientific significance.

As a result, a structured and functional MPA network has been gradually developed. The legal regulations and management system of MPA in China are listed in Table 1.

Table 1. The Legal regulations and Management system of MPA in China

Legislation	Marine Environmental Protection Law of the People's Republic of China
	Wildlife Protection Law of the People's Republic of China
	Regulations on the Management of Nature Reserves of the People's Republic of China
Regulations	Regulation of Marine Nature Reserve Management (1995)
	Regulation of Marine Special Protected Area Management (2012)
	Regulation of National Parks Management (2022)
	Regulation of Natural Parks Management (2023)
Technology standards for MPAs	National Standard (GB/T17504-1998): Principles of type and level of classification of marine nature reserves
	National Standard (GB/T 19571-2004): Technical specifications of marine nature reserve management.
	National Standard (GB/T 25054-2010): Selection technology guidelines of marine special protection areas
	Marine Industrial Standards (HY/T 117-2010): Special marine protected area classification and grading standards
	Marine Industrial Standards (HY/T118-2010): Technical guidelines for the preparation of overall planning, function zoning in marine special protection areas

These MPAs play a crucial role in conserving rare and endangered marine species, maintaining the integrity and stability of marine ecosystems, and promoting the sustainable use of marine resources. China also actively participates in regional cooperation through platforms such as the NEAMPAN. Through this platform, China collaborates with neighbouring countries to jointly address cross-border ecological and environmental issues, such as climate change and marine biodiversity loss, thereby supporting coordinated efforts in regional marine ecological (and environmental) protection.

This report applies multidisciplinary research methods and data analysis tools to comprehensively evaluate the impacts of climate change on China's marine ecosystems. It assesses the effectiveness of China's response measures to climate change, particularly through MPAs and other ecological protection measures, and systematically explores the mechanisms and potential of NEAMPAN in promoting regional cooperation and climate action. Through an in-depth analysis of China's existing strategies and research on the cross-border cooperation model of NEAMPAN, the report provides science-based and operational policy recommendations to improve MPA management, enhance ecosystem resilience and adaptability, and promote the sustainable management of marine resources. These efforts are of great practical significance and strategic value in securing the long-term health and sustainable development of marine ecosystems, as well as maintaining their rich ecological services and economic values in China and the wider North-East Asian region.

CHAPTER 2. IMPACT AND CHALLENGES OF CLIMATE CHANGE ON CHINA'S MARINE ECOSYSTEM

Climate change is having a profound impact on China's marine ecosystems. Although the country's vast maritime areas are rich in biodiversity, they are increasingly threatened by rising sea temperatures, ocean acidification, and sea-level rise due to climate change. Research findings indicate that from 2006 to 2020, the coastal marine ecosystems of all eastern Chinese provinces (including direct-administered municipalities) experienced cumulative impacts from multiple environmental stressors. The most significant pressure factor among them is climate change (Liu et al., 2024).

China's coastal ecosystems, particularly coral reefs, mangroves, and seagrass beds, are among the most vulnerable to the impacts of climate change. Ocean acidification and elevated sea temperatures have significantly deteriorated the health of these habitats, with significant implications for biodiversity and the ecological services they provide. Along gradients of normal pH levels (8.1-8.2) to more acidic conditions (mean pH 7.8-7.9; minimum pH 7.4-7.5), typical rocky shore communities rich in calcareous organisms have shifted towards communities lacking *scleractinian* (reef-building) corals, and experienced substantial reductions in sea urchin and coralline algal abundance. Coralline algal biomass has declined significantly, and gastropod shells have shown signs of dissolution due to periods of carbonate sub-saturation (Hall-Spencer et al., 2008). Increased acidification in the Bohai Sea and Yellow Sea has further contributed to habitat degradation for calcifying organisms such as shellfish, resulting in higher mortality rates. Meanwhile, rising sea levels have intensified coastal erosion and saline intrusion, which have degraded mangrove and tidal flat ecosystems, crucial habitats for many coastal species, thereby disrupting their survival and reproductive cycles.

The combined effect of overfishing and climate change has further exacerbated the vulnerability of marine ecosystems in China. Collectively, these stressors are continuously altering the structure and function of China's marine ecosystems, underscoring the urgent need for effective conservation and adaptive management strategies to ensure marine ecological balance and long-term sustainability.

To assess the impacts of climate change on the offshore areas, this study defines a coastal buffer zone of 100 km extending seaward from the Chinese coastline as the primary study area. This nearshore zone, as a dynamic interface between terrestrial and marine systems, supports ecologically complex and highly sensitive environments. The rate of temperature and climate change in this area plays a non-negligible role in the marine ecosystem. Different rates of temperature change lead to varying rates of alteration in the seawater heat content, which in turn affect the physiological activities, reproductive cycles, and migration patterns of marine organisms. Climate change velocity is an indicator used to measure the rate at which the climate conditions on the Earth's surface shift within a local area, allowing for a more precise assessment of climate change impacts on biodiversity. Sea surface temperature (SST), salinity, and acidity (pH) have been widely used to assess the potential (effects) of climate change. This study calculates the rate of climate change based on SST, salinity, and pH under the SSP5-8.5 scenario[1] for the future (2020-2100), and explores its impact on species survival and distribution. Environmental data are sourced from the Marine Environmental Dataset[2]. The climatology package in the R software is used to calculate the rate of climate change. Specifically, two methods, namely the distance-based algorithm and the gradient-based algorithm, are employed to estimate the rates of climate change for variables such as SST, salinity, and pH. Distribution data for coral reefs, mangroves, and seagrass are obtained from the General Bathymetric Chart of the Oceans[3], and an in-depth analysis is conducted to explore the impact of climate change on these ecosystems.

2.1 Sea Surface temperature

Among the various factors associated with climate change, temperature change is one of the key elements. The area within 100 km of the Chinese coast, serving as an interface between the ocean and land, comprises an extremely sensitive and complex ecosystem. The rate of temperature and climate change in this area plays a significant role in shaping marine ecological conditions. Variations in temperature change rates lead to different rates of alteration in seawater heat content, which in turn affect the physiological activities, reproductive cycles, and migratory patterns of marine organisms. In this context, the rate of climate change within 100 km off the Chinese coast has been analysed through projections to the year 2100. Under the SSP5-8.5 scenario, the spatial rate of ocean temperature change is illustrated in Figure 1-A. The average temperature velocity in China's marginal seas is 7.51 km/year, with notable regional differences: the Yellow Sea and Bohai Sea show a higher average of 10.36 km/year, compared to 4.41 km/year in the East China Sea and 6.77 km/year in the South China Sea (Table 2).

[1] the “fossil-fuelled development” SSP5-8.5 scenario of high emissions and low challenges to adaptation.

[2] Bio-ORACLE, https://www.bio-oracle.org.

[3] GEBCO, https://www.gebco.net.

Table 2. Average SST change velocity by method and region within China's 100 km coastal zone

area / SST change velocity	100 km buffer zone of China	Yellow Sea and Bohai Sea	East China Sea	South China Sea
distance-based (km/year)	7.51	10.36	4.41	6.77
gradient-based (°C/year)	6.03×10^{-3}	8.47×10^{-3}	3.71×10^{-3}	5.21×10^{-3}

The rate of change in ocean temperature based on the gradient is shown in Figure 1-B. The average temperature gradient of China's marginal seas is 0.006 °C/year, indicating an annual increase of 0.006 °C. The Yellow Sea and Bohai Sea continue to exhibit more rapid warming, with a temperature gradient of 0.008 °C/year, followed by the East China Sea at 0.004 °C/year, and the South China Sea at 0.005 °C/year (Table 2). The temperature rise reduces the oxygen solubility in seawater, leading to hypoxic conditions in some areas of the Yellow Sea and Bohai Sea, which adversely affects the survival of marine organisms, especially fish and invertebrates with high oxygen demand.

China's coral reefs cover an area of approximately 38,000 km^2. There are three types of coral reefs in China: atolls in Nansha, Xisha, and Dongsha islands; fringing reefs along the coasts of Hainan and Taiwan islands; and scattered coral polyps of individual species along the mainland provinces. The fringing reefs extend along the coastline from Dongshan Bay in Fujian Province to Leizhou Peninsula. In the northern South China Sea, more than 200 species of *scleractinian* corals have been recorded, representing about two-thirds of the world's known species. As shown in Figure 1-B, the distribution sites of coral reefs coincide with the areas experiencing the highest rate of temperature change. This suggests that under future climate change, the temperature variable will exert wide-ranging and profound impacts on the coral reef ecosystem. From the physiological functions of coral polyps and their symbiotic relationship with zooxanthellae to the structure and function of the entire coral reef community, significant alterations are expected to occur.

Figure 1. Climate change velocity of SST along the Chinese coast (2010 to 2100), under the SSP5-8.5

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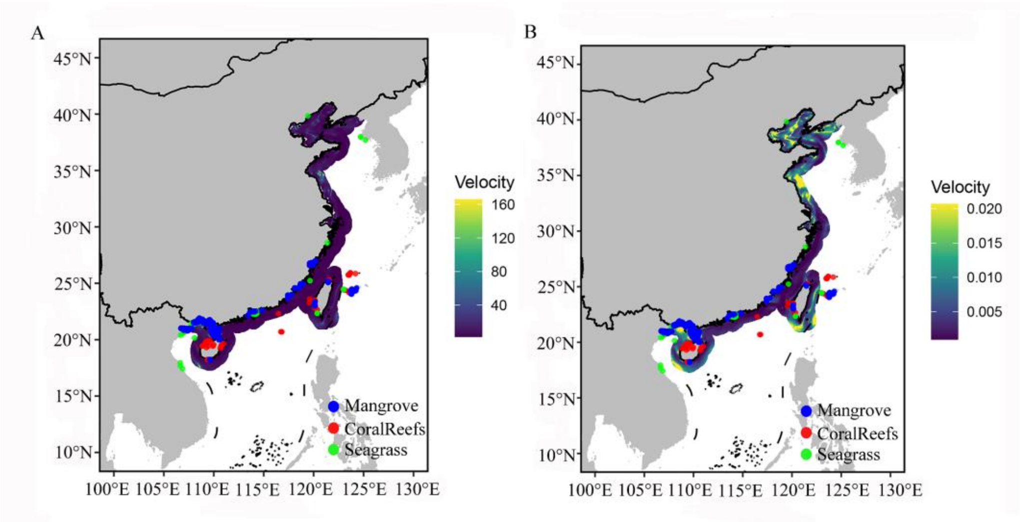


Note: (A) Distance-based velocity (km/year); (B) Gradient-based velocity (℃/year)

2.2 Sea Surface Salinity

The rate of temperature change interacts with other climate change factors, further exacerbating or mitigating impacts on coastal ecosystems. For instance, rising temperatures can alter ocean surface salinity by increasing evaporation and shifting precipitation patterns, triggering cascading effects on biota dependent on specific salinity conditions. Compared to 2010, future ocean surface salinity is projected to decline, with an overall rate of change ranging from -20.65 to 2.08 km/year, and an average of -1.06 km/year. This implies that species would need to migrate an average of 1.06 km per year to find suitable habitats (Figure 2-A). The Yellow Sea and Bohai Sea exhibit higher salinity change rates, averaging -2.01 km/year, while the East China Sea and South China Sea show lower rates of -0.34 km/year and -0.53 km/year, respectively (Table 3).

Table 3. Average salinity change velocity in China's marginal seas

area / salinity change velocity	100 km buffer zone of China	Yellow Sea and Bohai Sea	East China Sea	South China Sea
distance-based (km/year)	-1.06	-2.01	-0.34	-0.53
gradient-based (-/year)[4]	-8.31×10^{-4}	-14.92×10^{-4}	-3.21×10^{-4}	-4.74×10^{-4}

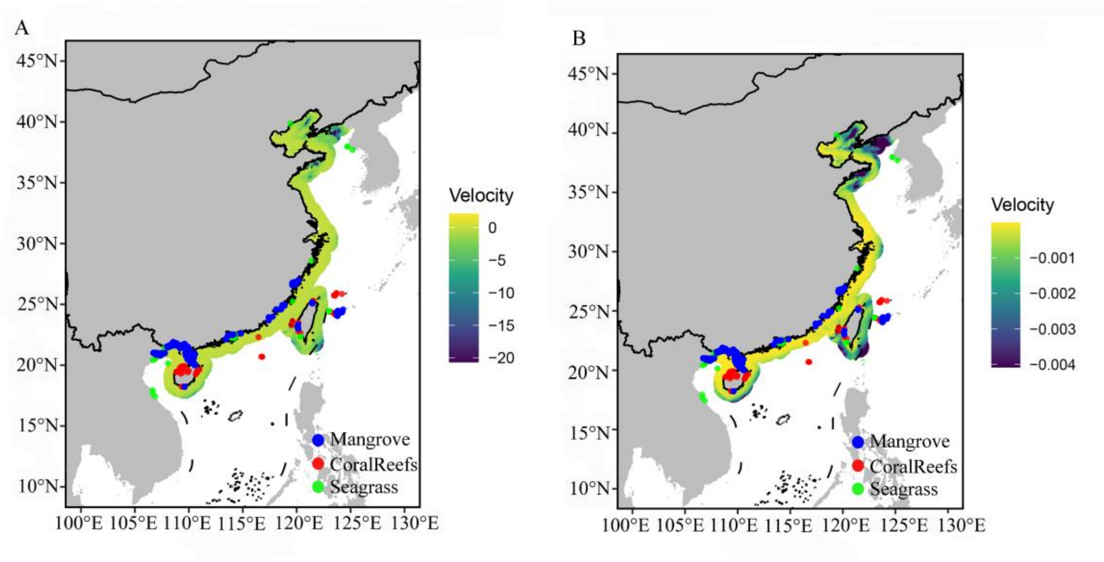
[4] Salinity Unit: Modern oceanography uses the "Practical Salinity Scale (PSS-78)", which is fundamentally a conductivity ratio and is therefore dimensionless.

The gradient-based calculation of salinity change shows that the surface salinity of seawater is projected to continue declining in the future. The average rate of decline in the coastal areas of China is 0.8×10^{-3} per year (Figure 2-B). The average rate of decline in the Bohai Sea and the Yellow Sea is 1.49×10^{-3} per year, which is significantly higher than in the East China Sea (0.3×10^{-3} per year) and the South China Sea (0.4×10^{-3} per year). Salinity changes may result in the loss of habitat for (particular) species, thereby affecting the biodiversity of the Bohai Sea and Yellow Sea regions. Shellfish and crustaceans inhabiting these areas may struggle to survive due to declining salinity level (Table 3).

The overall trend of ocean salinity is projected to decline, with the decrease in the Yellow Sea and Bohai Sea region being particularly pronounced (Figure 2-B). This region, characterized by distinct salinity features, serves as a crucial habitat for various marine organisms. Notably, seagrass is distributed across this area. Seagrass plays a vital role in maintaining the ecological balance of the marine environment by stabilizing sediments and providing food and shelter for numerous marine species. It is highly sensitive to environmental changes, including changes in salinity. In light of the ongoing downward trend in salinity, it is necessary to examine the potential impacts on seagrass-related ecosystems closely.

The situation in the East China Sea is also of concern. As illustrated in Figure 2-B, the rate of salinity decline along the coasts of Fujian Province and Taiwan Province is relatively rapid. Mangrove and coral reef ecosystems, which are (primarily) distributed in this region, are likely to undergo significant structural and functional changes in response to shifts in salinity. For example, mangrove species such as Rhizophora exhibit species-specific tolerance thresholds (Ball,1988), while corals may undergo bleaching when salinity exceeds 40 parts per thousand (ppt) (Coles & Jokiel, 1992). Model projections further indicate that climate-induced changes in salinity may place approximately 30% of global mangroves at risk by 2100 (Saintilan et al., 2020).

Figure 2. Climate change velocity of salinity along the Chinese coast (2010 to 2100), under the SSP5-8.5 scenario



Note: (A) Distance-based velocity (km/year); (B) Gradient-based velocity (-/year)

2.3 Ocean Acidification

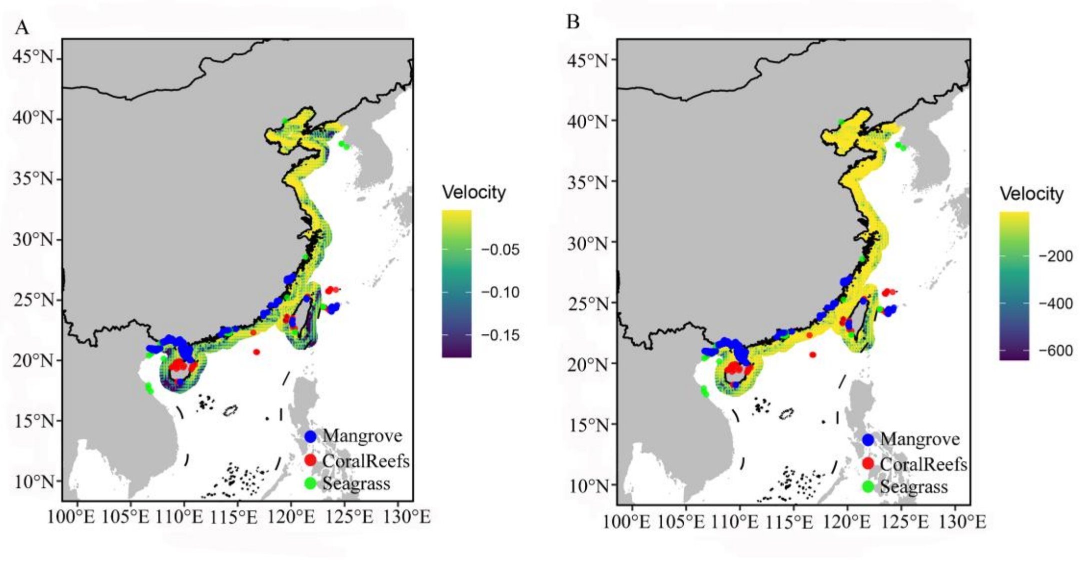
A relatively rapid rise in sea temperature may accelerate the process of ocean acidification, thereby posing a more severe threat to calcifying organisms. Ocean acidification, driven by increasing absorption of carbon dioxide, results in a decline in seawater pH. Studies have shown that when pH falls below 7.8–7.9, levels projected under the SSP5-8.5 scenario by 2100, marine ecosystems experience significant disruptions, including reduced calcification in corals and shellfish (Andersson et al., 2015). Notably, coral reefs begin to undergo net dissolution at pH level below 7.7 (Eyre et al., 2018), a threshold that some regions are expected to reach by 2100 under high-emission scenarios. According to the calculated pH change velocity, the pH value along the Chinese coast is projected to continue declining, indicating that the degree of seawater acidification will intensify. The average pH change velocity along China's coast is -55.70 km/year, meaning that marine organisms would need to migrate approximately 55.70 km/year to maintain exposure to similar pH conditions (Figure 3-A). Among China's coastal seas, the South China Sea exhibits the highest pH change velocity, averaging -68.40 km/year, followed by the Yellow Sea and Bohai Sea at -33.30 km/year and the East China Sea at -39.33 km/year (Table 4).

Table 4. The average pH change velocity in China's marginal seas.

area pH change velocity	100 km buffer zone of China	Yellow Sea and Bohai Sea	East China Sea	South China Sea
distance-based (km/year)	-55.70	-33.30	-39.33	-68.40
gradient-based (-/year)[5]	-4.32×10^{-2}	-2.66×10^{-2}	-3.28×10^{-2}	-5.36×10^{-2}

Based on the gradient-based calculation of the pH change rate, the overall pH in China's coastal waters is projected to decrease by 4.32×10^{-2} per year. Among these regions, the South China Sea exhibits the most rapid decline, with an annual decrease of 5.36×10^{-2} per year, followed by the East China Sea at 3.28×10^{-2} per year and the Bohai and Yellow Seas at 2.66×10^{-2} per year (Figure 3-B, Table 4). Coral reefs, which are a vital component of the South China Sea ecosystem, serve as critical habitats, breeding grounds, and foraging areas for numerous marine organisms. Ocean acidification hinders the growth of coral reefs, potentially leading to their degradation, which in turn damages reef structure, reduces biodiversity, and severely affects the stability and functions of the entire coral reef ecosystem.

Figure 3. Climate Change Velocity of pH along the Chinese coast (2010 to 2100), under *SSP5-8.5* scenario



Note: (A) Distance-based velocity (km/year); (B) Gradient-based velocity (-/year)

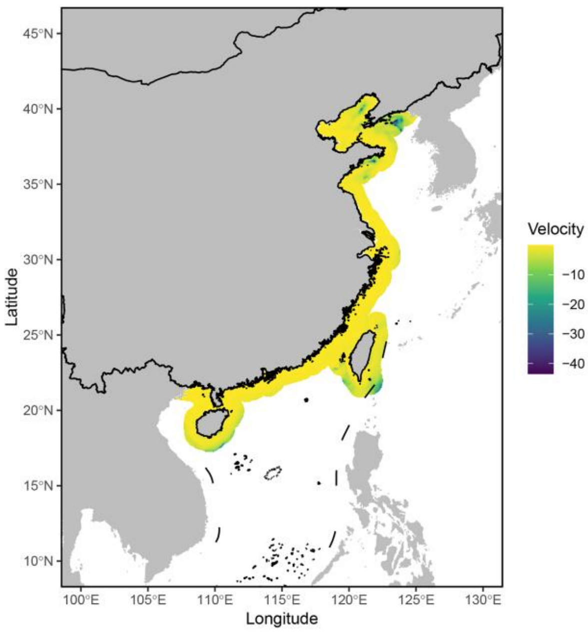
[5] pH Unit: pH is the negative logarithm of hydrogen ion activity, inherently a logarithmic ratio. The International Union of Pure and Applied Chemistry (IUPAC) explicitly defines it as a dimensionless quantity.

2.4 Comprehensive Impact Assessment of Multiple Environmental Factors

After individually analysing the rates of change in temperature, salinity, and pH, a comprehensive climate change velocity was calculated to assess the combined impacts on marine ecosystems more holistically. This metric integrates the rates of change in these three variables, reflecting the total distance marine species would need to migrate to adapt to multiple concurrent environmental pressures (Figure 4).

The results indicate that the average comprehensive climate change velocity along China's coast is -1.50 km/year, with the highest rate observed in the Yellow Sea and Bohai Sea at -2.30 km/year, followed by the South China Sea and East China Sea at -1.12 km/year and -0.49 km/year, respectively (Table 5). These findings suggest that the comprehensive climate change velocity differs from the rates associated with individual environmental factors, providing a more complete reflection of the cumulative impacts of multiple stressors. For instance, the combined impacts of rising temperatures and ocean acidification may pose greater threats to calcifying organisms, while changes in salinity further influence species distribution and habitat suitability. These results underscore the importance of adopting integrated conservation measures to address the complex impacts of climate change.

Figure 4. Comprehensive climate change velocity along the Chinese coast (2010-2100), under *SSP5-8.5* scenario



Note: Distance-based velocity (km/year)

Table 5. The average comprehensive change velocity in China's marginal seas

area / comprehensive change velocity	100 km buffer zone of China	Yellow Sea and Bohai Sea	East China Sea	South China Sea
distance-based (km/year)	-1.50	-2.30	-0.49	-1.12

2.5 Policy Responses and Ecological Restoration Projects

At the policy level, the Government of China has established a comprehensive governance framework for marine ecological conservation and climate change response, involving multiple ministries and agencies in a coordinated manner. The Ministry of Ecology and Environment (MEE) serves as the lead agency for climate change mitigation and marine environmental protection, while the Ministry of Natural Resources (MNR) oversees marine spatial planning and ecological restoration. The National Development and Reform Commission (NDRC) coordinates national climate strategies, and the State Oceanic Administration (SOA, under MNR) is responsible for the management of MPAs and coastal zone management. Inter-ministerial coordination is facilitated through mechanisms such as the National Leading Group on Climate Change and the Inter-Ministerial Joint Conference on Marine Ecological Protection.

China’s policy framework has evolved through a series of key documents:

1. **The National Plan for China’s Response to Climate Change** (2007, NDRC) established the foundational framework for national action, setting phased goals for emissions reduction and climate adaptation.
2. **The Marine Environmental Protection Law** (revised 2023, MEE) regulates pollution control and marine ecosystem management, including specific provisions for the designation and management of MPAs.
3. **The National Marine Functional Zoning Plan** (2012–2020, MNR) introduced an integrated land-sea spatial planning system designed to optimize the use of marine resources.
4. **The Major Engineering Plan for Coastal Zone Ecological Protection and Restoration** (2021, MNR and MEE) focuses on habitat restoration, with targeted actions for mangroves, seagrass beds, and coral reefs.
5. **China’s Biodiversity Conservation Strategy and Action Plan (2023–2030)** (MEE) incorporates marine ecosystems into national conservation priorities, setting ecological red line targets for the protection of coastal zones.

In ecological restoration, China is implementing large-scale projects to enhance coastal resilience and carbon sequestration:

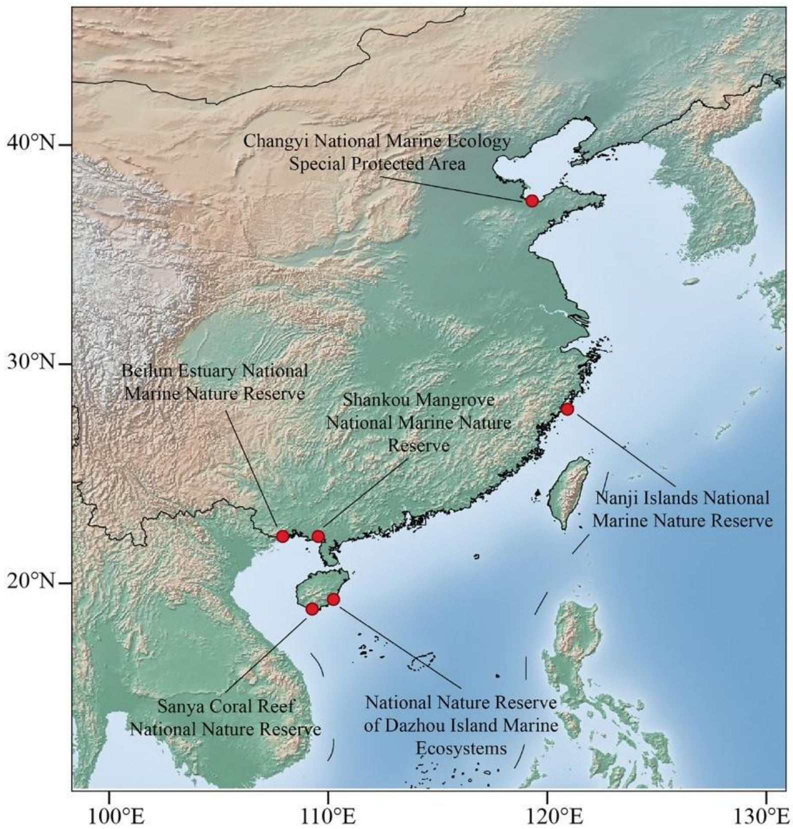
1. **Mangrove restoration**: Led by MNR and provincial forestry bureaus, these projects select appropriate species (e.g., *Avicennia marina, Aegiceras corniculatum*) based on local salinity and tidal conditions. Advanced techniques, such as GIS-based planting optimization and high-survival seedling cultivation, are employed to improve climate adaptation and carbon storage capacity.
2. **Seagrass bed rehabilitation**: Implemented under MEE’s monitoring network, degraded areas are restored through seed sowing and turf transplantation, supported by artificial substrates to enhance recovery rates.
3. **Artificial reef deployment**: Managed by local marine agencies, artificial structures (e.g., concrete reefs, shipwrecks) are deployed to promote fishery recovery and biodiversity, aligning with MPA objectives.

These efforts collectively strengthen the capacity of marine ecosystems to mitigate the impacts of climate change, while contributing to China’s dual carbon goals – peaking carbon emissions by 2030 and achieving carbon neutrality by 2060.

CHAPTER 3. INTERACTION BETWEEN CLIMATE CHANGE AND CHINA'S MARINE PROTECTED AREAS AND NEAMPAN

Climate change is profoundly affecting China's marine protected areas (MPAs) and the broader North-East Asia Marine Protected Area Network (NEAMPAN). Rising ocean temperatures, acidification, sea level rise, and increased frequency of extreme weather events directly threaten the integrity of coastal and marine ecosystems. These impacts are particularly pronounced in ecologically sensitive ecosystems such as coral reefs, mangroves, and coastal wetlands. Scientific research indicates that all six NEAMPAN sites in China are affected by climate change to varying degrees, facing challenges such as habitat degradation and declining biodiversity. These sites include Changyi National Marine Ecology Special Protected Area, Nanji Islands National Marine Nature Reserve, Beilun Estuary National Marine Nature Reserve, Shankou Mangrove National Marine Nature Reserve, Sanya Coral Reef National Nature Reserve, and National Nature Reserve of Dazhou Island Marine Ecosystems (Figure 5).

Figure 5. Geographic distribution of the six NEAMPAN sites in China



One of the most significant impacts of current global climate change is (the phenomenon of) global warming. Average monthly maximum sea surface temperature data were obtained from Bio-ORACLE[6], and land temperature data were sourced from WorldClim[7]. By applying advanced Geographic Information System (GIS) technology, the average ocean temperatures of Nanji Islands National Marine Nature Reserve and Sanya Coral Reef National Nature Reserve were extracted, along with the average air temperature of the National Nature Reserve of the Dazhou Island Marine Ecosystems. These data were then analysed to assess their impacts on the main protected targets of each protected area.

Another notable impact of global warming is the rise in global mean sea level (GMSL). According to the latest monitoring and numerical simulation results from the IPCC Sixth Assessment Report, the current rate of sea level rise is accelerating – now measured at 3.7 mm/year, and is expected to continue increasing, indicating an irreversible trend. Under the low emission scenario (SSP1-1.9) and the high emission scenario (SSP5-8.5), the GMSL is projected to rise by 0.15-0.23 m and 0.20-0.30 m by 2050, respectively; and by 2100, the GMSL is projected to rise by 0.28-0.55 m and 0.63-1.02 m, respectively. This study applied QGIS software (Quantum Geographic Information System; version 3.4.1) to conduct bathymetric and elevation analysis for the six NEAMPAN sites. Elevation data were initially obtained from GEBCO[8] and overlaid onto remote sensing imagery of the protected areas. Based on projections of a potential 1.02 m rise in GMSL by 2100, QGIS spatial analysis tools were used to identify and visualize areas with elevations below 1.02 m that may be vulnerable to inundation. A comprehensive analysis, simulation, and prediction were conducted by integrating current sea level data, regional topography, and future projections.

The spatial distribution of the protected areas is illustrated in Figure 5, and detailed information on NEAMPAN sites information is provided in Table 6.

Table 6. Key characteristics of the six NEAMPAN sites in China

Name	location	Key protected targets	Area (km^2)	Designation
Changyi National Marine Ecology Special Protected Area	Changyi, Shandong	tamarisk *(Tamarix chinensis)*	29.29	2007
Nanji Islands National Marine Nature Reserve	Pingyang, Zhejiang	shellfish and algae	201.06	1990
Beilun Estuary National	Fangchenggang,	mangrove	30	2000

[6] Bio-ORACLE: https://bio-oracle.org/.

[7] WorldClim: https://worldclim.org/.

[8] GEBCO: https://www.gebco.net/.

Marine Nature Reserve	Guangxi			
Shankou Mangrove National Marine Nature Reserve	Hepu, Guangxi	mangrove, seagrass, and the sea mammals	80	1990
Sanya Coral Reef National Nature Reserve	Sanya, Hainan	coral reef	85	1990
National Nature Reserve of Dazhou Island Marine Ecosystems	Wanning, Hainan	coral reef	70	1990

3.1 Changyi National Marine Ecology Special Protected Area

The Changyi National Marine Ecology Special Protected Area is located in the northern part of Changyi City, Shandong Province, east of the Dihe River, extending seaward from the beach coastline. It spans 5,000 m from east to west and 7,000 m from north to south. The area encompasses shallow sea, tidal flats, salt marshes, wetlands, and five rivers flowing into the sea, and is characterize by flat topography and an accretional coastal plain with an irregular, mixed semidiurnal tidal pattern. As a representative marine ecosystem in Laizhou Bay of the Bohai Sea, the Changyi protected area is the only national MPA in China that primarily protects tamarisk (*Tamarix chinensis*) coastal wetlands. This habitat plays a critical ecological role by (1) stabilizing sediments and reducing coastal erosion through its extensive root systems, (2) providing nursery grounds for commercially important fish and crustaceans, (3) supporting biodiversity, particularly migratory shorebirds along the East Asian-Australasian Flyway, and (4) sequestering blue carbon in salt marsh soils. These ecosystem services underscore the importance of Changyi's conservation for both ecological resilience and local livelihoods. The primary goal of the reserve is to protect a variety of coastal wetland ecosystems and marine organisms, with particular emphasis on tamarisk communities, which occupy approximately 70% of the protected area.

The lowest elevation point in the Changyi Nature Reserve is -3 m, the highest point is 2 m, and the average elevation is 1.24 m. According to projections for the year 2100, most of the protected area is expected to be submerged, with only a small portion in the southernmost part remaining above sea level (Figure 6). Due to its proximity to the ocean, sea-level rise is likely to increase seawater intrusion into terrestrial areas, leading to higher soil salinization. Although *Tamarix chinensis* is tolerant to saline-alkali conditions, excessive increases in soil salinity may still exceed its physiological tolerance, impairing water and nutrient uptake and inhibiting growth. Simultaneously, sea-level rise may flood portions of the *Tamarix chinensis* forest, reducing its viable habitat and forcing its distribution to retreat inland.

Figure 6. Projected impact of sea-level rise in Changyi National Marine Ecology Special Protected Area by 2100

Note: The black wireframe indicates the boundary of the protected area; and the red-shaded area represents the area projected to be submerged by 2100.

The Shandong Province Weifang Municipal Government has established the Changyi Marine Ecology Special Reserve Management Committee to oversee the protected area. The Committee has enacted regulatory documents such as the ***Management Rules and Regulations for Shandong Changyi Marine Ecology Special Reserve***. The reserve's maritime surveillance team has significantly strengthened law enforcement efforts. In addition to routine conservation activities, the Management Committee has actively sought funding support from central and provincial-level marine use funds, as well as from initiatives such as the Bohai Sea Ecological Restoration and Capacity-Building Programme. These resources have been allocated to support the restoration of key plant species (e.g., *Tamarix chinensis* and *Suaeda salsa*) and to enhance the reserve’s institutional capacity and standardized management.

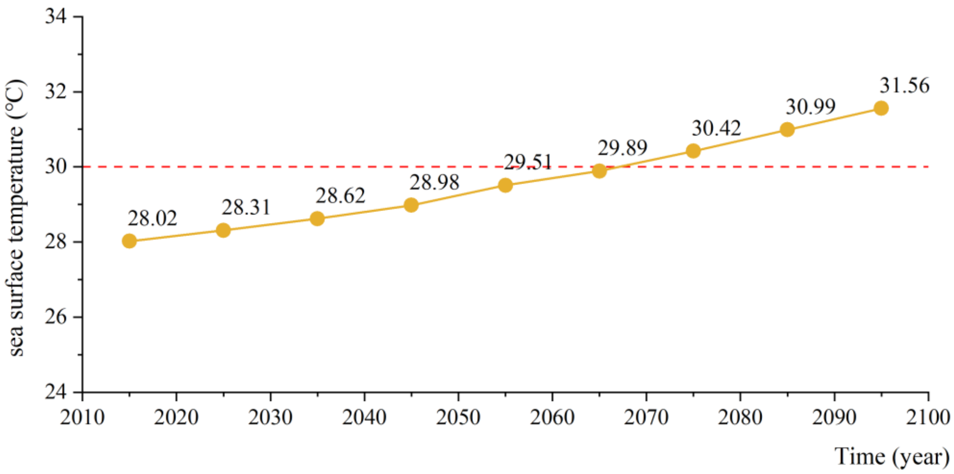
3.2 Nanji Islands National Marine Nature Reserve

The Nanji Islands National Marine Nature Reserve is located in the southeast of Pingyang County, Wenzhou City, Zhejiang Province. It comprises 52 islands, each with an area exceeding 500 m^2, along with dozens of exposed and submerged reefs and surrounding waters, with a total coastline of 74.66 km. The total area of Nanji Islands National Marine Nature Reserve is 201.06 km^2, including 11.13 km^2 of island land area and 189.93 km^2 of sea area. The geographical coordinates are 27°24′30″~27°30′00″N, 120°56′30″~121°08′30″E. As one of the first five national marine nature reserves designated in China, the Nanji Islands are renowned as the "kingdom of shellfish and algae" and serve as a living museum and gene bank for marine organisms across northern and southern Chinese seas. About 15% of the total shellfish species and 25% of the total algae species recorded in China are found in the reserve. Combined, they represent about 80% of the total number of such species in Zhejiang province. These shellfish and algae species are intermittently distributed across both the tropical and temperate marine realms, making this biodiversity-rich site particularly valuable for conservation and scientific research.

In recent years, due to the impact of global climate change, seawater temperatures have continued to rise, and the biodiversity of intertidal zone organisms in the Nanji Islands Reserve has shown notable changes. Temperature is one of the key factors influencing the structure of algal communities, as different algae species exhibit varying levels of temperature tolerance. With changing temperature regimes, dominant species in the algal communities may be replaced by those better adapted to warmer conditions. Temperature also largely influences the geographical distribution of shellfish species. With global warming and seawater temperature rise, the distribution ranges of some shellfish species may expand toward higher latitudes or low-temperature waters. In the marginal areas of their original distribution regions, shellfish populations may decline due to excessively high temperatures.

To assess this trend, decadal average values of monthly maximum sea surface temperatures were obtained from Bio-ORACLE. The analysis indicates that sea surface temperatures are projected to continue rising in the future (Figure 7). Previous research has revealed that once seawater temperatures reach 30 °C, a significant number of shellfish and algae species experience high mortality rates (Ivanina et al., 2013; Kleinteich et al., 2012). Therefore, by 2070, shellfish and algae in this reserve are expected to face grave threats from thermal stress.

Figure 7. Projected sea surface temperature during the warmest months in Nanji Islands National Marine Nature Reserve

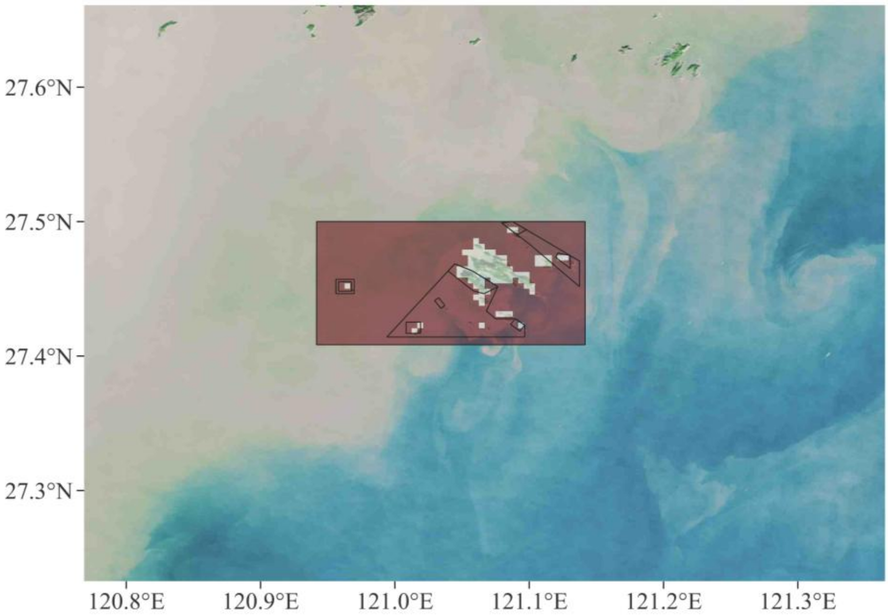


Note: When the critical threshold of 30℃ is reached, a large number of shellfish and algae species are expected to experience high mortality.

Data source: Bio-ORACLE (https://bio-oracle.org/)

Ongoing global warming has triggered a series of consequences, among which the melting of ice sheets and glaciers due to temperature rise is a prominent factor contributing to sea-level rise. Elevation analyses of the Nanji Islands National Marine Nature Reserve show a varied topographic profile, with the highest point reaching 129 m above sea level and the lowest descending to -49 m, yielding an average elevation of -11.91 m. Projections indicate that by 2100, with a predicted sea-level rise of 1.02 m, a significant portion of the reserve will be inundated (Figure 8). Only Nanji Island, situated at the core of the reserve, is expected to remain above water, underscoring the substantial vulnerability of this unique marine ecosystem to sea-level rise and the urgent need for strengthened conservation and adaptation measures.

Figure 8. Projected impact of sea-level rise in Nanji Islands National Marine Nature Reserve by 2100



Note: The black wireframe indicates the boundary of the protected area; and the red-shaded region represents the area projected to submerged by 2100.

The management of the Nanji Islands National Marine Nature Reserve primarily encompasses three key aspects: (1) the protection and management of the natural environment and resources; (2) scientific research and monitoring; and (3) the rational utilization of natural resources. Among these, conservation management serves as the foundation for the effective operation of the nature reserve. The level of management capacity directly influences the future trajectory and viability of the reserve. Since its designation as a national-level nature reserve by the State Council in 1990, management efforts have been progressively strengthened under the guidance and support of higher-level authorities. Notably, the current implementation of the “all-in-one ticket” system in the Nanji Islands tourism area, supported by the Global Environment Facility (GEF) project, has significantly enhanced ecological and resource conservation, scientific research and monitoring, sustainable use, public education, and community-based co-management efforts.

3.3 Beilun Estuary National Marine Nature Reserve

The Beilun Estuary National Marine Nature Reserve in Guangxi was established with the approval of the State Council in April 2000. The total area of the reserve is 30 km^2 (Table 1). Located in the north of the Beilun River, a transboundary river between China and Vietnam, the reserve is represented by the most extensive contiguous stretch of mangrove forest along China’s coastline and supports a relatively high diversity of halobios[9] and birds. The reserve operates as a semi-autonomous management agency under the Ningbo Municipal Government, holding an administrative status equivalent to that of a sub-county in China's governance hierarchy. This structure enables direct budget allocation from the municipal government while maintaining a specialized conservation team of 25 personnel. Over time, the reserve has witnessed significant improvements in its infrastructure, including enhanced office facilities, strengthened protection and management capabilities, and scientific research and monitoring systems.

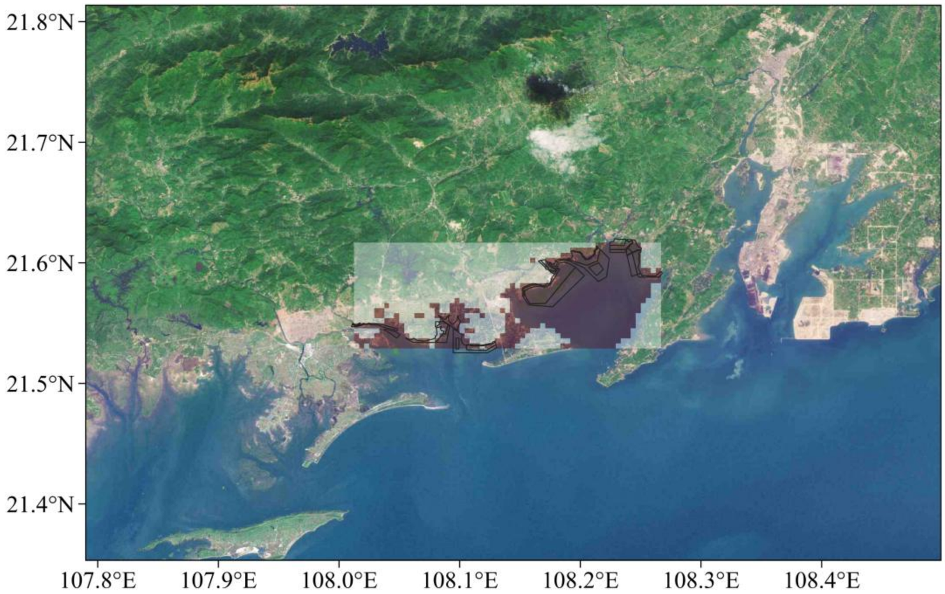
Due to global warming, temperatures in this region are projected to reach 29.15℃ by 2100 under the SSP5-8.5 scenario. In addition, the elevation analysis of the protected area shows that the highest elevation in the area is 148 m, while the lowest is -13 m. The average elevation is 12.23 m, reflecting a landscape where both relatively elevated terrains and areas below sea level coexist. This topographic diversity not only shapes the reserve’s unique ecological environment but also influences its vulnerability to factors such as sea-level rise and the spatial distribution of habitats and species.

In the context of the ongoing rise in the GMSL, projections indicate that by 2100, the entire reserve will likely be inundated (Figure 9). Seawater intrusion into the terrestrial areas will likely lead to significant soil salinization. Although mangrove ecosystems possess some tolerance to saline-alkaline conditions, they will face critical thresholds beyond which survival and growth are compromised. Such an increase in soil salinity not only reduces the efficiency of water and nutrient uptake in mangroves, thereby impeding their normal ontogenetic development, but also poses a direct risk of submergence to certain mangrove-dominated areas.

Consequently, the ecological niche of mangroves is expected to contract, forcing landward migration of these communities. This, in turn, leads to a continued contraction of their geographical distribution range, with potential cascading impacts on the associated biodiversity and ecological functions within the reserve.

Figure 9. Projected impact of sea-level rise in Beilun Estuary National Marine Nature Reserve by 2100

[9] halobios: (biology) life in the oceans; marine life collectively.



Note: The black wireframe indicates the boundary of the protected area; and the dark-red-shaded region represents the area projected to be submerged by 2100.

The reserve has significantly enhanced ecological conservation outcomes by strengthening institutional frameworks and infrastructure. Key developments include the establishment of a GIS-based biodiversity management system, plant nurseries, and ecological monitoring stations. The reserve has documented the continued expansion of mangrove forests, seagrass beds, and coastal transition zones. Through robust scientific monitoring, which generates over 5,000 datasets annually, and the implementation of more than 30 research projects, the reserve actively enforces ecological protection laws, including measures against illegal bird hunting and sand mining, and has pioneered pest control methods such as the use of biopesticides and the release of natural predators (e.g., wasps). Through community outreach and international collaboration, the reserve now supports 263 bird species (up from 187), serving as a critical stopover site for more than 100,000 migratory birds annually. This integrated approach combines ecosystem restoration, scientific research, and sustainable governance.

3.4 Shankou Mangrove National Marine Nature Reserve

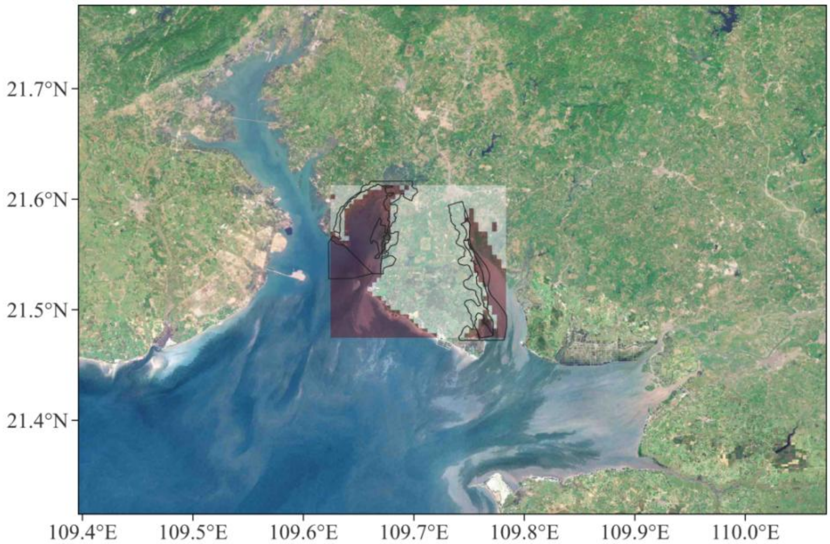
The Shankou Mangrove National Marine Nature Reserve is an important wetland area with rich biodiversity. Situated on both sides of the Shatian Peninsula, it comprises two areas featuring mangroves, salt marshes, and seagrass habitats. This combination of three coastal habitats in a single location is rare along China’s coastline. The key conservation priorities include protecting the mangrove ecosystem, rare seagrass species, and marine mammals.

The reserve has a coastline length of 53 km and a total area of 80 km^2 (Table 1), of which 8.18 km^2 is covered by mangrove forests. It supports 16 mangrove species, including five dominant communities such as *Rhizophora stylosa* and *Bruguiera gymnorrhiza.* The reserve is managed by the Administration Bureau of Guangxi Shankou Mangrove Ecological National Nature Reserve, which operates under the Oceanic Administration of Guangxi Zhuang Autonomous Region. A three-tier management mechanism has been established, comprising the Nature Reserve Management Office, Protection Station, and Forest Ranger. An integrated forest protection network has also been developed.

The reserve exhibits a wide elevation range, with the highest altitude reaching 66 m and the lowest to -7 m. After precise calculation, the average altitude is 12.87 m. In terms of average elevation and geographical and environmental characteristics, the reserve is similar to the Beilun Estuary National Marine Nature Reserve. These two areas also share geological, topographical, climatic, and hydrological features, making both key regions for mangrove concentration in China.

In-depth elevation analysis of the reserve indicates that, under a projected GMSL rise of 1.02 m by 2100, nearly half of the reserve area will be inundated (Figure 10). These flooded areas are primarily concentrated along the coastal zone, which serves as the main growth area of mangroves. This zone supports a unique mangrove ecosystem that provides critical habitats for numerous organisms to inhabit, reproduce, and forage. The impact of the GMSL rise on mangroves is therefore extremely significant. It results not only in the direct loss of mangrove plant communities but also in a broader ecological chain reaction in the entire ecosystem. Consequences include declining biodiversity, weakened ecological services, reduced coastal protection capacity, and other cascading effects, posing serious challenges to the region’s ecological stability and resilience.

Figure 10. Projected impact of sea-level rise in Shankou Mangrove National Marine Nature Reserve by 2100



Note: The black wireframe indicates the boundary of the protected area; and the red-shaded region represents the area to be submerged by 2100.

The reserve has established a comprehensive three-tier management system, comprising the reserve administration, protection stations, and rangers, supported by local regulations and established fee standards. The reserve advances mangrove restoration through increased funding, research-driven initiatives, and pest control, while strengthening law enforcement patrols to combat illegal activities. Diverse outreach approaches, including community visits and school lectures, foster public engagement, complemented by community co-management mechanisms that build a multi-stakeholder conservation network. Furthermore, long-term collaboration with research institutions facilitates joint studies and protection activities, cultivating a culture of collective participation in mangrove conservation.

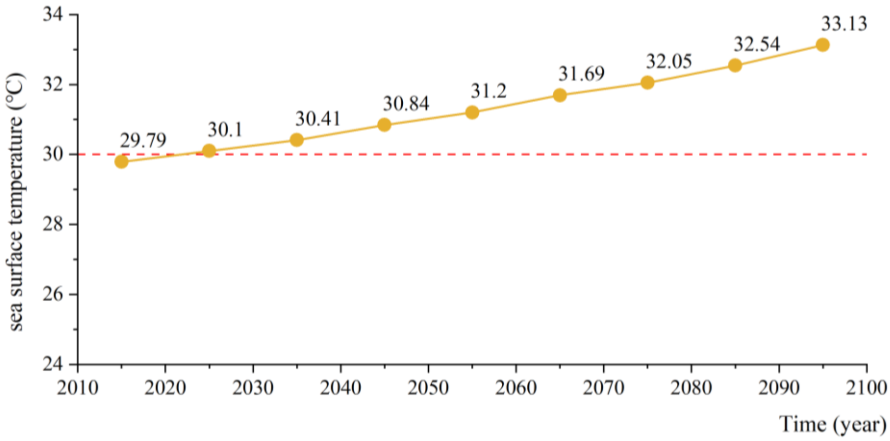
3.5 Sanya Coral Reef National Nature Reserve

Located in southern China, the Sanya Coral Reef National Nature Reserve is recognized as a crucial area for protecting marine biodiversity, characterized by high primary productivity and abundant biological resources. Differences in geomorphology are evident throughout the reserve: the eastern and western parts feature typical islands, while numerous capes and bays characterize the middle part. The key conservation priorities are coral reefs and the marine ecological system. High seawater quality, excellent water transparency, vibrant coral reefs, and diverse fish populations create favourable conditions for eco-tourism. The reserve also serves as a scientific base for protecting coral reef ecosystems.

However, rising ocean temperatures directly affect the relationship between corals and their symbiotic algae. When water temperature exceeds the threshold that corals can tolerate, the symbiotic algae come under stress and are unable to perform photosynthesis effectively. To reduce energy loss, corals expel the symbiotic algae from their bodies, resulting in coral bleaching. When seawater temperatures in Hainan exceed 30°C, coral reefs begin to experience bleaching events (Zhao et al., 2023). In the future, seawater temperatures are projected to continue rising. Under the SSP5-8.5 scenario, the temperature in the Sanya Nature Reserve is expected to exceed the thermal tolerance limit of coral reefs by 2030, leading to large-scale bleaching (Figure 11).

Figure 11. Threshold response of coral bleaching to sea surface temperature (SST)

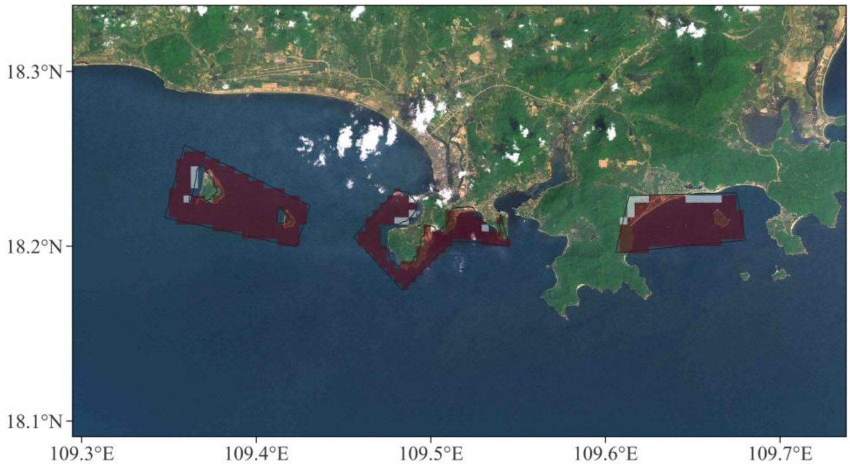
Note: (1) Mean during the season; (2) Critical threshold



Solid line: monthly SST warmest Dashed line: bleaching (30°C)

According to the analysis of the elevation data, the reserve shows a notable range of altitude variation. The highest elevation reaches 32 m, while the lowest descends to -38 m. The average elevation, calculated with precision, is 15.60 m. The total area of the reserve is 85 km^2, of which the land area accounts for only 15 km^2. In the future, the rise of GMSL is expected to further reduce the land area of the reserve (Figure 12). As GMSL continues to rise, seawater depth increases, and light penetration to deeper layers becomes more limited. This disrupts the symbiotic relationship between coral reefs and zooxanthellae, significantly impeding the growth of coral reefs. At the same time, GMSL rise alters the hydrodynamic conditions, intensifying the force of currents and waves, which can directly impact and damage the relatively fragile structure of coral reefs. Moreover, GMSL rise also triggers changes in seawater temperature and salinity. Warmer seawater leads to coral bleaching, interfering with the coral's normal physiological functions and disrupts the delicate balance of the coral reef ecosystem.

Figure 12. Projected impact of sea-level rise in Sanya Coral Reef National Nature Reserve by 2100



Note: The black wireframe indicates the boundary of the protected area; and the red-shaded region represents the area projected to be submerged by 2100.

The reserve exemplifies China's integrated approach to marine conservation, combining ecological protection with innovative management models. Established to safeguard reef-building corals and their associated ecosystems, the reserve enforces strict zoning regulations alongside active restoration measures, including coral transplantation and the deployment of artificial reefs. A landmark development occurred in 1996 with the creation of the Yalong Bay Coral Reef Conservation and Development Zone, which pioneered a groundbreaking "government supervision with corporate participation" model. This partnership enabled the establishment of three protection stations by 1997, equipped with patrol vessels, monitoring equipment, and trained staff, marking a significant transformation from the reserve's initially limited capacity to a robust protection system. The successful model was subsequently replicated in the Dadonghai and Xidao sections, demonstrating a practical framework for balancing ecological protection with sustainable development.

3.6 National Nature Reserve of Dazhou Island Marine Ecosystems

Dazhou Island is situated on the continental shelf and is classified as a continental island, located away from the mainland coast. The total area of the reserve is 70 km^2. The seabed consists primarily of reef structures and sandy substrate, providing ideal conditions for coral growth and reef development. The island boasts a typical insular ecosystem, characterized by abundant plant resources, diverse animal life, and a rich array of marine organisms with high biodiversity. The main conservation priorities are Swiftlets, their habitat, and the surrounding marine ecosystem. Swiftlets have been categorized as an endangered species since their nests are valued as a traditional Eastern curiosity and rare medicinal ingredient (Figure 13). The reserve, thus, plans to gradually expand the Swiftlet population by artificial breeding and release into the wild.

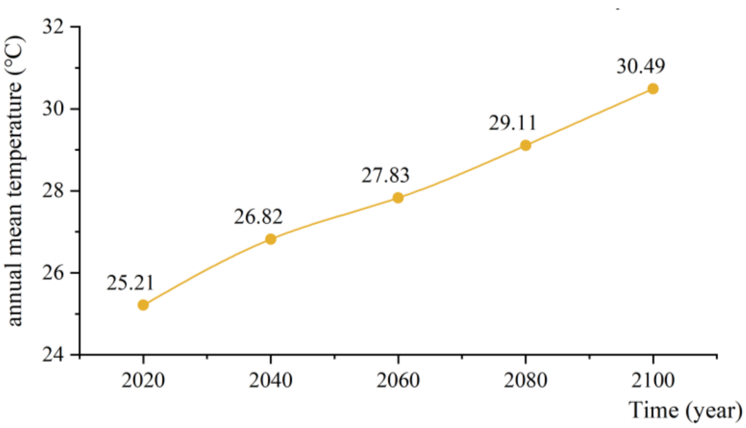
Figure 13. Successful nest building and breeding of second-generation golden swiftlets

Source: People's daily (2017, June 7). Retrieved from people's daily online.

According to the analysis of continental temperature data (Figure 14), the temperature within this reserve is expected to continue increasing in the future. Rising temperature, combined with changes in precipitation patterns, is highly likely to result in significant changes in the types and distribution of vegetation on the island. For the swiftlet, a major protected species, such changes may lead to a reduction or shift in its habitat range.

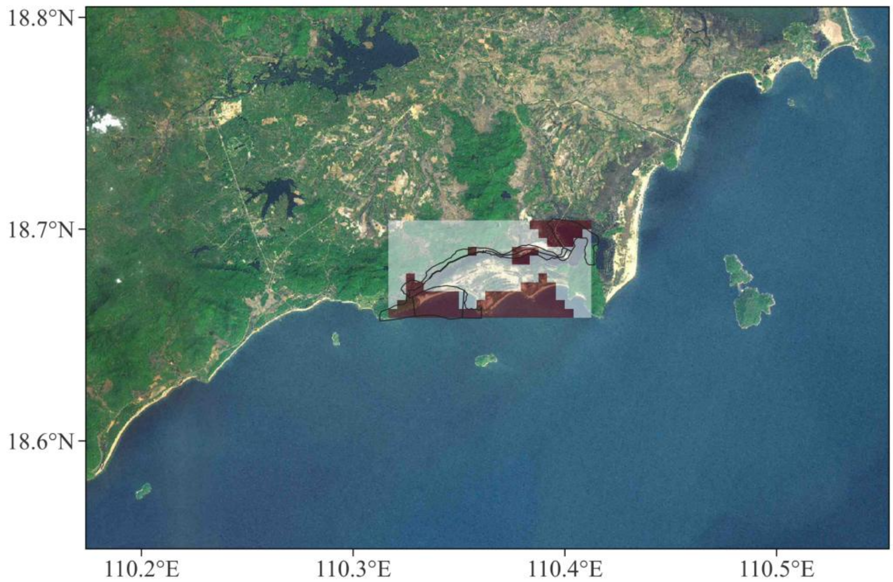
Elevation data analysis indicates that the highest point of the reserve reaches 173 m, while the lowest point drops to -28 m, with an average elevation of 17.81 m. Based on projections of future GMSL changes, a 1.02 m increase could result in a reduction of the reserve’s area by half (Figure 15). The coastal erosion phenomenon triggered by the rise in GMSL is expected to severely damage the traditional habitats of the swiftlet, such as seaside caves, greatly squeezing their living space.

Figure 14. Projected land temperature trends in the National Nature Reserve of Dazhou Island Marine Ecosystems



Note: Average of the warmest month, scenario: SSP5-8.5

Figure 15. Projected impact of sea-level rise on the National Nature Reserve of Dazhou Island Marine Ecosystems by 2100



Note: The black wireframe indicates the boundary of the protected area; and the red-shaded region represents the area projected to be submerged by 2100.

Following directives from provincial authorities, a joint task force was established in 2015 to address unauthorized activities in the reserve, initiating its ecological restoration programme. The reserve established a management body with operational protocols, patrol teams, and monitoring facilities, significantly enhancing conservation efforts through public education campaigns, law enforcement patrols, ecological monitoring, and research collaboration. A permanent island-based station now enables round-the-clock surveillance, with annual enforcement statistics including over 300 patrols, more than 100 marine inspections, and corrective actions taken against over 300 violators—effectively improving public compliance with conservation regulations.

3.7 SUMMARY

Climate change is fundamentally reshaping the ecological patterns of China's MPAs and the NEAMPAN's sites. Research reveals that ocean warming, acidification, sea-level rise, and increasing extreme weather events have caused systemic impacts across all six NEAMPAN sites in China, with coral reefs, mangroves, and coastal wetlands being particularly vulnerable. GIS analyses indicate that under the high-emission SSP5-8.5 scenario, a projected 1.02 m rise in GMSL by 2100 would inundate substantial coastal areas of reserves, such as the Changyi National Marine Ecology Special Protected Area and Nanji Islands National Marine Nature Reserve. Concurrently, rising sea temperatures are triggering ecological responses including coral bleaching, algal community succession, and shifts in shellfish distribution. Notably, saltwater intrusion from sea-level rise is exacerbating soil salinization, challenging even halophyte species such as tamarisk and mangroves. These changes not only threaten endemic species but may also cascade through food webs, causing ecosystem-wide repercussions.

In response, MPAs have implemented various adaptive management measures. The Nanji Islands enhanced monitoring systems were implemented through GEF projects, while the Sanya Coral Reef Reserve pioneered a "government supervision + corporate participation" governance model. The Shankou and Beilun Estuary mangrove reserves have established a three-tier protection network. However, current measures predominantly focus on short-term restoration and law enforcement, leaving systematic climate adaptation strategies underdeveloped. Moving forward, integrated approaches that combine climate projection models, ecosystem vulnerability assessments, and adaptive management frameworks are needed to develop site-specific resilience plans. For low-elevation sites like Changyi and Nanji Islands, nature-based solutions—such as constructing coastal buffer zones and facilitating assisted species migration—should be prioritized to enhance ecological adaptability to climate change.

Chapter 4. China's Marine Measures in Response to Climate Change

China has taken a series of proactive measures to address the challenges posed by climate change to the marine ecosystem, including policies, ecological restoration projects, the establishment of MPAs, scientific research and monitoring, international cooperation, as well as public awareness and education.

4.1 Establishment of Marine Protected Areas

China has established a diverse range of MPAs across the Bohai Sea, Yellow Sea, East China Sea, and South China Sea, tailored to different ecological characteristics and conservation priorities (please refer to Annex for details). These include marine nature reserves and marine ecological specially protected areas, forming a functional and well-developed network of marine protected areas. According to official statistics released by China, by the end of 2018, the country had established a total of 271 MPAs at various levels, covering a total area of 124,000 km^2. Based on China's claimed maritime area of 3 million km^2, this represents a protection ratio of approximately 4.1% (Zhao et al., 2019).

Building upon this extensive and systematic development of marine protected areas, China has successfully established hundreds of MPAs, with the coverage of protected areas continuously expanding. These efforts have significantly contributed to the conservation and management of marine biological resources. The establishment of these protected areas not only helps mitigate the impacts of climate change on marine organisms but also provides a valuable platform for scientific research and ecotourism. Through these integrated measures, China is progressively enhancing the resilience of its marine ecosystems and promoting the development of a sustainable blue economy.

4.2 Climate-Integrated Management Strategies Across NEAMPAN Sites

In addressing the impacts of climate change on marine ecosystems, China is not only continuing to strengthen the development of MPAs, but also actively promoting ocean-based solutions. These include improving MPA management, restoring ecosystems, and enhancing the adaptability of marine organisms. Specifically for the six NEAMPAN sites, China has adopted a number of targeted policies and practices to improve the management, restore ecosystems, and align with broader climate action initiatives, thereby enhancing China’s capacity to respond to climate change.

4.2.1 Climate-Adaptive Co-management in Coastal and Island Reserves

To mitigate the risks posed by future climate change, Changyi National Marine Ecology Special Protected Area has collaborated with multiple research institutes, including the First Institute of Oceanography of the State Oceanic Administration, utilizing the protection zone as a demonstration area for various marine public welfare scientific research projects. Based on previous investigations and monitoring, the Nanji Islands National Marine Nature Reserve has conducted environmental and resource background surveys, as well as surveys of island and reef fish resources, to comprehensively understand and assess the current status of island organisms and ecology, and implement long-term fixed-point tracking and monitoring. To provide basic data for the protection, development, and management of the biodiversity resources of shellfish and seaweed. Both locations adopt solutions based on scientific research.

4.2.2 Mangrove-Coral Resilience Partnerships

The Beilun Estuary National Nature Reserve and the Shankou Mangrove National Nature Reserve demonstrate complementary approaches to climate adaptation through ecological engineering and community engagement.

To strengthen mangrove conservation and enhance resilience against climate change and human disturbances, a coordinated combination of policy measures and ecological interventions is essential. First, increased government support and public awareness are crucial to emphasizing the ecological and environmental importance of mangroves. Strict regulations should be enforced against deforestation and conversion to aquaculture, while degraded areas—particularly in the western inland regions of the Beilun Estuary—should be restored to mangrove ecosystems where feasible. Second, nature-based engineering solutions can be employed to mitigate southeastern wave action that has caused partial mangrove degradation. For instance, placing environmentally friendly bamboo stakes in the exposed intertidal zone can help stabilize sediments and facilitate natural regeneration (Huang et al., 2023). Third, targeted mangrove afforestation should be promoted in suitable areas to accelerate forest expansion. The sheltered zones behind barrier islands on both sides of the estuary provide optimal conditions for mangrove growth, ensuring high survival rates and promoting natural expansion.

Meanwhile, the Shankou Mangrove Reserve has implemented a community co-management system in accordance with Guangxi's Mangrove Conservation Regulations. Local “mangrove patrol teams” integrate traditional ecological knowledge with modern monitoring to control invasive species, while elevated boardwalks minimize the impact of tourism on sensitive habitats. Together, these reserves demonstrate how engineered solutions and community-based stewardship can jointly address climate threats—Beilun's biophysical interventions and Shankou's socio-ecological approaches providing mutually reinforcing lessons for coastal adaptation.

4.2.3 Thermal-Stress Mitigation in Tropical Marine Ecosystems

China has implemented comprehensive climate adaptation strategies in both the Sanya Coral Reef National Nature Reserve and the Dazhou Island Marine Ecosystem National Nature Reserve, with clearly defined measures outlined in their respective management plans. The Sanya Reserve has established a multi-tiered response system to coral bleaching, incorporating real-time monitoring, designated thermal refugia with expanded protection zones, and innovative interventions such as the selective breeding of heat-resilient coral species and the installation of temporary shade structures during extreme warming events.

Similarly, the Dazhou Islands Reserve emphasizes ecosystem-based adaptation, including the construction of hybrid ecological seawalls, extended seasonal fishing closures to protect spawning stocks, and the development of an advanced ocean acidification monitoring network. These coordinated efforts combining Sanya's focus on coral genotype preservation with Dazhou's habitat-centric protections demonstrate a science-based approach to climate adaptation that aligns with both provincial conservation regulations and China's National Climate Change Adaptation Strategy 2035. Monitoring data indicate measurable success, including improved coral thermal tolerance and increased reef fish biomass, while maintaining the ecological connectivity essential for long-term ecosystem resilience under climate change scenarios.

4.3 Scientific Research and Monitoring

Scientific research teams conduct multi-disciplinary research on the response mechanisms of marine ecosystems to climate change. In terms of marine organisms, researchers examine the impacts of rising temperatures and ocean acidification on physiological characteristics, reproductive capacity, population dynamics, and the distribution ranges of species. A case in point, researchers from the Marine Geospatial Ecology Lab at Duke University have demonstrated that climate change is significantly affecting marine mammal populations, triggering distributional shifts, fluctuations in abundance, and alterations in phenology (Lettrich et al., 2023). Similar climate-driven ecological transformations are observed across marine taxa - studies document how rising sea temperatures have caused Atlantic mackerel (*Scomber scombrus*) to extend their summer migration routes poleward, while inducing prolonged or multiple breeding cycles in Pomacentridae species (Nye et al., 2009; Gladstone, 2007). These cross-taxa ecological disruptions collectively present substantial challenges for effective marine population management.

In terms of the structure and function of marine ecosystems, researchers analyse how climate change affects the aquatic food chain, energy flow, and material cycle of the ecosystem. For example, studies have shown that coral reef bleaching disrupts the survival of numerous dependent marine organisms, thereby disrupting the original ecological balance.

In addition, a comprehensive monitoring system for the marine ecological environment has been established. Spatially, the system covers a wide range of sea areas from inshore to offshore. Methodologically, it integrates various technologies, including satellite remote sensing, buoy observation, diving surveys, and underwater robot monitoring. By integrating these monitoring data, authorities can track dynamic changes in the marine ecosystem in a timely and accurate manner, providing a scientific basis for decision-making in response to climate change.

4.4 International Cooperation and Public Education

In addressing the impacts of climate change on marine ecosystems, China is actively engaged in international cooperation, vigorously promoting public education, and implementing a series of practical and effective actions. At the international level, China actively participates in discussions and joint projects related to global marine ecological protection and climate change response. It shares experiences and achievements in MPA management, draws on advanced concepts and technologies, and contributes to global marine ecological governance.

In promoting ocean-based climate actions, China actively conducts blue carbon research as a key entry point. In the Changyi Binhai Wetland Nature Reserve in Shandong Province, blue carbon stock assessments have supported wetland restoration initiatives, while blue carbon financing mechanisms are explored to raise funds for climate action. Ecotourism is also actively promoted. In the Dazhou Island and Sanya Coral Reef Nature Reserves, efforts to restore coral reefs and protect fisheries resources have promoted the development of ecotourism, attracting public participation in marine conservation and achieving a win-win situation of economic and ecological benefits.

These actions not only effectively reduce the impacts of climate change on MPAs but also enhance the adaptability of coastal communities, aligning with global targets such as the United Nations Sustainable Development Goals (SDG 13: Climate Action) and the Paris Agreement under the UNFCCC (Article 7 on adaptation). Furthermore, these efforts support the Kunming-Montreal Global Biodiversity Framework (GBF), particularly Target 3, which aims to protect 30% of marine and coastal areas by 2030 through ecosystem-based adaptation. Public education and awareness-raising are central to these efforts, in line with the UNESCO Ocean Literacy Framework and ESCAP's Ocean-Based Climate Action (OBCA) initiative, which emphasize stakeholder engagement. Through activities such as ecotourism, the public is given opportunities to directly experience the importance of marine ecological protection, gaining knowledge about climate resilience and marine conservation. This approach not only encourages public participation but also contributes to SDG 4 (Quality Education) and GBF Target 21 (Participatory Decision-Making), ultimately fostering a whole-of-society response to marine climate challenges.

Chapter 5. Policy Recommendations for NEAMPAN

To further expand and accelerate ocean-based climate action, NEAMPAN can play a key role in supporting China and other marine protected areas in the subregion in the following ways:

5.1 Strengthen Cross-border Cooperation and Scientific Research

NEAMPAN should actively promote regional cooperation among member States and establish a highly efficient and comprehensive online platform for data and knowledge sharing. This platform should integrate the technical and scientific resources of each country in marine ecological monitoring to construct a unified cross-border biodiversity monitoring system.

For instance, in NEAMPAN sites vulnerable to climate change, such as China's Shankou Mangrove and Sanya Coral Reef Reserves, international research teams could jointly implement long-term monitoring and studies. By applying advanced monitoring technologies, such as satellite remote sensing and underwater sensor networks, researchers can obtain real-time and accurate data on ecosystem changes, allowing for a deeper analysis of the mechanisms of climate change impacts on biodiversity, ecological structure, and functions. Through means such as big data analysis and model prediction, scientists can forecast future trends, providing a solid scientific basis for each country to formulate targeted conservation policies and adaptive management measures, ensuring evidence-based and forward-looking decision-making.

5.2 Formulate Ocean-based Climate Action Guidelines

NEAMPAN should develop regionally tailored yet standardized guidelines to address climate-related challenges in MPAs. Ad hoc group meetings may be convened to develop recommendations under the following three pillars:

5.2.1. Ecosystem Restoration Guidelines

Guidelines should provide standardized approaches for rehabilitating degraded marine ecosystems. For mangroves, this could include planting protocols related to spacing and the selection of salinity-tolerant species. Coral reef restoration guidelines may consist of artificial propagation techniques such as larval propagation and optimal substrate materials. All restoration efforts should be supported by monitoring frameworks that track key indicators such as survival rates and biodiversity trends to ensure ecological recovery.

5.2.2. Blue Carbon Assessment Standards

A unified methodology should be established for measuring and reporting blue carbon stocks. This includes field techniques (e.g., sediment core sampling), combined with remote sensing technologies. Guidelines could also explore the application of carbon markets, including protocols for carbon credit pricing and ecological compensation mechanisms to incentivize conservation.

5.2.3. Climate-resilient Infrastructure Planning

Guidelines should promote risk-based coastal design using regional climate projections for sea-level rise and storm surge patterns. They should emphasize nature-based solutions, such as hybrid mangrove-seawall systems, and set out elevation and buffer zone requirements. Regular vulnerability assessment protocols should be included to maintain infrastructure performance under changing conditions.

5.3 Promote Blue Financing and Technological Innovation

NEAMPAN should facilitate multilateral cooperation to promote blue financing and marine-related technological innovation. As a regional network, NEAMPAN can support member States by:

1. Establishing a Blue Finance Working Group to coordinate cross-border carbon markets (e.g., aligning with the ASEAN Taxonomy for Sustainable Finance) and share best practices on blue bond issuance;
2. Developing standardized risk assessment frameworks, based on instruments such as IUCN's Blue Natural Capital Financing Facility, to strengthen investor confidence; and
3. Hosting regional matchmaking events where member States, investors (e.g., HSBC Ocean Resilience Innovation Fund), and technology providers (e.g., satellite monitoring companies) can collaborate on scalable solutions.

In the area of technology, NEAMPAN could support collaborative R&D for low-cost monitoring tools (e.g., AI-based coral reef drones), promote the development of open-access data platforms for ecosystem tracking, modelled after UNEP's World Environment Situation Room, for real-time ecosystem tracking. Through organizing technology exchange activities and establishing technology transfer platforms, NEAMPAN can promote technology sharing and cooperation among member States, improving the overall level of marine protection technology in the subregion.

5.4 Support Community Participation and Capacity Building

To enhance the sustainability of protected area management, NEAMPAN should promote community-based conservation through three key approaches:

1. Conducting public awareness campaigns, including marine ecology-themed exhibitions and science lectures, to raise understanding of climate issues and marine conservation among local communities, using storytelling methods, such as sharing experiences from fisherfolk, to foster emotional connections to ecosystems;
2. Organizing tailored skills training through hands-on workshops (e.g., mangrove planting techniques, coral reef monitoring) to build capacity for local protection efforts, aligning with community-specific needs, such as fisheries-dependent or tourism-driven areas; and
3. Delivering eco-tourism initiatives that connect conservation efforts with local livelihoods, such as guided reef walks or mangrove kayaking, and ensuring equitable benefit-sharing through mechanisms that reinvest tourism revenues into local protection projects).

Particularly in areas where mangroves and coral reefs are found, local residents are encouraged to participate in hands-on conservation activities such as mangrove planting and coral reef restoration, enhancing their emotional connection with the ecosystem and creating mutually beneficial outcomes for communities and marine protection efforts.

5.5 Promote Best Practices

NEAMPAN should organize seminars and workshops to share experiences on effective climate change response and MPA management practices and strategies among protected areas. For example, the Shankou Mangrove Reserve has expanded mangrove areas significantly and restored ecological functions through innovative planting techniques and community engagement. In Shandong, the Changyi Reserve has established a complete blue carbon monitoring and trading system, promoting the development of the local ecological economy. These successful cases should be widely shared within the region, enabling countries to learn from each other’s experiences and avoid and apply inefficiencies in implementation.

5.6 Phased Implementation Framework

To ensure systematic progress, NEAMPAN could adopt a phased approach with clear timelines. Climate Adaptation Implementation Timeline:

1. Immediate Actions (0-2 years): Prioritize rapid-start capacity building through technical exchange workshops and pilot data-sharing platforms, leveraging existing regional partnerships like NOWPAP's monitoring networks.
2. Medium-term priorities (2-5 years): Institutionalize these efforts through standardized protocols, including the establishment of unified marine ecosystem monitoring systems across member states that utilize harmonized indicators from the IUCN Red List of Ecosystems.
3. Long-term strategies (over 5 years): Focus on systemic integration, embedding climate adaptation measures into national marine spatial planning frameworks, and creating permanent financing mechanisms through sustained public-private partnerships.

This phased structure enables adaptive management, where lessons from early implementation can refine subsequent stages while maintaining continuity with the guideline development, technological innovation, and community engagement pillars outlined in previous sections. Regular progress reviews will be conducted through biennial NEAMPAN ministerial meetings to assess milestone achievement and recalibrate timelines as needed.

CHAPTER 6. CONCLUSION

This report provides a comprehensive analysis of the impacts of climate change on China's marine ecosystems and their interactions with MPAs, reviews China's policy responses, and provides recommendations for advancing NEAMPAN efforts.

Regarding climate impacts, changes in sea surface temperature, salinity, and pH values vary across different marine areas, resulting in multiple effects on ecosystems such as coral reefs and mangroves. The interaction of these environmental factors creates more complex and compound impacts. For MPAs, climate change poses a significant threat to ecological balance, with different sites in China experiencing challenges such as habitat degradation and biodiversity decline.

China has implemented a multifaceted set of measures to address the challenges of climate change, including policy development, ecological restoration, expansion of protected areas, scientific research and monitoring, as well as international cooperation and public education. These efforts have contributed to partially mitigating the impacts of climate change on marine environments.

For the advancement of NEAMPAN, strengthening cross-border cooperation, formulating action-oriented guidelines, promoting blue financing and technological innovation, facilitating community engagement, and sharing best practices will enhance MPA resilience to climate impacts. These actions will help to preserve regional biodiversity, sustain ecosystem service functions, and promote the sustainable development of the North-East Asia region. Moving forward, continued attention should be given to monitoring climate change, deepening scientific research, strengthening international and regional cooperation, and jointly safeguarding the marine ecological environment.

ANNEX. LIST OF NATIONAL MARINE PROTECTED AREAS IN CHINA

No	Name	Area (ha)	Year of establishment
1	National Marine Park for Changshan Islands in Dalian	51,939	2014
2	National Marine Park for Jinshitan in Dalian	11,000	2014
3	National Marine Park for Xinghai Bay in Dalian	2,540	2016
4	National Marine Park for Xianyu Bay in Dalian	4,391	2016
5	National Marine Park for Tuanshan in Liaoning	447	2014
6	National Marine Park for Red Beach of Liao River Estuary in Liaoning	31,639	2014
7	National Marine Special Protected Area for Beacon Hill in Jinzhou, Liaoning	12,217	2009
8	National Marine Park for Juehua Island	10,249	2014
9	National Marine Park for Tateishi in Suizhong, Liaoning	14,634	2014
10	National Marine Park for Daling River Estuary in Liaoning	3,150	2016
11	National Nature Reserve for Coastal Wetland in Yalu River Delta	81,430	1997
12	National Nature Reserve for Coastal Landform of Chengshantou in Dalian	1,350	2001
13	Municipal Nature Reserve for Marine Ecology of Laopian Island-Yuhuangding in Dalian	2,353	2000
14	Municipal Nature Reserve for Marine Species of Sanshan Island in Dalian	1,103	1986
15	National Nature Reserve for Snake Island-Laotie Mountain in Liaoning	9,072	1980
16	National Nature Reserve for Harbor Seal in Dalian	561,975	1997
17	National Nature Reserve for Liao River Estuary in Liaoning	80,000	1988
18	National Marine Park in Beidaihe	10,215	2016
19	National Nature Reserve for Golden Coast of Changli in Hebei	33,621	1990
20	National Marine Special Protected Area for Oyster Reef in Dashentang, Tianjin	3,400	2012
21	National Nature Reserve for Ancient Coast and Wetland in Tianjin	35,913	1992

22	National Marine Special Protected Area for Coastal Shellfish and Ecology in Hekou, Dongying	44,812	2008
23	National Marine Special Protected Area for Benthic Fish and Ecology in Lijin, Dongying	9,404	2008
24	National Marine Special Protected Area for Ecology of Yellow River Estuary in Dongying	92,600	2008
25	National Marine Special Protected Area for Razor Clam and Ecology of Laizhou Bay in Dongying	17,958	2009
26	National Marine Special Protected Area for Clamworm and Ecology in Guangrao, Dongying	7,356	2009
27	National Marine Ecology Special Protected Area in Changyi, Shandong	2,929	2007
28	National Marine Special Protected Area for Marine Ecology of Shoal in Laizhou	6,780	2012
29	National Marine Park for Golden and Sandy Coast in Zhaoyuan	2,700	2014
30	National Marine Special Protected Area for Marine Ecology of Huangshui River Estuary in Longkou	2,169	2009
31	National Marine Ecology Special Protected Area for Dengzhou Shoal in Penglai	1,871	2012
32	National Marine Park in Penglai	6,830	2014
33	National Marine Park for Changdao	1,126	2012
34	National Marine Special Protected Area for Zhifu Islands in Yantai	770	2010
35	National Marine Park for Yantai Mountain	1,248	2014
36	National Marine Park for Laishan Mountain in Yantai	581	2016
37	National Marine Special Protected Area for Sandy Coast in Muping, Yantai	1,465	2011
38	National Marine Special Protected Area for Myriametre Beach and Marine Resources in Haiyang	1,513	2011
39	National Marine Special Protected Area for Costal Wetland of Wulong River Estuary in Laiyang	1,219	2011
40	National Marine Special Protected Area for Xiaoshi Island in Weihai, Shandong	3,069	2011
41	National Marine Special Protected Area for Marine Ecology of Liugong Island in Weihai	1,188	2009
42	National Marine Park for Liugong Island	3,828	2011
43	National Marine Park in Haixitou, Weihai	1,274	2014

44	National Marine Special Protected Area for Marine Ecology in Wendeng, Shandong	519	2009
45	National Marine Special Protected Area for Marine Ecology of Tadao Bay in Rushan	1,097	2011
46	National Marine Park for Daru Mountain	4,839	2012
47	National Marine Park for Jiaozhou Bay in Qingdao	20,011	2016
48	National Marine Park for Western Coast in Qingdao	45,855	2014
49	National Marine Park in Rizhao	27,327	2011
50	National Nature Reserve for Shell Bay and Wetland in Binzhou	43,542	2006
51	National Nature Reserve for Yellow River Delta	153,000	1992
52	National Nature Reserve for Changdao Island in Shandong	5,015	1988
53	National Marine Park for Haizhou Bay in Lianyungang, Jiangsu	51,455	2008
54	National Marine Park in Xiaoyangkou, Jiangsu	4,700	2012
55	National Marine Park for Liya Mountain in Haimen, Jiangsu	1,546	2006
56	National Nature Reserve for Rare Birds and Wetland in Yancheng, Jiangsu	247,260	1983
57	National Nature Reserve for David's Deer in Dafeng, Jiangsu	2,667	1986
58	National Nature Reserve for Dongtan Birds in Chongming, Shanghai	24,155	1998
59	National Nature Reserve for Wetland in Jiuduansha, Shanghai	42,020	2000
60	National Marine Park /Marine Special Protected Area for Ma'an Archipelago in Shengsi, Zhejiang	54,900	2005
61	National Marine Special Protected Area/Marine Park for Zhongjieshan Archipelago in Putuo, Zhejiang	21,840	2005
62	National Marine Protected Area /Marine Park for Yushan Archipelago in Xiangshan, Zhejiang	5,700	2008
63	Provincial Marine Special Protected Area for Pishan Island in Yuhuan	11,470	2011
64	Provincial Marine Special Protected Area for Ecology of Dachen Island in Taizhou	2,160	2008
65	National Marine Special Protected Area for Ximen Island in Yueqing, Zhejiang	3,127	2005
66	National Marine Park in Dongtou	31,104	2012

67	National Marine Park in Yuhuan	30,669	2016
68	National Marine Park for Hua’ao Island of Xiangshan in Ningbo	4,419	2016
69	National Nature Reserve for Jiushan Archipelago in Xianshan	48,478	2011
70	National Nature Reserve for Nanji Archipelago	20,106	1990
71	National Marine Park for Fuyao Archipelago in Fujian	6,783	2012
72	National Marine Park in Changle	2,444	2012
73	National Marine Park of Haitan Bay in Pingtan Comprehensive Experimental Area	3,490	2016
74	National Marine Park of Meizhou Island	6,911	2012
75	National Marine Park in Chongwu, Fujian	1,355	2014
76	National Marine Park in Xiamen, Fujian	2,487	2011
77	National Marine Park of Chengzhou Island in Fujian	225	2012
78	National Nature Reserve for Wetland of Minjiang River Estuary	2,100	2013
79	National Nature Reserve for Submerged Forest Area of Shenhu Bay in Fujian	3,100	1992
80	National Nature Reserve for Rare Marine Species in Xiamen	33,088	2000
81	National Nature Reserve for Mangrove of Zhangjiang Estuary in Fujian	2,360	1992
82	National Marine Park for Qingao Bay in Nan’ao, Guangdong	1,246	2014
83	National Marine Park for Zhelang Peninsula of Honghai Bay in Guangdong	1,878	2016
84	National Marine Park for Hailing Island in Guangdong	1,927	2011
85	National Marine Park for Yueliang Bay in Yangxi, Guangdong	3,403	2016
86	National Marine Park for Techeng Island in Guangdong	1,893	2011
87	National Marine Park for Wushi in Leizhou, Guangdong	1,671	2012
88	National Nature Reserve for Marine Ecology of Nanpeng Archipelago in Guangdao	35,679	1999
89	National Nature Reserve for Turtle in Huidong Port	1,800	1985
90	National Nature Reserve in Neilingding Island-Futian, Guangdong	922	1984
91	National Nature Reserve for Chinese White Dolphin of Zhujiang	46,000	1999

	Estuary in Guangdong		
92	National Nature Reserve for Mangrove in Zhanjiang, Guangdong	20,279	1990
93	National Nature Reserve for Rare Marine Organisms in Leizhou, Guangdong	46,865	1983
94	National Nature Reserve for Coral Reef in Xunwen, Guangdong	14,379	1999
95	National Nature Reserve for Mangrove in Shankou, Guangxi	8,000	1990
96	National Nature Reserve for Beilun Estuary in Guangxi	3,000	2000
97	National Nature Reserve for Dugong in Hepu, Guangxi	35,000	1992
98	National Marine Park for Coral Reef of Weizhou Island in Guangxi	2,513	2012
99	National Marine Park of Maowei Sea in Qinzhou, Guangxi	3,483	2011
100	National Nature Reserve for Mangrove in Dongzhaigang, Hainan	3,337	1986
101	National Nature Reserve in Tongguling, Hainan	4,400	2003
102	National Nature Reserve for Marine Ecology of Dazhou Island in Wanning, Hainan	7,000	1990
103	National Nature Reserve for Coral Reef in Sanya, Hainan	8,500	1990
104	National Marine Park of Laoye Sea in Wanning, Hainan	1,121	2016
105	National Marine Park of Qizi Bay in Changjiang, Hainan	6,021	2016

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