Chapter 3
Global Ocean Governance and Ecological Civilization: Building a Sustainable Ocean Economy for China

3.1 Background

3.1.1 Foreword

The ocean is fundamentally important for humankind. Simply stated, the ocean helps us breathe, regulates our global climate, and slows down the rate of global warming by absorbing 40% of anthropogenic carbon dioxide.

The ocean is also vital for the world's economic development. Three billion people globally rely directly on the ocean for their livelihoods. Ocean-based industries, such as fisheries, tourism, and maritime operations, are already today critical providers of employment and income. The ocean also holds the potential for the future development of new and expanded industries such as offshore renewable energies and marine biotechnologies.

However, a healthy ocean environment is a prerequisite for drawing on these direct and indirect benefits that the ocean provides—and the oceans and the ecosystem services they provide are under ever more serious threat than before.

This report looks at the opportunities that the ocean provides and the challenges it faces in continuing to provide for us these benefits.

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

At the same time, global ocean conditions are being seriously affected by large-scale environmental pressures such as global warming, increased ocean acidification under a continuously higher atmospheric carbon dioxide level, microplastics pollution, and overexploitation of natural resources.

China Council for International Cooperation on Environment and Development (CCICED) Secretariat,
Green Consensus and High Quality Development,
https://doi.org/10.1007/978-981-16-4799-4_3

The nature of the ocean ecosystem is both fragile, highly dynamic, and globally interconnected. Therefore, there is good cause to manage and govern maritime ecosystems to ensure a healthy and sustainable ocean supporting prosperous societies now and in the future. There is a need and a call to manage and govern the ocean with an ecosystem-based integrated approach to strike a balance between protection and production.

The work of this Special Policy Study has clearly demonstrated that now is the time for China and the world at large to ensure that the ocean environment plays a critical role in the national and international efforts toward developing an ecological civilization securing our own future.

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

The work underlying this report has been extensive, both in time and in the matters covered. Around 50 experts from the Chinese and international community have been directly involved in the work of this policy study, giving their time and expertise within a wide range of relevant ocean-related topics. Without their commitment and energy, this work could not have been as comprehensive and overarching as this complex and important topic deserves. We are truly grateful and thankful for the contributions from each and all.

The recent COVID-19 pandemic has shown how vulnerable societies are. This study was almost completed before the outbreak of the pandemic and thus does not reflect the effects of it, but we are certain that the ocean also carries important capability to support society in such an undesired event.

We hope that this report, its findings and recommendations, can be a contribution to the further discussions and actions required both nationally and internationally, enabling the global community to truly integrate the ocean environment into governance discussions.

Jilan Su Jan-Gunnar Winther

People ask: Why should I care about the ocean? Because the ocean is the cornerstone of earth's life support system, it shapes climate and weather. It holds most of life on earth. 97% of earth's water is there. It's the blue heart of the planet—we should take care of our heart. It's what makes life possible for us. We still have a really good chance to make things betterthan they are. They won't get better unless we take the action and inspire others to do the same thing. No one is without power. Everybody has the capacity to do something.

– Sylvia Earle

3.1.2 Introduction

The ocean covers more than 70% of the Earth's surface and is vital to the survival of life. It is fundamental for oxygen production, food sources, medicine, and many other products and essential ecological services. The oceans determine climate and weather, both on local, regional, and global scales. In addition to providing us with one of the most pleasing environments, the oceans are essential to energy, trade, transportation, and a number of other traditional and emerging industries.

There is currently a rising societal awareness and understanding of the overarching global importance of the ocean system as a living space and the basis for human civilization—as well as its highly dynamic and connected but fragile nature. In this context, all nations—individually and collectively—need to use and govern the ocean in a manner that will allow it to support society today and into the future.

Ensuring that the ocean system is integrated into and included in overarching societal strategies will be vital to China's ability to reach its goal of achieving a robust and viable ecological civilization. Three main themes merit attention, both to draw on opportunities and meet challenges: Environment, Industry, and Management. The three themes should not and cannot be seen as stand-alone pillars, but must be seen as three synergetic elements where each and all interact and impact each other in a number of ways and manners (Fig. 3.1).

The CCICED has explored the opportunities and challenges that the ocean provides within these three areas, through the establishment and work of an SPS for Ocean Governance and Ecological Civilization. This report constitutes the overarching findings of the SPS Ocean Governance.

The SPS has structured its work around the central theme and concept of ecosystem-based marine management. This concept addresses the impacts on marine ecosystems as a whole. Further, the SPS has focused its work on integrated ocean governance, which is an overarching and comprehensive tool for governing all human

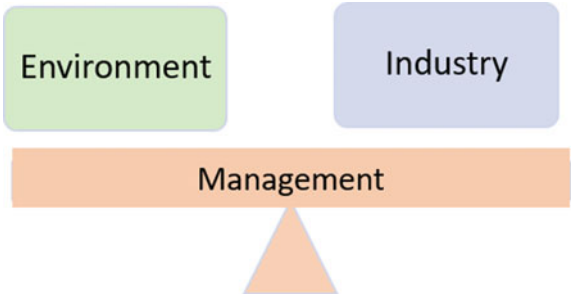

Fig. 3.1 Ensuring that the ocean system is integrated into and included in overarching societal strategies will be vital to China's ability to reach its goal of achieving a robust and viable ecological civilization. Three main themes merit attention, both to draw on opportunities and meet challenges: Environment, Industry, and Management

activities in the ocean space while at the same time considering environmental issues such as climate change, biodiversity, and pollution.

The Ocean Governance SPS has structured its work around this topic itself (ecosystem-based IOM and governance), as well as five additional interlinked themes:

- Marine living resources and biodiversity
- Marine pollution (plastics in particular)
- Green maritime operations
- Renewable energy systems
- Mineral resource extraction.

Climate change, technology, ocean economy, and gender have been a common thread through the various themes.

The Ocean Governance SPS has prepared reports for each of these six topics, and these reports serve as supporting documentation for this summary report. Below, we have included the summaries from each of the thematic reports to set the stage for this overarching summary report. Furthermore, the specific recommendations from the six task teams have been included as an appendix to this report.

Integrated and Ecosystem-Based Management

Summary of findings from the special study on integrated and ecosystem-based management

The oceans have always been key for the survival of humankind, and much of society's development has rested upon the qualities of the oceans. Marine ecosystems together form the largest aquatic system on the planet. The habitats of this vast system range from the productive nearshore regions to the barren

ocean floor. The ocean has attracted multiple uses for centuries, including fisheries, shipping, and transportation, military, recreation, conservation, and, more recently, oil and gas extraction and mining. Ocean activities will be essential in meeting future global challenges, including food, energy, transportation, and climate regulation.

Considering the key role that the oceans play as the basis for society, humanity, and the global future, it is a given that maintaining the health of the oceans is essential. Today, the well-balanced species communities of the marine ecosystems are becoming increasingly unstable, putting the health of the whole ocean systems at stake. There are a number of pressures that affect the health of the oceans, such as pollution (including noise), biodiversity loss, invasive species, climate change, and overexploitation of resources. The need for more and better governance of ocean uses has been widely recognized. Globally, ecosystem-based IOM is accepted as the appropriate approach for ensuring the protection and the sustainable use of coasts and oceans, taking sufficiently into account knowledge and the particularities of the ecosystems to be managed.

In China, over half of the population now resides along the coast, with coastal provinces and metropolises contributing more than 60% of national GDP [1]. These critical regions also hold the key to future development of China's initiatives such as the Blue Economy and Belt and Road Initiative (BRI) and its interconnection to the rest of the world. The development of coastal regions is also an important aspect to consider in the context of the Chinese Government's vision of a Beautiful China and efforts to build an "ecological civilization" [2]. Challenges remain in implementing integrated ecosystem-based ocean management at national, provincial, and local levels. These include silo governance, differing national–regional–local frameworks, overlapping roles and functions in administration, lack of integrated land–sea management, lack of public–private partnerships, and lack of general (public) understanding of the importance of a holistic system.

China is well placed to develop and implement a fully integrated ecosystem-based ocean management system and take on international leadership in this field. There are ample opportunities for China to move in this direction given the well-developed management basis, strong political will, and the emerging consensus among general public and business sectors in conserving the ocean system.

The specific recommendations put forward for integrated and ecosystem-based ocean management are found in the appendix to this report.

Marine Biodiversity and Marine Living Resources

Summary of findings from the special study on marine biodiversity and marine living resources

Feeding more than 9 billion people by 2050 while protecting biodiversity and the natural systems on which life depends is one of the greatest planetary challenges we face today. As one of the world's top seafood-producing nations, China has a significant stake in solving this challenge.

The ocean shelters a vast array of species and nourishes billions of people who depend upon it for food and livelihoods. However, while the ocean's ability to produce food is enormous, it is limited. About one-third of fisheries for which data exist are overexploited or collapsed. As a major contributor to food safety, aquaculture can also have negative impacts: it can displace native coastal and marine ecosystems, require large inputs of wild fish for feed, introduce non-native species and diseases, and cause significant pollution. Sustainably managing living marine resources to optimize food production over the long term while minimizing damage to the ecosystem is not an easy task, although there are many proven solutions and new ones in development to achieve these goals. Climate change will likely compound the challenge. Warming and acidifying waters are altering the productivity of many marine species and driving others across borders, intensifying the struggle for resources among competing countries. More extreme storms, altered weather patterns, and disrupted water and nutrient cycles will increasingly stress coastal food production systems.

Rapid economic growth along China's coasts over the last 40 years has imposed significant costs on the coastal and marine environment. More than half the country's coastal wetlands, nearly 60% of mangroves and 80% of coral reefs have been lost to land reclamation, mariculture and pollution [1]. Significant portions of seagrass beds, tidal marshes, and tidal flats that once provided critical habitat for a diverse array of marine life have also been affected. China produces enormous quantities of wild and farmed seafood, but the rate of extraction and exploitation has outstripped the ability of marine ecosystems to absorb the impact, and most of the top marine predators have been eliminated or nearly so. Furthermore, China employs more people in the fishing and aquaculture sector than any other nation, making the social dimension of bringing these industries under control much more challenging. China has begun making significant progress in addressing the challenges. Bold, concrete actions, including strengthening the seasonal closings of nearly all domestic fisheries each year, protecting habitat and establishing marine reserves, imposing stricter standards for discharging pollutants into the sea, shutting down illegal mariculture operations, and establishing a total acreage limit for mariculture have been imposed.

More must be done if China is to re-establish healthy coastal and marine ecosystems that can sustainably provide the levels of nutritional and economic

benefits historically enjoyed. Legal protections for living marine resources must be strengthened, monitoring expanded, and compliance improved, and more critical habitat restored and protected. Furthermore, because climate change is affecting living marine resources on a global scale, and because so many of these resources are shared, stronger regional and global governance is required to ensure living marine resources are managed sustainably at scale. Although these challenges are significant, solving them will produce enormous direct benefits for China by securing a large and sustainable supply of high-value seafood and livelihoods in its own waters. It will also create tremendous opportunities for China to demonstrate regional and global leadership among developing countries that lack the capacity to sustain the value of their living marine resources. These leadership opportunities are especially important and timely now as these countries begin to grapple with how to recover from the COVID-19 crisis and associated economic impacts.

The specific recommendations put forward for marine biodiversity and marine living resources are found in the appendix to this report.

Marine Pollution

Summary of findings from the special study on marine pollution

The ocean is vital to all life on Earth, providing many provisioning, regulating, and supporting services. Agricultural and industrial requirements for feeding, clothing, and housing the world's growing population and expanding economies have resulted in seriously degrading parts of the marine environment, especially near the coasts.

The lack of sewage and wastewater treatment and the release of pollutants from industrial, shipping, and agricultural activities are major threats to the ocean, particularly in terms of food security, safety, and maintenance of marine biodiversity. The ocean also suffers from the sewage, garbage, spilled oil, and industrial waste that we collectively allow to flow into the ocean every day. In addition to affecting marine and coastal ecosystems and biodiversity (as well as ecosystem services), such pollution has a direct connection to huge economic costs tied to marine fisheries, marine tourism, and human health and safety. Often, while production and emission to a large degree are land-based, the marine environment is, in fact, the end recipient. In addition to the well-known eutrophication effects from terrestrial nutrient input, the globally growing plastic pollution challenge is another prime example of such interactions. Continued growth in industrial production means that discharges and emissions likely will increase the inputs of heavy metals and other hazardous

substances into the ocean. The use of the best practicable means to limit the creation of waste, discharges, and emissions can help control these problems.

In the last 40 years, China has formed a coastal ribbon of high economic development, which has brought with it population density and urbanization. This rapid development has subjected the coastal and marine ecosystems to tremendous ecological damage. More than 70% of nutrients discharged into the sea have land-based origins, and these and other sources of pollution being leached into the marine environment have led directly to a decline in marine water, sediment, and biological quality. Although laws and policies have been much improved in the last 10 years, there are still some significant gaps that prohibit China from fully implementing its obligations in the international conventions and protecting its marine environment and resources. The gaps exist in the lack of an integrated ecosystem-based view, lack of laws in protection of resources and ecosystem, lack of detailed implementation rules, and lack of a cross-sector implementation mechanism.

Recently, China stepped up efforts to promote ecological civilization. Pollution control is one of the three tough battles that the Chinese government must win. Innovations in cleaner production methods and means of reducing discharges and emissions would be important to keep pace with the growth in production, especially in areas of rapid industrial growth. There is a tremendous opportunity for China to promote the case for marine pollution governance. China's ecological civilization construction is a useful exploration and practice of sustainable development, providing an economic reference for other countries to deal with similar economic, environmental, and social challenges.

The specific recommendations put forward for marine pollution are found in the appendix to this report.

Green Maritime Operations

Summary of findings from the special study on green maritime operations

As a country trading across all regions around the globe, maritime operation is becoming a crucial foundation of China's socioeconomic growth. China ranks first in the world in port cargo throughput and has the largest ocean fleet and highest number of seafarers in the world. Its marine [3]. Marine fisheries and oil and gas exploration lead the world as well. With the sustainable development of this industry, marine environmental pollution caused by maritime operations has become a challenge that must be faced and solved. At the same time, it also brings great opportunities and challenges for China's maritime operation to adapt to the global trend of green development.

As the dynamic and vulnerable nature of the marine ecosystems has become increasingly understood and appreciated, higher standards for green maritime operations are required both domestically and internationally. While land-sourced pollution is an important concern and contributor to the degradation of the marine environment, the impacts on the marine environment from maritime transportation, oil and gas exploration, and fisheries—as well as port and ship infrastructure—also represent a challenge to be addressed. It is believed that pollution from ships is a large proportion of maritime pollution, with the main pollutants being oily water and domestic sewage. Internationally, the shipping industry is increasing its attention to these issues and moving toward modes of operation that reduce the ecological footprint. New international environmentally driven regulations for shipping are constantly complemented and improved. They are expected to bring significant benefits for human health and the environment, but at the same raise fresh challenges for the shipping industry.

China's booming ocean economy over the last 40 years has exacerbated the overall pressures on the marine environment. Ports claim large swathes of land from the sea. Land-sourced pollution further threatens ocean ecosystems, as does the inadequacy of environmental facilities at ports and on vessels and offshore oil platforms along with worsening air and water pollution. Ship-sourced GHG emissions remain significant. The massive scale of maritime transportation and coastal storage of hazardous chemicals such as petroleum products cause marine pollution risks to rise. At present, the Chinese government has made substantial efforts in promoting pollution prevention and control of ports and ships and has made some achievements, in particular through the adaptation and implementation of several laws and regulations related to maritime operations.

China's maritime operation needs to shoulder its share of responsibility in building an ecological civilization and tackling pollution prevention and control. In this context, there are more green goals and tasks for the shipping industry, marine fisheries, and oil/gas industry ahead. Government actions, such as subsidies and tighter supervision, have aided the industry's ability to follow up. Nevertheless, the lack of technology and environmental awareness is an impediment that calls for further measures. Internationally, there has been a significant advancement with regard to developing green maritime operational practices, such as emissions-control areas, green ports and fleets, emergency response, pollution prevention, and control for fishing vessels and harbours, which can provide valuable experience for China. China needs to increase its efforts to adapt to the greening of the global marine industry.

The specific recommendations put forward for green maritime operations are found in the appendix to this report.

Marine Renewable Energy

Summary of findings from the special study on marine renewable energy

Ocean renewable energy (ORE) is notable as an emerging sector of the maritime industry. China, the world's biggest energy consumer, is stepping up its push into renewable energy and proposing higher green power consumption targets, including in the ORE area. Achieving the needed renewable energy transition will not only mitigate climate change but also stimulate the economy, improve human welfare, and boost employment worldwide.

Different ORE technologies (wind, wave, current, tidal range, ocean thermal) are under consideration in different stages of development, and each will present its own unique challenges. ORE—specifically offshore wind—is seeing rapid growth in installed capacity and environmental; however, socioeconomic, and technical challenges need to be considered. Achieving a viable cost of electricity is a challenge to the offshore wind industry but provides an even bigger challenge to other ORE technologies. Understanding and assessing the environmental impact of ORE installations, operations, and decommissioning is substantially challenged due to, e.g., baseline data, socioeconomic and diverse developing technologies. Development of ORE affects or is also affected by numerous stakeholders. Understanding who the stakeholders are and how they are engaged in the process is necessary for improving the responsible development of ORE technologies. Key stakeholders include fishers, community members, regulators, developers, scientists, and tourists and so on that depend on the specific ORE project and the specific location. The seabed off China's east coast is characteristic of soft, silty soils which are unlike soil conditions in other countries contemplating ORE growth. This causes difficulty with regard to foundation type and installation techniques. Furthermore, the technical challenges for the offshore wind industry are much greater in other typhoon-prone regions, where the weather conditions can be quite impactful on turbine performance. China's current legal system of environmental consideration related to ORE activities is limited and further regulations need to be developed.

China is particularly active in developing offshore wind technologies, an area which is set to become an important sector for the global energy future, while also demonstrating wave and tidal energy technologies. The Chinese government has made a commitment that non-fossil fuel energy will account for 20% of energy production by 2030, and operational installed capacity of ORE (offshore wind) in 2019 reached 3.7 GW in total, with another 13 GW under construction and over 41 GW permitted. The development of ORE, including offshore wind, in China has reached a turning point in 2018, moving toward zero-subsidy. China's first auction for offshore wind projects in 2019 achieved a price of electricity at 0.75 Yuan/kWh, lower than the guide price of 0.8 Yuan/kWh. China has also become one of the few countries in the world that

have mastered the technology of large-scale tidal current energy development and utilization.

ORE is a fast-growing ocean technology that is advancing the goals of the low-carbon and circular economy. Offshore wind technology only recently reached a policy turning point, while other ORE technologies are at an early stage of development. Nevertheless, there are encouraging signs that the investment cost of technologies and the price of electricity generated will decline further toward commercially viable ORE energy generation. Enhancing knowledge of the ORE technologies' potential impacts is crucial to inform future growth plans and as well as effectively licensing for ORE activities. Ongoing review of environmental impacts associated with the growing ORE sector and emerging ORE technologies will ensure that the best and most up-to-date information is available to decision makers, developers, and stakeholders. Furthermore, the opportunity of integrating emerging ORE technologies into military applications, electricity generation for remote communities, freshwater generation, or aquaculture applications, could be further opportunities. ORE technologies offer opportunities for China to develop a new industry, create jobs, and take advantage of opportunities within its competency to global markets.

The specific recommendations put forward for ocean renewable energy (ORE) are found in the appendix to this report.

Marine Mineral Extraction

Summary of findings from the special study on marine mineral extraction

The huge reserves of mineral resources (polymetallic sulphides, PMS; polymetallic nodules, PMN; cobalt-rich ferromanganese crusts, cobalt-rich crusts (CRCs); and rare earth elements [REE]) found on the deep seabed may be of great significance to the world's economic development as well as to the strategic reserve of mineral resources [4]. To date, 30 deep-sea mineral exploration contracts have been issued by the International Seabed Authority (ISA) for resources beyond national jurisdiction. Natural gas hydrates are widely distributed in most of the world's marine deep-water areas (~99%) and permafrost sedimentary environments (~1%) [5]. The amount of gas stored in the world's hydrate accumulations is significant, but estimates are highly uncertain.

Deep-sea mining (DSM) requires cutting, collecting, or dredging technology, and a rise-and-lift and return water system. Technology is currently being developed and tested. It is imperative that future exploitation of marine mineral resources can be carried out without causing significant environmental harm. There is, however, a challenge in that deep-sea environments in general

are little-explored and poorly understood. The nascent DSM sector has reached a crucial juncture of transition from exploration to exploitation, and the regulatory framework is still not complete. Establishing such a new industry will require a joint effort and collaboration to succeed in establishing a sustainable industry and maintain the seabed's status as "the common heritage of mankind" [6]. In addition to a number of technical risks, NGH exploitation also comes with serious environmental risks such as the increased risk of seabed landslides and huge amounts of methane released into the water column and atmosphere.

China's law on Exploration for and Exploitation of Resources in the Deep Seabed Area was adopted on 26 February 2016 and entered into force on 1 May 2016. This is the first Chinese law specifically regulating relevant activities from China. Environmental protection principles and measures are well covered in the law, and stringent rules, standards, and effective measures regarding the protection of the environment are reflected and adopted. Chinese state-sponsored companies hold five of the exploration contracts related to PMS, PMN, and CRC. In 2020, China carried out a successful gas hydrate production test in the South China Sea.

There are ample opportunities for Chinese industry to engage at all levels of the DSM value chain, including research, exploration, exploitation, equipment manufacturing, technology design, and mineral processing and to promote DSM as part of the circular economy. In the collaborative work between operators and interested parties, there is a need to focus on reducing the environmental risk as well as sharing of data and experience to ensure the industry adapts best environmental practice and continuous improvement. There would be benefit in China reviewing and updating its Deep Seabed Area Law in order to comply with the new requirement of the exploitation regulatory framework developed by the ISA within the context of the domestic legal system, to deal more specifically with future exploitation activities, and consider developing additional regulations to supplement the ISA requirements, drawing on the concepts of sound environmental management. With its high level of engagement in DSM, China is well placed to continue to bring on initiatives to strengthen ISA as a regulator and actively engage with ISA.

The specific recommendations put forward for marine mineral resources **extraction** are found in the appendix to this report.

3.2 Major Research Results

3.2.1 Environment: The Ocean as the Basis for Life

The ocean and humans are inextricably interconnected. The choices we make and the actions we take in managing and governing the oceans consequently have profound and lasting impacts on human well-being and societal development.

The ocean is the largest ecosystem on Earth and covers 70% of the earth's surface. The world's oceans contain more than 97% of the world's water and are home to the greatest abundance of life on our planet. Marine biodiversity is remarkable at the species, genetic, and molecular levels. All the creatures that live in the ocean play an essential role in the trophic chain of the ecosystems.

Marine environments are normally classified as either pelagic (open water) or benthic (bottom), although they are closely interlinked in many ways. For example, pelagic plankton are an important source of food for animals on soft or rocky bottoms, because the upper part of the water column is where photosynthesis occurs. Food chains in the oceans are generally regulated by nutrient availability. These determine the abundance of phytoplankton, which in turn provide food for the primary consumers, such as protozoa and zooplankton that the higher-level consumers—fish, squid, and marine mammals—prey upon.

The distribution patterns of marine organisms have been and continue to be influenced by physical and biological processes over time, such as temperature, salinity, density, and current patterns. Cycles of plankton production vary around the world based on seasonal differences of light and temperature. Changes in production depend on the season, the proximity to fresh water, and the timing and location of upwelling, currents, and patterns of reproduction. Recent estimates of extant marine species range from ~300,000 to 2.2 million, revealing high levels of uncertainty in our knowledge of global marine biodiversity. Coastal and marine habitats in China are home to more than 20,000 species, including 3000 species of fish alone.

The importance of the ocean as a life support system for humankind relates to the air we breathe, the climate we have, and the food we consume.

The world's oceans generate more than 50% of the oxygen we (need to) breathe, and the photosynthesis of phytoplankton is the source of this oxygen. Through photosynthesis, these microscopic plants in the ocean take up carbon and release oxygen.

The oceans are key regulators of the global climate. The ocean absorbs the heat from the sun and transports warm water from the equator to the poles and cold water from the poles to the tropics—this continuous pumping of water frames regional climates around the world. Through the phytoplankton's photosynthesis processes, the ocean absorbs carbon and as such is the largest carbon sink we have. This means that the oceans play an important role in maintaining the balance of the overall carbon cycle, and thus also the stability or change in climate.

Oceans provide at least a sixth of the animal protein people eat and are the number one source of protein for more than a billion people. Fish, crustaceans, molluscs,

algae and other sea plants are some of the food sources used around the world. With a growing global population, it is expected that the oceans will play an even more important role as a food source.

The marine ecosystem thus provides numerous benefits for people and society, including food, natural fibres, a steady supply of clean water, regulation of pests and diseases, medicinal substances, recreation, and protection from natural hazards such as floods. Environmental damage and degradation to marine ecosystems consequently may, therefore, have great social costs. Not only does it have economic costs such as those related to clean-up operations, reduced fishing catches, reduced coastal tourism, but also on general well-being due to negative impacts on, for example, recreational and aesthetic values of the marine environment. Aesthetic value, or beauty, is important to the relationship between humans and natural environments and is, therefore, a fundamental socioeconomic attribute of conservation alongside other ecosystem services.

Noting these important fundamental roles that the ocean system has for life, it is disturbing that the oceans are facing a constantly increasing number of threats, in particular habitat destruction, (coastal) pollution, overfishing, climate change, hypoxia, and ocean acidification.

China's marine environment has been deteriorating for many years. Major concerns regarding the coastal and marine environment in China include land reclamation and hardening of the coastlines of the Yellow and East China Sea, dramatic reduction in sediment discharge from the Huanghe and Changjiang River; navigation channel construction and deepening of ports; and increased nutrient and contaminant loading to the estuarine and coastal environment. Eutrophication related to the use of fertilizer is a prominent and overall "invisible" pollution source, which lead to a series of ecological effects such as harmful algal bloom, seasonal seawater acidification and hypoxia in the coastal oceans [7]. Pollutants from mariculture, agriculture and other land-based industries have eroded key habitats, including those further offshore that are buffered to some degree from alteration of the coastal zone.

Some marine ecosystems, most notably the central Bohai Sea, areas at offshore side of the Yangtze River Estuary and Pearl River Estuary, have been severely degraded and become seasonally hypoxic, while severe eutrophic pollution has occurred in other large bays or estuaries, such as Liaodong Bay, Bohai Bay, Laizhou Bay, Hangzhou Bay and Zhujiang River Estuary, compromising survival of fish populations and other living marine resources.

Many ongoing and emerging human activities have the potential to and are, in fact, destroying areas and ecosystems that marine plants and animals need to survive. The clearing of mangrove forests for shrimp production is one such activity, noting that approximately 240,000 ha of shrimp ponds have been built in the coastal areas of south-eastern China during the past 40 years, largely by destruction of mangroves and seagrass beds. Other activities that contribute to coastal degradation include land reclamation on coastal wetlands and destruction of the seabed by trawling. Furthermore, reclamation and eutrophication from both terrestrial input and mariculture are regarded as major causes for the decline of seagrasses, coral reefs, mangroves, salt marshes, and tidal flats.

Overfishing occurs when more fish are caught than are able to reproduce and to recruit. Normally, fishing occurs at a high level in the food chain, on the predators that live on the smaller organisms lower in the food chain. When essential predators are highly decimated or removed through overfishing, this impacts the populations of the other organisms in the food chain, often giving these the opportunity to increase. Affecting the top predators' role in balancing the ecosystem—from what they eat to how their bodies decompose—thus means important and potentially fatal ripple on effects for ocean ecosystems.

All the activities described above constitute threats to the ocean, causing degraded water quality, environmental degradation, decline in biodiversity, and the loss of ecosystem services, each of which may be difficult to account for in monetary terms but is significant nonetheless.

Overfishing is perhaps the most significant issue facing marine ecosystems overall. This is not to say that other issues are not important and in some locations more severe than overfishing; however, because fishing fleets are vast and widespread, and cause direct mortality to harvested organisms—often with incidental impacts on habitat—overfishing remains a major threat to ocean health at the global scale. The causes of overfishing are diverse and vary from fishery to fishery, though two of the most pervasive drivers include non-sustainable economic incentives that are not aligned with needed environmental outcomes, and fishers being disconnected from decision-making processes and therefore less likely to accept and comply with regulations.

Although the number of eggs a fish spawns usually reaches the level of one million, the fish eggs and larvae easily become prey for other animals. Therefore, the survival rates of fish eggs and juveniles (supplementary groups) are very low, possibly as low as 1 in 10,000 or 1 in 100,000. This is why larvae and juveniles of marine living resources need good habitats and shelters to grow properly and sustain their populations. The ecological function of coastal wetlands is very important for many coastal fish species. Numerous important fish habitats such as estuaries, seagrass beds, salt marshes, and tidal flats are distributed along the coasts of China. Besides being critical fish habitats, coastal wetlands also provide numerous ecosystem services, including water purification, which is indispensable for cleaning the coastal water by removing organic and inorganic nutrients, particulate matters and chemical pollutants.

Ocean ecosystems have no obvious physical boundaries, but rather are characterized by currents that transport nutrients and small marine organisms, by highly mobile species that migrate across entire ocean basins for feeding and reproduction. These horizontal and vertical movements connect the open ocean to coastal waters and the deep ocean and play an important role in maintaining healthy and productive ecosystems. Thus, transboundary connectivity is important in sustaining healthy populations of marine animals and functioning ecosystems which in turn provide a range of benefits for people and communities and society at large.

IPPC's Special Report on the Oceans and Cryosphere in a Changing Climate (SROCCC) records significant changes to the world's oceans as a result of climate change, noting that it is virtually certain that the global ocean has warmed unabated since 1970, and that since 1993, the rate of ocean warming has more than doubled.

Also, marine heatwaves have increased in frequency and intensity. SROCCC also documents that there are many marine species across various groups that have undergone shifts in geographical range and seasonal activities in response to the ongoing ocean warming and biogeochemical changes. This has resulted in shifts in species composition, abundance, and biomass production of ecosystems, from the equator to the poles. Coastal ecosystems, in particular, are affected by ocean warming, including intensified marine heatwaves, acidification, loss of oxygen, salinity intrusion, and sea-level rise.

By absorbing more CO_2, the ocean has undergone increasing acidification. Increasing anthropogenic nutrient discharge has resulted in widely distributed coastal hypoxia zones, often accompanied by severe acidification, called coastal acidification. Ocean acidification is expected to affect ocean species to varying degrees. Photosynthetic algae and seagrasses may benefit from higher CO_2 conditions in the ocean, as they require CO_2 to live, just like plants on land. On the other hand, studies have shown that lower environmental calcium carbonate saturation states can have a dramatic effect on some calcifying species, including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton.

Impacts from human activities both on land and in the ocean are already observed on habitat area and biodiversity, as well as ecosystem functioning and services. Humankind can, through appropriate actions, contribute to slow down the ongoing changes. This will, however, require fundamental transformations in all aspects of society—how food is grown, land is used, goods are transported, and how the energy that support our lives and economies is produced. It will require a joint effort between governments, businesses, civil society, youth, and academia to make this shift.

3.2.2 Industry: Ocean Economy

Generally speaking, the entire global community depends in one way or the other on the services of the ocean, and it is estimated that globally 3 billion people rely directly on the ocean for their livelihoods, the vast majority of these in developing countries. Ocean-based industries, such as fisheries and tourism, are critical providers of employment and income. Expanding ocean-based sectors such as offshore renewable energies and marine biotechnologies can boost job creation, energy supply, food security, and infrastructure.

A healthy ocean environment is a prerequisite for drawing on the direct and indirect economic opportunities that the ocean provides, and thus investing in the ocean environment is also an investment in the ocean economies. It is important to ensure that ocean investors are made appropriately aware of how their investments affect the marine environment and of how a declining ocean environment, in turn, may affect the outcomes of their investments. Environment and industry cannot be considered as separate themes and management entities but as a synergetic system.

The importance of marine sectors for China cannot be overemphasized. Over half of the population now resides along the coast, responsible for 60% of national

GDP. More importantly, the recent rapid development of China's economy and social well-being was initiated in the coastal cities and their opening to the international community. Currently, the key ocean-based economies of China are fisheries, mariculture, ship-building/shipping, tourism, and recreation-based industries. Renewable ocean energy and seabed mining, as well as ocean-based biotechnology, are emerging as potential and likely future large-scale industries. In many areas, China is a world leader in the scale of the industry, and as such, contributes to setting global standards for the industries.

For example, China's aquaculture industry has grown markedly for more than six decades, and it is today the largest aquaculture producer in the world, accounting for around two-thirds of global production. China still leads the world in marine capture fisheries by far. In 2016, China's fishing fleets harvested over 15 million tons, nearly 2.5 times the catch of the next largest fishing nation. Approximately 90% of the catch is from domestic waters. Fisheries remain an important economic driver in China. Although mariculture production now far exceeds that of wild catch, China's position in the global seafood supply chain, its world-leading volume of wild fisheries catch, and the size of its fisheries labour force mean that management of wild fisheries remains a critical policy issue for social, economic, and environmental reasons. Approximately 19 million people are now employed directly or indirectly by fisheries and aquaculture in China [8].

As a shipping country, China ranks first in the world in port cargo throughput and has the largest ocean fleet and highest number of seafarers in the world. By the end of 2018, China's coastal ports had 5734 berths for production terminals, 2007 berths of 10,000 tons and above, with passenger throughput of 880 million people and cargo throughput of 9463 million tons [9]. In terms of container throughput, China's ports occupy seven positions in the world's top 10 ports.

Ocean energy and offshore wind energy are abundant, geographically diverse, and renewable. To extract these energy sources, there are six distinct technologies (i) offshore wind energy, (ii) wave energy, (iii) tidal current, (iv) tidal range, (v) salinity, and (vi) ocean thermal energy conversion. The variations in ocean resources and location will require different technological concepts and solutions. Many marine-based renewable energy technologies are at relatively early stages of development, and currently only contributes a tiny proportion (far less than 1%) of the global renewable energy production due to the technological difficulties as well as the high cost [10]. There is still little in the way of demonstrated effectiveness, cost, or environmental effects of large-scale ocean-based systems, and in particular assessments of the environmental impacts of installation, operation, and decommissioning of renewable ocean energy systems is facing critical challenges as there is a lack of baseline data as well as a diversity in the developing technologies that have their own specific environmental aspects [11].

Rising demand for minerals and metals, including for use in the high-technology sector, has led to a resurgence of interest in the exploration of mineral resources located on the seabed, in particular seafloor massive (polymetallic) sulphides around hydrothermal vents, CRCs on the flanks of seamounts, or fields of manganese (polymetallic) nodules on the abyssal plains. In addition to mineral deposits, there is

interest in extracting methane from gas hydrates on continental slopes and rises. Seabed mining for minerals is still in the developing stage. The huge reserves of seabed mineral resources can be of great significance to the world's economic development, including China. However, there is a need to better understand the risks and potential impacts to ensure that any activity in this area is sustainable in the long term. Deep-sea environments are little-explored and poorly understood. Before initiating any large-scale DSM activity, it is necessary to understand the relevant ecosystems and the potential risks associated with the activity, both in general for an evolving industry and for specific exploration activities.

The creation of products and processes such as pharmaceuticals and cosmetics, food, chemicals, and biofuels from marine organisms through the application of marine biotechnology is a relatively young sector in the ocean economy, but which has the potential to contribute to economic and social prosperity by making use of recent advances in science and technology. Marine biotechnology is also playing an increasingly important role in the protection and management of the marine environment itself. Biotechnology, including marine biotechnology, has been one of China's strategic industrial sectors; however, this is field requires international cooperation in legally framing the industry and developing the technology to ensure economic prosperity in an environmentally sustainable manner.

In exploring and developing ongoing and potential future ocean-based industries, issues such as the environmental sustainability, the use and development of new technologies, social sustainability, and gender aspects are key factors to be considered.

Environmental sustainability is fundamentally important to consider in order to avoid putting the ocean's resources at risk, and thereby hampering the socioeconomic benefits they can deliver for future generations. The ocean is our greatest global common, and how we use it will determine much of the success toward achieving the SDGs. It is necessary to understand how various industrial activities may affect and degrade the environment, as well as invest in research on—and implementation of—technologies that minimize such impacts. The lack of sufficient scientific understanding of the vulnerability of the ocean ecosystems is an obstacle to understanding potential impacts, and efforts are required to decrease the knowledge gap. Emerging industries are in a unique position to define both national and global sustainable frameworks for the industry before it is fully developed.

Developing new technologies to support sustainable ocean economies is, in itself, an important contribution to the national and global economies. There are considerable potentials for pioneering technological innovations that could provide solutions for balancing the benefits of marine-based activities with a complex variety of risks that need to be carefully managed. In fisheries and mariculture for example, green technologies could include low-impact, fuel-efficient fishing methods, and innovative aquaculture production systems using environmentally friendly feeds; reduced energy use and greener refrigeration technologies; and improved waste management in fish handling, processing, and transportation. In the shipping arena, many national governments around the world have high aims for the greening of their national fleet and therefore formally encourage and support the introduction of incentive schemes

aimed at moving ship owners to adopt ship designs and technologies that reduce fuel consumption and pollution. Developing green, smart ports is also essential. Such incentive schemes give the industry great autonomy in deciding how to meet the set of targets and provide it with incentives to search for cost-effective ways to meet them, yet contributes to a continuous greening effort.

The inclusion of women has been shown to increase the effectiveness of the Green Economy. According to the IMO, women today represent only 2% of the world's 1.2 million seafarers and 94% of these female seafarers work in the cruise industry. The number of female captains, officers, and general seafarers in China accounts for over 15% of the country's total maritime staff. Women account for 50% of the workforce in fisheries and aquaculture worldwide when accounting for the secondary industry [12]. Women account for 20% of the total professional fishery-related workforce in China. China has a long and strong commitment to gender equality (in its society). China was one of the first countries to ratify the UN Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) in 1980. Through this Convention, China, along with other nations, has agreed to take appropriate measures in all fields, including the economic fields, to ensure the full development and advancement of women on the basis of equality with men. UN SDG #5 calls for achieving gender equality and empowering all women and girls. China has committed itself to contribute to this goal through eradication of all forms of discrimination and prejudice against women and girls and through strengthening women's employment and entrepreneurship capabilities [13]. CEDAW calls for effective special measures in the fields of women's employment and participation aimed at accelerating de facto equality between men and women in line with the Convention. With its strong historical commitment and desire to move toward fulfilling UN SDG #5, China stands in a unique position to be a leader in contributing to changing the skewed gender balance in maritime operations, by committing to and implementing gender equalizing efforts in the further development of ocean industries in China.

The ocean carries great potential for China's economic and social development. However, feeding more than 9 billion people by 2050 while protecting biodiversity and the natural systems on which life depends is one of the greatest planetary challenges we face today. With dedicated efforts to ensure further development of current and emerging industries in a sustainable manner, the ocean's potential can continue into the future. Recommended actions that the State Council could consider are summarized in Chap. 6.

3.2.3 Management: Balancing Environment and Economy

A healthy and sustainable ocean is essential for maintaining prosperous societies now and in the future. Recognizing the importance of the ocean for all aspects of human society and the habitability of the Earth, the need for more and better governance of ocean-related human activities has been widely accepted. There are ample opportunities for China to implement sustainable development approaches given the strong political will and the emerging consensus among the general public and the business sector in conserving the ocean system. This calls for ecosystem-based IOM to strike a balance between protection and production. IOM is an approach that brings together relevant actors from government, business, and civil society and across sectors of human activity. IOM is an important tool for ensuring the sustainable use of coasts and oceans and provides a framework for how the oceans could be managed under the premise of a knowledge-based and ecosystem-based approach. In short, IOM is a tool that enables society to optimize the benefits it derives from the ocean for the long term.

China issued the first National Marine Functional Zoning (MFZ) in 2002, which provided a basis for sea area management and preliminarily solved the problems of disorderly sea use. In the revised MFZ (2011–2020), China's coastal oceans are divided into eight functional zones, including agriculture and fishery, port and shipping, industrial and urbanization, minerals and energy, tourism and recreation, marine protected areas, special use, and reserved areas. An MFZ is the legal basis for rational development and utilization of marine resources and effective protection of the marine ecosystems. At the local level, Integrated Coastal Zone Management (ICZM) has been adopted in a few regions, with pilot projects successfully carried out over the past 30 years, to deal with certain cross-boundary issues. The Bay Chief System recently piloted in some regions is a coordinated mechanism led by governmental organizations with the participation of various departments and all sectors of the society. Its characteristics lie in the overall planning and coordinated management across departments to ensure that problems in bay environmental management are addressed more comprehensively. However, none of these practices (MFZ, ICZM or Bay Chief System) has an entirely "ecosystem-based approach," and challenges remain in implementing marine ecosystem-based integrated management at both national, regional and local levels, some of which are highlighted below.

Silo management is a common challenge within national and international governance, indicating management systems that are unable to operate with other systems and where management entities have different priorities, responsibilities, and visions. Sectoral silos need to be broken down to achieve IOM at national, regional, and local levels, as well as across borders. As a nation, China implements a top-down governance approach which includes three main governance levels (national, provincial, or metropolitan, and municipal or county). Despite the various strengths of this system, it also tends toward silo management. There needs to be a link between all levels to enhance the efficiency and effectiveness of implementation.

Traditionally, the focus has been on single pressures when developing management frameworks for the oceans. Single threats are indeed easier to study and understand, while multiple stressors are ubiquitous, and stressor interactions can lead to amplified effects. There is still very little understanding regarding how simultaneous stressors interact to affect species and ecosystems. Management rarely has the capacity to address more than one issue at a time. Greater reliance on the marine ecological sciences and application of a whole-system approach is needed.

The marine ecosystems are affected by human activities on both land and sea. However, standard approaches for management of the ocean often neglect to consider connections between ecosystems and thus are characterized by a sectoral approach to management. At present, China's coastal zone management has entered the stage where land and sea are coordinated. Land and its surrounding sea are an integrated system, so the marine ecosystem and land ecosystem should be considered as one in overall coastal planning. Challenges remain, however, and further measures to promote land–sea coordination are urgently needed.

The ecosystem-based management system can only be effective if it is understood by all concerned stakeholders. It is crucial to raise awareness of the multiple benefits provided by ecosystem-based approaches among all relevant policy sectors and stakeholders.

The recent COVID-19 pandemic has also shown how vulnerable societies are and could underscore the need to manage our ocean in a sustainable way. The ocean and its ecosystem services are important for people far beyond the coastal and marine regions themselves. Changes to the ocean itself, as well as changes to society that depend on the services of the ocean, may have detrimental effects, in particular in cases of unforeseen and sudden changes. In such a context, the resilience of the coastal and marine environment will be important. Societal resilience against climate-related, anomalous, and unprecedented disturbances of the ocean system can be strengthened by protecting resources, as well as other innovative approaches, such as a gender-based analysis.

Achieving a sustainable and integrated marine and coastal ecosystem management requires the involvement of women. Confronting gender inequality is essential to achieving the targets of the 2030 Agenda for Sustainable Development. It is important that women have an equal role in participating and managing ocean-related activities to enable this. Studies show that the participation of women in activities and their management often has a positive impact on issues related to the environment and sustainability.

Women and men use and manage marine and coastal ecosystems differently, have specific knowledge, capabilities, and needs related to this and are differently affected by changes in their environment due to climate change, pollution, and globalization. Gender mainstreaming is a critical and integral component because it is important to know how different groups of women and men use, manage, and conserve the marine and coastal environment, so that policies and projects can engage them equitably and effectively in sustainable management practices. Research has shown that involving women in decision making has positive impacts on social and environmental programs.

China would truly benefit by continuing to develop its efforts to manage its ocean interests (both nationally and globally) so as to strike a balance between protection and production and on the basis of the principle of IOM.

3.3 Recommended Actions

- ***Bring the ocean environment clearly into the framework of "Beautiful China" the importance of the ocean environment as the basis of life in the 14th FYP, and as such consider strengthening policies and activities that support and sustain the biodiversity of the oceans—in particular, actions that***:
  - *Aim to* significantly reduce *land-based pollution (and pollution from maritime operations) reaching the sea, including promoting innovations in cleaner production methods and means of reducing discharges and emissions.*
  - *Avoid further marine habitat destruction and prohibit reclamation of coastal wetlands, and, during 2020–2030, re-establish degraded/destroyed coastal wetlands that once served as key habitats.*
  - *Through innovation, development and use of new technologies*, promote environmentally friendly mariculture and combat illegal fishing. *By 2025, full output control should be implemented for all fishery activities.*
  - *Implement the ecological* environment *damage compensation system and improve the public participation system for marine environmental protection. The Ministry of Ecology and Environment should carry out natural capital accounting for the ocean in order to undertake an evaluation of an official's ecosystem-based performance when carrying out his/her term assessment.*
- ***Within the framework of the FYP, clearly flag a commitment to fulfil the Paris Agreement and actively use IPCC assessment reports and the IPCC special report on ocean and cryosphere in a changing climate in framing climate action policies. In particular, it is recommended that***:
  - *China considers how it can actively use the restoration of coastal wetlands in this context, noting the high capability of wetlands to sequester carbon.*[1]
  - *The development of a platform/framework for understanding and assessing the impacts of climate change on living marine resources and evaluate ways to mitigate the impacts.*

[1] Coastal wetlands are particularly effective at sequestering carbon. Although they occupy less area than woodlands, coastal wetlands take in carbon emissions and convert them into plant biomass more quickly, are better at trapping organic carbon from within their own ecosystem and other sources, and delay the decay of organic material (which releases carbon) for longer periods.

- ***The ocean environment will, over the next decades, undergo substantial change, in particular due to climate change, as will the types and extent of ocean industries. The scale of these changes challenges current management regimes. There is, therefore, an essential and urgent need to understand these changes and develop ecosystem-based integrated management frameworks that capture this dynamic development in nature and ocean economies, e.g., climate change adaptation***.
- ***Continue the efforts laid out in the current FYP with regard to strengthening the ocean economies, and, in doing so, in particular consider strengthening policies and activities within the ocean industries that***:
  - *Promote and embed the principle of circular and green economy in the ocean industries.*
  - *Enable restoration of important fishery habitats and implement enforceable measures on overfishing, including the two-way control of both fishing boat inputs and catch yield, based on the experience from the current pilot trial.*
  - *Enable the development of "green ports" and "green ships," including the fishing fleet/ports.*
  - *Deploy green technology and solutions along the BRI.*
- ***China can take international leadership on issues and actions supporting sustainable ocean industries and promote international cooperation in matters relating to sustainable ocean management. These include: e.g.***
  - *Through the BRI, formulating guidelines for zero-environmental-impact DSM, developing green fishing vessels and green fishing ports, green mariculture and promoting green shipping in the Arctic, as well as promoting the concept of IOM as a management principle.*
  - *Participating actively and spearheading relevant discussions in key international processes and foras that provide a framework for sustainable activities, such as the Paris Agreement, the Biodiversity Convention, the ongoing discussions on Biodiversity Beyond National Jurisdiction, the International Maritime Organization, International Seabed Authorities, etc., and through this* inter alia *contribute to the timely development of appropriate legal and environmental framing of novel and emerging ocean industries, such as ORE (Ocean Renewable Energy), minerals, and biotechnology.*
- ***Increase investment in maintaining an up-to-date knowledge base (science and technology) and data-sharing capability required for ocean management and governance and consider new and innovative approaches supporting such research and innovation, including: e.g.:***
  - *Expanding and implementing national and regional systematic programs for data and knowledge gathering and technology development, as well as innovative methods for disseminating data and knowledge.*
  - *Supporting and actively investing and engaging in the IOC Ocean Decade, acting as a spearhead for the international effort.*

- ***Encourage, through relevant means, the use and development of green technologies supporting the ocean-based industries of China. More targeted government investment and preferential fiscal and tax policies in green technologies could help industries overcome financial obstacles which sometimes impede the creation of environmental technologies.***
- ***Encourage and enforce the use of scientific knowledge and monitoring results relevant to the management of the ocean ecosystem and economies, in particular by providing mechanisms and opportunities to access to such a knowledge base. Consider establishing a formal mechanism at the national level, for example by a scientific advisory body, to underpin coordinated and holistic use of knowledge in instituting overarching policies on the development of ocean economy and the implementation of ecosystem-based IOM.***
- ***Develop and provide organizational structures/bodies, guidance and legal frameworks that enable cross-boundary (administration and land–ocean connectivity) and cross-sectoral coordination and communication, both on and between national, provincial, and local levels. Specifically, it is recommended to establish a coordination mechanism across relevant government ministries to support the development of policies fostering and underpinning ecosystem-based IOM in China.***
- ***Acknowledge the role of gender in sustainability focus in IOM and systematically work toward gender mainstreaming as an integral component in further developing IOM systems in China. Additional efforts are needed to understand the gender gap and improve women's educational, social, and economic opportunities and responsibilities in China's ocean economy. To support this, a clear, directed, and strategic gender program could be developed and implemented to enhance women's participation in all aspects of ocean economy, including industry, management and governance.***
- ***Additional efforts are needed to understand what role the ocean can play in strengthening societal resilience in the event of anomalous and unprecedented disturbances such as the recent COVID-19 pandemic which has shown how vulnerable societies are. Management of the ocean system and services should take into account the ocean's ability to support society in such undesired events.***

3.4 Future Directions of Work

The ocean is expansive, and the related and relevant governance and management issues are complex and extensive. Thus, even if this work has been addressing a number of key aspects, we urge that ocean studies need to continue within the framework of CCICED to fully reflect the importance of the ocean to society.

Through our efforts, we have identified a number of areas that could merit further consideration to provide guidance to China's leadership.

Given that a new 5-year period of CCICED is starting already in 2021, we suggest ***that CCICED in the period between AGM 2020 and AGM 2021 arrange and undertake an "ocean into the future" scoping workshop*** where all members of the current ocean SPS and members from other relevant SPSs will be charged to discuss and suggest what and how ocean issues can and should be taken further in the next five-year period of CCICED, in essence pointing to the direction for establishing a roadmap for where China should be with regard to ocean issues in the future.

Topics that the workshop could consider include—but are not limited to—the following issues:

- Opportunities to promote Green BRI (e.g., eco-friendly fisheries, Arctic green shipping, mineral exploration framework);
- How to achieve 2030 SDGs through enhanced global ocean governance;
- Areas and issues where China's leadership is particularly relevant in the global context;
- Challenges and opportunities in technology supporting ocean economies;
- Management frameworks for the ocean economy industries;
- Ocean- and coastal-related tourism;
- Structures and mechanisms supporting innovation in developing new ocean economies;
- Opportunities to consider gender-related aspects of ocean activities and management;
- Coastal restoration supporting both protection and climate action (the ocean's answer to replanting of forests on land);
- Biodiversity in the ocean context, including issues relating to MPA planning, seen in the light of recommendations and findings from the coming/planned COP 15 of the CBD;
- Opportunities to promote land–ocean coordination through basin-wide integrated governance; and
- Identification and framing of key strategic areas upon which new ocean innovation and blue finance can be built.

Appendix: Specific Recommendations from the 6 Task Teams of SPS Ocean Governance

Integrated Ecosystem-Based Ocean Management

Recommendations from SPS TT 1

Overarching

Recommendation 1: Taking full potential of the new government structures (2018), develop and provide organizational structures/bodies, guidance and legal frameworks that enable cross-boundary (administration) and cross-sectoral coordination

and communication (business) supporting ecosystem-based management, both on and between national, regional and local levels (across geographical scales, including land–ocean interactions). Specifically it is recommended to establish a coordination mechanism across relevant government ministries to support the development of policies fostering and underpinning ecosystem-based integrated ocean management in China.

Recommendation 2: An up-to-date and relevant knowledge basis is fundamental in order to undertake a fully ecosystem-based management of an ocean system that is in a constant flux, both due to natural variations, climate change and human interaction. It is suggested that:

A. Expand and implement national and regional systematic programs for data and knowledge gathering and innovative methods for disseminating data and knowledge, including but not limited to data and knowledge relating to coastal wetland ecosystems, nursery grounds, ecosystem services, sea level rise, phenological change.
B. Establish a formal mechanism on the national level, such as for example a scientific advisory body, to underpin coordinated and holistic use of knowledge supporting the development of overarching policies on ecosystem-based integrated ocean management.

Marine Spatial Planning

Recommendation 3: Marine Function Zones (MFZ) has been well established as key aspect for China's ocean and coastal management. Put increased emphasis on implementing an *ecosystem-based approach*, taking into account both the third (depth) and fourth (time) dimensions of the ecosystem dynamics, in the utilization of the well-developed spatial planning tool.

Recommendation 4: Integrate the ongoing MPA planning efforts into the broader marine spatial planning and ocean zoning efforts to strengthen the integrated and overarching management approach.

Land–Ocean Interaction

Recommendation 5: Ensure that the legal and administrative frameworks supporting IOM in China capture the connectivity and differences between land and ocean in an integrated and adaptive manner. Ensure the regulation and mandate from terrestrial and coastal management in same areas maintain consistent, while further improve cooperation and partnerships.

Recommendation 6: According to River Chief system, consider implementing a Bay Chief System nationwide, including providing an effective administrative support model through the establishment of a *Bay Chief Office* with comprehensive coordination capability.

Climate Change

Recommendation 7: Ensure that the significant ongoing climate changes affecting the entire ocean system is sufficiently considered in ocean governance and management through a dynamic and adaptive use of the best available projections of climate change.

Recommendation 8: Encourage and use knowledge, science and monitoring in the context of both global/regional climatic changes and localized stressors from the land and the coastal system as basis for ocean management and governance.

Sustainable Use of the Ocean

Recommendation 9: Develop and provide guidelines and principles to support the public–private partnership in the governance, management and financing for sustainable ocean-based economies. Learn from the global and international experience, such as the guidelines from UN Global Compact [14] and the High Level Panel for a Sustainable Ocean Economy.

Recommendation 10: Where appropriate, update current management and governance regimes relating to ocean economies to reflect the principles of knowledge-based, ecosystem-based and integrated approach.

Recommendation 11: China should design and implement a specific and strategic gender program targeting the enhancement of women's' participation in all aspects of ocean industry.

Marine Living Resources and Biodiversity

Recommendations from SPS TT 2

1. **Strengthen legal protections for coastal and marine ecosystems, while promoting sustainable production**. China should consider enacting a new aquaculture law that places limits on facilities' waste discharge and resource use and which should mandate stock reporting by all facilities, authorize routine onsite inspections and include other provisions that mitigate the industry's impacts on coastal and marine ecosystems. Ongoing efforts to shift toward output control in its capture fisheries should be integrated with rights-based approaches that allocate portions of the catch or local fishing areas to the fishing industry and communities. A Marine Habitat Conservation Law (MHCL) should also be enacted, to strengthen protections for coastal and marine habitats and encourage significant rehabilitation of lost ecosystem functions and resiliency.

2. **Implement a high-tech monitoring system to combat corrupt and illegal activities that undermine compliance and to improve marine science**. China's innovation in sensors, networking technologies and artificial intelligence can help create a transparent system that can operate across agencies, and even globally, to facilitate enforcement and promote compliance in protecting marine ecosystems. In addition to promoting compliance, a high-tech monitoring system will generate data for ecosystem understanding, emergency contingency actions, and climate change response and mitigation measures.
3. **Restore lost coastal and marine ecosystem functions needed to support fisheries production, biodiversity conservation and resilience to development, pollution and climate change**. Further actions than the ongoing redlining process need to be taken to restore lost habitat, including mangroves, seagrass beds, tidal marshes and flats, and coral reefs. If China's coastal and marine ecosystems are to withstand the impacts of pollution and climate change and continue to be a source of tremendous prosperity and food production, China should consider (i) establishing a national "marine ecological report card" on the health of China's coastal and marine ecosystems; and (ii) develop a national plan of action to restore lost ecosystem functions and services.
4. **Create a network of partnerships among countries along the Maritime Silk Road to promote sustainable marine governance and achieve the Sustainable Development Goals**. The Maritime Silk Road Initiative represents a historic opportunity for China to demonstrate leadership in global marine governance and advance the UN Sustainable Development Goals. Under this Initiative, China should consider creating a network of partnerships to encourage mutual learning and promote joint actions that promote a healthy ocean. Sustainability along the Marine Silk Road can also be promoted by information sharing and capacity building on developing and managing living marine resources sustainably. China's leadership could be further demonstrated by using the Maritime Silk Road Initiative to catalyze the development of regional and global approaches that can mitigate the impact of climate change on living marine resources.
5. **Assess the effects of climate change on living marine resources and evaluate ways to mitigate the impacts**. China could promote more research into the impact of climate change on capture fisheries and mariculture, and the natural ecosystem services upon which these industries depend. China may wish to consider ways to not only mitigate the effects of climate change, but effectively adapt to it.

Marine Pollution

Recommendations from SPS TT 3

I. **Establishing a holistic mechanism of land-sea coordination in joint marine pollution prevention and control**

Significantly enhance the land-sea ecological environment monitoring unity. In accordance with the principle of land-sea coordination and the unified plans, optimize the construction of a fully covered and refined marine ecological environment monitoring network, strengthen gridded and real-time monitoring, and develop the online monitoring for the primary rivers and outlets discharging and atmospheric deposition of pollutants into the sea. Establish a baseline survey/census system for marine pollution.

Enhance management and prevent land-based pollution from the agricultural, pharmaceutical sectors. Full consideration should be given to improving overall agricultural production capacity and to preventing and controlling rural pollution. Development of environmental protection facilities, such as those for handling rural wastewater and refuse, should be bolstered by subsidies from governments and village collectives, fee payments from residents, and the participation of non-government capital. A variety of assistive measures should be adopted to foster and develop market entities for the control of all types of agricultural pollution from non-point sources and for the handling of rural wastewater and refuse. Green production way in agriculture should be pursed to promote making full use of agricultural wastes. According to the market-based rules, a green finance system is encouraged to support the pilot of disposal and harmless treatment of livestock and poultry breeding. Comprehensive utilization of livestock and poultry manure might be gradually achieved on the spot. Subsidies for the production of organic fertilizers from the comprehensive utilization of livestock and poultry manure need to be increased, and simultaneously subsidies for chemical fertilizer to be reduced. The management of antibacterial drugs used for human and animals should be strengthened. Proper procedures should be introduced to restrict the use of chemicals such as antibiotics in accordance with the law, and prohibit the abuse of antibiotics.

Further improve China's marine environmental quality target system. China's marine environmental quality target system is mainly based on water quality targets, which are often expressed by the under-criteria rate of marine functional zoning or clean water (below the criteria of grade I, II). Suggest to further enrich the content of China's marine environmental quality target system, in addition to the water quality target, the spatial and temporal distribution characteristics of marine ecosystems need to be combined, further increase marine ecological protection target, such as the biodiversity, habitat suitability, ecosystem structure and function, etc., lay the foundation and direction for the marine ecological protection work. Strengthen the connection of sorting, indices selecting, and valuing of water quality standards between surface water and seawater, and introduce new indices such as total phosphorus, total nitrogen, and emerging pollutants. Advance seawater quality standards revision. Take a holistic approach for emissions control and water quality target management in the river basins and offshore areas.

Construct an integrated governance mechanism for the River Chief and Bay (Beach) Chief systems. In accordance with the holistic approach to conserving our mountains, rivers, forests, farmlands, lakes, and grasslands, strengthen coordination

of the comprehensive management of rivers discharging into sea, bay and estuarine. Establish a joint-action mechanism between the River Chief System and Bay Chief System, set a regular consultation mechanism and emergency response mechanism, and enhance the capability of pollution prevention and control in a holistic approach for land and sea.

II. **Strength lifecycle management for plastics, and formulates a national action plan for marine debris pollution prevention and control**

Strengthen the source control of plastics debris. Explore the waste reduction and harmless management pattern in line with national conditions, and effectively prevent the entry into marine environment of microplastics and plastic waste resulting from the manufacturing production and individual consumption process, severe weather events and natural disasters in coastal regions. Strengthen the management of plastic nurdle, and put on file and supervise of the process of "resin nurdles—plastic products—usage and circulating of commodity". Encourage extended producer responsibility (EPR) and related mechanisms. Promote EPR mechanisms to involve producers, importers and retailers in the establishment of resource-efficient product value chains from the design to the end-of-life treatment and in financing waste collection and treatment. Forbid to produce and sell personal care products containing plastic micro-beads. Introduce technologies in washing machines to better capture fibres from wash-loads in both domestic and commercial/industrial uses.

Support integrated sustainable waste management. Improve and developing national waste regulatory frameworks, including legal framework for EPR, and taking care for enforcement and governance. Support capacity development and infrastructure investments for improved waste management systems in cities and rural areas through existing instruments, and promote access to regular waste collection services and facilitate investments in waste management infrastructure in order to prevent plastic waste leakage into the sea. Establish sufficient waste reception facilities at harbors in coastal cities in order to allow ships to dispose of their waste in an environmentally sound manner.

Formulate a national action plan for marine debris pollution prevention and control. Promote the establishment of sound national regulatory frameworks on waste management. Construct an integrated coordination mechanism for marine debris prevention and control across sectors, regions and river basins. Encourage green development, speed up the research and application of innovative approach for substitute for plastic products and waste treatment, and urge the manufacturing and use of degradable plastic products and substitutes for plastic. Strengthen researches on sources, transport and fate of microplastics as well as the impact on marine ecological environment, and improve the scientific understanding of microplastics. Call on all relevant stakeholders to engage and encourage social organizations, communities and the public to reduce plastic waste generation, hold clean-up activities, significantly reduce the unnecessary use of single-use plastics, and live

green-consumption lifestyle, with the aim to prevent and significantly reduce marine microplastic pollution.

III. Develop a market system which allows economic levers to play a greater role in marine environmental governance and ecological conservation

Accelerate industrial innovative and green development and transformation in coastal areas. Promote industrial upgrading toward to emerging industries and modern service industries. Strengthen the construction of industrial zones, promote circular economy and green production, build ecological industrial zones, and enhance the integrated and recycling utilization of resources. Set the binding requirements including industrial structure and layout, resource and environmental capacity loads, and ecological red lines. Strengthen the management of project approval, enhance the market entry, compel industrial transformation and upgrading, and progressively fall into disuse lagged behind production capacity.

Improve the system for compensating marine ecology conservation efforts. Persist to the principle of "who benefits, who compensates", comprehensively use fiscal, taxation and market measures, adopt the form of incentive instead of subsidies, and establish a compensation mechanism for marine ecological conservation.

Strictly implement compensation systems for ecological and environmental damage. Tighten manufacturers' legal responsibilities for environmental protection, and significantly increase the cost of illegal activities. Improve legal provisions concerning marine environmental damage compensation, methods for appraising damage, and mechanisms for enforcing compensation. In accordance with the law, mete out penalties to those who violate environmental laws and regulations, determine compensation for ecological and environmental damage by the extent of damage and other factors, and pursue criminal liability when violations result in serious adverse consequences.

Establish a diversified funding mechanism. Integrate various types of marine environmental protection funds by central budget, increase financial support, and keep supporting the rural environmental governance and Blue Bay restoration actions. Bring into full play the initiative of local budget, enhance local financial support, make full use of market investment and financing mechanisms, and encourage and attract private, social, venture capital and other funds to gather in the area of marine environment protection.

Improve coastal wetland grading management system. Establish important coastal wetlands grading management systems at national and local levels, release in batches the national important coastal wetlands list, and identify the control proportion target of coastal wetlands at local level. Innovate the protection pattern, and establish the coastal wetland pilot national park.

Establish degraded coastal wetlands restoration system. In accordance with the natural attributes of marine ecosystems and the characteristics of coastal biota, carry

out the coastal wetland restoration. Implement the restoration projects, including restoring the coastal aquaculture farms back to wetlands, culturing densely vegetation, conserving habitat, improve the community structure of wetland vegetation, and raise the biodiversity of wetland habitats. Expand the coastal wetland area and recover the ecological services of wetland, such as water purification, carbon sequestration. By 2020, the restored area of coastal wetland will be more than 20,000 ha.

IV. Strengthen cooperation and exchanges, and jointly address global marine pollution

Strengthen research on emerging marine environmental issues of global concerns. Conduct survey and research on ocean acidification, plastics and microplastics, oxygen deficiency in hotspot areas, and comprehensively analyze the emerging marine environment issues of global concerns, particularly in the high seas and Polar Regions. Deeply participate in the designation of high seas protected areas, environmental impacts assessment of seabed development activities, and research on marine environmental protection in Polar Regions, and play our part in global marine environmental governance.

Establish Maritime Community with a Shared Future to jointly address marine pollution. With the aid of the twenty-first century Maritime Silk Road, carry out pragmatic and efficient cooperation and exchange under the framework of the Asian Infrastructure Investment Bank, China-Pacific Island Economic Development Cooperation Forum, China-ASEAN Maritime Cooperation, and Global Blue Economy Partnership Forum etc. Strengthen research on marine environmental issues of global concerns, build a broad blue partnership, jointly improve the ability to address and control marine pollution. Establish China-ASEAN Marine Environmental Protection Cooperation Mechanism, and promote international cooperation. Enhance capacity on pollution monitoring and governance through sharing knowledge making best use of other relevant efforts in the region such as PEMSEA, APEC, NOWPAP and COBSEA, GPML, GPNM, GWI and work together to build a community of shared future for mankind.

Green Maritime Operations

Recommendations from SPS TT 4

1. Establish emission control area under the framework of the MARPOL Convention

Expand the geographical area of ECAs and tighten emission standards. Meanwhile, cooperate with neighbouring countries in the application of IMO-designated cross-national emission control areas.

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

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

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

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

4. **Enhance vessel cleanliness**

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

5. **Improve GHG reduction mechanisms**

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

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

Enhance risk prevention of both land-sourced and marine pollution. Improve law enforcement, reduce latent risks and nib accidents in the bud. In the coastal waters with high risk of hazardous chemicals, relying on the existing ship oil spill emergency equipment storehouse, supplement the emergency equipment and materials of

hazardous chemicals, and continuously improve the capacity of hazardous chemical pollution accidents. Establish an inter-departmental emergency information system for more effective coordination, information exchange and decision making. Actively participate in international cooperation and accumulate more resources for China while contributing to global emergency response to pollution accidents at sea.

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

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

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

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

Marine Renewable Energy
Recommendations from SPS TT 5

The following are the specific recommendations put forward for ocean renewable energy (ORE). First of all, they emphasize that an industrial supporting policy mechanism should be established and improved. Furthermore, the scale of ORE utilization should be promoted, whilst financial or venture capital communities as well as private capital should be encouraged by governmental policies. Finally, offshore wind should be accelerated whilst environmental and socio-economic impacts assessed; mechanisms to accelerate commercial realisation of other ORE technologies should be supported by the government.

Policy

- Industrial supporting policy mechanism should be established and improved.
- Scale of ORE utilization should be promoted.
- Enable RD&I to address challenges to reduce costs further to reach parity with other energy technologies.
- Enhance capacity to accelerate innovative and resilient technology development.
- Engage at an early stage with stakeholders include fishermen, community members, regulators, developers, scientists, and tourists.
- Integration emerging ORE technologies into wider applications such as military applications, electricity generation for remote communities, desalination, hydrogen production or aquaculture applications.

Market

- Financial or venture capital communities as well as private capital should be encouraged by governmental policies.
- Strengthening the global export and market opportunities.
- Grow ORE industry, create jobs and take advantage of opportunities within its competency to global markets.

Offshore wind

- Offshore wind should be accelerated whilst environmental and socio-economic impacts assessed.
- Increase Offshore Wind deployment addressing many strategically important goals such as decarbonisation, security of supply, and new business opportunities.

Marine Energy

- Tidal current energy research and development should be encouraged by government as expected to be next type of ORE.
- Mechanisms to accelerate commercial realisation of ORE technologies ORE technologies (wind, wave, current, tidal range, ocean thermal) should be supported by the government.

Mineral Resource Extraction—Deep-Sea Mining

Recommendations from SPS TT 6

1. Improvement of environmental management system
    - **Engage with development of environmental rules**: China should actively engage with International Seabed Authority (ISA) regarding development of Regulations, Standards and Guidelines, specifically towards environmental baseline, EIA, and EMMP development.
    - **Further improve national legislation**: China may review and update the Deep Seabed Area Law in order to comply with the new requirement of the exploitation regulatory framework developed by the ISA within the context of the domestic legal system, to deal more specifically with future exploitation activities, including financial terms, inspection and management, and indemnities to ensure the State is properly protected. Based on the assessment China may seek to develop additional regulations to supplement the ISA requirements, drawing on the concepts of sound environmental management.
2. Filling gaps in environmental understanding and technology
    - **Strengthen scientific understanding and develop key technologies**: China should aim to improve the understanding of, and better assess both the risks and opportunities associated with DSM as well as exploitation of

NGH. This includes (but is not limited to) (1) strengthening environmental data collection in important marine areas to improve the understanding of deep-sea ecosystems; (2) developing environmentally critical technologies concerning environmental monitoring, EIA, safe operations and environmental restoration; (3) actively promoting the development of environmentally friendly solutions to key technical problems for exploration, exploitation and transportation of deep-sea mineral resources and natural gas hydrates.

- **Improve the understanding for NGH**: China should aim to improve the understanding of, and better assess both the risks and opportunities associated with NGH exploitation.

3. Expanding value chain and promoting circular economy

   - **Expand value chain**: China should seek opportunities for Chinese industry to engage at all levels of the DSM value chain, including research, exploration, exploitation, equipment manufacturing, technology design and mineral processing.
   - **Promote circular economy**: China's DSM policies should proactively support the intentions described in SDG #12, where the ambition of creating a circular economy is embedded in the design from the beginning of the design and concept phase and that "all" collected materials are fully utilized while waste streams are minimised. In addition, should NGH exploitation be deemed environmentally and economically feasible, China should promote the development of carbon capture and storage to accompany the development of hydrate extraction technologies that enable NGH to become a "bridge fuel" towards a low-carbon future.

4. Creation of cooperative and transparent mechanisms and platforms

   - **Enhance data sharing**: Seabed mineral contractors should be encouraged to share widely through globally and publicly accessible databases all environmental data acquired through DSM research programmes. China should play a leading role in establishing good practice for quality control, data sharing, and transparency.
   - **Conduct cooperation**: China should strengthen international cooperation, especially bilateral and multilateral cooperation and exchanges, including jointly contributing to the development of cooperation mechanisms and platforms, jointly building open markets, and jointly promoting marine technology exchanges.

5. Enhancement of leadership towards the ISA and active support of the UN SDGs

   - **Support the UN SDGs**: China should actively relate to the UN SDGs when further maturing the business case for DSM, such as contribution towards # 14—life below water and #5—gender equality in education and training for DSM professionals within geology, engineering and environmental technology.

- **Enhance of leadership**: China should continue to initiatives to strengthen ISA as a regulator, and actively engage with ISA, such as to take opportunities for convening group discussions as well as take active leadership both within thematic groups and in its geographic group (Asia–Pacific); to show the leadership around a good model for State sponsorship, to establish a network for consultations and informing of its national positions on DSM.
- **Support REMP process**: China should support a standardised, transparent and consultative REMP process at the ISA. This should include the establishment of a network of biologically representative, fully protected no-mining zones.

References

1. Ma, Z., Melville, D.S., Liu, J., Chen, Y., Yang, H., Ren, W., Zhang, Z., Piersma, T. and Li, B. 2014. Rethinking China's new great wall. Science, 346(6212), 912–914.
2. Xi, JP, 2014, The governance of China. Beijing: Foreign Languages Press.
3. MOT (Ministry of Transport), 2019a, Report on China's Shipping Development 2018, Beijing: China Communications Press.
4. Sharma, R., 2017, Deep Sea Mining: Resource Potential, Technical and Environmental Considerations. Springer International Publishing.
5. Klauda, J. B. & Sandler, S. I., 2005, Global Distribution of Methane Hydrate in Ocean Sediment, Energy and Fuels, 19(2): 459–470.
6. Gerber, L. J. & Grogan, R. L., 2020, Challenges of Operationalising Good Industry Practice and Best Environmental Practice in Deep Seabed Mining Regulation, Marine Policy, 114: 103257, doi:https://doi.org/10.1016/j.marpol.2018.09.002.
7. Rabalais, N.N., Diaz, R.J., Levin, L.A., Turner, R.E., Gilbert, D., Zhang, J., 2010. Dynamics and distribution of natural and human-caused hypoxia. Biogeosciences 7 (2), 585–619.
8. Bureau of Fisheries (BOF), Ministry of Agriculture and Rural Affairs (1949–2020). China Fisheries Statistical Yearbook. China Agriculture Press, Beijing.
9. MOT, 2019b, Statistical Bulletin on the Development of the Transport Industry 2018, http://xxgk.mot.gov.cn/jigou/zhghs/201904/t20190412_3186720.html.
10. University of Edinburgh's Policy and Innovation Group, Energy Systems Catapult, 2020. Wave and Tidal Energy: The Potential Economic Value. https://periscope-network.eu/analyst/wave-andtidal-energy-potential-economic-value.
11. Smart G, Noonan M, 2018. Tidal stream and wave energy cost reduction and industrial benefit. Offshore Renewable Energy Catapult. https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/05/04120736/Tidal-Stream-and-WaveEnergy-Cost-Reduction-and-Ind-Benefit-FINAL-v03.02.pdf.
12. Information office of MOT, 2019, Report on Chinese crew development 2018, https://www.msa.gov.cn/public/documents/document/mdk1/mdm5/~edisp/20190626095039643.pdf.
13. Government of the People's Republic of China, 2016. China's National plan on implementation of the 2030 agenda for sustainable development.
14. "Homepage: UN Global Compact." Homepage | UN Global Compact, www.unglobalcompact.org/.