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

Special Policy Study on Global Ocean Governance and Ecological Civilization

Report
Integrated and Ecosystem-based Ocean Management

CCICED

SPS Ocean Governance and Ecological Society

Report from Task Team 1

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1. Executive Summary and Policy Recommendations

The ocean is widely recognized to play a central role in supporting life on Earth, accounting for over 95 % of the habitable space on the planet, and harbors 80 % of all living organisms. Humans are linked to the ocean in various ways. Forty percent of the world's population live within a hundred kilometers of the coast with over 3 billion people relying on the oceans for their livelihoods, and the range of goods and services that flow from coastal and marine environments can be valued conservatively at US$2.5 trillion/year, and the overall value of the ocean as an asset is 10 times that" (Hoegh-Guldberg et al., 2015).

Traditionally seen as a sector dominated by the seafood industry (Morrissey et al., 2011), the ocean has nevertheless attracted multiple uses for centuries, including in addition to fisheries and aquaculture, shipping and transportation, military, recreation, conservation, and more recently oil and gas extraction and mining, among others. Ocean activities are now seen as essential in meeting future challenges including food, energy, transportation and regulating the climate.

A healthy and sustainable ocean is essential for societies now and in future. Recognizing the importance of ocean in all aspects of the human society and the habitability of the Earth, the need for more and better governance of human activities has been widely recognized. As such, both the opportunities for and challenges to achieving sustainable development of our ocean and seas have been more than ever reaching the top of the international agenda in forums such as the G20, the United Nations (UN) Ocean conferences, the World Economic Forum, the Our Ocean conferences, and the High Level Panel for a Sustainable Ocean Economy (Winther et al., 2020a). They are also prominent in the UN Sustainable Development Goals (SDGs). The recent covid-19 pandemic has also shown how vulnerable societies are and could serve as an inspiration for the need to manage our ocean in a sustainable way.

The importance of the ocean and marine sectors for China cannot be overemphasized. Over half of the population now resides along the coast, and the coastal provinces and metropolises are responsible for producing ~60 % of the national GDP (Ma et al., 2014). More importantly, the recent rapid development of China's economy and social wellbeing was initiated in coastal cities and their opening to the international communities. These critical regions also hold the keys to future developments of China's initiatives such as Blue Economy and One Belt One Road and its interconnection to the rest of the world, and is 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' (Xi, 2014).

Globally, Integrated Ocean Management (IOM) is accepted as the appropriate approach for ensuring protection and the sustainable use of coasts and oceans, taking sufficiently into account knowledge and the particularities of the ecosystems to be managed. A fully integrated ocean management strikes the balance between environment, economy and society, and between short-term economic gains and long-term prosperity of the ecosystem services. IOM is an approach that brings together relevant actors from government, business and civil society and across sectors of human activity (e.g., energy, fishing, aquaculture, mining, shipping and tourism) (Winther et al., 2020b). IOM is also helpful to frame new models of sustainable social-economic development (such as ocean economy as a new engine). By taking an ecosystem-based approach to IOM the full array of interactions within an ecosystem is recognized rather than single species or ecosystems services in isolation.

China is well placed to take on the opportunity 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. However, challenges remain in implementing marine ecosystem-based integrated management at both national, provincial and local levels. These include silo governance, differing national – provincial - local frameworks, single pressure management, lack of integration of management on land and in coastal areas, premature public and private partnership, and lack of general (public) understanding of the importance of a holistic system.

Based on the narrative and discussion held in this report, two overarching recommendations are put forward to support an effort by China to strengthen its IOM through efforts relating to strengthening the ecosystem aspect of existing management framework, encourage expanded cross-boundary coordination (administration, geography, sectors) and expand systems for knowledge production and use:

- **Recommendation 1**: Taking full potential of the new government structures implemented in 2018, develop and provide organizational structures/bodies, guidance and legal frameworks that enable cross-boundary (administration) and cross-sectorial (department) coordination and communication supporting ecosystem-based management, both on and between national, provincial and local levels that are often across geographical scales, including land-ocean interactions. Specifically, we recommend establishing 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 change, both due to natural variations, climate change and human interaction. It is suggested to:
    A. Strengthen, expand and implement national and provincial 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, especially important habitats for fisheries and endangered species, ecosystem services, sea level rise and phenological change.
    B. Support and actively invest and engage in the IOC Ocean Decade, being a spearhead for the international effort.
    C. Establish a formal mechanism at 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.

To further support strengthening progress toward a fully functional integrated and ecosystem-based governance of the ocean on all scales of governance by China, four overarching areas would benefit by substantial focus and efforts.

Marine Spatial Planning

Within the sustainable ocean economy framework, marine spatial planning (MSP) is a means to implement the ecosystem-based management concept through creating an optimal investment climate for maritime sectors and giving operators more certainty as to what opportunities for economic development are possible, while at the same time taking into account the spatial particularities of the marine ecosystem. To strengthen MSP as a key tool for its integrated ocean management, we offer the following recommendations:

- **Recommendation 3:** Place increased emphasis on implementing an *ecosystem-based approach*, taking into account both the three-dimensional feature and its time-dependent variability of the ocean, i.e. full dynamical range of the marine ecosystems, when utilizing the well-developed spatial planning tool, Marine Function Zones (MFZ) which has been well established as key mechanism for China's ocean and coastal management.
- **Recommendation 4:** Integrate the ongoing *MPA planning* efforts into the broader marine spatial planning and ocean zoning efforts to strengthen the integrated and overarching approach to management.

Land-Ocean interaction

Activities on land significantly affect the ocean environment, and to achieve effective ocean management it is necessary to include and manage the land - ocean interactions, while still distinguishing ocean planning processes from those on land. Focusing on source-to-sea management would link governance, operations, practices and finance across marine, coastal, freshwater and terrestrial systems and stimulates cooperation between upstream and downstream actors, as well as coordination across sectors to ensure outcomes that mutually benefit systems as a whole. To achieve this, we recommend the following:

- **Recommendation 5**: Ensure that the legal and administrative frameworks supporting IOM in China captures the *connectivity and differences between land and ocean* in an integrated and adaptive manner. Align terrestrial and coastal management affecting the same areas with respect to regulations and organization, and foster cooperation and partnerships.
- **Recommendation 6:** Consider implementing a *Bay-Coast Chief system*, inspired by the River Chief system, nationwide, including providing an effective administrative support model through the establishment of a *Bay Chief Office* with comprehensive coordination capabilities.

Climate change

Impact on ocean ecosystems (and associated activities) from climate change requires a whole new thinking about the relationship between activities and sustainability. The following recommendations are offered to ensure an appropriate level of climate sensitivity in China's future ocean management:

- **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 the use of *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

As ocean economy expands it is important to ensure that ocean industries and the use of ocean space, resources and ecosystems are ecologically sustainable and that the economic activities must be in balance with the long-term carrying capacity of the ocean ecosystems. At the same time, it is clear that the economic development of the ocean has the potential to contribute to true prosperity and resilience for people. As such, it is fundamental to institutionalize the concept of sustainable ocean economies as the key framework model for communities, provinces and the nation. To move toward such a target, we offer the following recommendations:

- **Recommendation 9**: Develop and provide *guidelines and principles* to support the public and private in their governance, management and financing for sustainable ocean based economies, guided inter alia by the principles coming out of global and international processes such as UN Global Compact[1] and the High Level Panel for a Sustainable Ocean Economy[2];
- **Recommendation 10**: Where appropriate, update current *management and governance* regimes relating to ocean economy to reflect the principles of knowledge-based, ecosystem-based and integrated approach;
- **Recommendation 11**: To support the effort to understand the *gender gap* and improve women's education, social and economic opportunities and responsibilities in China's ocean economy, China could develop and implement a clear, directed and strategic gender program to enhance women's' participation in all aspects of ocean economy, including industry, management and governance**.**
- **Recommendation 12**: Additional efforts are needed to understand what role the ocean can play in strengthening societal resilience in the event of anomalous, and unprecedented disturbance, 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.

[1] https://www.unglobalcompact.org/

[2] See Box 1: The High Level Panel for a Sustainable Ocean Economy (Chapter 2).

2. Introduction

This report on integrated and ecosystem-based ocean management is part of the Special Policy Study (SPS) on ocean within the CCICED. Due to the overarching nature of ocean governance, the paper captures key findings from other expert groups established under this SPS. These expert groups have each delivered in-depth reports on 1) marine living resources and biodiversity, 2) marine pollution, 3) green maritime operations, 4) renewable energy and 5) mineral resources. In addition to drawing on relevant outcome from these reports, this report addresses integrated ocean management in general and in a Chinese context. First, the report establishes the narrative of healthy oceans being critical for achieving an ecological civilization where oceans are productive and societies can prosper. Further, we present case studies of integrated ocean management in practice from different parts of the world. Finally, we discuss the importance of addressing climate change, partnerships, coordination, science, technology and gender in order to successfully develop and implement integrated ocean governance on national, regional and global scales.

There is an international backdrop to this topic. In recent years, opportunities and challenges to achieve sustainable development of our ocean and seas have reached the top of the international agenda in forums such as the G20 (Sverdrup et al., 2019), the United Nations (UN) Ocean conferences, the World Economic Forum, the Our Ocean conferences (Neumann & Unger, 2019) and the High Level Panel for a Sustainable Ocean Economy (Gaines et al., 2019; Hoegh-Guldberg et al., 2019; Costello et al., 2019; Winther et al., 2020a). It is also prominent in the UN Sustainable Development Goals (SDGs) (Neumann et al., 2017). With the unprecedented growth in economic activities relating to the ocean – "the blue economy" – the need for improved governance of human activity in the ocean environment is widely recognized[3]. Ocean economy also goes beyond viewing the ocean industries solely as a mechanism for economic growth. It also has the potential to improve human wellbeing and social equity. Realizing the full potential of the ocean economy means inclusion and participation of all affected social groups and sectors. It provides for the protection and development of more intangible "blue" resources such as nature, traditional ways of life, the role of women and young people.

The ocean economy has continued to grow alongside our need for food, energy, transportation and recreation from the ocean. Existing ocean industries expand whilst new ones also appear. At the same time, challenges rise as a consequence of climate change, loss of biodiversity, pollution, and extractive activities. Our ocean is now facing these pressures at unprecedented rates and magnitudes. The mismatch between the drive for short-term economic gain versus long-term prosperity and a healthy makes the need for a resilient ocean increasingly apparent. Thus, we see a pressing need for integrated, knowledge- and ecosystem-based approaches to the management of the ocean, commonly referred to as integrated and ecosystem-based ocean management.

[3] Although sometimes used to denote economic activity in the maritime sector, whether sustainable or not, the concept "Blue Economy" (in this document also referred to as ocean economy) today normally refers to a sustainable use of the oceans, along the line of the definition provided by the World Bank: "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem" (https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy).

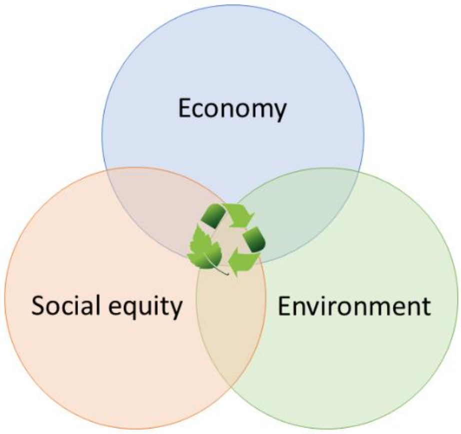

Figure 1: Sustainable ocean economy integrates economy social equity and the environment in order to ensure sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem

Integrated ocean management (IOM) considers multiple uses and pressures simultaneously and contribute to reconciling competing uses with the objective of ensuring the sustainability of societies and marine ecosystems. There are, however, still many challenges relating to the implementation of existing governance frameworks, ranging from knowledge and capacity shortages, to incomplete legislation and lack of enforcement. IOM is an approach that brings together relevant actors from government, business and civil society, from the entire spectrum of human activities (e.g., petroleum, fishing, aquaculture, shipping, tourism and mining), to collaborate towards a sustainable future of our ocean environment.

The functions of IOM include the promotion of environmentally sound economic development, societal inclusion, as well as balancing interests through spatial planning. IOM also addresses specific issues such as conservation of coastal and marine habitats and biodiversity, protection of the coastal and marine environment from land-based pollution, fisheries, and tourism, as well as impacts from climate change such as sea level rise. IOM is a dynamic process, building on existing initiatives and bringing industries and sectors together. Management through an IOM approach includes adequate governance and planning mechanisms that allow for holistic management, including such instruments and mechanisms as Integrated Coastal Management (ICM) and Marine Spatial Planning (MSP), the identification and recognition of trade-offs and compromises, and a participatory and adaptive approach.

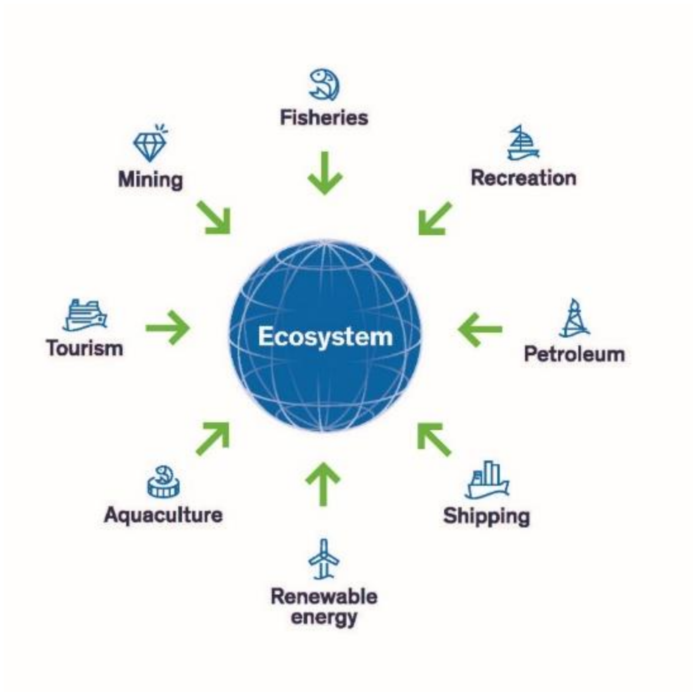

Figure 2. Examples of activities that need to be included in integrated ocean management. The ecosystem is at the core of IOM (Winther et al., 2020b). Note that even though the arrows are one-directional in this illustration, this does not imply that the ecosystem does not or should not influence the activities as well.

Box 1: The High Level Panel for a Sustainable Ocean Economy

The High Level Panel for a Sustainable Ocean Economy, established in 2018, is a unique group of world leaders from around the globe committed to developing, catalysing and supporting solutions for ocean health and wealth in policy, governance, technology and finance. The objective of the High Level Panel is to build a new, shared understanding of the current and potential future state of ocean economy and ecology, and generate a set of policy, governance, technology and investment solutions aimed at catalysing a truly sustainable ocean economy.

The intention behind the High Level Panel initiative, which taken by the Norwegian prime minister Erna Solberg, has been to increase international awareness of the fact that sustainable use of the oceans and the maintenance of good environmental status can lead to significant value creation, and can enable us to meet some of the world’s most vital needs in the years to come. At the same time, it was recognized that the world leaders need to work together to combat what threatens the sustainability.

The Panel will prepare and deliver its recommendations in 2020. Building on the latest research, analysis and debates from around the world, the solutions-oriented Report aims to demonstrate that sustainable ocean management is key to achieving the 2030 Agenda and the SDGs, including lifting people out of poverty, ensuring economic and environmental resilience, generating jobs and livelihoods, and building the industries of the future. The Report will put forward a set of recommendations for transitioning to a fully regenerative, Sustainable Ocean Economy.

3. Setting the stage

Oceans cover nearly three-quarters of our planet and hold most of the planet's water. The oceans produce more than half of the oxygen in the atmosphere and have absorbed 25-30 % of the recent CO_2 emissions. As such, the world's oceans have always been key for the survival of humankind and much of society's development has rested upon the qualities of the oceans. Considering the key role that the oceans play as the basis for society, humankind, and the global future, it is a given that maintaining the health of the oceans is essential. Healthy ocean system is of paramount importance as basis for an ecological civilization.

Marine ecosystems together form the largest aquatic system on the planet. The habitats of this vast system range from the productive near shore regions to the barren ocean floor. Some examples of important marine ecosystems are: oceans, estuaries and salt marshes, coral reefs, mangrove forests, lagoons, seagrass beds, and tidal flats. Marine ecosystems are fundamentally important for the overall health of both marine and terrestrial environments.

Today, the well-balanced species communities of the marine ecosystems are becoming increasingly unstable, thereby putting the health of the whole ocean systems at stake. There are several pressures that impact the health of the oceans, such as pollution (including noise), biodiversity loss, non-native species, climate change, and exploitation of resources exceeding sustainable levels.

Box 2: **Protecting marine biodiversity**

Marine biodiversity plays an important role in providing the ecosystem functions and services which humans derive from the oceans. Recent estimates of extant marine species range from ~300,000 to 2.2 million. Of these estimated species, approximately 240,000 have been described, suggesting that between 11 and 78 % of all marine species have been discovered and described, and reveals high levels of uncertainty in our knowledge of global marine biodiversity (Luypaert et al., 2020). Coastal and marine habitats in China are home to more than 20,000 species, including 3,000 species of fishes alone.

Biodiversity loss has become one of the greatest environmental concerns of the last century, owing to increasing pressure on the environment by humans combined with the realisation that our activities can seriously threaten the future sustainability of marine species and ecosystems. In its large assessment of the state of global biodiversity the intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), more than 40 per cent of amphibian species, almost a third of reef-forming corals, sharks and shark relatives and over a third of marine mammals are currently threatened and the Living Planet Index, which synthesises trends in vertebrate populations, shows that species have declined rapidly since 1970, with reductions of 35 per cent for marine species (IPBES, 2019). Among the most serious threats to marine biodiversity are over exploitation, pollution, habitat destruction and fragmentation, non-native species invasions and global climate change (see **Box 3** for examples). The high biodiversity and richness of marine species and living resources in China seas has seriously decreased. Under the impacts of global climate change and anthropogenic activities, the biodiversity has seriously declined, the number of endangered species increased, and some major populations collapsed (see e.g. Liu, 2013).

The Convention on Biological Diversity (CBD) is dedicated to promoting sustainable development. The Convention recognizes that biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live. One of the convention's three main objectives is the conservation of biological diversity. The 15th meeting of the Conference of the Parties (COP 15) to the CBD, to be held in Kunming, China in the second quarter of 2021, provides an important platform to discuss and pave a way forward for actions that may reduce the threats to marine biodiversity.

Box 3: Threats to marine biodiversity

Loss of marine habitats: China is home to approximately 5.8 million hectares of coastal wetlands. Wetlands are particularly important as feeding, spawning, nursery and overwintering habitats for wild fishes and invertebrates. Despite their importance, China has cumulatively lost more than 50 % of its coastal wetlands, 57 % of mangroves and 80 % of coral reefs, since the 1950s. Coastal wetlands continue to disappear at rates around 2.4 times higher than those of wetlands further inland[4].

Overfishing: Marine ecoregions in China were once world famous for rich fishery resources and high-quality seafood products. However, overfishing combined with other sources of deterioration of the marine environment in the past four decades has resulted in increasing occurrences of the "rare fish in the sea" phenomenon, whereby species that were once major components of China's fishery yield have become infrequent in both the catch and the ecosystem[4].

Pollution: In the 40 years following the Chinese economic reform and opening policy, China has formed a coastal ribbon of high economic development, which has brought with its population density and urbanization. Coastal and marine ecosystems are subject to tremendous ecological damage and land-based pollution pressures while supporting coastal economic development. More than 70 % of nutrients discharged into the sea are from 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, sediments, and biological quality[5].

Although introducing pressures on the marine ecosystems, coastal and ocean-based industries are nevertheless important for the economies of many countries and may play an even more important role in the future. Ocean based economic opportunities include shipping, traditional and renewable energy production, mineral extraction, tourism, food production and storage (e.g., fisheries and aquaculture) and bioprospecting. Understanding the potentials, obstacles and impacts of these industries in a global and regional context are essential not only to manage the industries individually, but also the ocean as a whole. A healthy ocean environment is a prerequisite for drawing on these direct and indirect economic opportunities that the ocean provides, and as such investing in the ocean environment is in turn an investment in the ocean economies. The oceans are not an unlimited resource, and challenges relating to maintaining the health of the ocean system and to utilize the opportunities it provides in a sustainable manner for the common good remains. Society need to focus on efforts that ensure that the ecological services that the ocean can provide are utilized in a sustainable manner. Maintaining harmony between humans and ocean, as well as between ecosystem and business, needs to be established as the firm foundation for ocean governance. Thus, it is important to keep in mind that the potential benefits derived from maintaining a robust and valuable ocean economy on one hand does not contradict the need to

[4] Details found in SPS Ocean Governance sub-report on Marine Living Resources
[5] Details found in SPS Ocean Governance sub-report on Pollution

protect and preserve the ocean systems on the other hand. Rather the two concepts may be looked upon as a symbiosis, where both thrive best when the ocean is managed for both needs. Such an approach is already reflected as part of Chinas national policy, as put forward in the 13th five year plan, where the aim to develop the marine economy and effectively develop marine resources while at the same time protect the marine ecosystems and habitats is highlighted.

IPCC's Special Report on the Oceans and Cryosphere in a Changing Climate (SROCC) records significant changes to the world's oceans as a result of climate change (IPCC, 2019), 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. By absorbing more CO_2, the ocean has undergone increasing surface acidification and a loss of oxygen has occurred from the upper parts of the ocean. SROCC 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. Impacts are already observed on habitat area and biodiversity, as well as ecosystem functioning and services. Climate change and impacts on ocean ecosystems (and associated activities) requires a whole new thinking about the relationship between activities and sustainability. Three matters related to climate changes stand out — ocean acidification that will affect aquaculture, coral reefs and very likely fish reproduction and the natural supply of food in the oceans; rising sea levels that will impact all coastal infrastructure and urban development; and the frequency and intensity of extreme weather events with consequences that occur in coastal areas, but also affect inland areas through changes in precipitation patterns. While climate change is having a devastating effect on coastal communities and life in the ocean, new research shows that the ocean also can contribute to reducing the impact of the changes, for example through efforts and innovation in renewable ocean energy, developments in green maritime operations, proper management of fisheries and aquaculture, by conserving existing "blue carbon" ecosystems (mangroves, seagrass beds, and salt marshes) and by improving the ability for carbon storage in the seabed (Hoegh-Guldberg et al., 2019).

The significant ongoing climate changes that ripple through the entire ocean system calls for a dynamic and adaptive approach to ocean governance and management rather than a static approach. Under a business as usual scenario with regard to global GHG-emissions, radical changes to the ocean system must be expected and planned for, while the more efforts toward reducing such emissions are put in place, the more potential to keep climate change within 1.5°C and thereby avoiding some of the potential ocean tipping points. Management regimes need to be adjusted to ongoing changes as new knowledge and observations indicate further changes to the systems, and what science, technologies and capabilities are required in the next decades depend on the GHG-emission scenario at play.

Box 4: Evolution of ocean management

Attempts to control ocean space and use go far back in history, but the need for formalized ocean management appeared fairly recently, during the 20th century when there was a realization that ocean space was not as plentiful as formerly perceived and resources could be depleted. Ocean governance and management was initially primarily sectoral, fisheries agencies were established to regulate fisheries catches, environmental agencies to deal with pollution prevention, and other specialized agencies to regulate aspects such as shipping and oil and gas extraction. When the activities expanded and increased, inter-sectoral conflicts appeared, and the management of sea uses on a sectoral basis came under pressure. The evolution toward integrated management has since proceeded and have paved the way for the development of several important tools key to ocean management around the world today.

ICM/ICZM: Integrated Coastal Zone Management (ICZM) is a resource management system following an integrative, holistic approach and an interactive planning process in addressing the complex management issues in the coastal area. The coastal focus of ICM means that marine and terrestrial areas are managed together, considering the impacts of land-based activities on marine habitats. This requires coordination and cooperation across different marine and terrestrial institutions, administrative agencies, and competent authorities at local, regional and national levels. The concept of ICZM came out of the 1992 Earth Summit of Rio de Janeiro and the ICZM policy is set out in the proceedings of the summit within Agenda 21.

MSP: Marine Spatial Planning (MSP) is a process that aims to organize the use of the ocean space, as well as the interactions among human uses and between users and the marine environment. MSP can also be thought of as a means on implementing Ecosystem Based Management (EMB) and ICM can be considered a subset of MSP. Over the last few years, an increasing number of nations have begun to implement MSP not only at local scales, but also in transnational efforts. Examples of international MSP initiatives include:

- **MSPgloba**l: A joint initiative by UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO) and the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE) to develop new international guidelines on Maritime Spatial Planning. The MSPglobal initiative will contribute to improving cross-border and transboundary cooperation where it already exists and promoting MSP processes in areas where it is yet to be put in place, with the objective to triple the marine area benefiting from MSP effectively implemented by 2030. For example, it aims to develop guidance on international cross-border planning.
- **EU MSP Platform**: The European Parliament and the Council have adopted legislation to create a common framework for maritime spatial planning in Europe to ensure human activities at sea take place in an efficient, safe, and sustainable way across borders. The Assistance Mechanism for MSP was launched in 2016 to provide administrative and technical support to EU countries in implementing the MSP legislation.

EMB: Ecosystem Based Management (EMB) is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive, and resilient condition, so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity, or concern; it considers the cumulative impacts of different sectors on the entire ecosystem.

An adaptive management regime requires careful planning and a planned structure for it to be implemented in an efficient manner. It also requires coordination among sectors, as well as among countries, especially as significant impacts such as climate change and long-range pollution have global origins and know no borders. Furthermore, an up-to-date and relevant knowledge basis is fundamental for the management of a system, such as the ocean system, that is in a constant flux, both due to natural variations, climate change and human interaction. Research and knowledge production will therefore need to play a key role in any modern ocean management regime.

Marine ecosystems are complex and are not easily definable with respect to geographic extent. Ecosystems cross administrative and political boundaries. This indicates that it is challenging to identify and delineate the spatial extent of areas to be managed. In making such decisions it is useful to identify and consider management areas in context of the Large Marine Ecosystems[6], ensuring that any management actions within parts of the LMEs consider the ripple effects into the full LME. This may entail international cooperation and collaboration where such LMEs cross lines of national jurisdiction.

Spatial planning and management on land is normally seen as a two-dimensional exercise and has traditionally also often been the case in the realm of marine planning and management (Levin & Danovaro, 2018). However, it is not possible or useful to consider the ocean as a two dimensional system, as most of the production and ecosystem functions that one aims to manage are depth dependent, and can be found in the whole water column from bottom to surface. There is great importance and potential in vertical conservation planning and zoning from the sea surface to the seafloor management (Levin & Danovaro, 2018). Adding to this complexity is the very dynamic nature of the system through the days, months, and years, where ecosystem values to be managed may have different spatial preferences over time. Time is thus a fourth dimension that need to be included in management considerations and research and knowledge production (Maxwell et al., 2015).

All the above indicate that developing a predictable ocean management regime today for a system that is in flux and will be different in the future requires careful planning and allocation of resources. This is fundamental and absolute if one is to succeed in managing the ocean system to maintain the basis for an ocean economy with longevity. The planning would benefit by being built upon a hierarchy of goals, objectives, management actions, and indicators that evaluate the performance of management actions in achieving those goals and objectives. Effective implementation is integral to the process and need particular attention in the planning phase as well. Many feedback loops need to be built into the process. Goals and objectives identified early in the process are likely to be modified as the effectiveness, efficiency, and equity of different management actions are identified later in the planning process. Analyses of existing and future conditions will have to change as new information is identified and incorporated into the process. Early integration of monitoring and evaluation in the process is therefore fundamental, and calls for measurable and specific objectives, clear management actions, relevant indicators and targets, and involvement of stakeholders throughout the process.

The onset of the Fourth Industrial Revolution is being driven by several key technologies, especially autonomous systems that will allow humans to go deeper and further than ever before, new energy systems, machine learning that is enabling a more rapid form of understanding and engaging with the ocean environment, as well as advanced genetics. These technologies allow us to create new

[6] Globally, the world's oceans have been divided into 66 large marine ecosystems (LMEs). These are defined as near coastal areas where primary productivity is generally higher than in open ocean areas.

economic sectors. Some may open more sustainable methods of fishing and harvesting new biological materials from the ocean, whereas others may be destructive, like weakly regulated seabed mining. The question is how we can use the development of new technologies in a manner that enables a responsible, ethical, and sustainable ocean economy.

Implementing a truly adaptive, integrated and ecosystem-based ocean management regime answers to United Nation Sustainable Development Goal number 14 on conserving and sustainably using the oceans, seas and marine resources for sustainable development, an aim China sets out to achieve in its national SDG implementation plan. Furthermore, SDG 14 has a cross-cutting role in the 2030 Agenda and interacts with all 16 other SDGs. The nature and intensity of these interactions is highly context-specific and differs across the SDGs.

4. Ocean management in China

The coastal ocean adjacent to China (China Seas) includes the South China Sea (SCS), East China Sea (ECS), Yellow Sea (YS) and Bohai Sea (BS) along with many estuarine and bay areas. These coastal marine systems are enriched with marine biological resources and a diversity of ecosystems. As elsewhere in the world, these coastal systems feature the most active land-ocean-atmosphere interactions. It is also where the most frequent and active socio-economic activities occur so that the near-shore ocean is the meeting point between the natural environment and humans and is as such the key to societal sustainability.

The rapid developments in China during the past four decades are particularly concentrated in the coastal regions. More than half of China's population now lives in the coastal areas which constitute only slightly more than 13 % of the total land area of China. The development of the coastal provinces and metropolises contributes to over 60 % of the national GDP. For example, the "Yangtze River Delta Economic Circle", "The Greater Bay Area of the Pearl River" and the "Bohai Economic Circle" contributes to over 40 % the national GDP. Yet, the marine ecosystem adjacent to these areas are highly impacted, perhaps among the most in the world.

The ocean economy itself has become an important part of China's economic growth. Note that there are different definitions of ocean economy which associate different statistics in their contribution to GDP in different nations. OECD defines the ocean economy more broadly as the sum of the economic activities of ocean-based industries, together with the assets, goods and services provided by marine ecosystems. China uses a similar scope that includes the sum of economic activities of ocean exploration, use and protection, together with the related activities (Wang, 2016). China's ocean economy concept includes three layers of content. The core layer represents 12 major ocean industries, which are outlined in **Table 1: Gross value added of China's ocean economy in 2019 (MNR, 2020)**

	Gross value added (billion yuan)	% of GDP	% of ocean economy GDP
Ocean Economy	**8941.5**	**9.0**	**100**
Ocean Industry	**5731.5**	**5.8**	**64.1**
Major Ocean Industry	**3572.4**	**3.6**	**40.0**
Marine fishery	471.5	0.5	5.3
Offshore oil and gas	154.1	0.2	1.7
Ocean mining	19.4	0.0	0.2
Marine salt	3.1	0.0	0.0
Marine chemical	115.7	0.1	1.3
Marine biomedicine	44.3	0.0	0.5
Marine electric power	19.9	0.0	0.2
Seawater utilization	1.8	0.0	0.0
Shipbuilding	118.2	0.1	1.3

Marine engineering & construction	173.2	0.2	1.9
Marine communications and transportation	642.7	0.6	7.2
Coastal tourism	1808.6	1.8	20.2
Ocean Scientific Research, Education, Management Services	**2159.1**	**2.2**	**24.1**
Ocean–Related industry	**3210**	**3.2**	**35.9**

. They are the major ocean activities that use ocean resources as key inputs or which provide goods and services that are directly used in the marine environment. The support layer represents the scientific, research, education and ocean management service sectors that provide key information to the core layer industries. The activities of the support layer provide the platform for the sustainable development of the major ocean industries. The outer layer represents the ocean-related enterprises which have a technical and economic link with the major marine industries (Wang, 2016).

According to the Marine Economy Report 2019 by Ministry of Natural Resources (MNR, 2020), the Chinese marine economy generated 8941.5 billion yuan with a growth rate of 6.2 %: accounting for 9.0 % of the overall Chinese GDP. The major marine industries generating 3572.4 billion yuan accounting for 3.6 % of the overall Chinese GDP. As the pillar industries of marine economic development, coastal tourism, marine transportation and marine fishery accounted for 50.6 %, 18.0 % and 13.2 % of the total added value of major marine industries.

It is interesting to point out that the above accounting has not included the assets, goods and services provided by marine ecosystems, which could be a good potential aspect to be examined in envisioning the increasingly recognized importance of marine ecosystem services.

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In general, China's approach to ocean policy and governance over time can be viewed in phases (see for example Jun'ichi, 2014),

Phase 1: After the foundation of the People's Republic of China in 1949, the ocean and coastal zone were managed in terms of different natural resources, and the marine and coastal zone management was basically an extension of natural resource management on land. All the government agencies related to marine resource management reflected a resource-based sectoral mechanism (Chen and Pearson, 2015)

Phase 2: From the mid 1970's China began to pay more attention to the use of the ocean and marine affairs in general, realizing that China's economic growth and political development would be linked to many aspects of the ocean (oil and gas, commercial shipping, shipbuilding etc.). Relevant for ocean management was also that China during this phase improved its national Legal Framework for Protection of the Environment and Ecosystem.

Phase 3: Come the turn of a new century, China increased its focus and strategies on ocean development. While the eleventh five-year plan, for 2006–2010, included just one section about the seas, the twelfth plan, for 2011–2015, had an entire chapter on the subject of promoting development of the marine economy, as does the current plan.

Moving into the future: China has the opportunity to develop and implement a fully integrated ocean management system and take on international leadership in this regard. This is envisioned given the well-developed management basis, strong political will and the emerging consensus among general public and business sectors in conserving the ocean system. However, challenges remain in implementing marine ecosystem-based and integrated management at both national, regional and local levels. These include silo governance, differing national - regional - local frameworks, single pressure management, lack of integration of management on land and in coastal areas, premature public and private partnership, and lack of general (public) understanding of the importance of a holistic system.

Box 5: Examples of ocean economies in China

The major current ocean economies

Fisheries: In 2019, the total output value of China's marine fisheries was 569 billion yuan, increased by 20 % of the output value in 2014 (476 billion yuan). The largest proportion of marine fishery output value is mariculture (357.5 billion yuan), followed by marine capture fisheries (211.6 billion yuan). The proportion of mariculture increased from 59.1 % in 2014 to 62.8 % in 2019. (Bureau of Fisheries (BOF) of the Ministry of Agriculture, 2020).

Shipping: China has an extensive ports and shipping industry. By 2018, five major port agglomerations have formed at the Bohai Rim, the Yangtze River Delta, the southeast coast, the Pearl River Delta, and the southwest coast respectively, occupying seven of the world's top ten ports by cargo throughput. China's fleet is the second largest one in the world, which services the whole globe with more than 100 international transportation routes and takes up about one-third of the world's ocean freight. By the end of 2018, the number of Chinese registered seafarers reached 1.575 million, ranking atop in the world, and China had signed agreements with 25 countries and regions to mutually or unilaterally recognize the Certificate of Competency of Chinese seafarers[7]. In 2019, the output value of shipping industry was 642.7 billion yuan (MNR, 2020). In 2014 and 2015, the added value was around 550 billion and grew continuously since 2016 (over 600 billion yuan). (SOA, 2015; 2016; 2017).

Potential future ocean economies

Renewable energies: 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. 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 renewable ocean energy systems is facing critical

[7] Details found in SPS Ocean Governance sub-report on Green Maritime Operations

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[8].

Mineral resources: The huge reserves of seabed mineral resources may be great significance to China's economic development. China has currently exploration contracts for five mining areas in the Area Beyond National Jurisdiction, and is a country with the most complete resource types and the largest size of mining areas in the world. However lack of regulatory framework, technological challenges, and the lack of sufficient scientific understanding of the vulnerability of the seabed ecosystems and potential impacts from mining operations are major challenges for future seabed mining exploitation[9].

Major anthropogenic drivers in China’s coastal zones include land reclamation and hardening of the coastlines; reductions in sediment discharge from rivers; navigation channel construction and deepening of ports; and increased nutrient and contaminant loading (Wang et al., 2016). These pressures are similar to those at the global level and are amplified by the climate change and loss of marine biodiversity. Among them, 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 both harmful algal blooms and green macroalgae blooms (see Box 6), seasonal seawater acidification and hypoxia in the coastal oceans. Under these pressures, 80 % of China’s near shore coastal ecosystems including many estuaries, bays, tidal flats, wetlands, coral reefs, mangroves and seagrass beds, such as are in sub-health or unhealthy state (SOA, 2015). Among others, habitat loss is one of the most substantial issues. 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 Bohai Sea and northern Yellow Sea have been severely degraded and become seasonally hypoxic (e.g., Gao et al., 2014; Zhai, 2018). Severe eutrophic pollution also occur to major Chinese estuaries and bay areas such as Yangtze River Estuary, Hangzhou Bay, Minjiang Estuary and Pearl River Estuary, compromising survival of fishes and other living marine resources (e.g. Wang et al., 2016; Zhao et al., 2019). The degradation of the coastal environment and ecosystem functions has significant economic consequences. For example, the estimated economic loss in the country’s marine fisheries alone reaches over US$ 500 million annually (CCICED, 2013). These environmental and ecological problems have also brought severe scientific and governance challenges for the implement of national land and ocean integrated management strategy.

Box 6: Green Macroalgae Blooms causing trouble for the 2008 Olympics

In summer of 2008, the world's largest green macroalgae blooms (green tide) caused by *Ulva prolifera* broke out in the coastal zone off Qingdao, a city of Shandong province located at the west coast of the Yellow Sea and the host city of 2008 Olympic sailing events. The green tide caused damages to the tourism, marine transportation and brought about serious environmental isues. The "green monster" led to the costs of billions of Chinese Yuan while ten thousands of people were involved in combating the green tide. More importantly, such green tides have become new summer norms in the southern Yellow Sea ever since, which poses big challenges to all levels of managements and mitigations.

[8] Details found in SPS Ocean Governance sub-report on Ocean Energy Resources
[9] Details found in SPS Ocean Governance sub-report on Mineral Resources

A foremost question is clearly on the science: where does the massive *Ulva prolifera* come from? Its formation mechanism? A multidisciplinary "Green Tide" project was thus initiated and implemented from 2015-2018 aiming for mitigation of the disastrous green tides in the southern Yellow Sea. Intensive field observations on more than 20 research cruises along with satellite remote sensing, and numerical modelling were conducted. The results show that the massive floating *U. prolifera* could be traced back to the massive offshore aquaculture areas in Subei Shoal of the northern Jiangsu Province. Under favourable conditions of temperature and nutrients, *U. prolifera* quickly grows and is transported along with coastal currents towards the coastal zones off Qingdao. Based on the key factors of the origination, the algal attachment / de-attachment, the early stage of the green tide formation, the environmental and ecological impacts, countermeasures to minimize the algal biomass blooms at the source area of the Subei Shoal and three front lines from the offshore areas off Subei Shoal to the Shandong Peninsula have been proposed as a prevention strategy in order to mitigate the green tide development.

During the past two decades, China has invested in both basic research and monitoring programs in order to better understand its coastal waters aiming for a better knowledge basis for both management and governance. However, systematic and forward-looking long-term studies that couple land-coast-ocean-atmosphere and ecosystem-resource-environment-socio-economy are still missing and there are no systematic scientific outputs so far, especially in terms of future predictions. Studies in terms of risk assessment and forecast systems are even less. Thus, the available knowledge is insufficient to serve a more comprehensive management scheme that is urgently required to sustainably balance human activities with ecosystem health and environmental protection.

4.1 Institutions

The recent ministry structural change (2018) had implications for the marine governance regime, including a reduction of conflicting management regimes. However, there are nevertheless still about eleven ministries and agencies related to ocean management, responsible for regulating its use in one way or the other at national level (see Box 7). Furthermore, there are similar horizontal sections at provincial, city and county levels taking responsibilities for management at the corresponding level.

Box 7: Key ministries and agencies with marine and ocean responsibilities in China

Ministry of Natural Resources (MNR): China's primary authority in protecting and managing the country's natural resources has taken over the main functions and responsibilities from former State Oceanic Administration for oversight of the development and conservation of non-living marine resources, spatial planning, surveying, natural disaster prevention and reduction, geological exploration of the seabed and restauration of marine habitats. Stimulating the development of ocean economy is also MNR's responsibility.

Ministry of Ecology and Environment (MEE): China's primary institution for protecting the country's air, water, and land from pollution and contamination. The MEE addresses climate change and greenhouse gas emissions; the permitting and enforcement of water pollution controls; and supervision of nonpoint source pollution; among other responsibilities. Following the March 2018 restructuring, the ministry received jurisdiction of ocean water quality from the erstwhile SOA. In addition, certain responsibilities for the enforcement of environmental law for oceans were transferred from the China Coast Guard to MEE.

Ministry of Agriculture and Rural Affairs (MARA) has broad authority over China's food systems. The Ministry retains authority over most aspects of both aquaculture and wild capture fisheries, making it a major player in China's ocean governance. The Ministry houses the **Bureau of Fisheries**, which oversees fisheries activities such as quota setting, aquaculture research, habitat management, and international agreements—including distant water fishing activities.

Ministry of Transport (MOT): As part of the March 2018 restructuring, the Ministry was assigned administration of the nation's fishing fleet, including inspection and supervision of fishing vessels, a jurisdiction which previously rested with the Bureau of Fisheries. The MOT houses Maritime Safety Administration who oversights for pollution prevention associated with marine facilities and ships, marine traffic safety, maritime safety affairs, ship inspection, and crew training.

Ministry of Culture and Tourism (MCT): responsible for Coastal tourism development and management.

4. 2 Legislation

There are a series of laws and regulations related to marine and coastal matters at national and local levels which provide legal guidance and justification for coastal management schemes and practice in China. The two main legal acts supporting and framing China's policy for sustainable and integrated management of the marine environment are the Marine Environment Protection Law, which promote sustainable economic and social development, and the Law on the Administration of the Use of Sea Areas, which promotes sustainable use of sea areas. The Marine Environment Protection Law has thus far undergone four amendments (1999, 2013, 2016 and 2017) since its promulgation on August 23, 1982. It fostered an inter-agency mechanism in marine management and stipulated the formation of a marine functional zoning scheme, establishment of marine nature reserves and implementation of marine environmental impact assessment system, and made provisions for the prevention and management of marine pollutions (Chen & Pearson, 2015). The 2001 Law on the Administration of the Use of Sea Areas contributed to the establishment of the right to the sea use authorization system, user-fee system and marine functional zoning system, which alleviated the intensive sea use conflicts, guided the distribution of marine development and ameliorated the eco-environment (Chen & Pearson, 2015). These acts lay the foundation for the current successful tools used for sustainable management of the marine environment.

4.3 Practices

China is taking various actions and practices to continuously improve its ability and competence in developing and utilising marine resources and protecting the marine ecological environment.

Marine Functional Zones (MFZs): MFZs are the legal basis for which marine resources can be reasonably exploited and utilised in order to effectively protect the marine ecological environment. Since MFZs were first proposed by the Chinese government in 1988, China has developed MFZ into an integral part in its territorial spatial planning. MFZ has become an important basis for the development, regulation and integrated management of marine space as well as an important tool for the management of its sea area, the protection of the marine environment, and development of its marine economy. After three generations of evolution, it has formed a relatively mature classification system, technical system and institutional arrangement for China's MFZ with targets specified at three administrative levels and management requirements defined for different marine functional zones, which in turn facilitate the implementation of MFZ. China now is aiming to build the next generation of MFZ into a land and sea integrated zoning plan guided by the principles of ecosystem-based management. The next round should continuously improve the engagement of stakeholders and comprehensively consider other existing maritime space management systems to achieve truly integrated ocean management. Considering increasing environmental awareness and public needs close to the sea, more emphasis should be placed on planning natural shorelines protection, maintaining coastal and marine biodiversity, and adapting to the effects of climate change (Teng et al., 2019).

The Marine Ecological Red Line (MERL): Marine Spatial Planning mechanism with ecological protection objectives. It has been partially implemented within China, but has only gained legal status in late 2014 and implementation in 2015, under which each province can develop their own Marine Ecological Red Line programme. It operates as an ecosystem-based approach, considering environmental protection, the protection of marine resources and economic development. It can be defined as the ecological baseline area needed to provide ecosystem services to guarantee and maintain ecological safety, living safety and biological safety.

Marine Protected Areas: China has over the last 30 years established more than 270 MPAs, comprising about 5 % of its national waters[10], but the overall management effectiveness has potential for improvement. Until June this year, local governments with limited scientific knowledge were responsible for designing and planning MPAs, and this led to opportunistic development of these areas. A lack of monitoring and enforcement made the MPAs ineffective for remediating habitat degradation and the overexploitation of resources. China's planned improvements include organizing national guidelines and a management institution by 2020; forming a comprehensive regulatory framework by 2025; and establishing a systematically planned and effectively managed MPA system by 2035.

River/Bay-Coast Chief System: Although not an ocean based mechanism the river chief system has relevance for ocean management through land-ocean interaction. China's Ministry of Water Resources introduced this new measure aimed at improving China's water governance by placing responsibility for protecting bodies of water squarely on the shoulders of government officials. The River Chiefs System stipulates that local river chiefs fully mobilize and integrate various technical and administrative forces to achieve environmental goals. River chiefs' responsibilities include water resource protection, pollution prevention and control and ecological restoration. Various government bodies have duties in river protection. Previously, they conducted their jobs independently. With the system, the river chiefs who are government heads can mobilize and coordinate the scattered strengths to make the process more orderly and efficient. Such a system has now been expanded into the coastal areas and piloted as a Bay Chief-Coast System in the Zhejiang province, Qinhuangdao, Qingdao, Lianyungang and Haikou at the start of 2017. In 2018, the pilot scope was further expanded to Zhejiang, Shandong, Hainan provinces comprehensively. Part of the coastal cities in Jiangsu, Hebei, Guangdong and Guangxi provinces are gradually exploring the concept. The Bay-Coast Chief System, organized much like the River Chief System and is as such a coordination mechanism led by the 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 the problems in the bay environmental management are addressed in a more comprehensive mode.

[10] See go.nature.com/2kn9htm

Integrated coastal zone management (ICZM): ICZM is 'the process of managing the coast and nearshore waters in an integrated and comprehensive manner with the goal of achieving conservation and sustainable use' (Katona et al., 2017). It is also called 'integrated coastal management'. ICZM covers the full cycle, including information collection, planning, decision-making, management and implementation. The approach seeks informed participation and cooperation from all relevant stakeholders. It seeks integration of the goals and instruments needed to meet these objectives; of different policy areas, sectors and levels of administration; and of the land and sea components of the target area. ICZM can be considered a functional approach to or one of several aspects of a fully integrated ocean management system. According to the Priority Project Plan of China's Agenda 21, integrated coastal zone management was one of the projects under the priority area of natural resource management and utilization. The Chinese government has piloted the implementation of integrated management at local levels, such as Xiamen, Fujian and Dongying, Shandong (see Box 8).

ICZM helps local governments to achieve social and economic development targets in a number of areas—pollution reduction and waste management; food security and livelihood management; habitat protection, restoration and management; and natural and man-made hazard prevention and management. In all cases, success has been achieved through an integrated approach.

Box 8: ICZM pilots

Xiamen: In 1994, Xiamen was selected by the Chinese government to be developed as an ICM demonstration site with the collaboration of GEF/UNDP/IMO (Global Environmental Facility/United Nations Development Programme/International Maritime Organization) Regional Program (Chua et al., 1997; Hong and Xue, 2006). To find the right balance between economic development and ecological protection, solve the management conflicts between different departments and industries, Xiamen has implementing ICM practices for over 20 years. The implementation of ICM in Xiamen has gone through four stages and achieved remarkable results. Xiamen's ICM practices started with the establishment of the ICM governance framework, which was focused on centralized coordination, science support, legislation/enforcement, and public participation. Then Xiamen carried out a series of marine ecosystem rehabilitation projects in areas including Yundang Lagoon, the West Sea, Wuyuan Bay, the East Sea, etc., and those projects had greatly improved the ecological environment and beautified the marine landscapes. After the co-governance of river and sea, the terrestrial pollutants were reduced and the seawater quality was improved, and now Xiamen's ICM practices are aimed at land-sea space overall management and "Blue Growth", which are in line with the ultimate goal of achieving sustainable economic development with a good environmental status. During the past years, Xiamen's marine space and resource use conflicts, ecological and environmental issues have all been greatly alleviated, ICM practices have also promoted the development of marine science and marine economy in Xiamen (see Appendix 2 for details on the case study).

Dongying City: Dongying is a coastal city located in the estuary of the Yellow River. The city hosts the second largest oil industry in PR China and is also one of the cities in northern China with a rapidly developing marine economy (Hou, 2011). The local government efforts in ensuring sustainable use of the coastal and marine resources were greatly enhanced with the implementation of a comprehensive ICM program. The setting up of an MPA and functional zoning was an integral part of the ICM program under the leadership and coordination of the local government. Dongying successfully hosted and implemented a natural nature reserve (NNR) and five special marine protected areas (SMPA) in close cooperation with national agencies. The NNR and five SMPA were able to form a local MPA network around Dongying City. This network played an important role in regional biodiversity conservation and protection, particularly for migratory birds and fish (Sun et al., 2015; Zhai et al., 2015). The biomass of protected targets increased through the control of human activities and the release of fingerlings of four species of fish. The water quality also improved through artificial wetlands restoration in the Yellow River Estuary Ecologic SMPA, an important spawning ground for crab and shrimp in Bohai Sea. The number of nests of oriental white storks increased year by year since 2005, the China Wildlife Conservation Association (CWCA) awarded Dongying "the home of the Oriental white stork in China" (Zhang et al., 2018).

China has been implementing integrated ecosystem-based management of the seas across the board, introduced a marine ecological red-line protection system and continuously improved its ability and competence in developing and utilizing marine resources and protecting the marine ecological environment. It has actively conducted international cooperation and made positive contributions to the implementation of the relevant sustainable development goals and targets at the global level (Ministry of Foreign Affairs of the People's Republic of China, 2019). Some achievements include:

- Established and improved laws, regulations and management regimes to actively promote sustainable management of oceans and seas.
- Strengthened the protection and restoration of the marine environment and the sustainable development and utilization of resources, achieving positive results in the conservation and management of marine and coastal ecosystems.
- Promoting green development of aquaculture, thus further strengthening the conservation of aquatic biological resources.
- Engaged in cooperation on blue economy to support the sustainable development of marine industries in the LDCs and small island developing states (SIDS).

5. Principles for effective implementation of IOM

5.1. Overarching

The World Ocean Assessment of the Regular Process to assess the status of the marine environment under the UN General Assembly concluded in its first report (2015): *"The sustainable use of the ocean cannot be achieved unless the management of all sectors of human activities affecting the ocean is coherent. Human impacts on the sea are no longer minor in relation to the overall scale of the ocean. A coherent overall approach is needed. This requires considerations of the effects on ecosystems of each of the many pressures, what is being done in other sectors and the way that they interact"* (United Nations, 2015). In the preamble of the 2018 resolution, UN states the following: *"The problems of ocean space are closely interrelated and need to be considered as a whole through an integrated, interdisciplinary and inter-sectoral approach, and reaffirming the need to improve cooperation and coordination at the national, regional and global levels."*

Thus, this shows the importance the international community contributes to collaboration and integration – they are key to successful integrated ocean management at all scales. At national level, it is essential that government agencies involved in ocean management are properly institutionalized, and have the skills, knowledge, and capacity to address challenges relating to the ocean and coastal communities in a long-term, integrated manner. Here, collaboration and coordination among stakeholders is essential. Also, adaptive capacity in ocean governance is needed in order to systematically and continuously improving management policies and practices (Katona et al., 2017). This is an approach that recognizes the inherent variability and dynamic nature of both bio-chemo-physical, social, and economic factors, in addition to scientific uncertainties.

In some countries around the world, the scientific capacity needed to implement international governance frameworks are severely lacking (IOC-UNESCO, 2017). New technologies combined with transparency give new opportunities for monitoring and policing of inappropriate behavior at sea, bringing practical and inexpensive solutions for transfer of know-how. In this respect, regional cooperation can be an effective vehicle for strengthening the role of science and providing advice for management.

5.2. Integrated ecosystem-based approach in existing management and governance structures and practices

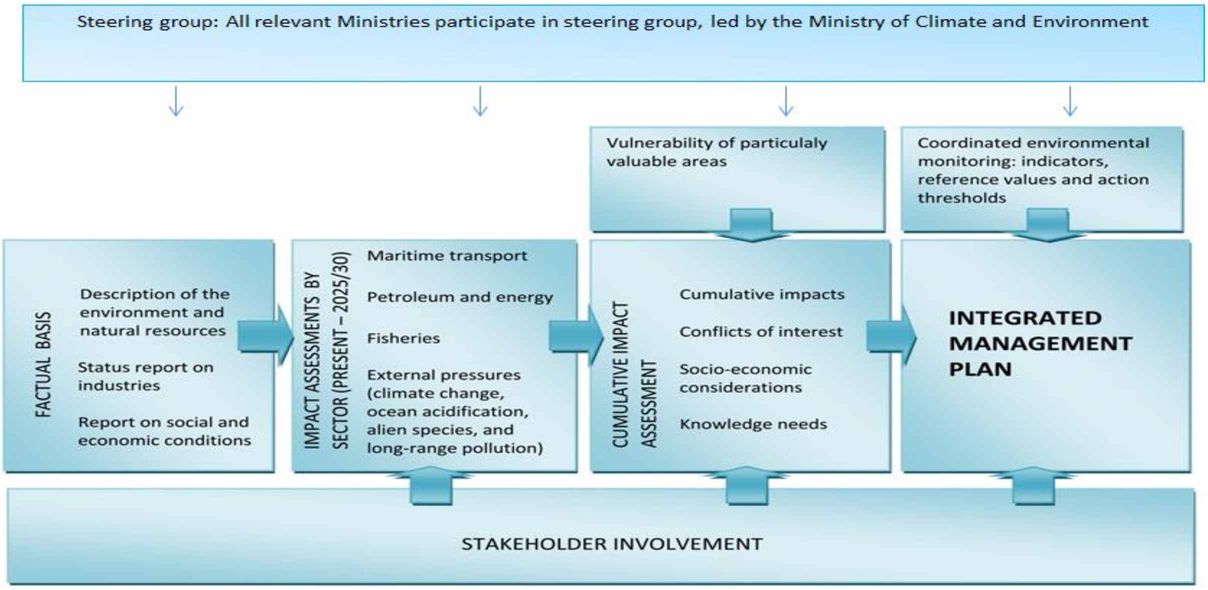
Protecting and restoring oceans requires a range of strategies including ecosystem-based approaches. Over the last twenty years more effort has been focused on managing regional ocean areas, in recognition of the interdependencies of marine resources and ecosystems. However, further efforts are required to achieve a sustainable balance. Experiences, both on local and provincial scales in China (for example the Xiamen case study in Case Study 2) and on larger scale internationally (such as the Barents Sea case study – see Case Study 4) has proved that a systematic and long-term focus on building a framework for an ecosystem based management system has proved beneficial, both for ecosystem, industry and management. Building on these experiences, it may be worth further strengthening and formalizing ecosystem based integrated management as a concept both for coastal waters and open sea areas of China.

Reinterpreting or adding to existing legislation or finding other mechanisms such as administrative orders and directives to establish authority for IOM, can facilitate improved coordination and supplement the sector-by-sector approach. The Netherlands took the reinterpretation of existing law approach as it developed an integrated ocean management plan for its near-shore areas through an Inter-Ministerial Consultation Body for the North Sea involving all relevant ministries, such as defense, transport, public works and water management, economic affairs and the environment (Douvere and Ehler, 2009). Rhode Island, a state in the United States, voluntarily developed an ocean plan in partnership with the federal government that implements ecosystem-based management principles by reinterpreting state's Coastal Resources Management Council's authorizing legislation within the national Coastal Zone Management Act (CZMA). The plan was approved by the National Oceanic and Atmospheric Administration's Office of Coastal Management which enhances the state's influence in federal waters through the Federal Consistency provisions in the CZMA.

Legislative provisions can also be added to existing law to establish authority and provide clarity for developing a more integrated management process. This can potentially be achieved by adding provisions to legislation that regulate new ocean uses to make IOM a requirement for new development to be permitted. These provisions can include making strategic environmental assessments a requirement. Developing directive language that ensures positive outcomes for the regulated sector for whom the original legislation was written is necessary to demonstrate the added value of requiring a more integrated approach with other sectors.

Administrative orders or directives can also be used to define a framework for coordinated management. These directives may articulate high-level targets and leave the definition of specific management goals and objectives to relevant regulatory agencies or planning entities. This approach was taken by the United States for both the Northeast and Mid-Atlantic regional ocean plans. Norway is another example demonstrating that IOM does not have to be grounded in law if political authority is provided. The basis for the Norwegian integrated ocean management system was laid down in a white paper to the parliament which framed a vision for a clean and rich sea for future generations (Norwegian Ministry of Environment, 2002). This white paper provided the basis for a structure of cooperation between existing ministries and agencies to support the development of integrated and ecosystem-based management plans for the Norwegian Seas (see details of case study in Appendix 4). Norway's integrated management plan is based on mapping and assessing the status of marine ecosystems, identifying ecologically valuable and vulnerable areas, and setting conditions for the use of ocean space including for the petroleum industry (Norwegian Ministry of the Environment, 2006).

Figure 3: The structure of Norway's approach to integrated ocean management



Source: Norwegian Ministry of the Environment (2009).

5.3. Need for cross-boundary (administration) and cross-sectoral coordination and communication

An integrated approach to management requires coordination and communication across both administrative boundaries and sectorial boundaries. Experiences both from domestic and international processes show that great leaps forward can be made by formalizing and providing legal frameworks for such coordination and communication. This is for example exemplified by the Xiamen case study (Appendix 2), where the putting into force and the implementation of several marine laws, regulations and planning programmes helped Xiamen build a comprehensive local law system that coordinated with navigation, fishery, conservation and urban planning, and provided guidance to stipulate marine functions, manage marine activities, solve sea-use conflicts, establish marine protected areas and save marine habitats. The experience from the ocean management system in Norway showed that the involvement of all institutions concerned in the development of the joint factual basis contributed to build trust between the institutions. It has shown that sharing knowledge and agreeing on the priorities for the development of better knowledge has led to the acquirement of more knowledge for the same economic costs. It may provide fruitful to provide an overarching legal framework that would provide incentive for such approaches.

Environmental processes are complex in nature. Environment and ecosystems are interlinked and are influenced by one another, with no regard for governmental or political boundaries. Thus, the governance of the ocean cannot be seen independently of the coastal areas and the freshwater systems associated and interacting with them. In short, land-based activities, such as agriculture and urbanization affect the quality and use of the coastal and marine environment and ecosystems.

The interactions across this land-ocean interface and the impacts of land-based activities on the ocean environment (e.g., eutrophication, sedimentation) are being exacerbated by cross-system threats (e.g., climate change). To achieve a holistic and integrated management and governance of the ocean coastal waters and ocean system, it is necessary to ensure a management and governance structure that allow for cross-sectorial assessment.

It is necessary and important to aim to work towards moving away from sectoral management of coastal and associated river catchment areas to a more integrated approach, thereby recognising the interdependence of freshwater (including groundwater) and coastal and marine systems and the cross-sectoral effects of land-based activities. Furthermore, it is important to ensure that also the impacts of land-based actions may have on the ocean environment when applying risk assessments, doing appraisals of long term benefits and costs of proposed actions, implementing environmental impact assessments to such activities.

The "Bay Chief System" (see **Feil! Fant ikke referansekilden.** in Chapter 4) is essentially a comprehensive coastal zone management system, whose implementation can be of great significance to the coordinated protection of the bay and coast environments. To succeed, the implementation of a *Bay Chief System* needs to seek an effective administrative support model, and the establishment of a *Bay Chief Office* with comprehensive coordination capability can be regarded as one mode that could be developed further and implemented. The following approach could be considered in this context:

- The *Bay Chief Office* should be given the function of coordinating all kinds of sea-related activities on behalf of the local government, to ensure the realization of sustainable development goals. To implement this function, the *Bay Chief* of an important bay should be the first person in charge of the region where the bay is located, so that he or she has the authority to coordinate the work of various departments. At the same time, by establishing and improving the supervision, assessment, and accountability system for the management of the bay, the *Bay Chief* will be encouraged to undertake the responsibility for ecological and environmental protection of the bay, and the management of the bay will be promoted from "department in charge" to "chief in charge and departments in co-governed". Of course, in addition to administrative authorization, the *Bay Chief System* should also be incorporated into relevant laws and regulations, and the *Bay Chief* should be entrusted with the corresponding responsibilities. The *Bay Chief System* can only have a long-term effect if there is a kind of internal lasting power created by thorough laws and regulations.
- The comprehensive coordination function of the *Bay Chief Office* should focus on the following aspects:
    - The integration of the different management departments, which is very important at the early stage of the implementation of the new national institutional reform. Based on the sustainable development of the bay area, the *Bay Chief Office* should coordinate different human activities (including natural resources utilization, ecological environmental protection, transportation safety, rational distribution of ports, exploitation of aquatic resources, development of tourism industry, exploration of marine energy, prevention and control of marine disasters, etc.), and also avoid repeated management and management white space, reduce or even eliminate the loss caused by resource utilization conflicts in this region.
    - The integration of space, which is crucial to the overall planning of land and sea. From the perspective of the main function protection of the bay area, the *Bay Chief Office* should comprehensively coordinate the integration of "Marine Functional Zoning" and the "Overall Urban Planning", so as to ensure the implementation of the concept of "managing land by sea" in terms of ecological protection.

- The integration of science and management, which directly affects the scientific decision-making process. The *Bay Chief Office* should explore to build an effective and easy-operational scientific decision-making mechanism, given full play to both the local scientific research talents and external think-tank, also apply the advanced marine management theory to guide the planning of the bay area, especially the Marine Functional Zoning of the bay area, in order to ensure the planning is forward-looking and scientific.
- Regional integration is an inevitable proposition of ecological civilization construction in the coastal zone. The fluidness and mobility of the ocean determines that cross-border cooperation is necessary for the management of the marine area, which is also an important reason why the United Nations and many international organizations continue to pay attention to the sustainable development of global coastal zones. The *Bay Chief System* should be committed to exploring new ideas and approaches to cross-border ocean management. The provincial government should support the comprehensive coordination between the *Bay Chief Office* and the marine departments in the adjacent waters on the protection of the marine ecosystem, and also support the *Bay Chief Office* to coordinate with the neighbouring river basin management departments and the related *River Chief*.

5.4. High need for production of, access to and use of knowledge, science, and monitoring

The availability and use of scientific knowledge about the ecosystem are a key requirement for enabling ecosystem-based and integrated management and for decision makers to make robust decisions. The need for a solid scientific basis for decision-making is particularly important given the complexity of interactions between the environment, resource users, economics and social well-being of people and communities. The time-consuming nature of scientific work and obstacles to data-sharing may be a hindrance and efforts are required to speed up scientific processes and sharing more data and information to facilitate sustainable development and management of the ocean. Knowledge also need to be looked upon as a renewable resource and new knowledge that is gained about the state of the ecosystem, important habitat structures or about the impact of human activity need to be integrated into any management process to improve it and provide a knowledge basis for implementing new measures.

Whilst technologies will develop new economic sectors, it will also enable a new era of ocean science and knowledge – a renaissance of the ocean. More data is likely to be collected about our ocean in the next decade than all of history. Combining the ability to better synthesise previous observations with real-time information through machine learning, there will be an ability to better understand the ocean environment than ever before. Harnessing the power of such technologies to advance ocean science and knowledge, requires an unprecedented ability to work across disciplines and develop international collaborations. This may require the development of new multi-disciplinary institutions to incubate such solutions for ocean science. History has shown that technology can be either restorative or destructive. Indeed, it has often been the case that there are unintended consequences of technology. There needs to be a science-based governance system to ensure the responsible development of new science and technologies for the ocean, whilst ensuring sustainability for future generations.

5.5. Efficient IOM tools

A variety of tools have evolved to achieve smart planning and management in coastal and marine areas. IOM uses a variety of these tools to ensure the sustainability of marine ecosystems.

Marine spatial planning

Internationally marine spatial planning (also known as “maritime spatial planning” and “coastal and marine spatial planning”) extended the ICZM approach further out to sea in the 2000s. Marine spatial planning aims to create a framework for the oceans that minimize conflicts between economic sectors and maintain good environmental status (GES) of the oceans through the identification of ocean spaces that are appropriate for different uses or activities. MSP is increasingly seen as a practical way to create and establish a more rational organization of the use of marine space and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in an open and planned way. MSP is widely used for setting targets for and implementing EBM (Katona et al., 2017). The marine functional zoning (MFZ) system, first implemented already in 1988, constitutes China’s MSP approach (see Chapter 4).

Marine spatial planning processes is an emerging paradigm for sustainable ocean management (Douvere et al., 2008; Domínguez-Tejo et al., 2016) and the operationalization of a sustainable ocean economy. MSP aims to move away from a traditional, sectorial focus to a more holistic approach which understands the full use of the ocean space (White et al., 2012). Within the sustainable ocean economy framework, MSP should ideally be a means of creating an optimal investment climate for maritime sectors and give operators more certainty as to what opportunities for economic development are possible, although inequity, greater conflict, and faster rates of degradation may occur if not calibrated appropriately with ecosystem goals and monitored over time. As a management tool, MSP allocates areas of the ocean for different uses or activities to reduce conflicts and achieve ecological, economic, and social objectives. A key theme of MSP is the adoption of an ecosystem-based ocean management. The application of an ecosystem-based approach to ocean management involves a focus on the functional relationships and processes within the marine ecosystem, attention to the distribution of benefits that flow from ocean ecosystem services, the use of adaptive management practices, the need to carry out management actions at multiple scales, and inter-sectoral cooperation (Douvere and Ehler, 2009). This is in direct contrast to current ad-hoc, sector-by-sector responsibilities and practices to the management and regulation of ocean activities. Although MSP is currently underway in 66 countries worldwide, only 22 countries have government-approved MSP plans (Santos et al., 2019).

Area-based measures including marine protected areas (MPAs)

Area-based measures are important tools in the management of ocean and seas. A marine protected area (MPA) is defined as “a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Oregon State University et al., 2019). Likely developed independently in many cultures, area-based management measures are a regulatory tool for conserving the natural or cultural resources of the ocean and for managing human uses.

If managed in isolation, coastal and marine protected areas are vulnerable to natural resource development and exploitation occurring outside these areas, in particular overfishing, alteration and destruction of habitats, climate change and marine pollution. Thus, protection of coastal and marine areas – of species, habitats, landscapes, and seascapes – should be integrated into spatial development strategies for larger areas, under the umbrella of integrated coastal and ocean management, including land-ocean interactions. Clear science-based criteria for designating MPAs are necessary. All stakeholders need to be involved in the planning stages. Effective monitoring programs and strict enforcement are essential. And institutional and learning systems should unite individual MPAs into an ecologically coherent network (Li et al., 2019).

Box 9: CBDs work on marine protected areas and COP 15 in Kunming

The Convention on Biological Diversity's (CBD) *Programme of Work on Protected Areas* (PoWPA) was agreed in 2004 in Kuala Lumpur, Malaysia and reaffirmed with additional elements in 2010 in Nagoya, Japan. PoWPA aims to encourage parties to the CBD to develop and manage ecologically representative networks of protected areas on land and sea. The PoWPA was an historic commitment by 188 governments. Today, only 5.3 % of the world's oceans are protected in implemented and actively managed marine protected areas. The 15th meeting of the Conference of the Parties (COP 15) to the CBD, to be held in Kunming, China in the second quarter of 2021, provides opportunities for China and the global community at large to continue discussions and work that underpin the aims of PoWPA.

Over the last 30 years China has established more than 250 MPAs in its coastal and marine areas. The term MPA, in the Chinese context, refers to two categories of marine re-serves: Marine Nature Reserves (MNRs) and Special Marine Protected Areas (SMPAs). The effectiveness of the current MPA system in China is debated and under consideration. China has made commitments to expand the MPA coverage in its waters and develop an "ecological barrier" along the coast by connecting MPAs and islands by 2020 (Li and Fluharty, 2017).

5.1. Educate and motivate the use of the principles and relevant methodologies and tools

To accomplish a successful transition from sector-based management to a fully integrated and ecosystem-based management framework it will be necessary for existing structures and individuals to change, adapt, learn and acquire new skills. Capacity building through education and motivation will be essential and requires resources and persistence.

5.2. New technologies as key support for sustainable ocean governance

Technology is providing new opportunities to understand the ocean ecosystems and how humans are using them. The rapidly evolving technological advances generate new opportunities for both scientific data collection (cf. Chapter 5.4) and opportunities to improve oversight of human activity at global and local scales, e.g. through vessel tracking. Technology can play a profound role of ensuring radical collaboration and transparency, to develop a new development model. This new development model would enable much closer land-ocean linkages and will help eliminate land-based pollution for the ocean. For example, new sensors such as satellites, can identify polluting actors. Autonomous sensors and clean-up technologies can rapidly intervene where such pollution has been identified. New collaboration tools can enable a diverse set of partners to collaborate on regional strategic plans, and ensure more agile monitoring and enforcement, through automatic reporting.

5.3. Governance of the Ocean Economy

Successful implementation of ecosystem-based integrated management is key to the sustainable protection and use of the oceans. Within this picture there is room for a sustainable ocean economy, including truly integrated maritime policies, adequate economic and legislative incentives, supportive public and private financial and investment flows, etc. Clear regulatory policies and financing principles for the blue economies will be important.

5.4. Setting goals and ensuring focused implementation is key

Experience shows that specifying MSP goals and objectives is essential in implementing an integrated and ecosystem-based management regime. Goals and objectives should be derived from the problems and conflicts identified in an initial assessment process. Measurable objectives are critical in order to evaluate performance, reducing uncertainty, and improving management over time. Management objectives are used to guide decisions in managing human activities in marine areas and should therefore be quite specific. Good objectives should be specific, measurable, achievable, relevant, and time-bound, i.e., SMART[11].

[11] The first-known use of the term occurs in Doran, G. T. (1981). "There's a S.M.A.R.T. way to write management's goals and objectives". Management Review. 70 (11): 35–36.

6. Challenges impeding a fully implemented IOM

Integrated management is understood to be an approach or mechanism that would secure more sustainable management of the world's marine systems. However, implementation of integrated management, occurring within existing governance structures, is hampered by a number of challenges and obstacles that must be overcome to be truly successful.

6.1. Silo governance

Silo management is a common challenge within national and international governance and cannot be avoided entirely. Silo management occurs when operation with and communication between different management systems is challenged. Organizational silos occur due to specialized areas of responsibilities with differing priorities and goals because of this. Fragmentation can occur on all levels of management. For example, although UNCLOS provides an overarching legal framework for governance of ocean areas outside national jurisdiction and the annual UNGA resolutions on Ocean and Seas and Fishery serves as an invaluable opportunity for the global community to identify key ocean issues and develop constructive ways to address them, it nevertheless lacks a framework for coordinated management and regulation between various sector entities such as ISA, IOC, IMO, UNEP, FAO, etc. (Figure 4). Moving ocean governance from sector-by-sector management to integrated management is a significant challenge on all levels of governance, and dedicated efforts are required to break down communication barriers across sectors and systems to achieve an integrated, knowledge-based and ecosystem-based ocean management, both on national, regional and local level, as well as across borders. Supplementing sector-based management with collaborative and coordinating mechanisms across sectors may in such cases be highly beneficial. As an example, it is relevant to look to the case of the Norwegian Management Plan for integrated Ocean Management (Case Study 4), which is a political document developed by the Government presented as a white paper to the Norwegian Parliament. In this way the overall ocean policy framework laid down in the Management Plan is anchored and approved at the highest political level. The Ministry of Climate and Environment holds the responsibility for coordinating the process, while involving all sectoral ministries. The process itself is cross-sectoral, but it does not mean a shift of responsibility: the sectorial Ministries maintain their day to day responsibility for regulating the activities of the ocean industries on the basis of their responsibility for existing legislation governing the different sectors.

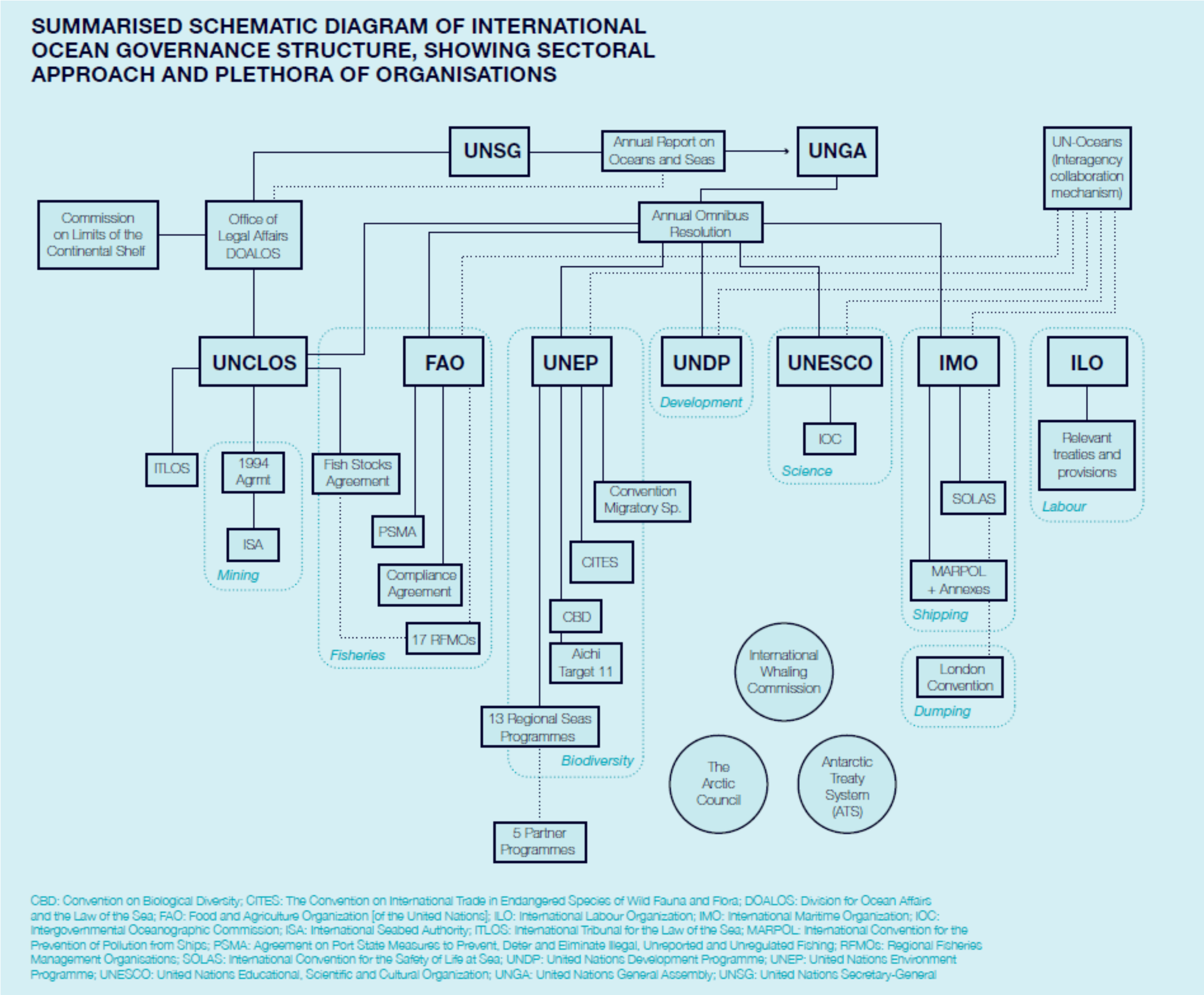


Figure 4: Summarised schematic diagram of international ocean governance structure, showing sectoral approach and plethora of organisations (Global Ocean Commission, 2014).

China is a country that implements a top-down governance approach which includes three main governance levels: national, provincial, and municipal. This kind of silo governance is mainly embodied in three aspects: administrative system, technical support, and financial support. Specifically, the top-down governance approach is reflected in the establishment and implementation of laws and regulations and personnel management from the national government to provincial and municipal government. It is also reflected in the formulation of technical guidance from top to down in various kinds of management (land, sea, economy, scientific research, etc.), and in the financial transfer and payment system from central to local government. Such a governance approach enables the development of all regions in China to move towards a unified direction and to have clear and coordinated plans. However, it can also lead to the neglect of local particularities and even the inconsistency between national development goals and real local needs. Therefore, the biggest challenge with silo governance will be to maintain the overall national development goals while considering the local development needs and characteristics.

In China there are a series of laws and regulations related to marine and coastal matters at national and local levels (see also Chapter 4). These laws and regulations provide legal guidance and justification for ocean management schemes and practice. There are, however, still many challenges relating to the implementation of existing laws and regulations to protect marine environment and resources, such as the lack of an integrated ecosystem-based view, relatively weakly developed laws and policies in the realm of protection of resources and ecosystem, and a lack of detailed implementation rules and cross-sector implementation mechanism. Improvement of the legal system of marine management can provide direction for integrated-ecosystem based ocean management, thus creating the context for defining and advancing cross-sectoral, long-term ocean-related goals and objectives. In all laws concerning use of the sea, China should abide by the principle of integrated ecosystem management and set substantial improvement and protection of marine ecosystems as a goal. Interpreting existing law to take an integrated management approach, adding provisions to existing laws, issuing an administrative order or other mechanisms can also be effective (Winther et al., 2020). Existing administrative and legal institutions are of importance to the design of new legislation and the amendment of existing legislation to achieve IOM and they are the key practitioners of integrated ecosystem-based management. In China, there is no specific agency or institution taking the responsibilities of IOM. The coastal zone management is a matter of shared responsibility involving many ministries and departments and local communities (see also Chapter 4). However, inter-agencies conflicts and overlapping jurisdiction is very common. The sectoral management systems are not necessarily equipped to cope with the adverse consequences of multiple resources-use and space interactions across sectoral jurisdictions and administrative boundaries. Coordination and power re-allocation among the many agencies of government play significant roles in management of coastal ecosystems. It would facilitate management if departments were to conduct law enforcement jointly and take joint and co-operative actions when necessary. Environmental protection and resource conservation call for concerted efforts across sectors and disciplines, therefore a close working relationship among related agencies is necessary for an improved institutional and authoritative mechanism that can effectively address these cross-agency management issues (Cao and Wong, 2007).

China's marine governance has also established a system for single sector handling of risk, disaster and disaster response management. There are specific response departments for natural and non-natural disasters such as red tide, oil spill, typhoon, and earthquake. These departments have their own functions, clear management tasks, and action plans, and can make the most timely and professional decisions and treatment measures when a disaster occurs. However, there are still some problems in this kind of single sector management system. Many disasters with large impacts in various aspects cannot be simply solved by a single department, but need the cooperation of multiple departments, such as dealing with typhoon disasters. In this respect, although China has implemented valuable efforts in coping with climate disasters, it is still a little short in coping with environmental disasters. Therefore, China's single sector management system needs to continuously strengthen the capacity of various departments to deal with corresponding accidents effectively and transparently, and also improve the coordination and cooperation mechanism among multiple departments.

6.2. Differing national-provincial-local frameworks

Ocean governance is carried out at local, national, regional, and international level. For a truly integrated governance to take place there needs to be a link between all levels of implementation. Structural and political obstacles challenge such an approach. Governance connectivity requires mechanisms that facilitate coordination between sectors at each governance level ("de-silofication") as well as across governance levels. Such mechanisms could be legislative, organizational (governance organizations, governance structures, etc.).

There are obvious differences between various levels of management frameworks in China. The national framework mainly reflects the overall and macro development goals and strategies, the provincial framework mainly communicates the national strategies and also provides guidance and supervision to the local level, while the local framework is mainly responsible for the implementation of specific development plans and regulations. Taking China's Marine Functional Zoning as an example, the national zoning is the main functional zoning of the country's internal waters, territorial seas, islands, continental shelves, and exclusive economic zones formulated by the Department of Marine Administration under the State Council[12]. The provincial zoning is a division of the sea areas and islands under the provincial jurisdiction according to the national zoning, while the zoning of cities and counties is mainly the refinement and implementation of the provincial zoning.

6.3. Single pressure management

Traditionally focus is 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 surprises. There is still very little understanding as to how more than one simultaneous stressors interact to affect species and ecosystems. Management rarely has the capacity to address more than one issue at a time. An integrated and ecosystem-based approach to management would aim to protect the coastal and marine ecosystems from long-term negative impacts caused by various activities and to balance different needs and conflicts between those who utilize the ocean resources.

Box 10: An illustration of the complexity of multiple stressors and cumulative impacts

Marine pollution mainly occurs in the coastal region, with complex interactions with other stressors, such as climate change (including warming and acidification due to increasing level of CO2), overfishing and habitat losses (Alava et al, 2017; Lu et al, 2018). These stressors could affect food webs, marine ecosystems, and the ecological services simultaneously. Moreover, the processes of climate change are likely to affect the exposure and bioaccumulation of marine pollutants. Studies indicated that, with global warming, exposure of apex predators in arctic to PCBs and mercury may increase due to the retreating of sea ice. The climate change will also affect status of marine nutrient pollution in many ways. Nutrient input into the sea, for example, is tightly coupled with freshwater discharge, which is driven by regional climate variability and global climate change. Therefore, it's necessary to have a comprehensive understanding on the complex interactions between marine pollution and other stressors like climate change. Further work is needed across scales exploring possible synergistic effects among multiple stressors and to assess the potential for biological acclimation and adaptation such stressors over time.

6.4. Connecting land-ocean

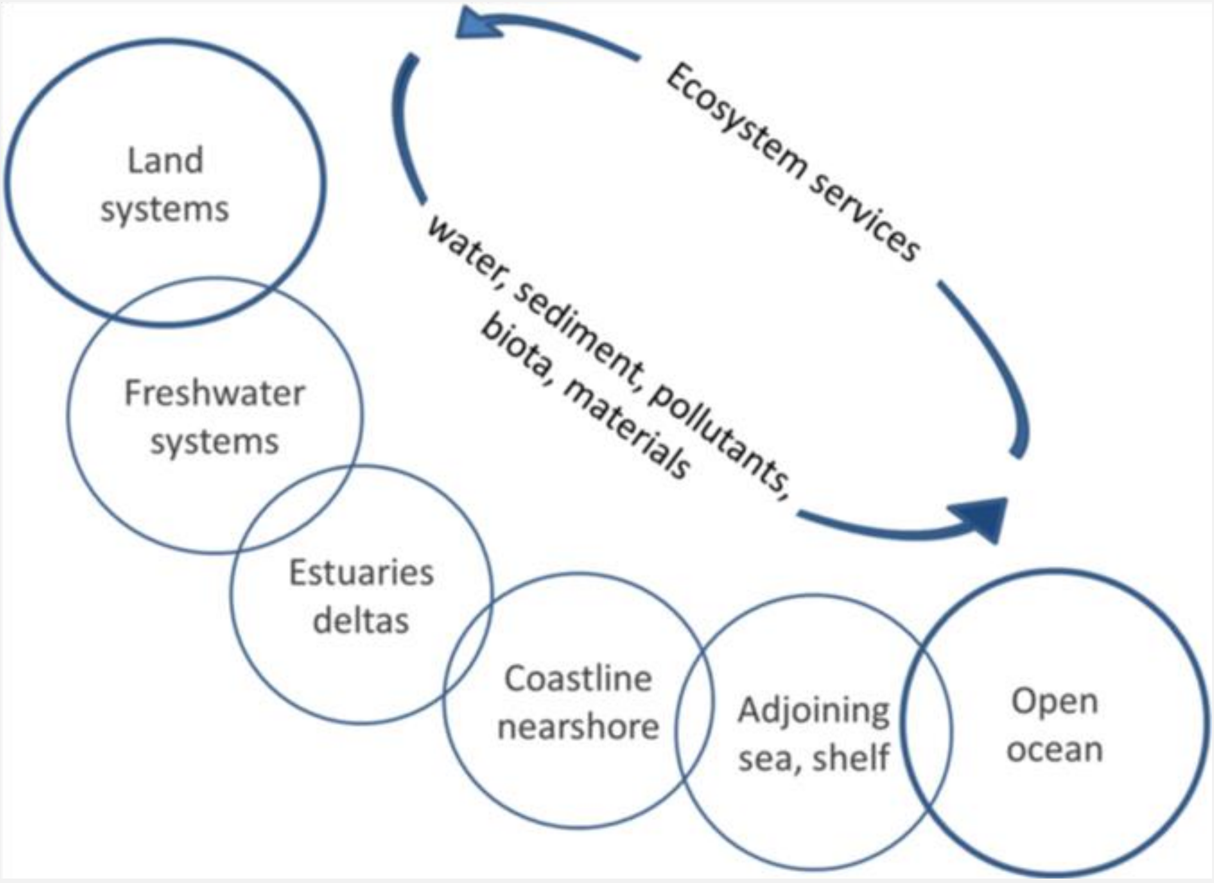
The marine ecosystems (including habitats) are impacted by human activities both on land and at sea. However, standard approaches for management of the ocean often neglect to consider connections between ecosystems and thus are characterized by a sectorial approach to management. Focus on source-to-sea management would link governance, operations, practices and finance across marine, coastal, freshwater and terrestrial systems and stimulates cooperation

[12] Previously part of the State Oceanic Administration, but now in the Ministry of Natural Resources.

between upstream and downstream actors, as well as coordination across sectors to ensure outcomes that mutually benefit systems as a whole. Protecting ocean health and promoting a sustainable blue economy thus requires sustainable development in river basins.

Box 11: Controlling pollution in coastal waters requires control of pollution upstream

Intensification of human activities can affect ecosystems from land and along rivers to the coastal zones and in marine environments. The relationship between upstream pressures and downstream effects highlights the importance of coordinating efforts on the management of freshwater and oceans. A "Source to Sea Approach" will be crucial to addressing land-based activities and pollution. The concept links the land-based with the marine and coastal pollution. Several factors that can affect ecosystems downstream, in the coastal zones and in marine environments, originate from upstream developments on land and along rivers. These include direct sources from production on land such as agriculture, industrial activities, forestry, and energy production and through indirect sources such as consumption. In addition, there are several pressures at sea derived from fisheries, transports, extraction of non-living-resources (mining, sand, oil and gas) that affect the marine environment. It may also have effects on coastal zones and upstream in deltas and rivers. China is addressing these issues through the River, Bay and Coast Chief systems (see **Feil! Fant ikke referansekilden.** in Chapter 4).



Key flows connecting geographies from source to sea: water, sediment, pollutants, biota, materials and ecosystem services flows. Source: International Water Association

China’s coastal zone management is moving into a phase of better land and sea coordination. Land and its neighbouring sea are an integrated system, so the marine ecosystem and land ecosystem need to be considered into one overall coastal planning. Currently, different levels of governments in China are preparing the “Overall Land-Sea Planning”, a zoning scheme that will coordinate development plans for both land and sea. This plan will put “land-sea space overall management” into the general regulation. First, it establishes the goals and principles of coordination between land and sea, and promote the interaction between land and sea industries and infrastructure development, to form a new pattern of coordinated development of land and sea. Second, it develops comprehensive utilization of land and sea space, establishes an environmental management system leading by local government and consist of development and reform, land, transportation, environmental protection, water conservancy, maritime, marine and fishery, and military-related departments. Third, it then uses this system to coordinate the spatial management and resource utilization from both land and sea, and maintain the health of both terrestrial and marine ecosystems. The biggest challenge of connecting land and sea is that there are still some conflicts between the existing land area planning (which is the “General Planning for Land Use”) and the sea area planning (which is the “Marine Functional Zoning Scheme”). Therefore, the new zoning plan that takes both land and sea environmental protection and economic development into consideration as mentioned above, and relevant institutional reforms, policies, and measures to promote land-sea coordination, are urgently needed.

6.5. Availability of and use of knowledge

A key challenge for enabling ecosystem based and integrated management is the availability and use of scientific knowledge about the ecosystem. However, comprehensive knowledge about the structure and functioning of marine ecosystems is still inadequate. Furthermore, climate changes and assessment of the vulnerability and resilience of marine ecosystem are mostly lacking. For example, IPCC SROCC (2019) identifies that there are a number of marine environments and ecosystem components where insufficient scientific understanding limits the assessments of risks. Examples of gaps include the linkages between single organisms to communities of organisms, knowledge of climate feedbacks in biological systems, and the capacity and limits of biological adaptation for many ecosystems. The report underscores that increasing observational capacity can help provide the data to improve understanding and modelling of these important biophysical responses to climate change. Some of the largest sea level increase that has been observed lately is in the Western Pacific, due, in part to changing wind patterns associated with climate variability Sea level rise and warming are thus particularly intensive for China coastal along the western part of the Pacific Ocean.

Consequently, more knowledge is needed and the knowledge that exists need to be available in order for the decision-makers to make robust decisions. Encouragement should be given to pursue efforts to improve the knowledge base, through i.a. monitoring and research. The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) should be a suitable process and platform to accelerate the development and use of ocean science.

At the local level (traditional) knowledge of the local population, in particular the fishermen and seafarers, should be considered as important contributions to the knowledge base. Collecting, making available and using such knowledge in a structured manner in management processes remains a challenge.

Access to regular and updated assessments of the knowledge base and thus the state of the marine ecosystem would likely provide very beneficial to create the necessary understanding for balanced decision making. Systematic programs for knowledge gathering and innovative methods for disseminating knowledge could be considered.

Box 12: UN Decade for Ocean Science

The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean.

Scientific understanding of the ocean's responses to pressures and management action is fundamental for sustainable development. Ocean observations and research are also essential to predict the consequences of change, design mitigation and guide adaptation. The Decade will as such provide a 'once in a lifetime' opportunity to create a new foundation, across the science-policy interface, to strengthen the management of our oceans and coasts for the benefit of humanity.

The Decade will strengthen the international cooperation needed to develop the scientific research and innovative technologies that can connect ocean science with the needs of society. It will also contribute to the UN processes protecting the ocean and its resources, such as the Aichi Biodiversity targets, the SAMOA Pathway, the United Nations Convention for the Law of the Sea and the Sendai Framework for Disaster Risk Reduction.

As mandated by the UN General Assembly, the Intergovernmental Oceanographic Commission (IOC) of UNESCO will coordinate the Decade's preparatory process, inviting the global ocean community to plan for the next ten years in ocean science and technology to deliver, together, *the ocean we need for the future we want*!

6.6. General (public) understanding of the need for an integrated management approach

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.

Public awareness about the integrated approach in China needs to be further enhanced. The current situation is that in the areas where relevant management is implemented, such as coastal cities that implement Integrated Coastal Management and counties that implement River Chief System and Bay Chief System, public awareness has been significantly improved. However, public awareness is relatively weak in areas where relevant management has not been carried out. Moreover, there are very few NGOs in China, especially those with great influences, how to encourage NGOs to promoting public awareness has always been a big challenge for China's environmental management. To raise the overall public awareness, there is a need to make the utmost of news and media to inform and explain, for example, weekly columns and articles in local newspapers and books, relevant programs broadcasting on local TV and radio. There is also a need to seek appropriate approaches for more NGOs and public participation in the holistic system, for example, selecting a community and industry representatives and developing online public survey systems.

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Appendices

Case Study 1

Hong Kong Waters towards Ecosystem-Based Management[1]

Abstract

This case will serve to overview the ocean governance progress and practices in the Great Bay Area of the Pearl River Delta (PRD) with a special focus on the waters off the Hong Kong area. We assess the experiences and lessons learned from the regional practices of ocean governance in order to identify challenges in the region, and generate important policy related recommendations to both the central government of China and regional governments such as the Hong Kong SAR. This case study is also aiming to provide significant science-based ocean governance concept to the new initiative being launched as a major development of high technologies in the Guangdong-Hong Kong-Macao Bay Area (also known as Greater Bay Area), which is the most highly populated bay area worldwide, home to over 69.5 million people, with a total GDP of over $1.69 trillion in 2017.

1. Introduction

The PRD covers ~ 4000 km^2 marine area and ~56000 km^2 land area (Figure 1). The ocean conditions and marine life, which supports a great diversity of marine life and ecosystems, largely shape the environment features of PRD. The ocean and humans are inextricably linked in the PRD via various key social and economic activities. Meanwhile, the marine environment and its ecosystem are under great pressures from both the land and ocean under climate changes.

Situated in the southeast part of the PRD, Hong Kong (HK) is surrounded by marine waters to which its overall environmental sustainability is intimately linked. HK waters are influenced by waters from the Pearl River Estuary (PRE) to the west, Mirs Bay to the east and the South China Sea continental shelf off HK to the south. The PRE is an estuary linked to the Pearl River, the 17th largest river in the world, and has an average annual discharge rate of ~10,000 $m^3\ s^{-1}$ (Dai et al., 2014). To the east of HK, the Mirs Bay is a semi-enclosed bay in the northern South China Sea (NSCS), embedded into the terrene about 18 km north-northwestwards (Li et al., 2014). Together the waters from these areas form the interactive river-estuary-shelf (RES) coastal waters.

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HK has a marine area of ~1651 km^2, about 1.5 times its total land area (Figure 1). Key social and economic activities in HK mainly occur in the region along its 1200 km coastline. The marine-related economy is substantial, with fisheries alone worth an estimated ~HK 2.9 billion in 2018 (HK Agriculture, Fisheries and Conservation Department, AFCD). Over the last 30 years, rapid industrial and agricultural development and urbanization have produced large amounts of anthropogenic nutrients input into the PRD and onto the adjacent shelf (Callahan et al., 2004; Harrison et al., 2008; Huang et al., 2003). The nutrient loading in the PRD increased more than seven fold during the last three decades (Ma et al., 2009). As a result, the coastal waters in PRD and around Hong Kong are affected by persistent and increasing eutrophication. This deteriorating situation may increase the frequency of harmful algal blooms (HABs), expand the area of hypoxic zones and lead to other ecosystem disruptions.

Figure 1. Coverage of the Pearl River Delta
(https://www.pland.Gov.hk/pland_en/misc/great_prd/images/prd.a.jpg)

Coastal eutrophication is caused by excessive nutrient loading which stimulates phytoplankton blooms when physical, chemical, and biological conditions are favourable. It may lead to harmful algal blooms (HABs) and hypoxia (or “dead zones”, where dissolved oxygen is generally below 2 mg/L), both of which threaten the ecosystem. Eutrophication/hypoxia has led to mass mortality of impacted marine organisms and changes in seawater chemistry, thereby altering elemental biogeochemistry and enhancing coastal acidification (Kristiansen et al., 2002; Rabalais et al., 2002; Grantham et al., 2004; Cai et al., 2011). Coastal eutrophication has been a global environmental issue for decades, yet its persistence reflects the scientific and socio-economic complexities involved in alleviating the problem. Understanding the full spectrum of intrinsic coupled physical, biogeochemical, and pollution processes in eutrophication is crucial to predicting and mitigating the impacts of eutrophication, and it remains a huge scientific challenge regionally and globally.

Eutrophication/hypoxia in Hong Kong waters is primarily caused by the ecosystem's responses to the increasing nutrient discharge from the Pearl River and local sewage effluent. Meanwhile, increasing discharge of organic pollutants also modulates the biogeochemical pathways and ecological consequences and it further increases the severity of eutrophication/hypoxia. Highly variable oceanic currents transport the nutrients in the interactive river-estuary-shelf (RES) waters around Hong Kong, which undergo complex coupled physical-biogeochemical processes and modulate eutrophication/hypoxia. To date, these key processes have not been investigated in a comprehensive manner in the RES waters, and they remain largely unresolved in similar ecosystems elsewhere in the world.

The risk of eutrophication and hypoxia is rapidly increasing around HK despite the massive HATS sewage treatment project (Qian et al., 2018). Indeed, the recent field survey in July 2014 showed that bottom hypoxia (DO<2 mg/L) now covers an area of ~3000 km^2 southwest of HK (Su et al., 2017). Similar hypoxic conditions were also observed in 2011, 2012 and more recently, 2016, 2017 and 2018 cruises. Long-term monitoring data collected in the area adjacent to Hong Kong by the Hong Kong EPD showed a decreasing trend of ~2 ± 0.9 $\mu mol\ kg^{-1}\ yr^{-1}$ in the annual minimum DO concentration in bottom water over the past 25 years between 1990-2014 (Qian et al., 2018). Associated with the decrease in DO was an increase in the annual maximum surface concentration of DIN at a rate of ~1.4 ± 0.3 $\mu mol\ kg^{-1}\ yr^{-1}$, suggesting that eutrophication is the most plausible driver of oxygen deficiency in this region. This also indicates that eutrophication and hypoxia are becoming increasingly widespread and large scale and are severely degrading water qualities around HK.

Furthermore, seasonal hypoxia has also been occurring frequently even in the eastern waters (Mirs Bay) during the past 10 years (Li et al., 2014). In contrast, before the 1990s only small-scale and short-lived hypoxia events were recorded (Yin et al., 2004), but, since then, these events have been increasing in intensity, frequency, and scale. Hypoxia has been growing and has reached to an alarming level in HK. If the current trend continues, large-scale hypoxia could spread to the entire area southwest of HK in the coming years and, as well as to other HK waters. This may eventually offset the progress made by costly HATS and cause severe ecological and environmental damage as eutrophication and hypoxia rapidly expand towards Victoria Harbour.

Various reclamation projects and busy maritime traffic in the western waters of HK lead to habitat loss which poses adverse effects to many marine species, such as the Chinese white dolphins (Lai et al., 2016).Overfishing, marine pollution, marine development projects such as (reclamation, sand dredging and mud dumping) resulted in a continual decline of the fisheries resources and productions in Hong Kong since the late 1980s (Report of the Committee on Sustainable Fisheries).

2. The implementation of ocean management

2.1 Current management practices in HK

In order to promote the sustainable marine environment, a number of management practices are implemented by the Hong Kong SAR Government. Also HKSARG and the Guangdong Provincial Government have been collaborating closely on cross-boundary water quality protection in PRD.

2.1.1 Sewage management

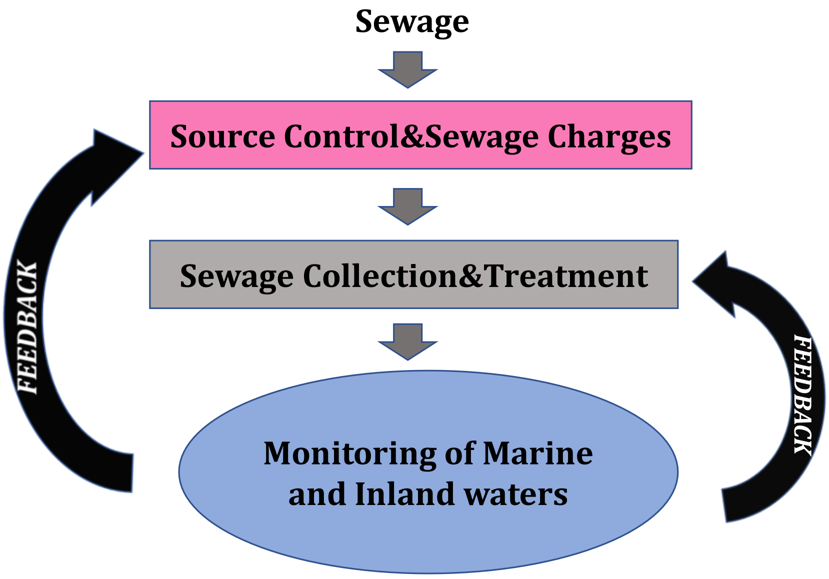

Figure 2. Sewage management practices in Hong Kong

Source control & Sewage charges

In Hong Kong, the effective control of water pollution is achieved through enactment of the Water Pollution Control Ordinance (WPCO) in 1980. In addition, sewage charges were introduced in 1995 to help pay for the growing operational and maintenance costs of sewerage infrastructure works. It also implements the polluter-pays principle to facilitate long-term sustainability of the environment. There are two types of charges under the charging scheme:

- Sewage Change (SC) aims to recover the cost of collecting and treating wastewater at or below domestic strength.
- Trade Effluent Surcharge (TES) aims to recover the additional cost of treating effluents of strength stronger than domestic sewage.

Harbour Area Treatment Scheme (HATS)

Harbour Area Treatment Scheme (HATS) is a major Government infrastructure project in Hong Kong. It is being implemented in stages to combat water pollution caused by urban development around Victoria Harbour. HATS Stage 1 was commissioned in December 2001 providing treatment to about 75% of sewage from urban areas around the harbour. Tens of billions of dollars have been spent to collect and chemically treat the sewage before being discharged into the southwestern part of Victoria Harbour. Because of HATS, dissolved oxygen (DO) levels increased by ~10% and un-ionized ammonia (UIA) levels decreased by ~60% in 2001 to the west of Victoria Harbour (HATS Environmental Impact Assessment Executive Summary, HK EPD). Unfortunately, the trend in dissolved inorganic nitrogen (DIN) has persistently increased and bottom DO has decreased.

HATS Stage 2 will be implemented in two phases, Stage 2A and Stage 2B. Stage 2A will provide treatment to the remaining 25% of sewage from the northern and southwestern parts of Hong Kong Island. In addition, a disinfection facility will be installed to further improve the quality of the harbour waters. E. Coli in Victoria Habour dropped significantly after the commissioning of HATS Stage IIA in end 2015. Implementation of another HATS (Stage 2B) may only marginally improve the level of DO and reduce the level of UIA in Victoria Harbour. The government is further anticipated that the level of NH_4 might increase due to the nitrification process occurring in the Stage 2B biological treatment. These are largely speculations without solid scientific assessment and a debate is raging on whether Stage 2B should proceed in view of its cost (tens of billions of dollars) and uncertain benefits.

Marine water quality monitoring

Since 1986, the Environmental Protection Department (EPD) of the Hong Kong SAR Government monitored the marine water quality at 76 monitoring stations and collects and examines phytoplankton samples from 25 of these stations every month. The rates of annual compliance with the key WQOs (i.e. dissolved oxygen, unionized ammonia, total inorganic nitrogen and E.coli) were assessed based on all the data collected at 76 marine monitoring stations during the year. EPD is responsible for developing policies covering environmental protection; enforcing environment legislation; providing collection, treatment facilities for various types of sewage.

2.1.2 Regional coordination

In August 2000, Hong Kong and Guangdong Governments established the Pearl River Delta (PRD) Water Quality Protection Special Panel (the Special Panel) under the Hong Kong-Guangdong Joint Working Group on Sustainable Development and Environmental Protection (the Joint Working Group) to promote exchange and cooperation on the protection of the water environment in the Pearl River Estuary region. To strengthen the scientific basis for water quality management and to enhance cooperation in the region, the Special Panel jointly developed a computer water quality model for the Pearl River Estuary region (the PRD Model) in 2008. The primary objective is to construct a computer model that is capable of simulating the complicated flow distributions and water quality processes in both the river network and the coastal waters.

2.2 knowledge gaps towards ecosystem-based management and planning

HK’s marine environment has been increasingly suffering anthropogenic pressures with eutrophication and seasonal hypoxias, which will be likely expanded in scopes causing ecosystem consequence yet such trends are not been assessed. Mechanistic and quantitative studies on the processes and influence of hypoxias are ongoing but yet to be conclusive. Developing a novel coupled physical-biogeochemical-pollutant (CPBP) modelling system to project trends under different treatment scenarios is under way but challenging. Moreover, the long term monitoring of water quality is still insufficient and the impact of global change is not considered sufficiently. The cumulative effects of multiple anthropogenic stressors on marine ecosystems needs to be assessed across different stakeholders such as scientists, politicians, policy-makers and the public.

3. Challenges and lessons learned

Like in many regions elsewhere in the world, silo management is one of the major issues in ocean governance in Hong Kong. Among others, missing components towards integrated/ecosystem based management also include impact assessment at cumulative levels and at the trans-boundary level.

Consideration of global change remains insufficient in the present marine management and planning scheme.

It is highly recommended that IOM concept and implementation be framed as the new Greater Bay Area initiative being launched. Here, cross-boundary mechanisms among Hong Kong, Macau and Guangdong province is especially vital to initiate the concept.

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Case Study 2

Xiamen Integrated Coastal Management System[1]

Abstract

Xiamen has implemented ICM for over 20 years. In the beginning, Xiamen introduced ICM concept and established an ICM management system. Then it started to implement a series of marine ecosystem rehabilitation projects in areas including the West Sea, Yundang Lagoon, etc., which have greatly improved the ecological environment, protected marine resources, beautified marine landscape, and promoted the rapid development of marine science and technology and marine economy. During the past 20 years, Xiamen's marine space use conflicts, resources and ecological problems have all been greatly alleviated, and the essence of marine management has successfully transited to ecosystem based integrated coastal management.

1. Introduction

Xiamen, with a population of 4.11 million in 2018, is a port city located on the west coast of the Taiwan Strait. As of 2018, it was the 7th largest container port in China and the 14th largest in the world. Xiamen Island is surrounded by 394 km^2 of sea and has a coastline of about 234 km. Xiamen Bay, including the Jiulong River Estuary, West Sea, Tongan Bay and East Sea (Figure 1), is home to nearly 2,000 marine species including protected species like Chinese white dolphins, lancelets and egrets. The bay has been a vital part of Xiamen's economy for centuries.

Following China's major reform initiative in the late 1970s, Xiamen became one of the first four special economic zones. Since then, Xiamen has experienced an economic boom that has brought with it a series of resource use conflicts and pollution problems. This was particularly visible in the early stages as little attention was paid to ecosystems and the environment (Chua et al. 1997; Xue et al. 2004). Seawall constructions and reclamations drastically modified the coastal morphology and hydrodynamics and reduced the area of surface water and tidal influence.

Starting in the 1980s, marine aquaculture grew rapidly and was further intensified in the mid-1990s. By 2001, it covered nearly half of the West Sea area. Waste from coastal aquaculture ponds and excess feeds from fish cages polluted the marine environment. Nearly all domestic and industrial wastewater was discharged into the sea untreated. Many natural habitats were damaged by pollution. Mangrove forests declined from 1.8 km^2 in 1987 to 0.2 km^2 in 1995. Major events of fish deaths occurred around twice per year in the period from 1984 to 1996 (PEMSEA 2006a) and populations of dolphins, egrets and lancelets declined (ITTXDP 1996; XDPO 1998; Xue et al. 2004; Lin et al. 2005; PEMSEA 2006a, 2006b).

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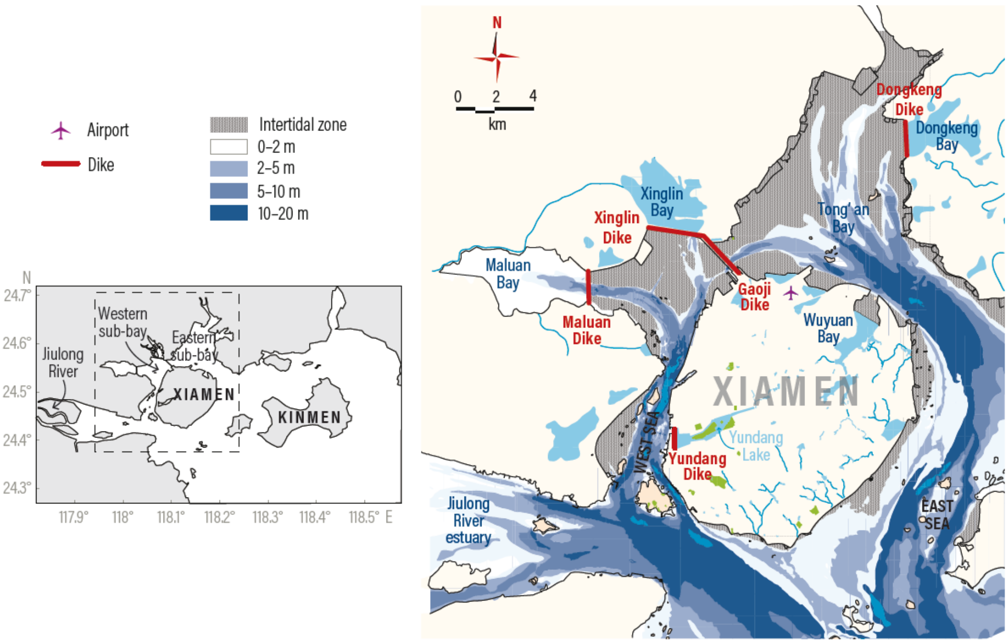
Faced with environmental degradation, sea-use conflicts and ineffective management as well as deficiencies in legislation, funds, public awareness, information and pollution-prevention capabilities (PEMSEA 1998), Xiamen implemented a new ocean and coastal management system in 1994. Integrated coastal management (ICM) in Xiamen has undergone four stages of development: structural design from 1994 to 2000, marine ecosystem rehabilitation from 2000 to 2009, co-governance of land and sea from 2009 to 2015 and sustainable ocean economy since 2015.

2. The implementation of ocean management

With this backdrop, the Chinese government decided in 1994 to make Xiamen a demonstration site for ICM in collaboration with GEF, UNDP and IMO's regional programme (Xue et al., 2004; Cao and Wong, 2007; Fang et al. 2011; Mao and Kong, 2018).

Figure 1. Map of the Xiamen Area

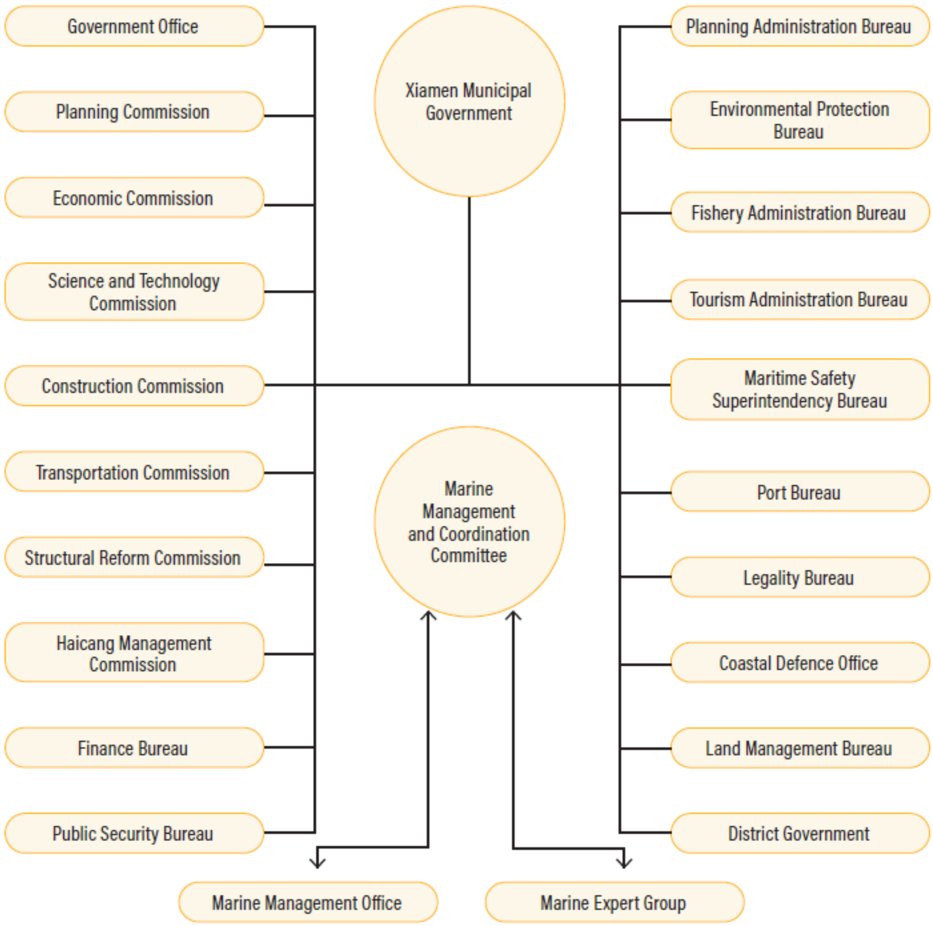


Note: In the legend, *m* stands for metre. *Source:* Winther and Dai et al. 2020.

3.1 Early stages of ICM in Xiamen

Between 1994 and 2000, in the early stage of ICM in Xiamen, a coordinating, law-enforced and science-supported mechanism was established. From 1994 to 1996, to advance ICM, individual projects were selected under the guidance of international organisations such as GEF, UNDP and IMO. These projects included, for example, establishing pollution management plans and sea use zoning (GEF et al. 2009). In 1996, the municipality of Xiamen initiated an ICM leadership group consisting of the mayor and officials from different governmental departments, under which an ocean office was established and tasked with organising regular meetings with ocean-related sectors within aquaculture, transportation, construction and science and technology (Xue et al. 2004) (Figure 2). During this phase, a series of marine laws and regulations, including the Administrative Regulations on Xiamen Sea Area Use for development and use and the Regulation on the Management of Natural Protected Areas for Chinese White Dolphin for environmental protection and ecological conservation, were adopted. A series of spatial planning programmes, including the Functional Zoning of Xiamen Sea Area, were also initiated. To provide support in developing these new tools, a municipal ocean specialist team consisting of leading researchers was formed.

Figure 2. Organisational Structure for Integrated Coastal Management in Xiamen



Source: Xue et al. 2004.

3.2 Ecosystem rehabilitation

Xiamen's ICM entered a new phase in the early 2000s with the initiation of a number of marine ecosystem rehabilitation projects. The first was established in the Yundang Lagoon, located in the downtown area of Xiamen Island. This lagoon used to be a fishing harbour connected to the Western Sea of Xiamen, enriched by mangroves, and had once sheltered huge flocks of egrets. During the 1970s, a dam was built at the mouth of the lagoon to cut off the water flow, converting the lagoon into an enclosed body of water. In addition, the surface water area was reduced from 10 km^2 to 2.2

km^2 due to reclamation for agriculture purposes. Untreated industrial and domestic wastewater was also being discharged into the lagoon. Residents began leaving the area (PEMSEA 2006b). Due to the poor environmental conditions, the site was blacklisted by the national Environmental Protection Agency. This situation was not resolved until a series of cleaning actions were implemented, including improving the waste management systems, constructing sewage treatment plants, building a retaining wall and performing dredging. The water exchange between the Yundang Lagoon and the sea was improved and mangroves were replanted.

According to the Functional Zoning of Xiamen Sea Area, the dominant functions of the area are ports, shipping and tourism. However, aquaculture was its primary function until the 1990s. In 2002, Xiamen stopped its aquaculture activity to solve ocean-use conflicts and initiate ecosystem rehabilitation in the area. The aquaculture facilities were completely removed, and waterways were dredged to ensure their prime functionality.

Several other rehabilitation initiatives were also implemented, including building a wetland park, restoring the shoreline, planting mangroves, building uninhabited islands for birds to forage and improving the sewage treatment system (Wang et al. 2018). In Wuyuan Bay, 89 hectares of wetland were established. Various measures improved the water exchange in the East Sea by 30 percent. Combined with better water quality, the conditions for the Chinese white dolphins improved significantly.

Following the successful rehabilitation projects, Xiamen's efforts in ICM during 2009–2015 were mainly focused on governing the rivers and sea by establishing a system for controlling the terrestrial pollution. Since 2015, after over 20 years of ICM practices and in response to major national guidelines ('Managing Land and Sea as a Whole' and 'Constructing Ecological Civilization'), Xiamen has begun stage four of development—integrating land-sea management and the concept of developing 'blue growth' (Mao and Kong 2018).

3. Challenges and lessons learned

The main aspects of ICM in Xiamen can be characterised by the establishment of a legal framework and enforcement mechanisms, science-policy integration, marine monitoring system and information sharing, and public awareness mechanisms. As a management instrument to rationalise the use of marine and coastal resources and environment, marine spatial planning (called 'marine function zoning' in China) is a significant component of the ICM programme in Xiamen (Su and Peng 2018). There are a number of lessons to be learned from Xiamen's experience.

First, coordinating numerous stakeholders—from sectors including urban planning, fisheries, shipping, transportation, science, port authority and conservation—has been a challenge. To meet this challenge, the existing and successful concept of 'River Chief System', where one stakeholder is given extended responsibility, is also being implemented for the ocean space, as the 'Bay Chief System'.

Second, a comprehensive ICM system for laws and regulations was developed without fully aligning with existing regulations for terrestrial management in the same area (Su and Peng 2018; Peng et al. 2006). Thus, land and ocean management has been insufficiently integrated, something that needs to be refined when ICM in Xiamen is further developed. This may include, for example, creating zoning plans that account for both land and ocean.

Third, more management efforts and enforcement measures are needed to control non-point source pollution from land-based activities in watersheds with runoff to estuaries and bays.

Finally, integrating science and technological guidance throughout the process—including during design, implementation, evaluation and refinements—has been very valuable.

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Case Study 3

Integrated, Ecosystem-Based Management in Bohai Sea[1]

Abstract

Bohai Sea is a shallow semi-enclosed sea with a total area of 77,000 km^2, it is the only inner sea in China. Bohai Sea is bordered by Shandong, Hebei, Liaoning provinces, and Tianjin municipality, it is one of the three major centres of fast economic growth in China. As such, the Bohai Sea region, with its growing population and economy, was expected to usher in industrial and urban development. The Bohai Sea used to be one of the most important fishing grounds in China and possesses a large amount of oil fields which provide natural resources for the economic development of the coastal regions. In recent decades, the massive human activities such as land reclamation, pollutant discharged from rivers and oil field exploitation caused a sharp deterioration of the marine ecological system in the Bohai Sea. There are great efforts from Chinese government and local governments to improve the ecological and environmental conditions of Bohai Sea, such as: " Bohai Blue Sea Action Plan" (2001-2005); "General plan for environmental protection in Bohai Sea" (2008-2020); "Bohai Marine Ecological Red Line System" (started from 2014); "Water pollution prevention and control plan in key basins" (2011-2015). Bohai marine environment governance is increasing, but the effect is not obvious. In 2015 Chinese Government adopted the integrated Water Pollution Prevention and Treatment Action Plan entailing measures for pollution reduction in ten priority industries, sewage treatment in urban and rural areas and ports; industrial restructuring and upgrading; water conservation through water efficiency improvement and technical support; use of market mechanisms; law enforcement; water environment improvement through total pollution load control, environmental risk assessment; safeguard of water security; clarity in roles and responsibilities of all parties; and enhancement of public participation and scrutiny. It is expected these measures will contribute to the recovery of a living Bohai Sea region. However, it remains a big challenge to alleviate the deteriorating trend of the marine ecosystem in Bohai Sea and to eventually reach a sustainable way of the regional development.

1. Introduction

Bohai Sea locates at 37°07' to 41°00' north latitude, 117° 35' to 122° 15' east longitude, the east connects to Yellow Sea via the Bohai Strait, the north, Bohai Sea adjacent to Liaoning, Hebei, Shandong provinces and Tianjin municipality (Figure 1-1). It is about 555 km long from northeast to southwest Bohai Sea, about 346 km wide from east to west, the total area is 77,000 km^2, the total coastline is 3,784 km, of which the continental coastline is 2,668 km long, the average water depth is 18 m, the maximum water depth is 85 m, 20 m shallow area accounts for more than half.

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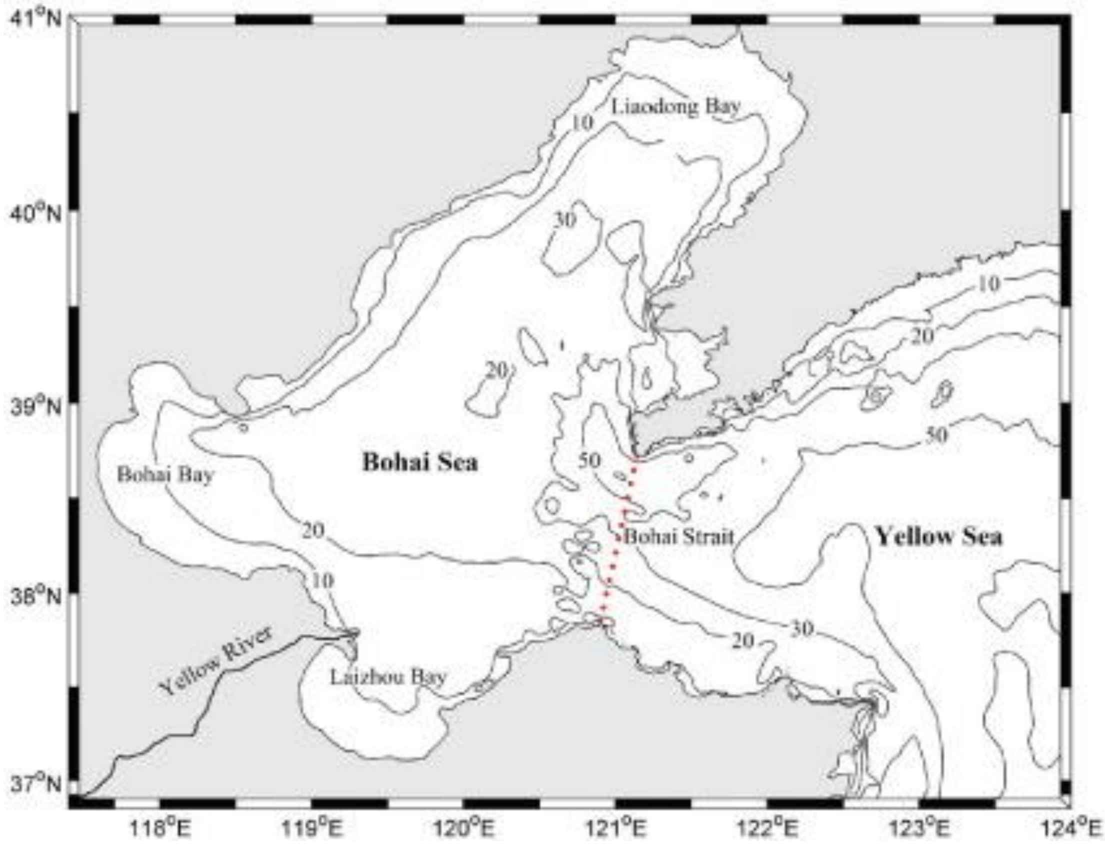

Fig. 1-1 Bathymetry of the Bohai Sea (m). The dashed line indicates the boundary between the Bohai Sea and the Yellow Sea

In general, the Bohai Sea is divided into five regions: Liaodong Bay, Bohai Bay, Laizhou Bay, Central Bohai Sea and Bohai Strait. The continent affects the Bohai Sea by river discharged freshwater, dissolved and suspended matters. There are 45 rivers around the Bohai Sea, and about 7.2×10^{10} m^3 freshwater, 1.3×10^{10} t sediment, 3×10^{10} t waste water, 2×10^4 t contaminants are directly discharged into the Bohai Sea annually (Zhang *et al.*, 2006). The freshwater input causes vertical and horizontal variations of salinity in estuarine areas, further forming stratification and fronts that act as barriers to water mixing. The Yellow River (also called Huanghe River), as the second largest river in the world in terms of sediment load, discharges 1.1×10^9 t of sediment into the Bohai Sea annually. Approximately 70 ~ 90% of the sediment transported to the sea is deposited at the mouth of the Yellow River, finally determining the morphological changes in the Bohai Sea. Sediment discharged from the Yellow River decreased sharply over the past 60 years with a reduction of about 75% due to the influence of human activities and climate changes (Zhang *et al.*, 2012), and the sediment load from the Yellow River will most likely remain small over the next 2 to 3 decades.

The Bohai Sea has experienced rapid coastline changes due to natural developments of the Yellow River delta and large-scale anthropogenic land reclamation. Satellite remote sensing studies indicated that over the last three decades the newly formed land reclamation area in the Bohai Sea cover 2278 km^2. These morphological changes induced by the coastal development have significant effects on the tidal regime in the Bohai Sea, leading to a rise of the tidal amplitude and the onshore sediment transport. And most importantly, the reclamation seriously damages the marine ecosystem, disturbs or takes away coastal wetland and reduces biodiversity.

The Bohai Sea used to be one of the most important fishing grounds in China and possesses a large amount of oil fields which provide natural resources for the economic development of the coastal regions. In recent decades, the massive human activities such as land reclamation, pollutant discharged from rivers and oil field exploitation caused a sharp deterioration of the marine ecological system in the Bohai Sea.

2. The implementation of ocean management

2.1 Ecological Context

The Bohai rim is an important economic zone in China, with rapid economic development relying on fisheries, ports and oil resources. However, with the development of economy, there are more and more problems of disturbance and pollution to Bohai Sea ecosystem. In recent years, the ecological problems in the Bohai Sea have become increasingly prominent, which are mainly manifested in the reduction of coastal wetland area, the increase of seawater salinity in the coastal waters, the aggravation of marine pollution and eutrophication, the frequent occurrence of red tide and jellyfish disasters, and the decline of fishery resources.

The eutrophication of the Bohai Sea is serious, and the ratio of nitrogen and phosphorus in the sea water is unbalanced. The main cause of eutrophication in Bohai Sea is the discharge of agricultural sewage, domestic sewage, aquaculture sewage and industrial wastewater. The results show that the eutrophication area of the Bohai Sea is about 20000 km2, accounting for 25% of the total area of the Bohai Sea. The eutrophication degree of the sea water in the bottom of the three bays and the adjacent areas of the Yellow River estuary is relatively prominent. Marine eutrophication affects the biomass and group composition of primary marine producers, induce ecological disasters such as red tide, and jellyfish bloom etc., it also affects the ecosystem health of the Bohai Sea. In addition, the problems of anoxia and acidification related to eutrophication have gradually emerged in recent years.

2.2 Governance Context

In order to contain and improve the increasingly serious marine environment problem in Bohai Sea, the state and local governments have carried out a series of governance work. In 1999, the "Comprehensive management plan of Bohai Sea" was launched, in 2001, the "Bohai Blue Sea Action plan" was put into practice. The "Bohai Sea environmental protection master plan" was approved by the State Administration in 2009. The local governments of Shandong, Liaoning, Hebei and Tianjin also formulated their own implementation plans to protect the Bohai Sea environment and continued to add 40 billion yuan to control the Bohai Sea pollution. In 2012, the State Oceanic Administration issued the most stringent Bohai environmental protection policy, setting the ecological protection red line for the Bohai Sea, and the three provinces and one city around the Bohai Sea also defined the corresponding ecological red line according to the requirements. In 2015 Chinese Government adopted the integrated Water Pollution Prevention and Treatment Action Plan entailing measures for pollution reduction in ten priority industries, sewage treatment in urban and rural areas and ports; industrial restructuring and upgrading; water conservation through water efficiency improvement and technical support; use of market mechanisms; law enforcement; water environment improvement through total pollution load control, environmental risk assessment; safeguard of water security; clarity in roles and responsibilities of all parties; and enhancement of public participation and scrutiny.

3. Challenges and lessons learned

3.1 Lessons learned

(1) The efforts of marine environment management in Bohai Sea are increasing, but the effect is not obvious. From the current Bohai Sea environmental governance policies and measures, the governance of the Bohai Sea marine environment has entered an unprecedented height and continues to strengthen. However, in the practice of these relevant countermeasures, there are some deficiencies, such as focusing on investment and construction, ignoring operation and supervision. According to the analysis of the management of the marine environment in the Bohai Sea, the marine environment quality of Bohai Sea has been improved to some extent, but the quality of the marine environment in the Bohai Sea has not changed fundamentally, the environmental pollution in the Bohai Sea is still serious.

(2) Lack of effective regional cooperation in marine environmental governance. According to the law of the people's Republic of China on the protection of the marine environment, the management power of the marine environment of Bohai Sea is divided into five parts: the Ministry of environmental protection, the Ministry of natural resources, the Ministry of communications, the Ministry of agriculture and the Navy, as well as the local governments at all levels in three provinces and one city around Bohai Sea, which determines that the marine environment management of China adheres to the principle of territoriality. Because of the mobility of the ocean itself, the scope of the impact of marine pollution is extensive. The pollution caused by a certain region in the development process will spread to the surrounding area or even a larger area with the flow of sea water, thus affecting the overall interests.

(3) The hierarchical marine environmental management system cannot meet the needs of the Bohai Sea marine environmental governance. The implementation of the Bohai Blue Sea Action Plan shows that, the more departments and regions involved in the implementation of the policy, the more conflicts there are, and the less effective the implementation is. The reason for the failure of the Bohai Blue Sea Action Plan is not the formulation of the policy planning itself, but the institutional environment and practice subject behaviour determined by the Bohai Sea environmental management system and mechanism.

3.2 Challenges

(1) Balance between the social economy development around Bohai Sea and the carrying capacity of Bohai Sea.

(2) Function of the Bohai Sea: Oil exploitation, fishery, aquaculture, port, land use heavy industry and tourism, big challenges in the Bohai Sea spatial planning.

(3) Ecosystem Based Management is not only pollution control, but the structure and function of the marine ecosystem, the production and service of the ecosystem.

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Case Study 4

Norway's model for ecosystem-based marine management: Integrated Marine Management Plans.[1]

Abstract

The Norwegian Integrated Marine Management Plans may serve as a model for how to introduce an ecosystem-based management across governmental sectors. The purpose of the management plans is to provide a framework for value creation through the sustainable use of natural resources and ecosystem services of the sea areas and at the same time maintain the structure, functioning, productivity and diversity of the ecosystems.). The scientific/factual basis for the Management Plans is developed with the involvement of all relevant public agencies and research institutions. The Management Plans are presented by the Government and approved by the Parliament and thereby anchored at the highest political level. Elements in the development of the Norwegian Management Plans may have relevance also for China

1. Introduction

Norway was an early adopter of the international call for a more integrated and ecosystem-based ocean management. A white paper to the Parliament in 2002 "Protecting the Riches of the Seas" introduced the integrated ocean management concept for the large marine ecosystems of the Norwegian ocean areas, emphasizing the need for combining sustainable use with the protection of the marine environment. The Norwegian Parliament endorsed the concept, and in 2006 the first integrated management plan was presented to the Parliament for the Lofoten–Barents Sea area, which was chosen as the first ocean area due to potentially conflicting uses and high economic and environmental stakes. In 2009 an integrated management plan was presented for the Norwegian Sea and in 2013 for the North Sea and Skagerrak. Later the plans for the Barents Sea and Norwegian Sea has been updated and recently, in the spring of 2020, the management plans for the three ocean areas was merged into one white paper. This case study provides a description and assessment of the approach taken in in developing and implementing the integrated management plans for the Norwegian ocean areas.

2. The implementation of ocean management

2.1 Ecosystem-based marine management on the international agenda

On a global scale the oceans have the potential to provide the world with more jobs, energy and food. However, the potential is under threat from a number of competing uses, climate change and environmental pressures. Ever since the 1992 UN Rio Conference on Environment and Development, it has been a global acknowledgement that an integrated and ecosystem-based approach to ocean management is key for sustainable development. Recent Reports, such as the OECD 2016 Report on

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Ocean Economy, calls for a strengthening of Integrated Ocean Management in order to reach the full potential in the Ocean Economy. The same goes for the UN Sustainable Development Goal 14.2 which states that "States shall by 2020, sustainably manage and protect marine and coastal ecosystems". The Global UN indicator for implementing Goal 14.2 is "the proportion of national exclusive economic zones managed using ecosystem-based approaches".

According to The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), marine ecosystems now show the impacts of human activities, with coastal marine ecosystems showing both large historical losses of biodiversity and rapid ongoing declines. Fishing activities and the many changes in the uses of the sea and coastal lands are the main drivers, along with pollution from rivers and other land-based sources. Climate change and ocean acidification is projected to become increasingly important as drivers of changes in marine ecosystems, including through shifts in species distribution. According to IPBES, a coordinated mix of measures addressing the human pressures on land, freshwater and the oceans is needed, including multilevel coordination across stakeholders.

2.2 Ecosystem-based marine management in Norway

In order to implement an ecosystem-based approach to marine management the Norwegian Government has since 2002 developed integrated and ecosystem-based Management Plans for the Norwegian Sea areas

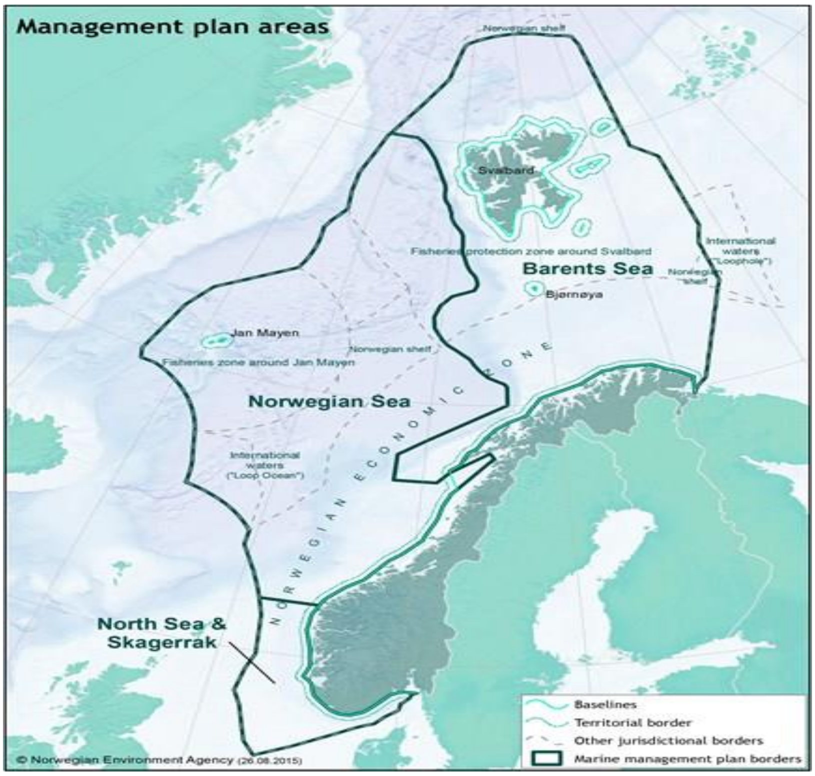

Fig. 1 Management Plan areas

The coastline of the mainland of Norway is 28 953 km (without islands). The number of islands is 239 057. The sea area under Norwegian jurisdiction is part of three distinct Large Marine Ecosystems: The Barents Sea, Norwegian Sea and the North Sea/Skagerrak.

The Norwegian part of the Barents Sea is 960 000 km^2 with an average depth of 230 m, the Norwegian Sea is 170 000 km^2 with an average depth of 1800 m (maximum 4000 m) and the Norwegian part of the North Sea/Skagerrak is 142 000 km^2 with an average depth of 90 m.

Fisheries and maritime transport has for centuries had a particular importance for the Norwegian economy. With the additional development of offshore oil and gas activities and aquaculture, the Norwegian ocean economy has for the last 50 years represented around 30 % of the national value creation (GDP) and well above 50 % of the total Norwegian export.

Well-functioning and productive marine ecosystems is a prerequisite for the role the oceans plays in the Norwegian economy and also the basis for the expected further increase of the Norwegian ocean economy. The purpose of the Management Plans is to provide a framework for value creation through the sustainable use of natural resources and ecosystem services of the sea areas and at the same time maintain the structure, functioning, productivity and diversity of the ecosystems.

2.3 Integrated Management Plans – a process in two steps

There is no one-size fits all solution. Nevertheless, elements in the development of the Norwegian Management Plans may have relevance also for China, in particular the way all 4 dimensions of the ocean (seafloor, water column, surface and time) is addressed and how all relevant parts of the government is integrated.

Geographically, the Norwegian Management Plans covers the sea areas under Norwegian jurisdiction beyond the baseline. Near-shore coastal waters and the fjords are covered by a separate management system through the implementation of the EU Water Framework Directive. The pressures on the marine ecosystems from land-based sources as well as pollution carried to the Norwegian Sea Areas through the ocean currents, is nevertheless addressed in the management plans.

Step one: **The development of a joint and comprehensive knowledgebase**.

All existing knowledge of the functioning, environmental status and pressures on the marine ecosystems, which includes the seabed, the water column and the surface as well as the interaction between the physical and biological conditions, forms the scientific basis for the management plans.

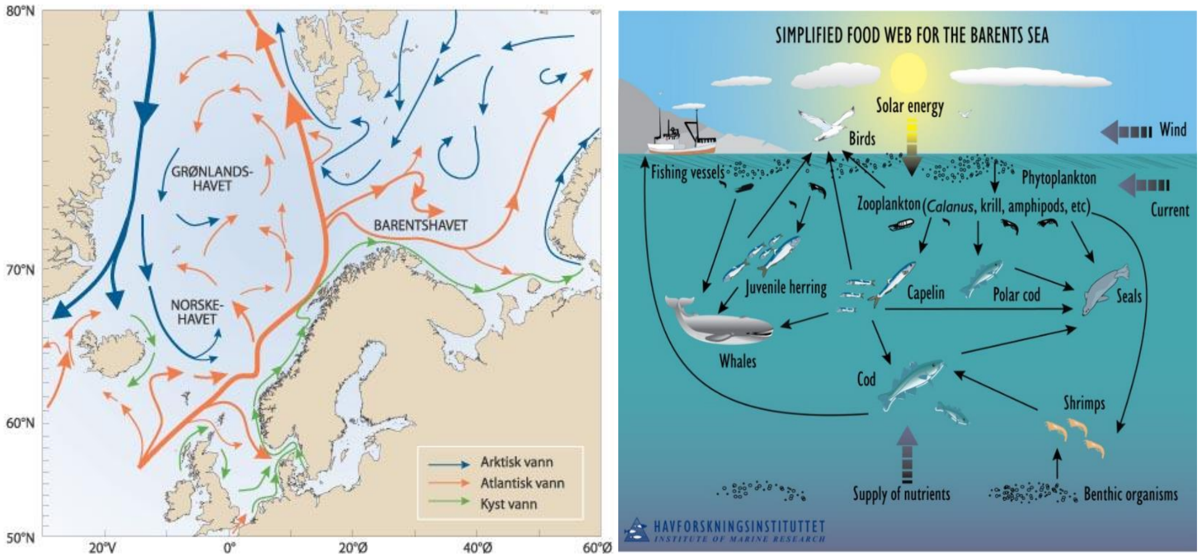

Fig 2: Illustration of the major ocean currents in the Norwegian Sea areas and illustration of the food web for the Barents Sea

The different bits and pieces of this overall knowledge is developed by a number of scientific institutions and agencies. This implies that only through the sharing of knowledge across institutions it is possible to develop a complete knowledge base. All relevant public institutions and agencies that develops knowledge about the marine ecosystems and related value creation are therefore involved in the Management Plan process. On the basis of their combined contributions a comprehensive report presents the best available knowledge on the current state of the marine ecosystem. The knowledge report addresses both the human pressure on the marine environment as well as the value creation of all ocean-based activities (including fisheries, shipping, offshore oil and gas). Considerations of emerging issues, trends and expected developments of the state of the ecosystems are also included. Areas of special importance for safeguarding the ecosystem production and biodiversity, so-called *Valuable and Vulnerable Areas*, are identified. This report, together with a public hearing, provides the knowledge base for the Management Plans.

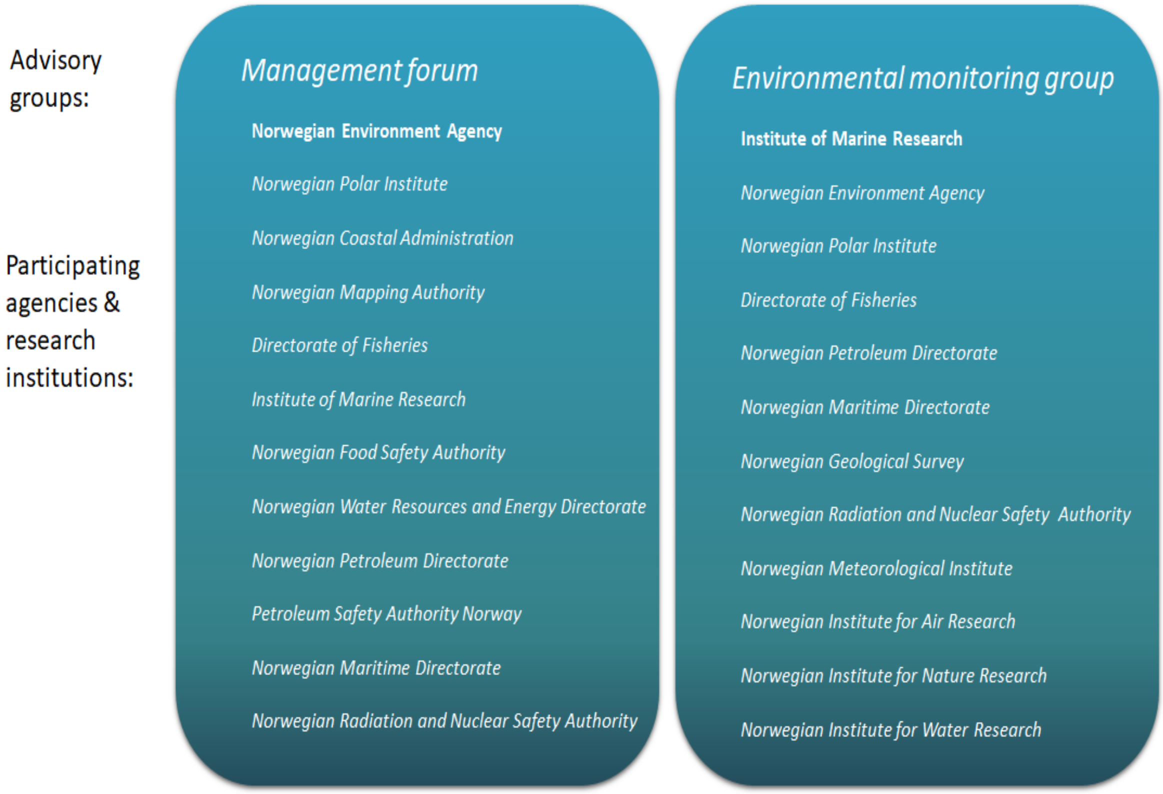

Fig. 3: The advisory Groups in the management plan process and their members.

Step 2. **Development of an integrated and ecosystem-based Management Plan**:

The Management Plan is a political document developed by the Government to be presented as a white paper to the Norwegian Parliament (the Storting). In this way the overall ocean policy framework laid down in the Management Plan is anchored and approved at the highest political level. The Ministry of Climate and Environment holds the responsibility for coordinating the process. It involves all sectoral ministries. The process itself is cross-sectoral, but it does not mean a shift of responsibility: the sectorial Ministries maintain their day to day responsibility for regulating the activities of the ocean industries on the basis of their responsibility for existing legislation governing the different sectors.

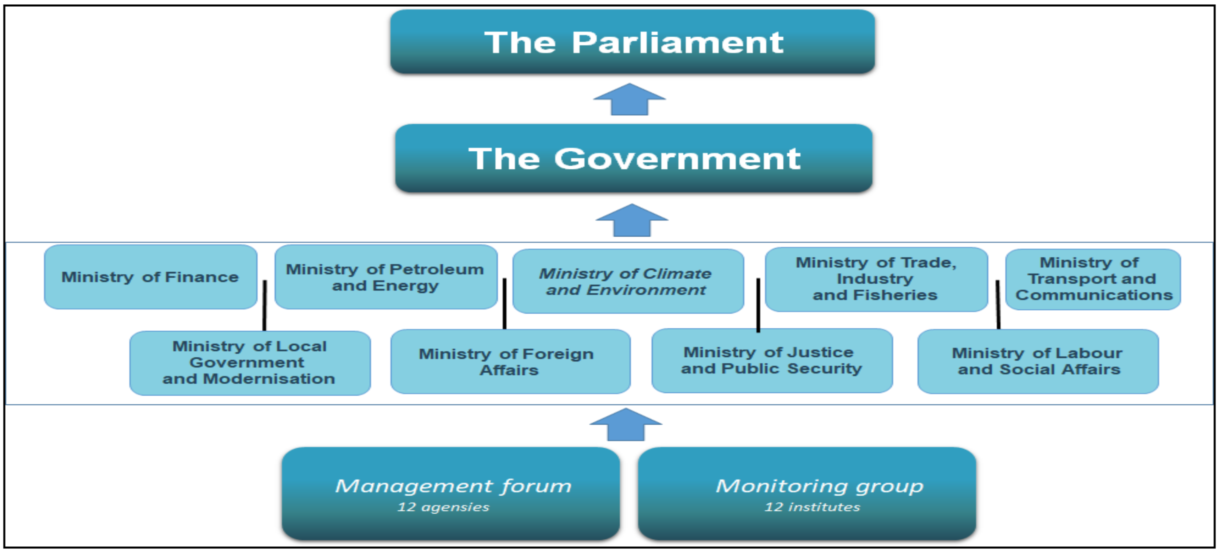

Fig 4: The different levels of the Management Plan process:

The joint factual report forms the knowledge basis for the development of the management plan. To have a joint knowledge base to build on means in practice that the discussions between the Ministries in the development of the management plan can be focused on what should be the policy response from the government to the factual basis presented, rather than discuss the facts themselves.

The process is concluded with a white paper that presents a summary of the factual basis combined with the overall management and policy response in order to safeguard the marine ecosystem and at the same time secure and enhance the value creation of the ocean industries.

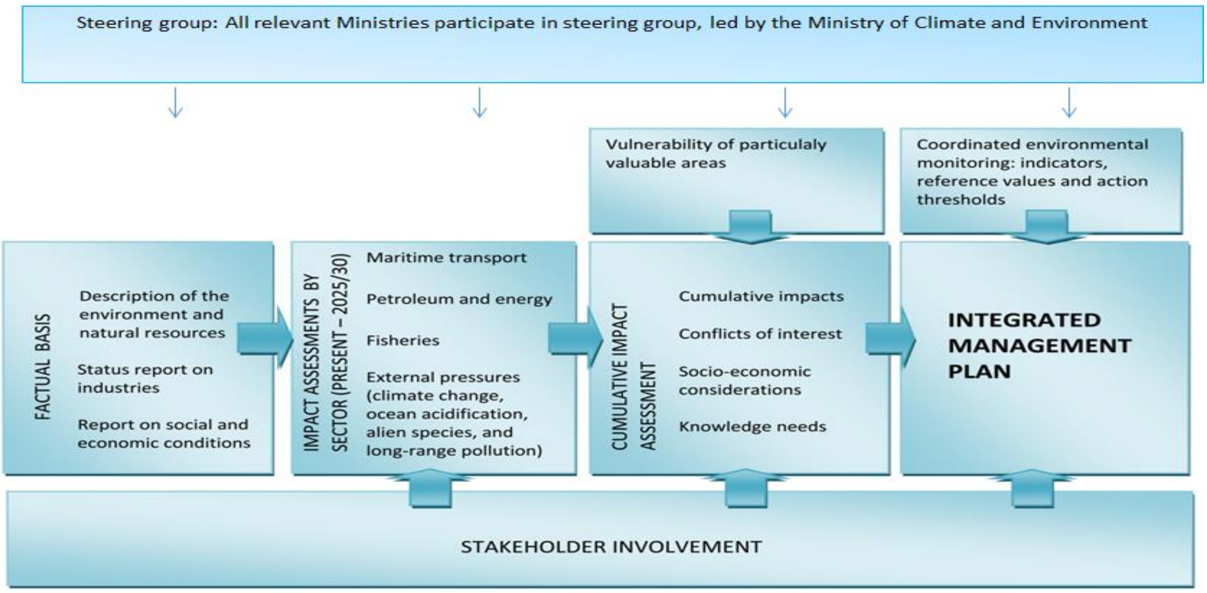

Fig. 5: The Management Plan process:

In order also to include the time-dimension and to be adaptive to change, the Management Plans (including the factual basis) are updated/revised. From now on this will take place on a regular basis every 4 year. A first management plan in this regular cycle and addressing all the three Norwegian LME's will be presented by the Government to the Parliament in 2020.

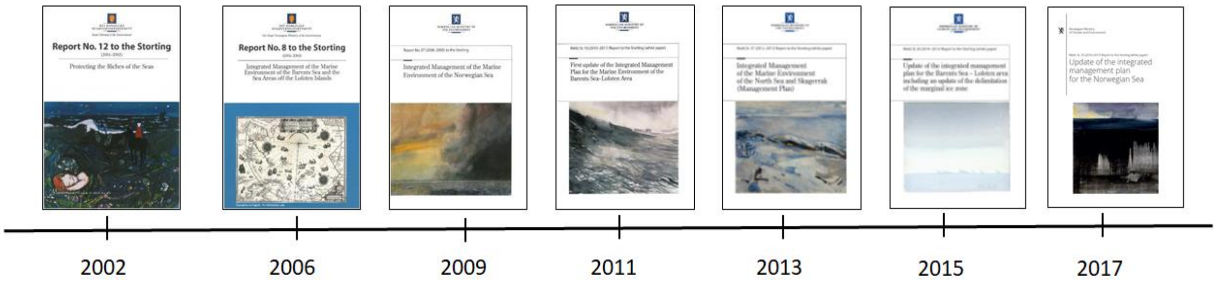

Fig. 6: Management Plans 2002 – 2017:

3. Challenges and lessons learned

3.1 Lessons learned

It can be claimed that the Management Plan models represent a shift in paradigm, in the sense that it means a shift from a fragmented and sector by sector approach to an integrated approach, from a focus on single species to ecosystem considerations and from single pressures to cumulative effects.

The Management Plans has been a useful tool for the Government to develop a more comprehensive and holistic ocean policy, which combines the need to protect the marine ecosystems with the need to produce from the oceans. They clarify the overall framework and encourage closer coordination and clear priorities for the management of Norway's sea areas.

The involvement of all institutions concerned in the development of the joint factual basis has represented a learning process and has built trust between the institutions. To share knowledge and agree on the priorities for the development of better knowledge also contributes to more knowledge for the same economic costs.

The Management Plans increase the predictability and facilitate coexistence between industries that are based on the use of the sea areas and their natural resources.

3.2 Challenges

The Management Plan model is still in a constant development phase, meaning that it is adjusted and adapted on basis of experience. Among those issues that are being considered are the need to cut the administrative costs of the development of the plans and also to enhance the openness and involvement of the non-governmental stakeholders in the process.

There is also a need to develop further the mechanisms and criteria to better link findings on changes in status and trends of environmental quality to management actions, including through systems of indicator and action thresholds.

Climate change is increasingly becoming a main driver of change in Norwegian waters, resulting in changes in species distribution, increasing unpredictability, and exacerbating other stressors. Climate change thus challenges our management systems and capacity to predict and adapt to rapid changes in environmental conditions. With the expected increase of economic activities at sea and the introduction of new industries, such as mineral extraction and offshore wind, the management plans has an important role in preventing future conflicts when it comes to access to areas and to prevent increased environmental pressures.

Geographically, the Norwegian Management Plans covers the sea areas under Norwegian jurisdiction beyond the baseline. As pointed out by IPBES, the many changes in the use of coastal waters and land have a major impact on the marine environment throughout the world, and need to be considered in ecosystem-based approaches coastal and marine management. In Norway the near-shore coastal waters and the fjords are covered by a separate management system through the implementation of the EU Water Framework Directive. The pressures on the marine ecosystems resulting from activities in coastal waters and from land-based sources, as well as pollution carried to Norwegian waters through ocean currents, are therefore also addressed in the factual basis for the Management Plans. The integration of the marine management plans with the management system for coastal zone needs nevertheless to be strengthened.

The comprehensiveness, flexibility and adaptive nature of the Management Plan model gives all reasons to believe that the model can be developed further to meet these challenges.

Case Study 5

Integrated, Ecosystem-Based Management in the Chesapeake Bay Region, United States[1]

Abstract

The Chesapeake Bay Program is widely recognized as one of the world's most effective partnerships for conservation of coastal and marine resources, cutting across six states and the District of Columbia (the national capital), and among agencies with otherwise widely disparate duties and obligations. The history of the program – and its successes and challenges offer important lessons to others interested in redressing environmental degradation and managing changing ecosystems. Undoubtedly the most important is to build partnerships in ways that help each partner meet their own goals, without threatening their basic jurisdictions and authorities. Two others include the establishment of clear and agreed goals and of monitoring and analytical systems to track progress against those goals. Perhaps the greatest reason for slow progress in the Chesapeake Bay was the slow and stepwise approach to expanding the partnership to enable management scale to match the scale of the problem -- only after more than 30 years were all key parties present at the table and in agreement on goals and management obligations at the Chesapeake Bay scale. Climate affects seems likely to require even broader coordination, and some potential solutions are underway there, too.

1. Introduction

Chesapeake Bay is the largest estuary in the United States – the third largest in the world – and one of the most important in terms of the ecological and human services it provides. The ecosystem has been highly altered by heavy land use, as well as extensive in-water uses. Over time, impacts from a growing population, industrial development, resource extraction and a high degree of alteration has led to serious deterioration in the water quality and fishing prospects in the bay. The large number of authorities involved on the land and in the water has historically made it difficult to implement and enforce overarching policies to effectively manage and protect ecosystem-level functions. The Chesapeake Bay was consequently the first estuary in the US singled out for integrated protection planning. In this case-study we provide an introduction to the background for and approach to integrated management of this important area.

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2. The implementation of ocean management

2.1 Ecological Context

Chesapeake Bay is the largest estuary in the United States – the third largest in the world – and one of the most important in terms of the ecological and human services it provides. The Bay has an open-water surface area of over 11,000 square kilometers, nearly 20,000 kilometers of shoreline, and drains a large watershed that covers about 166,000 square kilometers of the coastal plain, piedmont and mountain provinces of Eastern North America. The watershed stretches for more than 800 kilometers, and includes parts of six states: Virginia, Maryland, Pennsylvania, Delaware, New York and West Virginia, as well as all of the Nation's capital, Washington DC (Figure 1).

Figure 1. Chesapeake Bay Watershed (USDA NRCS, 2008)

The central parts of the Bay are brackish – mesohaline – with an extensive mixing zone where lighter freshwater moving downstream overruns denser salt water than can actually flow upstream on and near the bottom. Key habitats in the brackish portions of the Bay include tidal marshes, seagrass beds and oyster beds, all of which are critically important not only for resident and migratory fishes and shellfishes, but also for migrating waterfowl. The most valuable fisheries focus on blue crabs, which comprise roughly one third of national production, and oysters and striped bass, which support both commercial and recreational fisheries.

The human population of the Chesapeake Bay watershed has grown extensively since European colonization began in the early 17th century. The watershed population has more than doubled since 1950 – including a 43% increase from 1980 to 2017, to 18.2 million people, and is expected to pass 20 million within 15 years (CBP, 2012). As a result, the ecosystem has been highly altered by heavy land use on all sides (i.e. urban, residential, agricultural), as well as extensive in-water uses (e.g. fishing, boating, shipping, etc.). Over time, heavy use and high degree of alteration has led to serious deterioration in the water quality and fishing prospects in the bay. For example, excessive nutrient loading from both point and nonpoint sources – mostly sewer plants and farms, but also delivered through the air from wet and dry deposition of NOx emissions – led to blooms of microalgae, shifts in phytoplankton community organization and depressed bottom water oxygen levels. These anoxic events in the past have led to extensive fish kills – all over the region's estuaries – and also to periodic blooms of toxic dinoflagellates that can also kill fish and other aquatic animals. Over time, these impacts have worked to severely deplete oyster beds, seagrass beds, and coastal wetlands, exacerbating direct effects of intensive fishing on Chesapeake Bay resources.

2.2 Governance Context

Even when stakeholders and governments noticed these environmental challenges, the large number of authorities involved on the land and in the water (e.g. private landowners, municipalities, states and the federal government) made it exceptionally difficult to implement and enforce overarching policies. For example, different environmental laws, such as the Clean Water Act, the Coastal Zone Management Act, and the Magnusson-Stevens Fisheries Management Act all serve to regulate activities occurring in the Chesapeake Bay. Each act focuses on different, but often intersecting issues, and is administered by different agencies. For instance, the US Environmental Protection Agency (EPA) sets standards for pollution discharge permitting and water quality management, but delegates implementation to individual states. Meanwhile, the portion of the Clean Water Act focused on wetlands protection is still administered by the EPA, but implemented by a separate agency – the US Army Corps of Engineers. The Coastal Zone Management Act, focused on land-use planning in the coast zones, delegates management to states and local jurisdictions. The Magnuson-Stevens Fisheries Management Act, focused on the management of fishery resources, is implemented through an entirely different part of the federal government (the Department of Commerce), which devolves management design to regional fisheries councils made up of state representatives, while still holding approval power over final decisions.

As one can observe, the governance mosaic and the array of agencies which provide resources for management are much more complicated and can lead to silos, which make integrated resource management extremely difficult. To work towards cohesive management across jurisdictions, interstate compacts and commissions have formed. For example, The fishery resources of the nearshore waters of the Atlantic Coast are additionally managed by an interstate compact commission authorized under federal law, called the Atlantic States Marine Fisheries Commission (ASMFC), which not only specifically manages most of the valuable finfishes of the Mid-Atlantic (including all of the anadromous species, as well as most others), but which also is a key sounding board and action agency for key cross-cutting challenges – including climate change impacts on fisheries management. Another example is the Potomac River Fisheries Commission, which is a bi-state agency that regulates all fishing on the tidal main stem of the Potomac between the District of Columbia and the Chesapeake Bay, coordinating management between the Virginia, Maryland, and the District of Columbia.

2.3 The Chesapeake Bay Program

The key example of integrated management we will share here is the story of is the Chesapeake Bay Program. In response to a grim Congressional research study that identified excessive nutrient loading as the cause of a steep decline in the living marine resources, the Chesapeake Bay Program was formed in 1983. The program is a multi-jurisdictional and multi-stakeholder partnership established to coordinate policies, funding and technical capacity, and set ambitious, quantifiable goals with deadlines. The program was established as a part of an amendment to the Clean Water Act (Section 320), which created a National Estuary Program (NEP). The NEP provides a coordination function across federal programs and across stateliness within watersheds for integrated system-scale management – without impeaching the integrity of the individual component programs, or the authorities of the respective state and federal governments and agencies. These coordinated management programs are adopted through Comprehensive Conservation and Management Plans (CCMPS) for all NEP programs.

The Chesapeake Bay was the first estuary in the US singled out for integrated protection planning, now more than 40 years ago, as obvious signs of nutrient pollution induced action by the more affected states. Congress dedicated $27 million USD in the 1970's to a five-year study of needs and challenges, published in the early 1980s and leading to the creation in 1980 of the Chesapeake Bay Commission (initially a bi-state compact between Virginia and Maryland, then expanded to include Pennsylvania in 1985), and the signing in 1983 of the Chesapeake Bay Agreement by EPA; the States of Virginia, Maryland and Pennsylvania; the mayor of the District of Columbia; and the Chesapeake Bay Commission (CBP1983) The designated representatives of those institutions comprise today's Chesapeake Bay Commission, which serves as the legislative body for the overall program.

The initial focus of the Chesapeake Bay Program was coordinating actions to redress nutrient pollution and its ecological, social and economic effects. In 1987, Chesapeake Bay Agreement was revised to reflect the first numerical nutrient control targets, a 40% reduction in nutrient loading by 2000 (CBP, 1987).) This multi-state agreement was unique at the time, but has become common practice in the CBP, of establishing specific numerical goals for priority outcomes with specific deadlines for action. In 1992, in a revision to the Chesapeake Bay Agreement, the CBP began looking to reduce nutrient pollution sources more aggressively, and also to expand its area of interest to include toxicants. The second important expansion occurred in 2000, when the upstream states (NY and DE) committed to help reach goals; the last (WV) joined in 2002 (CBP, 2000).

3. Challenges and lessons learned

3.1 Lessons learned

Despite significant investments in coordinated action, impacts were less than what had been hoped for. Notable progress was made in land conservation, establishment of forest buffers from streams and also in reopening fish passage blockages (for anadromous species), but the returns downstream in the Bay (in nutrient impacts and also on oysters) lagged. In 2009, President Obama reemphasized the importance of integrated conservation, signing an executive order directing federal agencies to give it their full attention.

By 2010, EPA had worked with all seven jurisdictions to develop and adopt a formal and legally binding nutrient loading target, called a Total Maximum Daily Load (TMDL), with obligations for load reduction (to roughly 90,000 metric tons of nitrogen and about 6,800 metric tons of phosphorus per year from all sources) that must be achieved throughout the Bay by 2025. (Current loads of these two nutrients are approximately 130,000 metric tons for nitrogen and 7,400 metric tons for phosphorus). Each jurisdiction has now adopted a Watershed Implementation Plan to meet those objectives. (Sometimes, the TMDL and the WIPs together are called the "Chesapeake Bay Blueprint.") The most recent reauthorization of the Chesapeake Bay Agreement was in 2014; for the first time all necessary jurisdictions are in agreement about managing to achieve 10 specific goals and 31 specific outcomes. The 10 goals include managing for sustainable fisheries, protecting vital habitats, achieving high levels of water quality, reducing impacts of toxic contaminants, supporting healthy watersheds, driving citizen stewardship, promoting land conservation, protecting public access to the Bay, increasing environmental literacy among youth, and building climate resiliency in the social-ecological system (CBP, 2014). For each goal, there are specific outcomes that the agreement aims to achieve. For example, under sustainable fisheries, outcomes include maintaining a sustainable blue crab population, establishing a bay-wide allocation framework for crab, restoring native oyster habitats and populations, developing a strategy for the management of forage fish, and protecting critical fish habitat (CBP, 2014). Most ecological goals include both environmental outcomes, such as the improved status of a specific resource or part of a natural system, as well as process related outcomes such as monitoring or management systems that serve as a means to achieve the overall goal. Social goals, like improving literacy and maintaining public access, tend to include outcomes related to setting up outreach programs, and specific pursuits like improved diversity and inclusion. Private interests delayed the full implementation of the Chesapeake Bay Blueprint in the courts from 2011 to 2016, but the US Supreme Court refused to reverse lower courts, and the agreement remains in force today.

Today, many impacts from unchecked development and utilization remain, but measurable progress towards goals has been made, as evidenced by improvements in water quality, habitat and oyster, blue crab and other wildlife populations have been achieved through reducing pollution and other adverse impacts, protecting healthy habitats where possible, and widespread restoration efforts. For example, for the goal of sustainable fisheries, blue crab populations have increased, with the amount of adult female cables increasing 30% between 2018 and 2019 (CBP, 2019). While the most important contribution of the CBP is in coordinating planning and action among numerous agencies and institutions around key environmental targets, the CBP also is responsible for maintaining monitoring and assessment systems related to Chesapeake Bay. These efforts include data collection, analysis and reporting against priority goals, which help minimize conflict and supports decision making among a broad set of stakeholders and jurisdictions with competing needs or interests.

One clear lesson from the history of the program is that solutions must be emplaced at scale to create a chance for success, success against even well-stipulated goals. In the case of the Chesapeake Bay Program, it took from 1987 until 2002 for all necessary states to join the agreement, and until 2014 for all of those jurisdictions to formally agree to the most important overall goal of establishing the nutrient load caps, or TMDLs. So, even though the program has been hard at work for nearly 30 years, it is just now adequately organized for success on this key target.

We should also mention that even this larger scope still falls short in matching up with the scale of some of the very highly migratory marine and anadromous species that call the Bay home, and that full success requires coordinated actions through integrated fishery management planning and habitat protection planning at even broader scales. Thankfully, other programs are also in place that can help achieve those even broader goals. For instance, integrated management occurs at both a coast-wide scale for nearshore fisheries through the ASMFC, and for essential fish habitats through the work of the Mid-Atlantic Fisheries Management Council (and NOAA). Both of those federal and interstate processes are tightly focused on ecosystem-based management of nearly all key species not adequately tracked at the Bay scale.

3.2 Remaining Challenges

An emerging issue that the CBP could be well poised to tackle, with other multi-jurisdictional institutions, is to address climate impacts on this ecological system and the human services it provides. Already, species are shifting northward, some relatively rapidly. For instance, one of the key anadromous species, alewife (a river herring) may soon no longer be able to access its major historic spawning grounds in Albemarle Sound, just to the south, with uncertain effect on coastwide spawning potential. And more warm temperate species are moving in. Those shifts would make current allocations of access for fisheries obsolete, and even strain the way governance is organized. In addition, shifting precipitation patterns will affect nutrient delivery patterns and trends, and potentially induce ecological cascades within the Bay itself. Salinity and alkalinity shifts could exacerbate those effects. Many scientists are already concerned about already long-term shifts in phytoplankton and zooplankton communities in the Bay, induced by nutrient shifts that have replaced larger more available phytoplankton with nano- and picoplankton. So, beginning to understand what the future could hold, and how that might reshape potential future system conformations and then management goals will be ever more important. Thankfully, many institutions are hard at work on understanding this problem.

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