A scoping report of UNESCAP Ocean Accounts pilot study of China

Extend the System of Environmental-Economic Accounting (SEEA) to Ocean: A Chinese Perspective

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July, 2019

Contents

1 Background

1.1 Why SEEA need to be extended to the ocean

The ocean covers 71% area of the Earth surface, and is an essential life support system of the Earth[1]. It provides diversified resources including energy, spaces, aquatic organisms and minerals as well as ecosystem services including water purification, coastal protection, biodiversity provisioning, nutrient cycling, carbon sequestration and recreational areas for tourism. for example, the ocean recycles over 93% of the carbon dioxide and absorbing about 30% that humans produce [2], and absorbs 90% of the energy from the global warming and provide us with half of the oxygen we breathe.

The ocean also faces great pressures include over-fishing and over-exploitation of marine resources, pollution, invasive alien species, habitat destruction and climate change. Maintaining a healthy and productive ocean is vital for achieving sustainable development globally. the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals were adopted in 2015, in which the 14 one is “conserve and sustainably use the oceans, seas and marine resources”.

The System of Environmental-Economic Accounting 2012-Central Framework (SEEA CF), the first international statistical standard for environmental-economic accounting, was adopted by the United Nations Statistical Commission in 2012. It provides a framework for understanding the interactions between the economy and the environment, for describing stocks and changes in stocks of environmental assets, and emerged as a leading tool in the support of policy and analysis of the environment and its relation with economic and human activities. The System of Environmental-Economic Accounting 2012-Experimental Ecosystem Accounting (SEEA EEA) was released for developing a statistical framework for ecosystem service accounting. These technical documents provide a comprehensive platform for the development of comparable measures of the relationship between the environment and the economy across the world and support mainstreaming of the full range of ecosystem services and benefits in standard macro-economic accounts and indicators.

SEEA is confined to terrestrial resources accounting due to its unsystematically considering the ocean and ocean resources. Due to wide acceptance by the international society, SEEA will play an important role of promoting sustainable development in the come future. To rationally use oceanic resources and protect marine environment, it is particularly necessary to extend the SEEA to the ocean.

1.2 Issues for extending SEEA to the ocean

(1) The methodologies of SEEA CF and EEA are land-oriented, and the characteristics of the ocean are not systematically considered. To extend the use of them to the ocean, the foremost thing is to classify the oceanic environmental assets and ecosystems services according to the framework of SEEA CF and EEA.

(2) A 2-dimentional data framework is suggested in the SEEA EEA, and raster data such as remote sensing data as well as huge amount of monitoring data and economic and social data are enough for the terrestrial accounting. But the ocean is totally different. Its depth varies from meters to thousands of meters and are decisive factors for the ocean ecosystems. so a 3-dimentional data framework is essential for implementing SEEA on the ocean.

(3) Comparing with terrestrial data, most of ocean data are still acquired by in-situ monitoring, passive remote sensing methods are limited to acquiring sea surface data. The oceanic data are less than the coastal and offshore ones, and all of them are usually uneasy to acquire and even classified. As a result, the data limitation should be taken into consideration, and the size of spatial units may vary according to the depth and the distance to the coasts.

(4) the ocean is in a constantly dynamic status, such as the tide, current and living organism migration. To reflect the dynamic characteristics in fixed units, it is suggested to introduce the conception of range and buffer zone.

1.3 The purposes of this study

This study is a part of ESCAP Ocean Account pilot study in China. The purposes of this study include (1) identifying the stakeholders and their needs as well as potential values of SEEA for ocean in China; (2) reviewing Chinese researches and practices on SEEA and ocean economy statistics which may contribute to SEEA for ocean;(3) discussing the content of SEEA for ocean according to the principles and framework of SEEA CF and EEA;(4) reviewing Chinese available data for SEEA for ocean and discussing solutions for data gaps;(5) making recommendations and a pathway to implementation

2. Profiles of China

2.1 Nature and Resources

2.1.1 Geography and marine ecosystems

The China Seas consist of a series of marginal seas in the Western Pacific Ocean, around China. The four seas of China, the Bohai Bay, the Yellow Sea, the East China Sea, and the South China Sea. According to the United Nations Convention on the Law of the Sea and China's own consistent position, China claims jurisdiction over around 3 million square kilometers of sea areas, including inland waters, territorial sea, contiguous zone and the exclusive economic zone (EEZ), and a share of rights and interests on the outer continental shelf. These seas have complicated geology and rich natural resources. China has a continental coastline of about 18 000 km and a total island coastline of over 14 000 km. There are 10 provinces and municipalities along the mainland coasts. In addition, the coastal provinces also include Taiwan and Hainan island provinces, as well as the Hong Kong and Macao Special Administrative Regions.

Typical ecosystems such as mangroves, seagrasses, coral reefs, coastal marshes are dotted along the coasts and remote islands. China's coastal wetlands covers an area of 5 795 900 hectares, provide a wide range of ecosystem services, including water supply, flood regulation, wastewater storage and natural purification, carbon sequestration, wildlife and aquatic conservation. There are 4 families, 10 genera and 22 species of seagrass in China, accounting for about 40% of the world's seagrass species. Most of the mangroves are distributed along the South China Sea coast, and a small part of mangroves are distributed in the southern part of the East China Sea and along the coasts of Fujian and Taiwan. At present, China has established 22 mangrove nature reserves at various levels, including 6 national mangrove forest reserves, and the protected mangrove area accounts for 77% of the country's total. Most of China's coral reefs are distributed in the South China Sea. Some coral reefs are distributed along the western Pacific Ocean along the island of Taiwan and its neighboring islands, as well as the southern part of the East China Sea. The total area of coral reefs in the South China Sea Islands and its nearby shallow waters is about 3×10^4 km^2, accounting for 5% of the total area of the world's coral reefs.

2.1.2 Environment condition

From 2003 to 2017, the water quality of the China seas is generally good. The percentage of sea areas meeting the standard for first-class sea water quality is above 93.5%, and the annual variation is in 2%. In the recent five years, the percentage showed a tendency of increase, indicating that the quality of China's sea water is gradually improved. Spatially, the water quality of the offshore areas is good, all meeting the standard for first-class sea water quality. However, China's nearshore waters are seriously polluted, the sea areas with second-class, third-class, fourth-class and inferior fourth-class sea water quality standard concentrate in the offshore areas.[1]

1 According to the national standard Sea water quality standard (GB 3097), sea water quality is classified into four classes, the first class is for fishery, marine natural reserves and endangered marine organism reserves; the second class is for aquaculture, bathing beaches, marine sports and recreation, and industrial waster use directly

The main pollutants in seawater are inorganic nitrogen, active phosphate and lead. The seriously polluted sea areas are mainly distributed in the Yalu River Estuary, Liaodong Bay, Bohai Bay, the Yangtze River Estuary, Hangzhou Bay, the Pearl River Estuary and Nearshore waters of some large and medium-sized cities.

From 2011 to 2017, the degree of eutrophication of China's coastal sea waters is pretty serious, and the area of eutrophic seawater is more than 60 000 km^2/year. The area of eutrophic seawater has undergone large inter-annual changes. The areas in 2012 and 2015 are larger, which are both close to 100 000 km^2. The area has shown a downward trend, and the area of severe eutrophication seawater has declined in the last seven years, which has shown that the eutrophication degree of China's coastal seawaters has been reduced and the quality of seawater has been steadily improved. The quality of marine sediments in China's offshore and offshore waters continues to be good, while some coastal waters have poor sediment quality. The sediments in Dalian Bay, Jinzhou Bay, Qinhuangdao, Jiaozhou Bay, Shantou offshore, Daya Bay, Pearl River Estuary and Zhanjiang Port are polluted in different degrees.

2.1.3 Resources

China has huge oil and gas reserves, in which oil, gas and combustible ice resources are 20 billion tons, 14.09 trillion m^3, and 100 billion tons respectively. Marine renewable energy includes tidal energy, wave energy, ocean current energy, temperature difference energy and salt difference energy, totally amounting to 431 million KW. Coastal placer resources are also rich in China, and the main minerals are zircon, monazite, ilmenite, rutile and yttrium. In addition, the bottom of the southern South China Sea is rich in polymetallic nodules. There are also rich marine chemical resources, including brine, , sea salt and nuclear fuel.

There are various kinds of marine organisms, among which 20278 species have been identified, accounting for about 1/10 of the total marine species in the world. The Yellow Sea is rich in marine fishery resources, with about 320 species distributed in the stone island, Dasha, Lvsi and other main fishing grounds. With superior natural conditions, the East China Sea fishery is the largest one in China, with about 900 kinds of marine creatures with economic valuedistributed in Zhoushan, eastern Fujian, southern Fujian and Taiwan shoals and other major fishing grounds. The South China Sea is one of the sea areas with the richest marine fish biodiversity in China and even the world, with about 2200 kinds of marine creatures with economic value.

The coastal zones are rich in land resources and the estuarine deltas are expanding by the sediment flux of rivers. Moreover, China's sea area spans three climatic zones: tropical, subtropical and temperate. There are also kinds of tourism resources.

related to foods; the third class is for general industrial water use, and coastal resorts; and the fourth class is for port and extraction areas.

2.2 Ocean economy and Coastal Society

2.2.1 Coastal Society

China's coastal provincial regions make up 13% of the nation's territory, house 43.3% of the nation's population, contribute 57.7% of the national GDP in 2015. The coastal provinces (municipalities, autonomous regions) in China take the advantages of port, ocean and hinterland, serve as the pioneers of China's reform and opening and the "one belt and one road" construction. They are the region with the highest level of economic development, the most densely populated population and the highest level of urbanization. In 2017, there were 116 cities above prefecture level in coastal areas with 1 282 000 square kilometers, which account for 13.4% of the total area of China. According to the sixth national population census, the population of these cities is 576 million, accounting for 43.24% of the total in China. The GDP of coastal areas reached 46.17 trillion RMB in 2017, 9.2 times than that of 1999.

In 2017, the province with the highest natural population growth rate in coastal areas was Shandong Province, the growth rate was 10.44‰. The natural population growth rate of Fujian, Guangdong, Hainan and Guangxi exceeded 8‰. The natural population growth rate in coastal areas was far above the national average (3.81‰). The rate of Tianjin, Jiangsu and Shanghai was between 2‰ and 3‰. Liaoning had a negative growth rate of - 0.44‰. According to the data of the sixth census, the average life expectancy in coastal areas was over 75 years old, Shanghai had the highest life expectancy, which was 80.26 years old, all exceeding the national average.

Infrastructure and social services in China's coastal areas are better than the national average. In 2007, the length of expressways reached 39 400 km, accounting for 34% of the country's total. Half of the airports that handle more than 10 million passengers a year are distributed in coastal areas. By 2017, there were 1109 common universities in coastal areas and the number of students in school was 117 million, accounting for 42% and 42% of the total, respectively.

At the same time, in coastal areas, the pressure of resources and environment is high and the spatial distribution of resources is uneven. For example, water resources are less in the north and more in the south, the per capita water resources in Tianjin, Shanghai and Hebei are less than 200 m^3/person, while in Guangxi and Hainan, the per capita water resources are more than 4000 m^3/person. In 2017, there were 921 nature reserves in coastal areas, and the totaling area is 118 million hectares, accounting for 8% of the country's total.

2.2.2 Marine Economy

China's marine GDP in 2018 was 8341.5 billion RMB, which accounts for 9.3% of national GDP. The added value of the marine first, second and third industries accounts for 4.4%, 37.0% and 58.6% of the added value of total marine GDP, respectively. It is estimated that 36.84 million people involved in sea-related employment in 2018. The ocean economy grew steadily in 2018, the total amount reached a new level, the industrial structure was continuously optimized, the emerging industries and new businesses grew rapidly, and the ocean economy continued to play the "engine" role, promoting the high-quality development of the national economy. Coastal tourism, marine transportation and marine fisheries are the pillar industries, and their added value accounts for 47.8%, 19.4% and 14.3% of the added value of major marine industries, respectively.

Emerging industries such as Marine bio-pharmaceuticals and Marine power generation led the way with growth rates of 9.6% and 12.8%.

Table 1: China's gross marine product in 2004-2018

Year	Gross marine product (100 million yuan)	Gross product of the marine primary industry (100 million yuan)	Gross product of the marine secondary industry (100 million yuan)	Gross product of the marine tertiary industry (100 million yuan)	The proportion of gross marine product to GDP (%)
2004	14662	851	6663	7148	9.1
2005	17656	1009	8047	8600	9.4
2006	21592	1229	10218	10146	9.8
2007	25619	1395	12011	12212	9.5
2008	29718	1694	13735	14288	9.3
2009	32162	1858	14927	15378	9.2
2010	39619	2008	18920	18692	9.4
2011	45580	2382	21668	21531	9.3
2012	50173	2671	23450	24052	9.3
2013	54718	3038	24609	27072	9.2
2014	60699	3110	26660	30930	9.4
2015	65534	3328	27672	34535	9.5
2016	69694	3571	27667	38456	9.4
2017	77611	3600	30092	43919	9.4
2018	83415	3640	30858	48916	9.3

In 2004-2018, the composition of the gross product of China's marine industry is shown in Figure 1. The structure of the marine industry is relatively reasonable. The composition of the gross product of the marine primary industry is relatively stable, ranging from 3.1% to 5.8%. The composition of the gross product of the marine secondary industry and the tertiary industry has a large change in composition. The composition of the marine secondary industry's GDP is declining, from 45.4% in 2004 to 37.0% in 2018. Correspondingly, the composition of the tertiary industry's GDP is on the rise, from 48.8% in 2004 to 58.6% in 2018.

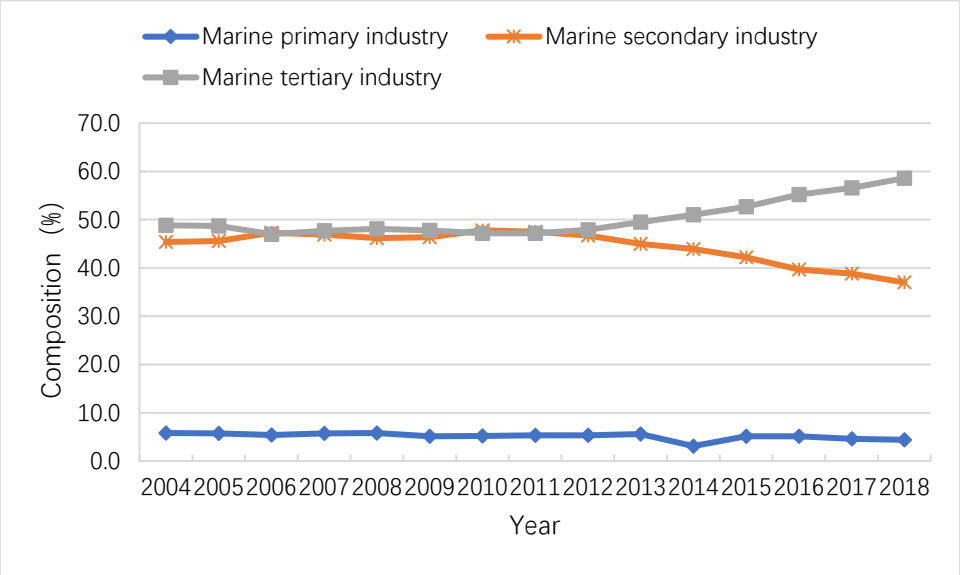

Figure.1. Composition of the gross product of China's marine industry in 2004-2018

As shown in Figure 2, in the past 15 years, the year-on-year growth rate of China's gross marine product is generally higher than the growth rate of GDP, and the growth trend of the two is consistent, indicating the development of the ocean economy and the economic development of the entire country. closely related. It is worth noting that the decline in the growth rate of gross marine product is relatively large, from 16.9% in 2004 to 6.7% in 2018, a drop of 60.4%.Therefore, it is extremely urgent to promote the sustainable development of the ocean economy by carrying out marine environmental economic accounting, coordinating the relationship between marine economic development and environment and resource protection.

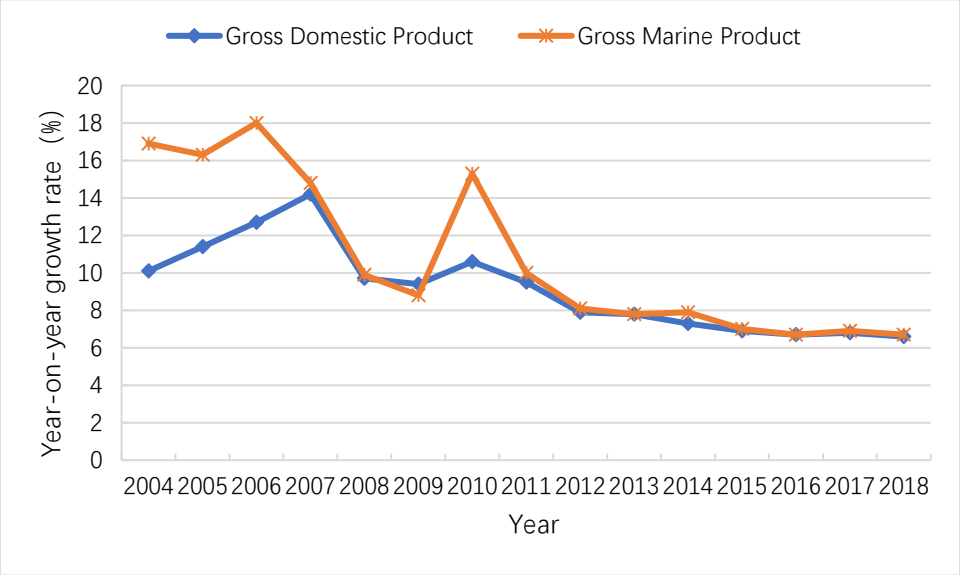

Figure 2. Year-on-year growth rate of China's gross marine product in 2004-201

2.2.3 Disasters and Risks

Coastal areas are at the intersection of oceans and continents and are vulnerable to marine disasters. Facing the Pacific Ocean, China's coastal areas are the areas with the most serious marine disasters, and are also one of the most serious disaster zones in the world. According to statistics, from 2001 to 2017, the direct economic losses caused by marine disasters exceeded 207.5 billion RMB. China's new urbanization and industrialization have developed rapidly and population, cities and economy highly concentrated in the coastal areas. Marine disasters brought rigorous challenges to the economic and social development of China's coastal areas and the development of marine resources.

the East China Sea region has the most serious disasters, storm surges, red tides, sea waves and tsunamis, account for 54% of the total sea area of China. The Bohai Bay and the Yellow Sea region have the most types of marine disasters, besides typhoon storm surges, red tides, sea waves and tsunamis, there are temperate storm surges and sea ice disasters. The disasters of the Bohai Bay and the Yellow Sea region account for about 18% of the total sea area. The South China Sea region is the most vast region. Various marine disasters in the South China Sea region account for about 28% of the total sea area, which mainly occurred in the north of 12 N, few occurred in the south.

Statistics from 1966 to 1990 show that the distribution frequencies of waves over 3 meters in the China Sea are 6.7% in the Bohai Bay, 26% in the Yellow Sea, 58.3% in the East China Sea and 46.8% in the South China Sea. Waves over 6 meters occurs 28 times a year on average, and waves over 9 meters occurs 5.8 times a year on average. Red tide disasters in China show the trend of increasing frequency, expanding outbreak scale, prolonging duration and increasing toxic algae. According to *2017 Marine Environment Quality Bulletin*, the polluted sea areas are mainly distributed in Liaodong Bay, Bohai Bay, Laizhou Bay, Jiangsu coast, Yangtze Estuary, Hangzhou Bay, Zhejiang coast, Pearl River Estuary and other coastal areas. The main elements exceeding the standard are inorganic nitrogen, active phosphate and petroleum.

2.3 Governance

The ocean governance system of China confines the range and basic principles, sets legislative basis, and defines the use and stakeholders of SEEA for Oceans. Generally, China's governance system can be separated into legislation, national strategies, administrative agencies and policy tools. The laws and regulations confine necessary information such as the spatial range, asset classification, stakeholders, etc. National strategies set the latest direction of China's development, which are usually proposed by CPC Central Committee and even written into the Constitution and laws. The administrative agencies of the State Council are usually adjusted and policy tools are designed for effective implementation of the laws and national strategies. There will be certain ministries responsible for the policy tools' implementation.

2.3.1 Legislation

Since the Marine Environment Protection Law of the People's Republic of China in 1982, many laws and regulations (Table 2) for marine and marine resources management have been enacted and came into force, which are the legal basis for the SEEA for Ocean in China. The SEEA for Ocean will also support their implementation. In SEEA EEA, It is suggested to extend the scope

of accounting to EEZ as well as the atmosphere and the sea floor aligned with it.[4] The Law of on the Territorial Sea and the Contiguous Zone and the Law on the Exclusive Economic Zone and the Continental Shelf define the breadth of territorial sea, contiguous zone, exclusive economic zone (EEZ). and continental shelf, which should be obeyed when designing the spatial units for SEEA. The mechanisms including national major marine functional zoning plans, national marine functional zonation scheme and marine nature reserves in the Marine Environment Protection Law are important references to set the spatial units, and will be contributed by SEEA for Ocean. The typical and representative ecosystems listed in this law, such as mangroves, coral reefs, coastal wetlands, islands, bays, estuaries and important fishery waters should be taken into consideration in the environmental asset categories, in which the Island Protection Law, the Law on the Administration of Sea Areas, the Fisheries Law, the Wild Animal Conservation Law, the Mineral Resources Law, the Law on the Exploration and Development of Resources in Deep Seabed Areas should also be considered.

Table 2 China's Laws and Regulations Related to SEEA for Ocean

No.	Laws and Regulations	Years
1	Law of the People's Republic of China on the Territorial Sea and the Contiguous Zone	1992
2	Law on the Exclusive Economic Zone and the Continental Shelf of the People's Republic of China	1998
3	Environmental Protection Law of the People's Republic of China	2014 *
4	Marine Environment Protection Law of the People's Republic of China	2017 *
5	Law of the People's Republic of China on Environmental Impact Assessment	2018 *
6	Island Protection Law of the People's Republic of China	2009
7	Law of the People's Republic of China on the Administration of Sea Areas	2001
8	Fisheries Law of the People's Republic of China	2013 *
9	Wild Animal Conservation Law of the People's Republic of China	2018 *
10	Mineral Resources Law of the People's Republic of China	2009 *
11	Law of the People's Republic of China on the Exploration and Development of Resources in Deep Seabed Areas	2016
12	Waterway Law of the People's Republic of China	2016
13	Law of the People's Republic of China on Ports	2018 *
14	Statistics Law of the People's Republic of China	2010 *
15	Regulations of the People's Republic of China on Nature Reserves	2017 *

* Amendment

2.3.2 National Strategies

Ecological civilization. With the high speed economy development since the Reform and Opening Up in 1978, the central government of China faces a great challenge to balance economy development and environment protection and makes decisions to pursue sustainable development. The ecological civilization (生态文明) has become one of China‘s national strategies since the 18th National Congress of Communism Party of China (CPC), and was written into China’s constitution in 2018. In subsequent sessions of 18th CPC Central Committee, the decisions including “building a beautiful China and deepening reform to achieve ecological civilization”, “speeding up the establishment of a sound legal system of ecological civilization” and the nation’s development concepts of “innovation, coordination, green, development and sharing” were proposed. Under the umbrella of ecological civilization strategy, many policy tools have been created and put into practice. Natural resource assets accounting, natural resource assets balance-sheet, auditing outgoing officials' management of natural resource assets are three main policy tools for promoting natural resources management and rational utilization. These tools will be discussed in details in 2.3.3.

Building China into a maritime power. Also in the report to the 18th National Congress of CPC, the willingness to build China into a maritime power (海洋强国) has also been declared, which will be realized by enhancing the capacity for exploiting marine resources, developing the marine economy, protecting the marine ecological environment, resolutely safeguarding China's maritime rights and interests [5]. In the background of ecological civilization, the development pattern of China’s ocean economy is transforming from pursuing short-term economic benefits to caring environment, ecosystems and long-term sustainability. For example, after the State Council released a notice on strengthening the protection of coastal wetlands and strictly controlling the reclamation in 2018, sea reclamation has been almost ceased national wide [6].

2.3.3 Administration agencies

In March 2018, the First Session of the Thirteenth National People's Congress ratified the State Council institutional reform proposal [9], and the administration agencies of natural resources and environments undertake a great change.

The Ministry of Land and Resources, State Forestry Administration, State Oceanic Administration, the National Administration of Surveying, Mapping and Geoinformation, and the responsibilities of other Ministries were integrated into the Ministry of Natural Resources (Figure 2) for solving problems such as inadequately exercising the ownership of state-owned natural resource assets, spatial plans overlapping, and poor ecosystems conservation and restoration. Its main responsibilities are to supervise the exploitation and conservation of natural resources, establish a spatial planning system and supervise the implementation, fulfill the owner’ duties of state-owned natural resource assets, natural resources investigation and rights confirmation and registration, establish a mechanism of natural resources paid use, and manage surveying, mapping and geological exploration industries.

The Ministry of Ecology and Environment took place of the Ministry of Environment Protection for integrating the dispersed ecology and environment protection responsibilities, uniformly

supervising pollution discharge and enforcing environmental laws. SOA's responsibility of marine environment protection was transferred to MEE.

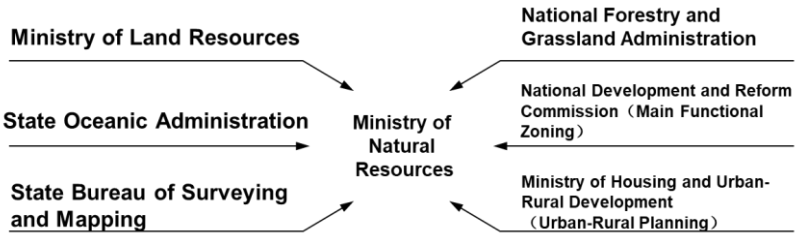

Figure 3 the origins of Ministry of Natural Resources

2.3.4 Policy tools

Natural resource assets accounting (NRAA). The MNR is responsible for establishing a statistical system and accounting state-owned natural resources assets. According to *the Guiding Opinions on Coordinating the Reform of Property Rights of Natural Resources Assets* by General Office of CPC Central Committee and the General Office of the State Council [7]. The natural resource classification standards should be unified first, and a national natural resource survey on the quantity, quality, distribution, and ownership of important natural resources need be carried out with full use of existing survey results. It is suggested to establish physical asset account first, and study on monetary asset account.

Natural resource assets balance-sheet (NRABS). The balance-sheet reflects the amount of natural resource assets and their change at the beginning and end of the accounting period (a calendar year). Its basic balance is: beginning stock + addition to the stock - reduction of the stock= ending stock. The beginning and ending stocks come from natural resource statistical surveys and administrative records. It is suggested to prioritize accounting for natural resources with important ecological functions, such as land, forest and water, which should reflect both the quantity and quality change (Table 2). The Bureau of Statistics, together with the Development and Reform Commission, the Ministry of Finance, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Water Resources, the Ministry of Agriculture and rural affairs, the National Audit Office (NAO), and the Forestry Bureau, are responsible for preparing a natural resources balance sheet by the end of 2018. [8]

Table 4 the categories of the natural resource assets balance-sheet in China

No.	Categories	Sub-categories	Indicators
1	Land resources	Cultivated land	Quantity indicator: areas of land use
		Forest land	Quality indicator: distribution by quality grades and its change
		Grass land	
2	Forest resources	Natural forest	Quantity indicator: stocking volume
		Man-made forest	Quality indicator: stocking volume per unit

		Other forest	
3	Water resources	Surface water	Quantity indicator: volume
		Ground water	Quality indicator: distribution by quality grades and its change

Audit of outgoing officials' natural resource assets management (AOONRAM). The purpose of AOONRAM is to stimulate leading officials of local party committees and government to establish a correct view of political achievements and in further accelerate the ecological civilization construction process by auditing their performance in natural resource assets management and environments protection during their tenure, and identifying their responsibilities. Because the audit results affect officials' promotion, it will effectively prevent and control environmental pollution at local levels. Key areas of the audit are land resources, water resources, forest resources, mine environment management and restoration, and air pollution control. It is led by NAO and implemented by local audit offices national wide.

2.4 Stakeholders

The construction of ecological civilization need to be accomplished on both terrestrial and oceanic aspects, and oceanic resources should be included in policy tools of NRAA and NRABS and AOONRAM. The integration of natural resources management and establishment of MNR extend the scope of these policy tools to the ocean resources. MNR is subsiding the study of marine spatial resources accounting, and coastal areas, such as Hainan, Fujian, Shandong, Zhejiang are formulating local oceanic NRAA and NRABS. SEEA Central Framework and EEA show a great potential in enlightening and contributing to NRAA and NRABS, and supporting AOONRAM, and can be integrated into them, which was also acknowledged in an official document on NRABS. As a result, expanding SEEA application to ocean and oceanic resources is needed in China.

MNR, NSB and NAO are leading ministries for the implementation of NRAA and NRABS, and AOONRAM. They and other ministries of State Council take the legal duties of ocean administrative management and make specific policies for national strategies implementation. They are main stakeholders in the central government. Local governments are responsible for laws, policies implementation, and connected to local communities, organizations and enterprises. (Figure 3)

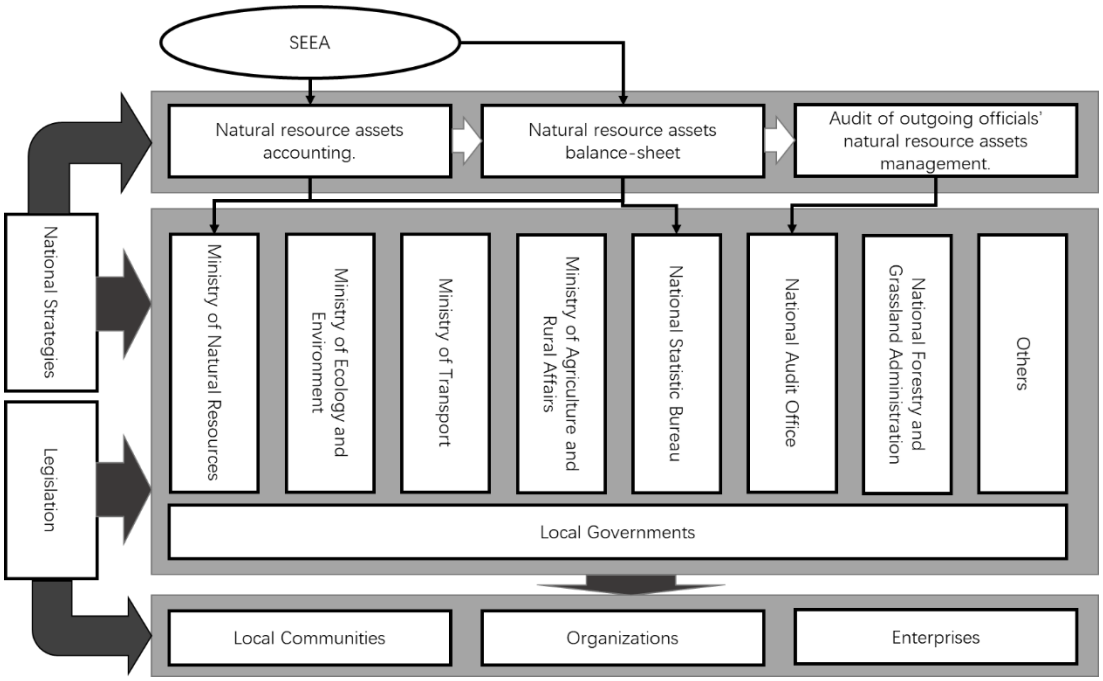

Figure 4 the stakeholders for extending SEEA to the Ocean in China

3. A Proposed Framework for a SEEA Ocean for China

3.1 Connect ocean to SEEA

As mentioned above, ocean and oceanic resources are partly considered in the SEEA CF and EEA. To connect ocean to SEEA, it is necessary to sort ocean environmental assets and ecosystem services and classify into the existing assets and ecosystem services categories in the SEEA CF and EEA.

3.1.1 the oceanic environmental assets

According to the SEEA CF, environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. Environmental assets are classified into the mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources, and water resources. Oceanic environmental assets can be properly classified into corresponding categories, such as the mineral and energy resources, aquatic resources and other biological resources.

But for other categories, it is necessary to understand their definition and scope first, and connect oceanic environmental assets with them cautiously.

Land resources are defined as a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located. It is obviously that the land is referred to terrestrial spaces, so the oceanic spaces including the sea areas and sea bed could be connected to this category.

Soil resources are defined as the top layers of soil that form a biological system, in which the role of supporting living organism are highlighted. The sediment of seabed supports benthic organisms, and can be view as an oceanic soil resource, while the nutrients in seawater also nourishes marine organisms, absorb carbon dioxides and play other similar roles to the land soil. As a result, it is suggested to connect the sediment and nutrients in seawater to the land resources without adding new oceanic category.

Mangroves can be classified into timber resources according to the definition, but other marine botanies may be classified into aquatic resources or other biological resources due to the uncertain definition. For example, the important coastal ecosystems of seagrasses and tidal marshes provide similar products and ecosystem services with mangroves, but may be grouped into other categories. Seawater is not treated as resources, but the icebergs on the sea may be treated as a kind of freshwater.

Table 5 Oceans assets based on the classification of SEEA CF

No.	Environmental Assets Classification in SEEA CF	Corresponding ocean assets
1	Mineral and energy resources	Marine minerals and energy resources
1.1	Oil resources	Offshore oil resources
1.2	Natural gas resources	Marine natural gas resources

1.3	Coal and peat resources	Submarine coal mine
1.4	Non-metallic mineral resources (excluding coal and peat resources)	Marine non-metallic mineral resources
1.5	Metallic mineral resources	Marine metal mineral resources
2	Land	Sea area
3	Soil resources	Sediment and seawater nutrients
4	Timber resources	Marine higher plants
4.1	Cultivated timber resources	Cultivated marine higher plants
4.2	Natural timber resources	Natural marine higher plants
5	Aquatic resources	Marine living resources
5.1	Cultivated aquatic resources	Cultivate marine living resources
5.2	Natural aquatic resources	Natural marine living resources
6	Other biological resources (excluding timber resources and aquatic resources)	Other marine living resources
7	Water resources	Marine freshwater resources
7.1	Surface water	Sea ice
7.2	Groundwater	
7.3	Soil water	
8		other

3.1.2 the oceanic ecosystem services

The ecosystem services are generally divided into provisioning, regulating and cultural sections which subdivided into divisions and groups in the SEEA EEA. It is obvious that the oceans provide many important ecosystem services from water, materials, energies provision, to global atmosphere, water, materials and ecosystems regulating, and to seascapes, cultures and religions. Besides some groups specific for terrestrial and freshwater aspects, most of the services can be connected to corresponding categories. (Table 6)

Table 6 the ecosystem services of oceans based on the classification of SEEA EEA

Section	Division	Group	Oceans	Example of ecosystem services
Provisioning	Water	Water	Y	Seawater for desalination, aquaculture, etc.
	Materials	Uncultivated terrestrial plants and animals for food	N	N
		Uncultivated fresh- water plants and animals for food	N	N
		Uncultivated marine plants, algae and animals for food	Y	Uncultivated marine plants, algae and animals (e.g., seaweed, crustaceans such as crabs, lobsters, crayfish) taken up for food

Section	Division	Group	Oceans	Example of ecosystem services
		Nutrients and natural feed for cultivated biological resources	Y	Nutrient resources for aquaculture products
		Plant and animal fibers and structures	Y	Marine and coastal plant and animal fibers and structure (e.g., seagrass and tidal marsh plant fibers, mangrove timbers, macroalgae, seashells, crustacean bones) to be harvested for manufacturing or domestic use
		Chemicals from plants and animals	Y	Substances and biochemicals (e.g., rubber, enzymes, gums, oils, wax, herbal substances) from living marine organisms taken up for medicinal use, manufacturing or domestic production
		Genetic materials	Y	Genetic materials taken up for breeding programmes (e.g., for aquaculture)
	Energy	Biomass-based energy	Y	Algae to be harvested for biofuel
	Other provisioning services	Other provisioning services.	Y	Other provisioning services that are not classified elsewhere in this section, such as provisioning of exotic animals, tamed marine animals trained to harness
Regulating	Remediation and regulation of biophysical environment	Bioremediation	Y	Chemical detoxification/breakdown of pollutants by marine and coastal plants, algae, micro-organisms and animals
		Dilution, filtration and sequestration of pollutants	Y	Dilution of waste-water, removal of organic materials and nutrients from waste-water by biogeochemical process, filtration of particulates and aerosols, sequestration of nutrients and pollutants in organic sediments, removal of odours
	Flow regulation	Air flow regulation	Y	Regulation air through air-sea interaction mechanisms
		Water flow regulation	Y	
		Mass flow regulation	Y	Coasts stabilization
	Regulation of physicochemical environment	Atmospheric regulation	Y	Capture of carbon dioxide, climate regulation
		Water cycle regulation	Y	Oxygenation of water, retention and translocation of nutrients in water
		Pedogenesis and soil cycle regulation	Y but need to be adjusted	

Section	Division	Group	Oceans	Example of ecosystem services
		Noise regulation	Unknown	
	Regulation of biotic environment	Life-cycle maintenance, and habitat and gene pool protection	Y	Pollination, seed dispersal, maintenance of habitat nursery population and habitats
		Pest and disease control (including invasive alien species))	Y	Control of pathogens
Cultural	Physical or experiential use of ecosystems [environmental setting]	Non-extractive recreation	Y	Seascape character and biodiversity of species for hiking, birdwatching, whale watching, recreation
		Information and knowledge	Y	Seascape character and biodiversity of species for scientific research and education
	Intellectual representations of ecosystems [of environmental settings]	Spiritual and symbolic	Y	Seascape character and biodiversity of species of cultural heritage values, sense of personal and group identity (sense of place), spiritual and religious function, etc.
		Non-use	Y	Ecosystem capital for future generation of ecosystem services

3.2 Data and Gaps

3.2.1 Data

(1) Statistics data and survey data

China has launched successive Marine Statistical Yearbook since early 1990s. In 1990, SOA organized and established the framework of 'National Ocean Statistics Indicator System and Explanation', laying the foundation of ocean economic statistics. It covers 11 aspects that includes ocean natural geography, ocean natural resources, social economic situation of the coastal regions, cities and counties, marine agency and personnel, marine funds, marine facilities, marine industrial activities, marine service, marine environment protection, marine scientific research and technology development and marine education, etc. Some statistics publications for ocean and marine conditions in China are listed in Table 7.

Table 7 Some of the statistics publications for ocean and marine conditions in China

Name	Frequency	Issuing Date	Remark
China Marine Economic Statistical Bulletin	Yearly	March next year	Public
China Marine Statistical Yearbook	Yearly	December next year	Public

China Ocean Development Index	Yearly	October next year	Public
China Ocean Economic Development Index	Yearly	November next year	Public
Marine Economic Climate Index Report	Yearly	November next year	Inner reference
Report on China's marine Economy Development	Yearly	September next year	Public
Bulletin of marine ecological environment status	Yearly	November next year	Public
Statistical communique of national economic and social development	Yearly	November next year	Public
Fisheries statistical yearbook	Yearly	September next year	Public

China Marine Economic Statistical Bulletin. The Bulletin covers three areas, namely Development of Ocean economy, Development of Major Marine Industries and Development of Regional Ocean economy. The statistical data come from the administrative departments of natural resources (Marine) in coastal areas, statistical institutions and relevant departments of the state council.

China Marine Statistical Yearbook. China Marine Statistical Yearbook is a data almanac which reflects in an all-round way the development of ocean economy, marine management and service in the People's Republic of China, and it is a Chinese-English bilingual edition. The Yearbook's statistics cover the production and activities in the marine and coastal areas in relation to the development, management and utilization of marine resources and space, and the development of marine socio-economy. The regions covered are the coastal regions, coastal cities and coastal zones with coastlines, which are arranged in order according to the Coastal Administrative Areas Classification and Codes (HY/T 094-2006). The data in the yearbook consist of 11 sections, namely, integrated data, marine economic accounting, major marine industrial activities, production capacity of major marine industries, ocean-related employment, marine science and technology, marine education, marine environmental protection, marine administration and public-good service, national and coastal socio-economy, part of the world's marine economic statistics data. The Yearbook is based on the Marine Statistics Report System (国统字 [2016] 7 号文) and the Ocean Gross Product Accounting System(国统字 [2016] 17 号文),and its data mainly come from the statistical bureaus and the oceanic administrations of the coastal provinces, autonomous regions, and municipalities directly under the Central Government as well as the 20 ocean-related ministries, bureaus and general corporations concerned.

China Ocean Development Index. The China Ocean Development Index is a quantitative evaluation about the overall development of ocean economy and ocean business in a certain period. Its index covers the following areas, respectively economic development, social livelihood, environmental ecology, scientific innovation, Comprehensive governance, Public service, International issues and cooperation.

China Ocean Economic Development Index. NMDIS released the initial 2016 China Ocean Economic Development Index Report. The China Ocean Economic Development Index is a

comprehensive index to reflect marine economic development status, which includes: Developmental level (size, composition, benefit, openness), Developmental achievements (stability, livelihood improvement), Developmental potential (innovation driving force, resource and environmental bearing capacity).

Ocean Economic Climate Index. Marine Economic Climate Index is a comprehensive description on the development status of ocean economy, which is used to reflect the booming state of ocean economy at present. It consists of coincident indicator, leading indicator and lagging indicator. Due to data limitation, we can only achieve yearly index analysis, quarterly and monthly climate index is to be studied.

Furthermore, China has taken out series of surveys related to the ocean and marine natural, social and economic status. Marine employment survey was in 2002 and China Marine Employment Survey Report of 21st Century was published in 2002, Island economic survey was implemented in 2007, Coastal Social and Economic Survey (2007-2008), First national ocean economic census (2014-) just finished in 2019.

(2) Monitoring Data

There are some operational monitoring data on ocean and marine conditions in China. Some of these monitoring data are publicly available over the web sites for download. Some of the monitoring data are introduced briefly that include the National Marine Science Data Sharing Service Platform, the South China Sea Ocean Database and the Chinese National Ecosystem Research Network.

The National Marine science data sharing service platform (http://mds.nmdis.org.cn/web/site/index.view) provides the monitoring data of China and other areas, as well as the analysis of the marine data and thematic information products. To be specific, the monitoring data include seabed topography, marine geophysics, sea-floor sediments, marine chemistry, marine biology, marine meteorology and marine hydrology. The data come from the ocean observation systems of the United States, Australia, Japan and other countries, as well as the quasi-real-time observation data of China ocean monitoring stations. The data format is mainly relational table, which can be downloaded.

The monitoring data are classified as follows. The ocean hydrological data obtained by monitoring stations, buoys, survey ships and other observation means cover the global sea area, mainly including temperature, salinity, waves, water level and ocean currents. The meteorological data, including sea surface meteorological and high-altitude meteorological data, are obtained through fixed land stations, ocean stations, observation ships, buoys and other observation means. The data covering the global sea area mainly include sea surface temperature, air pressure wind direction, wind speed, wind direction, potential height and other elements. The marine organism data set covers the offshore areas of the United States, eastern Japan, Ireland, Australia and other waters, including zooplankton, phytoplankton, primary productivity, fish, shellfish and other data. The marine chemistry data set covers the Atlantic Ocean, Pacific Ocean and other sea areas, including dissolved oxygen, PH value, alkalinity, nitrate, nitrite, heavy metal, suspended matter and other Marine water quality data. The seabed sediment data sets cover most of the world's sea areas,

including mineral resources, polymetallic nodules, cobalt-rich crusts, sediments, C14 dating, grain size, oxygen isotopes and other elements. The marine geophysical data set covers the global sea areas, including the data of marine gravity, marine magnetic force, submarine shallow section, etc., and the data were surveyed from 1960 to 2011. The seabed topography data set is collected from the data published by different organizations abroad. It is the raster elevation topography data covering the global ocean and land, with the data resolution ranging from 5', 2', 1', 30" and 15".

The South China Sea Ocean Database (http://www.scsio.csdb.cn/extend/jsp/data) provides data on marine physics, marine geology, marine organisms and marine ecological data of the South China Sea. The service resources of the South China Sea Ocean Database contain observation, investigation and monitoring, remote sensing and telemetry, simulation and assimilation, reanalysis and prediction, and other data and products, including nearly 200 different data variables such as temperature, salinity, sound velocity, density, ocean current, wave, tide level, sea breeze and precipitation. The South China Sea Ocean geology Database mainly collects and collates the Marine geological data obtained from the open voyage in the north of the south China sea and the survey of the south China sea section, established the south China sea reef geological and geographical data sets, the south China sea sediment grain size analysis data set, the sediments of the south China sea mineral composition data sets, the sediments of the south China sea biological components data sets, sediment chemical composition data sets, sediment physical properties data sets, sediment mechanics data sets, etc. The South China Sea Ocean Organism Database mainly collects and collates the marine biological data obtained from the open voyage in the north of the South China Sea and the survey of the South China Sea section, and establishes the data set of marine primary productivity in the south China sea, basic data set of south China sea phytoplankton data, South China sea coral reef foundation data set and so on. The South China Sea marine ecology database mainly includes the data of coral reef analysis in the South China Sea, the atlas of coral reefs and reef dwellers in the South China Sea and other marine ecological environment data.

Chinese National Ecosystem Research Network (http://cnern.org.cn/data/initDRsearch) provides ecological long-term monitoring data, including gulf phytoplankton primary productivity survey, marine benthic investigation, marine phytoplankton survey and gulf zooplankton survey (Table 2). The data format is relational table, which can be downloaded.

Table 8 List of partial data sets in Chinese National Ecosystem Research Network

Name	Main content	Start time	End time
Phytoplankton primary productivity survey	All the primary phytoplankton productivity surveys monitored by the bay ecological stations over time were recorded, 4 to 12 times per year.	1998	2016

Marine benthic survey	The species composition, density and biomass data of benthos monitored by all bay ecological stations were recorded, 4 ~ 12 times per year.	2002	2016
Marine phytoplankton survey after 2007	Data of phytoplankton species composition, density and biomass monitored by all the bay ecological stations since 2007 were recorded, and measured 4 ~ 12 times per year.	2007	2015
Marine plankton survey before 2006	The density and biomass data of phytoplankton, zooplankton and cultured organisms monitored by the bay ecological stations before 2006 were recorded, and the dominant species of phytoplankton, zooplankton and cultured organisms were measured 4-12 times per year.	1998	2006
2007 gulf zooplankton survey	Species composition, density and biomass data of zooplankton monitored by the bay ecological stations in 2007 were recorded, 4-12 times per year.	2007	2007
Marine zooplankton survey after 2010	Species composition, density and biomass data of zooplankton monitored by the bay ecological stations since 2010 were recorded, 4-12 times per year.	2010	2016
Marine zooplankton survey after 2008	The species composition, density and biomass data of zooplankton monitored by the bay ecological stations in 2008 and 2009 were recorded and measured 4-12 times per year.	2008	2009
Marine microbial survey	All the Marine microbial data monitored by the bay ecological stations were recorded, 4-12 times per year.	2002	2016

The bay ecological stations refer to Jiaozhou Bay, Daya Bay and Sanya Bay stations.

3.2.2 Gaps

Taking the ecological accounting as an example, spatial environmental and socioeconomic data available for the coastal area were compiled for evaluation and application within to the proposed tables (such as “measures of ecosystem condition and extent at end of ecosystem condition” shown in Table 3) included in the SEEA EEA framework document. These tables require data including ecosystem extent, characteristics, and services. The datasets available for the accounting are shown in Table 7 and Table 8.

Before applying SEEA-EEA to a specific region, we deed to determine the accounting unit. The hierarchy of units in SEEA-EEA includes basic spatial units (BSUs), land-cover/ecosystem functional units (LECUs) and ecosystem accounting units (EAUs). The EAUs and LECUs are commonly-used. A research area can be considered as one or several EAUs. According to land cover types, one EAU can be divide into several LECUs. The EAU is the most applicable to the measurement of ecosystem assets, since it should be relatively stable in area over time. However,

the most logical choice with respect to the organization and measurement of relevant information may be the LCEU, since the characteristics of interest and types of ecosystem services flow are likely to vary significantly by types of LCEU.

For each accounting unit, ecosystem assets can be measured from two perspectives—the ecosystem condition and ecosystem extent; and the ecosystem services it can provide. Ecosystem condition reflects the overall quality of an ecosystem asset in terms of its characteristics. Measures of ecosystem condition may be compiled in relation to key ecosystem characteristics (e.g., water, soil, carbon, vegetation, biodiversity). Ecosystem extent refers to the size of an ecosystem asset. For ecosystem assets, the concept of extent is generally measured in terms of surface area, for example, hectares of a land cover type.

The SEEA-EEA proposed a broad structure for organizing information on ecosystem extent and condition for a given ecosystem asset. The choice of characteristics of ecosystem condition will generally vary depending on the type of ecosystem asset. And the type of LCEU depend on the EAU.

For accounting the ecosystem condition in the coastal and marine areas of China at one time point or over a certain period, it should mainly focus on the accounting of water (e.g. water resources reserve in coastal cities, PH, chlorophyll concentration, salinity, temperature), vegetation (e.g. area of mangroves) and biodiversity (e.g. biodiversity and biomass of marine plants, marine animals, marine plankton). The data for the accounting can be extracted from the statistics publications, monitoring data and remote sensing data, *etc*.

The ecosystem extent can be accounted by using the remote sensing data of land use/ land cover in China and the USGS land cover dataset *etc*.

As for the accounting of water resources, the *China Ocean Statistical Yearbook* can provide total, surface water and groundwater resources volumes in all provinces, the area of sea of all water quality levels, and the main pollutants information. The PH value, chlorophyll concentration, salinity and temperature of sea water can be obtained from satellite observation data or data products and the world ocean dataset.

As for the accounting of the biodiversity, the China National Ecosystem Observation and Research Network Science and Technology Resources Service System provides data on marine benthic surveys, marine phytoplankton surveys and bay zooplankton surveys.

As for the accounting of ecosystem service, we can obtain the annual population of tourists, the number of inbound tourists and tourism revenue, etc. in coastal cities from the *China Ocean Statistical Yearbook*.

However, gaps exit between the accounting structure and data available.

(1) Data collection frequency mismatch. While data are available on coastal land use undertaken about every 10 years by the Chinese Ministry of Natural Resources of the People's Republic of China, no similar comprehensive surveys or assessments are regularly scheduled for habitat that are particularly significant in the marine environment, such as seagrass, mangrove and coral. Instead, surveying of typical ecosystem such as seagrass, mangrove and coral reef, occurs on and

ad hoc basis based on research interests and funding availability. This causes a mismatch in reporting across accounting periods since data collection activities are not conducted within every accounting period. Effective accounting would require strategies to address environmental data that are collected at differing frequencies and to adjust for the uncertainty associated with older data that nonetheless represent the most recent comprehensive data source. This clearly also presents a challenge for selecting a relevant baseline for tracking of marine and coastal condition measures.

(2) Accounting period averages of ecosystem condition measures will obscure seasonal variation of those measures: variation that might be relevant for decision making. For example, dissolved oxygen varied with the season based on fluctuations in temperature and water column mixing, among other considerations. Thus, it may be appropriate to use the minimum or maximum value observed during the accounting period instead of using the average as a measure for certain characteristics. There may also be a desire to link the accounting indicators to seasonally important times of year. Seasonality adjustments should likewise be compatible with an ecosystem accounting framework. Appropriate metrics to use for ecosystem indicators and seasonality adjustments should be made in consultation with ecosystem experts and managers within the target region. The level of detail, timescale, and frequency of reporting of an EEA will dictate the need for seasonality adjustments.

Information extraction from multiple spatial resolution remote sensing data, or hindcasting and forecasting from available extent and condition data may provide solutions to the challenges. Long-term monitoring to support regularly scheduled accounting is needed. For example, consistent, scheduled monitoring of mangrove extent would improve the extent accounts. The process of compiling the data also can organize data dispersed across a range of governmental, non-governmental, and research entities.

4 Recommendations

4.1 Recommendations for extend SEEA to the Ocean in China

(1) Adding oceanic resources into NRAA. Although only land, forest and freshwater were suggested to be accounted in NRAA, it is necessary to incorporate oceanic resource assets in a comprehensive natural resources accounts especially in coastal areas. The accounted oceanic resource assets should meet the urgent needs and directions of natural resources management, for example, the spatial resources for sea use regulation, aquatic resources for fishery management, and coastal ecosystems and aquatic wildlife for ecosystem conservation.

(2) Establishing oceanic resource accounts basing on the SEEA. As discussed above, the oceanic resources assets and ecosystem services can be classified according to the categories of SEEA CF and EEA. The classification should be discussed and reach an international consensus. Besides, a 3-D data framework should be established, which is a necessary but hard task.

(3) Establishing practical data acquisition methods. Not all of the methods for terrestrial data acquisition are adapt to the ocean. New methods for the oceanic resources investigation and monitoring are needed to extend the SEEA to the ocean. For example, active remote sensing methods such as sonar, are more adaptable to seagrasses and coral reef data acquisition. the methods for archive data scaling up and down are also required.

(4) Initiating pilot studies and periodic accounting. The research on extending SEEA to the ocean is still limited, so pilot studies in a relatively small scales such as a habitat, a city or a county should be carried out to check and renew the suggested framework and methods.

(5) Promoting regional and international cooperation. UNESCAP initiates the Ocean Accounting, from which our research benefits and is enlightened. By starting pilot studies in Malaysia, Vietnam, Thailand, Samoa and China, diversified needs and stakeholders will be identified. It is advised to work together with UN system, countries, organizations, local communities and enterprises together to form a wide-accepted documentary, which may be supported under the mechanisms of the Belt and Road, South-South cooperation, Sino-Asian Maritime Cooperation Fund and others from China's aspect.

4.2 Recommendations for Pilot Study

As the result of discussions above, we suggest to start the practice of SEEA Ocean at the coastal ecosystems which are under high pressures of human activities but easy to be monitored and surveyed. After exchanging the ideas with local governments, including Jiangsu, Shenzhen, Hainan and Beihai, we recommended to start the pilot study in Beihai, and focus on the assets and ecosystem services of mangroves.

Beihai is famous for its coastal ecosystems including mangroves, seagrasses and coral reefs as well as the endangered marine creatures including dugong (extinct), Indo-Pacific finless porpoise, Indo-Pacific humpback dolphin, green turtle, pearl oyster, etc. By accounting the assets and ecosystem services of mangrove of Beihai, the awareness of marine conservation will be aroused. The knowledge and methods from this pilot study will be expended to other oceanic resources.

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