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The Ocean Economic Statistical System of China and Understanding of the Blue Economy

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1. INTRODUCTION

The 21st century is the century of the ocean and blue civilization. Economic globalization is increasingly pushing inland economies to move toward the ocean economy. Exploration and protection of ocean resources play an important role in sustainable development. The ocean covers 71 percent of the Earth's surface and contains 97 percent of the planet's water. The ocean plays an integral role in many of the Earth's systems including climate and weather. Meanwhile, the ocean sector is being recognized as an engine for growth all over the world. A number of coastal countries have launched programs explicitly aimed at strategic initiatives for the development of their ocean resources (State Oceanic Administration of China, 2010). In March 2011, China's 12th 5-year Plan for National and Social Development (2011-2015) was released by the central government and is currently being implemented. This is the first time that China has adopted a five-year plan for economic development in which "developing the ocean economy" has been identified as a key national development strategy. In 2002 the Canadian Department of Fisheries and Oceans launched Canada's Oceans Strategy, which provides an overall strategic approach to ocean management in that country (Fisheries and Oceans Canada, 2002). In July 2010, U.S. President Obama signed Executive Order #13547 establishing a National Policy for the Stewardship of the Ocean, Coasts, and the Great Lakes, which aims to significantly improve the management of the U.S.'s marine resources (Joint Ocean Commission Initiative, 2011). European policy, such as the IMP (Integrated Maritime Policy), emphasizes the need for economic and social information on maritime affairs in its objectives. Accordingly, it is very important and urgent to evaluate the economic contribution of the ocean to the economy. As explained by McIlgorm, by identifying the economic contribution of the ocean sector, policymakers can be more aware of how external events, such as climate change, sea level rise, degradation and destruction of natural resources and pollution impact economic growth and prosperity (ECORYS, Deltares and Oceanic, 2012).

At present, measuring the economic contribution of the ocean economy is clearly still in its formative stage. A number of marine countries in the world have tried to conceptualize marine sectors and quantify the economic importance of the ocean sector in their respective economies. However, the ocean data among these countries are mostly inconsistent, and internationally incomparable. It has never been easy to quantify this particular sector of the economy, in any country, given the lack of a detailed, centralized database with adequate specifics covering the necessary sectors.

As Kildow and McIlgorm (2010) point out, different countries define or delimit ocean activities and industries in distinct manners.

It should be noted here that several studies have been conducted that attempt to establish internationally compatible and consistent data for the ocean economy. Juan C. Surís-Regueiro et al. (2013) sets out a specific proposal for the definition and characterization of marine sectors and economic activities within the EU (Surís-Regueiro, Garza-Gil and Varela-Lafuente, 2013). This may very well be the first study in the ocean economy research field that aims at establishing internationally comparable ocean economy data, although it focuses only on the EU level. The EU Interreg IV (Priority 1) project Marnet (Marine Atlantic Regions Network) brought together eight partners across the five European Atlantic Arc countries– France, Ireland, Spain, Portugal and the United Kingdom (UK). A primary aim of the project was to develop a framework for the collection of marine socio-economic data across the participating countries (Foley et al., 2014).

This study is concerned with establishing a practical methodology on compiling ocean economy data. In order to quantify the contribution of ocean sectors at the national and international levels consistently, three goals need to be achieved:

- A clear-cut, internationally applicable definition. While there is large overlap in the various national definitions of the ocean sector in different countries /regions, there are gray areas that need to be resolved;
- The establishment of statistical classification framework of the ocean economy industrially and geographically. There is a need to identify the scope and coverage of ocean economic activities that should be included and to define transaction boundaries in operational terms;
- Standardization of statistical indicators. In order to enhance the value of data, there is a need to establish a unified statistical indicator framework, to compile the data of the ocean economy globally and benefit stakeholders and decision-makers.

In this context, this study aims to establish a standard statistical framework to evaluate the ocean economy of different countries, serving to clarify the definition and classification of ocean economic activities, and guide in the compilation and analysis of data, and planning the management and development of the marine sector, allowing the comparison of the estimated results, both over time as well as among the different sectors of activity, countries and regions. Since the non-market value of the ocean economy has not been estimated in all countries (Park and Kildow, 2014), this paper will focus on the market value of the ocean economy. Given that the establishment of

a statistical system for the ocean economy is a large, systematic project, it should be done gradually.

2. CONCEPTUAL FRAMEWORK

In order to establish the statistical framework for the global ocean economy and quantify the value of the ocean economy, first we need a clear definition of the ocean economy and related concepts. From my point of view, uniform definitions of at least four basic concepts are needed: ocean economy, ocean industry, ocean-related industry and coastal economy.

2.1 Ocean Economy

Various studies conducted by different countries (or studies) in this world have defined the ocean economy (see Table 1). Although these definitions vary greatly, they can generally be divided into three categories, as seen below.

2.1.1 Emphasize Using the Sea as an Input (Directly or Indirectly)

In this category, 4 countries (U.S., Ireland, Australia and Canada) and 1 study (Surís-Regueiro, J. C et al, 2013) are involved. One of the most notable definitions was given by Colgan (2007). In this analysis, Colgan emphasized that the concept of the ocean economy derives from the ocean (or Great Lakes) being a direct or indirect input to the economic activity. Most importantly, Colgan (2007) pointed out that the ocean economy is partly defined by industry and partly by geographic location. Based on this definition, there may be one exception to the rule: ship & boat building. In the construction of one ship or boat, one need not consider ocean resources as direct or indirect input.

2.1.2 Emphasize Activities Taking Place in the Sea

3 countries (U.K., New Zealand and South Korea) and 1 study (conducted by Park and Kildow) are involved in this category. One of the most significant features of definitions in this category is that they all emphasize where the economic activities take place; specifically, those that take place in or on the ocean belong to the ocean economy. Park and Kildow (2014) collected definitions of main countries, analyzed the similarities and differences among different definitions, and concluded that the ocean economy can be defined as the economic activities that take place in the ocean, receive outputs from the ocean, and provide goods and services to the ocean. Nonetheless, using these

definitions, we might not obtain the whole picture of the ocean economy, because they do not consider all the indirect impacts of the ocean.

2.1.3 Emphasizing the Way that Humans Interact with the Oceans

In this category, China, Japan and Canada are involved. These countries define ocean activities from the angle of ocean-human interaction. In this case, ocean economy activities are defined widely. They range from developing and utilizing the ocean to protecting the ocean, and from individual to industrial to administrative uses. Compared to the other two categories, this category may fail to highlight the key industries of ocean economy. However, it does include all of the ocean activities.

The ocean economy therefore, as defined by China’s State Oceanic Administration’s Industrial Classification for Ocean Industries and Their Related Activities, is the summation of both ocean and ocean related industrial activities that are aimed at developing, utilizing or protecting the ocean.

Figure 1 depicts the relationship among ocean economy concepts in China. China’s ocean economy concept includes three layers of content. The core layer represents 12 major ocean industries, which are outlined in Table 1. 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.

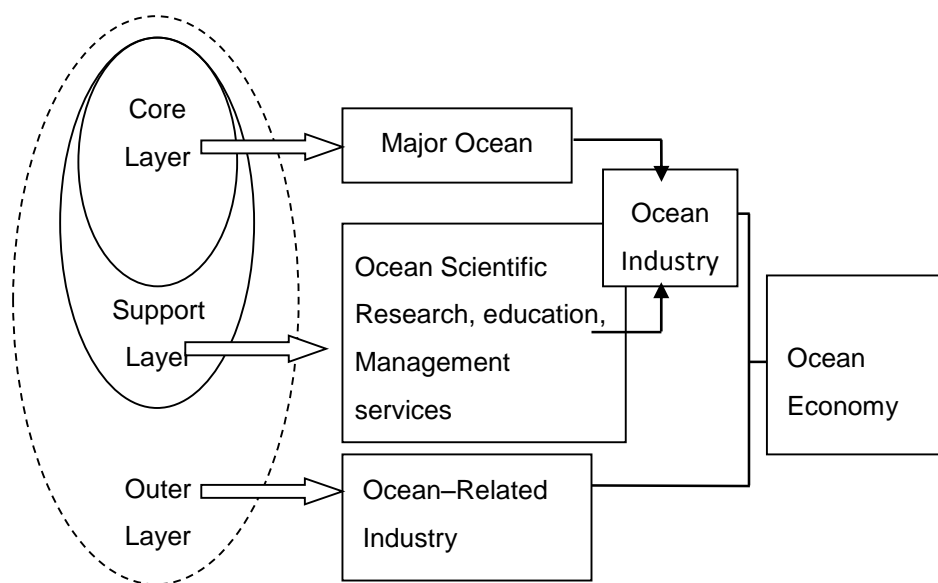


Figure 1. Relationship among concepts of ocean economy

In conclusion, having compared the three categories of definitions, we find the third, which emphasizes human interaction with the ocean, to be the most appropriate because, first of all, it can include all kinds of ocean activities. Second, we could make the definition more specific by distinguishing among ocean industries and ocean-related industries. We could give ocean economy the definition as China's ocean economy, is summation of both ocean and ocean related industrial activities that are aimed at developing, utilizing and protecting the ocean.

Table 1. Ocean Economy Definitions of Different Countries (or studies)

Country	Definition
a. Emphasize using the sea as an input (directly or indirectly)	
U.S.	The ocean economy consists of all economic activity that derives all or part of its inputs from the ocean or Great Lakes (Colgan, 2007)
Ireland	Economic activity which directly or indirectly uses the sea as an input (Vega, Corless and Hynes, 2013).
Australia	Ocean-based activity (Is the ocean resource the main input? Is access to the ocean a significant factor in the activity?) (Allen Consulting, 2004)
Surís-Regueiro, J. C et al(2013)	Assumes that an economic activity forms a part of the marine economy when the ocean and its resources constitute either directly or indirectly an input of the goods and/or services necessary to develop that activity (Surís-Regueiro, Garza-Gil and Varela-Lafuente, 2013).
b. Emphasize activities that take place in the sea	
U.K.	Those activities which involve working on or in the sea. Also, those activities that are involved in the production of goods or the provision of services that will directly contribute to activities on or in the sea (Pugh, D. and the Crown Estate, 2008).
New Zealand	The economic activity that takes place in, or uses the marine environment, or produces goods and services necessary for those activities, or makes a direct contribution to the national economy (Statistics New Zealand-Environmental Statistics, 2003).
South Korea	The economic activity that takes place in the ocean, which also includes the economic activity, which puts the goods and services into ocean activity and uses the ocean resources as an input (Hwang et al., 2011).
Park Kwang Seo and Kildow Judith T. (2014)	Ocean economy can be defined as the economic activities that take place in the ocean, receive outputs from the ocean, and provide goods and services to the ocean. In other words, ocean economy can be defined as the economic activities that directly or indirectly take place in the ocean and use outputs from the ocean,

Country	Definition
	while incorporating goods and services into the ocean's economic activities (Park and Kildow, 2014).
c. Emphasizing the way that human beings interact with the oceans	
China	Summation of both ocean and ocean related industrial activities that are aimed at developing, utilizing and protecting the ocean (Zhao, Hynes and He, 2014).
Canada ¹	The marine economy includes those individual, industrial and administrative activities dependent on or related to the ocean (Gardner Pinfold, 2014).
Japan	Industry exclusively responsible for the development, use and conservation of the ocean (Nomura Research Institute, 2009).

2.2 Ocean Industry and Ocean-related Industries

Both China and Canada divide the ocean economy into two parts. In China's case the whole ocean economy is divided into ocean industry and ocean-related industry. In Canada's case, it is divided into primary marine activities and secondary marine activities. Although the two countries don't give the two parts the same name, both of them divide the ocean economy according to a nearly identical standard.

In order to standardize the ocean economy data collected throughout the country, China's State Oceanic Administration released a document defining the statistical standard for Industrial Classification for Ocean Industries and Their Related Activities GB/T 20794-2006. This document sought to establish a statistical standard for ocean economy data collecting across all regions in China. The ocean industrial classifications within this document divided the marine sector into two parts: ocean industries and ocean-related industries.

- Ocean industries: these represent the core of the ocean economy and indicate industries involved in the production or supply of service for developing, utilizing and/or protecting the ocean. In China's case, this part of the ocean economy includes major marine industries such as offshore oil and gas, marine mining, marine salt manufacturing, the marine chemical industry, marine biomedicine, marine electric power generation, seawater utilization, marine shipbuilding, marine engineering and construction, marine communications and transportation, coastal tourism, marine scientific research, and education.
- Ocean-related industries refer to the enterprises that form a technical and economic link with the major marine industries. These industries are defined as

¹Gardner Pinfold, Economic impact of ocean activities in Canada, 2009.

suppliers and customers of the ocean industries; they produce inputs for the latter or use outputs from the latter in the production process. Some of these activities are not necessarily performed at sea or even in coastal zones. These industries include agriculture and mangrove forestry (which for example provide feed for marine use and that in turn use sea water to irrigate certain species of plants cultivated on Chinese wetlands), marine equipment manufacturing, ocean-related building and installation, marine wholesale and retail services, etc.

In Canada's case, ocean activities in the private and public sectors are identified as either primary or secondary according to their relative economic importance and the state of knowledge about the activity. Primary marine activities represent the core of the marine economy: industries deriving their economic rationale in a direct way from their extractive or non-extractive use of marine resources. Such activities include fishing, offshore oil and gas, ship and boat building and repair, water transportation, and marine construction. It also includes federal and provincial departments and agencies with management and administrative responsibilities over ocean uses. Secondary marine activities may be industries in their own right or form part of a broader industry grouping. Though their contribution to the economy may be accounted for as indirect impacts by an economic model (input-output model), they are singled out for attention in this study in order to shed more light on the nature and scope of the activity and the linkages with other sectors of the economy.

It should be noted that in China's case the input-output model is also applied in order to quantify ocean-related industries, a methodology also employed by the NOEP. Fewer differences exist in China and Canada's definitions of the ocean and ocean-related industry. Therefore, this study considers China's definitions of ocean industry and ocean-related industry the most appropriate one for the global economy. Sub-categories of ocean industry and ocean-related industry will be discussed in the third section.

2.3 Coastal Economy

The coastal economy is another basic concept for the ocean economy. NOEP actually made the first effort to define and measure the coastal economy. Furthermore, the NOEP differentiates between oceanic economics and coastal economics. The two are closely related, but respond to different concepts. According to Colgan (2007), the coastal economy consists of all economic activity in the coastal region, and thus represents total employment, wages, and output in each of the geographies defined as part of the coastal economy.

Based on the NOEP definition, defining the “coastal region” is the key to quantifying the coastal economy. A coastal region is the transition zone between land and sea. It can refer to the belt area extending a certain distance out to sea and, conversely, inland. Defining and classifying the coastal region will be discussed in the fourth section.

3. INDUSTRIAL CLASSIFICATION FRAMEWORK

Since the ocean economy is composed of ocean industry and ocean related industry, the industrial classification of the ocean economy could be done through the industrial classification of ocean industries and ocean-related industries. Regarding the coastal economy, there is no need to classify any related industries, given that all the economic activities in the coastal region belong to the coastal economy. As this is the very beginning of establishing the statistical system for the global ocean economy, it is crucial to start with common ocean industries and make them comparable across ocean economic sectors and industries in different countries.

In this section, we review recent studies related to ocean economy classification and then discuss Chinese ocean industrial classification. The final section gives a practical industrial classification for the global ocean economy based on ISIC (International Standard Industrial Classification of All Economic Activities, Rev.4)

3.1 A Review of Previous Research on Industrial Classification of the Ocean Economy

In recent years, ocean economic accounting studies have been carried out in many countries all over the world, where ocean sectors are defined in different ways and ocean data is collected based on different standards. Table 2 shows the main countries that have conducted ocean economy studies.

Table 2. Classification and Definition of Major Ocean Industries

Region	Main countries
Asia-Pacific	China, Australia, New Zealand, Japan, Korea, Indonesia, Philippines, Vietnam, Malaysia, Thailand.
America	USA, Canada
Europe	England, France, Spain, Ireland

In NOEP’s studies (Colgan 2003, Colgan 2007 and Colgan 2013), the data set defines the “ocean economy” through a combination of industry and geographic location features to measure 21 separate industries across six sectors, at the national,

state, and county levels. Colgan (2003 and 2007) also affirmed that the estimation of economic activity linked to the ocean is inherently limited due to limited data availability, conceptual difficulties and the need to make some subjective choices concerning what to include and what to exclude. The Canadian Department of Fisheries and Oceans (DFO) released a series of reports (2002, 2003 and 2009) to analyze the economic impact of marine related activities in Canada. The recent analysis (Gardner Pinfold, 2009) covers 7 sectors including offshore oil & gas, marine transportation, tourism and recreation, seafood, manufacturing and construction, national defense, public sector and research. Among the 27 Member States of the European Union, 22 have a coast and two thirds of the European borders are set by the sea. In Europe, these types of studies have been carried out in some coastal countries as well. It should also be noted that the ocean sectors are defined in different ways. In the U.K., Pugh and the Crown Estate (2008) researched ocean economic accounting. In it he studied 18 different ocean sectors that involve working in or on the sea, and also those relating to the production of goods or provision of services that directly contribute to activities carried out in or on the sea. In Spain's case, Innovamar defines the marine sector as a group of economic activities that do not have an official definition, but is made up of companies whose activities have a direct relationship with the sea and others with a close relationship with the sea. Fernández-Macho et al (2015) propose a theoretical structure for the maritime economy and then collects and classifies comparable and reliable maritime socio-economic indicators, focusing on the Spanish part of the European Atlantic Arc. The aforementioned researchers would go on to identify nine marine sectors of the marine economy.

Table 3 shows similarities and differences between the industrial classification of China's ocean economy and that of other countries. This study finds that major ocean countries classify the ocean economy in disparate ways. Whereas the different classifications of ocean industries agree on marine fishery, offshore oil and gas industry, ship building industry, marine construction industry, marine transportation, and coastal tourism, the rest of the Marine industry national statistical condition is not unified. Six countries (Canada, U.K., France, Spain, South Korea and China) consider marine research and education as a separate industry for ocean economy. Four countries (U.K., France South Korea and China) take marine renewable energy into account. Marine renewable energy industry is an emerging ocean industry, which in some sense represents the future of ocean economy. Generally, there are eight industries that different countries have in common.

There are many difficulties incomparable statistical ocean economy analysis of different countries. However, it is crucial to establish a recognized classification standard for all countries. To that end, we have compiled Table 3 (next pages).

Table 3. Ocean Economy Classifications across Nine Maritime Nations

	China	USA	Canada	U.K.	Fr.	Spain	Ireland	Australia	South K.
Major ocean industries	Marine Fishery	Living Resources- Marine	Seafood	Fish	Seafood Products	Living Resources	Sea-Fisheries Aquaculture Seafood Processing	Fisheries and Seafood	Fisheries Seafood Processing
	Offshore Oil and Gas	Minerals - Offshore	Offshore Oil and Gas	Oil and gas	Offshore Oil and Gas- related	Non-living Resources	Oil and Gas	Refining of Petroleum from Offshore sources	
	Ocean Mining	Minerals - Offshore		Aggregates	Extraction of Marine Aggregates	Non-living Resources			Marine Mining
	Marine Salt								
	Shipbuilding	Ship & Boat Building and Repair	Manufacturing	Ship & boat building and repairs	Ship Building and Repair	Ship Building		Shipbuilding	Ship and Offshore Plant Building
	Marine Chemical								
	Marine Biomedicine						Marine Biotech & Bio products		Marine Bio
	Marine Engineering & Construction	Construction - Marine	Marine Construction	Construction	Marine and River Civil Eng.	Construction	Marine Mfg., Eng. and Construction		Marine Construction
	Marine Electric Power			Marine Renewable Energy	Electricity Generation		Marine Renewable Energy		Ocean Renewable Energy
	Seawater Utilization								
	Marine Communications & Transportation	Transportation - Marine	Marine Transportation	Shipping Operations- Ports	Maritime and River Transport	Transport	Shipping and Maritime Transport	Shipping	Shipping Operations- Ports
Coastal Tourism	Tourism & Recreation	Ocean-based Rec & Leisure	Leisure and Recreation	Coastal Tourism	Tourism and Rec.	Marine Tourism and Leisure Cruise	Marine Tourism	Marine Tourism and Leisure	

	China	USA	Canada	U.K.	Fr.	Spain	Ireland	Australia	South K.
Ocean Scientific Research, Education & Management Services	Marine Information Services			Submarine Cables	Submarine Cables				
	Marine Environment Monitoring and Prediction services								
	Marine Insurance and Social Security				Maritime Insurance		Marine Commerce		
	Marine Science Research		Universities and Research	R&D	Marine Research	Education and R&D			Marine R&D
	Marine Technology Services			License and Rental			High Tech Marine Products and Services		Marine Technical Services
	Marine Geologic Exploration								
	Marine Environmental Protection			Marine Environment	Coastal & Marine Environ. Protection				
	Marine Education		Universities and Research	Education and training					
	Marine Management		Federal, Provincial, Territorial Gov'ts	Navigation and Safety	Public Intervention	Public admin.			Marine Public Admin. and Education
	Marine social and int'l organizations		NGOs						
Ocean-related	Marine Agriculture, Forestry								
	Marine equipment			Marine Equipment and Material					Marine Equipment and Material
	Ocean-related Products and Materials Manufacturing								

	China	USA	Canada	U.K.	Fr.	Spain	Ireland	Australia	South K.
	Ocean-related Construction and Installation								
	Marine Wholesale and Retail						Marine Retail Services		
	Ocean-related Services		Services	Business Service					
				Defense	Navy				

3.2 Chinese Classification of Ocean Economy Industries

The Chinese government set about launching and gradually improving ocean economic statistics from the 1990s, becoming increasingly institutionalized, standardized and regulated in data government (Song, He, and McIlgorm, 2013). With the aim of providing marine policy makers in China with marine activity statistics, the Ocean Economy Accounting System (OEAS) of China was established in 2006(He, 2006). In order to standardize the ocean economy data collected across the whole country, China’s State Oceanic Administration released a document in 2006 defining the statistical standard for *Industrial Classification for Ocean Industries and Their Related Activities* (GB/T 20794-2006). This document sought to establish a statistical standard for ocean economy data collecting across all regions in China. This standard assigns unique two-, three- and four-digit codes to each industry, see Table 4. The whole ocean economy is divided in 28 two-digit codes, 106 three-digit codes and 390 four-digit codes. It should be noted that navy activities are not included in this standard.

Table 4. The Basic Structure of Chinese Classification of Ocean Economy Industries

		Ocean sectors	Industries
Ocean Industry	Major ocean Industries	Marine Fishery 01	Mariculture 011
			Marine Fishing 012
			Fishery Service industry 013
			Seafood Processing 014
		Offshore Oil and Gas Industry 02	Offshore oil and gas exploration and production 021
			Support activities for oil and gas 022
		Ocean Mining Industry 03	Sea beach placer mining and quarrying 031
			Sand & stone Mining and quarrying 032

		Ocean sectors	Industries
			Submarine geothermal power and coal mining 033
			Deep sea mining 034
			Other ocean mineral resources mining 035
		Marine Salt Industry 04	Salt industry of seawater 041
			Salt processing 042
		Shipbuilding Industry 05	Ship & boat building and repairing 051
			Offshore fixed and floating devices manufacturing 052
		Marine Chemical Industry 06	Sea salt chemical industry 061
			Seaweed chemical industry 062
			Sea water chemical industry 063
			Offshore oil & gas chemical industry 064
		Marine Biomedicine Industry 07	Marine medicine producing 071
			Ocean health products 072
		Marine Engineering Building Industry 08	Ocean engineering building 081
			Offshore engineering building 082
			Submarine engineering building 083
		Marine Electric Power Industry 09	Oceanic energy 091
			Offshore wind 092
		Seawater Utilization Industry 10	Seawater desalination 101
			Direct seawater utilization 102
			Other seawater utilization 103
		Marine Communications and Transportation Industry 11	Marine cargo transportation 111
			Marine passenger transportation 112
			Submarine pipeline transportation 113
			Sea ports 114
Marine transportation service 115			
Coastal Tourism 12	Hotels and lodging places 121		
	Amusement and recreation, 122		
	Coastal tourism services 123		
	Coastal tourism and cultural services 124		
	Other coastal tourism services 125		
Ocean Scientific	Marine Information Services 13		

		Ocean sectors	Industries
	Research, Education, Management Services	Marine Environment Monitoring and Prediction services 14	
		Marine insurance and social security industry 15	
		Marine science research 16	
		Marine technology services 17	
		Marine Geologic Exploration Industry 18	
		Marine environmental protection industry 19	
		Marine Education 20	
		Marine Management 21	
		Marine social and international organizations 22	
		Ocean- related Industry	
Marine equipment Industry 24			
Ocean-related products and materials manufacturing 25			
Ocean-related construction and installation industry 26			
Marine Wholesale and Retail Industry 27			
Ocean-related Services 28			

In China’s case, specific ocean industries cannot be directly identified within national statistical databases. It is therefore of vital importance to find an appropriate way to measure and compile the data required to quantify the ocean economy. Measuring ocean economic activities is a complicated issue, especially when it is difficult to obtain sufficient basic data for all possible ocean industries as is the case in China. As a result, this paper focuses on the major ocean industries in China for which data is available. While some small emerging sectors are excluded from the analysis presented in this paper, the industries analyzed still represent a high proportion of the total value of the market-based ocean economy in China. The major ocean industries classified are marine fishery, offshore oil and gas, ocean mining, marine salt,

shipbuilding, the marine chemical industry, marine biomedicine, marine engineering, marine electric power, the seawater utilization industry, marine communications and transportation and coastal tourism. The definitions of these industries in China are presented in Table 5.

Table 5. Classification and Definitions of Major Ocean Industries

Ocean Sector	Definition
Marine Fishery	Includes mariculture, marine fishing, marine fishery service industry and marine aquatic processing, etc.
Offshore Oil and Gas Industry	Refers to production activities of exploring, exploiting, transporting and processing raw oil and natural gas in the ocean.
Ocean Mining Industry	Includes the activities of extracting and dressing beach placers, beach soil chloride and sand, submarine geothermal energy, and coal mining and deep-sea mining, etc.
Marine Salt Industry	Refers to the activity of producing salt products with sodium chloride as the main component by utilizing seawater, including salt extracting and processing.
Shipbuilding Industry	Refers to the activity of building ocean vessels, offshore fixed and floating equipment with metals or non-metals as main materials as well as repairing and dismantling ocean vessels.
Marine Chemical Industry	Includes the activities related to the production of chemical products derived from sea salt, seawater, sea algal and marine petroleum chemical industries.
Marine Biomedicine	Refers to the production, processing and manufacturing activities of marine based medicines and marine healthcare products by using organisms as raw materials (or by extracting these organism's useful components).
Marine Engineering and Building Industry	Refers to the construction of architecture projects and their preparations in the sea, at the sea bottom and seacoast for such uses as marine production, transportation, recreation, protection, etc., including construction of seaports, coastal power stations, coastal dykes, marine tunnels and bridges, land terminals of offshore oil and gas fields as well as building of processing facilities, and installation of submarine pipelines and equipment, but not the projects of house building and renovation.

Ocean Sector	Definition
Marine Electric Power	Refers to the activities of generating electric power in the coastal region by making use of ocean energies and ocean wind energy. It does not include the thermal and nuclear power generation in the coastal area.
Seawater Utilization	Refers to the activities of the direct use of sea water and the seawater desalination, including those of carrying out the production of desalination and applying the seawater as water for industrial cooling, urban domestic water, water for firefighting etc., but not the activity of the multipurpose use of seawater chemical resources.
Marine Communications and Transportation	Refers to the activities related to maritime transportation with vessels as main vehicles, including ocean-going passenger transportation, auxiliary activities of water transportation, pipeline transportation, loading, unloading and transport as well as other transportation and service activities.
Coastal Tourism	Refers to the tourism-related activities that take place in the coastal zone, on sea islands as well as recreational activities that use the ocean; including water based sports, marine mammal and bird watching, etc.

Because of the statistical classification in China, government Input-Output Data does not identify for ocean. Therefore, the corresponding input-output sectors in the China. In order to obtain data pertaining to ocean-related industry, input-output methodology should be used. According to Zhao (Zhao, 2015), corresponding industries of Chinese Input-Output table are selected based on the definitions of the input-output sectors and ocean economy I-O sectors. Generally, I-O tables of China are built with 144 I-O industries, 22 of which correspond with major ocean industries.

Table 6 provides the corresponding relationship between ocean industries and I-O sectors. Of the 12 major ocean industries, seven are related to only one I-O sector. Therefore, these seven ocean industries can use the multipliers of their corresponding I-O sectors. On the other hand, the other five industries need to be aggregated as calculating the multipliers of ocean industries. Following the methodology created by NOEP, the main aggregation method used in this research is to add up all the corresponding industries in rows and columns to develop a new I-O matrix.

Table 6. Corresponding Relationship between Ocean Industries and Input-Output Sectors

Ocean sectors	Ocean industries	Input-output sectors
Marine Fishery	Mariculture	03003 Fishing
	Marine Fishing	03003 Fishing

	Fishery Service industry	05005Agriculture, Hunting, Forestry and Fishing services
	Seafood Processing	13016Aquatic products processing
Offshore Oil and Gas Industry	Offshore oil and gas exploration and production	07007 Petroleum and Natural Gas Mining
	Support activities for oil and gas	
Ocean Mining Industry	Sea beach placer mining and quarrying	08008Ferrous Metals Mining and Dressing 09009Nonferrous Metals Mining and Dressing
	Sand & stone Mining and quarrying	10010Nonmetal Minerals Mining and Dressing
	Submarine geothermal power and coal mining	10010Nonmetal Minerals Mining and Dressing
	Deep sea mining	08008Ferrous Metals Mining and Dressing 09009Nonferrous Metals Mining and Dressing 10010Nonmetal Minerals Mining and Dressing
	Other ocean mineral resources mining	08008Ferrous Metals Mining and Dressing 09009Nonferrous Metals Mining and Dressing 10010Nonmetal Minerals Mining and Dressing
Marine Salt Industry	Salt industry of seawater	10010Nonmetal Minerals Mining and Dressing
	Salt processing	
Shipbuilding Industry	Ship & boat building and repairing	37075Ship and Floating Equipment Manufacturing
	Offshore fixed and floating devices manufacturing	
Marine Chemical Industry	Sea salt chemical industry	26039 Basic Chemistry Industry
	Seaweed chemical industry	
	Sea water chemical industry	
	Offshore oil & gas chemical industry	25037 Oil and Nuclear Fuel Processing

Marine Biomedicine Industry	Marine medicine producing	27046 Manufacture of Medicines
	Ocean health products	
Marine Engineering Building Industry	Ocean engineering building	47095 Construction of Buildings and Civil Engineering
	Offshore engineering building	
	Submarine engineering building	
Marine Electric Power Industry	Oceanic energy	44092 Production and supply of Electric Power and Heat Power
	Offshore wind	
Seawater Utilization Industry	Seawater desalination	46094 Production and Supply of Water
	Direct seawater utilization	
	Other seawater utilization	
Marine Communications and Transportation Industry	Marine cargo transportation	54102 Water Transport
	Marine passenger transportation	
	Submarine pipeline transportation	56104 Pipeline transport
	Seaports	57105 Loading, Unloading and Other Transport Services
	Marine transportation service	
Coastal Tourism	Hotels and lodging places	66113 Hotels
	Amusement and recreation,	67114 Catering Services
	Coastal tourism services	74125 Tourism
	Coastal tourism and cultural services	
	Other coastal tourism services	

Based on the relationship between ocean sectors and input-output sectors as presented in table 4, the ocean industries I-O table can be carried out by aggregating corresponding I-O sectors both in rows and columns.

3.3 Practical Classification

Based on the above analysis, ocean nations should have a practical industrial classification. Why not take “what we have in common” as the starting point of international ocean economy statistical classification? In other words, we should establish eight ocean industries as the international statistical classification and try to provide these industries with unified definitions.

In order to define these industries, we should make sure that definitions of these industries are based on the same classification. Accordingly, this study uses ISIC as the basis of classification and definition.

Since the adoption of the original version of ISIC in 1948, the majority of countries around the world have used ISIC as their national activity classification or have developed national classifications derived from ISIC. ISIC has therefore provided guidance to countries in developing national activity classifications and has become an important tool for comparing statistical data on economic activities at the international level. Generally, the major ocean sectors and industries in China were defined based on the statistical classification of CCSNEI (Classification and Code Standard of National Economy Industry), which is quite similar to the NAICS (North American Industrial Classification System). The US NOEP extracts their ocean economy data based on NAICS. In NOEP's case, the statistical data is compiled from official US statistical surveys and sources, where economic activities are usually identified both by the codes that correspond with the SIC (Standard Industrial Classification System) as well as with the NAICS (North American Industrial Classification System). The NAICS divides the different economic activities into smaller groups than the SIC, which makes it possible to identify the marine economy's activities more precisely and obtain more detailed information about them. Similarly, in Europe, the relevant institutes in France, Britain and Ireland collect ocean economic statistics based on the NACE (Classification of Economic Activities of the European Communities) coding system². Business activities in the Australian (and New Zealand) statistical systems follow international standards when defining an industry and these are set out in the Australian and New Zealand Standard Industrial Classification (ANZSIC). But all these national or regional industrial classifications have corresponding connections with ISIC.

In defining the different industrial sectors in the ocean economy, the primary concern is to establish the classification based on the commonalities of different countries in order to produce internationally comparable data. Basic industries should include:

- Fishing/aquaculture
- Marine transportation
- Marine tourism
- Offshore oil and gas

²Indeed an EU INTERREG funded project is currently underway along the Atlantic periphery of Europe (MARNET) that is attempting to map the value of the Atlantic marine economy through the development of reliable and comparable socio economic data across the coastal member states of Portugal, Spain, France, Britain and Ireland (see <http://www.marnetproject.eu/> for further information).

- Marine construction
- Boat and Ship Building, Maintenance and Repair
- Marine renewable energy
- Marine research and education

The corresponding four-digit codes of these eight industries are presented in Table 7 (next page). The industries are then divided further into both fully- and partially-ocean activities as presented. This study identified eight marine sectors comprising a total of 46ISIC codes. The data collected is at the ISIC four-digit level and shown in Table 7, in which “F” stands for “fully” and “P” stands for “partially”. In the latter case, proxies need to be used to identify the maritime share.

Table 7. ISIC Codes Identified for the Data Collection Framework Divided into Aggregate Ocean Sectors

Sector	ISIC Code	Description	Ocean share
Fishing/aquaculture	0311	Marine fishing	F
	0321	marine aquaculture	F
	1020	Processing and preserving of fish, crustaceans and mollusks	F
Offshore oil and gas	0610	Extraction of crude petroleum	P
	0620	Extraction of natural gas	P
	0910	Support activities for petroleum and natural gas extraction	P
Boat and Ship Building, Maintenance and Repair	3011	Building of ships and floating structures	F
	3012	Building of pleasure and sporting boats	F
	3315	Repair of transport equipment, except motor vehicles	P
Marine renewable energy	3510	Electric power generation, transmission and distribution	P
Marine construction	4290	Construction of other civil engineering projects	P
	4311	Demolition	P
	4312	Site preparation	P
	4321	Electrical installation	P

Sector	ISIC Code	Description	Ocean share
	4322	Plumbing, heat and air-conditioning installation	P
	4329	Other construction installation	P
	4390	Other specialized construction activities	P
Marine transportation	5011	Sea and coastal passenger water transport	F
	5012	Sea and coastal freight water transport	F
	5210	Warehousing and storage	P
	5222	Service activities incidental to water transportation	P
	5224	Cargo handling	P
	5229	Other transportation support activities	P
	4930	Transport via pipeline	P
Marine tourism	5510	Short term accommodation activities	P
	5520	Camping grounds, recreational vehicle parks and trailer parks	P
	5590	Other accommodation	P
	5610	Restaurants and mobile food service activities	P
	5621	Event catering	P
	5629	other food service activities	P
	5630	Beverage serving activities	P
	7911	Travel agency activities	P
	7912	Tour operator activities	P
	7990	Other reservation service and related activities	P
	9102	Museums activities and operation of historical sites and buildings	P
	9103	Botanical and zoological gardens and nature reserves activities	P
	9312	Activities of sports clubs	P

Sector	ISIC Code	Description	Ocean share
	9321	Other sports activities	P
	9329	Other amusement and recreation activities n.e.c.	P
Marine research and education	7210	Research and experimental development on natural sciences and engineering	P
	8521	General secondary education	P
	8522	Technical and vocational secondary education	P
	8530	Higher education	P
	8541	Sports and physical education	P
	8549	Other education n.e.c.	P

4. GEOGRAPHICAL CLASSIFICATION FRAMEWORK

4.1 A Review of Previous Research Geographical Classification

As of yet, there is no uniform definition of a coastal region or zone in the world, especially, as Hynes and Farrelly (2012) point out, a definition of the inland boundary of a country's coastal region is a hard to measure feature of the land-sea interface. Several representative studies from across the world are presented here.

United States: The Coastal Zone Management Act of the United States defined coastal zone as “the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches” (Coastal Zone Management Act, 1972). The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters, and to control those geographical areas which are likely to be affected by or are vulnerable to sea level rise. This definition is not particularly concrete in terms of boundaries of the coastal zone, and this fact may explain why all the 35 coastal states in the US have defined the boundaries of their coastal zone using their own standards. Based on the definitions of the US Coastal Zone Management Act, coastal states in the U.S. defined their own coastal zone boundaries. The landward boundaries can be divided into four types: (1) the coastal zone is the whole state, for

example, Delaware, Hawaii, etc.; (2) Natural boundaries: for example, Indiana's coastal zone is based on the watershed boundaries within coastal townships and the counties of Lake County and Porter County. (3) Administrative boundaries: for example, Washington's coastal zone is the 15 coastal counties that front saltwater; (4) Environment units, for example, California's coastal zone generally extends 1000 yards inland from the mean high tide line;

It should be noted that the seaward boundaries of the coastal states are relatively uniform. The seaward boundary of the Great Lake States is the U.S. – Canada international boundary, and for all other states it is the 3 nautical mile territorial sea mark, except for Florida (boundary in Gulf of Mexico), Puerto Rico, and Texas with its seaward boundary at three marine leagues from the coastal line.

South Africa: In 2009, South Africa released South Africa's Integrated Coastal Management Act (Integrated Coastal Management Act of the Republic of South Africa, 2009), the first chapter of which defines coastal zones as such: the area comprising coastal public property, the coastal protection zone, coastal access land and coastal protected areas, the seashore, coastal waters and the exclusive economic zone, and includes any aspect of the environment on, in or under above such an area.

Eurostat: European NUTS 3 Coastal Region is defined as a standard statistical region where at least half of the population is within 50 km of the shoreline. The Nomenclature of Territorial Units for Statistics (NUTS) was established by Eurostat more than 30 years ago in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union. At the NUTS 3 level most of the landmass of Ireland and Britain is defined as coastal which is a very broad definition.

World Bank: In 1996, World Bank defined the coastal zone as “the interface where the land meets the ocean, encompassing shoreline environments as well as adjacent coastal waters. Its components can include river deltas, coastal plains, wetlands, beaches and dunes, reefs, mangrove forests, lagoons, other coastal features.”

Mediterranean ICZM Protocol: In 2008, the coastal zone was defined by Mediterranean ICZM Protocol as “the geomorphologic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource system and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities.”

Generally, there is relatively little controversy concerning the seaside boundary of a coastal zone. In most countries the seaward limit is written into law as the maximum reach of that country's jurisdiction (Hynes and Farrelly, 2012). In China's case, this

might be the territorial sea limit of 12 nautical miles or the 200 nautical mile EEZ (Exclusive Economic Zone) or perhaps the continental shelf defined by the People's Republic of China.

One suitable approach for compiling the socio-economic data is used by National Ocean Economics Program (NOEP) in the US. According to Colgan (2007), the definition of Coastal Economy of NOEP relies on a tiered approach of geography extending inland from the shorelines of the ocean or Great Lakes. These tiers are based on definitions of zip code and county boundaries starting with the shore-line and proceeding inland. Six categories have been defined: (1) near-shore; (2) shore-adjacent coastal zone county; (3) non-shore-adjacent coastal zone county; (4) non-coastal zone watershed county; (5) coastal watershed county; and (6) inland county. In this case, coastal zone counties consist of shore-adjacent and non-shore adjacent counties. A shore-adjacent county is a county touched in whole or in part by a state's coastal zone for purposes of the Coastal Zone Management Act of 1972 and as defined by that state and which is adjacent to an ocean, Great Lake, or included river or bay. A none-shore-adjacent coastal zone county is a county touched in whole or in part by a state's coastal zone for purposes of the Coastal Zone Act of 1972, as defined by that state and which is not adjacent to an ocean, Great Lake, or included river or bay. Therefore, the coastal economy as an NOEP statistical region is generally based on the definition of coastal zone for purposes of the Coastal Zone Management Act of 1972 as defined by that state and which is adjacent to an ocean, Great Lake, or included river or bay, as previously mentioned.

Ireland also serves as a practical example for the development of socio-economic statistics in coastal zones. Following the approach of the NOEP framework, based on different administrative and political jurisdictions, Hynes and Farrelly (2012) defined Ireland's coastal region as three geographical scales extending inland from the shorelines of the oceans and seas surrounding the Republic of Ireland. The definitions of the alternative tiers are based on electoral districts, county boundaries and EU NUTS3 regions. Thus, we see shoreline electoral districts: establishments or populations located in an electoral district(ED) that is immediately adjacent to an ocean or sea, including estuaries and bays. Of the 3400 EDs in the country, 628 are shoreline electoral districts. There are also coastal counties: establishments or populations located in a county that has a shoreline of any length adjacent to an ocean or sea, including estuaries and bays. 15 of the 26 counties in the Republic of Ireland are coastal counties. European NUTS3 Coastal Region: a standard statistical region (EU NUTS3 level), where at least half of the population is within 50km of the shoreline. This is the Eurostat definition of a coastal region and in the Irish case would include 7 of the 8 NUTS3 regions in Ireland, the Border, the West, Dublin, the Mid-East, the Mid-West, the

South-East and the South-West. Only the four counties of the Midlands NUT3 region are excluded from this definition.

4.2 Practical Geographical Classification Using China as an Example

In China, there are numerous definitions of the term coastal region or zone in the literature that one might use in examining the socio-economic characteristics of the country's coastal regions. In the 1980s, China carried out a comprehensive survey of the national coastal zone and tideland resources, which specified the range of the survey work as extending landward from the shoreline 10km, extending to the sea to 15m isobaths (SOA, 1988). This scope is generally considered as the definition of China's coastal line in several kinds of ocean related literature. However, this survey was just a natural resource survey, rather than a socio-economic survey, and it is very difficult to gather information about the coastal economy and society using such a definition, given that data cannot be extracted from central databases based on a subjective distance from a shoreline inland boundary definition.

In terms of socio-economic statistics of coastal zones, any region-specific socio-economic statistics are generally collected based on administratively defined jurisdictions; therefore, based on the above analysis, the administration's boundary should play an important role in defining the standard statistical region of the ocean economy. The precise delimitation of coastal zones depends directly on the question posed initially. The limits should therefore extend into the sea and land just as far as required by the objectives of the management plan (UNESCO, 1997). This paper attempts to define the coastal region and its associated economic activities in such a manner that coastal socio-economic data may be compiled from a range of already existing statistical portals available at a national and regional level. Following the above discussion and the spatial approach of the NOEP framework, the definition of coastal region and coastal economy is drawn up on the basis of a tiered geographical approach extending inland from the shorelines of the oceans and seas surrounding the oceanic nations.

In China, coastal regions are critical components of the country's "economic engine". In the 30 years following reform and the opening-up of its borders in 1979, China's economy has developed at a remarkable rate. China has become one of the world's major economic powers. Also during this time, the coastal region of China has become one of the most economically developed and most densely populated areas in the world. Coastal regions, which account for 20% of China's land area, hold 40% of the population and account for 60% of China's GDP. From 2010 on, a new round of coastal economic development started with the introduction of coastal economic zone initiatives. These development strategies for the marine economy in the coastal areas

were approved by the central government. Additionally, the central government has also updated separate development plans in all 11 coastal provinces.

The Constitution of the People’s Republic of China stipulates that 1) the administrative areas in China be divided in provinces, autonomous regions and municipalities directly under the central government; 2) provinces and autonomous regions be divided into autonomous prefectures, counties, autonomous counties and cities; 3) autonomous prefectures be divided into counties, autonomous counties and cities; 4) counties and autonomous counties be divided into townships, nationality townships and towns; 5) municipalities and large cities be divided into districts and counties; and 6) the state establish, when necessary, special administrative regions.

The statistical classification structure of coastal areas in China includes three levels of administration: provincial administration areas, city administration areas and county administration area. Each of these three layers covers the entire shore line.

Province-level administration area: coastal region. Coastal regions represent the coastal province (or autonomous region or municipality) touched in whole or in part by shore-line, including sea area and islands under its jurisdiction. The coastal province is the largest layer of the ocean economy.

City-level administration area: coastal city. Coastal cities represent the coastal city touched in whole or in part by shore-line, including sea area and islands under its jurisdiction.

County-level administration area: coastal county. Coastal counties represent coastal counties touched in whole or in part by shore-line, including sea area and islands under its jurisdiction. China has 237 coastal counties, including 64 counties, 64 county-level cities and 117 districts.

Table 8 represents the classification structure of China’s coastal line, based on the above classification. The coastal region of Guangdong has the most coastal cities and coastal counties, followed by Shandong Province. It should be noted that Guangdong and Shandong also have the highest gross regional product in China.

Table 8. Classification Structure of China’s Coastal Zone

Coastal Region	Coastal City	Coastal County (District)
Total	53	237
Tianjin	1	1
Hebei	3	11

Coastal Region	Coastal City	Coastal County (District)
Liaoning	6	22
Shanghai	1	5
Jiangsu	3	15
Zhejiang	7	35
Fujian	6	34
Shandong	7	37
Guangdong	14	56
Guangxi	3	8
Hainan	2	13

5. FRAMEWORK FOR STATISTICAL INDICATORS

According to Foley, Naomi S. et al (2014), indicators should ideally be representative, quantifiable, comparable, reliable, adaptable and relevant. The studies mentioned in sections 2 and 3 have laid out respective ocean economy indicators. The dataset is supposed to be comprised of business indicators, physical indicators and social indicators. Business indicators include data on turnover, value added, employment, exports and number of enterprises. The physical indicators vary by sector. The physical indicators can be used to give further information on a sector.

Given the differences among the government databases of ocean nations, initial collection of global ocean economy data should focus on easily obtained indicators. This study identifies six indicators as basic indicators for the global ocean economy.

- Value added
- Employment (including self-employment)
- Taxation revenue
- Export revenue
- Wages
- Number of establishments

Examples of difficulties that can arise when trying to complete marine economic accounts include incomplete data on marine sectors, marine activities being part of statistical classes which also include non-marine businesses, indicators of marine activity being available at the country level but not at the local level and the issues surrounding the confidentiality of certain marine activities either for reasons of national security (in the case of defense). Furthermore, there can be commercially sensitive

activities or cases in which one business makes up too high a percentage of the total turnover of a given statistical class. These issues aside, Colgan (2007) proposes four principles for developing a methodology:

1. *Comparability across industries and space.*

For example, the definition of a unit of employment should be the same across all locations and industries.

2. *Comparability across time.*

Industry data should be observed and measured in a consistent manner over successive time periods in order to allow for trend analysis.

3. *Theoretical and accounting consistency.*

The data should reflect standard economic theory describing the measurement of economic activity.

4. *Replicability.*

The data should be replicable over time and form the basis of a future data series.

6. CONCLUSIONS

Economic activities related to the oceans are developing significantly throughout the world. The collection, compilation and management of socio-economic data for the various marine-related sectors is an important element of the information system required for promoting this more sustainable approach to marine policy. Much work has been done internationally in establishing the value of these other marine resources (and/or ecosystem functions) so that they may be accounted for in marine policy decision-making. However, up to now it has been clear that there is a significant lack of a systematic and permanent methodology for data collection in this world. The lack of consistent and comparable statistical data on the different activities of the global ocean economy makes it difficult for both governments as well as the agents involved in the ocean economy to make the right decisions.

Within this context of methodological diversity in the definitions and characterization of the ocean economy's sectors and activities, this paper aims to establish the conceptual, industrial, geographical and indicators framework for the global ocean economy. Four basic concepts make up the conceptual framework of the ocean economy: ocean economy, ocean industry, ocean-related industry and coastal economy. From here, this study has taken "what we have in common" as a starting point, a practical classification of the global ocean economy's activities, from which height ocean industries can be distinguished (fishing/aquaculture, marine transportation, marine tourism, offshore oil and gas, marine construction, boat and

shipbuilding, maintenance and repair, marine renewable energy, marine research and education). Each one of these industries can be linked to one or more economic activities from the statistical nomenclature of ISIC Rev.4 economic activities on a four-digit level. This paper also reviews previous research on geographical classification throughout the world and identifies that the statistical classification structure of the coastal areas in China includes three levels of administration: province, city and county. This study also identifies six indicators as basic indicators for the global ocean economy: value added, employment, taxation revenue, export revenue, wages and number of establishments. The conclusions of this study allow us to deepen our understanding of the global ocean economy and can serve as a basis for designing effective strategies that address the real concerns facing the world today.

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