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Blue Growth in the Middle Kingdom: An analysis of China's Ocean Economy

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1. Introduction

A nation's economy has been described as a mechanical engine comprised of interconnected, moving parts [1]. In China, the ocean economy is now seen as a critical component of that engine. Following the reform of economic trade policy, especially in the period 2001-2010, China's ocean economy has been growing rapidly, in line with national GDP. Also, as the second largest economy in the world, China is paying more and more attention to the sustainable development of its ocean economy. One important reason for this is that since joining the World Trade Organization (WTO), Chinese trade with other nations has steadily expanded as a proportion of national economic activity, to the point where it affects approximately 70% of China's economy [2]. China also has access to a significant marine resource base with a coastline of more than 32,000 km [3] and more than 7,300 islands [4] in its territorial waters. Coupled with this, China has sovereign jurisdiction over a vast area of continental shelves and exclusive economic zones (EEZs) (as defined by the UN Convention on the Law of the Sea) equal to approximately 3 million km² of offshore waters and 32,000 kilometers of coastline. China also has marine oil reserves of an estimated 24 billion tons and natural gas reserves of over 1.6 billion cubic meters [5].

Seaborne commerce is one of the most essential elements of international trade in China. According to Cheng [6], "without trade, China could not sustain its economy, let alone maintain the growth rates necessary to maintain high employment figures". Ocean commerce in 2008 alone represented approximately 10% of China's gross domestic product (GDP), with a value of approximately \$456 billion. Moreover, some 85% of its international trade moves by the sea lanes [2]. China's increasing reliance on oil imports to sustain its rapid economic expansion is a key element of this marine commerce. China imported over half of the oil it consumed in 2009, the majority of which was transported by tankers [7].

Since the land resources in China, as well as other countries around the world, are increasingly on the verge of economic and ecological exhaustion, the value of the oceans as a resource for economic development has become increasingly more prominent. A number of coastal countries have launched programs explicitly aimed at strategic initiatives for the development of their ocean resources. China has been no exception in

this regard. In 1996 the Chinese government unveiled the China Ocean Agenda 21 which put forward a sustainable development strategy for China's marine resources. The main aims of this strategy were to effectively safeguard the state's marine rights and interests internationally, provide protection for delicate marine ecosystems and realize the sustainable development of China's ocean economy.

With the aim of furnishing marine policy makers in China with marine activity related statistics, the Ocean Economy Accounting System (OEAS) of China was established in 2006. The purpose of the system was to develop the required range and quality of ocean economy data at regional and national level. This paper provides a critique of this system and also uses it to define and quantify the ocean economy in China. While Song et al. [8] have previously examined the developments in the Chinese marine economic statistical system over the past 20 years we add to the literature by examining how the industries within the Chinese marine economy has changed in both value and in terms of the numbers employed over the period 2001 to 2010. We also compare the Chinese OEAS to the marine economic accounting system used in the US and examine how closely the Chinese ocean economy follows the general movement in Chinese GDP.

In what follows, this paper first reviews Chinese marine policy that resulted in the increased need for reliable and standardized ocean economy statistics. The development of the OEAS is then described along with the accounts that the system is comprised of. The definition and value of the ocean industries in China and their relevant importance to the overall Chinese economy are then compared to the definition for ocean economy industries in the US and Europe.

2. Marine policy in China

Availability and easy access to a wide range of natural and economic-activity related data on a country's oceans and coastal regions is the basis for strategic decision-making on coastal and maritime policy [9]. In March 2011, *China's 12th 5-year Plan for National and Social Development (2011-1015)* was released by central government and is currently being implemented. This is the first time that China has adopted a "five-year-plan" for

economic development where “developing the ocean economy” has been identified as a key national development strategy in the top plan for China.

According to the Twelfth Five-Year Plan (2011–2015), China’s major objective in developing the ocean economy during the 2011-2015 period is to optimize the structure of the marine sector through the development of marine industries using scientific planning. The plan also has the aim of ensuring that marine resources are sustainably and reasonably utilized, that mechanisms of integrated marine management should be improved; that marine environmental protection and land-based pollution control should be coordinated; that the trend of excessive development of offshore resources will be controlled; that the management of any marine reclamation activities will be strengthened and that the protection and restoration of marine ecosystems should be promoted.

The first measure above related to the optimization of the structure of the marine sector is of particular relevance to the research presented in this paper. The availability of a wide range of accessible data on ocean economic activities is necessary for achieving the efficient management of the marine economy. Sustainable ocean and coastal management in China requires information on ocean industrial activities and socio-economic trends and on the environmental coastal effects of policies and financial instruments directed towards ocean related industries.

The first real indication of China’s interest in focusing on the ocean and coast, rather than on its hinterland, for potential economic growth, occurred in 2003 when the first guideline document for the development of its national marine economy was published by the state council. This document entitled “An Outline of the Planning of National Marine Economy Development” targeted a Gross Value Added figure for the Chinese Ocean economy of 4% of GDP in 2005 and approximately 5% in 2010. In the decade since this guidance document was published, and as can be seen in the results section of this paper, China’s marine economy has been steadily approaching these targets. Indeed, according to one of the few papers that profiled China’s Marine Economy, the value of marine related activity in 2008 was estimated at 9.87% of GDP [10]¹.

¹ This is a larger estimate of the value of the ocean economy than presented in this paper for 2008 as we have examined only the data on the 12 major ocean industries in China whereas the figure of 9.87 includes ocean related industries as well (the indirect and induced impact of the major ocean industries).

At the coastal provincial level, five ocean economic development zone plans have also been approved by China's central government for Guangdong, Shandong, Zhejiang, Fujian and Tianjin. The purpose of these zones is to establish a new sustainable development pattern for China's coastal regions that are heavily involved in marine related economic activities. Compared with the commercial development of land, there is a relative lack of experience in relation to ocean development in China. There are many aspects of this ocean zonal approach that needs to be explored, not least the need to balance increasing the economic opportunities from China's vast marine resources with the need to protect the marine environment and that is why the Chinese State Department decided to choose some provinces as pilot marine economic development test sites. Now within the top strategic plan for the country, the development plans of 11 ocean economic development zones have become national strategies in China.

In order to promote the development of what is seen as two strategically important marine industries; two national plans have also been released to boost the emerging ocean industries of seawater desalination and marine bio-medicine. In December 2012, the National Development and Reform Commission issued the *12th Five-Year Plan for Seawater Desalination*; this is the first specific ocean industry five-year plan, which targets China's desalination where output is forecast to reach more than 2.2 million cubic meters/day by 2015. In order to accelerate the development of bio-industry, at the very beginning of 2013, the Chinese State Council issued the *12th Five-Year Plan for Bio-industrial Development*, in which marine bio-medicine was identified as one of the key development areas.

The most important part of these plans is that the central government will make available more opening financial, investment policies on ocean economy development. It can be predicted that with these 5 year plans in place these industries, and indeed all industries in the Chinese ocean economy, will be given appropriate policy support that has not been available to the same degree up to this point. The policy makers in these industries and in the pilot marine economic zones will obviously require better quality baseline information related to the ocean economy than has been available previously. Given the series of national strategies related to the development of the ocean economy reviewed above, it becomes very important to provide all marine policy makers, planners and decision makers

with accessible and reliable information regarding the role of the ocean industries in local and national economies which ultimately should allow for better management and conservation of China's abundant marine resources.

3. Methodology

The methodology followed by the Chinese National Data and Information Service to quantify the size and composition of the ocean economy is very similar to the methodology employed by the US National Oceans Economic Program (NOEP) as well as methodologies followed by other coastal countries that have analyzed their respective ocean economies, such as Canada, Australia, Ireland, France, etc. [11, 12, 13, 14]. The Chinese methodology is reviewed here but for a more in-depth discussion in relation to the developments in the Chinese marine economic statistical system over the past 20 years the interested reader should see Song et al. [8]. In that paper the authors argue that marine economic data gathering has gone from dispersed efforts to a concentrated approach, increasing from partial coverage of industry categories to comprehensive statistics and transitioning to more institutionalized management of marine economic statistics. They suggest that the practical significance of these developments is an improved national data set for the marine economy and policy makers that will continue to develop in the future.

Similar to the issues faced by the other countries that prepare ocean economy statistics, estimates of the value of the ocean industries in China are limited due to the definitional and data limitations. Nevertheless with the growing realization of the importance of marine related activity to the wider Chinese economy, China's OEAS was established exclusively for ocean economy data collection in 2006 to meet the practical needs of ocean economic management. The system was developed and is operated by the Chinese National Marine Data and Information Service within China's State Oceanic Administration. The OEAS includes four basic parts, which are the Principle Account, the Elementary Account, the Natural Capital Account and the Green Ocean Account.

The Principal Account, which is also called the Gross Ocean Product (GOP) Account, is the most highly developed component within the system and is concerned with the identification and quantification of ocean economic activity. The Elementary Account is concerned with the development of an Input-Output matrix that disaggregates the major ocean industries from the standard industry classifications in the national Input-Output

tables. This account also analyses the quantity and value of exports and imports through Chinese sea ports and estimates the value of marine related capital. The third major account within the system is concerned with the assessment of the non-market values associated with China's marine resources. The Green Ocean Account combines the market and non-market analysis from the Principle and the Natural Capital accounts in order to provide policymakers with a holistic view of the overall value of China's ocean economy. The Elementary Account, the Natural Capital Account and the Green Ocean Account are still at an early stage of development. Figure 1 presents the framework of China's OEAS.

- **Figure 1 here**

Based on the OEAS, this paper focuses on the Principle Account where the major ocean industries in China are defined and quantified. The basic goal of defining and quantifying major ocean industries within the elementary account of the OEAS is to permit consistent measurement of the contribution of the ocean to the China economy across time and regions. Similar to many other ocean economy reporting exercises [11, 12, 13, 14], five basic steps are followed to quantify the Chinese ocean economy:

1. Source the data.

In this step, the ocean economy activities are identified via government collected data within national accounts. These sources in China's case are outlined in section 4.

2. Estimate the ocean proportion within a sector.

This involves estimating the proportion of total economic activity within a particular sector that is ocean-related. For example, within the pharmaceutical sector a number of companies produce marine based bio-products. Distinguishing between marine and non-marine businesses within such a sector requires a more disaggregated look at the profile of the companies within this sector.

3. Compile the data.

This involves recording the levels of value-added, employment etc. for each industry that is identified within the marine sector.

4. *Identify gaps.*

Certain ocean sectors are clearly identifiable within national account (for example marine transport and fishing) but for some other industries, in particular emerging ocean industries, it is more difficult to quantify the size and composition of the sectors. These industries and the data deficiencies need to be highlighted.

5. *Ocean economy as a percentage of GDP*

Estimate the value of the ocean economy relative to total economic activity in the wider economy.

These five steps were applied to estimate China's ocean industries. As previously noted, identifying the marine activity in national accounts can be difficult and often requires additional national accounts manipulation [15]. Examples of difficulties that can occur 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 country level but not at local level and the issues surrounding the confidentiality of certain marine activities either for reasons of national security (in the case of defense) or for various other reasons, such as commercially sensitive activities or in cases where one business makes up too high a percentage of the total turnover of a given statistical class and can thus be too easily identified. These issues aside, Colgan [16] proposes 4 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.

In addition to the above, where possible the sectors identified and the method of quantification should be defined in such a manner so as to allow the data to be compared internationally. Also the release of information on the state of the ocean economy should be timely. That is to say, the length of time between the marine economic activity or event taking place and the availability of statistical outputs related to that activity should be as short as possible to be of the most relevance to policymakers. This latter principle is often not in the control of those attempting to assemble ocean economy accounts but depends on the time lags involved between the collection and dissemination of national accounts by central statistical agencies.

As outlined above, defining the ocean industries in the Chinese ocean economy is the first step towards quantifying the value of the ocean economy. 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. The ocean industrial classifications within this document divided the marine sector into two parts; ocean industries and ocean related industries.

- Ocean Industries refers to industries involved in the production or supply of service for developing, utilizing and/or protecting the ocean. This part of the ocean economy includes 12 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 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 the coastal zones. These industries include agriculture and mangrove forestry (that 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.

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 and protecting the ocean.

Figure 2 provides the relationship between the different layers that make up the Chinese ocean economy in China. China's ocean economy 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 2 here**

In China's case, specific ocean industries cannot be directly identified within national statistical databases. It is therefore vital to find an appropriate way to measure and compile the data required to quantify the ocean economy. Measuring ocean economic activities is therefore a complicated issue, especially when it is difficult to obtain sufficient basic data for all possible ocean industries as is the case in China. This paper therefore focuses on the major ocean industries in China for which data is available. While some small and 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 1².

- **Table1 here**

4. Marine economic data sources in China

Once the Chinese ocean industries are defined, the data collection and quantifying phase begins. As previously mentioned not all the ocean industries outlined in table 1 are easily identifiable within the national economic datasets [11]. Thus, to estimate the value of all the marine sectors a variety of collection methods must be employed [16].

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 National Ocean Economic Program (NOEP) which compiles marine economic data in the US extracts their ocean economy data based on the NAICS. 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 system³. All government statistics programs in China are compiled on the basis of CCSNEI.

Table 2 provides a comparison of definitions and codes for each of the ocean sectors reported in China and America (in the later case reported by the NOEP). In China's case, 12 industries are defined based on the 4-digit codes of CCSNEI, while 6 ocean industries are defined by the US NOEP based on the 6-digit codes of NAICS. Seven of China's defined ocean industries have corresponding classification in the USA ocean economy accounting system. However the corresponding classification in the US system is often at a

² In what follows when the value of the 'ocean economy' in China is mentioned it refers to the value of the 12 major ocean industries identified in table 1.

³ 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).

higher level of aggregation. For example while the Chinese system has separate categories for offshore oil and gas and offshore mining, in the US system these industries are grouped together under the heading of “Minerals – Offshore”. The types of activities under the headings of offshore mining, shipbuilding and marine construction is also much broader in the Chinese classification compared to the US one.

- **Table 2 here**

As table 2 demonstrates, certain ocean industries are clearly identifiable within the Chinese national accounts. Indeed many of the major ocean industries have their own 4-digit CCSNEI code (see for example marine fishing, seawater salt industry and Submarine pipeline transportation). However, as mentioned in section 3, data on some ocean based activities is very difficult to obtain; for example, one cannot isolate marine chemical industries data from general chemical industry classification employed by the National Bureau of Statistics of China (NBSC). Therefore, certain sub-sectors especially the emerging ocean industries (marine biomedicine industries, seawater utilization industries, etc.) require additional survey activity to ensure that all ocean industries are represented. This additional survey work is carried out by the NBSC on behalf of the Chinese State Oceanic Administration. Using this information the NBSC provides data on gross value added and employment for each of the ocean and ocean related sectors within China’s national economy. The NBSC censuses and surveys used for the collation of the ocean economy data include:

- The First National Economic Census, 2004
- The Second National Economic Census, 2008
- National Accounts Comprehensive Statistical Reporting System (quarterly, biennial and yearly reported statistics)

In what follows the data extracted from these censuses and national accounts to quantify the size and composition of China’s ocean economy is reported.

5. Results

In 2010 the major ocean industries had a combined value (in terms of Gross Value Added (GVA)⁴) of US\$239.09 billion⁵; accounting for 4.03% of China's overall GDP. China's major ocean industries employed approximately 9.25 million individuals. Table 3 presents the value added and employment for each major ocean industry within the China's ocean economy. In terms of GVA, coastal tourism is the largest contributor to the overall value of the ocean economy with US\$78.33 billion of value added. The marine communications and transportation industry is the next largest category producing US\$55.92 billion. When it comes to employment, the marine fishery industry is the biggest contributor, employing 5.53 million individuals, followed by Coastal tourism at 1.24 million and the marine communications and transportation industry at 0.81 million. In China's case, the coastal tourism, the marine communications and transportation industry and the marine fisheries industry dominate the ocean economy. These are categories that have also been found to dominate other ocean economies internationally [11, 12, 13, 14]. It would appear however that the high numbers employed in the fisheries sector relative to the other two dominant sectors is somewhat unique to China's ocean economy.

- **Table3 here**

Since the data sources employed to quantify the ocean economy are also a historical record of the economics activities it is possible to analyze the growth (or otherwise) of the major ocean industries over time. Figure 3 examines the growth rate of the Chinese ocean economy from 2002 to 2010. In this figure one can see that all the ocean economy follows a very similar pattern to the general movements of total GDP in China over the same period. In this decade of rapid development for all the major ocean industries, 2003 and 2007 are worthy of note. The annual year on year growth rate of the major ocean industries in this decade averaged approximately 20%, except in 2003 (1.28%) and in 2009 (7.33%).

- **Figure 3 here**

⁴ Gross Value Added (GVA) refers to a sectors turnover (output) minus intermediate consumption (the inputs into the process of production). It is measured at market prices.

⁵ The exchange rate between Chinese Yuan and US Dollar used in this article is 6.7705 which is the average rate of 2010 calculated based on the website: <http://www.x-rates.com/average/?from=USD&to=CNY&amount=1&year=2010>

In 2003, the SARS (Severe Acute Respiratory Syndrome) virus broke out in China. SARS was the first severe and readily transmissible new disease to emerge in the 21st century [15]. This hit the Chinese economy heavily, especially the industries involved in international trade. Due to their export-oriented characteristics, the ocean industries were greatly affected. The fall in the growth rate of the ocean economy in 2009 was due to the financial crisis of 2007/2008, which is considered by many economists to be the worst financial crisis since the Great Depression of the 1930s [18]. A massive stimulate package from the Chinese government saw the economy through the worst of the financial crisis but still the growth rates of national GDP went down significantly, especially for the ocean related industries. It would therefore appear that the major ocean industries are more vulnerable to the impact of unexpected events (e.g. the SARS outbreak in 2003 and global recession in 2007) than the general economy. Also any events impacting on international trade have a higher impact on the ocean economy. This is not surprising given, as mentioned in section 1, that seaborne commerce is an essential part of Chinese trade; alone represented 10% of China's gross domestic product in 2008 [2].

Figure 4 provide a more in-depth breakdown of the changing trends of the major ocean industries from 2001 to 2010. Coastal tourism was the largest contributor to China's ocean economy from 2006 to 2010. Coastal tourism includes hotels and lodging places, coastal tourism services, amusement and recreation, coastal tourism and cultural services. The coastal tourism sector had been achieving growth rates of over 20% almost every year throughout the decade, greatly boosting the development of China's marine economy. For China's coastal tourism, 2003 was a significant year due to the outbreak of the SARS virus. Total tourism output had decreased dramatically in the first half of the year, and in the whole of 2003, the added value created by coastal tourism was \$13.37 billion, down 27.39% compared to 2002. By the time that the World Health Organization lifted its two-month advisory warning against non-essential travel to China in late June 2003 the outbreak had cost China's travel and tourism industry sectors an estimated US\$20.4bn [20]. The tourism sector bounced back strongly in 2004 due in part to a rescue package from the government that included tax rebates, employment and training measures and financial aid. Also domestic and pan-Asian tourism boards put in place action plans to revitalize the stricken sector.

- **Figure 4 here**

As mentioned above, when it came to the global financial crisis, the major Chinese ocean industries also suffered severely in 2009, resulting in the decline of two important major ocean industries; marine communication and transportation industry and offshore oil and gas industry. The value of these sectors decreased by 8.51% and 39% respectively in 2009. The marine communication and transportation industry has long been the dominant support of China's international trade and continues to integrate markets between China and other countries. In the decade of 2001-2010, the marine communication and transportation industry had been growing rapidly due to the fast development of China's international trade. The only year that saw a decrease in the rate of growth of this sector was 2009. The offshore oil and gas industry is also a very important component of the ocean economy in China. In 2010, marine oil and gas output exceeded 50 million tons of oil equivalent, which makes China one of the world's major marine oil and gas producers. China's offshore exploration platforms are distributed both on coastal waters and in its deepwater territorial seas which increases the risk of ocean environmental pollution of the coastal area. The sharp drop off in the value of the offshore oil and gas industry in 2009 was in line with global trends and was mainly due to the decline in the international oil prices caused by the financial crisis.

The marine communication and transportation sector was the second largest industry within the Chinese economy in 2010. The Chinese marine communications and transportation industry can be divided into five categories; marine passenger transportation, marine cargo transportation, sea ports, submarine pipeline transportation, and marine transportation service. With the center of world trade shifting to Asia and rapid growth of the China's economy, marine shipping has become the main mode of transport in terms of international trade with China.

Figure 5 provides the volume of cargo handled at China's Coastal seaports from 2006 to 2010. In 2010, the volume of cargo handled was 5640 million tons, representing an increase of 15.8% compared to 2009. The sector achieved an average annual growth rate of 13.4% in the "11th Five-Year Plan" period of 2006 - 2010. In 2010, the majority of shipping activity occurred in 16 coastal ports which between them handled more than 100 million tons of cargo (Ningbo-Zhoushan (633 million tons), Shanghai (563 million tons),

Tianjin (413 million tons), Qingdao (350 million tons), Dalian (314 million tons), Qinhuangdao (263 million tons), Tangshan (246 million tons), Rizhao (226 million tons), Yingkou (226 million tons) , Shenzhen (221 million tons), Yantai (150 million tons), Zhanjiang (136 million tons), Lianyungang (127 million tons) and Xiamen (127 million tons), Beibuwan (119 million tons).

- **Figure 5 here**

Figure 6 presents the volume of container traffic handled by China's seaports from 2006-2010. In 2010 container throughput exceeded the pre-crisis level. In 2010, coastal ports handled 131 million TEUs (twenty foot equivalent units), representing a growth rate of 25.5% compared with the peak years of 2007.

The marine fishery sector is also a vital component of China's ocean economy. It provides a high proportion of the protein intake for Chinese people. It also provides employment for the highest number of persons working in the Chinese ocean economy, often in rural locations where few other employment opportunities exist. In 2010, marine fishery production in the coastal region of China increased slowly, perhaps reflecting a resource that was already been exploited at near maximum capacity. The output of living sea resources amounted to 27.97 million tons in 2010 which was a decrease of 2.9% compared with that of the previous year. The production of mariculture amounted to 14.82 million tons in 2010, 3.5% down from the previous year. The yield from near-shore fishing in 2010 was 12.07 million tons, 10.5% down from the previous year with a further 0.89 million tons from the deep-sea fishing fleet, 8.5% up from the previous year.

- **Figure 6 here**

Table 4 provides a comparison of the Chinese ocean economy value (as a percentage of GDP) and employment figures to other ocean economies internationally. Such comparisons, while interesting, can be misleading as the "marine/ocean" sector does not formally exist in most national accounts and figures made available by national marine agencies are often based on different underlying definitions of the sector and different methods of collection of data and classification of activities into different categories [19].

Indeed, it is worth noting that all of the marine economic reports reviewed in table 4 recognize the limitations of official statistics-gathering procedures in capturing the importance of marine activities in their national economies.

In general, the value added by ocean based activity to a country's national income is less than 5% of GDP. In France, Ireland, the US and Canada it is less than 2% of GDP. It should also be noted that the figures for France, the UK and Canada include public sector marine related output such as defense, education and research. France has the longest running track record for publishing national marine economic accounts. IFREMER publishes the marine economics assessment every two years for France. The 2011 version reported on in table 4 includes separate categories for the private and public sectors of the economy and estimates a total value for its ocean economy of \$28.19 billion, representing 1.2% of GDP.

The only country with a marginally higher share of marine activity in national GDP than China is Britain at 4.2%. The one major difference between the marine economies in both countries driving this statistic is the relative importance of offshore oil and gas. In Britain, offshore extraction of oil and gas is a substantial industry that makes a very important contribution to the UK economy. Pugh [21] reports a gross value added (at current basic prices) for the offshore oil and gas sector in Britain of £19,845m. This figure represents 43% of the entire value of the ocean economy in Britain whereas in China the offshore oil and gas sector represents only 8% of the total value of the ocean economy although activity in this particular field in China is likely to increase with a number of new exploratory offshore licenses being issued in recent years and proven substantial marine oil and gas reserves [5].

The comparison of China's ocean economy and the US ocean economy is worthy of further examination, given the comparative economic value and influence these two countries share. In 2010, the value added by ocean based sectors in these two countries are almost at the same level. In the USA it was worth \$266.72 billion while in China it was \$239.09 billion. However, the share of the ocean based income in overall GDP is quite different, in China it is 4.03% (and this includes only the 12 major ocean industries classified in table 1) while in the US it is only 1.82% (based on the fact that the national GDP of the USA is almost twice that of China). It would also appear that the indicative

employment in China's ocean economy is much larger than that of America. The discrepancy between the shares of employment in the sector and the share of ocean based activity in the countries respective GDP would appear to indicate that labor productivity might be relatively lower in the Chinese ocean economy compared to China's. However the real explanation is more likely to be reflected in the fact that in China 553,000 individuals are employed in the labor intensives primary production activity that is the marine fishery industry. In comparison, more persons are employed in higher value added industries in the US ocean economy. While shifting up this value added chain is an important objective for the Chinese ocean economy sector as can be seen in the government's support for emerging industries such as the marine power industry, marine biomedicine and marine technology and the fact that industries using marine high technologies have been developing rapidly at an average annual rate of more than 20% in the last decade, the importance of the primary fisheries jobs to rural China in particular should not be underestimated.

- **Table 4 here**

6. Conclusion

This paper builds on the work carried out by OEAS in China, which established the framework of ocean economy accounting in China. It also demonstrates how it is possible to compile ocean economy data, from the existing government databases in China. The Chinese ocean economy was divided into two separate parts for the purpose of the analysis presented; the ocean industry and ocean-related industry. Data was collected for 12 major ocean industries. Using a similar methodology to that developed in previous international studies, it was found that the major ocean industries produced US\$239.09 billion in value added output in 2010 and accounted for 4.03% of China's national GDP. The major ocean industries were found to employ 9,253,000 individuals. This analysis also found that coastal tourism, marine communication and transportation industry and the marine fishing industry dominate in China's ocean economy. A time series analysis for the period 2001 to 2010 found that the Chinese ocean economy follows a very similar growth path to that of the national economy. It would appear from the analysis however that given the international nature of the activities in the ocean economy, the major ocean industries

demonstrate a higher level of vulnerability in terms of the impact of unexpected shocks on the economy.

While this paper has undertaken an analysis of the Chinese Ocean economy, defining and quantifying the Coastal economy in China is an area worthy of further research. In this case the Chinese Coastal economy could be defined as all activity which takes place in a predefined coastal area and would include all economic activity in the coastal region; however those areas and regions are defined⁶. This task is all the more relevant given the five ocean economic development zones that have been established in a number of China's coastal provinces. Along with the ocean economy information described in this paper such coastal economy statistics would allow policy makers, planners and government to make more informed coastal planning and marine environment management decisions.

Due to the rapid development of marine science and technology in recent years, all kinds of new marine industries are emerging, expanding the scope of the marine economy. Therefore, further research is required in order to establish an appropriate methodology for the classification and collection of economic data for these emerging ocean industries – data that is very difficult to extract from national economic accounts. As Colgan [16] points out “knowledge of the marine economy is very imprecise because little has been invested in developing the needed data, especially in comparison with the investment in understanding of other natural resources”.

The adoption of the “Developing the Ocean Economy” strategy and the establishment of five ocean economy pilot test sites by the Chinese government were in recognition of the importance of marine related activity to the economy in China. This increased focus on the ocean economy means policy-makers require accessible and reliable information regarding the role of the ocean industries in the wider economy [2]. With the implementation of the ocean-related plans, the goal of “developing the ocean economy” is occurring at a rapid base. This rapid development however requires detailed information on the marine activities that policy makers can use to ensure that the development is sustainable and does not jeopardize other marine related policy goals especially in relation to the marine environment and the conservation of marine species.

⁶ For a discussion of the relevant literature involved in the defining and characterisation of the ‘Coastal Region’ and ‘Coastal Economy’ the interested reader should see Hynes and Farrelly [8].

In the past China's traditional model of development was characterised by the extensive exploitation of marine resources and spaces particularly in regards to the extraction of marine life for human consumption. Intense competition among coastal provinces in relation to the developing of traditional marine industries such as fishing, aquaculture and port activity was another feature of Chinese marine development in the past. Indeed it could be argued that the establishment of container terminals in all provinces has not been an efficient use of valuable coastal resources in China. The new model of marine development in China places a higher value on the management and conservation of marine resources and ecosystem functions and recognises the importance of these resources to the new emerging marine industries and to coastal tourism in particular.

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. This however has not generally been the case in China. If the country truly wishes to underpin the value of the marine economic activity and the many biotechnology and other opportunities associated with it, with the quality of its marine environment then significant investment will be required in research aimed at establishing the non-market or public good element of the total economic value of marine resources in China.

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Figures and Tables

Figure 1. Framework of Ocean Economy Accounting System in China

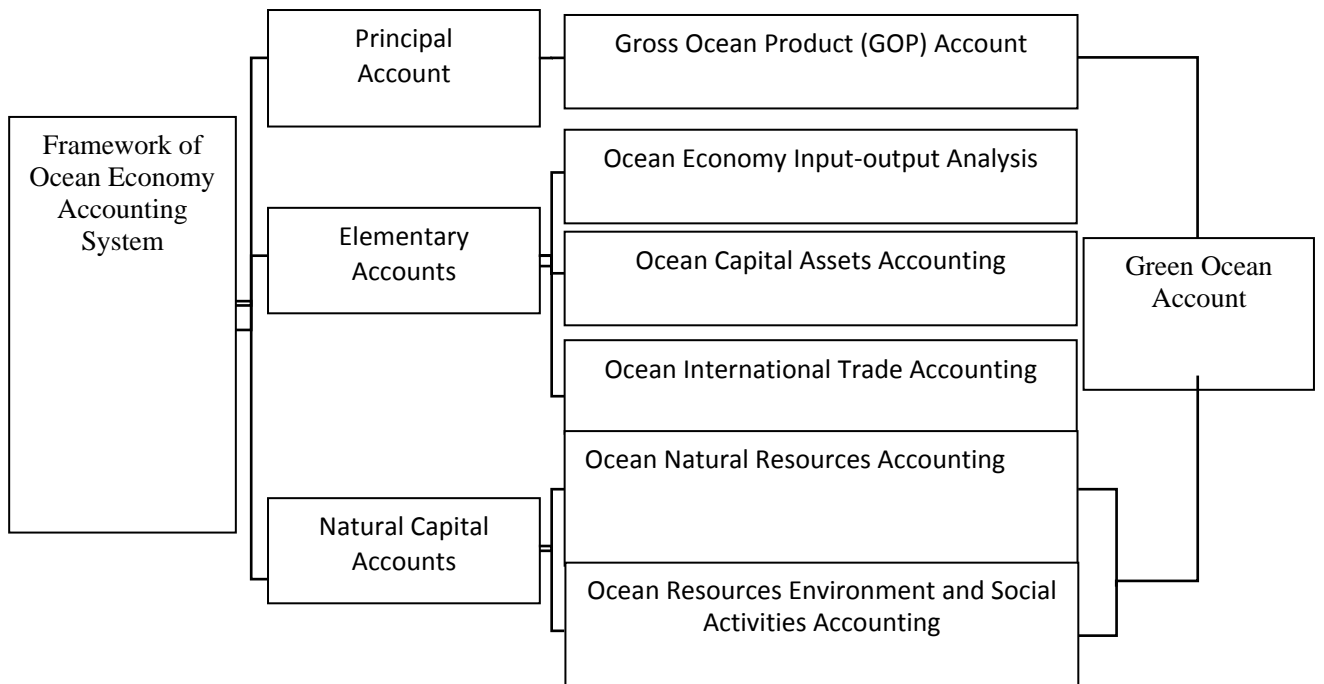


Figure 2. Relationship between the different layers of the Chinese Ocean Economy

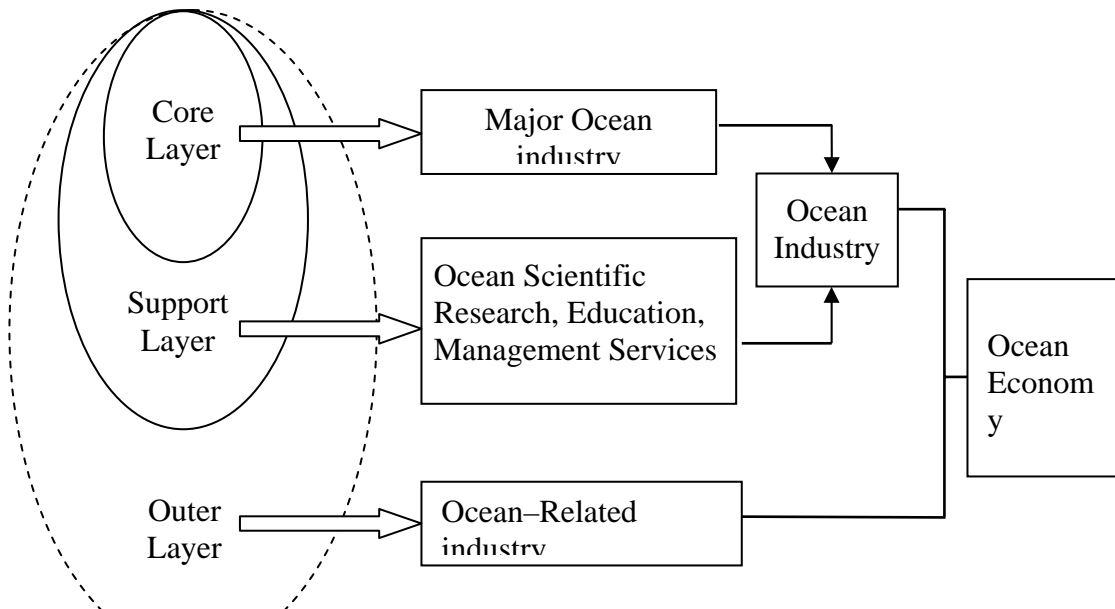


Figure 3. Growth rate of major ocean industries (GVA) compared to national GDP

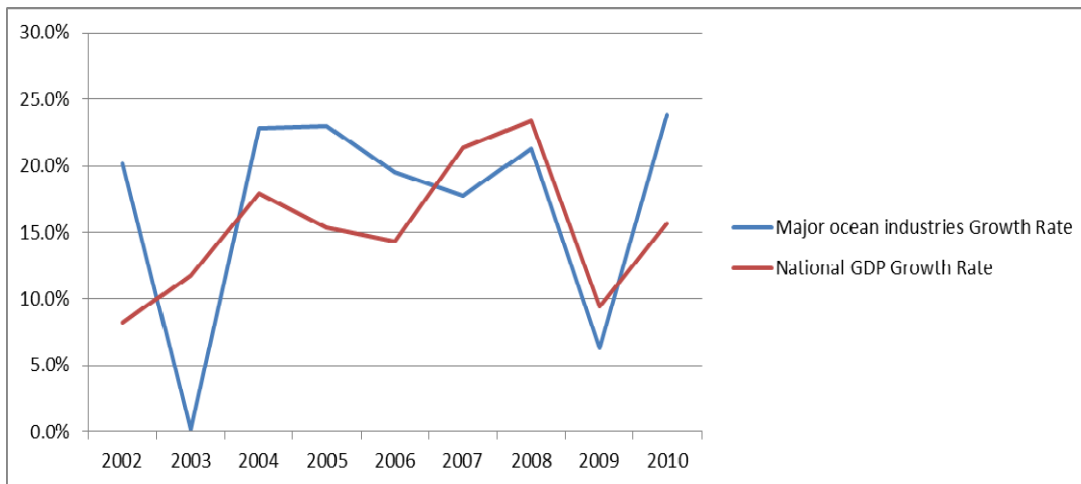


Figure 4. Trends of major ocean industries from 2001 to 2010

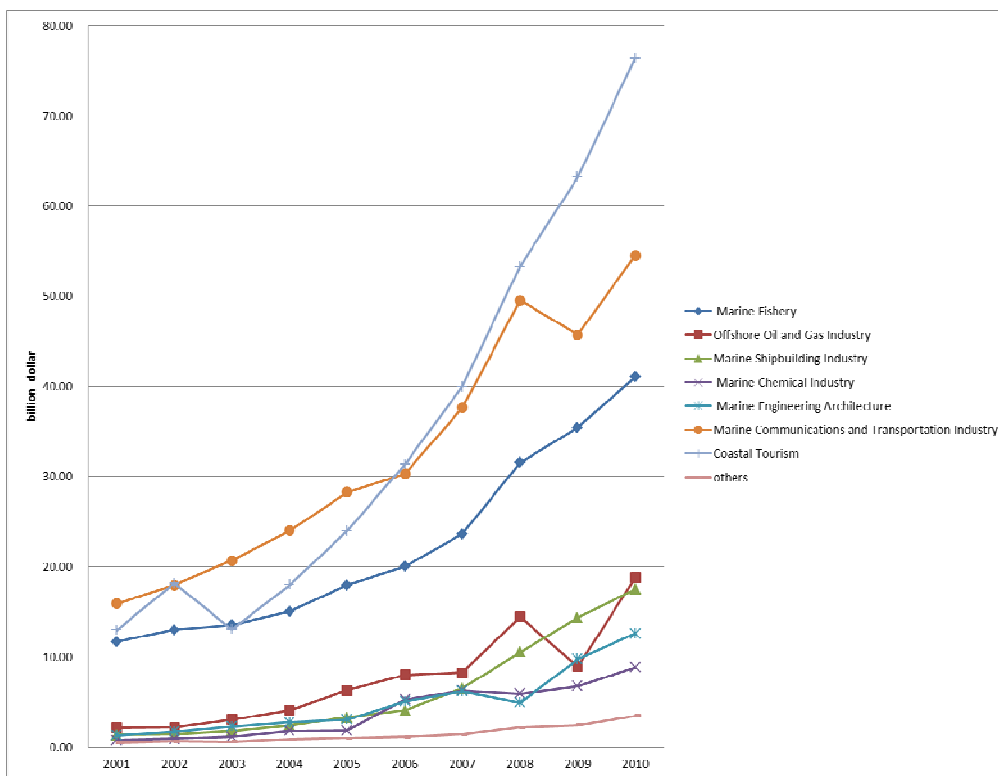


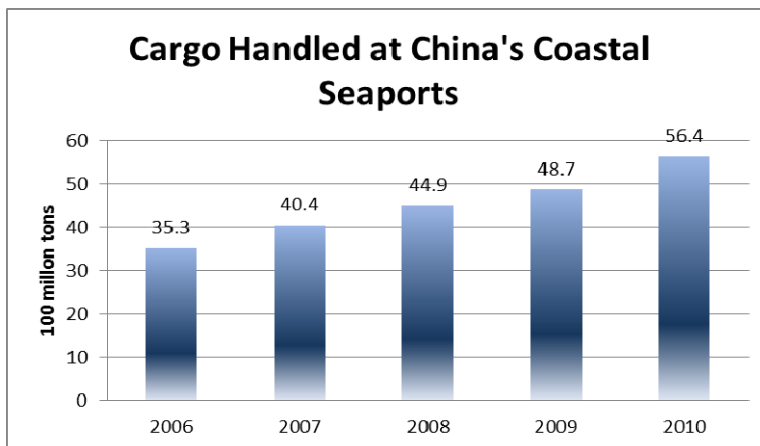
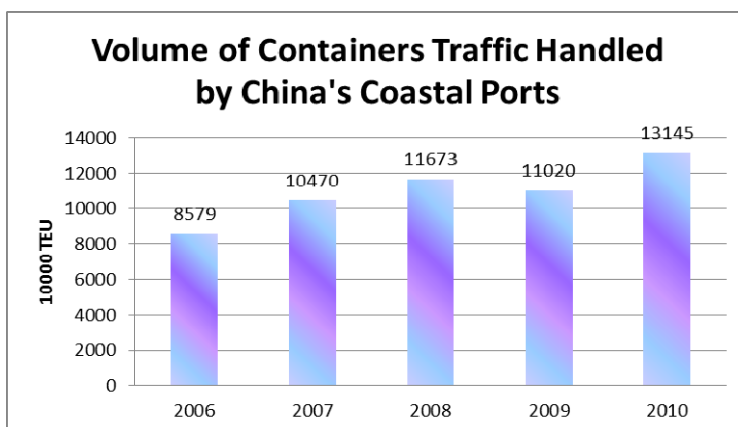
Figure 5. Volume of cargo handled by China's coastal seaports**Figure 6. Volume of containers traffic handled by China's coastal seaports**

Table 1. Classification and definition 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 the 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 production activities of chemical products of 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 health care products by using organisms as raw materials (or by extracting these organism's useful components).
Marine Engineering and Building Industry	Refers to the architectural projects construction and its preparations in the sea, at the sea bottom and seacoast for such uses as marine production, transportation, recreation, protection, etc., including constructions 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.
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 of carrying out and serving the sea transportations 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 tourist 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.

Table 2. Comparison of the definitions and codes of ocean sectors between China and America

Ocean Sectors (title of comparable USA sector in brackets)	Ocean Industries of China (relevant CCSNEI code in brackets)	Ocean Industries of USA (relevant NAICS code in brackets)
Marine Fishery (Living Resources-Marine)	Mariculture (0411) Marine Fishing (0412) Fishery Service industry (0540) Seafood Processing (1361,1362,1363,1364,1452,1369)	Fish Hatcheries & Aquaculture (112511,112512) Fishing (114111,114112) Seafood Markets (445220) Seafood Processing (31171,31172)
Offshore Oil and Gas Industry (Minerals - Offshore)	Offshore oil and gas exploration and production (0710) Support activities for oil and gas (0790)	Oil & Gas Exploration and Production (211111, 213111, 213112 , 541360)
Ocean Mining Industry (Minerals - Offshore)	Sea beach placer mining and quarrying (0810,0911,0912,0913,0914,0917,0919,0921,0922,0929,0932,1093,1099) Sand & stone Mining and quarrying (1011,1012,1013,1019) Submarine geothermal power and coal mining (1100,0610,0620,0690) Deep sea mining (0890,1020)	Limestone, Sand & Gravel (212321,212322)
Marine Salt Industry	Seawater Salt Industry (1030) Salt processing(1493)	
Shipbuilding Industry (Ship & Boat Building and Repair)	Ship & boat building and repairing(3751,3752,3753,3755) Offshore fixed and floating devices manufacturing(3759,3755)	Boat Building & Repair(336612) Ship Building & Repair(336611)
Marine Chemical Industry	Sea salt chemical industry(2611,2612,2613,) Seaweed chemical industry(2710) Sea water chemical industry(2619) Offshore oil & gas chemical industry(2614)	
Marine Biomedicine Industry	Marine medicine producing(2760,2720,2730,2740) Ocean health products(1364, 1491)	
Marine Engineering and Construction Industry (Construction - Marine)	Ocean engineering building(4723,4710,4722,4723,5010) Submarine engineering building(4721,4724,4710) Offshore engineering building(4722,4729,4723)	Marine Related Construction(237120,237990)
Marine Electric Power Industry	Oceanic energy (4419) Offshore wind (4419)	
Seawater Utilization Industry	Seawater desalination(4690) Direct seawater utilization(4690) Other seawater utilization(4690)	

<p>Marine Communications and Transportation Industry (Transportation - Marine)</p>	<p>Marine passenger transportation(5421,5422) Marine cargo transportation(5411,5422) Sea ports(5431,5432,5710,5890,7220) Submarine pipeline transportation(5600) Marine transportation service(5439,5720,5439,5232)</p>	<p>Marine Passenger Transportation(483112,483114) Deep Sea Freight(483111,483113) Warehousing(493110,493120,493130) Search and Navigation Equipment(334511) Marine Transportation Services(488310,488320,488330,488390)</p>
<p>Coastal Tourism (Tourism & Recreation - Coastal)</p>	<p>Hotels and lodging places(6610,6620,6690) Coastal tourism services(7480) Amusement and recreation (8132,8131,8139,9290,9220,9230,8012) Coastal tourism and cultural services(9040,9050,9060)</p>	<p>Hotels & Lodging Places(721110,721191) Eating & Drinking Places(722110,722211,722212,722213) Boat Dealers(441222) Marinas(713930) Recreational Vehicle Parks & Campsites(721211) Scenic Water Tours(487210) Sporting Goods(339920) Amusement & Recreation Services(487990,611620,532292,713990) Zoos, Aquaria(712130,712190)</p>

Table3. Value added and employment by major ocean industry category 2010

Ocean Sectors	Gross Value added (billion US dollars)	Employment (10000 persons)
Marine Fishery	42.12	553.2
Offshore Oil and Gas Industry	19.23	19.7
Ocean Mining Industry	0.67	1.6
Marine Salt Industry	0.97	23.8
Shipbuilding Industry	17.95	32.7
Marine Chemical Industry	9.07	25.6
Marine Biomedicine Industry	1.24	1
Marine Engineering Building Industry	12.91	61.5
Marine Electric Power Industry	0.56	1.1
Seawater Utilization Industry	0.13	
Marine Communications and Transportation Industry	55.92	80.7
Coastal Tourism	78.33	124.4
Total	239.09	925.3

Table 4. International Comparisons

Country	Year	Value Added of Ocean Sector (billion US \$)	% National GDP	Indicative Employment
China	2010	239.09	4.03%	9,253,000
USA[11]	2010	266.72	1.82%	2,770,000
Canada[12]	2006	17.69	1.20%	171,365
Australia[13]	2003	19.8	3.60%	-
UK[21]	2006	88.44	4.20%	548,674
France[22]	2009	28.19	1.50%	459,358*
Ireland[19]	2007	1.9	1%	17,000
New Zealand[23]	2002	2.64	2.90%	-

*Employment numbers for France do not include port authorities, handling, pilotage or towage.

A dash indicates data not available.

