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Measuring the contribution of the ocean: A comparison of the statistical classification of the marine economy used by China and Canada

Weiling Song
National Marine Data and Information Service, Tianjin, China

Jing Guo
Ocean University of China

Yuxin Liu

Yue Yin

Yue Wang

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1. INTRODUCTION

With the constant development of economic globalization, oceans have played an increasingly vital role in global economic relations. The marine economy has become an important focus for coastal nations, The growth of the marine economy continues to rise based on the exploration of maritime resources and the increasing utilization of ocean space.

Canada has the longest coastline of any country in the world, surrounded by oceans on three sides (Karo, 1956). With the development of their marine economy, marine-based economic activities are now making a great contribution to the national economy (Song and Guo, 2014; Bailey et al., 2016; Hossain et al., 2019). According to Statistics Canada, in 1998, the added value of the marine industries was $10.4 billion, representing 1.4% of the country's GDP. The marine industries were responsible for more than 120,000 jobs. In 2018, the marine economy generated $36.1 billion (1.6% of GDP) and 298,333 jobs (Statistics Canada, 2019).

On the other side of the Pacific, China, has a long coastline of 18,000 km and an abundance of marine resources (Zhang et al., 2004; Zhu et al., 2021). Under the guidance of national marine policies and plans, China's marine economy has experienced rapid growth (Liu et al., 2017; Ren et al., 2018; Wang and Wang, 2019). Over the period 2001 to 2018 ocean economy growth averaged 10.8% per year (using constant prices), a pace of 1.6 percentage points higher than the national economy. Employment growth averaged 3.3% per year (Ministry of National Resources, 2018).

Socio-economic statistics are used to quantitatively describe the status of economic development and reveal the true nature of development; thus they have played an important role in a country's economic and social development planning. Comparisons of marine economies among countries are of great significance for summarizing the policies of marine economic development of various countries and promoting the sustainable marine economy. However, measurements of the marine economy are still in their infancy, and the accounting methods and standards differ across the world, resulting in low comparability of marine economic data (Zhang et al., 2012). Canada and China have both made remarkable achievements in developing their ocean economies. It is common to compare the scale and performance of ocean-based industries and their contribution to the overall economy. Through the systematic analysis of accounting standards of the marine economy between China and Canada,

this paper elaborates the differences between these two countries in terms of marine economic definition, accounting scope, and industrial classification, in order to broaden the mind for marine economic accounting and development with useful inspiration and reference, improve the comparability of economic statistics and realize a more meaningful comparative analysis of the marine economy between China and Canada.

The rest of the paper is constructed as follows. Section 2 describes data sources. In section 3, we present the analysis results in terms of definition of marine economy, classification of marine industry and comparability of statistics. Some limitations and suggestions are discussed in section 4 and section 5 concludes.

2. DATA SOURCES

In this study, we compare the accounting methods of the marine economy between China and Canada for three points: (1) the marine economic definition, (2) the accounting scope, and (3) the classification of marine industries. We used the following materials to compare these three points:

(1) Industrial Classification for Ocean Industries and their related activities (GB/T 20794-2006) released by China's State Oceanic Administration to establish a statistical standard for ocean economy data collecting across all regions in China.

(2) Canada's Ocean Strategy published by Fisheries and Oceans Canada (DFO), available online https://waves-vagues.dfo-mpo.gc.ca/Library/264678.pdf.

(3) Canada's oceans and the economic contribution of marine sectors developed by DFO and Statistics Canada, accessed July 19, 2021, https://www150.statcan.gc.ca/n1/pub/16-002-x/2021001/article/00001-eng.htm

(4) Reports on annual statistics regarding marine-based industries as cited below.

3. METHODS AND RESULTS

3.1The definition of marine economy

3.1.1 Marine economy in Canada

In July of 2002, Canada's Ocean Strategy (COS) was released in order to provide comprehensive strategic guidance for sustainable economic development and to ensure Canada's leading position in the field of ocean economic activity. In the COS,

the marine industry is initially defined as “marine entertainment, commence, trade, development activities and diversified industrial economic activities based on the related industries in the marine space and coastal zone, not including some industrial activities in the inland waters” (DFO, 2002). In 2019, Canada updated the definition as “Those industries that are based in Canada’s maritime zones and coastal communities adjoining these zones or are dependent on activities in these areas for their income” (OECD, 2019).

The economic impacts of Canada’s marine sectors are generated through direct, indirect and induced demand in the economy (Pinfold, 2009). Specifically, purchasing goods and services to produce outputs are defined as direct impact, while the inter-industry purchases caused by the direct demand is defined as indirect impact. Induced impact refers to impact arising from the spending of consumers who are employed in direct and indirect activities.

3.1.2 Marine economy in China

In China, the concept of “marine economy” first emerged in the 1990s. Over the last three decades, many definitions have been proposed (Song et al., 2013). The most widely accepted definition comes from the national standards “Ocean and Related Industrial Classification” (GB/T 20794-2006) as “all kinds of industrial activities of exploring, utilizing and protecting ocean, as well as the sum of related activities, which is constituted of marine industry and marine related industry”.

In China, the main component and the foundation of the marine economy involves the following attributes: (1) deriving products and services directly from the ocean; (2) using the ocean as an input for economic activities; (3) contributing directly to ocean exploration; (4) taking place in the ocean space; (5) including marine research, education, management, and other related services.

The concept of marine *related* industry is also proposed in the standards. It can be regarded as an industry that is connected to the marine industry through input-output linkages. Such linkages range from goods and services, and investment to technology (Song et al., 2021).

3.1.3 The comparative analysis of the definitions

The definitions of marine economy from the two countries are similar. First, from the perspective of geopolitics, both countries consider the coastline as the basis of identifying the coastal areas. In Canada, the marine economy takes place in a specified geographic area comprised of marine and coastal areas, where inland areas

are not included, while the Chinese definition of the marine economy does not make this distinction. However, according to another Chinese national standard, called "Coastal administrative region classification and code" (HY / T094-2006), the term "coastal areas" are restricted to "provinces, municipalities and autonomous regions that have a coastline, as well as their affiliated sea and islands" (SOA, 2006). Secondly, marine industry is identified in both counties, by their representative statistical agencies, on the basis of input-output theory, including the economic activity that is directly or indirectly dependent on the ocean.

The extension of the marine economy varies in China and Canada. The impacts of Canada's marine economy on the national economy are realized at three different levels. Based on the definitions, the first level, termed as "direct impact" correspond to China's marine and marine-related industries. However, the second and third level of the Canadian marine economy, termed "indirect impact" and "induced demand", are not included into China's marine economy.

3.2 The classification and scope of marine economic statistics

3.2.1 The classification of territorial units for statistics

Canada's marine economy covers the coastal zones of the Atlantic region, Central Canada, Prairie Provinces, West Coast and Arctic (Ganter et al., 2021). Atlantic Canada is comprised of four provinces: Prince Edward Island, Nova Scotia, New Brunswick, and Newfoundland and Labrador. In Canada, the regional statistical unit of the marine economy is set at the province-level. The Pacific region has only one province, British Columbia. The Arctic region includes Yukon Territory, Northwest Territory, Nunavut Territory, and Nunavik.

China's coastal areas in comparison are defined at three different levels including province, city, and county-level (Standardization Administration, 2006). At the provincial level, there are 11 coastal provinces and municipalities, which are Liaoning Province, Hebei Province, Tianjin, Shandong Province, Jiangsu Province, Shanghai, Zhejiang Province, Fujian Province, Guangdong Province, Guangxi Province, and Hainan Province. At the city level, there are 55 coastal cities. At the smallest statistical unit, (county level) 225 counties are included, although this number is changes in accordance with the adjustment of the national administrative areas.

Comparing the classification of territory between the two countries, the similarity in the administrative division of the province level is evident, which is used as the basic statistical unit. Canada's classification is from the relative location of the coastal

areas where the ocean boards the coastal area. On the other hand, in China, for administrative purposes, the coastal areas are divided into coastal provinces, next being divided into coastal cities, and finally divided into coastal counties. Another difference lies at Ottawa, which is not a coastal city, but is still included into Atlantic Canada area because the Department of Defense and Fisheries and Oceans Canada is located in Ottawa where they conduct marine related activities. Under the classification system of China Ottawa would not be considered as a coastal city. Although a number of marine related government agencies are based in Beijing it is not considered a coastal city. (Hynes and Farrelly, 2012).

3.2.2 The scope of marine economic statistics

The Canadian marine economy includes for-profit and non-profit activities. The for-profit industries rely directly on the ocean, containing extractive (e.g. fisheries, oil and gas, marine aquaculture) and non-extractive activities (e.g. shipbuilding, maritime transport, marine tourism, and construction). The non-profit activities are indirectly dependent on the ocean, such as security, administration, and research. The industrial scope of Canada's marine economy is shown in Table 1.

Table 1. Industrial Scope of Canada's Marine Economy (DFO, 2002)

Sector	Industry
Marine fisheries	Ocean Fishing
	Sea water cultivation
	Aquatic products processing
	Fishing livelihoods
Offshore oil and gas	Oil and gas exploration and production
	Oil and gas support services
	Petroleum refining and processing
	Pipeline transportation
Maritime transport	Freight and passenger transport
	Maritime transport security services
Marine tourism	Recreational fishing

	Sea cruises
	Coastal tourism and entertainment
Marine construction industry	Installation of oil and gas installations
	Harbor, bay, ocean plant construction
	Other (submarine cables, renewable energy facilities, etc.)
Manufacturing	Navigation and navigation equipment
	Small ships and shipbuilding
	High-tech manufacturing
Services	Professional consulting services
	High-tech services
Federal Government	Department of Fisheries and Oceans
	Department of Defense
	Ministry of Communications
	Ministry of Environment
	National Parks
	Natural Science Engineering Research Council
	Indian and Northern Affairs
	Department of Natural Resources
	Food Inspection Department
Provincial / territorial governments	Fishing and Culture Bureau
	Transportation / Ferry Board
	Energy Bureau

Universities and research institutions	Selected universities and research institutions
Non-governmental environmental organizations	Selected Organizations

In China, the marine economy has two sectors at the higher level of aggregation: the marine industry and marine-related industry. These sectors can be further broken down into 28 classes, 107 subclasses, and 380 groups. The specific industry scope is shown in Table 2.

Table 2. China's Marine Industriesy[Error! Bookmark not defined.]

category	sector	Sub sector
Marine industry	Marine fisheries	Sea water cultivation
		Marine fishing
		Marine fishery services
		Marine Aquatic Products Processing
	Offshore oil and gas industry	Offshore oil and gas exploration
		Offshore oil and gas exploration services
	Marine mining	Seashore placer mining
		Seashore soil gravel mining
		Submarine geothermal, coal mining
		Deep - sea mining
		Exploitation of other marine mineral resources
	Marine salt industry	Salt water
		Sea salt processing
	Marine manufacture industry	Manufacture of marine vessels
		Manufacture of marine fixed and floating equipment
	Marine chemical industry	Sea Salt Chemical Industry
		Algae chemical industry
		Seawater chemical industry
		Offshore petrochemical industry

		Manufacture of other marine chemical products
	Marine biomedical industry	Manufacture of Marine Drugs
		Marine health products manufacturing
	Marine Engineering and Construction	Offshore Engineering Construction
		Subsea engineering construction
		Coastal engineering construction
	Marine power industry	Ocean power generation
		Ocean Wind Power Generation
	Seawater utilization	Direct use of seawater
		Desalination
		Other seawater utilization
	Marine transportation industry	Ocean passenger transport
		Ocean freight transport
		Marine port
		Submarine pipeline transport
		Marine transportation support activities
	Coastal tourism	Coastal tourism accommodation
		Coastal tourism business services
		Coastal excursions and entertainment
		Coastal tourism and cultural services

		Other coastal tourism services
	Marine Information Services *	
	Marine Environmental Monitoring and Forecasting Services *	
	Marine Insurance and Social Security *	
	Marine Science Research *	
	Marine Technology Services *	
	Marine Geological Prospecting Industry *	
	Marine Environmental Protection Industry *	
	Marine Education *	
	Marine Management	Integrated Marine Management
		Marine Economic Management
	Maritime societies and international organizations *	
Marine related industries	Marine Agriculture and Forestry *	
	Marine Equipment Manufacturing *	
	Sea-related Products and Materials Manufacturing *	

	Sea-related construction and installation industry *	
	Marine Wholesale and Retail Trade *	
	Sea-related Services *	

Note: * For convenience of comparison, the detail of the sub sectors are not listed, since they are not involved in Canadian classification. Detailed information on the sub-sectors can be found at Industrial Classification for Ocean Industries and Their Related Activities (GB / T 20794-2006).

3.2.3 Statistical analysis of marine economic sectors in China and Canada

Table 3 compares the information shown in tables 1 and 2. As shown in Table 3, the relationship of the Sino-Canadian marine statistical classifications is demonstrated across a number of areas:

First, the scope of the Canadian marine industry is encompassed within the Chinese marine economy. All marine industry statistical classifications in Canada are included in China's statistical classifications, except for the Inuit-specific subsistence fishing that resides in the Canadian Arctic.

Second, China has a wider marine industry classification, specifically including marine mining, marine salt, marine biomedicine, marine power, marine water utilization, marine information services, marine insurance and social security industry, marine agriculture and forestry, marine products and materials, marine manufacturing and installation, marine wholesale and retail, and marine services.

Third, China and Canada’s understanding of the scope of for-profit industry is very similar while the understanding of the scope of non-profit industry has some differences. The for-profit marine industries in China are close to a one-to-one relationship with the Canadian industrial classification, except for tourism. The non-profit industry in the marine economy in China is more difficult to identify compared to Canada, due to the difference of governance in the two countries.

Fourth, specific to the classification of individual industries, there are

differences in the breakdowns between the two countries. For example, offshore oil refining and processing fall in the category of offshore oil and gas industry in Canada, while it belongs to the category of marine chemical industry in China. Ship and small ship manufacturing is contained in the manufacturing category in Canada while belongs to the marine shipping industry in China.

Table 3. The Contrast of China and Canada Marine Industry Statistical Classification

China			Consistent or not	Canada	
Categories	First class	Second class		Industries	Sectors
Marine industry	Marine fisheries	Sea water cultivation	√	Marine fishing	Marine fisheries
		Marine fishing	√	Sea water cultivation	
		Marine fishery services			
		Marine Aquatic Products Processing	√	Aquatic Products Processing	
				Subsistence fishing	
	Offshore oil and gas industry	Offshore oil and gas exploration	√	Oil and Gas Exploration and Production	Offshore oil and gas
		Offshore oil and gas exploration services	√	Oil and gas security services	
	Marine mining	Seashore placer mining			
		Seashore soil gravel mining			

		Submarine geothermal, coal mining			
		Deep - sea mining			
		Exploitation of other marine mineral resources			
	Marine salt industry	Salt water			
		Sea salt processing			
	Marine manufacturing industry	Manufacture of marine vessels	√	Ships and small ships	manufacturing
		Manufacture of marine fixed and floating equipment			
	Marine chemical industry	Haiyan Chemical Industry			
		Algae chemical industry			
		Journal of Hydrodynamics			
		Offshore petrochemical industry	√	Petroleum refining and processing	Offshore oil and gas

		Manufacture of other marine chemical products			
	Marine biomedical industry	Manufacture of Marine Drugs			
		Marine health products manufacturing			
	Marine Engineering and Construction	Offshore Engineering Construction	√	Installation of oil and gas installations	Marine construction
		Subsea engineering construction	√	Other (submarine cables, renewable energy facilities, etc.)	
		Coastal engineering construction	√	Ports, bays, marine plants construction	
	Marine power industry	Ocean power generation			
		Ocean Wind Power Generation			
	Seawater utilization	Direct use of seawater			
		Desalination			

		Other seawater utilization			
	Marine transportation industry	Ocean passenger transport	√	Freight and passenger transport	Maritime transport
		Ocean freight transport			
		Marine port			
		Submarine pipeline transport	√	Pipeline transportation	Offshore oil and gas
		Marine transportation support activities	√	Marine transportation security services	Maritime transport
	Coastal tourism	Coastal tourism accommodation			
		Coastal tourism business services			
		Coastal excursions and entertainment	√	Recreational fishery	Marine tourism
				Sea cruises	
				Coastal tourism and entertainment	

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		Coastal tourism and cultural services			
		Other coastal tourism services			
	Marine Information Services *				
	Marine Environmental Monitoring and Forecasting Services *		√	Ministry of Environment	The federal government
	Marine Insurance and Social Security *				
	Marine Science Research *		√	Natural Science Engineering Research Council	The federal government

				Selected universities and research institutes	Universities and research institutions
	Marine Technology Services *		√	High-tech services	Services
				Professional advisory services	
	Marine Geological Prospecting Industry *		√	Energy Bureau	Provincial / Regional Government
	Marine Environmental Protection Industry *		√	Ministry of Environment	The federal government
	Marine Education *		√	Selected universities and research institutions	Universities and research institutions
	Marine Management	Integrated Marine Management	√	Department of Fisheries and Oceans	The federal government
				Department of Defense	

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				Ministry of Environment	
				National Park	
				Indian and Northern Affairs	
		Marine Economic Management	√	Ministry of Communications	
				Department of Natural Resources	
				Food Inspection Department	
				Fishing and Culture Bureau	Provincial / Regional Government
				Transportation / Ferry Board	
				Energy Bureau	
	Maritime societies and		√	Selected Organizations	Non - governmental

	international organizations *				environmental organization
Marine related industries	Marine Agriculture and Forestry *				
	Marine Equipment Manufacturing *		√	Navigation and navigation equipment	manufacturing
				High - tech manufacturing	
	Sea-related Products and Materials Manufacturing *				
	Sea-related construction and installation industry *				

	Marine Wholesale and Retail Trade *				
	Sea-related Services *				

3.3 Coherence and comparability of statistics

3.3.1 Regional statistical caliber consistency analysis

The above analysis has shown that both China and Canada set provincial administrative units for the marine economic regional taxonomic units. Therefore, the marine economic statistics of China and Canada are comparable at the national marine economic level, which is aggregated by provincial administrative divisions. However, the comparability of the regional or provincial marine economic activities is limited due to the large geographical differences between the two countries and their regional classifications.

It is noteworthy that Canada has incorporated some marine management activities in the non-coastal region of Ottawa into the marine economic statistics, while China has not included statistics on the non-coastal areas. For example, Beijing, as the capital city, is involved in a large number of marine management activities, although it is a non-coastal area. However, the value generated by these activities is negligible compared to the value of the marine industry in coastal areas.

3.3.2 Industry statistics consistency analysis

Combining the above information, the analysis of the consistency of the statistical standards should consider the differences in statistical conceptual framework and statistical classification. From the perspective of the marine economy, Canada's direct influence industries are comparable with China's marine industry and marine-related industry. Once again it should also be noted that China’s definition of the marine economy does not include the concepts of indirect and induced impacts as seen in Canada. From the analysis of the industry classification of the marine economy, Table 4 shows comparable ranges of marine industry statistics for China and Canada.

3.3.3 Comparing the marine economic statistics of Canada and China

In terms of comprehending the statistics at the region and national levels, the marine and related industries in China and Canada could be compared to some extent. The comparable marine industries between the two countries is shown in Table 4.

Table 4. Synchronizing the Marine Industry Classification of China and Canada

China		Canada	
sector	**sub-sector**	**sector**	**sub-sector**
Marine fisheries	Sea water cultivation	Marine fisheries	Marine fishing
	Marine fishing		Sea water cultivation
	Marine aquatic products processing		Aquatic products processing
Offshore oil and gas industry	Offshore oil and gas exploration	Offshore oil and gas	Oil and gas exploration and production
	Offshore oil and gas exploration services		Oil and gas security services
Marine manufacturing	Manufacture of marine vessels	Manufacturing	Ships and small ships
Marine engineering and construction	Offshore Engineering Construction	Marine construction industry	Installation of oil and gas installations
	Coastal engineering construction		Ports, bays, marine plants construction
Marine transportation	Ocean passenger transport	Maritime transportation	Freight and passenger transport
	Ocean freight transport		
	Marine transportation support activities		Marine transportation security services

	Submarine pipeline transport	Offshore oil and gas	Pipeline transportation
Coastal tourism	Coastal excursions and entertainment	Marine tourism	Recreational fishery
			Sea cruises
			Coastal tourism and entertainment

4 DISCUSSION

(1) Different industrial classification

Statistics Canada utilizes the North American Industry Classification System (NAICS), which has a detailed industrial classification, and information related to the marine industry and marine-related enterprises can be directly extracted from it (Gunton and Joseph, 2010). It is convenient for the processing and analysis of micro-issues with detailed data.

(2) Different accounting methods

Limited by data sources, the data of various industries in Canada are generally underestimated (DFO, 2009), which is shown as follows:

Marine food: the overall quality of the data in this industry is desirable, which reflects the development status of the industry. However, there is a lack of full-time equivalent (FTE) official employment statistics, and the data used is the required employment level calculated based on a specific output level.

Marine oil and gas: due to confidentiality restrictions, Statistics Canada prohibits the release of the output value and production data of the marine oil and gas industry. The output value is estimated by using the published output data and the price applicable to the average market.

Marine transportation: data in this section only accounts for shipping activities carried out through ship leasing (referred to as “leasing”), while those with self-owned ships (referred to as “self-operated shipping”) are not included. The value of self-operated shipping activities is greater than that of the leasing activities. Therefore, the data is underestimated.

Tourism and recreation: data in this part only includes cruise ships,

recreational fishing, and some marine tourism and recreation data from the Travel Survey of Residents of Canada (TSRC). Since non-residents are not included in the survey, the impact of tourism and recreation activities is greatly underestimated.

Marine construction and manufacturing industry: the private facility investment is not included in the marine construction industry, so the impact of this industry will be underestimated.

Therefore, when conducting statistical analysis of China-Canada marine economic data, comparing relative indicators is more meaningful than comparing absolute indicators.

(3) Different research focuses

Accounting for the marine economy needs to be based on national conditions, and research should be carried out on key issues. In China's marine economic accounting, due to the lack of detailed industrial classification, it is necessary to define how many components of the national economic industry belong to the marine economy. The focus of the research is to determine the partial coefficient, and the main work is to determine the marine-related attributes, that is, to decide which industrial activities belong to the marine economy, and which ones do not. On the contrary, Canada's industrial classification is well-developed, and its marine economic accounting research focuses on analyzing the direct, indirect, cumulative, and induced impact of marine economic activities on the national economy through the input-output method based on the products' name and Harmonized System (HS) of commodities.

5 CONCLUSION

This paper makes a comparative analysis of the accounting methods of the marine economy between China and Canada from the marine economic definition, accounting scope, and industrial classification, and presents the corresponding relationship of the China-Canada marine industry under a comparable perspective. Socio-economic statistics is the language for international communication. The research conclusions of this paper are of great theoretical significance for conducting comparisons of marine economy among countries from the perspective of statistics, summarizing the status of marine economic development, and promoting the development of marine economics. However, it is also found that due to the lack of international

standards for marine economic accounting, measurement methods and industry definitions are different among countries. The comparable industries in China and Canada still have many incomparable items. Therefore, the creation of an internationally comparable set of ocean accounts is conducive to improving the transparency, reliability, and comparability of marine economic statistics of various countries, and is helpful for the international community to make accurate estimation on the status and trend of marine economic development.

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