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The Brazilian coastal and marine economies: Quantifying and measuring marine economic flow by input-output matrix analysis

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ABSTRACT

Internationally nations are estimating the value of the sea and acknowledging its importance to the national Economy. Even though Brazil has one of the world's longest coastlines with hundreds of coastal cities, there are no specific statistical data on the contribution of the sea to the Brazilian Economy reinforcing the importance of this work. The purpose of this paper is to quantify the Brazilian Coastal and Marine Economies in the year of 2015 by estimating a National Input-Output Matrix which creates marine sectors. As far as we know it is the first time that Brazilian Coastal and Marine Economies have been presented using an Input-Output model. The results estimate that Brazilian Coastal and Marine Economies generated US$ 286 billion (19.0%) to the GDP in 2015, (16.4% for the coastal economy and 2.6% for the marine economy). It should be highlighted that Brazilian Coastal and Marine Economies are dominated by the service sector.

1. Introduction

According to the Ministry of Environment (Ministério do Meio Ambiente, 2008), the Brazilian coastline, also known as of the five longest coastlines in the world, has some peculiarities such as metropolitan areas with high population density– and others with low density – artisanal fishermen and indigenous communities. In addition to this, another feature is the conflict of economic activities where large industrial complexes compete for space with tourism and fragile ecosystems, such as mangroves and estuaries.

The recently developed Blue Amazon concept reinforces the importance of the sea to the Brazilian national economy and raise the debate about the quantification of the coastal and marine economies in Brazil. The idea of the Blue Amazon was originated from the proposal submitted in 2004 by the Brazilian government to extend the continental shelf limits from 3.5 thousand km^1 to 960 thousand km^2. If approved, Brazilian marine space would reach approximately 4.5 thousand km^2, which corresponded to almost half of the national terrestrial territory (do Brasil, 2016). In 2007, the UN partially approved the Brazilian claim, extending the continental shelf to 712 thousand km^2 which enlarged Brazil's maritime area.

The increase of the presence of the sea in the national and international economy, push the activities related to the sea and your resources to become increasingly more prominent for economic development. This can potentially increase sea economic activities, such as industrial fishing and cobalt and deepwater oil reserves exploration. The estimation points out that up to 2024 Brazil will increase its share of the world oil market by acting as a net exporter of oil and oil products mainly derived form sea reserves (94% and 76% of total Brazilian oil and gas was produced by sea reserves, respectively) (Ministério de Minas e Energia, 2015).

Because it is possible to quantify the uses of sea resources, acknowledge as Marine Economy, the studies in this field are a world trend on several grounds, such as: (i) increase of demand for coastal environment resources to human survival, coastal protection, recreation and climate control; (ii) growth global population and economic (pressure on entire coastal environment); (iii) marine ecosystem conservation (Heinrich Böll Foundation Schleswig-Holstein and Heinrich Böll Foundation; University of Kiel's Future Ocean Cluster of Excellence, 2017); (iv) governance of resources and uses in Exclusive Economic Zones. Thus, the growing urge to sea resources occurs in a uses conflict environment for which the public policies have to accurate.

Kildow and McIlgorm (2010) point out that studies of the economic contribution of oceans to the national economy enable governments to

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plan actions that are aimed at protecting environmental areas. They state that researches that aim at evaluating the total of marine economy often use their results to highlight the importance of the sea to a country's economy. According Zhao et al. (2014) China is a one of the countries that best recognized this target. They have, established in 2006 the Ocean Economy Accounting System and, in 2011, elected for the first time the developing ocean economy as part of the Five-Year plan's goals.

Brazil is not inserted in this world trend. Despite having more than 60% of its population living in coastal areas, the size of Brazil's coastal and marine economies are still unknown. There are simply no studies on coast-dependent industries nor measurements of their socioeconomic impacts on the coastal regions or for the whole country as well as there are no specific public policies for these areas. For instance, according to the Ministry of Tourism (do Turismo, 2014) 78.9% of international tourists who came to attend the 2014 Football World Cup visited the coastal cities. And still there are no researches that have tried to measure or quantify the impact of coastal or marine economy in the Brazilian context.

Considering the emergence of the Brazilian new marine resources, in addition to previously traditional uses - such as artisanal fishing, very important due to the socioeconomic vulnerability of these groups – there is an urgent need to specific studies on the Brazilian coastal and marine economies. This paper contributes to fill this gap, by estimating an Input-Output matrix that enables calculate the contributions of the coastal and the marine economies in 2015.

Therefore, we present an overview of the Brazilian coastal and marine economies, proposing its quantification for the year of 2015 and evaluating the linkages and coast-dependent industries economic impacts to the national economy. The biggest contribution of the present article lies in the quantification of a specific geographic and environment segment of the Brazilian economy in connection with the sea. The specific research questions are:

(i) What is the concept of Brazilian Coastal and Marine Economies?
(ii) What is its participation in the GDP and its prevalent activity?

Economic impacts can be evaluated by measuring economic activities for development, improvement of technology production for sustainable development and ocean conservation, job creation, income generation, and the number of public policies enforced. Furthermore, it is very important to identify the Gross Domestic Product (GDP) of the sea as a relevant indicator of economic growth that can support the formulation of public policies and investments. As a result, we expect to stress the relevance of the Brazilian coastal and marine economies suggesting a category of analysis with an analytical-methodological tool-aid development and its implementation for specific public policies that can be adopted by coastal states and cities.

The paper is divided into five further sections. Next section reviews studies that applied the Input-Output model and other methods used to estimate the size of either marine or coastal economy in their countries. In this section we also present an overview of the Brazilian maritime States in 2015. Third section describes the theoretical structure of the Input-Output model, called IOMSea, and the features that refers to estimate the IOMSea, such as new rows and columns related to the Brazilian coastal and marine sectors. Fourth section presents the results of the IOMSea. Fifth section discusses them in the context of the Brazilian coastal and marine economies. The sixth and the last section present the final remarks of the article.

2. Marine economy in the world and the input output model

Several studies have been carried out internationally to investigate the economic contribution of ocean, that is, marine economy at regional, national and continental levels, since the 1980s. World Bank (World Bank; United Nations Department of Economic and Social Affairs, 2017) uses the conceptualization of blue economy to describe the oceanic economy and related aspects of sustainable uses of the oceans. Fundamentally, blue economy must include traditional ocean industries – namely fishing, tourism and maritime transportation, but also other emerging activities as renewable energy, aquaculture, deepsea extraction and marine biotechnology and bioprospecting. According to, (Kildow and McIlgorm, 2010), (World Bank; United Nations Department of Economic and Social Affairs, 2017)- (Colgan, 2003), each country or economic zone can develop its own methodology to define the sea or coastal economy. The relevant sectors linked with marine or coastal activities and their share in national output. Consequently, depending on their own national attributes, the approach that these nations embrace would be useful to their own strategic policy planning (World Bank; United Nations Department of Economic and Social Affairs, 2017).

According to Kildow et al. (2001), informations related to the marine economy are essential to demonstrate the role that ocean activities play in the economic formation of a state. In this sense, the authors mention the state of California in the USA, as an example. New laws were enacted to improve the management and protection of the state's ocean and coastal resources, which has reflected in substantial budget increases for these programs as (Kildow et al., 2001) point out.

Colgan (2003) states that some studies aimed at evaluating Marine Economy used a production estimation of production obtained by regional econometric models. Nonetheless, the author emphasizes that the Input-Output model estimates relations with other intermediate industries more precisely showing multipliers for ocean-related economic activities.

In their study of the role played by marine economy in South Korea, Kwak et al. (2005) used five national Input-Output Matrices (1975–1998). Sectors Marine Transport Industries, Ports, Fishing and Marine Products, Naval and other marine Industries were identified as marine sectors. They concluded that the gross value production (GPV) of Korean Marine Economy was three per cent of the national industry in 1998. Measuring the economic effects, forward linkages are lower than those of other national sectors. In contrast, backward linkages are higher compared to other sectors of the economy showing that the marine industry has greater interactions within the economy.

Complementary to marine economy in South Korea, Shin and Yoo (2009) also measure the contribution of marine industry to the economy using 2006 national Input-Output Matrix. Five sectors were used: Marine Transportation (coastal, inland water, deep sea), Harbor (construction and services), Fishery and marine products, Shipbuilding, and Other marine sectors (marine tourism, marine defense and marine materials). As a result, Korean marine economy represents almost three per cent of the national GVA. For the economic effects, forward linkages are lower than those of other national sectors. In backward linkages, maritime sectors are higher than those of other national sectors. It has demonstrated the greatest impacts of marine sectors in investment expenditures on the national economy in comparison of other national sectors, in the same sense of Kwak et al. (2005).

Morrissey and O'Donoghue (Morrissey and O'Donoghue, 2013) used the same input-output tool to analyze the contribution of the Marine Economy in Ireland at national and regional levels. In the Input-Output Matrix for 2007, analyzing ten sectors were disaggregated (Fishing, Oil and Gas, Seafood Processing, Naval Construction, Water Construction, Water Transport, Marine Engineering, Marine Retail Activities, Water-based Activities and Auxiliary Transport Activities). As a result it was found that the GVA of the Marine Economy corresponds to one per cent of the national GVA. The sectoral disaggregation– based on secondary information from social and economic statistics – carried out by the authors is the same to the one proposed to construct the IOMSea in this paper, even though the marine sectors are not exactly the same. When considering the economic impacts, three sectors with values greater than 1 were identified in backward linkages. Forward linkages were registered in only one sector with a value greater than 1. Demonstrating the importance of the Irish sea sectors as suppliers to the

national economy.

Zhao et al. (2014) point out that when the Chinese government acknowledged the importance of evaluating Marine Economy, they decided to create an exclusive department to collect data and carry out analyses in the area. Even though four accounts were established, this paper highlights only the Elementary Account because it is responsible for developing Input-Output Matrices. The results depicts that Chinese marine economy has a GVA which represents four per cent of the GDP, being the consisting of Marine Fishing, Offshore Oil and Gas, Mining, Sea Salt Industry, Naval Construction, Chemical Industry, Marine Biomedicine, Marine Engineering and Construction, Marine Electrical Energy, Use of Sea Water, Marine Communication and Transport and Coastal Tourism. The downside is that this specific study does not measure economic impacts.

The National Ocean Economics Program (NOEP)[1] has developed a methodology to distinguish and quantify United States sea-related economy in coastal and oceaneconomies. In this sense, coastal economy was represented as an all economic activity carried out in water coastal states, whereas the oceanic economy consists of all economic activity that comes, even if partially, from the seas (Kildow et al., 2016). NOEP proposed a definition of oceanic economy, which includes aspects of industry and geography simultaneously. The figures for 2014, NOEP accounts that 84% of American GDP is associated with the coastal economy, while in 2013, only 2.2% of the American GDP would be oceanic economy comprehended by six major sectors: Construction, Living Resources, Minerals, Naval Industry, Recreation and Tourism and Transportation (Kildow et al., 2016).

In Australia, Allen Consulting (Allen Consulting Group, 2005) estimated the oceanic economy for the 2002–2003 period. Ocean economics is understood here as therelationship between industry and ocean, in several ways: 1) employment of ocean resources; 2) offered services that are ocean dependent; 3) obtained advantage from oceanic resources or environment. There are six sectors, or twenty activities, that comprehends Australia's oceanic economy: Marine Tourism, Oil and Offshore Gas, Fishing and Seafood, Marine Transport, Naval Industry and Port Activities. The sum of the Australian oceanic industry within these sets amounts to 3.6% of total industrial output (Allen Consulting Group, 2005).

Within this framework, Brazil has about 324 thousand km^2 corresponding to the territory of over 400 coastal cities (Ministério do Meio Ambiente, 2016), out of them 280 are located directly in front of the sea distributed along seventeen coastal states. There are 13 state capitals located by the coast summing up more than 38 million people living in them. According to Table 1 the Northeastern coast shows the higher values due to the number of states and municipalities located there, especially BA, MA and CE. In the second tier is the Southeastern coast comprising 55 municipalities in the states of SP and RJ located in front of the sea.

Table 1
Overview of Brazilian maritime states in 2015 ((Instituto Brasileiro de Geografia e Estatística, 2019)).

Region	Maritime states	Number of municipalities located in front of the sea	Coast Population (1,000)
Coast	17	280	38,254
Coast/BR	63.0%	5.0%	18.7%
North	Amapá (AP)	4	449
	Pará (PA)	14	494
Northeast	Maranhão (MA)	25	1882
	Piauí (PI)	4	196
	Ceará (CE)	21	3860
	Rio Grande do Norte (RN)	22	1474
	Pernambuco (PE)	14	3656
	Paraíba (PB)	10	1097
	Alagoas (AL)	15	1271
	Sergipe (SE)	8	812
	Bahia (BA)	36	4694
Southest	São Paulo (SP)	16	2166
	Rio de Janeiro (RJ)	25	11,428
	Espirito Santo (ES)	14	2000
South	Paraná (PR)	6	270
	Santa Catarina (SC)	30	1954
	Rio Grande do Sul (RS)	16	551

3. Materials, methods and IOMSea

3.1. Input-output fundamentals

Input-output Table Compilation and Analysis Handbook, United Nations (United Nations, 1999), cites 1973 Nobel laureate, Wassily Leontief, who pioneered the Input-Output tables in 1936 for the United States economy from 1919 to 1929. In Leontief's definition (Leontief et al., 1987) IOM assumes that economic system would be easy to be represented as an elementary tool, connected with the National accounting system, desegregating output in sets of economic sectors interconnected with each other.

The analysis method uses an Input-Output models. Miller and Blair (2009) state that the Input-Output models are based on the observation of data in the economy of a region, state or country. The Input-Output model is a set of tables and charts that are divided into two groups: 1st – Basic Tables named Tables of Resources and Uses (TRU); and 2nd–Tables that result from the application of the model to information found in the basic tables (Considera et al., 1997). TRU's include data on the production of economic activities, intermediate consumption, salaries, social benefits, gross fixed capital formation and other investments.

According to Ramos (1996), consumers of intermediate goods exhibit for each row (or good) the value in final consumer prices sold to each economic activity (columns) the line with industrial or service transformations processes. Miller and Blair (2009) specify that an essential set of information needed for an Input Output Model are the monetary values of transactions between a pair of sectors, designated as Zij. Sectors j's demand inputs of other sectors, i's, to transform in final goods to final demand along one year time.

According to Miller and Blair (2009) final demand, is a sum of exogenous sectors: household consumption of goods and services (or C), investment or corporate consumption or gross fixed capital formation (represents by I), government consumption (G), and exports or rest of the world consumption (X). To obtain the GDP, is necessary to subtract total imports from final demand.

In a second group of tables, the most important theme is the denominated Leontief Matrix. It enables the calculation of direct and indirect impacts resulting from changes in the final demand of an Economy (Considera et al., 1997). Equation (1) presents the calculation of model.

$$X = AX + f \tag{1}$$

$$X = AX + f$$

$$X = (I - A)^{-1} f$$

Where:

X = vector of total output of sector j

A = matrix of coefficients

$(I - A)^{-1}$ = Leontief inverse matrix or matrix of the sum of direct and

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indirect coefficients

f = vector of final demand.

Coefficients of the inverse matrix are direct and indirect production requirements. They show variations – in the production of different sectors – that are needed to meet variations in the final demand. Moreover, it should be noted that Leontief developed a closed model which endogenize the household consumption. In this case the induced effect is obtained due to the families' household payment are not in the final demand. This is important because some marine industries, such as Living Marine Resources, are stimulated by household consumption.

Thus, according to Feijó et al. (Feijó and Ramos, 2013), Equation (1) represents the Input-Output model and enables the calculation of the output (X) needed to meet the final demand (*f*).

Miernyk (2020) states that the input-output model can be used by policy makers in underdeveloped countries to determine the types of investments that stimulate economic growth.

The Brazilian System of National Accounts follows the international recommendations presented in the Manual of System of National Accounts of 2008 and presents the information according to a classification of products and activities integrated with the National Classification of Economic Activities - NACE 2.0 of the Brazilian Institute of Geographical and Statistics (IBGE). The IO table structure, that consists of 67 activities (column) and 127 products (lines), was used to build the Brazilian IOMSea.

3.2. Multipliers

The multipliers are constantly used to indicate economic impacts and can be evaluated at the level of production, added gross value, employment, taxes and exports (Miller and Blair (2009)). Therefore, they can subsidize any projects and/or policies that depend on data related to impacts of different events, considering the links with distinct sectors. Zhao (2013) states that two types of multipliers can be used to analyze the economic effects. Type I is obtained by Leontief open model and measures the industrial response. Type II is obtained through the Leontief closed model and measures, besides industrial response, household consumption induced response. Type II multipliers provide the direct, indirect and induced effects.

Zhao (2013) cites the type II multipliers are able to describe the whole picture of the economy what explains his preference for type II. Colgan (2007), points out that NOEP uses economic impact modeling to calculate the indirect and induced impacts for each of the thirty coastal states.

In line with (Zhao, 2013)- (Colgan, 2007) strategies, this paper presents the type II multipliers, that measures the direct, indirect and induced effects. The type II is used because some marine industries, such as Living Marine Resources, are extremeally stimulated by household consumption.

3.2.1. Production multiplier

It is defined as the total value of output in all sectors of the economy needed to satisfy a change in one monetary unit in final demand of sector *j* (Miller and Blair (2009)).

$$\overline{M}P_j = \sum_{i=1}^{n+1} \bar{l}_{ij}$$

Where:

$\bar{l}_{ij}$ = Closed Model Leontief Inverse Matrix elements.

3.2.2. Employment multiplier

The employment multiplier allows the assessment of jobs generation in each sector of an economy due to change in the final demand of the sector j.

$$\overline{M}Emp_j = \sum_{i=1}^{n+1} e_i \bar{l}_{ij}$$

Where:

ei = employment coeficient;

$\bar{l}_{ij}$ = Closed Model Leontief Inverse Matrix elements.

3.3. Interindustry linkages

Guilhoto and Picerno (1995) state that input-output model indicates which sectors in the economy have the most powerful interindustry linkages. Thus, as (Morrissey and O'Donoghue, 2013) proposed, this paper uses interindustry linkages to analyze the economic impacts of coastal and marine economies. They can be divided in:

(i) backward linkages: indicates purchases of a specific sector to others sectors. It is the demand of a sector.

$$U_j = \frac{l_{*j}}{n} \Big/ l_{ij^*}$$

Where:

lij^* = Leontief Matrix average;

l^*j = sum of the j elements of the Leontief Inverse Matrix;

n = number of elements of the Leontief Inverse Matrix.

(ii) forward linkages: indicates the sales of a specific sector to other sectors. It is the supply of a sector.

$$U_i = \frac{\frac{l_{i^*}}{n}}{l_{ij^*}}$$

Where:

lij^* = Leontief Matrix average;

li^* = sum of the i elements of the Leontief Inverse Matrix;

n = number of elements of the Leontief Inverse Matrix.

When the index is higher than 1 in both linkages, it indicates that sectors are beyond national average. In practice, they can be understood as key sectors to foster economic growth.

3.4. The Brazilian coastal and marine economies input-output matrix 2015

The Brazilian I–O 2015, which consists of 67 activities (column) for 127 products (lines), enables the construction of the Brazilian coastal and marine economies Input-Output Matrix. Scholars (Zhao et al., 2014), (Kildow et al., 2016), (Allen Consulting Group, 2005)– (Vega et al., 2012), have defended that the first challenge to define marine GDP methodologically is to choose which approach will be studied: either the marine or the coastal one. After, that economy sectors can be chosen. Thus, both approaches - coastal and marine are adopted, that is, economic activities that either directly or indirectly related to the sea, developed in seafront cities (280) were classified. Thus, states and cities which are not contiguous with the ocean have been excluded from the analysis.

This approach involves aspects of marine economic activies (directly related to the sea), while it considers the whole economic activities developed (indirectly related to the sea) in Brazilian cities. Along with these definitions, we developed a general approach to coastal and marine economies, aligned with geographical Brazilian features, between the coastal states that registers the largest contributions in terms of GDP - big part of the economic activity is in seafront cities.

Therefore, coastal and marine economies in Brazil have been defined as economic activities that are directly influenced by the sea, including the ones which raw material do not necessarily comes from the sea, but

that are carried out in its surroundings. The proposed methodology is similar to the Australian concept developed in the study carried out by Allen Consulting (Allen Consulting Group, 2005). There, the marine economy considers all economic sectors that have any sort of relation with the marine environment, if they use marine resources, offer services that depend on the sea or get economic advantages derived from the marine environment. This is a similar approach of the definition used by the American ocean economy proposed by Kildow et al. (2016) exclusively regarding the classification of economic activities in both industrial and geographical dimensions. Table 2 clarifies studies that support the conceptualization of Brazilian coastal and marine economies.

Furthermore, the World Bank selected the components of the blue economy according to the type of relationship it has with the ocean. World Bank (World Bank; United Nations Department of Economic and Social Affairs, 2017) points out the following types of activities: (i) Harvesting and trade of marine; (ii) Extraction and use of marine non-living resources (non-renewable); (iii) Use of renewable non-exhaustible natural forces (wind, wave, and tidal energy); (iv) Commerce and trade in and around the oceans; (v) Indirect contribution to economic activities and environment. This paper and the World Bank study converge on the same types of activities except that due to the national economic structure our set of actitivities is more inclusive. Activities selected for the Brazilian coastal and marine economies are available in Table 4.

Thus, spatial outline used for coastal and marine economies in Brazil starts in political land division of seafront cities and it stretches up to 200 miles (370.5 km), including Trindade Island and São Pedro and São Paulo Archipelago.

The proposed concept requires clarification of activities that are directly affect by the sea, in contrast to the ones that are only carried out near the sea but whose raw material is not originated by the sea. Colgan (2013) defends that ocean economy results from what and where it is produced simultaneously. Therefore, definition of marine economy should be take into account industrial and geographical components. This study uses the perspective proposed by Colgan (2013) to classify Brazilian coastal and marine activities. Direct activities will be called Marine Dimension since they either are developed in the sea or yield products that are used in the sea. Colgan (2013) also mentions that some industries, such as Fishing and Fish Processing, are considered, regardless of their location, whereas Tourism and Leisure are only included when they are located in a specific region. It is important to point out that certain activities, such as food and hospitality, neither use sea nor yield anything that are used in the sea. However, they are relevant when they take place in coastal cities so they comprise the scope of activities that are directly related to the sea. Activities that are merely developed close to the sea (the indirect ones) are named Activities Adjacent to the Sea.

The participation of sea and coastal economy was calculated simultaneously in this paper and form the Brazilian coastal and marine economies. That is, the sum of the sea economy (6 sectors, named Marine dimension) and the coastal economy (3 sectors, named Adjacent to the Sea) as a result the Brazilian coastal and marine economies is obtained, as detailed in Table 3.

Therefore, unlike some experiences in the international literature, this work quantifies at the same time the sea and coastal economy without considering rivers and lakes (inland waters) - just the 280 seafront cities.

Table 2
Overview of Brazilian coastal and marine concept approach.

Approach	Reference Study	Justification
Direct relation with sea	Australia-USA (Kildow et al., 2016) (Allen Consulting Group, 2005)	Use marine resources; offer services that depend on the sea; get economic advantages resulting from the marine environment
Indirect relation with sea	USA (Kildow et al., 2016)	Industrial and geographical dimensions

Table 3
Coverage of the concept of the Brazilian Coastal and Marine economy.

Coverage	Approach	Number of sectors
Sea economy	Direct relation with sea	6
Coastal economy	Indirect relation with sea	3
Brazilian Coastal and Marine Economies		**9**

It is necessary to disaggregate from previous sectors that already exist in original figures in order to materialize sea sectors and products in a new framework revealing the coastal and the marine economies. Table 4 indentifies activities that form every row and column of the IOMSea in Marine Dimension, since it is very dependent on sea.

Table 4 shows that, in the Marine Dimension scope, forty activities were grouped into six rows and six columns in the IOMSea. Names of rows and columns identify the types of activities that conjugates them. The criterion applied to compose new rows and columns in the IOMSea formed a similar group of economic activities.

OECD (Organisation for Economic Cooperation and Development, 2019) recognizes which sectors involved in marine economy can vary considerably among economic areas. Furthermore, their study indicates there are no international or standard definitions, as well as statistical terminology for ocean-based activities, in present time.

Therefore, the Living Marine Resources sector consists of activities that explore live resources from the sea. Marine salt is included in this sector because its extraction and refining are close links to the food sector. Marine Energy is the sector that encompasses the production of energetic resources based on the sea. That is, extraction and use of marine non-living resources (non-renewable). Nowadays, it has mainly been related to resources from oil exploration in pre-salt basins – a considerable volume in 2015 – and post-salt ones.

Marine manufacture consists of activities related to construction, maintenance and extraction that either use some raw material from the sea or whose final products are used in the sea, such as ships and fishing material. Thus, this sector encompasses the production of the naval industry, connected to a large growth of the sector of offshore oil exploration, which has boosted modernization, enlargement and construction of shipyards across the Brazilian coast since 2003. Also, real estate comprises residences and offices that in Brazilian context enjoy scenic beauty of sea and beaches. Many real estate properties, in cultural consumption of Brazilian families, are more valued in sea adjacencies. These values correspond in the same sense of populational movements connected with climate amenities in USA and Europe. Marine Transport comprises the category of transport that either operates in the sea or provides the basis of port structures management and activities related to assistance given to ship agencies.

Marine Services include all activities related to services that not only use the sea to carry them out but also get advantages from its proximity, such as hotels and restaurants which are located on the coast. These activities are only included when they are located in a specific region, that is, in 280 Brazilian seafront cities. It can be considered mostly a touristic sector.

Finally, the Marine Defense sector is composed of Defense activity, which is responsible for administration and management of national defense activities, such as those conducted by the Naval defense. In particular (Kildow and McIlgorm, 2010) identifies that countries such as Canada, France and the United Kingdom (Pugh, 2008) include in sea economy studies about the defense sector. McIlgorm (2016) mentions that the List of Marine Industry categories produced by the APEC MRC Expert Consultation Workshop in 2004 also includes activities such as defense and government services related to the ocean. Although, (McIlgorm, 2016) also points out that studies in countries such as Korea and the Philipines partially address these sectors for national strategic

Table 4
Original I–O, rows and columns of the IOMSea and NACE activities classified in the Marine Dimension.

Original I–O	NACE[a] Activity	Row/Column IOMSea
(02802) Fisheries and aquaculture	Seawater fishing	**Living Marine Resources-RMar**
	Brackish and marine water aquaculture	
(05802) Non-metallic minerals	Marine salt and gem salt[b] extraction and refine	
(10914) Industrialized fished	Fish preservation and fish product manufacture	
(06801) Oil, natural gas and support services	Oil and natural gas extraction	**Marine Energy-EMar**
	Supporting activities for oil and natural gas extraction	
	Supporting activities for mineral extraction, except oil and natural gas	
(05802) Non-metallic minerals	Gemstone extraction (precious and semi-precious stones)	**Marine Manufacture-MMar**
(28002) Machines and equipment for mineral extraction and construction	Manufacture of machines and equipment for oil prospection and extraction	
(3001) Aircraft, vessels and other transport equipment	Construction of vessels and floating structures	
	Construction of vessels for sports and leisure	
(31802) Products of various industries	Manufacture of equipment for fishing and sports	
(33001) Maintenance, repair and installation of machines and equipment	Vessel maintenance and repair	
(41801) Buildings	Real estate developments	
(41802) Infrastructure works	Port, marine and fluvial construction	
(45801) Wholesale and retail trade	Wholesale commerce of meat, meat products and fish	
	Retail commerce of meat and fish-butcher shops and fish stores	
(50001) waterborne transport	Coastal marine transport	**Marine Transport-TMar**
	Deep sea shipping	
	Navigation support	
	Watercourse crossing	
	Previously unspecified water transport	
(52801) Storage and auxiliary transport services	Port and terminal management	
	Ship chandling activities	
	Previously unspecified water transport auxiliary activities	
(49002) Land passenger transport	Tourism trains, cable cars and similar transport	**Marine Services-SMar**
(55001) Hotel or similar accommodation	Hotels and similar facilities	
	Other previously unspecified types of accommodation	
(56001) Food services	Restaurants and other types of food and beverage services	
	Mobile food services	
(68001) Effective rent and real estate services	Real estate activities carried out by the owners	
(77001) Non-real estate rentals and management of intellectual property assets	Intermediation in real estate selling, buying and renting	
(78802) Other administrative services	Sports and recreation equipment rental	
	Travel agencies	
	Tour operators	
(90801) Arts, culture, sport and recreation services	Reservation services and other previously unspecified tourism-related	
	Management of sports installations	
	Sport and social clubs (and similar ones)	
(84001) Public administration services	Defense	**Marine Defense-DMar**

[a] National Classification of Economics Activities (NACE).
[b] Gem salt is used to produce chlorine and caustic soda (Brasken, 2020).
[c] National Classification of Economics Activities (NACE).

intentions.

Regarding the rows and columns named as activities Adjacent to the Sea, it should be highlighted that this scope is a part of the IOMSea. Even thoug they do not depend on the sea, due to their location - in 280 cities located in seafront - they may be affected by the sea and/or sea-based policies. Hence, the sectors named Primary Activities Adjacent to the Sea (PAS), Secondary Activities Adjacent to the Sea (SAS) and Tertiary Activities Adjacent to the Sea (TAS) comprise 633 activities.

The PAS sector encompasses economic activities that belong to the primary sector, that is, productive activities related to agriculture,

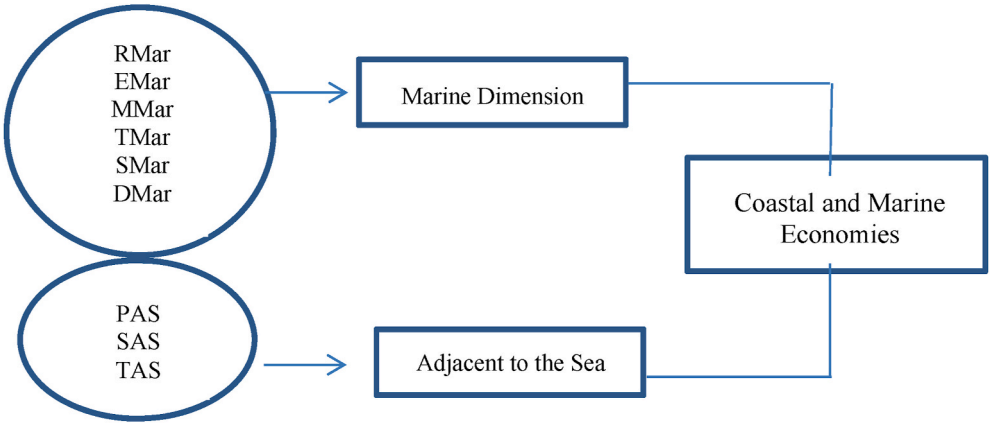

Fig. 1. Components of Brazilian coastal and marine economies.

		Purchases		Final Demand				Total Output
		Intermediate Consumption						
		Original sector	Sea sector	C	I	G	E	
Sales	Original sector	Z_{11}	Z_{12}	C_1	I_1	G_1	E_1	x_1
	Sea sector	Z_{21}	Z_{22}	C_2	I_2	G_2	E_2	x_2
Gross Value Added	Labour	l_1	l_2					L
	Capital	n_1	n_2					N
Imports		m_1	m_2					M
x'		x_1	x_2	C	I	G	E	X

Fig. 2. Summary of IOMSea ((Miller and Blair, 2009) (Carvalho, 2018)).
Where: Z = intermediate consumption, C = household consumption, I = gross fixed capital formation, G = government consumption, E = exports, L = labour, N = capital, X = total output of sectors.

Table 5
GDP and Occupation of the Brazilian coastal and marine economies and coastal and marine sectors.

	GDP (US$million)	% National GDP	Occupation (mil)	% National Occupation
Marine Dimension				
Marine Services	15,439.18	1.0	1,320,004	1.3
Marine Manufacture	9749.96	0.6	314,593	0.3
Marine Defense	5720.11	0.4	179,814	0.1
Marine Energy	4298.58	0.3	48,275	0.05
Living Marine Resources	2756.87	0.2	130,408	0.1
Marine Transport	2353.50	0.2	91,066	0.09
Marine Dimension sub-total	**40,318.20**	**2.6**	**2,084,160**	**2.1**
Adjacent to the Sea				
Tertiary Adjacent to the Sea	195,268.16	13.0	15,828,093	16
Secondary Adjacent to the Sea	44,411.76	3.0	1,175,127	1.1
Primary Adjacent to the Sea	6116.54	0.4	742,059	0.7
Adjacent to the Sea sub-total	**245,796.46**	**16.4**	**17,745,279**	**18.0**
Total	**286,114.66**	**19.0**	**19,829,439**	**20.0**

animal husbandry and extractivism developed in coastal cities. The SAS sector comprises the secondary sector i. e., industry and production of consumer goods. In this case, the output of these industries is not directly related to the sea, even though their production units are located in coastal cities. The TAS sector includes activities connected to maintenance, energy generation, civil construction, commerce, other transport categories, finances, education and some other fields that take place in Brazilian coastal cities. It is important highlight that the activities Adjacent to the Sea (PAS, SAS and TAS) are not included in the marine dimension by intermediate consumptions. The Adjacent to the Sea scope is another component by coastal and marine economies given by geographic aspect

Fig. 1 schematically shows the scopes that form the Brazilian coastal and marine economies.

The procedure used for constructing new rows and columns was to disaggregate sectors corresponding to every activity classified as marine in the general IOM. First the number of workers allocated in each activity was captured and organized by their geographical dimension, in each seafront municipality. Consequently, it is clear how much each sector has contributed in new lines related to sea economy. Secondly, the participation of each activity was multiplied by its monetary value (correspondent value for 2015) and added to the result obtained in the first step above mentioned. This procedure would generate a value for each new line.

For example, the Living Resources of Sea is formed after the sum of the four activities connected and declared in Table 4, and this value is subtracted from the original line. The same procedure is applied to consolidated columns in sea sectors to establish a correspondence with the inputs. However, participation obtained is the total number of workers in the previous correspondent column, instead of line.

Thus, the I–O Brazil changes dimensions, from 127 × 67 to 135 × 76, incorporated new sea sectors and named IOMSea, as Fig. 2 summary shows. In the last procedure, the estimation of Leontief coeffcients are available and the multipliers are revealed, in procedure described in the equation system (1) above, clarifying the direct and indirect impacts of output, employment as well as interindustrial links of sea sectors.

4. Results

The methodology to calculate Brazilian coastal and marine economies GDP was organized from the expenditure perspective. In 2015, the estimate value of the Coastal and Marine GDP in Brazil was US$286 billion, which corresponded to 19.0 per cent of the country's annual GDP (US$1.53 trillion). The Coastal and Marine GDP are divided into two scopes: (i) Marine Dimension, related to sea economy (2.6% of the national GDP); (ii) Adjacent to the Sea, related to coastal economy (16.4% of the national GDP). Occupations in the coastal and marine sectors include both formal and informal workers and totaled 19,829,438 million. Table 5 indicates the sectors of coastal and marine economies, respective GDPs, occupations and participations in national economy.

Fig. 3 displays the Brazilian coastal and marine economies participation in national economy in 2015, as well as the three marine sectors with the highest GDP's.

Fig. 4 displays the participation of Brazilian coastal and marine economies workers in the national economy for the year of 2015.

Fig. 3. Coastal and Marine GDP by comparison with national GDP.

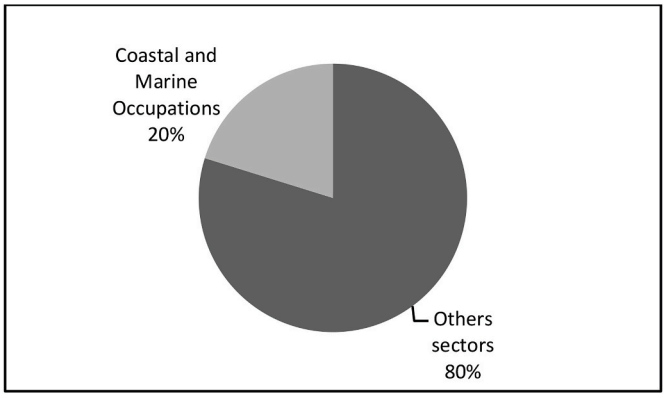

Fig. 4. Occupations in coastal and marine activities by comparison with occupations in Brazil.

4.1. Multipliers[2]

Table 6 presents the production and employment inducing effect of each sector of the Brazilian coastal and marine economies and their respective ranking in the national economy.

Table 6 shows that the sectors Marine Manufacture, Living Marine Resources and Marine Transport are at the top of the three sectors with highest production multipliers in marine dimension.

4.2. Industrial linkages[3]

Table 7 indicates the sectors of coastal and marine economies, their respective linkages and national rankings.

According Table 7 the backward linkages for Marine Manufacture, Living Marine Resources and Marine Transport show the highest linkages. However, only Marine Manufacture is higher than 1, depicting that this is a relevant inputs buyer from other Brazilian economic sectors. The forward linkages, in the second column of Table 7, show that the Marine Energy sector is the only one with a value above 1, demonstrating that this sector has a higher supply capacity for the other economic sectors.

5. Discussion

The three marine dimension sectors with the highest GDPs in 2015 were: Marine Services (SMar) - mainly the coastal tourism sector; Marine Manufacture (MMar) - mostly industries, and Marine Defense (DMar). In the scope Activities Adjacent to the Sea, the highest GDP is found in both Tertiary Activities Adjacent to the Sea (TAS) and Secondary Activities Adjacent to the Sea (SAS) sectors. This finding is aligned with a document issued by the Ministry of the Environment (Ministério do Meio Ambiente, 2008) which shows that the main characteristic of Brazilian coastal zones is the industrial concentration developed in metropolitan areas. As a result, the industrial productive structure competes for space that has already been taken over by other activities, such as tourism. It may be observed that the results found in other marine countries are similar to this study ((Zhao et al., 2014); (Direção Geral de Política do Mar 2012)- (Kalaydjian et al., 2010)).

Furthermore, in what follows the occupations, as Table 5 shows, the Marine Services sector had the highest occupations within marine

Table 6
Type II multipliers of production, employment and national rank of Brazilian coastal and marine sectors.

	Multipliers	
	Production & national rank	Employment & national rank
Marine Dimension		
Marine Manufacture	3,28(31)	2,69(46)
Living Marine Resources	3,04(48)	3,03(42)
Marine Transport	3,02(49)	3,28(38)
Marine Defense	2,72(59)	2,69(47)
Marine Energy	2,32(71)	23,25(4)
Marine Services	1,91(75)	1,68(67)
Adjacent to the Sea		
Secondary Adjacent to the Sea	3,59(20)	5,28(30)
Tertiary Adjacent to the Sea	2,64(63)	1,78(64)
Primary Adjacent to the Sea	2,31(72)	1,40(72)

Table 7
Linkages and national rank of Brazilian coastal and marine sectors.

	Index	
	Backward & national rank	Forward & national rank
Marine Dimension		
Marine Manufacture	1.0(32)	0.6(52)
Living Marine Resources	0.9(48)	0.4(71)
Marine Transport	0.9(49)	0.6(48)
Marine Defense	0.8(61)	0.3(76)
Marine Energy	0.7(71)	1.9(6)
Marine Services	0.6(75)	0.7(41)
Adjacent to the Sea		
Secondary Adjacent to the Sea	1.2(20)	4.1(2)
Primary Adjacent to the Sea	0.7(71)	0.7(45)
Tertiary Adjacent to the Sea	0.8(63)	5.3(1)

[2] Only the Marine Dimension scope is analysed since it is formed by direct activities of the sea, as previously mentioned.

[3] Only the Marine Dimension scope is analysed since is formed by direct activities of the sea, as previously mentioned.

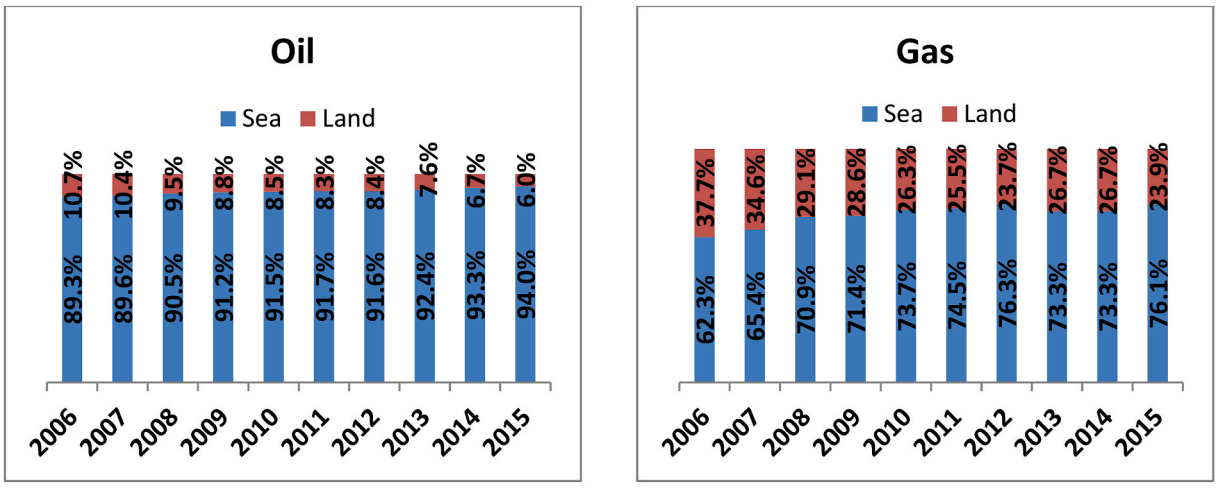

Fig. 5. – Comparison between sea and land daily oil and gas production in Brazil ((Ministério de Minas e Energia, 2016)).

economy in Brazil, followed by Marine Manufacture and Marine Defense. It is important to highlight, as (Zhao et al., 2014) found for the Chinese ocean economy, the relevance of employment in the Living Marine Resources sector, specially due to the socioeconomic role of this activity.

In what follows the occupations, as previously mentioned, tourism predominates in the Marine Services sector. This sector is very developed in Brazil which has the most of its territory with temperatures around 30 °C throughout the year. Almost 20% of national population is located in cities seafront, 13 out 76 Brazilian metropolitan areas are located by the coast. Hence, the tourists find a developed urban infrastructure, especially a powerful tourism and leisure sector, beautiful beaches closed to the Atlantic Ocean.

Colgan (2003) states that it is challenging to compare both Marine Economy and the respective national economy, mainly when the sectors – the objects of comparison – are extremely seasonal. European countries have also registered a high number of workers in coastal tourism. According to Weber and Nevala (2006), this is mainly due to peoples longer leisure periods and willingness to pay for leisure services.

The second largest sector in the Brazilian marine economy is the Marine Manufacture. Shipbuilding and naval repair activities stand out in this sector. In the 2003–2012 period, these activities were strongly encouraged by public policies, having as a main driver the oil industry (specially the pre-salt oil extraction policy), quotas for national products, strong demand from PETROBRAS for drilling platforms and ship building, in addition to construction of shipyards in several Brazilian ports. As of 2012, the national economic crisis combined with the decrease of international oil prices and corruption scandals resulted in the retraction of the Brazilian naval sector.

The Marine Energy sector, which consists in production of energy based on the sea, has a very important role in the national and marine economy participation. In the period from 2006 to 2015, national reserves of oil increased by 6.6% from 12.2 to 13.0 billion barrels, mostly due to increased production form reserves situated on the sea (Ministério de Minas e Energia, 2016). According tothe Ministry of Mines and Energy (Ministério de Minas e Energia, 2016), the reserves on the sea were also the biggest responsible to the increase of gas production growing almost 142.5% in the period. Compared to 2014, daily gas production at sea registered an increase of 13.1% (76.1% of national production). In the Fig. 5 is shown the increase in daily offshore oil and gas production in opposition to the decrease of onshore production.

It should also be emphasized that the sector Marine Energy represents 0.6% of total national exports. Data published by the Brazilian Institute of Petroleum (IBP) (Instituto Brasileiro do Petróleo, 2017) show that oil exports have grown 25% from 2005 to 2015. It is higher than the total imports in the same period that amounted to 19%.

The impacts of $1 change in marine investment demonstrates that the strongest multipliers that the sectors have had were the most "traditional" marine sectors. The sectors that tend to react more strongly are those susceptible to household consumption, i.e marine salt and living resources, which are the ones closely related to food. Comparing the results of the marine sectors with those obtained for the Brazilian economy, the Marine Manufacture, Living Marine Resources and Marine Transport sectors occupy the 31st, 48th and 49th places respectively. It should be noted that the top three sectors with the highest type II multipliers in national economy in 2015, were: Manufacture of computer equipment, electronic and optical products; Manufacture of electrical machinery and equipment; Non-ferrous metal metallurgy and metal casting.

The type II multipliers of employment, according to Table 6, it is displayed that the Marine Energy sector has the highest employment inducing effects - fourth in the overall Brazilian economy rate, showing the pre-salt dynamic effects; followed by the Marine Transport, Living Marine Resources and Marine Manufacture. A sector with most developed supply chain tends to present higher multipliers (Kildow et al., 2016), thus the Brazilian Marine Energy sector are part of an oil and gas chain which frequently received public and private investments which can explain the large job multiplier effect. Comparing the results of the marine sectors with those obtained for the Brazilian economy, the Marine Energy, Marine Transport, Living Marine Resources sectors occupy the 4th, 38th and 42nd places, respectively.

Table 7 shows only the Marine Manufacture sector as a relevant inputs buyer from other Brazilian economic sectors. Considering the results of the marine sectors with those obtained for the Brazilian economy, the Marine Manufacture, Living Marine Resources and Marine Transport sectors occupy the 31st, 48th and 49th places, respectively. The forward linkages shows that the Marine Energy sector is the only one demonstrating a high supply capacity for the other economic sectors.

Brazil has a high dependence on oil, gas and energy industry. However, the IBP (Instituto Brasileiro do Petróleo, 2020) cites that country must take advantage of all of its energy sources, exploring decarbonization and energy transition strategies. These are existing challenges as the world will continue to consume oil and gas, but with greater concern for reducing and offsetting carbon emissions.

Comparing the results of the marine sectors with those obtained for the Brazilian economy, Marine Energy, Marine Services and Marine Transport the sectors occupy the 6th, 41st and 48th places, respectively.

With the exception of the Marine Energy sector, with high sales capacity, the other sectors related to the sea show lower values of linkages.

According to Kwak (Kwak et al., 2005) the insignificant linkages in the sea sectors, denote that they are less stimulated by general industrial growth. According to (Morrissey and O'Donoghue, 2013), low forward linkages - in the Brazilian case Marine Transport, Marine Manufacture, Marine Services, Living Marine Resources and Marine Defense - represent higher sales to final demand.[4]

It is important to highlight the magnitude of the Brazilian coastal and marine economies. The year of 2015 was marked by a deep recession in the country; the GDP had declined 3.5% in relation to the previous year. According to the Brazilian official data the only sector that showed growth was the robust agricultural sector. In fact, the IOMSea showed that the coastal and marine economies was comparable to the Brazilian agricultural sector (accounted for almost 20% of the GDP) with players incorporated downstream and upstream of their production chains.

Then, once again, the relevance of this study is emphasized, expanding the identification of the profile of the sea economy that Brazil already has. It is impossible to manage and access efficient and effectiveness of the policies if the real size and contributions of the natural resource is not yet known. This applies socially, economically as well as environmentally.

6. Conclusion

The information and the knowledge about Coastal and Marine Economies regarding the contribution for national GDP qualifies the development of specific public and private policies for coastal states and cities as well as activities connected with the ocean.

Therefore Brazilian Coastal and Marine Economies were defined in two parts for a better analysis: a sea economy named marine dimension, including only the direct activities related to the sea and, coastal economy named adjacent Activities to the Sea, including indirect activities related to the sea. Methodological option of the input-output model for quantifying the Brazilian Coastal and Marine Economies is justified among previous studies applied for other countries and economies as it allows to explore interconnections through economic activities and high importance of marine economy.

The Brazilian Coastal and Marine Economies Input-Output Matrix, denominated IOMSea was estimated for the year 2015. Procedures that splits the concept into two parts allows individual analysis from each marine sector and/or activity. A marine dimension is the most important part (including the sea economy - direct activities related to the sea), once its estimated GDP is US$ 40,3 billion in 2015 - which corresponded to 2.6% of the national GDP. The second part of the concept is Adjacent Activities to the Sea (including the coastal economy - indirect activities related to the sea) the evaluate GDP was US$ 245,7 billion in 2015 - which contributed 16.4% of the GDP.

Hence, while estimating the value of coastal and marine sector, two mainly sectors were highlighted. Marine Services stands out in terms of GDP and sea-related occupations - analysis of economic markers in the scope Activities Adjacent to the Sea showed that the most relevant sector was Tertiary Activities Adjacent to Sea (TAS) - activities developed in seafront cities. Coastal and Marine Economies generated US$ 286 billion to the country's GDP and employed around 19 million, summing up to almost US$ 128 billion in salaries. Final demand of coastal and marine sectors totaled US$ 335.4 billion. Thus, Brazilian Coastal and Marine Economies is dominated by the category of services, mainly tourism. This result stands in accordance with the ones found in previous marine economies for other economic zones, for example France, China, Portugal, and Australia. Interestingly, the magnitude of Brazilian Coastal and Marine Economies, 19.0% of national GDP, is corresponding to the absolute GDP of South Africa or Colombia in 2015.

In this sense, is important to highlight even with this great coastal and marine economies the country has a regulatory gap. Brazil does not have a spatial maritime planning, strategic plan or specific public policy that leads or boosts marine economy, beyond the potentials that this economy shares with the environmental sustainability. There are several sectoral policies disconnected from each other, which does not consider the socioeconomic and environmental disparities of the national coast and disregard the multiple uses that actors and related structures can use. Therefore, the possible strategies adopted by the country will affect marine and whole economy growth. When not aligned, they cause conflicts pressuring on natural resources, i.e. an increase in pollution at sea or marine ecosystems can create economic distortions that impact the generation of employment and income, especially those in coastal communities, but not limited to them. In a country with an enormous coast and large population, these issues are extremely critical. We hope that these evaluations and methodology create discussions and stimulate research related with a better understanding of the harnesses of sea resources in Brazil.

[4] Household consumption; gross fixed capital formation; government consumption; exports.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2021.105885.

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