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BCG ECONOMIC VALUATION: METHODOLOGY AND SOURCES

REVIVING THE OCEAN ECONOMY

The case for action - 2015

BCG

THE BOSTON CONSULTING GROUP

Front cover

A fisherman shows some of his catch in Mafamede, Mozambique, part of the Primeiras and Segundas Environmental Protection Area.

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The *Reviving the Ocean Economy: the case for action - 2015* report has been developed in association with:

The **Global Change Institute** (www.gci.uq.edu.au) is an Australian-based research institute that is focused on evidence-based solutions to global challenges such as food security, clean energy, sustainable water, and healthy oceans. Professor Hoegh-Guldberg also undertakes research on coral reef ecosystems and their response to rapid environmental change, which is supported primarily by the Australian Research Council (Canberra), National Oceanic and Atmospheric Administration (Washington, D.C.), Catlin Group (London), and Great Barrier Reef Foundation (Brisbane). He did not receive salary for writing this report.

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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International)

Methodology and sources document

The Boston Consulting Group ocean annual and asset-valuation methodology & sources

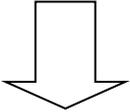
The assumptions, analysis and data sources that inform the ocean's annual contribution and asset-valuation are outlined below. Our intent was to triangulate and refine existing primary research in order to determine the valuations cited in the report, "Reviving the Ocean Economy: The case for Action – 2015", issued by WWF International. (The full report can be found at ocean.panda.org). This methodology refers to the discussions on economic value in part 1 of the report and to figures 1 to 3 in Box 2 (page 14 and 15).

The analyses are partly based on information that has not been generated by BCG and has not, therefore, been entirely subject to our independent verification. The information, opinions and analyses contained herein are based on sources believed to be reliable and comprehensive but no representation, expressed or implied, is made as to the accuracy, completeness or correctness of the actual methodology used to gather the primary data.

Furthermore, the analyses and conclusions contained in this document are based on various assumptions that BCG has developed regarding economic growth, and the current and future state of the ocean (based upon factors and events subject to uncertainty). Of course, future results or net present values derived from forecasted future results could be thus be materially different.

Total asset categories valued at 24 Tn USD

Seven primary 'value generating' asset categories

	Asset	(Tn USD)
<i>Direct Output of the Ocean</i>	<i>Marine Fisheries</i>	2.9
	<i>Mangroves</i>	1
	<i>Coral Reefs</i>	.9
	<i>Seagrass</i>	2.1
<i>Trade and Transport</i>	<i>Shipping Lanes</i>	5.2
<i>Adjacent Assets</i>	<i>Productive coastline</i>	7.8
	<i>Carbon Absorption</i>	4.3
		
	Shared Wealth Fund (SWF) asset base	~24

Four of the seven assets are notably direct output from the ocean, while all assets except "shipping lanes" are synergistically linked to the health and wellbeing of the ocean environment to generate value.

Total asset value of 24Tn USD is an aggregate of all the asset categories. Methodology for arriving at these sums can be found in the corresponding appendices.

These categories are not a collectively exhaustive list but aim to tackle main buckets where primary analysis exists (e.g. insufficient data on oyster reefs).

Methodology: In order to value each asset class two different methods were utilized:

1. **Market Based:** Derived asset value looking at quantity of a resource priced at its current market value
2. **Value Based:** Implied asset value ascertained by identifying annual value generation of the asset, and conducting a Net Present Value (NPV) of future years

For several of the asset categories, a hybrid or modified version of the two above methods was employed to better estimate and triangulate total asset value.

- **Net Present Value Calculations**

For all calculations utilizing the NPV method, certain assumptions were established to ensure consistency and accuracy.

In order to appropriately calculate the net present value of our asset classes, we needed to determine an appropriate global risk-free rate and global risk premium to utilize. We leveraged a report from 2013, which calculated "Market Risk Premium and Risk Free Rate Used for 51 countries in 2013" (survey n= 6,237). The researchers surveyed "finance and economics professors, analysts and managers of companies obtained from previous correspondence, papers and webs of companies and universities" and asked them to share the "Free Rate and the Market Risk Premium (MRP) used 'to calculate the required return to equity in different countries'". Based on these results, we calculated the arithmetic mean across these 51 countries, to determine **the global risk free rate (4.1%) and global risk premium (7.1%) for our NPV calculations**. To provide further context, the corresponding numbers from the survey are 5.7% and 2.2% for the US, and 7.7% and 3.8% for China, respectively.

Source: Market Risk Premium and Risk Free Rate used for 51 countries in 2013: a survey with 6,237 answers Pablo Fernandez, Javier Aguirreamalloa, and Pablo Linares (IESE Business School, 2013) <http://www.scribd.com/doc/185124918/02-2-Market-Risk-Premium-and-Risk-Free-Rate-Survey#scribd>

Additionally, for when dealing with figures from different years, we always tried to maintain as close to present day as possible. When previous year numbers needed to be utilized in the absence of more current data, we ensure all figures were consistent (2012 quantities and 2012 prices). All NPV calculations were brought back to current date.

For each asset category, complete methodology and sources are provided:

- **Marine Fisheries**

Type of Valuation: Market Based

Calculation: Total productive fish bio-mass (in tons) multiplied by an implied market price for 1 ton of fish

Considerations: This valuation does not take into account supply and demand elasticities, recognizing that the larger the supply becomes the lower prices are likely to become. Additionally, this figure does not distinguish between readily catchable and common fish varieties, and those fish categories that may not in high market demand, or that are too difficult to feasibly catch (deep sea varieties)

Primary Sources:

- **Total Fish:**
Wilson RW, Millero FJ, Taylor JR, Walsh PJ, Christensen V, Jennings S and Grosell M (2009) "Contribution of Fish to the Marine Inorganic Carbon Cycle" Science, 323 (5912) 359-362.
- **Market Value of fish:**
FAO – 2012 World Review of Fisheries and Aquaculture:
<http://www.fao.org/docrep/016/i2727e/i2727e01.pdf>

- **Mangroves**

Type of Valuation: Value Based (using some market assumptions – i.e. quantity of resource)

Calculation: Net present value of all future mangrove values based on the following assumptions:

- A. Total Mangroves: 152,000M²
- B. Degradation of Mangroves at -2.1% yearly
- C. Value derived from Mangroves = 4,000 USD per Hectare (applied for each year, not adjusted for forecasted inflation as we want NPV in current dollars)
- D. Discount rate: Average global risk free rate

- E. No risk premium – decision made not to apply risk premium to natural assets (only on assets directly connected to industrial / market output)

Primary Sources:

- **Total Mangroves:** UNEP. The Importance of Mangroves to People: A Call to Action. 2014
- **Value Generation:** Brander, L.M., Wagtendonk, A., Hussain, S., McVittie, A., Verburg, P., de Groot, R., and van der Ploeg, S. (2012). Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services*, 1: 62-69.

NOTE: Identifying the correct value estimation for 1 hectare of Mangrove forest proved challenging as many widely varying values are reported. We selected Brander et al as the most accurate source for this calculation as it looks at direct benefit transfer across "fisheries, fuel wood, materials, coastal protection, and other value transfer elements". Additionally, the value is from 2012 – closest value we could identify.

The value often cited from the UNEP is based on the "Importance of Mangroves to People: A Call to Action", however this value is actually from " Sathirathai, S. & Barbier, E. Valuing mangrove Conservation in southern Thailand. *Contemp. Econ. Policy* 19, 109–122 (2001)."

Secondary Sources:

- Destruction of Carbon-Rich Mangroves Costs up to US\$42 billion in Economic Damages Annually - UNEP Report
<http://www.unep.org/newscentre/default.aspx?DocumentID=2796&ArticleID=11005#sthash.GG4s8CUf.dpuf>
- Murray, Pendleton, Jungwiwattanporn, Vegh. "Mangrove Ecosystem services Valuation: State of literature". Nicholas Institute for Environmental Policy Solutions, Duke University
https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_14-06.pdf

- **Coral Reefs**

Type of Valuation: Value Based (using some market assumptions – i.e. quantity of resource)

Calculation: Net present value of all future coral reef values based on the following assumptions:

- A. Total Coral: 250,000km²
- B. Degradation of coral at -2% yearly
- C. Value derived from coral = 2,800USD per hectare (applied for each year, not adjust for forecasted inflation as we want NPV in current dollars)
- D. Discount rate: Average global risk free rate
- E. No risk premium – decision made not to apply risk premium to natural assets (only on assets directly connected to industrial / market output)

Primary Sources:

- **Total Coral:**
International Coral Reef Initiative. Reefs at Risk Revisited – Regional Key Points
<http://www.icriforum.org/news/2011/02/reefs-risk-revisited-regional-key-points>
World Resources Institute. Reefs at Risk Revisited. WRI Fact Sheet. February 2011
http://www.icriforum.org/sites/default/files/factsheet_reefs_main.pdf
- **Value Generation:**
Cesar, Herman; Burke, Laretta; Pet-Soede, Lida. "The Economics of Worldwide Coral Reef Degradation"
Published by: Cesar Environmental Economics Consulting (CEEC)
WWF – Netherlands

NOTE: In their article, Cesar et al apply a NPV analysis over 50 years and a 3% discount and arrived at an Asset Value of 797.4 bn USD. This supports our conclusion, but also allows us to also build upon the value.

Secondary Sources:

- <http://coralreef.noaa.gov/aboutcorals/values/>
- UNEP – Coral Reef Unit. "Coral Reef – Valuable but Vulnerable"
http://coral.unep.ch/Coral_Reefs.html
- World Wildlife Fund. Fast facts: why coral reefs are important to people – financially and biologically..
http://wwf.panda.org/about_our_earth/blue_planet/coasts/coral_reefs/coral_facts/

- **Seagrass**

Type of Valuation: Value based (using some market assumptions – i.e. quantity of resource)

Calculation: Net present value of all future seagrass values based on the following assumptions:

- A. Total seagrass: 500,000km²
- B. Degradation of Sea Grass: -1.5% yearly
- C. Value derived from Sea Grass = 172 Euro per M² – (converted to US Dollars at 1.33 USD/ EURO – 2013 average)
Value applied for each year, not adjust for forecasted inflation as we want NPV in current dollars
- D. Discount rate: Average global risk free rate
- E. No risk premium – decision made not to apply risk premium to natural assets (only on assets directly connected to industrial / market output)

Primary Sources:

- **Total Seagrass:**
Ocean Health Index. Seagrass.
<http://www.oceanhealthindex.org/Components/Seagrass/>
Smithsonian Institute. Ocean Portal. "Sea Grass and Sea Grass Beds"
<http://ocean.si.edu/seagrass-and-seagrass-beds>
- **Value Generation:**
Vassallo, P., et al. The value of the seagrass Posidonia oceanica: A natural capital assessment. Mar. Pollut. Bull. (2013), <http://dx.doi.org/10.1016/j.marpolbul.2013.07.044>
http://www.academia.edu/4310379/The_value_of_the_seagrass_Posidonia_oceanica_A_natural_capital_assessment

Secondary Sources:

- Unsworth RK, et al., Economic and subsistence values of the standing stocks of seagrass fisheries: <http://opwall.com/wp-content/uploads/unsworth-et-al-2010-SG-Economics.pdf>

- **Shipping Lanes**

Type of Valuation: Value Based

Calculation: Net present value of all future Shipping and Transport values based on the following assumptions:

- A. Total Shipping and transport value produced annually: 463,392,490,000 USD (taken from yearly calculation)
- B. Perpetual growth rate: 2%
- C. Discount rate: Average global risk free rate + average global risk premium
- D. Risk premium – decision made to apply risk premium to all assets deriving value from industrial / market based sources.

Primary Sources:

- UNCTAD "2014 Review of Maritime Transport"
http://shipbrokers.co/pdf/UNMartimeReport2014_en.pdf
- World Shipping Council – Trade Statistics
<http://www.worldshipping.org/about-the-industry/global-trade/trade-statistics>
- UNCTAD Review of Maritime Transport 2011
<http://www.statista.com/statistics/264117/tonnage-of-worldwide-maritime-trade-since-1990/>
- World Shipping Council – Benefits of Linear Shipping
<http://www.worldshipping.org/benefits-of-liner-shipping/global-economic-engine>
- World Ocean Review – Transport. "Global Shipping – A Dynamic Market"
<http://worldoceanreview.com/en/wor-1/transport/global-shipping/3/>
- World Bank. Ports and Waterborn Transport. Misc articles;
http://www.worldbank.org/en/topic/transport/x/portsandwaterborntransport?qterm=cost+of+transport&lang_exact=English&admreg_exact=The+World+Region&tf=y&os=20

- **Productive / Destination Coastlines**

Type of Valuation: Value Based

Calculation: Net present value of all future coastal production (tourism based) values based on the following assumptions:

- A. Total value produced annually: 819,841,590,000 USD (taken from yearly calculation)
- B. Perpetual growth rate: 1% (note: BCG has done analysis to conclude that only 27% of potential coastlines are utilized by human development. It is likely this will continue to rise in the coming decades, however this also may diminish value of this and other connected assets- thus a conservative perpetual growth of 1% was used)
- C. Discount rate: Average global risk free rate + average global risk premium
- D. Risk premium – decision made to apply risk premium to all assets deriving value from industrial / market based sources.

Primary Sources:

- Coastal Value annual assessment – see below sections for methodology.

Secondary Sources:

- World Wildlife Fund. Marine Problems: Tourism and Coastal development.
http://www.panda.org/about_our_earth/blue_planet/problems/tourism/
- <http://www.prb.org/Publications/Reports/2003/RippleEffectsPopulationandCoastalRegions.aspx>
- <http://worldoceanreview.com/en/wor-1/coasts/living-in-coastal-areas/>
- <http://www.oceansatlas.org/servlet/CDSServlet?status=ND0xODc3JjY9ZW4mMzM9KiYzNz1rb3M->
- <http://www.rockefeller.edu/labheads/cohenje/PDFs/256Cohensmall.htm>
- UNWTO. Tourism Highlights. 2014 Edition.
http://91.74.184.33/videoplayer/unwto_highlights14_en.pdf?ich_u_r_i=35330464a703d6dc8e794e2bebd1d6d1&ich_s_t_a_r_t=0&ich_e_n_d=0&ich_k_e_y=1545028922751963122400&ich_t_y_p_e=1&ich_d_i_s_k_i_d=4&ich_u_n_i_t=1
- World Wildlife Fund – Blue Plan: Coasts
http://www.panda.org/about_our_earth/blue_planet/coasts/
- Sustainable Development of Tourism – UN World Tourism Organization. Coast Project.
<http://sdt.unwto.org/en/content/coast-project>
- World Ocean Review. Coasts.
<http://worldoceanreview.com/en/wor-1/coasts/living-in-coastal-areas/2/>
- Intergovernmental panel on Climate Change. "Increasing human utilization of the coastal zone"
http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch6s6-2-2.html
- NOAA – State of the Coast
<http://stateofthecoast.noaa.gov/population/welcome.html>
- UN Atlas of the Oceans
- <http://www.oceansatlas.org/servlet/CDSServlet?status=ND0xODc3JjY9ZW4mMzM9KiYzNz1rb3M->
- Estimates of Coastal Populations
<http://www.rockefeller.edu/labheads/cohenje/PDFs/256Cohensmall.htm>

- **Carbon Storage / Sequestration**

Type of Valuation: Value and market based

Primary Calculation: Net present value of future expected ocean carbon sequestration multiplied by market price of carbon.

- A. Ocean ability to sequester carbon: 30%
- B. Carbon emissions per year: 37,723 mn tons for 2012 (growing @ 2% per year)
- C. Social cost of carbon: 39 USD
- D. Discount rate: average global risk free rate + Average global risk premium
- E. Risk premium – decision made to apply risk premium to all assets deriving value from industrial / market based sources.

Primary Sources:

- **Ocean sequestering % :**
Ocean Health Index – Ocean Acidification
http://www.oceanhealthindex.org/Components/Ocean_Acidification/
Sabine, et al – The Oceanic Sink for Anthropogenic CO2
<http://www.pmel.noaa.gov/pubs/outstand/sabi2683/sabi2683.shtml>
- **Carbon Emissions:**
Energy Information Administration – International Energy Statistics
<http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=ww,&syid=1980&eyid=2012&unit=MMTCD>
Carbon Dioxide Information Analysis Center
<http://cdiac.ornl.gov/GCP/carbonbudget/2013/>
- **Cost of Carbon / Price of Carbon:**
Interagency Working Group on Social Cost of Carbon, United States Government - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis
<http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf>

Secondary Sources:

- NOAA – Habitat Conservation . Coastal Blue Carbon
<http://www.habitat.noaa.gov/coastalbluecarbon.html>

ANNUAL VALUE GENERATED FROM 'OCEAN ECONOMY' WOULD PLACE THE OCEAN AS 7TH LARGEST GLOBAL ECONOMY (~2.5 Tn USD)

The analysis in Box 2 of the report demonstrates the annual economic value of ocean-related activities globally. If the ocean economy were its own economy, it would be the 7th largest economy in the world.

We determined the annual economic value range using both a top-down and bottom-up analysis. Our top-down analysis (~\$2.6Tn) was conducted by surveying available public information for the G20 nations regarding the annual economic value of the ocean to local economies. By extrapolating the cumulative impact of the ocean of those respective countries, the global estimate of the ocean economy was able to be ascertained. Our bottom-up analysis (~\$2.4Tn) was conducted by categorizing and evaluating the global annual market for ocean-related goods and services.

Methodology: We conducted research on the 20 largest global economies to determine what portion of each nation's GDP was attributed to "ocean related activities" (or the "blue economy" as it is referred to in some circles). Information on the blue economy was available for the United States, the European Union, China, Canada, Australia, and South Africa, which accounts for ~64% of global GDP.

- For countries which reported ocean impact in terms of their respective currency, all currencies were exchanged to USD at the 2014 year-over-year average exchange rate to derive a USD amount.
- The blue economy dollar-values were then contextualized as a percentage of the country's overall GDP using World Bank global GDP numbers for 2014.
- For countries which reported ocean economy impact in terms of respective country proportion of GDP %, a reverse analysis was conducted, taking the % impact for each country and finding the product between its' GDP and the % of ocean economy. For example, previous analysis conducted for China shows 4.03% of national GDP attributed to the ocean economy. This value was then utilized to find the total USD value of the ocean economy.
- Based on this analysis, we were able to ascertain the average percent of GDP attributable to the blue economy, for the abovementioned 9 countries, including all member states of the European Union.
- This percentage (~3.7%) was then extrapolated to the global GDP number (~\$77 trillion), while taking into account the % of landlocked countries (~11%) in order to determine the top-down value of the global ocean economy (~\$2.6 trillion). Granted

this approach lends itself to some uncertainty, however for the purposes of this exercise and to arrive at a theoretical estimate, this uncertainty is acceptable.

Primary sources:

- Global GDP & growth numbers taken from:
 - The World Bank. "1980-2014 GDP (current US\$)." <http://data.worldbank.org/indicator/NY.GDP.MKTP.CD>
 - Forbes. "Lower inflation: Another Chance For Government Mistakes." <http://www.forbes.com/sites/currentevents/2015/01/21/lower-inflation-another-chance-for-government-mistakes/>
 - The World Bank. "2013 GDP ranking" <http://data.worldbank.org/data-catalog/GDP-ranking-table>
 - International Monetary Fund. "World Economic Outlook (WEO) Update." <http://www.imf.org/external/pubs/ft/weo/2014/update/01/>
- Currency exchange rates taken from:
 - US Foreign Exchange Services. "Yearly average rates." <http://www.usforex.com/forex-tools/historical-rate-tools/yearly-average-rates>
- United States data taken from:
 - National Ocean Economics Program (NOEP). "State of the U.S. Ocean and Coastal Economies 2014." http://www.floridaoceanalliance.org/documents/NOEP_2014/NOEP_National_Report_2014.pdf
- European Union data taken from:
 - European Commission Maritime Affairs. "Blue Growth." http://ec.europa.eu/maritimeaffairs/policy/blue_growth/
- Australia data taken from:
 - Australian Institute of Marine Science. "The AIMS Index of Marine Industry." <http://www.aims.gov.au/documents/30301/23122/The+AIMS+Index+of+Marine+Industry+2012.pdf/d0fc7dc9-ae98-4e79-a0b2-271af9b5454f>
- Canada data taken from:
 - Fisheries and Oceans Canada. "Economic Impact of Marine Related Activities in Canada." <http://www.dfo-mpo.gc.ca/ea-ae/cat1/no1-1/no1-1-summary-eng.htm>
 - China data taken from:
 - Center for the Blue Economy. "Blue Growth in the Middle Kingdom: An analysis of China's Ocean Economy." http://cbe.miis.edu/cbe_working_papers/3/
- South Africa data taken from:
 - Municipal Focus. "Ocean economy, major boost for coastal cities." <http://municipalfocus.co.za/ocean-economy-major-boost-coastal-cities/>

Ocean related activities group into 5 primary categories with ~70% of annual value at risk or dependent on healthy oceans

5 categories of annual ocean activities

Category	Total value (Bn USD)	Affected by ocean health
Direct output of the ocean <ul style="list-style-type: none"> Activities related to the contents of the ocean 	\$400-420	Yes
Services enabled by the ocean <ul style="list-style-type: none"> Activities occurring in/on the ocean 	\$365-400	Yes
Trade & Transportation within the ocean <ul style="list-style-type: none"> All activities related to shipping and transportation of goods 	\$700-750	No
Adjacent benefits of the ocean <ul style="list-style-type: none"> Quantifiable benefits enabled by the ocean 	\$890-1,000	Yes
Other intangible benefits of the ocean <ul style="list-style-type: none"> All undefinable activities attributed to the presence of the Ocean 		Yes

Total value: ~2.5 Tn USD¹

This demonstrates a classification of all goods and services that rely on the ocean. As one moves down the table, the direct correlation to the ocean becomes less direct, moving from direct output, to services enabled by the ocean, trade & transportation within the ocean, adjacent benefits of the ocean, and other intangible benefits of the ocean. All activities related to oil & gas have been excluded to not inflate the true value of the ocean, as they would still be accessible with or without the ocean.

Categories include the following services: A) fishing related activities, marine renewable energy B) education & training, research, ocean survey, marine tourism, security & control C) shipping & transport, ports, marine services, marine IT, other marine equipment, all activities related to ship/boat building D) direct impact of coastal tourism, carbon sequestration, and marine biotechnology E) security, spiritual & cultural benefits, climate change benefits, & overall utility

1. \$2.4 trillion estimate based on conservative bottoms up analysis, and \$2.6 trillion estimate based on top-down analysis
 Note: Shipping calculated as annual total shipping & transport industry by the marginal value contribution of shipping over other transportation mediums
 Source: BCG Analysis, Marine Industries Global Market Analysis by Douglas Westwood, Global Industry Analysis, World Bank, additional sources cited in appendices

Methodology: We conducted a complementary "bottom-up" analysis to estimate the annual economic value generated by Marine related industries. Marine industries were broken down into 5 primary categories, each with respective services allocated within. The below list is not exhaustive and only takes into account the primary activities related to the ocean. This analysis is decidedly conservative in its approach, and only values what we are capable of assessing and quantifying. Thus, the true yearly economic value of the ocean in tangible and intangible terms may be much higher.

Please see below for the activities that comprise each category:

- Direct output of the ocean: Fishing/seafood related activities, Marine renewable energy
- Services enabled by the Ocean: Education & training, research & development, ocean surveying, cruise industry, marine tourism, and security & control
- Trade & transportation within the Ocean: Shipping & transport, ship building, naval shipbuilding, yacht & boat building, marine equipment, ports, marine services, submarine telecoms, marine IT, underwater vehicle industry, and underwater technology
- Adjacent benefits of the Ocean: Coastal tourism, carbon sequestration, and marine biotechnology

Once all primary industries were identified, and placed into the categorization framework, we calculated the annual value generated for each sub-category. Publicly available data for the global aggregate value for each of the industries is not fully available for some activities, with some data estimated from the past. Multiple publicly available sources were leveraged and triangulated to arrive at a fair and estimated amount for each respective industry. For certain industries where past information was available, but not most recent data, historical CAGR (compound annual growth rate) was calculated and used to estimate current market value. Additionally, all oil & gas production revenue and expenditures are not included in this overall analysis. The contribution of yearly off-shore production, in conjunction with potential off-shore reserves and annual oil & gas expenditures such as oil rigs, LNG containers, etc, would inflate the true value of an industry that would remain operational with or without the ocean.

Please see below for the methodology leveraged to arrive at market estimate (for source information please see primary source citation):

- **Direct output of the Ocean:**
 - **Marine fisheries** - Total value of wild-caught seafood industry in 2010 and grown at a historic CAGR of 2% based on average growth of seafood related industries (e.g. fishing, seaweed, seafood processing, etc).

- **Marine renewable energy** – 2014 expenditures on marine renewable energy (e.g. tidal and wave), excluding off-shore wind expenditures due to their dependence on wind, and their lack of dependence on the ocean to remain operational.
- **Services enabled by the ocean:**
 - **Education & training** – Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 3%. Data found in Euros and converted to USD at 2014 exchange rate.
 - **Research & development**- Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 2%. Data found in Euros and converted to USD at 2014 exchange rate.
 - **Ocean survey** – Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 3%. Data found in Euros and converted to USD at 2014 exchange rate.
 - **Cruise industry** – Total worldwide cruise industry size for 2014 reached by analyzing 2015 worldwide cruise industry and the 2014 to 2015 yearly growth rate to calculate 2014 market size.
 - **Marine tourism** – Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 3%. Data found in Euros and converted to USD at 2014 exchange rate.
 - ◆ Note: Excludes accommodation and coastal tourism
 - **Security & control** – Total expenditures on Maritime related security for 2014.
- **Trade and transportation within the ocean:**
 - **Shipping & transport** – Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 3%. Data found in Euros and converted to USD at 2014 exchange rate.
 - **The marginal value generation of ocean shipping** – If we assume that in the absence of oceans, goods would still be transported (likely by rail or truck), it is important to assess how much marginal or additional value is generated due to the fact we can use more efficient ocean shipping as an alternative.
 - ◆ **Analysis:** Looking at the cost basis of ocean shipping vs. rail (the next best alternative) we find that shipping is ¼ the cost per ton / mile of shipping (Source: BCG project experience, Bureau of Transportation Statistics). Thus it can be deduced that for every \$100 of cost generated by shipping, \$200 would be generated by rail. If we accept this logic, the value we have derived

for Annual shipping should be difference between the shipping cost and the potential cost generated by rail. However, assuming that if rail was the primary mode of transportation globally, certain economies of scale would develop and mitigate the 4X differential. If we assume that the figure is closer to 2X, for every \$100 of cost generated by shipping, \$200 would be needed for rail. Thus the marginal value "created" by ocean shipping is the delta, or \$100.

- ◆ **Implication** –For our analysis, it is important to note this concept and its potential to better refine shipping numbers. In this case, given the assumed ratio of 1:2 for the cost differential, no further adjustment is needed.
- **All other trade and transportation sectors** – Includes shipbuilding, naval shipbuilding, yacht & boat building, marine equipment, ports, marine services, submarine telecoms, marine IT, underwater vehicle industry, and under water technology. All trade and transportation sectors derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate. Data found in Euros and converted to USD at 2014 exchange rate.
 - ◆ Note: All oil & gas related expenditures, including off-shore drilling, resources, LNG containers, etc are not included in this analysis of trade and transportation
- **Adjacent benefits of the ocean:**
 - **Coastal tourism:** Due to limited data available to estimate overall value of coastal tourism to the global economy, thus various methodologies have been leveraged. However, direct economic benefits related to coastal tourism is available for the United States and European Union. The aggregate total of these direct coastal tourism benefits were taken and the ratio of tourism attributed to coastal tourism as a % of GDP for both entities was calculated. This estimate was scaled up to global GDP, estimated by the World Bank. Additionally, this estimate was taken into account with the % of landlocked countries, to derive the total estimate due to coastal tourism.
 - ◆ To validate this approach, an additional analysis was conducted consisting of taking total international tourism receipts and the % of tourism attributed to coasts to arrive at global estimate for coastal tourism. For source information please see primary source citation.
 - Additionally, in order to remain conservative in our estimate, the analysis has removed marine tourism activities from the overall value of coastal tourism due to high likelihood that marine tourism has already been taken into account.

- **Carbon sequestration:** Limited data available to truly estimate yearly benefit of ocean in regards to carbon absorption and sequestration. Additionally, ability to disentangle absorption solely by ocean or other entities has proven a difficult analysis to be conducted. Yearly range estimate of annual benefits of carbon sequestration provided. Average of minimum and maximum taken to arrive at annual value for carbon sequestration for 2014.
- **Marine biotechnology:** Annual expenditures derived from "Marine industries global market analysis report and grown at historic 5 year CAGR rate of 4%. Data found in Euros and converted to USD at 2014 exchange rate. For source information please see primary source citation
 - ◆ Additional methodology consisted of outlining total marine biotechnology market annually at \$4 Bn in 2015.
- Note: Indefinable activities attribute to the ocean include (but not limited to) security, spiritual & cultural benefits, climate change benefits, & overall utility. These are highly valuable activities in their own right, but we were unable to ascribe a dollar-value to these in the time taken to conduct the analysis.

Primary sources: Please see below for all sources leveraged for the above analysis:

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 - The Fish Site. "World Seafood Market to Exceed US \$388.9 Billion by 2010." <http://www.thefishsite.com/fishnews/6407/world-seafood-market-to-exceed-us3889-billion-by-2010/>
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 - **Marine renewable energy:**
 - The Marine Institute. "Marine industries global market analysis." <http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>
 - Borderless. "Wave & tidal energy spend to hit US\$1.2bn by 2015." <http://borderless.net/content/wave-and-tidal-energy-spend-hit-us12bn-2015>
 - WTSH, KIEL & Douglas Westwood. "World Marine Markets." http://www.schleswig-holstein.de/MJKE/DE/EuropaOstseepolitik/Meerespolitik/Download/studieWorldMarine_blob=publicationFile.pdf
 - **Education & training:**
 - The Marine Institute. "Marine industries global market analysis." <http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>
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 - **Research & development:**
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 - **Ocean survey:**
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 - The Marine Institute. "Marine industries global market analysis." <http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>
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- **Security & control:**
 - The Maritime Executive. "Growth forecasted for Maritime Security Market." <http://www.maritime-executive.com/article/Growth-Forecasted-for-Maritime-Security-Market-2014-10-14>
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 - **All other trade and transportation sub-segments including shipbuilding, naval shipbuilding, yacht & boat building, marine equipment, ports, marine services, submarine telecoms, marine IT, underwater vehicle industry, and underwater technology**
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 - **Coastal tourism:**
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- http://www.cruising.org/sites/default/files/pressroom/Global_Cruise_Impact_Analysis_2013.pdf
- <http://www.terabitconsulting.com/downloads/2013-submarine-cable-market-industry-report.pdf>
- http://sedac.ciesin.columbia.edu/es/papers/Coastal_Zone_Pop_Method.pdf
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