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Measurement of the Ocean Economy From National Income Accounts to the Sustainable Blue Economy

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1. INTRODUCTION

The term “blue economy” has emerged as a focus of attention throughout the world to denote an increasing awareness of the role of the oceans in national economies. The term’s widespread use is derived in part from the multiple meanings that have been attached to it. For some it reflects the “industrialization” of the oceans- the increasing scale of economic uses of ocean resources (The Economist Intelligence Unit, 2015). For others it represents new technologies and new industries that may spur economic growth (Spinrad, 2016; Ecorys, 2012). For still others, the focus is on the ecological and environmental resources of the oceans and the constraints that these place on economic uses (Group of Experts of the Regular Process, 2016).

These overlapping but somewhat distinct perspectives highlight both important opportunities and challenges. Echoing the definition of sustainable economies from the World Commission on Environment and Development (Brundtland, 1987), the Economist Intelligence Unit proposed a definition of the blue economy for the 2015 World Ocean Summit: “A sustainable ocean economy emerges when economic activity is in balance with the long-term capacity of ocean ecosystems to support this activity and remain resilient and healthy” (The Economist Intelligence Unit, 2015). But this definition is more an aspiration than a blueprint. Moving towards this goal will require reforms in policy and planning, investment, governance, and institutions that will be complex and time consuming.

At the heart of this change, however, lies the mundane but critical question of measurement. How can the blue economy be distinguished from other types of economic activity? How are changes to be measured in order to know whether whatever the blue economy is expanding or contracting? How will it be known whether the blue economy is moving towards or away from a balance of ecosystems and economic uses? How will new technologies and innovations affect changes in the composition of the blue economy? Without temporally and spatially consistent data systems to provide answers to these questions, the blue economy will be a destination forever lying just over the horizon, towards which no course can be charted.

Fortunately the movement towards the blue economy is occurring at the same time as significant efforts to develop the appropriate data systems. A number of countries are already developing means of measuring the oceans’ contributions to national economies using the standard measurements of the national income

accounts, the most commonly used measures of economic performance. Many of these efforts are described in the papers prepared for a symposium on how to better include ocean economic values in national income accounts that took place in October 2015 in Pacific Grove, California hosted by the Center for the Blue Economy of the Middlebury Institute of International Studies at Monterey. This symposium brought together representatives of governments, universities, and nongovernmental organizations from ten countries to investigate these issues. The papers presented at the symposium are presented elsewhere in this special edition.

These papers report on a number of countries that have already embarked on the process of constructing measures of the ocean economy. International organizations such as the OECD have also been working to develop estimates of the blue economy in a cross-national context. This paper begins by looking at the purposes for which measurement of the ocean economy is being undertaken. It then provides an overview of the development of blue economy measurements, beginning with the incorporation of ocean economic values into national income accounts. It then begins exploration of means to incorporate environmental and ecosystems services values into the measurement of the ocean economy, a topic identified at the symposium but which was not examined in detail there. The objective is to discuss how to address the three major components of a measuring system needed to track the “sustainable blue economy”:

- Contributions of the oceans to the market transaction based national income accounts
- The value of ocean environmental and natural resource assets on which contributions to national income depend
- The services to the economy and populations provided by marine and coastal ecosystems

In the conclusion, the paper identifies a number of specific actions that can be taken to advance blue economy measurement recognizing that efforts are most likely to be fused across countries and years.

2. OBJECTIVES OF EFFORTS TO REGULARLY MEASURE OCEAN ECONOMIC VALUES

One major reason that so many efforts are underway to explicitly measure economic values is to allow oceans to be discussed in the economic terms on a par with other economic issues. Those interested in oceans want to make sure that policy makers understand their value, and economic measurements are the most easily understood way of expressing value. Thus an estimate of the contribution to national economies expressed in monetary terms permits comparison to other natural resource sectors in the national income accounts (Kildow et al., 2016). In this sense, ocean economic values are as much about the politics of policymaking as the content of policy.

Nonetheless, having measurements of ocean economic values is of course critical to policy. Tracking changes in the levels of economic activity permits public and private decisions about investment, spending, and macroeconomic management. For resources not traded in markets, the estimation of values extends the information available to take full account of tradeoffs counted as costs and benefits so that decisions are more likely to result in net gains to society than net losses to society, and so that the distribution of gains and losses can be identified.

When added to the estimates derived from markets, the estimation of values not directly determined by market transactions provides the most complete picture of economic values in order to permit economic systems (including public and private sectors) to get as close as possible to both short-term and long-term optimal resource allocation within the constraints set by ecological systems. In order for measurements of economic values to serve this purpose, measurement systems must:

- Be focused on creating information that decision makers can use

The effort to develop meaningful measures of ocean values will require significant resources in time and personnel, and these resources will be forthcoming only if decision makers see the relevance of the effort. This should not be difficult as there is a very wide array of decisions for which this information can be used from national and regional budget policies to project level assessments. Both *ex ante* policy analyses of policy and investment alternatives and *ex post* evaluation of choices made will greatly benefit from having good economic valuation data available. *Ex post* evaluations may be particularly important because the commitments to sustainability mean that

decisions must be continually assessed to see if the choices made are producing results that tend toward or away from sustainability.

- Be able to distinguish between both common and distinctive aspects of the world's oceans

The oceans may be the dominant geographic feature of the planet, touching the boundaries of the vast majority of nations, but there is also huge variety in national relationships to the oceans. Economic relationships can vary significantly from island nations to continental nations. Data systems must provide comparability across the oceans but also be capable of taking account of the differences between coastal seas, regional seas (such as the Baltic or Caribbean) as well as the high seas, which belong to no nation. Extension of ocean accounts to take environmental resources and ecosystem services into account means that economic data must also be consistent with Large Marine Ecosystems that are the organizing framework for major ocean management efforts across national borders and effective management will be hampered by inconsistent data. (Melorose, Perroy and Careas, 2006)

- Be designed for comparability and additivity

It is essential that measurements of economic value be consistently measured across time and space, be theoretically consistent to avoid double counting, and additive from more detailed levels to more general levels. At the 2015 symposium, significant attention was paid to issues of taxonomy: how are ocean industries to be defined within the context of different industrial taxonomy systems. Industrial taxonomies are the essential organizing framework for all economic data systems. But the taxonomies can both aid and impede comparability and additivity. Those challenges become even more significant when economic and ecological values are to be included.

As discussed below, a common framework for incorporating ocean economic values in national income accounts is a realistic prospect, one that will identify common definitions applicable across most countries while reflecting local conditions. There are also a number of common challenges across countries in measuring the structure and function of the ocean economy as it is currently and as it will change.

3. THE OCEANS IN NATIONAL INCOME ACCOUNTS: DEFINITIONS, MEASUREMENTS AND INTERNATIONAL COMPATIBILITY

Much of the focus in the papers presented at the CBE symposium revolved around the question “what is ocean related economic activity?” The underlying premise is that existing economic data systems are capable of measuring key aspects of such activity such as gross output/value added, factor incomes to labor and capital, and levels of employment. But which output, incomes, and employment should be “ocean” and which “non-ocean”? In fact, is “ocean” even the right term? The OECD (2016) report notes at page 21 the sometimes confusing terminology applied to the “ocean” economy: “‘Ocean’ is usually used in Ireland and the United States, whereas ‘marine’ is widely used in Australia, Canada, France, New Zealand and the United Kingdom. ‘Maritime’ is frequently used by the European Union, Norway and Spain. Furthermore, terminologies are also translated differently into English when they are taken from Japanese, Korean or Mandarin”.

In a paper published prior to the symposium, Park and Kildow wrestle with the appropriate preposition to describe the ocean economy, differentiating between industries that are “from”, “in” or “to” the ocean.(Park and Kildow, 2015) There were proposals to distinguish between those industries that are dependent on ocean ecological health and those that are not. Candidates for inclusion in the “ocean” or “marine” or “maritime” economy¹ were also separated by whether they were “core” or “ancillary” and whether they were “directly” or “indirectly” related. There was also widespread recognition that there is a distinguishable group of “core” ocean industries and an “emerging” group that has generally not been widely incorporated in ocean economy.

Table 1 represents an informal consensus from the symposium of how twenty eight industries might be grouped to represent different approaches to the industrial definition of the ocean economy. Table 1 is based on the ocean accounts of China and are taken from the paper in this volume by Wang (Wang, 2016), which analyzed twelve different approaches to identifying ocean-related economic activity. These included national definitions from China, the United States, Canada, France, the United Kingdom, Ireland, Australia, South Korea, and the Philippines,

as well as academic definitions for the European Union and the Partnerships for Environmental Management of the South East Asian Seas (PEMSEA).

Table 1. Candidate List of Ocean Industries Grouped by Percent of Nation's Analyzed Using that Sector in their Definition of the Ocean Economy

	Industry	Number of Taxonomies	Percent
Group 1 (Core)	Marine Fishery	12	100%
	Offshore Oil and Gas Industry	11	92%
	Ocean Mining Industry	9	75%
	Shipbuilding Industry	10	83%
	Engineering & Construction	11	92%
	Communication & Transportation	12	100%
	Coastal Tourism	9	75%
	Marine science research	8	67%
	Marine Education	6	50%
	Marine Management/ Pub Admin/Defense	9	75%
Group 2	Marine Electric Power Industry	7	58%
	Ocean-related Services	4	33%

	Industry	Number of Taxonomies	Percent
	Marine insurance and social security industry	5	42%
	Marine technology services	4	33%
Group 3	Marine Environment Monitoring and Prediction services	1	8%
	Marine Geologic Exploration Industry	1	8%
	Marine environmental protection industry	3	25%
	Marine social and international organizations	2	17%
	Marine Agriculture, Forestry Industry	1	8%
	Ocean-related products and materials manufacturing	1	8%
	Ocean-related construction and installation industry	1	8%
	Marine Wholesale and Retail Industry	2	17%
	Marine Chemical Industry	1	8%

	Industry	Number of Taxonomies	Percent
	Seawater Utilization Industry	2	17%
	Marine Information Services	3	25%
	Marine Salt Industry	2	17%
	Marine Biomedicine Industry	3	25%
	Marine equipment Industry	3	25%

Table 1 breaks the 28 industries into three groups. The first is a core set of ocean industries, which are to be found in most of the national “ocean” taxonomies; these industries are found in sixty percent or more of the taxonomies examined at the symposium. The one apparent exception is marine education, included in half of the taxonomies examined. But this is actually an example of exactly the kind of constraint that taxonomies can impose; there was agreement that “marine research and education” is an appropriate category for those that addressed this sector, but not every taxonomy allows that definition. There was strong agreement at the symposium that these core industries should be the focus of the next round of efforts at refining measurement.

Groups 2 and 3 comprised industries that are found in substantially fewer taxonomic groupings. These industries may not be present in some countries, or may be subsumed within other industries where the “ocean” component is not visible. There is also likely some overlap in systems other than China’s between such industries as “ocean related services” and “marine environmental monitoring and protection services”

This division between the core or the “traditional maritime industries” and other ocean industries is also reflected in the taxonomy used in a study of the global ocean economy prepared by the Organization for Economic Cooperation and Development and released after the CBE symposium, which is shown in Table 2. (OECD 2016) The OECD taxonomy distinguishes between “established (roughly

equivalent to “core” in Table 1) and “emerging” industries, a distinction that is not specifically reflected in Table 1. The distinction between “emerging” and “established” in the OECD approach appears derived from the purpose for which that study was prepared, which was to identify future economic growth opportunities related to the oceans. Thus, aquaculture, oil and gas, and offshore wind are already well established in many parts of the world, but they are listed by the OECD as “emerging” because of their perceived growth potential.

Table 2. Ocean Industries Identified by OECD (2016)

Established	Emerging
Capture fisheries	Marine aquaculture
Seafood processing	Deep- and ultra-deep water oil and gas
Shipping	Ocean renewable energy
Ports	Offshore wind energy
Marine and seabed mining	Maritime safety and surveillance
Shipbuilding and repair	Marine biotechnology
Offshore oil and gas (shallow water)	High-tech marine products and services
Marine manufacturing and construction	Others
Maritime and coastal tourism	
Marine business services	
Marine R&D and education	
Dredging	

An examination of Tables 1 and 2 highlights many of the issues that will need to be addressed to create an internationally comparable set of ocean accounts. These include:

3.1 Aggregation

All taxonomies exist to create groups that are connected by similarities and that are distinguished from other groups by dissimilarities. But similarities are not always easy to see. The example cited above about marine research and education makes the point. In many countries, marine research and education take place at institutions of higher education, but there are marine research organizations that are unconnected with educational institutions (government laboratories or laboratories associated with nongovernmental organizations). Taxonomies usually manage this issue through different levels of similarity from the broadly inclusive to the narrowly defined.

The challenge in creating comparable accounts is to deal with different approaches to aggregation. Combining different definitions into larger aggregations (marine research and education) is the obvious solution, but each additional level of aggregation makes it more and more likely that non-marine related activity will be included with marine related, which creates the next issue, how to deal with “partials”.

3.2 Partials

Partials are industries that include both ocean and non-ocean related activity. Often the industry that can be located anywhere and its relationship to the ocean is defined by that part of the industry located in or near the ocean. Oil and gas exploration and production and tourism are good examples. Tourism is also an example of a partial where location is only one aspect of the ocean relationship. Hotels in a coastal location may serve people who travel for business purposes rather than recreation, and restaurants serve both local residents and visitors. The OECD “emerging” industries list contains a number of industries with significant issues around “ocean partials”. For example, “high tech marine products and services” implies two divisions: between marine and non-marine and high tech and low tech.

There are three broad approaches to estimating the “ocean” proportion of partially related industries:

- Location of economic activity

When economic activity can be spatially located with some precision, the ocean relationship can be inferred. The U.S. estimates of the ocean economy rely on geographic locations in shore adjacent postal (zip) codes to infer ocean relationship for tourism and recreation industries. The OECD distinguishes

between “shallow” and “deep” water oil and gas exploration and production based on location.

- Imputation from other data sources

Other data may distinguish between ocean and non-ocean activity. Production data for oil and gas frequently distinguishes between onshore and offshore locations of activity, often because the government owns offshore lands. The ratio of offshore to onshore production could be used to estimate ocean related economic activity.

A particularly noteworthy example of imputation is contained in the OECD (2016) study, which uses a Cobb-Douglas production function to impute the capital and labor contributions to Gross Value Added for a number of the sectors and in several of the countries where data is absent. The OECD imputed data provides what is currently the most comprehensive and consistently estimated GVA data for ocean economies, but it is not clear how the imputed data will compare with actual measured data when that is available.

- Original data collection

Data collected through surveys can be modified to request identification of ocean-related activities. Alteration of industrial taxonomies to distinguish between ocean and non-ocean components is another possibility of intervention at the original data collection level.

- Cluster frameworks

Another way to approach the problem of partials is to shift the analytic perspective from an industry-by-industry assessment to a cluster assessment. Clusters are regional agglomerations of economic activity that are characterized by a high degree of interdependence in production and, to varying extents, consumption (Porter, 1998). The cluster concept has become widely used to examine industrial structures in considerable detail and in ways that can be less constrained by the strictures imposed by industrial taxonomies. A number of cluster framework studies have been conducted on ocean industries (Hsieh and Li, 2009; Connecticut Maritime Coalition, Michael Gallis & Associates, and Connecticut Economic Resource Center, 2000).

Cluster studies may uncover connections to industries that can be important suppliers to the more recognized ocean industries but would not be immediately

apparent from taxonomic lists. Study of the Marine Supplies cluster in Europe conducted for the European Commission (BALance Technology Consulting GmbH, 2014) examined many of the supplier industries to the ship and boat building sector in Europe including the role of such industries as steel, propulsion systems, cargo handling systems, and electrical systems that are critical components of ships. Such interconnections are important to understanding the full scope of ocean economic activity. Cluster studies expand the definition and measurement of the ocean industries, but they can also be time consuming and expensive to undertake. They also tend to be one-time-only or occasional studies that provide significant information for one time and place and may be limited in their generalizability to national studies unless specifically designed for that purpose.

3.3 Geography

Spatial location is one of the criteria used to distinguish ocean related activities, but the use of geography raises other issues about how geography is measured and what geography counts. Political jurisdictions such as cities or counties, and administrative jurisdictions such as postal codes are usually available on the address elements of administrative records, but political and administrative boundaries inevitably include much territory that is not ocean related. Records that contain more precise geographic locations, such as latitude and longitude allow greater precision when analyzed through geographic information systems. Greater location precision can help, though at potential cost in confidentiality (discussed below). But “ocean related” implies to some extent “coastal located” and there is also substantial variation in the world’s coastlines.

Major bays often reach far inland, and coastal cities located on rivers often host ocean related activities such as ports. Montreal, Quebec is included in the Canadian definition of the ocean economy because ocean-based waterborne transportation on the St. Lawrence River reaches Montreal (at least during ice-free months). Because of the legal definitions of the “coast” in the United States², the Great Lakes up through Lake Superior are included in the U.S. ocean economy. The U.S. measurement of the ocean economy extends to the transition zone between Lake Erie and the St. Lawrence River in New York State, meaning there is about a 100

² The Coastal Zone Management Act of 1972 (16 U.S.C. Chapter 33 §1451 et seq. applies to thirty states including those bordering the Great Lakes.

kilometer stretch of the St. Lawrence not included in either the U.S. or Canadian ocean economy. This example illustrates how different approaches to policy and physical geography shape national definitions of the “ocean economy” and create comparability challenges across nations.

3.4 Confidentiality and Imputation

Economic data is collected either through administrative records (e.g. reports for tax purposes) or through specially constructed surveys. In either case, there is either an implicit or an explicit commitment on the part of the government that the information collected will not be made publicly available in any way that the values for any single reporting unit (company or establishment) can be revealed. There are a number of screening tests that are used to provide sufficient aggregation of data to avoid the release of any single entity. Perhaps the most common is the n/k rule, which holds that any released data includes n or more units and no one unit comprising more than k percent of some measure such as employment or wages paid. N is frequently set to 4 and k is set to 80%. Alternatives include the p-percent rule and the p/q rule. (Sukasih, Jang, and Czajka, 2012; Colgan, 2013)

The challenge presented by the need to protect confidentiality of information is that the more specific the industrial and geographic criteria applied, the more likely suppression of data will be needed to protect confidentiality. Increasing needs to protect confidentiality, particularly as geographic scale decreases, will offset more precision in the definition of ocean industries. Differing applications of confidentiality protection may create inconsistencies in measurements. Methods exist to impute values missing because of confidentiality suppressions (Isserman and Westervelt, 2006; Ahang and Guldman, 2009), which will yield a more complete set of estimates but may add to the burdens on comparability across data systems.

3.5 Measuring Value Added

Gross value added (GVA) is the common metric for ocean-related estimates of national and regional income accounts, although it goes by different names. In the United States the measure is called Gross Domestic Product-State. (Bureau of Economic Analysis, 2006) GVA is the gross value of output less the value of material inputs (for goods related industries). The estimation of GVA, however, can be done in different ways. Nations that have Value Added Taxes (VAT) have

access to data on inputs that nations without VAT's do not. Survey based data used to construct input-output tables are used by countries that do not have VAT's.

Another issue is whether estimates of GVA are constructed from the top down, the bottom up, or both. Top down estimates begin with national estimates that are then disaggregated to the regional level, while bottom up estimates begin with individual establishment or regional data that are then aggregated to the national level. The choice of which approach to take depends to a large extent on the structure of national statistical systems, and it is unclear whether there are any inherent biases in one or the other in the estimation of ocean economies.

3.6 Expanding National Participation in Low Income Countries

Measurement of ocean economic values is currently most active in Asia, North America and Europe, so significant portions of the world still lag behind in any efforts to create a global measurement of the global ocean. There is relatively less participation in the Indian Ocean, Africa, Central and South America. Most of the nations that have begun systematic measurement of ocean values have had limited guidance or shared experience; indeed, the Fall 2015 symposium was the first time most of the countries became aware of how much activity was actually under way in this field. But the sharing of experiences begins the process of making it easier for countries that will undertake the creation of ocean accounts in the future.

An additional factor encouraging more widespread adoption of ocean valuation is the need for many countries to cooperate with neighbors in the management of marine ecosystems and resources in the multiple regional seas around the world. For example, European countries on the Mediterranean, spurred by the European Union, are already moving towards systematic estimation of ocean values. This information will become more and more important as management of the Mediterranean intensifies and countries on the African side will see the need to have comparable estimates for their own economies in order to understand the consequences of choices that the coastal nations of the Mediterranean face. (O'Brien-Malone, 2012)

These are all substantial, but not insurmountable, challenges, suggesting that there is every possibility of both significantly improving the measurement of ocean values within nations and developing sufficient comparability between nations that at least a group of core industries can be consistently measured at a global scale if

a sufficient number of coastal nations participates in the process of developing ocean economy measurements within the national income accounts. However, creation of an internationally comparable set of ocean national income accounts is only the first leg on the course to measuring the sustainable blue economy.

4. MEASURING THE SUSTAINABLE BLUE ECONOMY: ENVIRONMENTAL AND ECOLOGICAL VARIATION

The limitations of conventional national income measurements for measuring the relationship between economic activity and the environment have long been known (Nordhaus and Kokkelenberg 1999; The World Bank 2010). Traditional national income accounting touches on the concept of sustainability through the concept of Net (rather than Gross) Domestic Product, which subtracts depreciation of physical assets (buildings and equipment) to offset investment in those assets. Negative net investment (depreciation in excess of new investment) is an indicator of unsustainable economic growth. But NDP still does not address environmental assets.

The result has been efforts to extend the national income framework to incorporate the environment in several different ways. To the U.N.'s System of National Accounts (European Commission et al., 2009), which provides international standards for national income accounting, the System of Environmental and Economic Accounting (SEEA) (United Nations Statistics Division, 2014) and the System of Environmental and Economic Accounting Experimental Ecosystem Accounting (EEA) (European Commission et al., 2013) have been added. There are also a number of countries that have undertaken extensions of their national accounting to include the environment, at least on an experimental basis. These efforts form the basis for extending ocean accounts to serve more effectively as a measure of environmental sustainability, but each also presents formidable challenges for creation of a unified set of ocean economic accounts.

Originally developed in 1993 in response to the 1992 Rio Conference's Agenda 21, the *Handbook of National Accounting: Integrated Environmental and Economic Accounting* was updated in 2003 and again in 2012. The 2012 *System of Environmental and Economic Accounting: A Central Framework* is the currently operational standard. The SEEA consists of three components: (1) measures and

models of the physical relationships between economic activity and the environment; (2) a set measures of the stocks of environmental assets that change as a result of the economic activities; and (3) economic activity and transactions related to the environment.

These components point to two major differences between SEEA and EEA accounts and SNA accounts: the measurement of physical systems and their links to economic systems is a central component of the approaches to environmental accounting that is not present in standard national income accounting. While SNA-related income accounts measure flows of economic activity in a specific period, the environmental and ecosystem accounts include measures of both stocks *and* flows of economic values. But there is an important distinction between the SEEA and EEA accounts. The former deals with “environmental activities”, which are defined in the *Central Framework* as “the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity”. The latter deals with the economic values of “ecosystem services” which link the functioning and processes of systems of environmental assets to beneficial services that have value. For example, the SEEA measures the economic stocks and flows associated with a fishery, while the EEA measures the economic value of inputs to the fishery such as juvenile habitats in coastal wetlands. This distinction is critical because the measurement of economic values affecting sustainability in the blue economy requires different approaches for environmental and ecosystem assets.

4.1 The Values of Environmental Activities and Natural Resources: SEEA

A key virtue of the combination of physical and monetary accounting in the SEEA is the ability to expand the definition of “capital assets”, which is limited to physical capital such as real estate and equipment in SNA accounts, to include natural resource assets, including minerals, energy, land, soil, timber, and water and to account for both depreciation and depletion in these resources. A completely specified set of accounts conforming to SEEA standards would include separate accounts for each of these natural resources that would identify the starting stock of a resource in each period, the additions and reductions³ in the resource during that period and the net change in the stock at the end of the period.

³ Changes to stocks of renewable resources occur through changes in biological potential for reproduction. Changes in stocks of nonrenewable resources such as minerals occur

Both the stocks and flows would be measured in physical terms (biomass, land, mineral reserves, etc.), as well as the monetary values of the stocks and flows. Valuation is based on market transactions, and includes both the rents accruing to the resource and the industry. The Central Framework contains detailed guidelines for the valuation of the resources in order to assure theoretically consistent measurements. The most important insight gained from the construction of these accounts is the measurement of depletion.

The Central Framework defines depletion for a renewable resource in physical terms, as the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration. Depletion is different than extraction; it is a reduction in the capacity for a given resource to regenerate owing to extraction. The classic example is the “more mommies equals more babies” model of fisheries. Extraction (catch) of fish reduces the number of reproducing females, which reduces the subsequent population size and as long depletion continues, the stock continues to decline. Extraction (catch) decreases as depletion increases and vice versa.

For nonrenewable resources, depletion implies eventual exhaustion of the resource from a physical perspective. Additions to mineral or energy resources in the form of new discoveries offset depletion when the change in stock (reserves) is calculated, but all nonrenewable resources are subject to depletion so expansion of reserves simply adds to the total amount of resources subject to depletion.

However, depletion for nonrenewable resources can take on a different meaning when the monetary accounts are created. The mineral or energy resource is not renewable, but the wealth created by it can be. If a share of the revenues from extraction of the nonrenewable resource is set aside into a fund that can grow at some interest rate (which should be greater than the depletion rate), then a portion of the stock of wealth from the mineral resource can be maintained indefinitely. Sustainability of the mineral wealth is possible if the rate of extraction from the fund is less than the interest rate at which the fund is invested.

This perspective on physical flows also points to another important difference between the SEEA and SNA frameworks. In the SNA framework, measurement of

with additions or reductions in reserves, that is minerals that are economically available, which depends on prices and costs at any given time.

values created can be taken at both the consumption or production stages because of the fundamental identities contained in the circular flow model of the economy (output=income adjusted for trade and investment). In the standard definition of the production side of the GDP, which is usually value added by industry (as is done in the examples of ocean accounts discussed earlier) many of the expenditures on goods and services related to the environment are overlooked because there is no industry that defines them or because they are transactions internal to enterprises or households and are simply subsumed as intermediate goods and not recorded in market transactions. This would include such items as production of energy or water use that is self-produced rather than purchased. Measuring such intra-enterprise transactions is not critical in the SNA accounts since their values are represented in the ultimate value added or purchase price values, but they are essential to understanding the total physical flows affecting the environment and the total economic values associated with those flows. A separate taxonomy for environmental activities (goods and services) has been developed to assist this process (U.N. Department of Economic and Social Affairs-Statistics Division, 2016) and the SEEA contains detailed guidance on the valuation of these goods and services.

There are some limitations on the measurement of environmental goods and services. Expenditures aimed at repairing or restoring the consequences of environmental damages to physical assets (such as avoiding local pollution by changing residence or job; cleaning and restoring buildings and expenditure on health care for people adversely affected by the environment) are not included in the SEEA accounting, although they could be included if appropriate information is available.

4.2 Implication for Ocean Economic Accounting

Application of the SEEA framework to the ocean economy presents some important opportunities to expand our understanding of the ocean economy and to get closer to the measurement of the sustainable blue economy. Most importantly, the applications of the framework of the SEEA will allow estimation of the Net Ocean Product in addition to the Gross Ocean Product, which has been almost entirely the focus of efforts to date. But there are also some significant issues.

The most important addition to the ocean accounts would be providing a more complete picture of the extractive resource industries, including fisheries, oil and

gas, and other minerals. Fisheries and aquaculture provide an example from the Central Framework, as shown in tables 3 and 4.

Table 3. Physical Accounts for Marine Fisheries

(Metric Tons)		Aquaculture-Fixed Assets	Aquaculture-Inventories	Wild Inventories	Total
Opening Stock		406	150	1393	1949
Additions to Stock	Growth	19	192	457	668
	Upward Reappraisals			33	33
	Reclassifications	40		11	51
	<i>Total Additions</i>	59	192	501	752
Reductions to Stock	Catch/Harvest		-183	-321	-504
	Natural Losses	-37	-5	-183	-225
	Catastrophic Losses	-4	-2	-9	-15
	Uncompensated Seizure			-7	-7
	Downward Reappraisals	-5			-5
	Reclassifications	-9		-35	-44
	<i>Total Reductions</i>	-55	-190	-555	-800
Closing Stock		410	152	1339	1901
Change over accounting period		4	2	-54	-48

Table 4. Economic Accounts of Marine Fisheries

Currency Units		Aquaculture-Fixed Assets	Aquaculture-Inventories	Wild Inventories	Total
Opening Stock		3250	1125	9750	14125
Additions to Stock	Growth	150	1440	3200	4790
	Upward Reappraisals			250	250
	Reclassifications	280		75	355
	<i>Total Additions</i>	430	1440	3525	5395
Reductions to Stock	Catch/Harvest		-1375	-2050	-3425
	Natural Losses	-275	-35	-1460	-1770
	Catastrophic Losses	-30	-15	-70	-115
	Uncompensated Seizure			-50	-50
	Downward Reappraisals	-35			-35
	Reclassifications	-75		-280	-355
	<i>Total Reductions</i>	-415	-1425	-3910	-5750
Revaluations		160	50	480	690
Closing Stock		3425	1190	9845	14460
Change over accounting period		175	65	95	335

Table 3 is a hypothetical physical account for a nation's fisheries, while Table 4 is the corresponding monetary account. The SEEA makes provisions for both aquaculture and wild fisheries. In the case of aquaculture, there can be a distinction between fixed assets (a breeding stock) and inventories (biomass available for the market). In both cultured and wild fisheries there is natural growth and catch/harvest, with certain additional technical adjustments to the accounts. The problem of illegal fishing can be reflected in the accounts by estimating "uncompensated seizures". In Table 3, the stock of the fishery asset between the opening of the accounting period and the end of the accounting period declines by a total 48 metric tons (a decline of 54 metric tons in wild fisheries offset by an increase of 6 metric tons in aquaculture stocks).

Table 4 records the monetary values associated with assets in that period. In this example, there is an increase in the value of both the cultured and wild fisheries and in the overall fishery. The increase in value in the wild fishery occurs in spite of a drop in the physical stocks, and illustrates how a decline in stocks creates shortages in the markets relative to demand and thus an offsetting rise in prices. This illustrates why the SEEA approach adds important information; in the standard national income accounts, the gross contribution of the fishing industry (assuming constant costs of production) would be seen as a gain for the economy when in fact it represents a fishery that is in distress. If a sustainable extraction rates are available from biological modeling, then the rate of depletion would also be known.

The fishery example also points to some of the challenges in adapting the SEEA framework. The valuation of fisheries for purposes of the account is more complex than simply the market revenues. The relevant capital value to be measured is that of the fishery resource, not the industry, whose capital value is measured in the boats, fishing equipment, and processing plants. If a market exists for permits to fish (as in a catch shares program (NOAA Fisheries, 2016)) then the value of the fishery resource may be imputed from the license prices. But since such market-based license systems are still relatively rare, the residual value method, essentially a present value calculation based on estimation of the gross operating surplus estimated in value added measurements of the industry can be used.

Another challenge indicated by the fishery example is the need for robust modeling of both near shore and offshore ecosystems together with physical ocean dynamics in order to establish sustainability levels as well as to account for natural changes and occasional catastrophic changes. Such models may not exist for many fisheries.

The identification and measurement of values for environmental activities, goods, and services in the Central Framework opens the door to measuring parts of the ocean economy that are increasingly the focus of attention. This would include industries in Table 1 such as “marine environmental monitoring and prediction services” and “marine environmental protection”. Equally important, following the Central Framework would require attention on intra-enterprise expenditures on these kinds of goods and services that would be overlooked in the industry-focused standard accounts. Expenditures on wetlands restoration activities, which would come from environmental services, construction, and other industries would be a good candidate for an ocean related environmental activity to be measured. The

measurement of the values of environmental activities, goods and services would also draw attention to innovative approaches to pollution control in the marine environment.

The inclusion of expenditures on environmental activities, good, and services within enterprises and households, including both the physical and economic components, will require changes in the data collection processes for the national income accounts in the form of additional surveys deployed to gather the necessary data. The input/output tables that form a part of the national income accounting system may provide some guidance, but that would depend on the level of detail in the taxonomy used in the I/O tables.(UN Department of Economic and Social Affairs, 1999) It is more likely, however, that specialized surveys detailed enough to identify relevant data requirements will have to be deployed with sufficient sample sizes to gather data across industries and geographies.

There are also environmental activities, goods, and services which are likely to be important in the ocean economy but which the SEEA does not currently address. One group is the general category of “resource management”, which is recognized in the Central Framework as an environmental activity but for which detailed accounting procedures have not been developed in the Framework. Since much of the resource management in the oceans takes place in the public sector, it may be possible to construct a “resource management” activity from public expenditure data, assuming the public expenditure data is organized to permit this. Such an approach would be largely consistent with the Current Framework and the inclusion of resource management activities within the core “ocean economy” industries discussed above with respect to the oceans and standard national income accounts should address this element of environmental activities under the SEEA.

The other area missing from SEEA is one of increasing concern for inclusion in the ocean accounts: the expenditures for dealing with natural hazards including shoreline erosion, flooding, and inundation. The relevant economic activity includes both mitigation of such hazards and responding to them. Sea level rise and the threats to coastal regions represent a largely unprecedented change in the concept of the ocean economy which will have to be accounted for as climate change drives up the threat from sea level rise related hazards. But this is a field on which the Current Framework is currently silent, though it is identified as an area for future research. Efforts to include the effects of natural hazards in the ocean economy will probably have to proceed without specific guidance from the SEEA

for some time, though the general principles of the SEEA framework will provide some useful directions.

4.2 The Value of Ecosystems: The Experimental Ecosystems Accounts and Natural Capital

The SEEA Central Framework extends the measurement of ocean economic values in a number of ways and expanding national ocean accounts to incorporate the SEEA framework is an important step. But there are also important environmental values that lie beyond those addressed in the Central Framework. The concept of ecosystem services has emerged as a way of understanding important economic values derived from the functioning of ecosystems, which are not captured anywhere in the conventional national accounts or in the SEEA Framework. Because of the recognition that the values of ecosystem services must be included in any comprehensive picture of national economies but also in recognition of the difficulties involved actually including these values, an Experimental Ecosystem Account (EEA) (European Commission et al., 2013) has been added to the SEEA to assist countries wishing to include the value of ecosystem services in their environmental accounts.

The EEA defines ecosystem services as: “the contributions of ecosystems to benefits used in economic and other human activity”. Three different broad types of ecosystem services have generally been recognized:

- Provisioning services, which are the contributions of ecosystems to the production of marketed goods. The habitat for larval and juvenile provided for commercial fisheries by coastal wetlands is an example.
- Regulating services, where certain characteristics of ecosystems beneficially affect natural processes. Flood control/mitigation provided by intact shorelines are an example.
- Cultural services, where ecosystems support human activities such as tourism and recreation.

These three classes form the basic structure of ecosystem service taxonomies, of which there are now several. The European Environment Agency has developed the Common International Classification of Ecosystem Services (CICES) (European Environment Agency, 2016), while an international initiative hosted by the United Nations Environment Program, The Economics of Ecosystems and

Biodiversity (TEEB), has also developed an ecosystem taxonomy (Sukhdev et al., 2010).

As with the SEEA Central Framework, the EEA approach involves measuring both stocks and flows of values using a combination of physical and economic accounts. With ecosystems, however, there are some critical differences. First the EEA physical accounts must be based on a much more complex understanding of the natural systems whose values are to be measured. Rather than single resources (or groups of resources), ecosystem services valuation must be based on a thorough understanding of the structure, composition, processes, and functions of ecosystems. Complex systems models become significantly more important in order to understand how the ecosystems work and must be coupled to socioeconomic models in order to understand both how ecosystems support services to humans and how humans affect the ecosystem to preserve, enhance or degrade the functions that are associated with valued services. (Jin, Hoagland and Dalton, 2003)

Ecosystems values analysis also adds another dimension to the physical and economic accounts: space. The functioning of ecosystems is heavily dependent on their location, extent, configuration, landscape forms, and interactions with climate. While the stocks and flows of fisheries can be measured at a national or a regional level, the ecosystems associated with fisheries can vary significantly within a country or across national boundaries. Smaller countries may have single ecosystems, but larger countries may have dozens of different ecosystems that interact with economically valuable services.

For this reason, the EEA adds a geographic framework within which the construction of accounts takes place. The geographic framework must be based on well-defined boundaries that must be applicable at different spatial scales. There are three spatial units that must be identified for each ecosystem:

- Basic Spatial Units (BSU) are the smallest geographic scale of measurement and are usually specified in as a unit of area in a grid cell, such as a 100 square meter grid.
- Land cover/ecosystem users (LCEU) identify the dominant land cover type, such as urban, forest, agriculture, wetlands, etc.
- Ecosystem Accounting Units (EAU) represent the area where the physical data, ecosystem models, and economic information are

available. The EAU consists of basic spatial units within LCEU's. Within a given jurisdiction, there may be one EAU or many.

As with the basic national income accounts and accounts developed consistent with the Central Framework, the data on ecosystem services must be constructed on a spatial and temporally consistent basis and with consistent measurement techniques so that they are additive. The accounts must be additive across all EAUs and measurements for all EAUs must be additive from the regional level to the national level. This requirement for additivity presents the most significant challenge to the creation of ecosystem based accounts because there are no standard measurements of either the physical and monetary aspects of ecosystems

The valuation principle used in the standard national income accounts is exchange or transaction value- the value established when goods and services are actually exchanged in markets. The EEA sets a goal that ecosystem services should, to the maximum extent possible, be valued using exchange values. But this is not always possible because many ecosystem services are not usually traded. Although markets in ecosystem services are being developed, for example markets for carbon sequestration (CCS TLM Ltd and Charles Russell LLP, 2013) or biodiversity in forest ecosystems, (Victorian Government, 2011) valuing ecosystem services more often than not requires either imputation of rents from market prices of final products, the use of shadow prices, or stated preference methods such as contingent valuation.

Each of the three major types of ecosystem services can be valued with different approaches but some are more amenable to revealed preference or transaction-based values than others. For provisioning services, the value of the ecosystem is essentially equal to the resource rent, which can be derived from the market value and production costs of the final good supported by the provisioning service. Methods for the estimation of resource rents are provided in both the EEA and the SNA.

There are also transaction based options for valuing regulating services such as flood control and mitigation. Setting the value of a wetland or open space as the avoided costs of damage to property or other economic activity is one option, while identifying the costs of replacing the ecosystem service with engineered alternatives is another. Assuming the avoided or replacement costs are valued at

market prices, the value of the regulating services would be consistent with other national income account values.

The most difficult problems lay with the cultural services like recreation. For example, one of the most common ocean resources used for recreation is beaches. Only a small proportion of beaches charge admission fees that reflect the value of the beach itself (the resource rent) as opposed to parking; the majority of beaches are relatively open access and used at zero price. The value of beaches and similar cultural ecosystem services can be estimated using revealed preference approaches such as the travel cost method, which derives the beach value as a shadow price based on the expenditures for travel to the beach by users. Another frequently used approach is stated preference methods in which the value is estimated by eliciting estimates from resource users or stakeholders using contingent valuation surveys which may or may not measure exchange values.

But many if not most of the studies of cultural ecosystem service values are undertaken for purposes of benefit-cost analyses and are done using a welfare framework rather than an exchange framework. Such studies are focused on estimating consumer surplus (the difference between willingness to pay and actual prices), rather than the market value. Consumer surplus is important to understand in a benefit-cost framework since it is the change in net social welfare that is at issue in such studies, but consumer surplus is not an exchange value and so is not comparable to other values included in an SNA or SEEA account. Consumer surplus may be added to exchange values to compute total economic value but it is not a substitute for exchange value. Thus the results of a large proportion of studies of certain types of ecosystem services are really not usable in the ecosystem accounting framework.

This diversity of valuation approaches to ecosystem services raises serious questions about whether additivity is possible and thus whether consolidated accounts can be constructed for ecosystem services in the same way as other environmental and resource values. And in fact, the guidance document for the Experimental Ecosystem Accounts reaches the conclusion that there is little chance for a standardized accounting system for all ecosystem services and thus “deliberately refrains from providing specific recommendations” on methodology standards. Rather, the EEA recommends that ecosystems accounting comprise a parallel accounting system of its own and offers several options to that effect:

- Use the general balance sheet framework of the standard national income accounts and extend the coverage to incorporate the value of those assets (primarily providing and regulating services)
- Modeling a total value of assets (economic, environmental and social), for example using the net present value of future consumption, and then decomposing this total value into various asset types. This is the essence of the approach referred to as comprehensive wealth accounting or genuine savings (Edens and Hein, 2013).
- Estimate shadow prices for all of the asset types, including ecosystem assets. In theory, the shadow price incorporates the effects of externalities that are not represented in market prices. This approach is referred to as inclusive wealth accounting (Dasgupta, 2012).

In fact the range of options for dealing with ecosystem services is broader than this list implies. As noted, the EEA incorporates both the capital (stocks) and flows (changes in stocks) account structure of the SEEA and the physical capital elements of standard national income accounts. Analysis of ecosystem services values has its “stock” analog in the related field of natural capital analysis. “Natural capital” is not a new concept in economics; Henry George (George, 1880) was formulating early theories of natural capital, as was Harold Hotelling in his work on mineral economics (Hotelling, 1931). The modern descendants of these theoretical perspectives are contained in the SEEA General Framework. Today, “natural capital” is most often taken to mean the asset values of ecosystems expressed usually as the present value of some stream of the services from those ecosystems measured using of the valuation options.

The EEA addresses natural capital through its asset accounts for ecosystem services. There are also a number of other efforts to create capital accounts from ecosystem services values. In addition to the European Environmental Agency project noted above, the Secretariat of the U.N. Convention on Biological Diversity has created a natural capital framework focused on biodiversity services. Both the World Bank’s Wealth Accounting and Valuation of Ecosystem Services (WAVES) (WAVES Partnership, 2016) and the global initiative known as The Economics of Ecosystems and Biodiversity (TEEB) (Sukhdev et al., 2010) initiatives address natural capital. There is also a generalized model to estimate the value of ecosystem natural capital called InVest, developed by the Natural Capital Project at Stanford University (Natural Capital Project, 2015).

In addition to the absence of a settled approach to valuation for ecosystem services, the EEA does not address the question of how to measure the ecosystem equivalent of depletion in extractive resources, which is generally referred to as “degradation”. Incorporating measures of degradation into income accounting is an analog to depletion and depreciation is a major objective of the drive to create “green GDP” accounts, although “green GDP” is, like “blue economy” a term with many meanings. The inclusion of a degradation measure for ecosystems is clearly a theoretically desirable step, but the EEA guidance document notes that in addition to the lack of a standard valuation approach to measure ecosystem degradation, there are likely to be significant difficulties unwinding the economic effect through the ecosystem models to the geographic area associated with the ecosystem, though approaches have been suggested (Edens and Hein, 2013). The point is not that degradation should be examined as part of the relationship between ecosystems and economic systems but that doing so in a sufficiently standard format that national measures of degradation can be derived is unlikely and attempts are not recommended.

4.3 Implications for Ocean Accounts

Attention to ecosystem services and the associated valuation of natural capital is obviously important to development of a complete measurement of the values of the ocean economy. There are clearly ocean related ecosystem services whose values can be estimated in a manner consistent with national income accounts or the SEEA accounting when exchange, or market-based, values are available. Examples include provisioning (juvenile fish habitat) and regulating (flood control) services and a limited number of cultural services such as some types of ocean and coastal recreation where exchange values can be made available could be included.

However, in each of these cases the valuation estimates are only a part, perhaps only a small one, of the process of establishing ecosystem values sufficient to the creation of accounts consistent with the EEA recommendations. To be consistent, a spatial framework must be established and ecosystem models that link structure and function of the ecosystems to the production and distribution of services must also be developed. That is, the estimation of the values must be accompanied by a spatial framework and a physical connection between ecosystem characteristics and economic values to complete the EEA framework.

Although the definition of a spatial basis for ocean ecosystems is possible, existing data series sufficient for the purpose may be rare. While the Basic Spatial Units would be defined in any geospatial data set, the existence of multiple geospatial data sets for different components of the marine ecosystems (biological, geological, hydrological) is more likely than in terrestrial environments in large part because the concept of land cover does not provide the same kind of organizing framework. Estuaries, wetlands, near shore, offshore, continental shelf, and deep ocean might provide analogs to land use/land cover but the suitability of these concepts for use in the spatial organization of ecosystems services accounts requires further investigation.

Similar issues exist with respect to the models needed to couple ecological functions and economic values. These are, as noted, most likely complex models requiring significant resources of time and money to construct, the more so if they are to be specified so that both production and degradation of ecosystem services are included. Many such models exist in various places and at various scales and levels of detail, but incorporating them into functional ecological-economic is another challenge of time and funding.

However, it may be possible to provide some of the information needed to link ecosystems to services and values by using implicit rather than explicit models. Implicit models are built using indicators whose measurement provides information about the overall functioning of the ecosystem. There are a number of examples, some of which may be identified in the physical components of the ecosystem accounts that would be part of any EEA-consistent approach. These could include the Ocean Health Index (Halpern et al., 2012) developed by Conservation International or the MARNET project underway in Europe. (Fernandez-Macho, 2016)

In sum, the development of an ecosystems services account for the oceans that is fully integrated within the national income accounts, or the income accounts as modified according to the SEEA Central Framework or EEA, is unlikely in the near future. It is theoretically possible to specify the elements of such an accounting system, but the translation of theory into practice on a significant scale would require resources not likely to be available. The challenge, therefore, is not to see the measurement of ocean economic values and the sustainable blue economy as an insurmountable problem of finding a single block of time and money to create a

comprehensive integrated set of accounts, but to set a course towards a destination and then undertake a journey subject to vagaries of wind and tide. In fact, the journey is already underway and progress has been made.

5. CHARTING A COURSE TO THE BLUE ECONOMY

Developing the means to understand the economic values associated with ocean and coastal resources is an essential part of efforts to restore, maintain, and enhance the oceans as a sustainable source of wealth. Without economic values, it is difficult if not impossible to know how changes in the oceans contribute to wealth creation, but also how the means to wealth creation affect the oceans as resources or ecosystems. The good news is that the theoretical and many of the empirical foundations for measuring economic values exist and, in fact, are receiving a great deal of attention in many quarters around the world. The bad news is that parts of the ocean economy will remain opaque to complete economic valuation for some time. The way ahead lies in taking continual steps to build on and improve what we have and add new information on a regular basis through platforms of opportunity that continually build towards a more comprehensive picture at the national and ultimately the international level.

There are three basic building blocks to measuring the ocean economy:

1. The National Income Accounts

These are standard measures of production and consumption for national and regional economies that are constructed to be consistent with the U.N. System of National Accounts (SNA) standards.

2. The System of Environmental and Economic Accounts

These measure the stocks and flows of extractive resources such as fisheries and minerals and also the expenditures on activities, goods, and services designed to reduce environmental impacts.

3. The Ecosystems Services Accounts

The measures the economic values for provisioning, regulating, and cultural services derived from the functioning of ecosystems within defined areas.

Based on the current state of practice, an action plan for cooperative actions within and between nations can be identified for applying the accounting and

measurement approaches to ocean and coastal resources in order to integrate the oceans into existing accounting frameworks. The following is only a preliminary identification of the elements of these action plans; significant elaboration will be needed both within and between nations for progress to occur.

5.1 Actions to Integrate Ocean Accounts into National Income Accounts

A consensus conclusion of the 2015 symposium was that the most significant opportunity for international cooperation in the development of ocean accounts lay in the exploration of ways to develop common approaches to the measurement of the core of industries that are present in all or almost all of the current national efforts. These include fisheries (including aquaculture), minerals (including oil and gas), ship and boat building, tourism & recreation, transportation, ocean related research and education, and public resource management. Among the issues to be addressed for these core industries:

- Precise definitions of the industries within varying industrial taxonomies and arranging taxonomies for comparable levels of aggregation of industries
- Identification of geographic aspects of measurement (e.g. inclusion of bays, estuaries, etc.)
- The implications of confidentiality protection protocols for available data and the possible use of data imputation methods to address missing data
- The allocation of the “ocean” portion of industries whose operations and output have both ocean and non-ocean components
- Improving measurement of value added
- Addressing the capacity of low income countries with less developed national statistical systems to adapt their systems to include oceans.

One important addition to the national income ocean accounts based on value added would be to add capital accounts for ocean industries, accounting for changes in physical capital, including depreciation. This would begin the process of estimating net product as well as gross product, which is a starting point for measuring long term wealth creating sustainability. The addition of a capital account for these industries would then be a foundation for the integration of

depletion accounts for resources and minerals sectors in the SEEA accounts and natural capital accounts consistent with the EEA.

Beyond the core accounts, national efforts at creating ocean income accounts will continue to add industries as ocean economies evolve. This will include new industries such as offshore wind or new chemical/pharmaceuticals based on ocean resources. It may also include reorganizations of existing industries in order to highlight ocean specific activities, such as activities related to wetlands restoration and repair.

As new industries are added to national ocean accounts, it is critical that the definitions and approaches to measurement of these industries be fully documented and the documentation be made available for other nations to learn from. Data collected for new industries should also be collected with a view to incorporating environmental accounting. This means creating physical accounts of inputs and tracking intra-industry transfers. For example, pharmaceuticals and chemicals extracted from ocean plants (“sea weeds”) should be set up from the beginning for sustainability measurements of net output as well as gross output and depletion.

5.2 Actions to Extend National Income Accounts to Environmental Accounts for the Oceans

There are three major elements in creating ocean versions conforming to the Central Framework of the System of Environmental and Economic Accounts: (1) the addition of a physical accounting system that tracks inputs from the environment and outputs to it; (2) resource management accounts for extractive resources; and (3), accounting for expenditures on economic units that are designed to reduce environmental impacts, as well as the purchase of goods and services that serve the same purpose.

For the ocean sectors, the extension to environmental accounts should begin with the living resources (fisheries and aquaculture) and tourism & recreation sectors. There are numerous reasons for starting with living resources. As the example above shows, gross value added measures are a useful measure, but can hide important information about the underlying state of the fishery. Data on the physical dimensions of stocks is essential to management efforts and therefore likely to be available in many cases. Sustainability of fisheries is already a well-

examined field with appropriate models and measures already developed in many countries.

The case for including tourism and recreation as an early sector for development of environmental accounts rests on four premises. First, the sector is, in many countries, the largest sector for employment in the ocean economy and one that is located throughout most of the coastal zone. Second, tourism & recreation is both land intensive and extensive and it has significant ecological interactions on both land and sea. Third, it is a service as opposed to a goods industry. Much of the focus in the environmental accounts is on extractive industries, but service industries eventually come to replace or dominate goods industries as economies evolve and so understanding how to construct environmental accounts for service industries is important. Finally, developing environmental accounts for tourism & recreation forms the basis for creating ecosystem accounts; the physical tables will translate to ecosystem services measurement and addressing the ecosystem services values is particularly important in this sector since non-transactional values tend to be quite large.

5.3 Actions to Create Ecosystem Services Accounts for Oceans

The World Bank has recognized that many diffuse studies will be needed to develop ecosystem services accounts of sufficient quality for economic accounting purposes (The World Bank, 2014). Their framework for such studies identifies three key components: The first is a spatial and temporal framework that is used to define and bound data collection for specific ecosystems and that can scale from local to national or global measures of ecosystems. The second is physical accounts constructed from models of ecological-economic interactions that identify how ecosystems processes and functions generate environmentally viable services. This requires biophysical models of sufficient detail and validity to reliably link ecosystem processes with economic uses. The third is the valuation of the ecosystem services, which will comprise a mixture of methods measuring both exchange (market based) value and which can be integrated with other accounts, and nonmarket valuations through stated and revealed preference methods which will need to be maintained in their own accounts. It also requires reconciling the valuation estimates produced by different methodologies.

For at least some ecosystem services therefore, there will be need to be physical accounts, accounts with market/exchange values/ and accounts with welfare-based

values. The physical accounts may be derived from fully specified dynamic models of ecosystems or may, in the absence of such models or as part of them, be comprised of key indicator series that can serve as implicit models. Indicator series such as the Ocean Health Index or the MARNET project in the EU may provide key information on sustainability issues until more complete ecosystem accounts are created. There is also guidance available on the collection of environmental data can serve as the information for the physical accounts needed.

The starting point for ecosystem services accounts related to the ocean should be the same sectors mentioned above as the starting points for environmental accounts: living resources and tourism & recreation. For living resources, the measurement of the provisioning ecosystem services is key to linking the economic health of fisheries to ecosystem health, and as with the environmental accounts, fisheries are extensively studied so many of the key ingredients may already exist, at least in preliminary format. For tourism & recreation, it is opportunity to measure the combination of transaction (market) and welfare (nonmarket) values as a model for other sectors.

Ecosystem services values are by far the most complex and difficult of all the measurement challenges facing the ocean economy, but in fact there are difficulties in each of the elements of ocean economic accounting. But there are several tactical elements that are shared across all of the elements. The development of ocean accounts should be seen as single long term task with discrete elements building towards a whole rather than piecemeal unconnected projects. The integration of efforts is the essential ingredient to the eventual integration of the accounts. The following are elements in common to all the steps in creating ocean accounts:

5.4 Metadata

The *sine qua non* for national income and environmental/ecosystem accounting is consistency of measurement. Consistency of measurement is needed to assure comparability across time and space and to provide for additivity of measures so that values measured at one geographic or functional scale can be added together to create regional or national totals that are free of double counting. But consistency of measurement across all of the countries and regions undertaking ocean accounting is itself a major difficulty. The UN economic accounts documents provide guidance on consistency of theoretical and empirical approaches, but they cannot address all of the data issues that will be encountered. The guidance on

environmental statistics prepared by the U.N. Department of Economic and Social Affairs referenced above may also be used as metadata standards for the physical accounts.

At least a partial solution to the problem of creating consistency of measurement is by starting with consistency of metadata or data about the data. Metadata standards specify what information about the data should accompany each data set and provide users of the data with information necessary to decide whether and how comparable data sets are. Metadata also indicates whether conversion of data collected under different methods can be done to make comparable data. Some examples of metadata elements that could be included in an ocean economy metadata standards:

- Geography
- Industrial taxonomy used
- Economic and environmental/physical account data collection methods
- Valuation method
- Ecosystem model specifications
- Rules for maintaining confidentiality of data required to be kept private
- Survey processes, including sampling strategies and standard errors.

There are a number of international metadata standards that provide starting points for ocean economy data including standards for geospatial data (International Standards Organization, 2014), environmental data (U.N. Department of Economic and Social Affairs-Statistics Division, 2016) and the data systems being created by such initiatives as WAVES and TEEB may be adapted as metadata standards.

5.5 Using Discrete Projects to Build the Data Systems

Until recently, the history of ocean economic studies is largely comprised of single studies focused on single regions and single issues. Many studies are undertaken for purposes of policy analysis and evaluation while there are also many national and regional projects addressed to ocean economy sectors that emphasize sustainable development of ocean economies. In fact it is almost certainly the case that far more effort is expended on single purpose ocean economy related studies and development efforts than on integrated economic and environmental

accounting. Such effort should not be dissipated in the creation of data sets that cannot contribute to a more complete picture of ocean economic values.

There is now sufficient guidance and experience in the collection and analysis of the economic value data that many if not most projects studying the ocean can potentially be contributors to the long-term understanding of ocean economic values. This includes not only one time ocean values studies, but also ecosystem modeling and environmental data collection. Physical oceanographic and biological studies will be undertaken for their own purposes, and investigators in these studies are usually unaware, for example, of how their studies of marine or coastal ecosystems can contribute to the understanding of ecosystem services. However, with some modest changes in standard procedures these studies can become “platforms of opportunity” to collect data needed for the estimation of economic values.

Economic development and conservation projects related to sustainable use of ocean resources can also be platforms of opportunity, particularly those taking place in low income countries, where international development agencies can shape the design of the projects and use these projects to help low income countries build their ocean economic accounts. Such projects frequently have evaluation steps included in project design to assess outcomes, which are ideal opportunities to develop and use appropriate economic data. The Global Environment Facility, a major international funder of sustainability projects maintains its own evaluation staff, which assesses all of the projects in which the GEF participates in funding, although the current evaluation approach focuses on non-economic aspects of project management and outcomes (Independent Evaluation Office-Global Environment Facility, 2016).

There are two broad categories of projects that could provide possible platforms for the development of ocean economy data in all three aspects of sustainable blue economy accounts (national income, environmental assets, and ecosystem services). One group of projects focuses on economic development in a sustainability context includes fisheries, infrastructure in coastal areas, resource management programs and renewable energy. The special needs of small island nations, where the ocean comprises extremely high proportions of the national economy provide a special case of developing ocean accounting (Nunes, 2014).

There is also an array of conservation projects where economic values can provide critical information. Marine protected areas have become one of the most common ways to manage environmental assets and preserve ecosystems and their services. They are a key component of efforts to manage large marine ecosystems and their effects on national economic values are often a matter of debate. The use of natural infrastructure such as wetlands, coral reefs, and mangrove forests is also an important emerging type of ecosystem service whose value can be just as critical an asset as physical infrastructure normally included in the national income accounts such as dikes and other flood control measures.

A major advantage to using actual development and conservation projects as the platforms of opportunity for the collection of data is that, particularly for low income countries with weak economic data systems, these projects can develop the capacity with nations, regions, non-governmental organizations, and businesses to sustain the measurement process beyond the limits of the specific projects. The measurement of the sustainable blue economy will depend as much, or more, on building the capacity to undertake that measurement, as it will on resolving the theoretical, empirical, and practical issues discussed above.

This approach to developing a global blue economy measurement that is capable of both understanding the ocean's contribution to wealth creation, the sustainability of that contribution, and the sources of threats to that sustainability reflects the underlying reality that there will be no single directing and funding source to make that happen. It will be a cooperative effort of many governments and private organizations from around the world that proceeds at an uneven, but hopefully steady pace. The key to that cooperation will be information sharing across disciplines, countries, economic, and environmental organizations on the process and methods of economic data collection and analysis and the transformation of ocean economic studies from occasional or externally provided efforts to a regular part of the planning and conduct of ocean policy throughout the world. The efforts will almost surely more than pay for itself in increased understanding of the oceans' relationships to man's uses and vice versa. In their review of the feasibility and importance of creating comprehensive accounts linking the economy and environment, a review panel of the United States National Academy of Sciences concluded, "... improved data on the interaction between the economy and the natural environment would have substantial economic benefit for the nation" (Nordhaus and Kokkelenberg, 1999).

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