Natural Capital Considerations for an Extension of the U.S. Marine Economy Satellite Account

Jeffrey Wielgus[1], Monica Grasso[1], Charles Colgan[2], Jennifer Zhuang[1], Sarah Siegel[1], Joseph Conran[1], Tadesse Wodajo[1]

Abstract

In an effort to measure and track marine-dependent economic activities, the United States National Oceanic and Atmospheric Administration (NOAA) has developed two statistical tools: The Economics: National Ocean Watch (ENOW) and the Marine Economy Satellite Account (MESA). In both efforts, the focus has been on certain activities in selected sectors of the economy. MESA is developed within the framework of the System of National Accounts (SNA) and includes only economic activities that use essential marine inputs, produce goods or services to be used predominantly in the marine environment, take place in the marine environment, or need to be placed in proximity to the coast to take place. In addition, MESA only employs data on the annual flows of market-based values related to the marine activities. As an SNA-based tool, MESA also fails to systematically keep track of the contribution of the environment to the economy by properly accounting for the changes (both additions and reductions) in the environmental capital stock values.

This paper proposes an initial extension of MESA to include natural capital considerations by employing key elements of the System of Environmental-Economic Accounts Central Framework (SEEA-CF) adopted as the initial international statistical standard for environmental-economic accounting by the United Nations Statistical Commission in 2012. In addition to reporting the economic activities captured by the SNA structure, the SEEA-CF requires measuring both additions to the environmental capital stocks (due to natural growth or improved resource management) and reductions in these stocks (resulting from depletion from use in the production process or removal of resources from the natural stock). Considering the complexity involved in the measurement of the natural capital foundations of the ocean-related economy, the paper proposes to launch the MESA extension as a pilot project focusing only on selected data rich marine activities defined in MESA, namely, offshore oil and gas, commercial fishing, and beach recreation.

I. Introduction

The marine environment provides space and resources for a large number of economic activities. Some countries have developed satellite accounts[3] for the ocean based on the United Nations System of National Accounts (SNA), which provide valuable information on the role of oceans as providers of products for the economy, For example, the United States National Oceanic and Atmospheric Administration (NOAA) has developed the Marine Economy Satellite Account (MESA)[4]

[1] National Oceanic and Atmospheric Administration (NOAA)
[2] Middlebury Institute of International Studies
[3] Satellite accounts provide statistics for a particular aspect of the economy. Data presented in satellite accounts are consistent with BEA's core statistics.
[4] In this paper, "marine" refers to the U.S. Exclusive Economic Zones of the Atlantic, Pacific, and Arctic oceans (approximately 200 nautical miles off the US coast); the Gulf of Mexico, the Great Lakes (up to the international boundary with Canada), major estuaries and embayments, as well as segments of inland river downstream from the major seaports that accommodate ocean-going vessels, even though they are located far from the coast (e.g., Portland, Oregon, New Orleans and Baton Rouge, Louisiana).

in collaboration with the United States Bureau of Economic Analysis (BEA), and the Economics: National Ocean Watch (ENOW) data set. These efforts are a substantive improvement in our ability to understand how marine industries and activities contribute to society, and similar efforts are being undertaken around the world (Jolliffe et al. 2021).

However, these efforts do not account for specific environmental inputs and ecosystem services that support economic activities, or the manner and degree to which natural capital stocks are consumed or adversely affected by those economic activities (Colgan 2016, Fenichel et al. 2020, Hoagland et al. 2020). Applying the United Nations System of Environmental-Economic Accounts (SEEA) framework to understand the contributions of natural capital to activity in the marine environment would be a logical next step in characterizing the U.S. marine economy. Other countries, including Portugal and Canada, are beginning the process of developing ecosystem accounts for the ocean by building upon efforts to create marine satellite accounts.

MESA measures the economic contribution associated with the marine economy at the national level, identifies the economic activities responsible for producing these goods and services, and measures the output, value added, compensation, and employment associated with that production. To make the contributions of marine natural capital to the United States economy visible, MESA can be extended by following the guidelines of the SEEA Central Framework (SEEA-CF)[5], which is an internationally agreed standard for accounting for environmental assets and their supply to and use in the economy. SEEA-CF provides guidance for services from non-produced assets, such as minerals and fisheries, in greater detail than the System of National Accounts (UN et al. 2014).

This paper proposes an initial extension of MESA to include natural capital considerations by adopting key elements of SEEA-CF. It contributes to the implementation of guidelines to create a national system for natural capital accounting in the newly released United States National Strategy to Develop Statistics for Environmental-Economic Decisions. The paper is organized as follows: Section 2 discusses the United States Marine Economy Satellite Account (MESA). Section 3 provides a general discussion of natural capital considerations in future extensions of MESA. The fourth section outlines a general plan for extending MESA based on elements of SEEA-CF to three pilot sectors. The final section concludes and discusses possible challenges to the MESA extension as well as theoretical issues that will need to be addressed.

2. The U.S. Marine Economy Satellite Account

After World War II and the formation of the United Nations (UN), there was a desire to create international statistical standards that would allow comparisons of national economies across different countries. The UN Statistical Office released the first System of National Accounts (SNA) in 1953 and has released multiple updates, with the most recent in 2008 with support and input from other statistical agencies (EC et al. 2009).[6] The SNA provides standard recommendations to compile measures of economic activity and includes a strong statistical setup with internal consistency checks which allow for robust statistics. The recommendations describe a "coherent, consistent, and integrated" set of macroeconomic accounts that provide an overview of economic processes (EC et al. 2009: p. 1). The most well-known measure from the SNA is gross domestic product (GDP), but the accounts provide much more information about the economic state of a country at a certain point in time.

[5] See https://seea.un.org/content/seea-central-framework.
[6] For the historical updates of the SNA, see https://unstats.un.org/unsd/nationalaccount/HistoricSNA.asp

The SNA provides guidance for four types of accounts: (1) production accounts (to measure how much producers make and sell); (2) consumption and expenditure accounts (to measure how much households buy and consumer); (3) accumulation accounts and balance sheets (to measure the change in assets and their value—i.e, wealth); and (4) supply and use or input-output tables (to describe the interconnections of how goods and services flow through the economy). The SNA also provides guidance to adjust for changes in price through time (UN et al. 2009: p. 15).

The SNA does not explicitly focus on the ocean or marine dependent portions of a nation's economy. In the United States, efforts trying to measure marine economic activities date back to the 1970s. Building upon the National Ocean Economics Program (NOEP)'s methodology, the National Oceanic Atmospheric Administration (NOAA) started to develop and maintain the ENOW dataset in 2011. These data are focused on six economic sectors: living resources, marine construction, marine transportation, offshore mineral resources, ship and boat building, tourism and recreation.

However, the ENOW/NOEP approach has some drawbacks due to the limitations of the model and data sources used. For example, the ENOW/NOEP method used coefficients based on wages to allocate published GDP statistics to individual counties and industries, which introduced some bias compared to estimating the added value (GDP) directly using the input-output model and primary data sources from National Accounts. Therefore, in 2017 Congress directed NOAA and BEA to develop a satellite account for the U.S. marine economy. As a satellite account, MESA is consistent with the SNA and provides a measure of the economic activities associated with the marine economy in the United States.

The United States is not the only country moving to the satellite accounts approach. Portugal (Statistics Portugal, 2016), the United Kingdom (Stebbings et al., 2020), China (Wang and Wang, 2019), and Norway Randen et al. 2022) have also rolled out their experimental accounts in the past few years. The Organization for Economic Co-operation and Development (OECD) is also currently exploring an international ocean economy satellite account aiming to provide global totals and comparison across countries (Jolliffe et al. 2021).

There are four criteria as to whether an economic activity is included in MESA: (1) the activity takes place in the marine environment (e.g., marine transportation); (2) it uses essential inputs from the marine environment (e.g., seafood processing); (3) it produces goods/services predominantly for use in the marine environment (e.g., marine navigational equipment); (4) it would not take place if not located in proximity to the coast (e.g., beach vacation rental property). All economic activities in the SNA that meet the four criteria above are identified and categorized into 29 marine industries and ten sectors, including: Dredging, Restoration, and Other Construction, Fisheries and Other Bio-Products, National Defense and Public Administration, Offshore Oil and Gas, Power Generation, Professional and Business Services, Research and Education, Shipbuilding, Tourism and Recreation, and Transportation.

The marine environment referred to in the criteria above includes the U.S. Exclusive Economic Zones of the Atlantic, Pacific, and Arctic oceans (approximately 200 nautical miles off the US coast); the Gulf of Mexico, the Great Lakes (up to the international boundary with Canada), and major estuaries and embayments (e.g., the Chesapeake Bay and Puget Sound); as well as segments of inland river downstream from the major seaports that accommodate ocean-going vessels, even though they are located far from the coast (e.g., Portland, Oregon, New Orleans and Baton Rouge, Louisiana).

Many activities along the coast are not solely marine related, so a geographic determination of marine-dependent activity is not enough. Instead, MESA relies on the use of a set of coefficients that allows a more precise estimation of the marine-related portion of the activities . The development of coefficients, called "partials," establishes the portion of each class and demand

category that is specifically marine-dependent. If a good or service is not marine-related, then a partial of "0" is assigned to the category and it is excluded from MESA; if a good or service is entirely marine-dependent, then a partial of "1" is assigned to the category; finally, if one category includes both marine and non-marine activities, a percentage is estimated to partially include the category in MESA. For example, for electric power generation, we estimate the percentage of energy produced in the U.S. via water in the Great Lakes or Oceans or located offshore (such as offshore wind farms). To estimate the percentage, statistics collected either by private sectors or government agencies are used, including NOAA, BLS, Census, Department of Energy, Department of Defense, National Marine Manufacturers Association, Baker Hughes oil field service company, and DK Shifflet travel performance research firm, among others. Data released by government agencies are prioritized.

These partials are applied to the seven final demand categories of each good and service class in BEA's supply-use framework: personal consumption expenditure (PCE), exports (EXP), imports (IMP), intermediate inputs (II), government expenditure (GOV), inventory changes (INV), and private fixed investment (PFI) (Nicolls, et al., 2020). The application of partials and the more detailed industry classification allow generating a more complete estimation of the marine economy than the previous methods. Also, through this approach, the actual footprint of marine-related activities could extend far from coastal areas. For example, MESA is able to use partials to estimate the portion of inland sporting goods manufacturers that produce gear for use in ocean sports.

MESA reports the resulting statistics for both the customized set of groupings (the sectors and activities) that align better with natural "breakpoints" in the marine economy and the standard BEA industry groupings in the national accounts. The latest release of MESA, in June of 2022 with the 2020 annual data showed that the U.S. marine economy contributed $361 billion to the national GDP in 2020, generated $610 billion in gross output, and supported more than 2.2 million jobs. The marine economy accounted for 1.7% of national total gross output, 1.7% of total GDP, and 1.5% of total employment. The largest sector was the government, accounting for 38.4% of marine economy current-dollar value added. After that was real estate and rental and leasing. Compared to the whole economy, the marine economy contracted more in 2020 due to the Covid-19 pandemic, with a decrease of 5.8% from 2019 to 2020 of real GDP (compared to 3.4% decrease for the overall economy). The largest activity declines were tourism and recreation (a decline of 19.7%) and minerals (a decline of 12%).

3. Natural Capital in MESA

Although the SNA has been in use for policy for over half a century, there has long been criticism that the accounts, and especially GDP, are not comprehensive and do not provide a full representation of a society's well-being, including that linked to a healthy environment (Nordhaus and Tobin 1973). Alternatives have been proposed that help provide a greater context to the health of society, including the Human Development Index and Gross National Happiness Index, among many others (Fleurbaey 2009).[7] In many of these proposed indicators as well as the SNA, there is no consideration of the economy's impact on the environment nor a systematic process to keep track of the environment's contribution to the economy. Furthermore, with international focus to address climate change and its implications on natural capital, it is important to have measures tracking changes and any potential depletions of natural capital.

[7] The Human Development Index is found here: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI; The Gross National Happiness Index is found here: https://www.grossnationalhappiness.com/

Initiatives to account for natural capital in the measurement and reporting of economic performance culminated in the development of SEEA in 1993, but it took two more decades for SEEA- CF to be adopted as a statistical standard by the United Nations Statistical Commission (UN et al. 2014). The goal of the framework is to provide a comprehensive view of the stocks and changes in stocks of environmental assets. SEEA-CF generally follows the SNA's accounting structures, which allows the integration of information on economic and environmental assets. MESA and ENOW provide SNA-consistent data on the annual flows of market-based values related to the ocean activities. The Investment part of the SNA's National Income Accounts include both additions to capital stocks and reductions in capital stock values through consumption of fixed capital (depreciation) (BEA 2022).

The marine economic sectors captured in MESA can be classified into four types according to their connections with natural capital: 1) Marine Living Resources (including commercial fisheries) and Offshore Minerals (including offshore oil and gas) are the sectors that extract natural resources from the ocean; 2) Marine Living Resources and the Ocean and Coastal Tourism and Recreation (including beach recreation) are the sectors that directly benefit from a healthy and sustainable marine environment; 3) Offshore Minerals, Marine Transportation, Marine Construction, Ship and Boat Building, and Coastal Utilities are the sectors that do not heavily rely on the health of the natural ecosystems but may bring potential significant impacts to the environment 4) the Defense and Public Administration, Research and Education, and the Professional and Technical Services are the sectors that provide regulation, management, scientific and technological advances, and education on the uses of marine resources.

An expansion of MESA to consider natural capital will help fill in the gaps to include the value of stocks as well as the flows between the above economic activities and the natural environment, including investments needed to reduce the extent of environmental damage caused by the activities and the value of residual damages, consistent with the standards set out in SEEA-CF. However, these measurements of the natural capital foundations of the ocean-related economy requires a significantly more complex process than the estimation of MESA because the data and methods are much more complex and, for the most part, not nearly as readily available. The specific measure of natural capital is unique to each type of good or service in the ocean economy. Therefore, the MESA extension will start from the major marine economic activities with the most abundant statistics and explicit relationship between the economic activities and the flows and stocks from the environment.

The following is an illustration of these issues based on a discussion of three major ocean activities selected as the focuses for the experimental extension account: offshore oil and gas, commercial fisheries, and beach recreation. Conceptually, the natural capital underlying each of these economic uses of the ocean is the same: the value that the natural environment contributes to creation of valuable goods and services through the application of labor and capital. But the nature of that capital is very different among the three.

Offshore oil and gas exploration and production is one of the largest ocean related contributors to the U.S. GDP in the offshore mineral extraction sector (NOAA 2022). The value of the mineral reserves extracted and sold in the market is monitored in BEA's national accounts, statistics from the Department of Energy, and private sectors throughout the years. The valuation of mineral reserves is a well-established field in mining and mineral economics, and the methodology is fairly straightforward. As will be shown in Section 4, the U.S. system for managing offshore oil and gas rights is also ideally suited to estimation of natural capital.

Commercial fishing is the one economic activity that is found in virtually all the marine waters of the United States from the Bering Sea to the Caribbean. For more than 50 years, NOAA has been maintaining a variety of time-series statistics on fisheries in the U.S., including harvests, stocks,

spawn and mortality rates, overfishing status, etc., and conducting in-depth research studies on both deep sea and coastal ecosystems for sustainable fisheries. Some of these statistics, such as fish landing values, have been incorporated into BEA's models for the national accounts. Internationally, the SNA framework uses fish stocks as an example of natural assets that are in scope for the non-produced non-financial balance sheet[8]. The basic approach for measuring fisheries-related natural capital is also well defined in the SEEA-CF as measuring the value of fish stocks.

While oil and gas is the largest contributor to GDP among ocean sectors, the largest sector by far in terms of employment is tourism and recreation (NOAA 2022); beach recreation, extending from Maine to Hawaii, is the primary activity underlying the ocean tourism and recreation industries. Stakeholders would benefit immensely from the environmental data and natural capital information to sustain the future growth of this industry. Beach recreation presents a natural capital estimation process that has some similarities to minerals and fisheries but also some unique features. The natural capital value of beaches is a function primarily of the value of beach use for recreation, a value that has been extensively estimated for beach systems around the country using various versions of stated or revealed preference methods. For the purposes of promoting their coastal economies, state and local tourism bureaus and industry associations also keep active track of beach visits and consumer behavior statistics through regular surveys and IRS tax reports, which provide a foundational understanding on the value of the natural environment for tourism and recreation.

Extending concepts from the SNA framework, SEEA-CF requires measuring both additions to capital stocks and reductions in the stocks. Those reductions may be from depletion (removal of the resource from the natural stocks) and from the external environmental effects of utilizing the resource. Some of these external effects are associated with the production process, such as overfishing, others are connected to environmental residuals that offset the value of the natural capital goods, such as oil spills. Other reductions in stocks may be caused by effects external to the production process such as climate change.

The following discussion outlines the basic approach to estimating natural capital stocks and flows for the three ocean related resources identified above. At this stage of the project, it is possible to identify the conceptual basis for measuring natural capital, but the actual estimation process is riddled with data issues, some of which can be easily addressed, and some of which require significant investments in data collection. The ways in which natural capital can be reduced or augmented are also considered and methods for estimating changes will be tested.

4. Proposed Initial MESA Extension

For each of the marine activities defined in MESA, estimation of natural capital requires clarity with respect to the conceptual basis for accounting, the data issues, and how reductions in natural capital might be appropriately measured. Extending concepts from the SNA framework, SEEA-CF requires measuring both additions to natural capital stocks that support marine activities and reductions in the stocks. A completely specified set of accounts conforming to SEEA-CF would identify, in physical and monetary terms, the starting stock in each period, the additions and reductions to the stock, and the net change in the stock at the end of the period. This specification allows reporting on Net National Product (GDP minus depreciation), which is a measure of sustainable growth in the economy.

[8] A Non-Produced Non-Financial asset occurs without human production, but can be used in production. Examples are natural resources such as land, mineral and energy reserves, and non-cultivated biological resources.

Offshore Oil and Gas

Conceptual Basis for Accounting

The calculation of the resource rent may start with the issue of ownership of the resource. The three marine resources being evaluated have distinct ownership features. In the case of oil and gas and commercial fisheries, the Government of the United States is the owner. Offshore oil and gas lying under the seabed from 3 nautical miles seaward belongs to the national government under the Law of the Sea Conventions (LOSC)[9] of 1958, 1964 and 1982. Under the Outer Continental Shelf (OCS) Lands Act of 1954, as amended in 1978 (43 USC 29), the steward of that resource is the Department of the Interior, specifically the Bureau of Ocean Energy Management (BOEM). The OCS Lands Act is based on the premise that the seabed oil and gas resources will be developed and sold in the market and that the private oil and gas industry is authorized to explore, develop, produce, and sell the oil and gas.

The employment of the private oil and gas industry to explore, develop, and produce the resources presents the opportunity for optimal extraction of rents. This is accomplished through an auction system which works as follows:

Pursuant to the requirements of the OCS Lands Act, the Department of Interior develops a 5-year program which sets a schedule under which BOEM offers for sale a defined group of blocks (of nine square nautical miles) within an OCS planning area. The auction is called a lease sale because the winning bidder is given lease hold rights to the designated block; ownership of the undersea lands remains with the government, but the oil and gas becomes the property of the firm producing the resource. A lease gives the winner the right to drill for oil or gas (subject to environmental reviews) for up to five years; this period may be extended. The winning bid must be considered "fair market value"[10] as required by the OCS Lands Act. The use of sealed bid auction processes is used to assure that the bids are received in a fair market.

If oil and/or gas are discovered, the lease owner has the right to install development wells to extract oil or gas. Once the field development is complete, the lease owner may produce and sell the oil and gas. The lease owner is also responsible for transporting the oil and gas to shoreside processing via pipelines or tankers.

The terms of the lease ownership call for three payments to be made to the government. A rental fee is charged per acre for each 5,700-acre block. The rental fee is paid regardless of any discoveries or drilling activity. A royalty is charged as a percentage of the gross value of all oil and gas sold. The royalty is charged only if oil or gas are found.

The third payment is the value on which the auction is based, which is called bonus. The bids in the sealed bid auction are for what amounts to an up-front payment of a share of the value of oil and in excess of the royalty and rental payments. Because it is a competitive market, the optimal bid for the company wishing to have the right to explore for and perhaps acquire producible reserves is all remaining rents. The oil company, in other words, must pay to the government a substantial amount for an unknown (and at the time unknowable) right to possibly produce and sell oil. The only

[9] Although not yet a party to the treaty, the U.S. observes the LOSC as reflective of customary international law and practice.

[10] See https://www.boem.gov/oil-gas-energy/resource-evaluation/fair-market-valuation-methodology for a description of BOEM's fair market valuation method.

rational maximum bid in this situation is to offer an amount that just leaves the company the likelihood of a minimum return if oil is present.

In other words, the lease sale system using bonus bidding identifies and measures the resource rent which is transferred from the oil company to the government as a competitive market price.

Data

With this system it is possible to use BOEM records to measure the capital value of the currently leased OCS lands. This information may be retrieved from the website https://www.data.boem.gov, "Leasing Information" subsite. The value reflects both deposits that are being produced, and the value of bonus payments paid for leases based on oil company forecasts of the probability that they would contain oil and/or gas. Therefore, it can be considered a full asset value for the stock of oil and gas at any specific time.

This measure of the capital stock of offshore oil and gas can be updated every year to show changes in the stocks' values. This update will reflect changes in expected physical levels of oil and gas and expectations of prices as reflected in bonus bids. Additional information for the physical supply and use table may be constructed from reserves estimates prepared by BOEM.

Method: Reductions in Capital Value

This method meets many of the needs for a capital asset valuation for oil and gas, but it is incomplete because it does not include many of the important environmental issues associated with offshore oil and gas. SEEA-CF ensures that goods and services that protect or improve the environment are identified and their value recognized. The environmental accounts cover two broad categories of environmental expenditures: resource management and environmental protection.

Expenditures on environmental protection are generally internal expenditures within organizations that are accounted for as "inputs" to the final produced goods. SEEA-CF calls for these expenditures to be extracted from the standard accounts to explicitly measure environmental protection as a good or service. The environmental protection aspects of natural capital should include both those investments needed to reduce the extent of environmental damage caused by extraction of the oil and gas, and the value of residual damages that cannot be avoided. In the case of oil and gas, these can be grouped as operational environmental effects and investments and catastrophic effects.

Environmental impacts of oil and gas operations are well understood because of decades of experience in managing these effects under the authority of the OCS Lands Act, the Clean Air and Clean Water Acts, the Oil Pollution Act, and other federal (and state) environmental laws. Major effects of concern include small scale oil spills (from transferring fuels), air emissions from venting and flaring of natural gas, and the impacts of disposal of drilling materials. There are also solid and domestic wastes typical of ship-bound populations. In general, all of these impacts are managed by the oil companies to the extent required by their permits of operation. The physical extent of possible versus actual pollutants should be documented from permitting records. It is unclear if the monetary expenditures on environmental protection are routinely accounted for[11].

While regulation of the environmental effects of OCS exploration and production results in extensive investment in environmental protection, there are known to be uncontrolled residual

[11] If some of these activities are currently not accounted for, this leads to an underestimation of GDP.

effects. These include oil spills that are small individually but are cumulatively quite significant. This is particularly the case in the transportation subsystems of OCS oil and gas. These residual effects have been extensively studied and to the extent possible brought into their own account of environmental damages.

The final major element in the environmental accounts is the possibility of catastrophic oil spills. These are quite rare as the most frequent causes of such events are understood and controls are put in place. However, as the Deepwater Horizon oil spill of 2010 showed, the right combination of individually low probability events can still result in a large disaster. The damages to the environment as well as to the fishing and other ocean industries were of an order of magnitude to exceed total bonuses paid in some years.

Measuring the losses in environmental capital value from catastrophic oil spills is a major challenge for this project. The events are too large to be ignored but too infrequent to forecast. The development of an appropriate methodology will be an important part of the prototype project. An initial approach may be to adapt the stochastic simulation methodology that is used by DOI to estimate the probability of oil existing within a designated, but, this would be highly experimental research.

In addition to environmental protection expenditures, SEEA also calls for spending on resource management to be included in the accounts. For purposes of the prototype account, the OCS program management expenditures by BOEM can serve as a measure of resource management expenditures. Expenditures by other public agencies at the federal and state levels may also be included to the extent that distinct budgetary lines and expenditures can be identified.

Commercial Fishing

Conceptual Basis for Accounting

Natural capital for commercial fisheries represents the value of fish stocks from which fish are caught and sold. This value is a primary input to the commercial fisheries industries but one which is generally unpriced. The economic conceptual challenge with fisheries is to identify this unpriced value.

The valuation task will start with the selection of fisheries to examine. NOAA recognizes over 450 distinct fish stocks, of which some 250 are designated as "high value"[12]. The natural capital estimate will attempt to determine the economic value of some subset of these stocks. The discussion of asset valuation for fisheries in SEEA-CF focuses on market-based transactions used to secure the right to fish. Such transactions could include tradable fisheries permits or individual transferable quotas, the prices of which can be assumed to represent the resource rents that fishing enterprises are willing to surrender for the right to fish (Newell et al. 2005). However, data on share prices are not readily available for U.S. fisheries managed under tradeable catch shares.

In the absence of a market-based resource allocation system, the method recommended is the residual method. This method starts with the gross output value (essentially the landed value) and works backward to remove the costs of inputs such as fuel, bait, and labor to yield an approximate value of the profits of fishing. These profits are a combination of the return to the capital invested in the fishing boat, gear, etc. and the return to the natural value of the fish stock (however that is defined).

[12] These stocks make up about 80% of total landed value; see https://www.fisheries.noaa.gov/topic/population-assessments/fish-stocks.

Data

The empirical issues associated with a residuals estimate of value for a specific fishery begin with data on the gross output values. These data are regularly maintained by state and federal fisheries agencies and are generally of high quality. However, the same is not true of the values of the various purchased inputs, which are not regularly measured in any economic statistics series. Labor in commercial fishing, for example, is not measured by standard wage data because crew on fishing vessels are, with some exceptions, treated as individual contractors and their labor compensation computed as a share of the catch value. Other input cost data for variable costs such as ice, fuel, and bait may or may not be available, and there is little good data on the value of fishing vessels and gear. Some of these data may be available on an episodic basis for specific fisheries through various studies by NOAA's Fisheries Office in support of management decisions.

Method: Reductions in Capital Value

It is expected that a portion of the capital stock will be removed each year as depletion from both natural and man-made causes. In a renewable resource such as fisheries, the critical natural capital question is whether there is a long-term reduction in exploitable stocks and output in the fishing industry. The usual assumption is that this reduction in the physical size of fisheries stocks is brought about by overfishing, that is, fishing beyond the biological reproduction rate such that removal exceeds population growth.

This question of sustainable exploitation of the resources is clearly an important issue. U.S. fish stocks support a mix of unsustainable and sustainable fisheries, so this will become an additional criteria in selecting the stocks to be examined. However, traditional issues of over exploitation are not the only source of possible long-term change in capital stocks. Climate change is expected to reduce the size of fish populations in some areas and increase populations in other areas as populations respond to changes in thermal and chemical properties of the ocean. In addition, indirect impacts across multispecies fisheries (e.g., prey responses when fishing for predatory species) commonly result in stock changes.

Beach Recreation

Conceptual Basis for Accounting

The natural capital value derived from recreational use of beaches accrues in part to the recreational users and in part to the businesses that supply services, such as lodging or recreational equipment sales and rentals. The recreational user value is normally taken as an unpriced benefit since few beaches have entrance fees, and other variables included in the willingness to pay for recreation (e.g., travel costs) need to be estimated. This unpriced benefit has been extensively studied by economists using both stated and revealed preference methods. The majority of these studies have been done in a few states, including Florida, California, and New Jersey, but estimates have tended to fall within a narrow enough range to be useful. The share of the beach value accruing to businesses supporting tourists is, like the value of fish stocks, a portion of the profits of the relevant businesses.

DRAFT

Data

The estimation of beach values for recreational users has a substantial data foundation in the literature, but data on the number of users of beaches are almost entirely absent in most of the country. The same public access that creates the unpriced benefit that has been so extensively estimated also makes it extremely difficult to measure the number of beach visitors (and visits).

A further complication in user values is that a significant portion of the studies of user benefits are done with stated preference studies using one method or another (e.g., Landry et al., 2020; Lew et al., 2022). Such studies are well grounded in economic theory and methods, but the variety of statistical and empirical approaches used in such studies raise questions about comparability (De Valck et al., 2018; Glenk et al., 2020). These validity issues led the SEEA-CF and SEEA-Ecosystem Accounting standards to recommend against using stated preference studies and instead using market-price based valuation methods. The two benefit estimation methods that fit this criterion are hedonic pricing (e.g., Landry et al., 2019; Catma, 2020) and travel cost (e.g., Pascoe, 2019).

The producer side of the capital value may be estimated from industry data in the national income accounts for selected industries. The Tourism and Recreation industries in the ENOW and MESA data provides basic information. For industries such as hotels, the ENOW data includes only establishments located in shore adjacent zip codes, which will permit some localization of the relevant data.

Like commercial fisheries, therefore, natural capital estimation for beaches will require selection of case studies to estimate natural capital. In this case the choice of case studies will be made from beaches for which adequate user volume data is available; where user benefit studies, most likely using the travel cost method, have been done; and where there is adequate localized data on relevant businesses.

Method: Reductions in Capital Value

Beach use is generally not subject to substantial reductions in use, with the exception of occasional closures related to water quality issues, business cycle reductions in tourism spending. The COVID pandemic also generated beach closures. Like commercial fisheries, climate change is a threat to beach recreation through erosion of beaches or, in the case of some activities such as surfing, changes in water levels that alter recreation. The economic value of erosion on beaches, which reduces the available area and increases congestion has been studied to determine if user values decline with changes in the physical nature of the beach.

5. Discussion and Conclusions

In the United States, the development of the Marine Economy Satellite Account (MESA) and the Economics: National Ocean Watch (ENOW) database have provided a focus on the contribution of the ocean to the national and regional economies. Both of these efforts are based on conventional measurements for assessing relationships between the economy and the environment, and thus are limited in their assessment of the contribution of natural capital accounting to the economy. This paper has outlined a plan to extend MESA so that it begins to incorporate key aspects of the United Nations System of Environmental-Economic Accounts Central Framework (SEEA-CF) as a foundation to gain an understanding of the contributions of natural capital to economic activities in the marine environment.

DRAFT

Standard national income accounting based on the United Nations System of National Accounts, including MESA, measures flows of economic activity in a specific period. In contrast, accounting based on SEEA-CF includes measures of both stocks and flows of economic values. An extension of MESA would allow expanding the definition of "capital assets" to include natural resource assets and to account for their depreciation and depletion. Measurement of the natural capital foundations of the ocean-related economy requires a significantly more complex process than the estimation of MESA because the data and methods are much more complex and, for the most part, not nearly as readily available. Thus, this paper proposes to begin the MESA extension by developing pilots for ocean activities defined in MESA that are relatively data rich: offshore oil and gas, commercial fishing, and beach recreation. However, a number of challenges will need to be addressed.

Fish stocks are sometimes well defined from a biological perspective, but traditional ideas of fish stocks have been significantly undermined by the presence of multi-species fisheries in which complex predator-prey and ecosystem conditions have more influence on the total amount of fish available to be caught than the simple process of natural population change adjusted for the amount of fish caught. There are also dozens of commercial fisheries throughout the U.S., each with its own natural and economic characteristics, as well as stocks shared with other countries, and spread between state and federal waters. The SNA contains a national balance sheet that includes "non-produced" assets, such as fish stocks. However, their value is not fully accounted for, as discussed below. There is also little systematic economic data of the type needed for natural capital estimates. There will be no single natural capital estimate for commercial fisheries but a set of experimental applications of natural capital.

There are biological and ecological challenges in fisheries as well. Traditional fisheries economics models, which underpin natural capital valuation, assume that there is a well-defined biological population in which natural population change is modified by population reductions from fishing. The problem is that it is increasingly recognized that single species "stocks" are a misrepresentation of what actually happens in the ocean, where complex multi-species predator-prey relationships mean that a more complex concept of the natural capital being value is required. For fish stock valuation, trophic interactions can be captured in the shadow prices of prey and predator species (Yun et al., 2017).

A challenge related to beach recreation is that the SEEA standards indicate a definite preference for market-based (or revealed preference) measurement of non-market values, which may limit the available valuation data. More importantly, there is very little accurate measurement of the actual number of people using beaches. Beaches, even when publicly owned and freely available for recreational uses, rarely have accurate counts of users from which total beach values, and thus natural capital estimates can be made.

There are now efforts to create SEEA accounts across 90 countries, including efforts in a number to develop ocean accounts (Global Assessment 2022). Australia released experimental estimates for a National Ocean Account in August of 2022 which include measures of extent, condition, and carbon stocks for mangroves and seagrasses. Norway published a pilot ocean satellite account in the spring of 2022 and has released information on plans for developing an ocean account.

In January 2023, the United States launched the National Strategy to Develop Statistics for Environmental-Economic Decisions, which provides guidelines to create a national system for natural capital accounting. The work proposed in this paper will contribute to the national strategy and will benefit from the lessons learned by countries that are already conducting natural capital accounting for the oceans. The extension of MESA will be a first step to account for the contribution of ocean natural capital to the economy. It will also provide essential information for industries relying on the ocean. The proposed pilots will shed light on data and research needs for the development of a consistent accounting system for marine natural capital. The pilots will offer

exploratory work to identify challenges and identify solutions to continue advancing in helping to implement the National Strategy. The data gleaned in the MESA extension will also be useful for the eventual development of accounts for specific ecosystems, which will provide another layer of information to ocean-dependent industries. A decline in the health of ocean ecosystems will affect key industries such as commercial fishing and tourism. A decline in the healthy cover of coastal ecosystems such as mangroves will make coastal communities more prone to damages from natural disasters. Decision makers at all levels will benefit from ocean natural capital accounting data in helping make a wide range of policy decisions.

Acknowledgements: We are grateful to Arnab Acharya, Jeff Adkins, Doug Lipton, and Andrew Scheld for their insightful suggestions, which helped improve an earlier version of the manuscript. Errors and omissions remain solely the responsibility of the authors.

References

BEA (Bureau of Economic Analysis). Concepts and Methods in the U.S. National Income Accounts (Chapters 1-13), December 2022.Also available from: https://www.bea.gov/resources/methodologies/nipa-handbook

Catma, Serkan. "Non-market valuation of beach quality: Using spatial hedonic price modeling in Hilton Head Island, SC." Marine Policy, Volume 115, 2020. https://doi.org/10.1016/j.marpol.2020.103866

Colgan, Charles S. "Measurement of the ocean economy from national income accounts to the sustainable blue economy." *Journal of Ocean and Coastal Economics*, Volume 2, 2016.

De Valck, Jeremy, and John Rolfe. "Spatial heterogeneity in stated preference valuation: Status, challenges and road ahead." International Review of Environmental and Resource Economics 11.4 (2018): 355-422.

European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank. System of National Accounts 2008. New York, 2009. United Nations Publication, Sales No. E.08.XVII.29. Also available from: https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

Fenichel, Eli P., Ethan T. Addicott, Kristine M. Grimsrud, Glenn-Marie Lange, Ina Porras, and Ben Milligan. "Modifying national accounts for sustainable ocean development." Nature Sustainability 3, no. 11 (2020): 889-895. https://www.nature.com/articles/s41893-020-0592-8

Fleurbaey, Marc. "Beyond GDP: The quest for a measure of social welfare." *Journal of Economic literature* 47, no. 4 (2009): 1029-1075.

Glenk, Klaus, Robeert J. Johnston, Jürgen Meyerhoff and Julian Sagebiel. "Spatial Dimensions of Stated Preference Valuation in Environmental and Resource Economics: Methods, Trends and

DRAFT

Challenges." Environ Resource Econ 75, 215–242 (2020). https://doi.org/10.1007/s10640-018-00311-w

Hoagland, Porter, Di Jin, and Stace Beaulieu. "A primer on the economics of natural capital and its relevance to deep-sea exploitation and conservation." In *Natural Capital and Exploitation of the Deep Ocean*, (2020) pp. 25-52. Oxford University Press. https://doi.org/10.1093/oso/9780198841654.001.0001

Jolliffe, James, Claire Jolly and Barrie Stevens. Blueprint for improved measurement of the international ocean economy: An exploration of satellite accounting for ocean economic activity. OECD Science, Technology and Industry Working Papers, 2021/04. Available from: https://doi.org/10.1787/aff5375b-en.

Jolliffe, James; Jolly, Claire; and Stevens, Barrie (2021) "Key Considerations for the Development of Internationally Comparable Statistics on Ocean Economic Activity," Journal of Ocean and Coastal Economics: Vol. 8: Iss. 2, Article 6. DOI: https://doi.org/10.15351/2373-8456.1140

Landry, Craig E. , J. Scott Shonkwiler, John C. Whitehead. "Economic Values of Coastal Erosion Management: Joint Estimation of Use and Existence Values with recreation demand and contingent valuation data." Journal of Environmental Economics and Management, Volume 103, 2020.

Landry, Craig E., Dylan Turner and Tom Allen. Hedonic Property Prices and Coastal Beach Width, Working Paper (October 1, 2019). Available at SSRN: https://ssrn.com/abstract=2474276 or http://dx.doi.org/10.2139/ssrn.2474276

Lew, Daniel K., Anderson, Leif E., Lipton, Douglas W., Murphy, Tammy B., and Wallmo, Kristy (2022) "Adherence to Best Practices for Stated Preference Valuation within the U.S. Marine Ecosystem Services Literature," Journal of Ocean and Coastal Economics. Vol. 9: Iss. 1, Article 3. DOI:https://doi.org/10.15351/2373-8456.1159

Newell, Richard G., Papps, Kerry L., and Sanchirico, James N. (2005) "Asset Pricing in Created Markets for Fishing Quotas. Discussion Papers 10639, Resources for the Future, Washington, D.C.

Nicolls, William, Connor Franks, Teresa Gilmore, Rachel Goulder, Luke Mendelsohn, Edward Morgan, Jeffery Adkins, Monica Grasso, Kate Quigley, Jennifer Zhuang and Charles Colgan. Defining and Measuring the U.S. Ocean Economy Bureau of Economic Analysis, U.S. Department of Commerce. Available from: https://www.bea.gov/system/files/2021-06/defining-and-measuring-the-united-states-ocean-economy.pdf

NOAA (National Oceanic and Atmospheric Administration), "NOAA Report on the U.S. Marine Economy." NOAA Office for Coastal Management. 2022. Charleston, SC. Available at: http://coast.noaa.gov/digitalcoast/training/econreport.html

Nordhaus, William D., and James Tobin. "Is growth obsolete?." In *The measurement of economic and social performance*, pp. 509-564. NBER, 1973.

DRAFT

Pascoe, Sean. "Recreational beach use values with multiple activities." Ecological Economics 160 (2019): 137-144.

Randen, Trine H. B., Kristine Grimsrud, Tarik Ogbamichael and Tor Kristian Ånestad. Progress on ocean accounting in Norway. Paper for the 28th London Group meeting 2022. Siegburg, Germany. Available from: ttps://seea.un.org/sites/seea.un.org/files/randen_1.pdf

Statistics Portugal. Satellite Account for the Sea - 2010-2013, Methodological Report, Department of National Accounts, December 2016. Available from: https://www.ine.pt/ngt_server/attachfileu.jsp?look_parentBoui=300613867&att_display=n&att_download=y.

Stebbings, Emily, Eleni Papathanasopoulou, Tara Hooper, Melanie C. Austen, and Xiaoyu Yan. "The marine economy of the United Kingdom." *Marine Policy*, Volume 116, 2020. https://doi.org/10.1016/j.marpol.2020.103905

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, and The World Bank. System of Environmental-Economic Accounting 2012— Central Framework. New York, 2014. United Nations Publication, Sales No. E.12.XVII.12. Available from: https://unstats.un.org/unsd/envaccounting/seearev/seea_cf_final_en.pdf

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, and The World Bank. The System of National Accounts, 2008. New York, 2009. Available from: https://unstats.un.org/unsd/nationalaccount/docs/sna2008.pdf

Wang, Yixuan and Nuo Wang. "The role of the marine industry in China's national economy: An input–output analysis." *Marine Policy*, Volume 99, 2019. https://doi.org/10.1016/j.marpol.2018.10.019

Yun, Seong Do, Barbara Hutniczak, Joshua K. Abbott, and Eli P. Fenichel. "Ecosystem-based management and the wealth of ecosystems." Proceedings of the National Academy of Sciences of the United States of America 114 (2017): 6539-6544.

DRAFT