Title: Accounting for Natural Inputs in the Marine Economy Satellite Account
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NOAA has spent many years developing better measures of the U.S. marine economy. This includes the Marine Economy Satellite Account (MESA)- developed in collaboration with the US BEA- and the Economics: National Ocean Watch (ENOW)**,** created using data from the BLS and Census. These efforts are a substantive improvement in our ability to understand how marine and coastal environments contribute to society, and similar efforts are being undertaken around the world (Jolliffe et al 2021). However, these ongoing efforts to characterize the U.S. ocean economy 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 (Fenichel et al 2020, Hoagland et al 2020). Applying the UN-SEEA framework to understand the contributions of natural capital to activity in the marine environment is a logical next step in characterizing the U.S. Marine Economy. Other countries, (e.g., Portugal, Canada) are also beginning the process of developing ecosystem accounts for the ocean by building upon efforts to create satellite accounts.

Natural capital accounting (NCA) for the marine environment based on the SEEA framework would create the following benefits:

1. Provide a consistent way to track the health of ocean ecosystems and the capacity of these systems to provide ecosystem services and other inputs to the economy;
2. Highlight trade-offs that may exist between human activity and the depletion of natural capital;
3. Track progress in ocean conservation activities, and identify areas for improvement;
4. Inform policy makers, industries, and the public on the use and management of ocean resources and economic activities that rely on the ecosystem services that oceans provide.

Creating comprehensive national scale accounts for the marine environment based on the SEEA framework presents several challenges:

1. While observing infrastructure in marine and coastal environments continues to improve, we lack comprehensive coverage for data to track the health of key ocean resources. Groups such as the Global Ocean Observing System provide a list of key ocean variables necessary for tracking ocean health and are working to improve observational capabilities. Many existing remote sensing technologies are unable to monitor the entire water column or benthic conditions. Existing data is often not consolidated, nor easily discoverable for non-experts (Hooper et al 2019).
2. There are excellent examples of local and ecosystem specific measurements of the stock and flow of marine ecosystem services such as for Gulf of Mexico reef fish (Fenichel and Abbott 2014), Long Island marine and coastal habitat (Dvarskas 2019), and several case studies for natural infrastructure and blue carbon (Rouleau et al. 2021). National scale pilot accounts have been created for several terrestrial based ecosystem services (Bagstad et al 2021), but we are not aware of any efforts to develop national scale accounts for marine specific ecosystem services.
3. There are many efforts to understand marine related ecosystem processes that could be leveraged, but most are not framed explicitly in terms of natural capital and final ecosystem goods and services (FEGS) as defined by Boyd and Banzhaf (2007). There have been several efforts to explicitly classify the physical components that contribute to ecosystem services. One example is the Coastal and Marine Ecological Classification Standard (FDGC 2012), which accounts for unique attributes of the marine environment. Another example is the EPA's National Ecosystem Services Classification System, which provides a more comprehensive taxonomy of FEGS (US EPA 2020).

To create a comprehensive set of marine natural capital accounts following the SEEA framework, we must track the extent and condition of important marine ecosystems, and measure the flow of ecosystem services to industries and individuals. A primary challenge for the extent and condition accounts in the marine environment is identifying and aggregating the necessary biophysical data. To address the flow of

ecosystem services to industries and individuals there are two main approaches. The first is to start with the ecosystem service in question and determine what economic activities it supports. The second approach is to start with an economic activity and determine which ecosystem services support it (Colgan et al. 2021).

We will show how MESA can contribute to the second approach and can be used as a building block for creating supply and use tables for ecosystem services that support ocean industries. To do this, we will present as examples two industries from MESA: commercial fishing (renewable) and offshore minerals (non-renewable).We have identified these industries as candidates for pilot studies based on their heavy dependence on, and clear linkage to natural inputs, the likely availability of data, and their ability to serve as examples for future cases. For each of these industries we will determine the type of marine based ecosystem services that contribute to the industry. We will attempt to determine the flow of ecosystem services to the industry and the value of these ecosystem services. In general, extending national income accounts, such as MESA, to account for the contribution of, and impacts to, ecosystems services involves adding measures of the value of natural capital used as raw material inputs to the production of goods and services, and adjusting the values in the national income effects for the negative effects of economic activities such as pollution (Colgan et al. 2021).

For commercial fishing, MESA has captured the GDP and gross output of the harvest, seafood markets, processing, and aquaculture in the income account. The Environmental Account will expand upon MESA to assess the values of the fish stocks, which are determined by the size of the stock and the landing prices. These statistics can be obtained from NOAA Fisheries' quarterly National Fish Assessment reports for federally-managed fish stocks and the annual Commercial Landing Statistics, with landing value identified by species. The stock values, combined with other fixed assets (e.g., boats) and the income account, provides a more comprehensive view of the fishing industry. In addition, pollutants and other environmental stressors will be taken into account, which can impact fish stock or make the fish unsuitable for human consumption. Some of this information can be found in NOAA's Integrated Ecosystem Assessments, which provide a scientific basis for ecosystem-based fisheries management, including the status and trends of the ecosystem conditions and ecosystem services, predictions under different management scenarios, and impacts of relative factors and activities like clean water policies, agriculture runoffs, recreation, and marine shipping. The MESA (income account) framework can also be adjusted to better reflect the expenditures of the public and private sectors on pollution prevention and mitigation to achieve sustainable fisheries. For the offshore minerals example, MESA captures GDP and gross output for oil, gas, sand and gravel production. Data to compile natural capital accounts for those resources can be obtained from the Energy Information Administration US Crude Oil and Natural Gas Proved Reserves and the Bureau of Ocean Energy Management Outer Continental Shelf Reserve Estimates.

Measures of natural capital become valuable when they are reliably compiled over time. Building on existing efforts to measure the contributions of marine resources is likely the most reliable way to create and maintain the production of natural capital accounts for the marine environment.

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