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COMMENTARY

Including biological diversity in natural capital accounts for marine biodiversity conservation and human well-being

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Abstract
Natural capital (NC) accounts measure and value the benefits that ecosystems provide to humans. Marine biodiversity supports human well-being directly by providing a source of food (e.g. wild fish), and indirectly by providing employment (e.g. fisheries, and tourism) and recreation (e.g. diving). The inclusion of the marine environment in NC accounting is relatively new. Central to the NC framework, biodiversity is one of the most challenging aspects to account for. Here, we consider the potential for marine biodiversity to be included in NC accounts, and explain why this is in line with current policy directions towards achieving sustainability and well-being. We present a set of potential indicators that could be used to assess ecosystem extent and ecosystem condition through their biodiversity, and inform policies aimed to improve sustainability and human well-being. We conclude that including biological indicators in NC accounts will help to consider marine biodiversity conservation and economic activities in blue spaces as complementary components of well-being. NC accounts can facilitate decision-making by showing, in few interconnected tables, trends in the provision of biodiversity in a specific area and for specific ecosystems. This makes potential trade-offs between ecosystems, ecosystem services, and economic activities more apparent.

Keywords Ecosystems · Ecosystem services · Sustainable development

Introduction

Humans depend on a wide range of ecosystem services provided by nature, including clean air and water, and the raw materials that form the basis of all economic activities. The average global consumption of this terrestrial and marine ‘natural capital’ (NC) currently

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exceeds its natural ability to regenerate (Brondizio et al. 2019; Dasgupta 2021). The total global contribution of marine, coastal and transitional ecosystems to human well-being is high compared to their terrestrial and freshwater counterparts (Barbier 2011; de Groot et al. 2012; Costanza et al. 2014). The importance of NC, of nature as an 'asset' to be appropriately managed (Dasgupta 2021), is increasingly recognised. This has led to a growing interest in NC accounting, i.e. the recording of the condition of the essential components (assets) of NC, their value, and how these are changing over time (Mace 2019), to understand the contribution of the environment to the economy and the impacts of economic activities on the environment.

Natural capital accounting for the marine environment

NC accounting brings together economic and environmental information to measure the contribution of the environment to the economy, and the impact of economic activities on the environment, highlighting the dependency of economic activities on nature, and our stewardship role in protecting nature. NC accounts are designed to present information that is comparable over time and across regions (Turner et al. 2019), to inform measures of intervention and to allow policy-makers to objectively review the outcomes of management decisions. Accounts are developed following the System of Environmental-Economic Accounting (SEEA)'s Central Framework (SEEA CF) (UN et al. 2014) and the newly released spatially-explicit integrated statistical framework SEEA Ecosystem Accounting (SEEA EA) (UN 2021). Other nation-specific guidelines are also applied, but always following the System of National Accounting (SNA) overarching guidelines (UN 2021), such as, for example, using exchange values (e.g. market prices) only (UN et al. 2014) to be consistent with existing standards. The SEEA EA includes accounting tables for producing internationally comparable statistics on ecosystem extent and condition, physical ecosystem services supply and use tables (physical accounts), and monetary accounts tables, where a valuation on the ecosystem assets and ecosystem services reported in the physical accounts is performed (UN 2021). The inclusion of the marine environment in NC accounting is relatively new. The SEEA EA locates an Ocean Accounts Framework within its thematic accounts. Thematic accounts are standalone (sets of) accounts that organise data around specific policy-relevant themes, including biodiversity (i.e. the variety, quantity and distribution of life on Earth). The consideration of biodiversity, including marine biodiversity, is limited due to challenges related to its accounting. Figure 1 illustrates the position of marine biodiversity within a SEEA EA Ocean Accounts Framework.

Here, we consider how marine biodiversity indicators could be integrated in NC accounts.

Marine biodiversity and human well-being

The importance of biodiversity for human well-being is acknowledged by numerous international commitments, starting from the Convention on Biological Diversity (CBD) that, in 1992, shifted the importance of biodiversity from mere inventory of life on Earth to the need for its conservation, sustainable use and equitable sharing of its benefits. More recently, the UN Sustainable Development Goals (SDGs) and various influential reports have re-emphasized the importance of biodiversity and the dangers

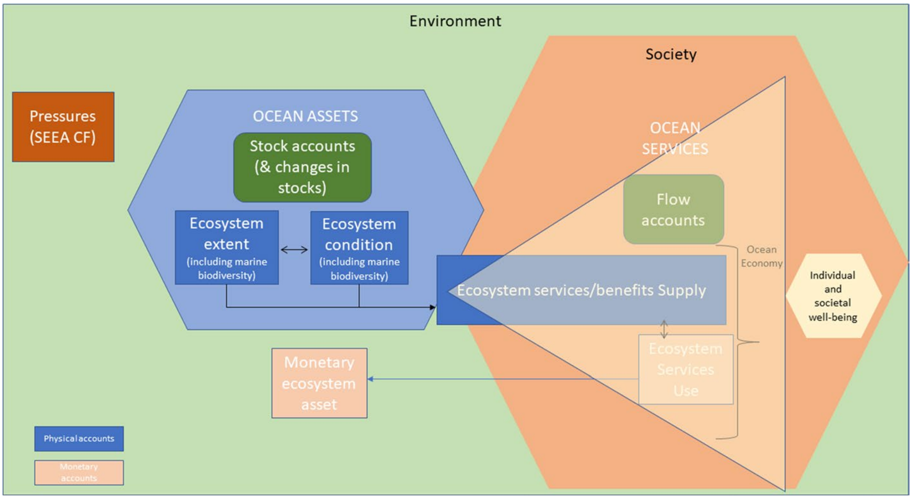

Fig. 1 Marine biodiversity within a SEEA EA Ocean Accounts Framework. Adapted from Figs. 13.2, 2.1, and 2.2 of the System of Environmental-Economic Accounting—Ecosystem Accounting—Final Draft—Version 5 February 2021 Prepared by the Committee of Experts on Environmental-Economic Accounting Copyright © 2021 United Nations. Used with the permission of the United Nations (UN 2021)

it faces (King et al. 2021). Nearly 30 years on, in the wake of the failure to meet previously agreed biodiversity targets, the CBD outlined the ambitious vision of "Living in Harmony with Nature".

In the 1990s, national economic accounting started to consider the contribution of nature to the economy and how economic activities were contributing to the degradation and depletion of natural resources (Cavalletti et al. 2020; Bartelmus 1994, 2015). Today, the SEEA EA provides a framework to systematically collect physical and monetary data about ecosystems, their health, and their contribution to human well-being. As suggested by the SEEA EA (UN 2021), one use of these data is to develop composite indices to aid policy development and decision-making, much like the data in the SNA provide information on gross domestic product (GDP). The warning here is to avoid the use of single indicators or indices as proxies for complex entities. The perception of GDP as a proxi for well-being has produced distorting effects in society (Dynan and Sheiner 2018; Coyle 2016).

Single indicators for human well-being appear desirable because of their simplicity, as do single indicators for biodiversity to track progress towards targets. However, complexities of biodiversity and human well-being require multiple measures across scales of space and time, and across ecological and socio-economic dimensions (Pereira et al. 2013; Daly et al. 2018; Mace et al. 2018; Stiglitz et al. 2018).

A major difficulty in producing a coherent picture of the current status and trends of marine biodiversity is the lack of standardised indicators and coordinated approaches for measuring and tracking change. A recent alternative approach by Mace (2019) focuses on 'critical ecosystem capability', i.e. those aspects of nature we have reason to value. These aspects are defined as "the capabilities and functioning required from the natural environment for society". To support the realisation of a Blue Economy, NC accounts need to indicate the state of the marine environment, and whether marine resources are used sustainably to continue supporting the Ocean, marine economic activities and human well-being.

Marine biodiversity indicators

Potential biodiversity indicators to inform marine biodiversity accounts are considered in Tables 1 and 2. Table 1 lists indicators of ecosystem extent described in terms of a specific spatial unit [according to the SEEA EA (UN 2021) definition of Ecosystem Accounting Area (EAA), this could be the boundary of a country or a protected area]; its disaggregation by ecosystem type; and the unit of measure considered such as hectares or a percentage of the opening areal extent. Table 2 includes potential biodiversity indices, also subdivided by their spatial unit in terms of EAA; disaggregation by ecosystem type and ecosystem condition classes; and unit of measurement in terms of composite indices of condition for each indicator.

Marine biodiversity accounts using such biodiversity indicators would support ambitions to inform biodiversity policies and develop the indices needed to monitor progress towards the achievement of the biodiversity goals and targets set out by the Post-2020 Global Biodiversity Framework (UN 2021).

The SEEA EA (UN 2021) acknowledges that biotic ecosystem characteristics, and their associated indicators, have metrics at a range of scales from local to global (Tables 1 and 2). As biodiversity is scale-dependent, it cannot simply be upscaled or aggregated across scales. The total biodiversity value of larger EAAs therefore cannot be derived merely by averaging or summing biodiversity estimates of ecosystem assets recorded in ecosystem condition accounts (King et al. 2021). Consequently, some individual biodiversity metrics, such as the diversity of ecosystem types within an EAA, should not be attributed to individual ecosystem assets. They should instead be considered aggregate measures of biodiversity. Technical guidance on spatial aggregation of biodiversity-focused metrics for ecosystem condition accounts is under development (UN 2021), but links between EAAs remain under-analysed, especially in the marine environment (Chen et al. 2020). Changes in abundance or distribution of a species in one accounting area may spread to other places, areas, species, and ecosystems. Spill-over of multiple target and non-target species from Marine Protected Areas (MPAs) to areas outside, for example, can affect species diversity both within the MPA and in unprotected areas nearby (Schratzberger et al. 2019). Such effects cannot be entirely mapped or counted.

The use of SEEA accounts has been experimented for the Great Barrier Reef in Australia (ABS 2015) and for potential disaggregated MPA accounts in Italy (Cavalletti et al. 2020). As highlighted in the UK, biodiversity and other ecosystem services indicators reported in NC accounting tables could facilitate the evaluation of potential marine net gains and their policy implementation (NCC 2019; Dasgupta 2021). The Netherlands have highlighted how ecosystems and biodiversity accounts could support the implementation of the SDGs and in particular SDG 14 (PBL 2018). A ‘Natural capital accounting for the North-East Atlantic area’ was published in summer 2021 (Blazquez 2021; OSPAR 2021).

Marine biodiversity in natural capital accounts for conservation, economic prosperity and human well-being

NC accounts would provide a stronger evidence base to inform policy such as the SDGs through the monitoring and management of coastal and marine ecosystems as suggested in the Poverty-Environment Accounting Framework (United Nations Development Programme 2017). For developing countries, where new data need to be collected to inform

Table 1 Potential marine biodiversity extent indicators. Adapted from Table 14.1 of the System of Environmental-Economic Accounting—Ecosystem Accounting—Final Draft—Version 5 February 2021 Prepared by the Committee of Experts on Environmental-Economic Accounting Copyright © 2021 United Nations. Used with the permission of the United Nations (UN 2021)

Extent indicators[a]	Spatial unit	Disaggregation	Unit of measurement
EAA covered by a specific habitat type (e.g. IUCN or EUNIS habitat classification)	EAA (e.g. Marine Protected Area; Exclusive Economic Zone etc.)	Ecosystem type (e.g. kelp forests, seagrass beds, saltmarsh, mangroves, rocky reefs, soft sediments)	Spatial measure (various area cover statistics to link habitat type and Ecosystem Services (see Lai et al. 2018)
Change of area covered by a specific habitat type (e.g. IUCN or EUNIS habitat classification) during an accounting period	EAA	Ecosystem type	Proportion of ecosystem retained between various points in time during an accounting period
Area unchanged (opening stock − reduction)	EAA	Ecosystem type	Proportion of area changed in respect of opening stock
Area changed (additions + reductions)	EAA	Ecosystem type	Proportion of area changed in respect of opening stock

[a] The extent account would present the area recorded for a specific ecosystem at two points in time, i.e. ‘opening stock’ and ‘closing stock’, respectively. This would help explain changes over time through identification of additions and reductions to stock

Table 2 Potential marine species-based biodiversity indices that reflect key ecosystem components and processes that influence the extent, state and functioning of ecosystems. Adapted from Table 14.2 of the System of Environmental-Economic Accounting—Ecosystem Accounting—Final Draft—Version 5 February 2021 Prepared by the Committee of Experts on Environmental-Economic Accounting Copyright © 2021 United Nations. Used with the permission of the United Nations (2021)

Marine biodiversity condition indicators[a]	Further description	Spatial unit	Disaggregation	Unit of measurement
Physical condition state index		EAA (e.g. Marine Protected Area; Exclusive Economic Zone etc.)	Ecosystem type (e.g. kelp forests, seagrass beds, saltmarsh, mangroves, rocky reefs, soft sediments) and ecosystem condition classes	Index (composite index of all ecosystem condition classes and sub-classes; e.g. estuary condition and harbour condition)
Compositional state indicator	Composition/diversity of ecological communities at a given location and time	EAA	Ecosystem condition sub-classes	Index (e.g. species richness, genetic diversity etc.)
Structural state indicator	Aggregate properties (e.g. density) of the biotic components of the marine ecosystem	EAA	Ecosystem condition sub-classes	Index (e.g. presence/absence of threatened marine species, endemics etc.)
Functional state indicator	Summary statistics (e.g. frequency, intensity) of interactionsbetween marine species	EAA	Ecosystem condition sub-classes	Index (e.g. metrics on the size, structure and function of different trophic levels in marine food webs)
Seascape indicator	Aggregate properties of the seascape (e.g., seascape diversity, connectivity, fragmentation of biogeographical sea regions based on their distinct combinations of salinity and temperature regimes)			Aggregate metrics from above, describing mosaics of ecosystem types at coarse (seascape) spatial scales (e.g. Arctic, Baltic, Atlantic, Mediterranean, Black Sea)

[a]Indicators should encompass all levels of biodiversity including genetic, within species, between species and ecosystems. Many components of biodiversity are relevant and contribute to quantifying characteristics of ecosystem condition, and should not be constrained to taxonomic units. Indicators should be developed based on a benchmark or reference condition. For specific UK examples see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925779/25-yep-indicators-2019.pdf

marine NC accounts, and where the poverty-environment nexus is stronger, marine biodiversity measurement and the implementation of guidelines such as those under development by the Global Ocean Accounting Partnership (https://www.oceanaccounts.org/) could be supported by public and/or private financial mechanisms (Ferraro and Kiss 2002; Duarte et al. 2020).

Discussing the relevance of biodiversity in NC accounts is timely with the recent release of the IPBES global assessment report on biodiversity and ecosystem services (Brondizio et al. 2019), the publication of The Dasgupta Review on the Economics of Biodiversity (Dasgupta 2021) and the imminent 15th Conference of the Parties (COP15) of the CBD in 2022. Accounts to record economic activities are established, and NC accounts are being developed. A further step will involve the development of accounts that systematically collect information and data about human and social capital including the relevance of human diversities and capabilities (Sen 1999), to create polices aimed at a more sustainable and fairer future (Solow 1973). A practical way forward could be to couple NC accounts information with re-organised, adapted, and existing data and knowledge on the marine realm and related socio-economic data through a network of complementary accounts (Turner et al. 2019; King et al. 2021). As discussed here, the use of NC accounting tools, and biodiversity indicators in policy-making, will help to adopt a perspective which considers marine biodiversity and economic activities in blue spaces as complementary components of well-being, support policies to meet the SDGs and their evaluation (Bordt 2018), and approach the CBD's 2050 vision of humans living in harmony with nature.

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