Marine Spatial Planning and Ocean Accounting: synergistic tools enhancing integration in ocean governance

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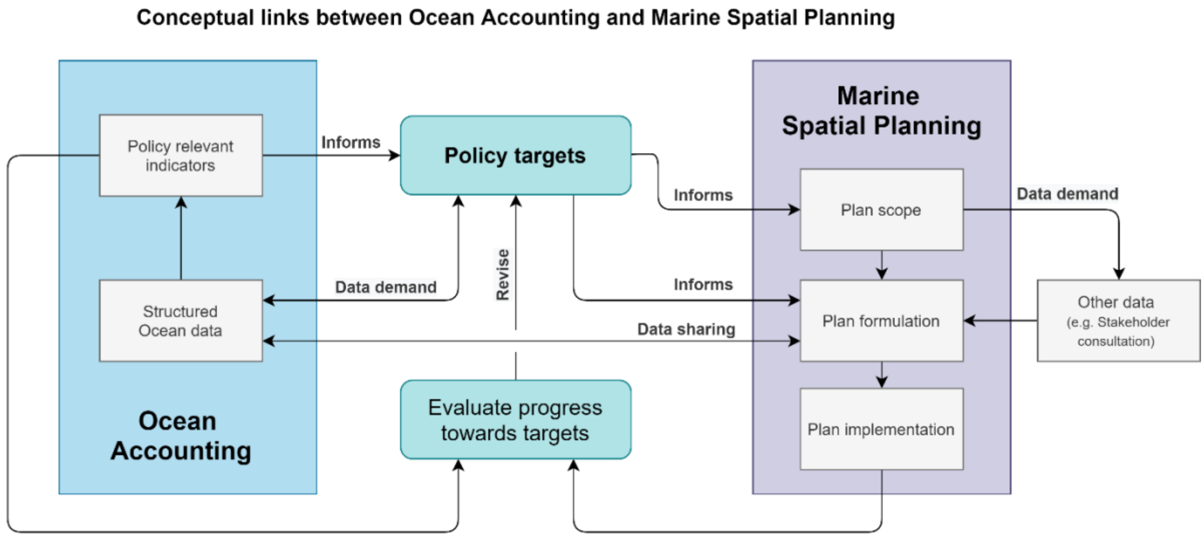

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1. Introduction

From local to international scales, decision-makers are increasingly required to deliver on a wide range of social, economic, and environmental objectives with respect to the marine and coastal (henceforth 'ocean') space. Domestic ocean policy, informed by international commitments including UN conventions and Sustainable Development Goals (SDGs), shapes a nation's strategic vision of the ocean (Rudolph *et al.*, 2020, Obura, 2020). Achievement of this vision, however, is contingent on the ability to inform and implement management action and evaluate its effectiveness in progress towards objectives. Thus, there is a need to support the integration of data from a range of knowledge domains, towards a structured and standardised 'data foundation'. The two ocean governance frameworks discussed in this paper complement each other as a 'data foundation' and 'implementation mechanism' in achieving policy goals, that can be reviewed and adapted at regular intervals.

Ocean ecosystems are increasingly pressured by the growing diversity and intensity of human activities (Halpern *et al.*, 2008). Management of ocean activities requires a comprehensive understanding of the multiple pressures posed on ocean ecosystems, in altering their condition, extent, and functioning. Thus, ocean management is characterised by highly contextual challenges, multiple stakeholders, varying spatial scales, and unpredictable feedbacks between components (Schultz *et al.*, 2015). Progress towards sustainable, inclusive and equitable uses of oceans relies on aligning conservation (ocean health) and development (ocean wealth) strategies at these multiple scales and contexts (Ruijs *et al.*, 2019).

To provide a coherent point of reference across ministries and departments, several countries have produced strategic ocean plans and policies (e.g., Portugal[1], South Africa[2]), which provide guidance and actions towards achieving a vision of a nation's relationship with the ocean. Commonly embedded within such documents are strategies for ocean-based economic development, focusing on the sectors related to ocean space and resources ('ocean economy'), the growth in production of such sectors (e.g., 'Blue Growth' within the European Union, COM/2021/240 final) and the consideration of sustainable development through a 'blue economy' (Fenichel *et al.*, 2020). In response to the policy challenges that

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[1] National Ocean Strategy 2013-2020, Portugal - https://www.dgpm.mm.gov.pt/enm-en

[2] Antarctica and Southern Ocean Strategy (ASOS), Republic of South Africa - https://www.gov.za/sites/default/files/gcis_document/202007/draftantarcticasouthernoceanstrategyasos.pdf

arise from such strategies, integrated management approaches such as marine spatial planning (MSP) have been championed to overcome siloed sectoral management.

Marine Spatial Planning is widely used to analyse and allocate human activities within the marine domain[3], often through a participatory process (Douvere, 2008). The area-based framework is advocated to promote integration in managing inter-sectoral conflicts for space and resources, and the pressures posed by human activities on the environment (Saunders *et al.*, 2019a). Many MSP processes are ecosystem-based[4] (Katsanevakis *et al.*, 2011), in striving to better represent the highly interconnected relationships between society and the ocean, in its recognition as a socio-ecological system (Lauerburg *et al.*, 2020). The socio-ecological lens furthers the integration of knowledge by recognising how social structures and human interactions impact ecosystems, and conversely, how the health and functioning of ecosystems impact social interactions and wellbeing. Employing such an approach accounts for the potential impacts on a diverse range of ocean stakeholders when defining the future relationships between society and the ocean (Charles, 2012).

Thus, ecosystem-based approaches are purported to enhance various dimensions of integration within ocean governance involving, *inter alia*, meaningful engagement with multiple policies and sectors, stakeholders, spatial (including cross-border considerations) and temporal scales, in addition to the collation of knowledge across multiple knowledge domains (Saunders *et al.*, 2019a). A challenge remains, however, in adequately measuring and accounting for material contributions of the ocean to society and the economy, in addition to socio-cultural aspects of a system, such as non-market (Domínguez-Tejo *et al.*, 2016) and non-material (Saunders *et al.*, 2019b) considerations within MSP implementation.

Ocean Accounting (OA) is an emergent framework for the structured compilation[5] and standardisation of different domains of ocean-related data (social, environmental, economic), in a manner consistent with methods and concepts from national (macro-economic) accounting (System of National Accounting, SNA) and environmental-economic accounting (System of Environmental Economic Accounting, SEEA). The OA framework provides a foundation for a diverse range of statistics and indicators produced from a

[3] Some plans also encompass the coast (e.g., Republic of Korea's 1st Master Plan on Marine Spatial Management for 2019-2028) https://www.mof.go.kr/en/board.do?menuIdx=1491&bbsIdx=30620

[4] Ecosystem-based approaches are required within the European Union, through the Maritime Spatial Planning Directive 2014/89/EU, Article 5(1).

[5] Here, we define 'compilation' as used within the field of accounting, in taking and manipulating data to conform with structures defined within guidance documents or standards.

common set of accounting tables (Figure 1). OA provide guidance for ecosystem accounting to the ocean domain, to monitor ecosystem extent and condition[6], the provisioning of ecosystem services, and flows to society and the ocean economy (Fenichel *et al.*, 2020). The OA framework further provides guidance in resolving challenges in classifying and measuring ocean economic activity, flows from ocean ecosystems supporting such activities, and the beneficiaries of within society and the economy. Overcoming such challenges furthers international cooperation, through sharing experiences and lessons learnt and collaboration in developing ocean accounting towards an international accounting standard.

Both MSP and OA contain aspects that support several dimensions of integration within ocean governance, which may be furthered by the intersection of the two frameworks. For example, OA has the potential to collate knowledge from a variety of sources (both quantitative and qualitative), providing a potential avenue to engage with citizen science, traditional knowledges, and a diverse range of stakeholders (GOAP, 2021), of which may be used directly in plan formulation within MSP. Similarly, MSP may drive integration of institutions vertically across levels of governance and horizontally, across administrative borders.

This paper explores the roles of, and relationships between, OA and MSP in formulating, implementing, and evaluating actions towards the achievement of policy goals and commitments, framed within the theme of ‘integration’. We provide (1) a brief overview of both frameworks and (2) present the role of the frameworks in strategic planning and ocean governance and (3) explore synergies, framed through the lens of ‘integration’ (see Figure 2).

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[6] As defined and measured within SEEA (2012) as “the overall quality of an ecosystem asset in terms of its Characteristics”. There are currently no standardised indicators or classifications per ecosystem, although a conceptual basis for the selection of variables and indicators has been proposed (see Czúcz et al., 2019).

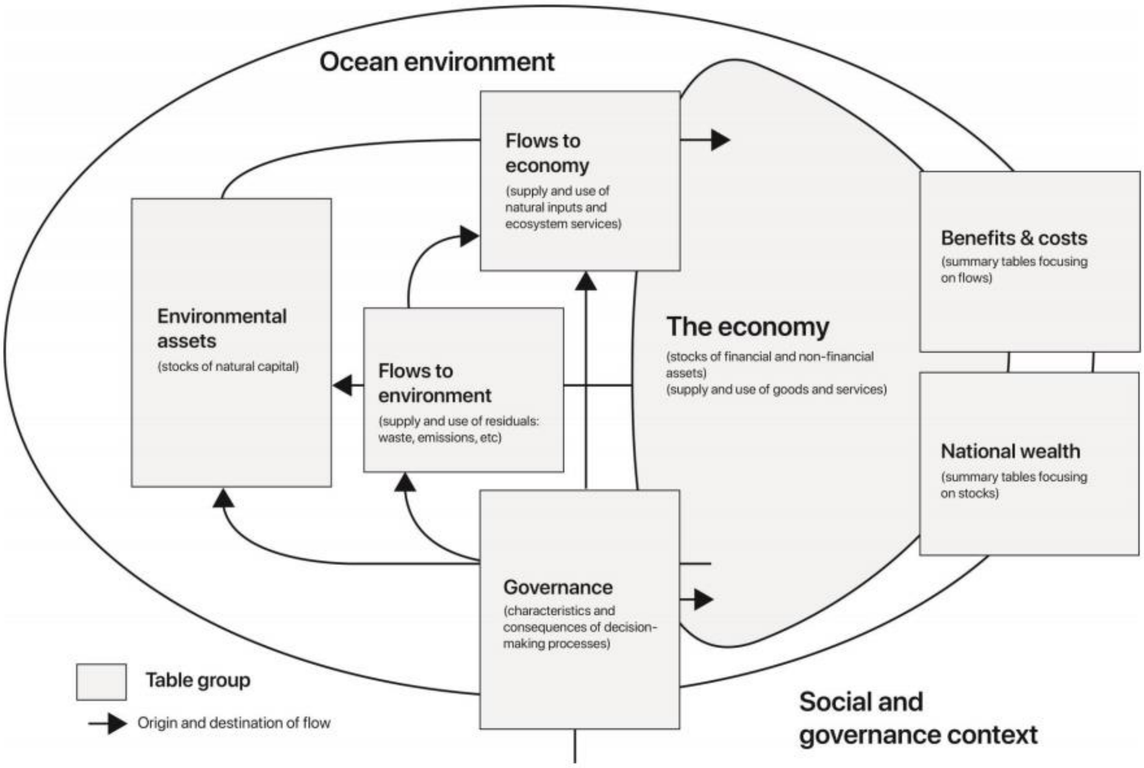

Figure 1. General structure of the Ocean Accounts Framework adapted from the Technical Guidance on Ocean Accounting (GOAP, 2021). An environmental asset account could be compiled through ecosystem accounting (i.e., SEEA-EA), with flows to the economy measured through ecosystem services. Statistics related to the ocean economy could be contained within an Ocean Economy Satellite Account. Details for governance accounts are described in Supplementary Materials.

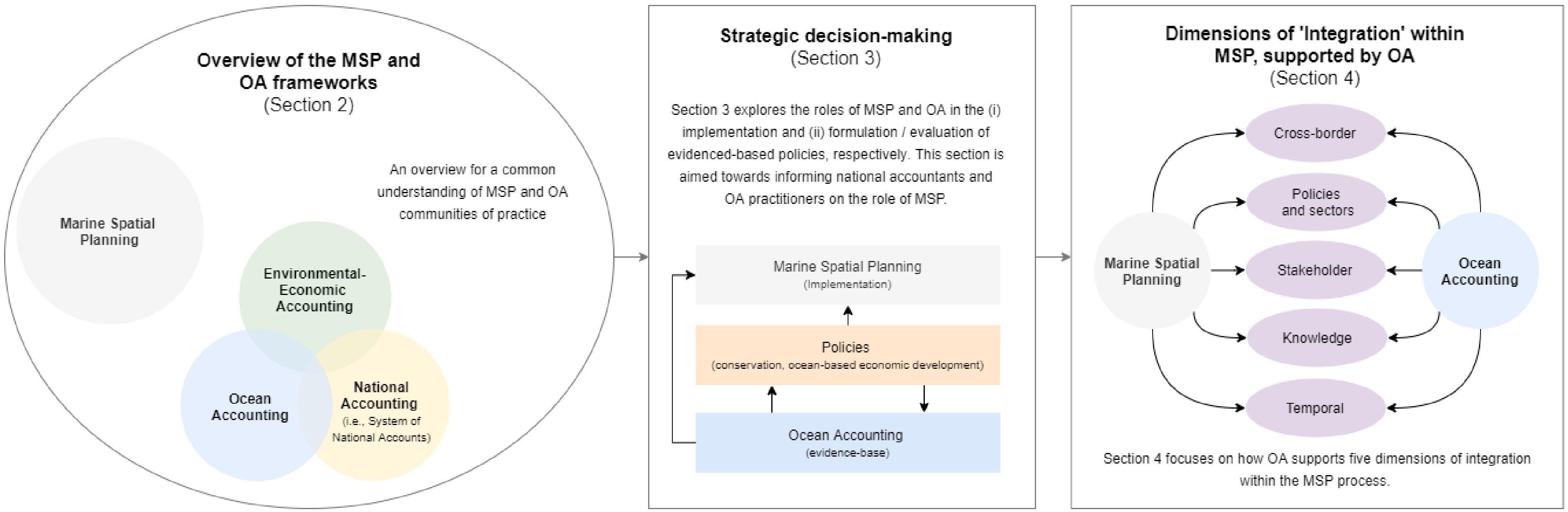

Figure 2. Flow of the paper, noting key concepts explored. As the study attempts to bring together two communities of practice, we provide an overview of both marine spatial planning (MSP) and Ocean Accounting (OA) within ocean governance, and focus on the contributions of MSP and OA in strategic decision making and dimensions of 'integration' (Saunders *et al.* (2019a)) respectively.

2. Spatial planning and environmental-accounting in ocean governance

As MSP and OA are both multi-disciplinary frameworks, practitioners hail from many fields of expertise. The following section provides a context for both communities of practice[7], highlighting the integrative nature of both frameworks in ocean governance.

2.1. Marine Spatial Planning

Within the last century, the establishment of jurisdictional zonation and technological advancements have led to the expansion of existing, and the development of novel, ocean activities (Barbesgaard, 2018). The increased intensity and diversity of activities, however, increases the pressures to ocean ecosystems (Halpern *et al.*, 2008). Traditional approaches to ocean management are sectoral (e.g., shipping and fisheries) and ongoing on a project or permit basis, reflecting terrestrial management philosophies (Smith *et al.*, 2011). MSP evolved from the need to overcome siloed management, and has become a key implementation mechanism towards achieving a State's strategic objectives of its ocean space (Qiu and Jones, 2013). Its main directive is the spatial and temporal allocation of human activities, towards the achievement of pre-determined objectives (Douvere and Ehler, 2009). It further provides an opportunity to reconcile differing values and priorities between diverse stakeholders (Domínguez-Tejo *et al.*, 2016). The framework is endorsed by IOC-UNESCO, and has been embedded into regional legislation (e.g., European Union[8]) and international MSP initiatives (e.g., MARISMA project[9]). Approximately 75 of 150 countries with marine waters have implemented, or are in the process of developing some form of MSP (Ehler, 2020). The interpretation and implementation of MSP varies greatly, shaped by local contexts and strategic objectives (see Section 3).

2.2. Ecosystem-based management, natural capital, and ecosystem services

Spatial planning with sustainability as a central goal may incorporate an 'ecosystem-based' management approach, encapsulating ecosystem relationships and feedbacks, both across habitats and towards society and the economy (Ehler and Douvere, 2009, Domínguez-Tejo *et al.*, 2016). Ecosystem-based MSP (referred to as EB-MSP, Douvere and Ehler, 2009) is framed to address activity pressures on the environment and understand the capacity of the

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[7] Here, we define a 'Community of Practice' as a group of people and institutions who share common aims and objectives, that engage and interact regularly through diverse channels (e.g., literatures, seminars etc.), to advance a specific field or framework.

[8] Maritime Spatial Planning Directive (2014/89/EU)

[9] MARISMA Project (www.benguelacc.org/index.php/en/marisma)

ecosystem to sustain activities into the future (Katsanevakis *et al.*, 2011). Recent MSP assessments have incorporated (Schernewski *et al.*, 2018), and in some instances are required (Bouwma *et al.*, 2018), to integrate the concepts of natural capital (*e.g.,* fish stocks and biotic habitats) and the ecosystem goods and services (henceforth 'ecosystem services') they provide (Figure 3).

Indeed, ecosystem services assessments have become central in communicating the consequences of ecosystem change on human and societal wellbeing (Luisetti *et al.*, 2014), and have been conducted as part of several MSP processes (Schernewski *et al.*, 2018, Friedrich *et al.*, 2020). As an 'organising' framework, ecosystem services can be used to link environmental assets to the economy and inform sustainable development through ensuring the continued flow of services (Dunford *et al.*, 2018). Linking activities to their reliance on ecosystem services requires a diverse array of information, and an understanding of relationships between components (Galparsoro *et al.*, 2021). Therefore, MSP efforts have coincided with initiatives to acquire and collate datasets, often in novel ways, for use in decision-making (Gacutan *et al.*, 2019, Friedrich *et al.*, 2020).

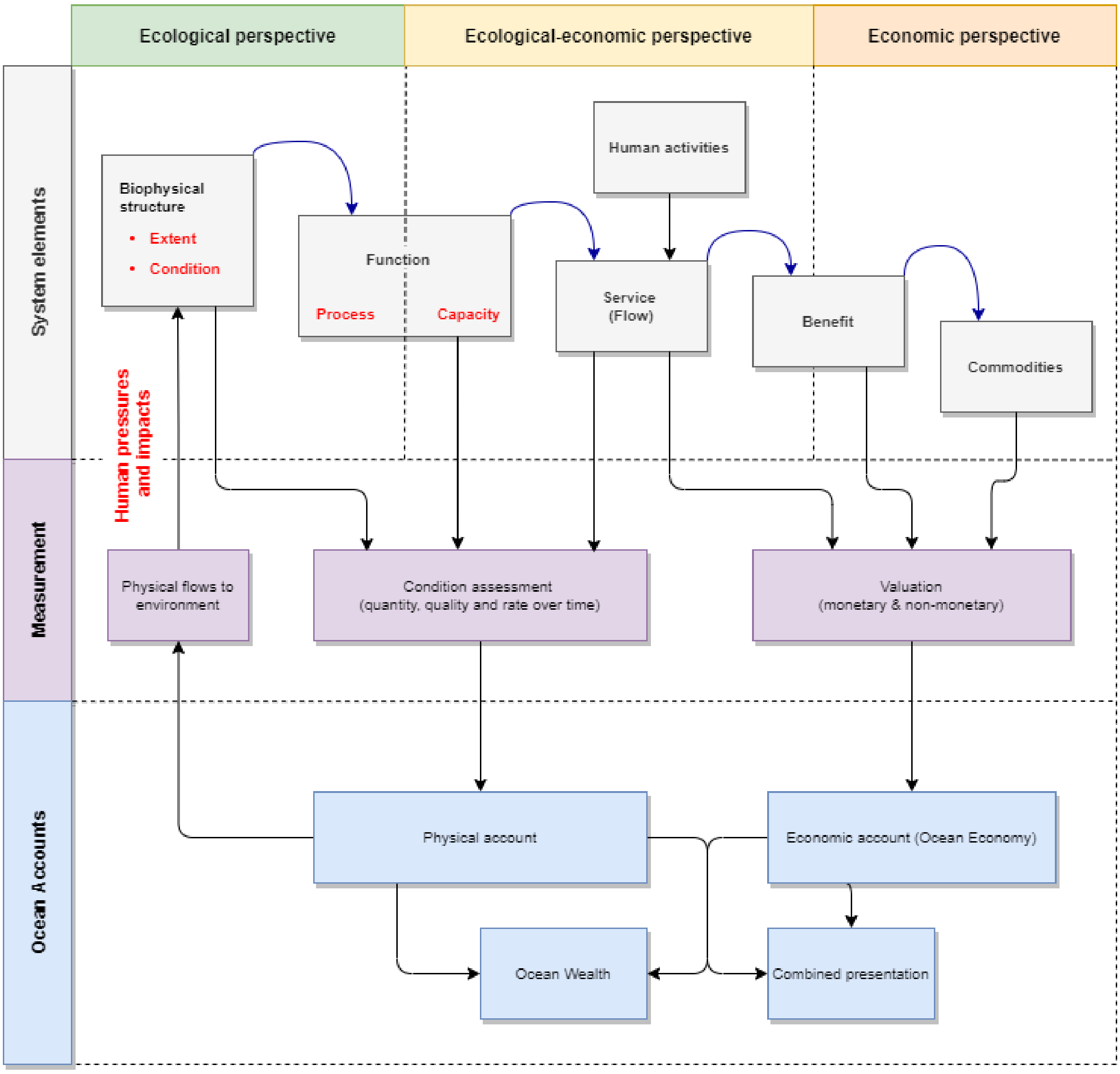

Figure 3. The Ecosystem Service cascade (Haines-Young and Potschin, 2010) and its adaptation to Environmental-Economic Accounting (from SEEA-EA). The ecosystem services cascade is further linked to ocean accounts, as defined within “Ocean Accounting for Sustainable Development, Detailed Technical Guidance for account compilers, data providers, and end-users" (GOAP, 2021).

2.3. Environmental-economic accounting

Decision-making concerning the economy has long been supported by indicators (e.g., Gross Domestic Product), produced through international standards such as the System of National Accounts (SNA, UN, 2008). A key strength of the SNA is the rigorous methodology to produce statistics and indicators, combining a diverse array of information in a standardised manner (Bos, 2003). Through strict definitions and classifications, there is limited consideration of the environment, largely by design (i.e., production boundaries). Thus, indicators produced from national accounts have long been critiqued for their limited consideration of the environment, leading to the prioritisation of economic activity at the detriment of ecosystems (Rockström *et al.*, 2009, Dasgupta, 2021).

Whilst some environmental flows are measured, the extent and condition of the underlying assets are omitted (Fenichel *et al.*, 2020). For example, most countries record the monetary value of fish caught and landed, although few include measures of the underlying stock producing the fishery. The capacity for continued fisheries production is neglected and thus, decisions may favour increased production, leading to the unsustainable exploitation of the resource (Kubiszewski *et al.*, 2013).

To overcome these knowledge gaps, the System of Environmental-Economic Accounting (SEEA) was developed as an international accounting standard to provide concepts, definitions, and classifications to measure environmental stocks and flows, and their relationships with the economy. As sustainability is a multi-dimensional concept, the SEEA allows for the production of a range of aggregate indicators and the ability to measure and present physical units (*e.g.*, Litres, Hectares, etc.) alongside their monetary value (Kubiszewski *et al.*, 2013). The SEEA is composed of a ‘Central Framework’ (SEEA-CF, UN, 2012) and ‘Ecosystem Accounting’ (SEEA-EA, UNSD, 2021), where the former provides guidance in measuring thematic assets and flows between the economy and environment, whilst the latter provides methods towards quantifying the extent and condition of ecosystem assets, and subsequently, the supply and use of services produced.

The SEEA-EA takes a spatially-explicit approach to statistical accounting, and includes an understanding of the services, benefits and beneficiaries related to an entire ecosystem. By combining a diverse set of information, SEEA-EA provides a means to correlate economic and environmental impacts with policies within an accounting area (Vardon *et al.*, 2018). The SEEA, however, is generally more suited to the terrestrial environment, where flows are readily simplified into two-dimensional space. In contrast, the ocean is three-dimensional, with complex flows, where defining ocean activities and their production remains a challenge, as data is often aggregated within large, non-marine sectors (e.g., tourism and transport) (Jolliffe *et al.*, 2021).

2.4. Ocean Accounting

Most countries contain existing accounts of ocean-related sectors and resources (*e.g.*, fisheries, aquaculture), with few countries disaggregating and quantifying the contribution of the ocean (Hooper *et al.*, 2019). Thus, there is a clear need to extend, adapt and synthesise concepts from the SNA and the SEEA towards an accounting framework for the ocean context. The need for an ocean-centric approach is recognised by the High-Level Panel for a Sustainable Ocean Economy[10], where commissioned research stresses the necessity for multiple indicators in understanding the ocean' contribution to inform decisions impacting these relationships (Fenichel *et al.*, 2020). Several pilot studies have been performed, supported by the UN Economic and Social Commission for Asia and the Pacific (UN-ESCAP), in addition to numerous ongoing national pilots and accounting efforts globally. The growing community of practice is supported by the Global Ocean Accounting Partnership (GOAP), which has produced a technical guidance for the production of Ocean Accounts (GOAP, 2021).

[10] High-Level Panel for a Sustainable Ocean Economy: https://www.oceanpanel.org/

3. Strategic decision-making in ocean governance

Optimism for the ocean as a solution to global challenges is apparent within the strategic plans of multiple nations, predominantly due to the ocean's espoused potential to drive economic growth (OECD, 2016), leading to a 'blue acceleration' of maritime activities and the privatisation of once public space (Jouffray *et al.*, 2020). The development and continued growth of some sectors, however, is contingent on the continued supply of ecosystem services and thus, healthy ecosystems. In response, many strategic plans weigh growth priorities with the maintenance or improvement of ecosystem health through conservation and restoration, as seen in the revision of the 'Blue Growth' agenda within the European Union, to focus on a 'Blue Sustainable Economy' (COM/2021/240 final).

3.1. Marine Spatial Planning as an implementation mechanism

The use of MSP as a policy choice may be distilled into two motivations, firstly as a tool for integrating multi-sectoral planning and secondly, environmental conservation. MSP implementation follows strategic priorities, as either 'hard' or 'soft' sustainability, where conservation is either the central theme, or relegated as a consideration amongst others, respectively (Santos *et al.*, 2014). The strategic focus of plans may be defined by a nation's high-level commitments (e.g., SDGs, Convention on Biodiversity) and national priorities shaping domestic policy and legislation (Grip and Blomqvist, 2021).[11] As such, MSP may be considered an 'implementation mechanism', aligning numerous policies within the marine domain (Figure 3).

Ocean-based economic development strategies have heavily influenced MSP implementation towards inter-sectoral planning in many countries (Jay *et al.*, 2016), generally leading to clear benefits for novel ocean sectors, at the detriment of others (EASME, 2020). Most strategies prioritise novel sectors due to their potential for growth, leading to future inter-sectoral conflicts for space and resources. For example, offshore wind excludes fisheries and shipping through fixed structures, where MSP mitigates future conflicts by providing regulatory certainty for novel sectors by reducing administrative and planning costs, and shaping investment decisions (EASME, 2020).

Nearly all ocean human activities will have an impact, positive or negative, to components of ocean ecosystems, where economic growth could be decoupled with impacts on ecological

[11] Within the Europe Union, where MSP is enshrined in legislation, several interacting directives shape the growth and conservation of marine areas including, *inter alia*, Habitats (92/43/EEC), Birds (2009/147/EC) and Marine Strategy Framework Directives (2000/60/EC). Whilst conservation is mentioned in the Maritime Spatial Planning Directive (MSPD Preamble 15, 2014/89/EU), the focus of MSPD is the spatial allocation and distribution of human activities within the marine domain (Preamble 4, 5, and 14).

integrity for some sectors. The nature of extractive sectors, such as wild-catch fisheries, poses unavoidable pressures to ecosystem assets and MSP may play a role in mitigate risks and impacts, through understanding the capacity of the system to support such activities and subsequently define activity intensity and distribution (Douvere and Ehler, 2009). Another strategy is the prioritisation of non-extractive sectors such as tourism and offshore energy, which are projected to grow rapidly by 2030 (OECD, 2016, Bugnot *et al.*, 2021). Such sectors may displace extractive industries and their associated pressures, although will themselves introduce novel pressures and impacts. The sustainability of 'blue' or 'ocean-based' growth strategies and inequitable impacts to ecosystems and segments of society have been critiqued (Leposa, 2020). The extent to which MSP mitigates ecological impacts and maximises resilience, rests on the policy priorities and institutions defining the MSP process.

In contrast to inter-sectoral planning, some MSP processes are grounded in 'hard' sustainability, with mandates around the maintenance or improvement of environmental health (Santos *et al.*, 2014, Trouillet, 2020). The Great Barrier Reef Marine Park in Australia, for example, uses conservation as the guiding principle for informing both human uses and delineation of protected areas[12]. Similarly, MSP within Norway facilitated the development of protected area networks for environmental conservation, to manage activity pressures and meet international and national protected area targets (OECD, 2017). Whilst marine protected areas and MSP are separate area-based tools, especially within the European context, there are opportunities to maximise the conservation of environmental values, whilst maintaining specific activities (Trouillet and Jay, 2021).

3.2. Ocean Accounting provides indicators for integrative management

Ocean Accounts perform several support functions for strategic and planning decisions that justify the investment to compile them. By virtue of their integrative structure, OA are a basis for analysing the present state of the ocean and its link with the economy and society. Maintained accounts provide time-series, which allow both the evaluation of existing policies and support scenario analysis for future actions. Specifically, the OA framework provides a basis for producing three broad domains of aggregate indicators that are directly relevant to performance monitoring of ocean development strategy, outlined by Fenichel *et al.* (2020) as:

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[12] Great Barrier Reef Marine Park Act 1975 (Commonwealth of Australia), 32(1)(a), retrieved: https://www.legislation.gov.au/Details/C2017C00279

— *Ocean product*, focusing on the economic outputs of human activity regarding the ocean, with monetary components aggregating to 'ocean' Gross Domestic Product,

— *Change in the 'ocean balance sheet'*[13], which provides an important sustainability indicator when the balance sheet is sufficiently comprehensive including both environmental assets and other sub-components of national wealth recognised in the OA Framework.

— *Ocean income*, as the benefits received by nationals from the ocean, including physical measures of ecosystem services, and monetary measures of ocean income that can be aggregated to net or gross national income. Income measures can be (and benefit from being) disaggregated to show the importance of the ocean for different segments of the population.

The production and use of multiple indicators support strategic decisions (including MSP) by shaping policies and their targets, but also provides avenues to identify the contribution of the ocean to the wellbeing of multiple stakeholders, such as marginalised groups (e.g., ocean income to fisherfolk, women, indigenous peoples). This could be achieved, in part, through greater disaggregation of ocean activities, which may include the measurement of traditional and small-scale economic activities (e.g., small-scale fisheries) (e.g., Zeller *et al.*, 2006). Such indicators align with existing international processes and could be used to report on progress towards a range of existing international commitments (e.g., SDGs).

3.3. Values represented in Ocean Accounts

A strength of accounts is the diverse sources of data used to produce them, which supports incorporation of diverse stakeholder knowledge and data (see Section 4.3). As explored by Chen *et al.* (2020), however, environmental-economic accounting is biased by what is selected for inclusion and the how they have been measured.

In considering a 'domain' of values ranging from intrinsic to instrumental, and eco-centric to anthropocentric (Turner *et al.*, 2003, Díaz *et al.*, 2015), ocean accounting, as an extension of accounting practices and traditions, focuses on quantifiable and instrumental values, in physical (e.g., hectares, litres) and monetary terms (exchange and market values) (Figure 4). The growing intersection between OA and MSP are driven primarily by strategies that are instrumental in nature, such as ocean-based economic growth, which may be motivated towards economic prosperity and improving material aspects of human wellbeing. Nonetheless, the OA framework provides the flexibility to extend towards qualitative and

[13] An ocean 'balance sheet', akin to financial accounting, could summarise the 'stock' of produced (e.g., ports) and ecosystem ocean assets (e.g., mangroves, seagrass) at a given point in time, where changes in the balance sheet over time indicate the amelioration or amelioration of such stocks, and could be used to contextualise other indicators.

relational descriptors, through spatially explicit accounts (e.g., governance accounts, explored in Section 4.3), although application in practice has been limited to date.

Intangible and non-material values, that are important in supporting human wellbeing, may be less represented within OA. To better represent the plurality of ocean values, uses and relationships in ecosystem-based MSP, and integrated ocean management generally (Allison *et al.*, 2020), complementary frameworks could be used alongside OA in Ocean decision making (Barton *et al.*, 2019, Voyer *et al.*, 2021).

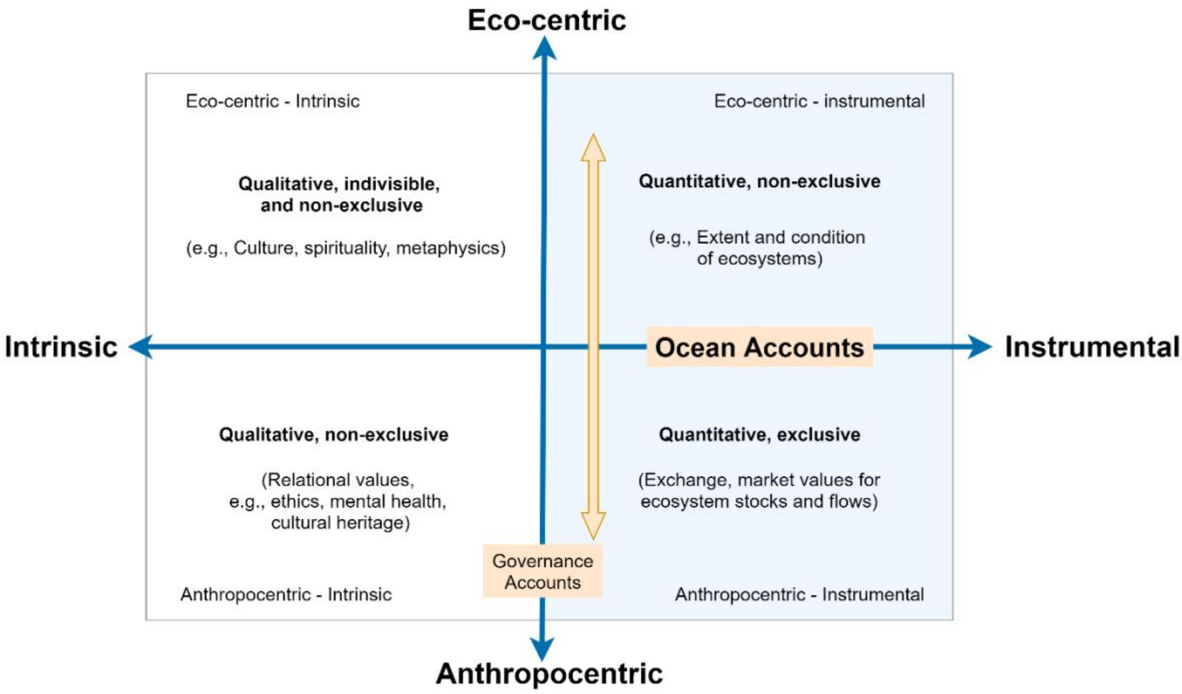


Figure 4. A domain of values of relationships between ecosystems, society, and the economy. The values readily incorporated into Ocean Accounts highlighted in orange, noting that governance accounts contain qualitative, relational values. ‘Exclusive’ (i.e., rivalrous) refers to a good or services, where consumption by one consumer prevents its use by another. Adapted from Barton *et al.* (2019).

4. Furthering integration in ocean governance

As the MSP framework has been more widely disseminated and implemented, Section 4 explores how the compilation and maintenance of OA supports MSP processes, explored in full in Figure 5 and the Supplementary Materials. Both frameworks are purported to advance several dimensions of integration in decision-making, which we explore in the context of the framework proposed by Saunders *et al.* (2019a).

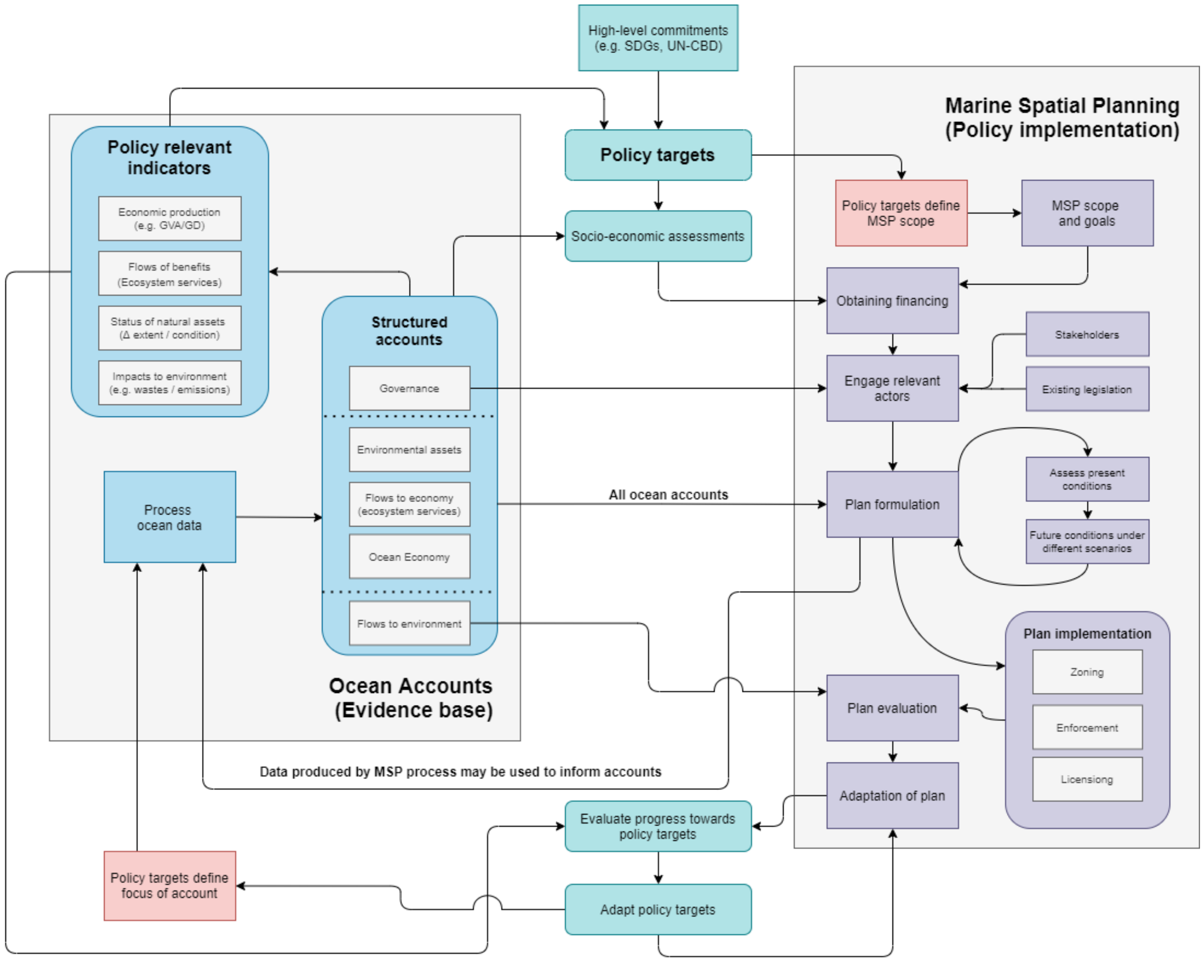


Figure 5. Overview of Ocean Accounting (OA) and Marine Spatial Planning (MSP), informing policy targets and implementation towards their achievement.

Table 1. Dimensions of integration within Marine Spatial Planning (MSP) (adapted from Saunders *et al.* (2019a)) and synergies with Ocean Accounting.

Integration Dimension	MSP ambition and implementation	Facilitating integration within governance through Ocean Accounting
Policy and Sector integration	• Pre-emptively address sectoral use incompatibilities, but also to achieve synergistic interaction between sectoral interests. Further, emphasize and seek mutual benefits and interests. • Identify synergies and trade-offs between existing sectors and ocean-based economic sectors, and conservation goals, in the context of policy and legislation.	• 'Governance accounts'* identify layers of governance within relevant ocean areas, including policies, legislation, and current management actions. • OA helps untangle complexities in bureaucracy within the ocean space. • Policy targets may be aligned using common concepts (e.g., framed through ecosystem services). OA supports the use of ecosystem services in aligning policy targets, by measuring services and producing indicators.
Cross-border integration	• Garner cooperation among administrative borders (both within and between countries) to further the coherent planning between activities and meet environmental targets across coastal (including land-sea interactions) and marine space. • This requires coordination in the achievement of policies across administrative levels and between and within States.	• 'Governance accounts'* for cross-border comparison of relevant policy, legislation, and stakeholders. • Promotion of collaboration both within and between countries. • Standardized, consistent and coherent information as a baseline for collaboration across borders. • Vertical integration through comparable and scalable information and framework (i.e., local to national government scale).
Stakeholder integration (or 'engagement')	• To develop processes to support engagement amongst a range of stakeholders and put measures in place to manage conflicting interests in a fair and deliberative manner. • This may be achieved through the representation of interests, as well as terms of stakeholder inclusions and participation.	• Identifies relevant stakeholders. • Open access accounts provide a 'common set of facts' during discourse, addressing information asymmetry and reducing information costs to some stakeholders. • Flexibility of OA allows incorporation of a diverse range of sources (including citizen science, indigenous and traditional). • Findings can be presented in both physical (e.g., litres, hectares) and monetary measures (combined presentation).

Integration Dimension	MSP ambition and implementation	Facilitating integration within governance through Ocean Accounting
Knowledge integration	• To link different forms of multi-disciplinary knowledge to support evidence-based approaches to underpin MSP decision-making in pursuit of sustainable marine governance. • This may be achieved through a diverse evidence-base and valuing the broad range of stakeholder knowledge.	• Compilation of data inventories provides an overview of the state of knowledge related to social, economic, and environmental conditions. • Identifies and justifies the investment of filling knowledge gaps in ecosystem functioning. • A standardised framework provides guidance for data collection and compilation *a priori*. • Integrates spatial and non-spatial data in an internally-consistent conceptual framework. • Provides guidance towards disaggregating components of the ocean economy from current economic reporting.
Temporal integration	• Design governance arrangements that respond effectively to existing problems but can be able to adapt to changing environmental, economic, and social conditions. MSP processes require the capacity to implement a reflexive approach.	• Assist in cost-benefit analyses during scenario analysis, in providing social, environmental, and economic values. • Maintained accounts (over time) allow for an evaluation of plans and their progress towards pre-determined objectives.

*See Supplementary Materials for a description of a 'governance account', unique to the Ocean Accounting approach and technical guidance.

4.1. Policy and sector integration

As explored in Section 3, MSP implementation is framed by existing policy and legislation, which shapes the focus and objectives of plans. The interpretation of these objectives influences the assessments of synergies and trade-offs between sectors, and environmental protection. Governance accounts may act as the first step in untangling the complex 'web' of bureaucracy faced during plan formulation (Boyes and Elliott, 2014). Once policies and their mandates have been identified through OA, MSP provides a means to align, monitor, and evaluate objectives through common definitions and classifications, namely natural capital (environmental assets) and ecosystem services (see Section 2.2, Figure 2). For example, the use of both concepts identifies environment assets vital for ocean-based sectors (e.g., critical natural capital, Brand, 2009). Similarly, the services and their benefits may be quantified from accounts, to recognise the importance of ecosystems, and give greater weight to their conservation and rehabilitation (Vardon *et al.*, 2019).

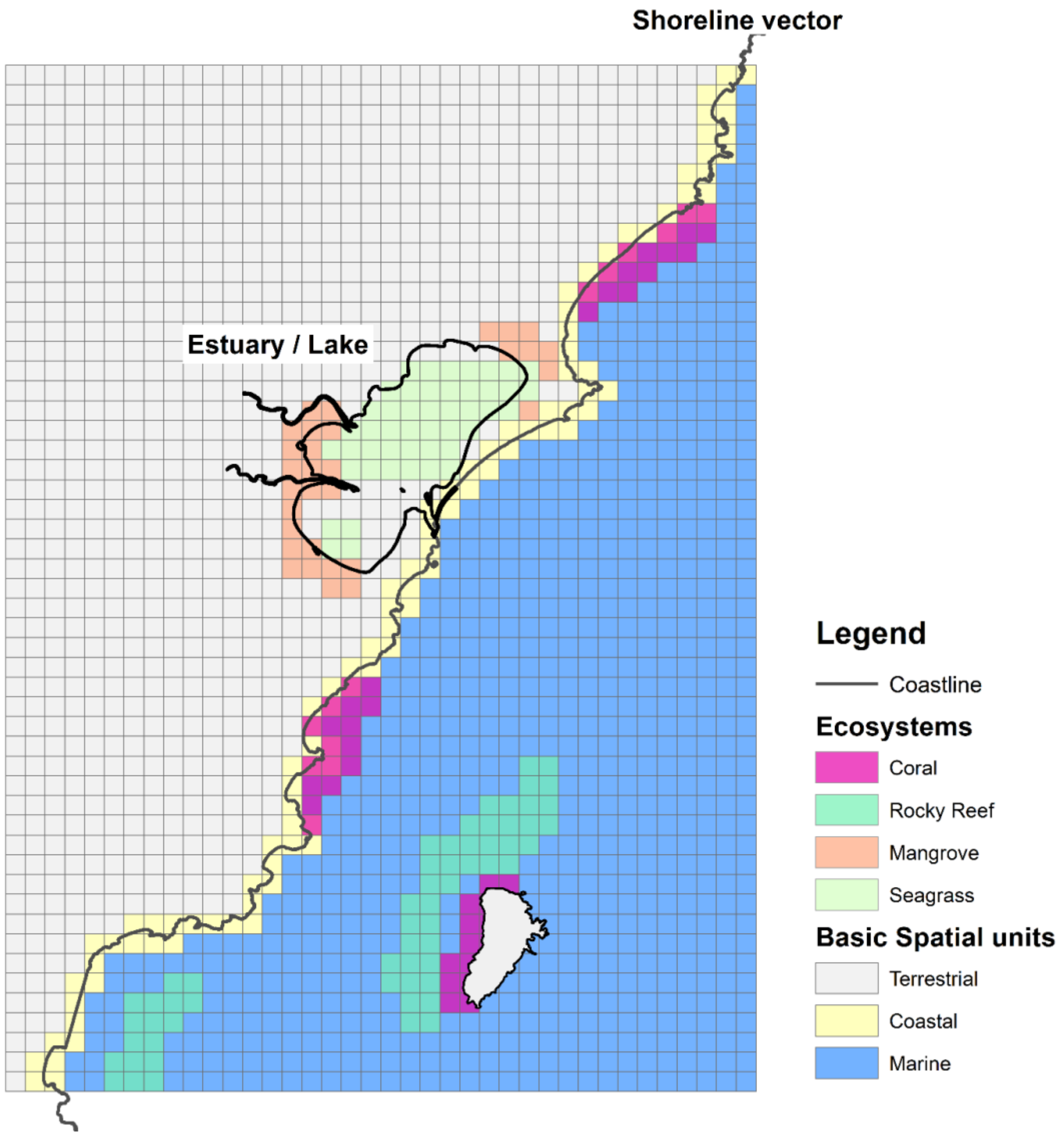
Quantifying environmental assets and their ecosystem services towards measuring progress towards policy targets remains difficult, where direct measurement of complex phenomena is often infeasible, with 'indicators' used as a proxy (Hattam et al., 2015, Maes et al., 2016, von Thenen et al., 2020). These bio-physical and social indicators could be produced, in part, from information contained across several accounts, where OA provides guidance to how ecosystem condition may impact the provisioning of ecosystem services (GOAP, 2021). Thus, through the production of a range of existing indicators, OA facilitates the integration of multiple policies and their targets, needed to define the implementation of MSP.

4.2. Cross-border integration: scalability and data coherence

Within the same jurisdiction, ocean policy may be complicated by the disconnect at the ocean-coast interface, where differing instruments may govern marine and coastal areas (Saunders *et al.*, 2019a). Coherent plans are supported by a governance account, in providing spatially-explicit information of policy and legislation both within and between administrative areas (see Supplementary Materials). Governance accounts provide a basis to establish the appropriate authority to form a spatial plan and carry out implementation, partnering and coordinating with relevant stakeholders.

OA furthers ecosystem-based management through providing a coherent data structure, which facilitates the collation of the diverse knowledge and datasets needed to understand multiple components of a management area. Accounting efforts of most countries are often coordinated with high-level government oversight and arise from a collaboration across multiple departments and stakeholders. The use of standardised grids (i.e., basic spatial units, Figure 6), founded on standardised concepts, definitions, and classifications, facilitates the vertical integration of statistics and indicators across administrative levels (e.g., local, state, and national). A common spatial unit in adjacent administrative areas also assists in the horizontal movement of data flows and comparisons between jurisdictions. Through the intersection of environmental, social, and economic knowledge, OA encourages collaboration and knowledge exchange both within and between countries.

Figure 6. A theoretical example of an accounting area by Basic Spatial Unit (BSU), used for statistical reporting within Ocean Accounting. BSU may be divided into terrestrial, coastal, and marine areas. Each BSU contains information on ecosystem / asset type and condition (overlayed in the figure), governance conditions and other relevant information.



4.3. Stakeholder integration

The success of marine spatial plans have been related to the level of stakeholder integration within various phases of the MSP process (Flannery *et al.*, 2018, Noble *et al.*, 2019). The involvement of stakeholders, however, requires due consideration of which stakeholders are approached, the way they are engaged, their influence on the MSP process, and power relations between both stakeholder groups and the coordinating MSP body. These considerations have proved difficult in practice, with many lessons learnt demonstrating the importance of engaging stakeholders early and continuously (Jones *et al.*, 2016, Ritchie and Ellis, 2010).

Ocean accounts that are accessible (i.e., open access) and maintained over time may alleviate information asymmetry between stakeholders, particularly between stakeholders and the institutions responsible for the MSP process. Open-access Ocean accounts effectively reduce the cost of data and knowledge acquisition, where the sourcing, manipulating, and analysing the underlying data may require expertise and resourcing infeasible to single stakeholders. Thus, dialogues may be grounded upon a 'common set of facts' for economic production, links to employment, dependencies on ecosystems and impacts on the environment for each sector, produced from a common set of accounts (GOAP, 2021). The standardised nature and repeated production of accounts furthers the trust placed in the resulting indicators and statistics amongst parties (Vardon *et al.*, 2018). Further, the 'combined presentation' (Vardon *et al.*, 2019) of ocean ecosystems, in both physical and monetary measures of stocks and flows reflects a wider range of stakeholder values. As explored in Section 3.3, however, the data and values reflected within the accounts will alter its utility and ability to reflect specific stakeholder interests.

The Ocean accounts framework also provides greater flexibility relative to existing SNA and SEEA standards. For example, governance accounts are the first to extend accounting towards qualitative, relational values (GOAP, 2021), and endorsed within the research agenda of the UN Statistics Division.[14] For example, biodiversity accounts require significant taxonomic expertise to identify species of flora and fauna within an accounting area. Such data could be sourced, in part, through citizen science and indigenous knowledge. Datasets produced by citizen science programs have been increasingly identified to produce data quality on par with formal studies (Newman *et al.*, 2017) and traditional knowledge has been shown to add value to formal biodiversity assessments through the identification of rare and

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[14] United National Statistical Commission, Report on the fifty-second session (1–3 and 5 March 2021), Economic and Social Council Official Records, 2021 Supplement No. 4, E/2021/24-E/CN.3/2021/30, accessed online: https://unstats.un.org/unsd/statcom/52nd-session/documents/2021-30-FinalReport-E.pdf

cryptic species otherwise missed by western researchers (Ward-Fear *et al.*, 2019). By sourcing knowledge from a variety of sources, marine spatial plans could be informed from a bottom-up perspective (i.e., local knowledge, stakeholder values) (Carolus *et al.*, 2018), to better engage with and represent a greater variety of stakeholders (Luisetti *et al.*, 2014).

It should be noted, however, that OA draws from national accounting traditions and practices, and is thereby an exercise performed largely by governing institutions and more aligned with top-down regulatory control. Ocean accounts may contain local knowledge and data but are ultimately compiled to inform and address normative objectives and policies. A holistic assessment and incorporation of all stakeholder values within MSP may require complementary analyses alongside OA (See Section 3.3).

4.4. Knowledge integration

Many MSP processes require an ecosystem-based approach, the success of which relies on (1) an integrative understanding of the marine socio-ecological system, (2) data availability to support cost-benefit assessments and (3) a framework that ensures the consideration of data across knowledge domains, beyond economic valuation. The OA approach assists in understanding the components within the ocean domain, and provides guidance in measuring ecosystem assets, flows and the ocean economy.

4.4.1. *Ecosystem condition and data availability*

Ecosystem-based MSP promotes the integration of multiple objectives towards the sustainable and equitable development of marine space. Such integration, however, relies on a comprehensive understanding of ecosystem extent, and how their condition (e.g., ecological integrity) impacts the provisioning of ecosystem services used by human activities (Domínguez-Tejo *et al.*, 2016). Untangling such condition 'factors', including degradation and restoration of ecosystems, at different spatial and temporal scales are a challenge for accounting within the ocean domain, with development of classification systems underway (Bordt and Saner, 2019). Whilst OA does not directly contribute to an understanding of ecosystem service production, it provides an opportunity to standardise the treatment and manipulation of data towards how such services are measured. The identification of knowledge gaps and uncertainties by OA could be used to justify investment into further research (GOAP, 2021).

Another challenge faced by MSP is the inaccessibility of relevant and coherent data, which is often highly aggregated or non-spatial for the marine domain (Shucksmith and Kelly, 2014). Of data that is spatially explicit, differences in resolution pose challenges to inter-operability between datasets, where assumptions and manipulations are often employed to achieve compatibility amongst data formats and classifications, usually at the cost of data quality. There are numerous efforts, however, to harmonise national and regional data infrastructure, especially data related to the environment (e.g., INSPIRE [2007/2/EC], UN-ESCAP Ocean Accounts data viewer[15], data cube technologies (Lewis *et al.*, 2016)). Ocean Accounting mitigates the opportunity cost of gathering data with limited application for integrated decision-making, through concepts and definitions that guide data needs and compilation *a priori*. Existing datasets that have been used within MSP, including remote sensing (e.g., satellite, LIDAR, drone, etc.), readily align with the OA process and allow for the large-scale analysis of ecosystem extent (Figure 5).

4.4.2. *Defining ocean activities and their importance*

In managing activity distribution and abundance, MSP requires an understanding of activity economic performance, their contribution to society, and impacts to the environment. The capacity of the ocean to support activities is increasingly uncertain. The economic impact (both positive and negative) of MSP were difficult to untangle due to the lack of accurate and standardised economic data, and difficulty in isolating economic effects (EASME, 2020). Understanding shifting space and resource needs, in the context of an increasingly diverse ocean economy, is vital in achieving adaptive and resilient ecosystem-based management (Kildow and McIlgorm, 2010).

Delineating ocean activities is an ongoing challenge, as whilst some activities are geographically dependent on coastal or marine areas (e.g., marine fisheries, shipping), others are not dependent on ocean space or resources (e.g., ship-building) (Kildow and McIlgorm, 2010). Even where activities are spatially contingent, diverse sources of information must currently be integrated to achieve global or national estimates of extent and projected growth (Bugnot *et al.*, 2021). Statistics on the ocean economy are also limited due to aggregation within current economic reporting (Jolliffe *et al.*, 2021), where the International Standard Industrial Classification of All Economic Activities (ISIC), does not explicitly identify ocean activities, nor their components. Several efforts have been made towards disaggregation (Foley *et al.*, 2014, Jolliffe *et al.*, 2021).

Thus, there is a need for ocean economy satellite accounting[16], which is compatible with national accounting, and mitigates the risk of over-estimating and double counting that is

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[15] ESCAP regional ocean accounts platform (https://communities.unescap.org/environment-statistics/tools/regional-ocean-accounts-platform)

[16] An Ocean Economy Satellite Account (OESA) may be defined as a satellite account that measures all economic activity related to or dependent on ocean space and resources, including activities that use ocean resources as an input (e.g., fishing), produce products and services for use in the ocean environment (e.g., shipbuilding), or depend on the ocean due to geographic

prevalent within current methods of estimating the ocean economy (Jolliffe *et al.*, 2021). No international standards exist for the compilation of ocean economy satellite accounts, although OA provides guidelines towards their development and maintenance (Figure 2). The OA framework proposes a range of statistics and indicators (see Section 3.2), that enable decision-makers to understand facets of the ocean economy in both physical and monetary data. In this way, MSP can more readily identify the dependencies that human activities may have on natural capital and ecosystem services (Gacutan *et al.*, 2019).

4.5. Temporal integration

In the formation of plans, MSP uses scenario analysis to address the situation at present, whilst remaining oriented towards future conditions (e.g., regulatory uncertainty, and a changing ocean economy). Scenarios allow for a prediction of impacts due to management intervention, where subsequent outcomes may be assessed through cost-benefit analyses that are used to identify optimal investment and planning decisions (Carolus *et al.*, 2018). Assessing the outcomes of scenarios (i.e., allocations of activity intensity and distribution) reveal inferior management options, and demonstrate the impacts of activities to environmental assets, their services and other users (White *et al.*, 2012). Integrative cost-benefit analyses of human activities and their use of space and resources are supported through ecosystem and ocean economy satellite accounts, in generating statistics and indicators (see Section 3.2) and economic valuation of services.

Shifts in the nature and composition of the marine economy will change due to societal demand and access to resources. Responding to these changes, and ensuring plans are progressing towards predetermined objectives requires consistent monitoring and a means of evaluation (Ehler and Douvere, 2009). Stelzenmüller *et al.* (2021) identify a lack of formal or standardised evaluation frameworks, where linkages between objectives, indicators and data remain weak. This shortcoming could be addressed through OA, where several accounts could be used to monitor progress towards both conservation and economic objectives. Furthermore, the maintenance of accounts over time (i.e., time-series) increases the reliability of data, providing a stronger foundation for identifying trends.

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proximity (e.g., coastal tourism, warehouses that service ports). The OESA extends existing measures of ocean economy reporting by compiling supply / use tables, as well as methods for calculating full-time equivalent employment.

5. Conclusion

The Communities of Practice for both MSP and OA are growing rapidly, and intersections between the two frameworks are beginning to emerge. The roles of both frameworks in strategic decision-making are distinct, although share synergies through their 'integrative' nature across, *inter alia*, policies, knowledge, and temporal scales in supporting ocean governance. MSP aligns strategic targets from several policies, in managing human activities, which may be supported by structured and standardised information contained within ocean accounts.

Both frameworks also identify and collate ocean information, where OA provides a way to organise ocean information, through the compartmentalisation of stocks (natural capital) and flows (ecosystem services), supporting the integrated consideration of social, environmental, and economic values within scenario and trade-off analyses performed by MSP. OA also provides guidance towards the measurement of the ocean economy, supporting MSP decisions for the allocation of space and resources for human activities. Further, the maintenance of OA over time lends to the evaluation of trends, which can in support the monitoring of marine spatial plans and evaluate their progress towards objectives.

High-level policy intent is behind both MSP and OA, and the investment in both activities continues to increase globally. An early recognition of the relationships between the frameworks and advancements in their co-development reduces the potential risk of duplication in overlapping processes. Future work should endeavour to align and integrate aspects of OA within MSP efforts, to overcome potential fragmentation in knowledge across institutions and disciplines and allow for a standardised statistical foundation in plan development.

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