Ecosystem accounts for Marine Protected Areas: A proposed framework

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Abstract

Many policy initiatives and scientific studies promote the use of economic accounting as a statistical basis for end-users and policy makers in order to evaluate the distributive and allocative effects of implementing environmental and economic policies. This could help in assessing cost-benefit analysis on taxes and subsidies, public expenditure on environment protection, payment schemes for ecosystem services or the construction of "green" gross product indicators. In this paper we develop an ecosystem-economic accounting framework for testing some practical issues connected with building disaggregated accounts for single institutional units. We focus in particular on MPAs for the direct relationship they have with ecosystems and their flows and for the strong contribution of ecosystems to productive and consumptive activities. The accounting framework is designed to be integrated into the System of Environmental and Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) recommendations, and to serve as a management tool for protected areas managers.

Keywords: Ecosystem services; Economic-environmental accounting; SEEA-EEA

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1. Introduction

Over the last two decades, the increased environmental pressures, greater public awareness, and the new concept of sustainable growth have compelled international bodies to develop new environmental accounts and indicators aimed at making explicit the relationship between the environment and economic activity (e.g. the SEEA CF 2012 (United Nations et al., 2014a); the Sustainable Development Goals (SDGs), adopted by the UN General Assembly in 2015; the new European Strategy for Environmental Accounts for the period 2019-2023 released by Eurostat in 2019).

The main goal in environmental economic accounting is to realize a conceptual framework for describing consistently the interlinkages among natural resources flows and stocks and the socio-economic system (i.e. produced goods and services and institutional sectors), and the circular flow of corresponding monetary costs and benefits. As physical and monetary flows typically refer to a specific area (single countries, regions or a group of them) for a given period, this framework would form a statistical basis for end-users and policy makers in order to evaluate the distributive and allocative effects of implementing alternative environmental and economic policies. This could help in assessing cost-benefit analysis on taxes and subsidies, public expenditure on environment protection, payment schemes for ecosystem services (ES) or the construction of "green" gross product indicators (many policy initiatives draw attention to the relevance of these analytical tools; e.g. the European Commission, COM (2009) 433 final - GDP and beyond; the EU Biodiversity Strategy to 2020 (European Commission, 2011); the adoption of the 2030 Agenda for Sustainable Development; the UN Sustainable Development Goals (and SDG indicators); the Paris Agreement and the 2030 framework on climate change).

Nowadays, interest is growing towards ecosystem accounting, a field of environmental accounting that uses ES to link the stock of natural capital to economic activity, integrating ecological and economic disciplines (see for a review Costanza et al., 2017). ES, defined as the contribution of ecosystems to benefits used in economic and other human activities (United Nations et al., 2014b), represent a perfect link between ecosystems and the economy (Geneletti et al., 2016; Haines-Young et al., 2016). From an ecological perspective, they measure the value of the flows produced by the stock of natural capital, which is crucial to get an idea of the effectiveness of an investment on ecosystem conservation. From an economic perspective, ES allow to elicit the environmental contribution to the production of economic value and well-being.

In 2014, the statistical unit of the United Nations developed and released a set of definitions and guidelines for national ecosystem accounting, aligned with the System of National Accounts

(SNA). These are referred to as System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) guidelines, thus underlining its work-in-progress nature. Accordingly, the Italian Ministry of the Environment and Protection of Land and Sea (MATTM) launched the Environmental Accounting in Marine Protected Areas (EAMPA) project, whose aim was to promote the development and implementation of ecosystem accounting for Italian Marine Protected Areas (MPAs).

Following the EAMPA project, the main contribution of this paper consists in developing a specific framework for environmental economic accounts for MPAs complemented with a set of indicators that allow interpreting the ecological, economic and financial values at different levels of aggregation in terms of management performance of the MPA and of the sustainability of the way ecosystem services are used. With this framework we respond to the encouragement of the SEEA-EEA to further test and experiment ecosystem accounting by showing some practical issues connected with building disaggregated accounts for single institutional units. We focus in particular on MPAs for the direct relationship they have with ecosystems and their flows and for the strong contribution that the ecosystems they manage have on local productive and consumptive activities. In fact, MPAs are public bodies entrusted with the preservation and restoration of ecosystems (habitats, biodiversity levels, and food channels) and of the relative flow of ES in areas of particular interest for flora, fauna, or geological nature. Since 2015, a steady decrease in the amount of public funds allocated to MPAs in Italy has raised critical issues for several management decisions. Against this background, accurate ecosystem accounts are essential for informed management decision on the trade-off between ecosystem preservation and human fruition, to evaluate the effectiveness and efficiency of the existing protection policies, and to shed light on the impact of investments in preservation on regional/national GDP.

The framework proposed fulfils two tasks. On the one hand, the standard proposed for the ecosystem accounts is in line with the SNA and the SEEA-EEA recommendations, thus facilitating the integration of the MPAs accounting items into national records. On the other hand, the ecosystem and financial accounting items are organized so that the framework and the indicators form a management tool useful to both the MATTM and MPAs.

In our approach we distinguish between the ES that have a public good/service nature (e.g. regulation) and those that have a private nature (e.g. provisioning) and we allocate them accordingly to two classes of beneficiaries, namely community and single institutional sectors. The distinction between different types of beneficiaries is desirable for many reasons. First, it allows identifying immediately the sectors involved when integrating these disaggregated accounts into regional/national Supply/Use (SUT) tables. Second, it offers the MPA a detailed management tool allowing comparing purely ecological with economic entries and calculating disaggregated indicators. Finally, the distinction between beneficiaries corresponds to the methodological issue of the appropriate approach for quantifying and valuing the ES (e.g. see Small, Munday and Durance, 2017 for a discussion on the representation of the links between ecosystems and beneficiaries and for the open challenges on ES valuation). Private services contribute to the so-called SNA benefits, which are individually appropriated and, therefore, have a market for transactions and a market price. Hence, to estimate the value of this kind of services, methods based on a utilitarian approach are entirely consistent. Instead, public services - often measured in ecological terms - contribute to the so-called non-SNA benefits that accrue to the whole community as they can be appropriated only in a collective manner. Hence, their economic value can be estimated at factor costs, consistently with the national economic accounts' conventions.

In a similar way, we include accounts for environmental damages produced by economic agents and bore by ecosystems. In particular, we define and measure environmental damages as the reduction in the flow of some ES. This allows us to derive a measure of net ecosystem services and provide insights in terms of the level sustainability of the different forms of human fruition.

Finally, we provide an insight on how the approach proposed can be generalised beyond the specific case described in the paper. In fact, the way in which is organized and its coherence with the SEEA-EEA allow a straightforward integration of the accounting scheme into National Accounts.

This paper proceeds as follows. In Section 2, we provide an overview of the latest developments on environmental and ecosystem accounting. Section 3 describes the EAMPA project and describes the approach. Section 4 and 5 illustrate the accounting scheme and indicators respectively. Section 6 contains some discussion and, finally, Section 7 draws concluding remarks.

2. Literature Review

Economic and environmental accounting have evolved independently and with limited exchanges until the 1990s, when, following the United Nations Conference on Environment and Development held in Rio de Janeiro, the Agenda 21 called for their integration in order to monitor the transition towards an environmental, social and economic sustainable development. It was not a straightforward task because of the different measurement units and accounting conventions of the two disciplines. In particular, environmental accounting principles and classifications were not yet standardised as for economic accounting, but various forms of conventions existed as a result of uncoordinated and *ad-hoc* statistics produced for independent environmental programs.

At the beginning of the 1990s, the United Nations worked with other supra-national bodies and scientific experts on the reorganization of the existing environmental statistics and the design of an integrated system of environmental and economic accounting based on the System of National Accounts (SNA). The System of Environmental Economic Accounting (SEEA) published in 1993 and evolved in the SEEA Central Framework (SEEA-CF) in 2013 represents a first attempt in this direction, a handbook that defines statistical standards and a common information framework for national environmental economic accounting. It is based on a system of satellite accounts that complement the SNA to incorporate the interactions between the economy and the environment, and the changes in stock of environmental assets. The integration between economic and environmental disciplines is pursued through classifications and definitions consistent with the SNA and through the conversion of flow and stock data from physical to monetary terms with different methods. The comparison between physical and monetary data is made through "hybrid" account formats (e.g. supply-use or input-output tables) or through indicators.

In parallel with the definition of a standard framework for environmental economic accounting, an increasing demand for statistics on ecosystems degradation and biodiversity loss (Millennium Ecosystem Assessment, 2005; TEEB, 2010; UKNEA, 2011) led to the development of the ecosystem approach and ecosystem accounting. Ecosystem accounting provides a different and complementary way of integrating the economic and environmental/ecological disciplines as it evaluates the environment from the perspective of ecosystems and explicitly links the flow of services they produce to human activity. A number of economic and ecological papers attempted to estimate ecosystem stock and services, recommending possible approaches to their economic valuation (see the reviews of Atkinson et al., 2012; Barbier, 2007; Ferraro et al., 2012) and proposing possible variations to the existent economic accounting structures in order to integrate ecosystems and their services (Bateman et al., 2011; Edens and Hein, 2013).

In 2014, the UN published the SEEA-EEA, a first step towards a statistical standard framework for ecosystem accounting. The handbook provides a definition and classification of ES, conventions on how to measure them in physical terms, and approaches to their monetary evaluation. Since its publication, attempts have been made in drafting ecosystem accounting for specific ES and specific local areas (see e.g. Busch et al., 2012; Obst et al., 2016; Remme et al., 2014; Suwarno et al., 2016; WAVES, 2012) or on a continental scale (La Notte et al., 2017) based on the recommendation of the SEEA-EEA guidelines. Moreover, a number of academic papers explored some of the challenges that limit a proper integration of ecosystem assets and services into national accounts and were not yet tackled by the UN publication. In particular, they addressed: classification challenges connected with the definition of ecosystem services and their complete inventory (Edens and Hein, 2013; Obst et al., 2016; Remme et al., 2014); methodological challenges connected with the biophysical assessment and measurement of ecosystems (Vallecillo et al., 2019), valuation method challenges (Caparrós et al., 2017; Droste and Bartkowski, 2017; La Notte et al., 2019; Obst et al., 2016), indicators challenges on how to properly measure ecosystems degradation (Ovando et al., 2016) and implementation challenges (Bordt, 2018; Dvarskas, 2018).

In this paper, we focus on implementation challenges. As discussed by Dvarkas *et al*. (2018), there still are three main hindrances to the applicability of the SEEA-EEA accounting framework. Firstly, there are not consolidated environmental/economic datasets and time-series. Secondly, it is not clear how to define and select spatial accounting units. Thirdly, there are still no indications on how to compile ecosystem accounting schemes at a local level or for single institutional units/sectors in a way that is consistent with national accounting tables.

To this purpose, we join a still limited but growing strand of the ecosystem accounting literature that focuses on marine and coastal ES. Lai *et al.* (2018) illustrated how Finnish ES indicators - produced nationally as a part of the European initiative "Mapping and Assessment of the Ecosystems and their Services" - can be exploited to create ecosystem accounts for water-related and fish provisioning ecosystem services. In a case study on the Gulf of Saint-Malo. Martin *et al.* (2018) used an *ad-hoc* survey to estimate the value of cultural marine ES offering an insight of the relationship between cultural and recreational services. Furthermore, Dvarskas *et al*. (2018) developed a pilot application of the SEEA-EEA to Long Island coastal bays in physical terms proposing new indicators of ecosystem condition and ecosystem services.

However, differently from the mentioned studies, we do not aim at producing a final economic value for marine ecosystems and their services, but we want to present a sample for a standard accounting framework that can be applied on a local scale as a logical linkage between local and national accounting. Furthermore, we focus on the economic interpretation of the accounting records in order to highlight their role in the process of public decision-making and management choices.

3. EAMPA project and our approach

In 2014, the MATTM launched the four-year EAMPA project that aimed at developing and implementing an environmental accounting system for 29 Italian MPAs, with particular reference to their ES. The objective of the project was an assessment of the value of MPAs' natural capital and flows of services obtained from its integrated ecological and economic balances. In 2017, the MATTM published the "Second Report on the State of Natural Capital in Italy" (SNC), stressing the importance of quantifying natural capital and its flows in terms of ES following the SEEA-EEA recommendations on ecosystem accounts (Comitato Capitale Naturale, 2018).

The EAMPA project is articulated in several phases. The first phase consists in a biophysical evaluation of the natural capital of the MPAs separately for each ecosystem. The second, third, and fourth phases consist in identifying ES and quantifying their value in both physical and monetary units. In the fifth phase, previous results are combined with the MPA financial statements to form a final MPA's balance. In this paper, we do not address the estimation and assessment of ecosystem assets. Our aim is to illustrate an approach to the accounting structure of an MPA, and this refers to the last phase of the project.

Our approach is based on the premise that there is a natural sector, composed of a set of different ecosystems, which "is the "producer" of all environmental asset services and net environmental benefits and the "consumer" of all environmental damages" (Peskin, 1976). In some areas, this sector is particularly productive due to the presence of certain types of ecosystems and their favourable condition. Typically, these areas are "protected" by the government to preserve them and maintain the flow of services that derives from them. MPAs are the institutional entities entitled to manage these areas, carry out a series of activities and establish rules to limit the depreciation of the assets and maintain a non-diminishing flow of services.

In this paper, we assume that the existence of ES in a specific territorial area is completely attributable to the presence of the MPA and, in line with the SEEA-EEA guidelines, we define as ecosystem accounting unit the spatial area managed by the MPA.

Table 1 presents the ES that can be associated with an MPA, which belong to the three well-known Common International Classification of Ecosystem Services (CICES) classes: provisioning, regulating and cultural. For each ES, the table also details the group, classification code and the associated benefits, as well as the nature of the ES, which we classify as private or public according to their nature and beneficiaries.

Ecosystem service	**Group**	**CICES v5.1**	**Benefits**	**Nature**
Provisioning	Cultivated aquatic plants for nutrition, materials or energy	1.1.2	Plants and algae from in-situ aquaculture	Private
	Reared aquatic animals for nutrition, materials or energy	1.1.4	Animals from in-situ aquaculture	Private
	Wild aquatic plants for nutrition, materials or energy	1.1.5	Wild plants, algae and their outputs	Private
	Wild aquatic animals for nutrition, materials or energy	1.1.6	Wild animals and their outputs	Private
	Genetic material from plants, algae or fungi	1.2.1	Genetic materials from all biota	Public/Private

Regulation and maintenance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	2.1.1	Bio-remediation by micro-organisms, algae, plants, and animals	Public
	Mediation of nuisances of anthropogenic origin	2.1.2	Mediation of smell/noise/visual impacts	Public
	Regulation of baseline flows and extreme events	2.2.1	Stabilisation and control of erosion rates, Buffering and attenuation of mass flows, Hydrological cycle and water flow maintenance and flood protection	Public
	Lifecycle maintenance, habitat and gene pool protection	2.2.2	Pollination and seed dispersal, Maintaining nursery populations and habitats	Public
	Water conditions	2.2.5	Chemical condition of salt waters	Public
	Atmospheric composition and conditions	2.2.6	Global climate regulation by reduction of greenhouse gas concentrations	Public
Cultural	Physical and experiential interactions with natural environment	3.1.1	Experiential use of plants, animals and land-/seascapes in different environmental settings, Physical use of seascapes in different environmental settings	Public/Private
	Intellectual and representative interactions with natural environment	3.1.2	Scientific, Educational, Heritage and cultural, Aesthetic	Public
	Spiritual, symbolic and other interactions with natural environment	3.21	Symbolic, religious, entertainment	Public
	Other biotic characteristics that have a non-use value	3.2.2	Existence, bequest	Public

Table 1: List of ecosystem services considered in the analysis and the relative benefits

We also account for environmental damages intended as a reduction in ES due to the negative environmental pressures of anthropic activities on ecosystems (e.g. emissions, waste, non-sustainable behaviours). Hence, we obtain a value of net ecosystem services equal to the net balance between ES and damages. In our view this value should enter the SNA expanded to include ecosystems, instead of populating an account *per se*, which seems to be the norm.

4. Structure and description of the accounts

The accounting structure we propose is composed of the following three modules, all measured in monetary terms:

- *Module 1* presents the flow account of ES (Figure 1)
- *Module 2* presents the environmental damages from fruition activities (Figure 2)
- *Module 3* presents revenues and costs from the financial accounts (Figure 3)

4.1. Flows of ecosystem services (Module 1)

Module 1 presents the flow of ES for a given period (generally a year) for an MPA. The module organization reflects our above-mentioned approach: entries are recorded in terms of ES and beneficiaries are separated into two categories (i.e. community and single activities). Rows represent the different types of ES and columns represent the beneficiaries, distinguishing community from the single fruition activities. All entries are reported in monetary terms. As ES and the single activities vary among protected areas, Figure 1 provides an exemplification of *Module 1* structure.

Ecosystem Service		**Community**	**Professional fishing**	**Recreational fishing**	**Scuba Diving**	**Boating**	**Bathing**	***Total benefits from each ES***
PROVISIONING	Wild aquatic animals for nutrition, materials or energy		x					xxx
REGULATING AND MAINTAINANCE	Atmospheric composition and conditions	x						xxx
CULTURAL	Physical and experiential interactions with natural environment			x	x	x	x	xxx
	Intellectual and representative interactions with natural environment	x						xxx
Total services fruited		xxx	xxx	xxx	xxx	xxx	xxx	**xxx**

Figure 1 - *Module 1*: flow of ES in monetary terms

Module 1 should be compiled following the SEEA-EEA guidelines. For accounting purposes, ES are defined as "the contribution of the ecosystems to benefits used in economic and other human activities" (United Nations et al., 2014b) and they should be valued at their exchange value in line with the SNA. As a consequence, the value of an ES can be derived as the difference between the total value of the produced benefit and the value of the human contribution. This is the approach recommended by the SEEA-EEA for provisioning and cultural services and it is particularly convenient for their elicitation from the SNA existing records and to ensure avoiding double counting.

In economic terms, the value of benefits coincides with the producer revenues and the ES with the resource rent. In welfare terms, the rent coincides with the producer surplus which is a measure of economic benefit. Total welfare, i.e. total benefit, includes also the consumer surplus which, according to the SEEA-EEA should not be accounted for as it does not involve monetary transactions.[1] The economic interpretation of the ES definition leaves some margin for reflection. Indeed, it could be argued that the producer surplus is not expected to always coincide with the ES as this part of economic benefit could have other sources than the ecological ones. For instance, for cultural services, the producer surplus could depend not only on the beautiful landscapes but also on

[1] In the next section, we will discuss how its valuation would provide valuable information for sustainability assessments.

the fame of the site (i.e. Portofino, Capri). Furthermore, the ES interpretation is founded on the assumption that the market is competitive and producers are profit maximisers (Edens and Hein, 2013). In the MPA case, for example, the number of suppliers (e.g. diving clubs) authorised is limited and there are entry barriers.

The critical issues pointed out, call for further research on the appropriate way of defining and valuing ES to appropriately account for their context of use, but this is out of the scope of the present paper. In the remaining of the section, we focus on how current conventions recommend estimating the value of the different classes of ES with specific reference to MPAs.

Provisioning services are traditionally regarded as the easiest type of ES to valuate as they produce benefits that are exchanged in markets (e.g. food, plants, and fibre) and are characterised by a market price. In MPAs, provisioning services are represented mainly by harvested fish.

Differently, cultural services can either have a market or not, and have a public or private nature. Services connected with the experiential and physical use of landscapes – sometimes referred to as touristic and recreational services – typically have a private nature and they can have a market and a price (e.g. hotel accommodation, pedal boat rental, scuba diving activities) or not (e.g. bathing). In the first case, the procedure is the same as for provisioning services; in the second case, a valuation method should first be applied in order to derive the willingness to pay (WTP), and hence, the demand for the benefits associated with the service.

The estimation methods available (see Bateman et al., 2011; TEEB, 2010; United Nations et al., 2014b for an overview) belong to the classes of revealed and stated preferences and they can be more or less desirable depending on their characteristics and the context in which they are used. A debated topic concerning valuation methods regards consumer surplus as methods such as contingent choice or stated preferences lead to an estimation of the value of the environmental non-marketed service in which consumer surplus cannot be drawn apart (Caparrós et al., 2017; see Edens and Hein, 2013) but they are nevertheless often employed.

Other cultural services, i.e. intellectual, spiritual, existence and bequest services, generally have a public nature, they are rarely associated to an economic activity in the scope of the SNA and their presence is usually site-specific (e.g. a particular specie of flora or fauna or landscape). To elicit their economic value, a valuation method could be applied based on the concept of individual' WTP.

For what concerns regulating services, the human element is missing, and ES coincide, in fact, with the benefits. Furthermore, regulating services provide the so-called "non-SNA" benefits, i.e. benefits that are not produced by economic units and are not traded in markets. Nevertheless, their estimation is not straightforward since there are not shared conventions yet. Given that the SNA recommends to value public goods at cost (European Commission et al., 2009) and regulating services share a public nature, previous literature has often resorted to avoided-damage cost methods (e.g. carbon sequestration and Social Cost of Carbon). However, the only attempts at the estimation and valuation of regulating services have so far concerned only climate regulation.

4.2. Environmental damages (Module 2)

Module 2 records the flows of environmental damages produced by human in terms of reduction in ES. Indeed, the negative environmental pressures of fruition are sustained by ecosystem assets, whose general condition is affected quantitatively and qualitatively resulting in a lower supply of ES. Human pressures can be of a multitude of types (e.g. carbon emissions, production of waste, unsustainable behaviours, consumption and misuse of natural resources) and are produced by all the activities carried out in a specific area, including the conservation activity of the MPA. For accountability purposes, we consider only final damages (i.e. fishing endangered species reduces aquatic wildlife), but we also acknowledge the existence of indirect damages (e.g. damage to the *coralligeni* habitat reduces the supporting service and, thus, the aquatic wildlife).

We decided to organise the module taking the viewpoint of the MPA –paying a particular attention to the ecosystems – in order to allow a direct juxtaposition between Module 1 and Module 2 and to facilitate the calculation of a net balance for ecosystem services.

Figure 2 presents an example of *Module 2*. The AMP conservation activity (e.g. surveillance and maintenance) as well as all the other activities that imply the use of an engine boat can lead to carbon emissions, which can be measured and then translated into monetary terms. Instead, professional fishing can lead to a reduction of the wildlife for nutrition when it is not sustainable and small sized fishes and endangered species are harvested. The reduction of the services should be estimated applying a probability determined based on a case study in the area under analysis. Marine littering by the different activities could impact on cultural services as well as other unsustainable behaviours (e.g. abandoning fishing nets in the sea, damaging the sea bottom with fins or anchors). Its impact in terms of reduction of the flow of services should be measured using the valuation methods described in the previous section.

Ecosystem Service		AMP conservation activity	Professional fishing	Recreational fishing	Scuba Diving	Boating	Bathing	*Total damage sustained by each ES*
PROVISIONING	Wild aquatic animals for nutrition, materials or energy		x					xxx
REGULATING AND MAINTAINANCE	Atmospheric composition and conditions	x	x	x	x	x		xxx
CULTURAL	Physical and experiential interactions with natural environment		x	x	x	x	x	xxx
	Intellectual and representative interactions with natural environment		x		x	x		xxx
Total damage produced by human activities		xxx	xxx	xxx	xxx	xxx	xxx	**xxx**

Figure 2 - *Module 2*: Environmental damages from fruition activities

4.3 Financial revenues and cost (Module 3)

This module records the financial inflows and outflows of the MPA that are yearly reported in its financial statements, reorganized to convey useful information to MPA managers and policy makers. The proposed reclassification aims at establishing a more understandable link between the financial flows and the operations performed by and within the MPA.

Module 3 illustrates the financial benefits generated and received by the MPA and how they are employed for different types of institutional activities. Financing sources are disaggregated to make explicit the revenues obtained from government funds, European funds (i.e. project funds), and specific fruition activities (i.e. permits), as exemplified in Figure 3. Expenditure is divided into current (e.g. maintenance and surveillance of mooring fields), capital (e.g. purchase of durable goods and unscheduled maintenance operations), for specific projects (e.g. service provision and temporary personnel) and other expenditures (e.g. administrative personnel and consumables).

Financing source	Current expenditure for conservation activities	Capital expenditure for conservation activities	Expenditure for specific projects	Other expenditure	***Total from financing source***
Public funds					Xxx
National/regional governemnt	x	x		x	Xxx
European Union	x	x	x		Xxx
Self-financing					Xxx
Professional fishing	x	x		x	Xxx
Ricreational fishing	x	x		x	Xxx
Boating	x	x		x	Xxx
Scuba-diving	x	x		x	Xxx
Bathing	x	x		x	Xxx
Reserves	x	x		x	Xxx
Total for financial expenditure	xxx	xxx	xxx	xxx	Xxx

Figure 3 - *Module 3:* Financial benefits

5. Indicators and margins

The above-described structure of accounts allows constructing a number of indicators and margins of economic, environmental, financial, and mixed nature. A detailed description of all of them is beyond the scope of this paper, thus, in the remaining of this section, which focuses on two types of mixed indicators and margins that in our view are of particular interest for policy-makers at a governmental and MPA level.

5.1 Efficiency indicators

A first general measure of efficiency refers to the MPA institutional activity and measures the Rate of Return of Investments in ES (RORIES), defined by the following ratio:

$$RORIES = \frac{Total\ ES}{(Public\ funding\ +\ self-financing)}$$

If we take the denominator as a cost measure of the value of the conservation actions carried out by the MPA, the ratio can be interpreted as the return (in terms of ES flow) of each euro invested in conservation activities. Additionally, RORIES can be disaggregated into two indicators:

$$\frac{SNA\ ES}{(Public\ funding\ +\ self-financing)}$$

$$\frac{Non-SNA\ ES}{(Public\ funding\ +\ self-financing)}$$

These indicators inform on the efficiency of an investment in conservation in terms of public and private services produced by the ecosystem assets.

However, RORIES type indicators should be interpreted with caution since it is difficult to clearly disentangle the (positive and negative) effects attributable to the MPA activity from those that can be considered site-specific and imputable to the specific condition of the ecosystem asset. Therefore, the value of these indicators can be compared over time for a given MPA to observe trends in the efficiency of conservation policies, but the comparison between MPAs is not as straightforward because they can considerably diverge in terms of asset characteristics (e.g. composition, functions, configuration, landscape, functions, and biodiversity).

A more appropriate measure of efficiency should be properly defined in marginal terms by the following ratio:

$$\frac{\Delta_{\,t_1-t_0}(\,Total\ ES)}{\Delta_{\,t_1-t_0}\,(Public\ funding\ +\ self-financing)}$$

where the nominator and denominator represent the variation in total ecosystem services and the variation of funding between two periods respectively. This could be interpreted as the marginal return (in terms of ES flow) of an increase of conservation funding from one period to the other. However, marginal data on ES are rarely available.

Average and marginal measures of the efficiency should be interpreted with caution because they refer to a set of different ESs and for each of them the relationship linking the MPA management capacity to the quantitative and qualitative characteristics of the ecological asset may greatly differ. With regard to the climate regulation or provisioning services, for instance, the relationship between stock and flow depends only on the quantitative characteristics of the asset (e.g. square meters of algae) and can be estimated in ecological terms. In this case, comparing efficiency between MPAs is reasonable, at least in marginal terms.

For cultural services, the flow of services generally depends on the asset (e.g. marine landscape) from both a quantitative and qualitative point of view and the form of their relationship is unknown. Therefore, in this case, a comparison among MPAs is not straightforward.

5.2 Management margins

The MPA management activities aim to: (i) regulate the use in protected areas; (ii) directly and actively intervene on the quality or quantity of the ecosystem asset. From both viewpoints, it is relevant for MPA managers to have information on the environmental sustainability of the different fruition activities and, in particular, those connected to economic activities of third beneficiaries (e.g. diving).

An overall measure of sustainability (Net_ES) is the difference between the value of the total environmental benefits – coinciding with the ES – and the value of the total environmental damage generated by the fruition and institutional activities of the MPA:

$$Net\_ES = Total\ ES - Total\ environmental\ damages$$

This overall measure can be replicated separately for specific uses that are particularly relevant in the evaluation and management of MPAs. Environmental sustainability can be compared with the self-financing generated by the payment that the AMP requests from third-party beneficiaries as payment for their use, at least for some activities. The comparison between these two values can help to identify situations in which the benefits are lower or equal to the environmental damage and the payment is at most merely compensatory for the damage. Moreover, it constitutes a starting point for determining the price to be set as a payment for specific fruition activities in all other cases. For example, the *Net ES* margin can provide a term of comparison for evaluating the amount that an MPA can set for diving permits, so that their price takes into account the level of sustainability of the specific activity and of the value of the environmental services it consumes.

For what concerns sustainability measures, there is still space for further research based on consumer surplus analysis. Ecological studies provide the rate that measures the relationship between the level of exploitation of an ES and the depreciation of the ecosystem stock. Hence, from consumer surplus, one should be able to measure the margin, in terms of price, that allows a reduction in quantity such that the ecological rate is at its optimum.

6. Discussion: from MPA accounts to national SUT tables

This paper proposes an approach that can be used to draft the economic and environmental accounting of an MPA. The structure we built has a dual purpose: it provides an account that could be easily integrated into national accounts and it also serves as a management tool for MPAs. This section focuses on the former objective by exemplifying how the integration could be achieved and it shows that the integration into national SUT tables is straightforward thanks to the way in which we structured the account on the flows of ES (i.e. making explicit the beneficiaries).

The way in which ES are typically included in national accounts is the following: the value of the provisioning and cultural services is made explicit among the intermediate inputs and the value of the regulating services is added to the final products. In the remaining of this section, we provide an example of the transition from our MPA accounting schemes to the national S/U table. We employ the accounting convention proposed by Edens and Hein (2013) and presented in the SEEA-EEA: the ecosystem is regarded as a new sector that produces resources (i.e. ES) that are consumed by the other sectors.

Table 2 shows a simplified version of our *Module 1* account and Table 3 shows an example of a SUT table. The ecosystem sector produces provisioning services for “b”, regulating services for “a” and cultural services for “c”, as it appears in the rows of Table 1 and in the second column of the supply table. The provisioning and cultural services (i.e. SNA services) become intermediate inputs for the production of harvested fish and recreational activities consumed by the professional fishing and diving sectors respectively (see columns of Table 2 and Table 3), while regulating services (i.e. non-SNA services) become final benefits consumed by the community (see “Households” column in Table 3).

Ecosystem services	**Community**	**Professional fishing**	**Diving**
Provisioning		b	
Regulating	a		
Cultural			c

Table 2 – Example of Module 1 for an MPA

SUPPLY	**Ecosystem**	**Professional fishing**	**Diving**	**Households**	
Provisioning – fish	b				b
Harvested fish		d			d
Regulating	a				a
Cultural	c				c
Recreational			e		e
USE					
Provisioning – fish		b			b
Harvested fish				d	d
Regulating				a	a
Cultural			c		c
Recreational				e	e
VA	**a+b+c**	**d-b**	**e-c**		**a+d+e**

Table 3 – Example of national SUT table

7. Conclusions

National environmental-economic accounting is a field of study that is gaining increasing attention since it supports national decision making in pursuit of global targets (Sustainable Development Goals). The latest advancement in this field of study is the development of ecosystem accounting, in which ecological and economic data are integrated thanks to the new concept of ES. Even if in 2014 the United Nations released a handbook synthetizing the current knowledge on ecosystem accounting and a set of accounting conventions and structures (i.e. SEEA-EEA), the topic needs to be further investigated in order to develop a standard framework.

In this paper, we shift the focus from the national perspective to a single institutional unit, i.e. the MPA, trying to design ecosystem accounts following the SEEA-EEA recommendations. Indeed, the integration of single institutional units' financial statements into the national economic accounts is standardised within the SNA, but no conventions on how their ecosystem accounting records should enter into national ecosystem accounts are currently lacking. Based on these considerations, our aim is to provide an accounting framework for MPAs that is in line with the current norms on ecosystem accounting and that can be easily integrated into larger scale accounts. At the same time, we try to organise the accounts so that they can become a management tool for MPA managers.

In pursuit of this purpose, we designed three modules consisting in an ES flows account, an ecosystem damages account and a financial account. In each of them, we disaggregated the records to make explicit the institutional unit involved, thus easing the transition towards national accounts. This approach also allows constructing a series of indicators of mixed type (financial, economic and environmental) that provide information on the return of investments in conservation and allows evaluating alternative conservation policies.

Although we do not provide an exemplification of how to populate the presented accounting schemes with real numbers, we outline the main obstacles that need to be tackled when attempting to fill them, emphasizing the issues on which economic and ecological researchers are still debating.

The approach we illustrated can be easily replicated for rural protected areas once the ES provided and the human activities present on the territory are identified.

We believe that a further step towards standard disaggregated ecosystem accounting would regards those sectors closely linked to the environment (i.e. agricultural sector, energy sector); a similar approach could be employed to draw up ecosystem accounting schemes for them and to reorganize their financial statements. Then, once conventions for single institutional units are consolidated, these can be aggregated to a sectorial level to form local and regional ecosystem accounts that, eventually, will merge into a single national account, following a bottom-up approach.

References

Atkinson, G., Bateman, I., Mourato, S., 2012. Recent advances in the valuation of ecosystem services and biodiversity. Oxford Rev. Econ. Policy 28, 22–47. https://doi.org/10.1093/oxrep/grs007

Barbier, E.B., 2007. Valuing ecosystem services as productive inputs. Econ. Policy 22, 177–229.

Bateman, I.J., Mace, G.M., Fezzi, C., Atkinson, G., Turner, K., 2011. Economic analysis for ecosystem service assessments. Environ. Resour. Econ. 48, 177–218. https://doi.org/10.1007/s10640-010-9418-x

Bordt, M., 2018. Discourses in Ecosystem Accounting: A Survey of the Expert Community. Ecol. Econ. 144, 82–99. https://doi.org/10.1016/j.ecolecon.2017.06.032

Busch, M., La, A., Laporte, V., Erhard, M., 2012. Potentials of quantitative and qualitative approaches to assessing ecosystem services. Ecol. Indic. 21, 89–103. https://doi.org/10.1016/j.ecolind.2011.11.010

Caparrós, A., Oviedo, J.L., Álvarez, A., Campos, P., 2017. Simulated exchange values and ecosystem accounting: Theory and application to free access recreation. Ecol. Econ. 139, 140–149. https://doi.org/10.1016/j.ecolecon.2017.04.011

Comitato Capitale Naturale, 2018. Secondo Rapporto sullo Stato del Capitale Naturale in Italia. Roma.

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., Grasso, M., 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosyst. Serv. 28, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Droste, N., Bartkowski, B., 2017. Ecosystem Service Valuation for National Accounting: A Reply to Obst, Hein and Edens (2016). Environ. Resour. Econ. 1–11. https://doi.org/10.1007/s10640-017-0146-3

Dvarskas, A., 2018. Experimental ecosystem accounting for coastal and marine areas: A pilot application of the SEEA-EEA in Long Island coastal bays. Mar. Policy 100, 1–11. https://doi.org/10.1016/j.marpol.2018.11.017

Edens, B., Hein, L., 2013. Towards a consistent approach for ecosystem accounting. Ecol. Econ. 90, 41–52. https://doi.org/10.1016/j.ecolecon.2013.03.003

European Commission, 2011. The EU Biodiversity Strategy to 2020. https://doi.org/10.2779/39229

European Commission, 2009. GDP and beyond. Measuring progress in a changing world COM (2009) 433 final. Brussels.

European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations, The World Bank, 2009. System of National Accounts 2008, United Nations, New York. https://doi.org/10.1057/ukna.2008.3

Ferraro, P.J., Lawlor, K., Mullan, K.L., Pattanayak, S.K., 2012. Forest Figures: Ecosystem Services Valuation and Policy Evaluation in Developing Countries. Rev. Environ. Econ. Policy 6, 20–44. https://doi.org/10.1093/reep/rer019

Geneletti, D., La Notte, A., D'Amato, D., Liquete, C., Paracchini, M.L., Mäkinen, H., Egoh, B., Crossman, N.D., 2016. Ecosystem services classification: A systems ecology perspective of the cascade framework. Ecol. Indic. 74, 392–402. https://doi.org/10.1016/j.ecolind.2016.11.030

Haines-Young, R., Potschin, M., Fish, R., Turner, R.K., 2016. Defining and measuring ecosystem services, in: Routledge Handbook of Ecosystem Services. Routledge, Taylor & Francis Group, London, New York, pp. 25–47. https://doi.org/10.1017/CBO9781107415324.004

La Notte, A., Maes, J., Dalmazzone, S., Crossman, N.D., Grizzetti, B., Bidoglio, G., 2017. Physical and monetary ecosystem service accounts for Europe: A case study for in-stream nitrogen retention. Ecosyst. Serv. 23, 18–29. https://doi.org/10.1016/j.ecoser.2016.11.002

La Notte, A., Vallecillo, S., Marques, A., Maes, J., 2019. Beyond the economic boundaries to account for ecosystem services. Ecosyst. Serv. 35, 116–129. https://doi.org/S2212041617307246

Lai, T.Y., Salminen, J., Jäppinen, J.P., Koljonen, S., Mononen, L., Nieminen, E., Vihervaara, P., Oinonen, S., 2018. Bridging the gap between ecosystem service indicators and ecosystem accounting in Finland. Ecol. Modell. 377, 51–65. https://doi.org/10.1016/j.ecolmodel.2018.03.006

Martin, J.C., Mongruel, R., Levrel, H., 2018. Integrating Cultural Ecosystem Services in an Ecosystem Satellite Account: A Case Study in the Gulf of Saint-Malo (France). Ecol. Econ. 143, 141–152. https://doi.org/10.1016/j.ecolecon.2017.07.005

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis, The Millennium Ecosystem Assessment series. Island Press, Washington DC. https://doi.org/10.1196/annals.1439.003

Obst, C., Hein, L., Edens, B., 2016. National Accounting and the Valuation of Ecosystem Assets and Their Services. Environ. Resour. Econ. 64, 1–23. https://doi.org/10.1007/s10640-015-9921-1

Ovando, P., Campos, P., Oviedo, J.L., Caparrós, A., 2016. Ecosystem accounting for measuring total income in private and public agroforestry farms. For. Policy Econ. 71, 43–51. https://doi.org/10.1016/j.forpol.2016.06.031

Peskin, H.M., 1976. A National Accounting Framework for Environmental Assets. J. Environ. Econ. Manage. 2, 255–262.

Remme, R.P., Schröter, M., Hein, L., 2014. Developing spatial biophysical accounting for multiple ecosystem services. Ecosyst. Serv. 10, 6–18. https://doi.org/10.1016/j.ecoser.2014.07.006

Suwarno, A., Hein, L., Sumarga, E., 2016. Who Benefits from Ecosystem Services? A Case Study for Central Kalimantan, Indonesia. Environ. Manage. 57, 331–344. https://doi.org/10.1007/s00267-015-0623-9

TEEB, 2010. The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. https://doi.org/10.1007/BF02331707

Thompson, H., 2006. The applied theory of energy substitution in production. Energy Econ. 28, 410–425. https://doi.org/10.1016/j.eneco.2005.01.005

UKNEA, 2011. UK National Ecosystem Assessment: Technical Report. Cambridge. https://doi.org/10.1109/ICPP.2015.14

United Nations, European Commission, Food and Agricultural Organization of the United Nations, International Monetary Fund, Organisation for Economic Cooperation and Development, Word Bank, 2014a. System of Environmental-Economic Accounting 2012 - Central Framework, New York. ed. New York. https://doi.org/ST/ESA/STAT/Ser.F/109

United Nations, European Commission, Food and Agricultural Organization of the United Nations, Organisation for Economic Co-operation and Development, The World Bank, 2014b. System of Environmental- Economic Accounting 2012 - Experimental Ecosystem Accounting. New York. https://doi.org/ST/ESA/STAT/Ser.F/109

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., Maes, J., 2019. Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. Ecol. Modell. 392, 196–211. https://doi.org/10.1016/j.ecolmodel.2018.09.023

WAVES, 2012. Moving Beyond GDP How to factor natural capital into economic decision making. Washington DC. https://doi.org/10.5840/philotheos200554