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Challenges of Introducing Marine Ecosystem Services in the System of National Accounts

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Mestrado em Governação e Sustentabilidade do Mar

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IPMA

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"Things get done only if the data we gather can inform and inspire those in a position to make a difference."

Mike Schmoker

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"Done is better than perfect".

Resumo

O Oceano é reconhecido como fundamental para um planeta saudável. Os serviços prestados pelo Oceano são essenciais à vida humana. Os Serviços dos Ecossistemas Marinhos (SEM) são difíceis de contabilizar e avaliar devido à complexidade do sistema oceânico. Esta dissertação visa avaliar os desafios da integração dos SEM no Sistema de Contas Nacionais. Pretende-se analisar como os dados do descritor 3 - "Populações de peixes e moluscos explorados para fins comerciais", da Diretiva Quadro "Estratégia Marinha", de interesse nacional e comunitário, podem ser incluídos numa conta nacional que pode ser incluída na Conta Satélite do Mar e, por sua vez, no Sistema de Contas Nacionais, acrescentando deste modo valor à economia portuguesa, reforçando a consciência da importância dos SEM e, em particular, dos serviços associados à atividade piscatória, promovendo também a sua reestruturação e preservação e respondendo a uma das medidas emblemáticas da Estratégia Nacional para o Mar 2030 – Objetivo Estratégico 1: Combate às Alterações Climáticas e à Poluição, e Recuperação de Ecossistemas; Medida nº 1: Implementar um Programa Nacional de Mapeamento de Habitats e Serviços de Ecossistemas Marinhos e Costeiros incluindo medidas de restauro. Como o presente estudo é curto no tempo e o conhecimento sobre a criação de contas de serviços de ecossistemas ainda é recente e complexo. O trabalho procurou utilizar os métodos e abordagens recomendados mais recentes, como o Sistema de Contas Económicas Ambientais – Contas Experimentais de Ecossistema (SEEA-EA), tendo sido limitado pelos desafios inerentes que são referidos na literatura.

Palavras-chave: Economia Ambiental, Economia dos Recursos Naturais, Governança, Serviços de Ecossistema Marinhos, Áreas Marinhas Protegidas, Sistema de Contas Nacionais.

Abstract

The Ocean is recognized as fundamental for a healthy planet. The services provided by it are essential to human life. Marine Ecosystem Services (MES) are difficult to account for and value due to the complexity of the Ocean system. This dissertation aims to evaluate the challenges of integrating MES into the System of National Accounts. It analyzes how the data of Descriptor 3 - “Populations of fish and shellfish exploited for commercial purposes”, of the Marine Strategy Framework Directive, which are of national and European interest, can be included in a national account that can be integrated in the Satellite Account for the Sea, and therefore in the System of National Accounts; it adds value to the Portuguese economy, reinforcing awareness of the importance of MES, and in particular, of the services associated with fishing activity, promoting their restructuring and preservation. Finally, it answers one of the emblematic measures of the National Strategy for the Sea 2030 – Strategic Objective 1: Combating Climate Change and Pollution and Restoring Ecosystems; Measure nº 1: Implement a National Program for the Mapping of Habitats and Services of Marine and Coastal Ecosystems including restoration measures. As the present study is short in time, and knowledge regarding the creation of ecosystem service accounts is still recent and complex. The following work seeked to use the most recent methods and approaches recommended, namely the System of Environmental Economic Accounting - Experimental Ecosystem Accounting (SEEA-EA).The study faced the same limits as referred in the literature.

Keywords: Environmental Economics, Natural Resource Economics, Governance, Marine Ecosystem Services, Marine Protected Areas, System of National Accounts.

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Glossary

CFP - Common Fisheries Police

CICES - Common International Classification of Ecosystem Services

EC - European Commission

EEA - European Economic Area

EEZ - Exclusive Economic Zone

ES - Ecosystem Service

EU - European Union

FAO - Food and Agriculture Organization

GDP - Gross Domestic Product

GES - Good Environmental Status

GT - Gross Tonnage

ICES - International Council for the Exploration of the Sea

ICNF - Institute for The Conservation of Nature and Forests

INE - National Statistical Institute Office

IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC - Intergovernmental Panel on Climate Change

IUU - Illegal, Unreported, Unregulated fisheries

MEA – Millennium Ecosystem Assessment

MES – Marine Ecosystem Services

MPA - Marine Protected Area

MS - Member State

MSFD – Marine Strategy Framework Directive

MSY - Maximum Sustainable Yield

NCA – Natural Capital Account

NESCS - National Ecosystem Services Classification System

PMPLS - Professor Luíz Saldanha Marine Park

PNAB - National Biological Sample Program

POPNA - Management Plan for the Arrábida Natural Park

SAS - Satellite Account for the Sea

SDG - Sustainable Development Goal

SEEA - System of Environmental Economic Accounting

SEEA-EA - System of Environmental Economic Accounting - Experimental Ecosystem Accounting)

SNA – System of National Accounts

SSB - Spawning Stock Biomass

SST - Sea Surface Temperature

TAC - Total Allowable Catch

TEEB - The Economics of Ecosystems and Biodiversity

TES – Terrestrial Ecosystem Services

UN – United Nations

UNCEEA - UN Committee of Experts on Environmental Economic Accounting

UNCLOS - United Nations Convention of the Law of the Sea

WWF - World Wide Fund for Nature

Introduction

The importance of the Ocean is recognized as fundamental for a healthy planet. The services it provides are essential to human life, from carbon sequestration and oxygen production, which are considered regulatory services, to the capture of seafood to feed the world population. It is also home to important genetic resources with highly recognized monetary value. This dissertation aims to evaluate and study the challenges of integrating Marine Ecosystem Services (MES) into the System of National Accounts (SNA).

MES are harder to account for and value than Terrestrial Ecosystem Services (TES), due to the complexity of the Ocean system. The lack of physical borders, the mobility of its resources, the difficulty of evaluating its environment, the three-dimensional structure of the Ocean, and the high investment needed for appropriate equipment and technology for its study, are some of the main global challenges related to the study of the Ocean system. These issues justify the delay in the study of MES when compared to TES (Pendleton et al., 2015, Townsend et al., 2018).

Nevertheless, it is important to integrate these services into national accounts, as this integration reinforces the value attributed to the services, especially at a time when ecosystems are threatened by degradation. If there is an understood and recognized value of the services provided to us by marine ecosystems, these will be better understood by civil society, governments, and decision-makers. This might lead to better measures of protection and restoration, which are more likely to be defended and respected. By creating value, we develop a sense of belonging and highlight the need to protect our planet's resources.

Several international organizations and institutions have already created legislation and recommendations for the protection of ecosystem services. The SEEA (System of Environmental Economic Accounting), and the SEEA-EEA (SEEA - Experimental Ecosystem Accounting), both developed by the United Nations (UN), contain environmental accounting systems for the physical and economic valuation of ecosystems. At the European Union level, the Marine Strategy Framework Directive (MSFD) was created and implemented among Member States, to guarantee the good environmental status of the Union marine waters by 2020, through periodic evaluation of the qualitative descriptors of good environmental status and application of monitoring and measures programmes. Since this directive entered into force, various actions have been taken for creating Natural Capital Accounts (NCA) and MES accounts.

Descriptor 3 of the MSFD – “Populations of fish and shellfish exploited for commercial purposes”, used in line with the Common Fisheries Policy – fisheries regulatory policy of EU Member States, is an example of a useful tool for the application of a national fisheries account that includes the services provided by this activity.

The objective of this dissertation is to analyse how these data, of national and EU interest, can be integrated and monitored within a national account that can be included in the Satellite Account for the Sea, an account that integrates the different activities of the Blue Economy and, therefore, fits within the SNA, thus, adding value to the Portuguese economy, reinforcing awareness of the importance of MES, particularly services associated with the fishing activity, promoting their restructuring and preservation. Finally, it contributes to one of the emblematic measures of the National Strategy for the Sea 2030 – Strategic Objective 1: Combating Climate Change and Pollution and Restoring Ecosystems; Measure nº 1: Implement a National Program for the Mapping of Habitats and Services of Marine and Coastal Ecosystems including restoration measures.

The Earth is known as the blue planet (Townsend et al., 2018) since 70 % of its surface is covered by water. It should therefore be unthinkable to consider the economy without estimating the value the marine ecosystem services.

The Ocean is universally recognized to influence Earth regulation processes (Stocker, 2013). However, these processes are not well studied or yet prioritized (Stocker, 2015). The Ocean is a vast system with different basins and marine regions. This slight detail in nomenclature is of great importance and is already recognized by the United Nations (IOC-UNESCO, 2017). The change from Oceans to Ocean considers that there are no boundaries nor spatial separation between regions, which emphasizes the transboundary, integrity, and connectivity of the system itself.

The Ocean's main processes, which are vital for life, are global gas (oxygen production and carbon uptake) and climate regulation (Stocker, 2013), food production, and nutrient regulation Watson et al., 2015). Those are at the same time, marine ecosystem services since we benefit from such processes. Other services provided by the Ocean are waste treatment, coastal protection, genetic and medicinal resources, recreation, spiritual and cultural identity (Peterson and Lubchenco, 1997, Beaumont et al., 2007, 2008, Barbier et al., 2008, Chan and Ruckelshaus, 2010, Guerry et al., 2011, Stocker, 2013, Townsend et al., 2018).

Unbalances in those processes produce consequences whose magnitude is still significantly uncertain, such as Ocean warming (Christensen et al., 2013), Ocean level rise (Church et al., 2013, Slangen, 2014, Joughin 2014) and Ocean acidification (Stocker, 2013, Gatusso et al., 2015). These unbalances were mainly created by anthropogenic activities such as industrialization, fossil-fuel production and use, and deforestation (Stocker, 2015).

The global dimension of the Ocean marine ecosystem services and long temporal scale tend to pass as “invisible” to the human eye. Consequently, it becomes harder to recognize the impacts, benefits and to act toward their resilience and sustainability, especially when compared with terrestrial ecosystem services. The inherent difficulty of accessing vast areas of the Ocean also plays a relevant role in camouflaging its environmental and ecological damages.

As a consequence, the destruction of habitats and loss of biodiversity is happening at an accelerated rate (IPBES, 2019). However, by not acknowledging the variety of ecosystem services provided by the Ocean, humanity has often thought of it as endless, guaranteed, and renewable. Moreover, the absence of borders, the huge depths, the different seabed types, and the remoteness have all made us neglect it. We only know around 5 % of our Ocean (Santoro et al., 2017). However, with the rise of the global population and intensified demand for resources, problems have become more visible.

One of the major differences between mapping terrestrial areas and the Ocean is its complexity: accessing terrestrial mapping is as easy as opening a map, and with the usage of satellites everyone can explore a little bit of land. On the other hand, the mean depth of the Ocean is 4000 m (UN, 2022) and there is a lack of high-resolution remote sensing systems. This leads to a general lack of information regarding Ocean habitats, as data are scarce, even with the improvements achieved. New solutions and data are now being acquired at a faster pace due to technological advances (Townsend et al., 2018).

Climate Change and Ecosystem Equilibrium

Climate change is already affecting the distribution of resources in the Ocean. Ecosystem services are seen as a tool to help nations understand the value we have been disregarding in the past decades. Presenting values in units that governments, organizations and civil society understand, helps to put in place policies and change behaviours, to lead to resource protection and restoration. The consequences of losing those services can therefore be exposed to anyone in understandable metrics and scenarios that push for action.

To study marine ecosystems and their services, the approach shall be focused on their properties, using the ecosystem approach, considering a holistic point of view, such as trophic level, diversity, variability, and resilience, rather than using the single-species approach which would compromise the evaluation by marginalizing all the others interacting with the ecosystem (Murawski, 2000). As said above, the trophic level is pointed out as a key feature to understand the health of the ecosystem by studying the linkage between species, which allows to perceive how species and/or ecosystem functions may be affected, therefore how the equilibrium can be affected (Tansley, 1935, Diaz et al., 2017).

The capacity to maintain or return to the ecosystem equilibrium is known as ecosystem resilience and elements such as biodiversity and abundance are pivot contributors to a resilient marine ecosystem (Roberts, 2012). According to Mccauley et al., (2015), human activities have modified the major ecosystems on the planet, even though the defaunation has been seen as less severe in the Ocean than on land. Marine biodiversity is also being affected by climate change (Perry et al., 2005), mostly caused by anthropogenic activities such as commercial fishing (Priede et al., 2011) and pollution (Pauly et al., 2002). According to the Millennium Ecosystem Assessment (MEA, 2005), around 60 % of the overall assessed ecosystem services were in persistent degradation, in which marine ecosystem services such as fisheries were included.

Coastal areas are highly populated; around 40 % (2.4 billion people) of the global population lives within less than 100 km from the coast and around 10 % (600 million people) live in coastal areas with less than 10 m elevation from sea level (ST/ESA/SER.A/423). This concentration is an important driver of pressure on coastal ecosystems and can also amplify coastal hazards, such as sea-level rise, floods, or extreme events, and at the same time, promote damaging outcomes such as biodiversity loss, new diseases, hypoxia, eutrophication and algal blooms, reduced water quality, pathogens, and toxin ingestion/contact (WWF, 2020). In coastal areas which more than 3 billion people rely for their livelihood, there are tremendous economic interests such as navigation, coastal fisheries, tourism, recreation and human settlements (UN, 2021).

Physical indicators such as sea surface temperature (SST) represent a strong environmental parameter to study climate change (Houghton et al., 1996). SST has been increasing significantly albeit heterogeneously (Solomon, 2007, Allan et al., 2021). This increase happens to be greater in the Northern Hemisphere, especially in the Atlantic Ocean (Levitus et al., 2000, Strong et al., 2000) and in Europe, where changes are happening faster than in the rest of the world, and the Southern European regions, including the Iberian Peninsula, are considered more vulnerable than other regions (Albritton et al., 2001, Gómes-Gesteira et al., 2008, 2011, Santos et al., 2006, 2011).

Changes in SST have several consequences for Ocean health such as changes in primary production (Gregg et al., 2003), redistribution of fish stocks (Cheung et al., 2010, Teixeira et al., 2016), and the successful establishment of invasive species (Sorte et al., 2010). Noticeable changes are not only physiological but also chemical, affecting species growth, survival, and reproductivity, plus leading to changes in landing trends (Perry et al., 2005, Portner and Knust, 2007, Teixeira et al., 2014, 2016, Leitão et al., 2018).

The collapse of fisheries

The collapse of fisheries is worldwide known. The overexploitation of fishing resources represents a major problem (Pauly et al., 2003, Leitão, 2019) since it causes the depletion of resources and induces changes in the natural equilibrium of the ecosystem (Odum, 1993, Diaz et al., 2017). It is important to take into consideration that impacts can be synergetic, cumulative, and additive, since an ecosystem works as a whole and is dependent on all variables (Halpern et al., 2008). Data from the 2020 Living Planet Report, supported by the 2021 Sustainable Development Goals Report, suggest that one in three stocks are overfished and that the maximum fisheries catch potential by 2100 will be reduced by 20-24 % if no mitigation measures take place.

In order to understand how fish stocks as a provision service change, it is necessary to understand the ecosystem's integrity and function.

As mentioned in the previous subsection, the ecosystem approach will allow species and habitats to be accounted for and to improve long-term sustainability by increasing the resilience of the ecosystem and its productivity (Diaz et al., 2017). For a fish stock to be classified as sustainable the largest catch that fisherman can take each year must correspond to its Maximum Sustainable Yield (MSY), defined as the largest catch or yield that can be taken from a stock in prevailing ecological and environmental conditions, allowing it to be fished again in the next year (OECD, 1998).

The importance of fisheries is reflected in jobs as well; 97 % of the fishermen live in developing countries and rely on fishery resources as their source of food and income. Around 229 205 tons of fish were discarded by the EU fleet in 2019 (WWF, 2022) and of all the landed fish, around 27 % is lost until consumption (SOFIA, 2018). Moreover, there is a relevant underground economy in fisheries, with seafood that is not declared but still sold. This makes accounting much more complex. The amount of Illegal, Unreported, Unregulated (IUU) fisheries may seriously compromise ecosystems (Borges et al., 2005, Leitão et al., 2014).

Until 2013, according to the Common Fisheries Policy, species with fishing bans could not be landed. Since Regulation (EU) no. 227/2013 was approved by the European Parliament and European Council, previously discarded fish must be given economic value, which is a step forward to achieve total landings equal to total catches (Leitão et al., 2017). This measure is an important, more accurate valuation of the fishing industry. It also allows a more accurate assessment of the state of the waters, the state of the stocks, and the state of the ecosystems.

CHAPTER 1

Ecosystem Service Accounting and the System of National Accounts

1.1 Marine Ecosystem Services

Ecosystem Services (ES) can be defined in various ways. According with the Millennium Ecosystem Assessment (MEA, 2005), ES are the "benefits that people obtain from ecosystems". On the other hand, Fisher and Turner (2008) highlighted differences between ES and benefits for valuation purposes; in their view, ES are the aspects of ecosystems utilized (actively or passively) to produce human well-being.

Marine Ecosystem Services refer to different kinds of services, from provision services coming from fisheries or aquaculture, regulation services such as flood protection or carbon storage, and cultural services such as surf or scuba diving (Figure 1.1). Navigation, tourism, spirituality, transportation, water supply, biological resources, and pharmaceuticals are some of the other MES from which we benefit as a society. However, monetary valuation of Natural Capital and ecosystem services can be wrongly interpreted.

The importance of MES is becoming clearer as studies provide more data to assist in marine policy and marine planning strategies (Börger et al., 2014, Pendleton et al., 2015, Townsend et al., 2018).

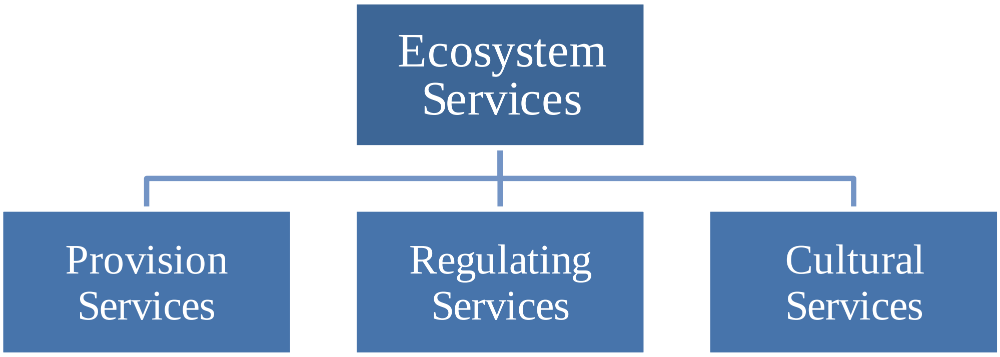

Figure 1.1 - Types of Ecosystem Services according to SEEA-EA (2020)

1.2 Marine Ecosystem Services Approaches

Various methods to ensure a good valuation of MES are being developed and applied around the world. Still, MES classification can be confusing, since there are divisive classification systems and interpretations.

The international framework developed under the auspices of the United Nations, SEEA-EA, was first formally published in 2014. Its revision was launched in 2019 and the final draft was submitted for discussion in March 2021 (https://seea.un.org/). The Revised SEEA-EA sums up the different MES approaches that were previously developed (SEEA, 2020).

1.2.1 System of Environmental Economic Accounting - Experimental Ecosystem Accounting (SEEA-EA)

The SEEA-EA aims to provide and develop a statistical framework for ecosystem accounting in which parties agree upon terminology, concepts, definitions, and classifications in both monetary and physical terms in the accounting sphere.

To perform such a task the SEEA acts in coordination with the UN Committee of Experts on Environmental Economic Accounting (UNCEEA). The work took a multidisciplinary approach gathering experts, but also allowing a global public consultation.

The revised classification aims to bring clarity, support, and consistency to the measurements, consistency, by allowing comparison between valuation techniques and accounting results, and support and clarity, by seeking to avoid double counting.

1.2.2. Major Types of Accounts in SEEA-EA

There are several types of Ecosystem Accounts in the revised SEEA-EA. Physical accounts do not account for monetary valuation and depend on the interaction between the indicators used. Ecosystem extent accounts and condition accounts are the most common types of physical accounts, but capacity accounts, supply accounts, and use accounts can also be developed. The monetary ecosystem accounts, on the other hand, gather information to be included in the SNA and require information from physical accounts.

An extent account is an account that establishes and records the total area, and the changes in the ecosystem assets on the EAA (the area from the terrestrial zone until the country EEZ boundaries), defining it by ecosystem type, which is normally translated into maps, illustrating changes in the area in the given accounting period (SEEA, 2020).

A condition account is a structured approach of data, that describes characteristics of quality of ecosystem assets; it changes in terms of biotic and abiotic characteristics with data consolidated in temporal and spatial scales and it indicates the state of the ecological integrity of the ecosystem and its ability to provide ecosystem services. Condition accounts may be used to support environmental policies and decision-making, and to measure the ecosystem condition progress as it is restored, by aggregating different data sources and monitoring systems (SEEA, 2020). Its development allows observation of the condition of the ecosystem by aggregating the different assets of the same ecosystem type, measuring the change during the accounting periods, and working as a roadmap to the development of projects.

The SEEA-EA (2020) approach is divided into three stages. The first and second stages comprise the conditions of the ecosystem, while the third is optional and implies the derivation of composite indices. The structure will depend on the choice of the selected characteristics, as well as data availability, their uses, and applications. This approach is spatially explicit and part of the data regarding biodiversity needs adjustments since some attributes are not suitable for individual assets. Accounting implies the definition of the characteristics and therefore their variables and indicators. It is recommended that different ecosystem assets have comparable indicators among themselves to improve transparency and reliability.

Choosing the ecosystem characteristics that will describe it in the long term requires defining the system properties based on the major abiotic and biotic components. Variables are supposed to represent the stocks rather than connect the flows, to allow comparability among different studies, be representative of the ecosystem structure, and include sensitive variables that will easily change with ecosystem condition variations, especially under anthropogenic pressures (SEEA, 2020). This means not including all possible variables, taking into account the role of each variable in the ecosystem processes (Schreckenberg et al., 2018). The result should include as less variables as possible, that at the same time provide the most possible relevant ecological information. Taking as an example existing accounts, six to ten variables may be enough to provide an overall condition account of the ecosystem (SEEA, 2020). To present ecosystem accounts, technological tools involving modulation and artificial intelligence are becoming popular for analyse and compile data from ecosystems.

1.2.3 Ecosystem Service Models

Various modelling initiatives and software are emerging, to answer the challenges of measuring ecosystem services. Examples are the Mapping and Assessment of the Ecosystems and their Services (MAES) and the Knowledge Implementation Project on the Integrated system for

Natural Capital and ecosystem services Accounting (KIP-INCA) (both developing ecosystem accounting) (La Notte et al., 2017, Maes et al., 2016), the Artificial Intelligence for Ecosystem Services (ARIES) (Bagstad et al., 2013) and Multiscale Integrated Models of Ecosystem Services (MIMES) (Boumans et al., 2015). Integrated Valuation of Environmental Services and Trade-offs (INVest) is an available online open-access software that allows mapping and valuation of ES of land and seascapes, by providing quantitative datasets on ES. The INVest project was developed by Natural Capital Project as a tool to assist in resource management and decision-making processes, by exploring changes in ecosystems and how those may affect benefits resulting in outputs expressed in either biophysical or economic terms. On the marine side, there are specific ES modelled as coastal blue carbon, coastal vulnerability, fisheries production, habitat quality, habitat risk assessment, marine fish aquaculture, nutrient delivery ratio, offshore wind energy, recreation, scenic quality, sediment delivery ratio and wave energy (https://naturalcapitalproject.stanford.edu/software/invest, Ruckelshaus et al., 2013). These types of software are excellent tools to model data and create knowledge when data are available and if information in the models is regularly updated, to increase findability.

1.2.4. Initiatives

A criticism of the MEA (2005) was the lack of monitoring of the ecosystems that were studied, resulting in a void in terms of ecosystem changes, leaving scientists clueless on the mounting risks, and lack of data for correct modelling, information, and preparedness (Guerry et al., 2012, Karp et al., 2015).

At the European level, the European Union is also taking steps on ES accounting, with 327 ecosystem service indicators developed to be mapped across Europe, for marine services the set of indicators were divided in climate change, water pollution, introductions of invasive alien species and fishing activities (MSFD and CFP). (Maes et al., 2014). It is noteworthy that only 42 % of marine services could be mapped in the short-term (in developed countries). Individual nations can help fill the voids, by creating national accounts, even if incomplete ones (as in national strategies, the Convention on Biological Diversity (CBD) or the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)). The strategy of national initiatives is to work with available statistics to create databases integrating the information supplied by national bodies with demanding European frameworks and international data sets.

1.3 System of National Accounts

The "System of National Accounts" (SNA), first published in 1953 and included in the United Nations Statistics Division, emerged from the need to create international statistic standards to meet policy needs by carrying out economic analysis, decision-making, and policymaking. The SNA 2008, along with the "European System of Accounts 1995" (ESA, 1995), are globally recognized manuals, ensuring comparability of data from different countries around the world (SNA, 2008). The goal is to deliver a framework of macroeconomic databases that are useful to analyse and evaluate economic flows, from the production of services and goods to their delivery and consumption. The framework measures what takes place in an economy, accounting who does it and where, in a continuous flow of information.

National accounts are dependent on national statistics bodies, who develop complex approaches with data from different sources, so that they can be compiled, organized, and adapted to fit the SNA formulas and methods (SNA, 2008).

Gross Domestic Product (GDP) is a commonly used indicator of economic activity, which should not be confused with National Wealth since the latter concept refers to the stock of the nation assets, whereas GDP represents the statistical flow of total output within a given time. Besides being widely used and reported by every country, GDP, by itself, is not enough to evaluate the challenges that the world population faces, since it does not account for social costs, environmental impacts, or income inequality (Mankiw and Taylor, 2022). Stating that a country is "growing" at a certain pace by measuring GDP overlooks the importance of challenges, such as the climate crises or social inequalities, which were even more noticeable since 2020 with the pandemic SARS-CoV-2.

Natural Capital Accounts (NCA) which are based on the SEEA, are increasingly being developed by national governments. The link to the SNA is beneficial to governments and policymakers, since the type of data presented in these accounts is comparable with that already provided by SNA, while delivering better indicators to assess well-being and sustainability than GDP.

1.3.1 SAS – Satellite Account for the Sea

The Satellite Account for the Sea (SAS) is developed by the Portuguese Statistic Institute Office (*Instituto Nacional de Estatística – INE)* in partnership with the General Directorate for Maritime Policy (*Direção Geral de Política do Mar – DGPM),* as established by the Resolution of the Council of Ministers no. 99/2017, of 10 July. SAS is integrated into the Portuguese System of National Accounts (PSNA) and aims to introduce and share statistical information that allows an evaluation of the importance of the Portuguese Blue Economy. Although it is still an exploratory work, the SAS provides information, consolidates decision support in maritime policies and their implementation and supports the monitoring of the National Strategy for the Sea (*Estratégia Nacional para o Mar – ENN)* in its economic aspects. At the same time, it provides information for the Integrated Maritime Policy (*Política Marítima Integrada – PMI)*, which is included in the European document "Blue growth" supporting the EU Maritime Strategy for the Atlantic Area (Addamo et al., 2022).

The main goal of the SAS is to provide an economic information system related to the sea. The urge to create this account reflects the importance of the Blue Economy and aims to provide a reliable, systematized, and comparable set of information. It embraces both supply and demand and includes activities directly and indirectly related to the sea. Since the SAS and SNA are based on the European System of National Accounts, their definition does not account for natural capital or non-tradable services of the marine ecosystems. It is important to include the economy as a whole, integrating all of its sectors, including the Ocean and that allows comparability between the GDP and GVA. Satellite Accounts are the ones to facilitate this approach between different international economic classifications allowing comparability and uniformization at the international level. Nomenclature as Maritime Economy, Ocean Economy and Blue Economy are similar, yet different. In Portugal we can

Maritime Economy is thus defined as "A set of economic activities that take place at sea and others that, not taking place at sea, depend on the sea, including marine natural capital and non-tradable services of marine ecosystems" (SEC, 2010); Blue Economy on the other hand refers, accordingly with the UN definitions to the economy that "comprises a range of economic sectors and related policies that together determine whether the use of ocean resources is sustainable", however, different definitions are presented by different stakeholders (https://www.un.org/regularprocess/sites/www.un.org.regularprocess/files/rok_part_2.pdf).

The Satellite Account for the Sea, reports on the Blue Economy in trienniums: the first was for the time period 2010 – 2013, published in 2016 and the second, and most recent, for the triennium 2016-2018, published in 2020. In the most recent report, the economic activities considered in the SAS show a higher Gross Value Added (GVA) performance than the overall Portuguese economy in the same period. In the SAS the GVA grew 18.5 % from 2016 to 2018 while the GVA for the Portuguese economy grew 9.6 %. However, fishing activities are in the same group as agriculture and forestry, whose GVA growth was only 2.4 %.

The SAS divides its divided into 9 Ocean related activities; regarding Fisheries, the set is "Fisheries, aquaculture, processing and marketing of their products" and it is the second most important in terms of units of economic activities, GVA and number of employees. However, the mean paid remuneration is the lowest among all the considered sets (INE, 2020b).

Regarding employment between 2016 and 2017, the maritime activities represented in SAS rose 8.3 % and incomes increased 8 %. These values can be compared with those for the national economy, which are 6.0 % and 3.4 %, respectively. Direct and indirect impact of the activities considered in SAS are estimated to have reached, in 2018, 5.4 % of the GVA and 5.1 % of the total GDP (INE, 2020b).

CHAPTER 2

Legal Aspects regarding Fisheries and Marine Ecosystem protection

2.1 Common Fisheries Policy

The Common Fisheries Policy (CFP) was introduced in 1970 to establish a set of rules to manage European fishing fleets and the conservation of fish stocks. Its last update is in force since the 1st of January 2014. The latest version introduces topics such as the discard ban policy and the use of MSY.

Other relevant bodies that assist the European Commission are the Scientific, Technical and Economic Committee for Fisheries (STECF) and the International Council for the Exploration of the Sea (ICES).

STECF, established body by the EC, is an expert group whose task is to assist EC in legislative proposals and monitor the evaluation of policies, answering in the field of conservation and management of living marine resources (COM/2016/1084). ICES was the first intergovernmental organization to be created, established in 1902, whose mission is to meet conservation, management, and sustainability goals, by developing scientific advice and offering training and workshops, as well as data and tools (ICES, 2019). Both STECF and ICES are responsible for advising the EC on fish Total Allowable Catches (TACs) in the commercial fishing industry.

Total allowable catches are set annually or every two years by the EU fisheries ministries, including for stocks shared with non-EU Member States. TACs are distributed as fishing quotas among the Member States, which are responsible for handing out fishing licenses using transparent and objective criteria, as well as for monitoring stocks (INE, 2022). Member States are also responsible for enforcement and for ensuring that overfishing is not occurring.

According to INE (2020), in 2019 the total allowable catches within EU waters increased 29 %. This increase might indicate that some stocks are being well managed. On the other hand, the reductions in the annual quotas of some species require attention to mortality causes and how to prevent them (COM/2022/253).

It is also important to mention that it is possible to exchange accumulated quotas among Member States and to accumulate it from one year to another, up to 10 % of the non-used quotas, as predicted in EC Regulation no. 1380/2013 and EC Regulation no. 847/96. These measures allow Member States and therefore their fishing industry to improve efficiency in their work, by buying or selling quotas, as well as being allowed to keep the quotas that were not used during the year.

2.2 Marine Strategy Framework Directive

Following Lai et al. (2018) methodology on the conception of a condition account for provision services for fisheries, it is relevant to use the Marine Strategy Framework Directive (MSFD), since its criteria are defined by the European Commission and countries have to report on the assessment of the good environmental status of marine waters, based on common descriptors and methodologies.

The MSFD, defined by the Directive (EU) 2008/56/EC of the European Parliament and Council, amended by the Directive (EU) 2017/845 of the European Commission, is the European framework on marine policy that intends to ensure that Member States adopt measures to obtain Good Environmental Status (GES) of their marine waters. The strategy also aims to ensure that marine-related economic and social activities are protected. This Directive is the first legislative document specifically aimed at the protection of the marine environment and natural resources and creating a framework for the sustainable use of the UE marine waters (https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/index_en.htm). It includes 11 qualitative descriptors in various crucial matters – biodiversity, non-indigenous species, commercial fish and shellfish, food webs, eutrophication, sea-floor integrity, hydrographical conditions, contaminants in the marine environment, contaminants in fish and other seafood for human consumption, marine litter, and energy including underwater noise - on which anthropogenic activities have an impact, merging concepts of environmental protection and sustainable use. As a European Directive, it also aims at promoting cooperation between Member States that share marine regions and subregions, as also predicted in the Regional Sea Conventions. Member States must develop strategies for their marine waters, to be updated and reviewed every 6 years, following an adaptive management approach (Directive (EU) 2008/56/EC).

According to the MSFD, the process was adopted and developed in stages. Firstly, there was an initial assessment of environmental status, environmental impact, and socio-economic analysis of human activities, followed by the determination of the GES for each State marine waters, the establishment of environmental targets to be achieved by 2020, the establishment of the monitoring programmes, with regular target updates, and finally the establishment of programmes of measures, to be implemented to achieve GES (COM/2014/097).

As of 2020, the European Commission produced a report which evaluates whether the initial assessment of marine waters by MS was complete, adequate, consistent and coherent as required by the MSFD. Results illustrate a lack of coherence both at regional and subregional levels, as well as a lack of consistency amongst MS in applying the assessment criteria and methodological standards as defined in Decision no. 2010/477/EU. One of the most remarkable outputs of the report was the acknowledgment that the Aichi Target of protecting marine waters, through the creation of Marine Protected Areas MPAs had been fulfilled before the 2020 deadline. Nonetheless, there is no guarantee that management and monitoring programmes, and rules are being applied inside those areas (COM/2018/562).

For Provision services, Descriptor 3 aims to evaluate the Good Environmental Status of the populations of all commercially exploited fish and shellfish.

Descriptor 3 is an important one from a social and economic point of view, especially for a coastal state like Portugal, where fisheries still have some relevance. The Descriptor specifically addresses the impact of fishing activities on target species of commercially exploited fish and shellfish, assuming that GES has been reached when populations are within safe biological limits, exhibiting a population age and size distribution indicative of a healthy stock. Therefore, Descriptor 3 can be a starting point to help to identify and value nursery areas or marine protected areas, touristic spots, and areas suitable for recreational fisheries.

2.3 Marine Protected Areas

The rising awareness of the importance of marine ecosystems and the impact of human activities on them have led the scientific community and governments to recognize that protection of these ecosystems is needed. Marine Protected Areas are conservation tools with recognized value for protecting biodiversity (Kirsten et al., 2021). The importance of studying MPAs lies on the fact that they are determined based on studies that acknowledge the importance of the areas, regarding aspects such as biodiversity, species reproduction and growth, and other marine ecosystem services. In a MPA there may be different levels of protection to limit human activities. MPAs are excellent areas to obtain scientific knowledge that can inform policymakers, managers and decision makers on how they are evolving following the protection measures adopted and the monitoring work carried out (Bongaarts, 2019).

Action is required to avoid ecosystems collapse and prevent ecological damages that can further lead to socio-economic damages. Brander et al. (2015) pointed out that for each € 1 invested in MPAs, € 3 would, at least, be generated.

Overfishing, erosion, and coastal defence are some of the most critical challenges, especially in a context of climate change, that drastically affects ecosystems and their resilience. Defining areas in which protection and monitoring is ensured, will influence the way the ecosystems react and resist.

2.3.1 Marine Protected Areas - International Goals

At the international level, a number of treaties define goals for a more sustainable future, focused on the protection and conservation of marine ecosystems.

The Convention on Biological Diversity (CBD) was signed in 1992 by 150 countries in the Rio Earth Summit dedicated to sustainable development. The CBD has three main goals: conservation of biological diversity, sustainable use of biological components, and fair and equitable share of benefits from genetic resource usage (UNEP/CBD/COP/DEC/VII/5). In 2010, the update of the Strategic Plan by the Conference of the Parties (COP) created the 20 Aichi Biodiversity targets for 2011 - 2020 (UNEP/CBD/COP/10/27/Annex).

Under Strategic Goal C – "Improve the status of biodiversity by safeguarding ecosystem, species and genetic diversity", target 11 establishes that by 2020 at least "10 % of coastal and marine areas, in particular, those of special importance for biodiversity and ecosystem services shall be conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other conservation measures".

The United Nations Agenda 2030, adopted in 2015, aims to achieve Sustainable Development Goals (SDGs) by defining 17 goals with specific targets (A/RES/70/1 – UN, 2015). Regarding the Ocean, Goal 14 – Life below Water - Conserve and sustainably use the oceans, seas and, the marine resources for sustainable development - has 10 targets addressing ecosystem protection measures, pollution, Ocean acidification, fishing activities and policies, and scientific knowledge of the marine environment and marine technology. The targets have different associated dates. For the protection and conservation of coastal and marine ecosystems, targets 14.2 and 14.5 were meant to be achieved in 2020. The first aimed to "sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts" and the second to "conserve at least 10 % of coastal and marine areas". According to the 2021 Sustainable Development Report, marine protected areas achieved a total of 7.74 % of global coastal waters and Ocean. As for the coverage of key biodiversity areas, the percentage rose from 28 % in 2000 to 44 % in 2020; yet, enforcement is recommended by the report since many areas have partial or no effective protection.

2.3.2 Marine Protected Areas Governance

Governance is considered a word with different meanings with an increasing presence in common vocabulary in the past years. For the purposes of the present dissertation "governance" is defined according to the International Bureau of Education (IBE) by UNESCO as a group of structures and processes following norms, values, and rules on how public affairs are managed in a transparent, participatory, inclusive and responsive way (http://www.ibe.unesco.org/en/geqaf/technical-notes/concept-governance).

As IBE states, governance has different meanings. Groups such as the United Nations Development Programme (UNDP), the World Bank and the OECD Development Assistance Committee (DAC), define governance in a stricter manner, closer to management, as the exercise of political, administrative and economic authority required to manage the affairs of a country.

Similarities between governance and management are perceptive, and their connection shall not be misused. Management refers to running an organization and implementing decisions and policies according to the mission and strategic vision decided by the stakeholders and administrative board (Kaehler et al., 2019). On the other hand, governance oversees management and performance, ensures that the organization is achieving its goals and works in a prudent, ethical and legal way to ensure the accomplishment of the set goals (Kersbergen and Waarden, 2004).

To achieve effective protection and conservation goals within an MPA, governance is fundamental, which sometimes fails in being a maximum priority, thus undermining the success of the MPA due to weak connection with local communities and MPA users. When applying good governance techniques and ensuring connection with the community, the ability to influence the community behaviour towards the MPA goals rises (Vasconcelos et al., 2012, UN Environment, 2019).

When referring to an MPA we should not only consider its management but also its governance. While management is the part and the actions that are formally and readily available to provide management plans or regulations, governance is a continuous, adaptable process that includes all the background operations, such as informal negotiations and agreements that influence human behaviour, and therefore management practices (Kersbergen and Waarden, 2004).

There are different approaches to governance; the key types are “top-down”, “bottom-up” and “co-management” which may be rigid and restrictive. To effectively accomplish MPA goals, the type of governance structure to be applied must be a combination of the approaches that interact with the practical reality, considering the roles of the state, markets and people, as defined by UNEP, 2019. The aim is an integrated, effective, equitable and practical governance approach that considers the MPA reality as different from place to place, and that pends on political will, community engagement, financial status, legislation and the enforcement capacity (UNEP, 2019).

States play an important role purveying the resilience by the implementation of policies and legislative environments, as well as controlling and mitigating driving forces.

According to UN Environment (2019), to achieve stable governance a Framework for Marine Protected Area Governance (MPAG) combines 5 key incentive categories - legal, knowledge, economic, participation and communication. Incentives are a governance approach that are designed to stimulate people to act in a supportive way apropos strategic policy outcomes. Along with a combined and appropriate use of the incentive categories, an effective achievement of the governance goals is expected, even if the approaches lead to the assignment of different relevance to each of them.

As relevance for each incentive category changes depending on the governance approach, it is possible to choose which type of key initiative categories are the ones that most fit the purpose of the project, as suggested by UN Environment (2019). While incentives for communication and knowledge support all three approaches (market, state and people), economic incentives support the market approach, legal incentives support the state approach and top-down hierarchy, and finally, participation incentive support the people approach and the bottom-up hierarchy. Therefore, a good governance approach, combining key incentives categories is essential to ensure that MPAs can succeed, be resilient and capable of achieving their conservation goals, independently of their location, since adaptation to the approach is flexible, thus more effective on achieving its goals.

CHAPTER 3

The Portuguese Context

3.1 Portugal, a small land state, a huge Ocean state

In the Portuguese geographical context, there are several historical drivers for the consumption of fish. The rise of tourism should also be mentioned, since Portugal is recognized internationally to be a place where fish is a delicacy.

Mainland Portugal is located in the Southwest of Europe; it has a coastal line of 987 km long (Litoral, G. G. T. 2014). The Portuguese Exclusive Economic Zone (mainland and the archipelagos of Madeira and Azores), is one of the largest EEZs in the world, occupying an area of 1,660.456 km^2 (https://www.dgrm.mm.gov.pt/pt/web/guest/am-ec-zonas-maritimas-sob-jurisdicao-ou-soberania-nacional). Mainland Portugal is included in the Bay of Biscay and Iberian Peninsula ecoregion, which encompasses the area from SW Britany (France) to the Gulf of Cadiz (Spain). This ecoregion is divided into four main areas: the Bay of Biscay, the Cantabrian Sea, the West Iberian Shelf (where the Portuguese coast is included) and the Gulf of Cadiz. The West Iberian shelf is a narrow one, where upwelling events occur mainly during summer months and the Iberian Poleward current occurs during the winter months (Fiuza, 1982). It is important to refer that the West Iberian Shelf includes not only Portugal, but also the region of Galicia in the north of Spain (https://www.ices.dk/advice/ESD/Pages/Bay-of-Biscay-and-the-Iberian-Coast-Ecoregion-description.aspx).

Fisheries in this region are managed in accordance with the Common Fisheries Policy (CFP). Other organizations, such as the Northeast Atlantic Fisheries Commission (NEAFC), the North Atlantic Salmon Conservation (NASCO) and the International Commission for the Conservation of Atlantic Tunas (ICCAT) also play their role in the management of some stocks. In Portugal,

The flora and fauna present in the Portuguese marine waters are especially vulnerable to climate change as Ocean warming affects the abundance and diversity of species (Cheung et al., 2010, Teixeira et al., 2014). The Portuguese coast is recognized as a transition zone between the boreal/temperate waters of Northern Europe and the subtropical/tropical waters in the South. This means that some species from northern and southern waters have their south and north distribution limits along the Portuguese coast (Ekman, 1953, Briggs, 1974, Santos et al., 2001).

The transitional feature inherent to the Portuguese coast allied to the the rise of sea surface temperature have an impact on the regional fauna, also reflected in landing profiles. This has been noted as species that have their north range limit along the Portuguese coast (subtropical/tropical affinity) are increasing in abundance. On the other hand, species that have their south limit range in the region (boreal/temperate affinity) have been decreasing (Cabral et al., 2001, Henriques et al., 2007, Vinagre et al., 2009, Teixeira et al., 2016). Plus, Vinagre et al. 2011) states that this emerging substitution will lead to an increase in species richness on national waters, more noticeable in the southern region than in the northern region of the country.

Ocean warming consequences for fisheries include changes in abundance and distribution of species, as well as socioeconomic implications for the sector (Allison et al., 2009, Cheung et al., 2010, Blanchard et al., 2012). This may even create a commercial opportunity for fisheries, since most of the new species emerging in the Portuguese waters are thought to have a commercial value (Vinagre et al., 2011); on the contrary, the species in the South range that are less present are not targeted by fisheries; this encourages a vision that fish assemblages in the coast of mainland Portugal may evolve from subtropical/temperate to subtropical/tropical ones, due to Ocean warming (Cheung et al., 2010, Vinagre et al., 2011).

3.2 Upwelling and species recruitment

Upwelling events occur along the coast of mainland Portugal during summer associated to the Canary current (Fiúza et al., 1982, Stevens et al., 2000, Baptista et al., 2018).

The upwelling process is associated with wind stress on the surface water, forcing a colder water mass to emerge to replace the surface water masses pushed/blown offshore. This colder water is enriched in nutrients that lead to the enhancement of phytoplankton, which means high rates of primary production therefore, becoming a richer area for species to feed (Ambar et al., 2008).

Small pelagic fish such as sardines, one of the Portuguese *ex-libris,* benefit from this summer upwelling, which is crucial for the recruitment of the species, since it enhances the abundance of phytoplankton, on which sardines feed directly near the coast (Fiúza et al., 1982, Borges et al., 2003).

However, upwelling events during winter have been increasing, which cause a decrease in the recruitment of small pelagic fishes (Borges et al., 2003, Santos et al., 2004).

3.3 Marine Protected Areas in Portugal

In mainland Portugal there are two natural reserves and three natural parks, which include terrestrial and marine areas: the Berlengas Natural Reserve, the Santo André and Sancha Lagoons Natural Reserve, the North Coast Natural Park, the Natural Park of Southwest Alentejo Coast and Vicentine Coast, and the Arrábida Natural Park whose marine area encompasses the Marine Protected Area named "Professor Luiz Saldanha Marine Park" (Decree Law no. 142/2008 of 24 July; https://www.icnf.pt/biodiversidade/sistemanacionaldeareasclassificadas). A detailed map depicting the areas with conservation status in mainland Portugal can be found in the following link, provided by the Conservation Institute for The Conservation of Nature And Forests ICNF: https://www.icnf.pt/api/file/doc/0ba51eb2b536f924.

According to the working group established by the Portuguese Ministry of the Sea, in 2017 by Order no. 1/2017 of 6 March, a report was provided in 2018 that resulted in the Resolution of the Council of Ministers no. 143/2019 of 29 August. This resolution approved the guidelines to establish the National Network of Marine Protected Areas (RNAMP). The mentioned report states that MPAs should be linked under long-term monitoring that can ensure the state of the environment, certify the recover and management of habitats, and species conservation measures. These measures should assess the condition of natural values, the evolution of pressures, the evolution of pressure and threat variables and ensure society's participation and awareness. At the same time, the report highlights the need to protect sensitive marine ecosystems by preserving marine biodiversity and its services that provide benefits to society. The report goes further and points out the need for future studies to identify and value MPA ecosystem services. As an output the MFSD also refers to spatial measures that include MPAs.

The Professor Luiz Saldanha Marine Park falls under this category and it is one of the most studied MPAs in mainland Portugal. The seabed is composed of different sediment types (sandy, muddy, and rocky bottoms) and depth range varies from the coastline down to 100 m. Both characteristics favour the occurrence of diverse habitats, which are considered hotspots of biodiversity (Cunha et al., 2014, Henriques et al., 2015). For such reason, an analysis of the existing information on this MPA and the projects carried out in the area, will be detailed below.

3.3.1 Professor Luiz Saldanha Marine Park (Parque Marinho Professor Luiz Saldanha)

The history of the Professor Luiz Saldanha Marine Park (PMPLS) dates back to 1965 when the first attempts to design and create the first marine park in Sesimbra were developed (CPAS

1965 a, b). After the creation of the Arrábida National Park (PNA) integrated in the Nature 2000 network of protected areas, in 1976, by the Decree Law no. 622/76, of 28 July, the marine park, the first in mainland Portugal, was created by the Regulatory Decree no. 23/98, of 14 October. This MPA covers a total of 53 km^2 along 38 km of coastline, from Figueirinha beach at the mouth of the Sado estuary to Foz beach located north of Cabo Espichel (Cunha et al., 2014). There are three different types of protection areas in this MPA - Total Protection Area (TPA), Partial Protection Area (PPA), and Complementary Protection Area (CPA) - to help increase and reconcile the biodiversity and the ecological importance with the socio-economic activities in the site. In the TPA no commercial fishing and recreational activities are allowed. In the PPA allowance is given to recreational craft to navigate and access the beaches by the marked corridors, and also to some leisure activities (e.g., snorkelling, amateur scuba diving), but sport fishing is forbidden, and commercial fishing is restricted to jigs and octopus traps that must be set at more than 200m offshore. In the CPA the activities allowed in the PPA are permitted, sport boats to moor and anchor in all the areas, sport fishing, and commercial fishing by hook, lines and traps are allowed, but nets can only be set at more than 0.25 nautical miles from the coastline (Cunha et al., 2014).

Fishing and tourism activities such as scuba diving, recreational fishing and nautical recreation have long negatively impacted the ecosystem (Cunha et al., 2014) in the area. Integrating the strategy goals with projects developed to study the area challenges and using the knowledge that is already available, creates an opportunity to build a pilot to investigate links with MSFD descriptors and create local marine ecosystems accounts.

The Management Plan of the Arrábida Natural Park (POPNA) was introduced in 2005 (Resolution of the Council of Ministers no. 141/2005 of 23 August). Until full implementation of the POPNA in 2009, there was a transition phase during which commercial fishing restrictions were gradually adopted (Cunha et al., 2014).

The high interest of the scientific community and the rising conflicts between stakeholders of the PMPLS and the POPNA caused a lack of confidence in the Plan. Thus, to achieve agreement among parts and create resilience in the approach, a Collaborative Governance Model was designed by the MARGov project to further ensure an effective agenda (Carneiro et al., 2011, Vasconcelos et al., 2012).

Major concerns of the stakeholders were the restrictions to commercial fishing, including prohibition of some fishing gear, limitation of access to the area, and abusive use due to the lack of monitoring (Vasconcelos et al., 2012). It must be noted that fishing, in the area, is cultural and a socio-economic activity, and that the implementation of no-take zones as restrictions to the fisheries industry resulted in the decrease of licensed fishing boats (23 licensed boats less from 2006 to 2007).

3.3.2Developing projects in the Professor Luiz Saldanha Marine Park

Research and monitoring projects in MPAs are fundamental to assess if conservation goals are being achieved and to monitor the quality of the environment. In the PMPLS several projects took place, such as MarGOV, BIOMARES and INFORBIOMARES. The projects had different aims and different outputs, from collaborative governance, ecosystem restoration, conservation, mapping and cataloguing.

The MARGov project was developed to couple conservation of biological and cultural diversity through a Collaborative Governance Model, which aimed to empower and involve key elements and stakeholders in the PMPLS sustainable management and policies by integrating them as changing agents (Vasconcelos et al., 2012). As for Environmental accounts, the perception of the stakeholders and society are key factors for success. In this sense, MARGov was able to deeply understand the conflicts, the doubts regarding the area and to establish trust with and among the managers and stakeholders, hence, to build empathy towards the cause. The latest report by Araújo et al. (2020), refers to the project as successful, emphasizing that the participatory part that involved the community as fundamental for the achievement of the goals should be included in the implementation of future management plans.

The BIOMARES project aimed at the restoration and conservation of biodiversity in the PMPLS. Several actions were developed, including mapping and monitoring the biodiversity and habitats, and developing measures to restore the seagrass meadows which were abundant in the past, but were destroyed by fishing and recreational nautical activities (Cunha et al., 2011, 2014). This project resulted in evidence regarding the different protection areas (TPA, PPA and CPA) of the marine park, in particular regarding non-commercial species and commercial species sizes, highlighting the advantages of MPAs (Cunha et al., 2014, Lester et al., 2009), and, at the same time, supporting the present management plan in place (Cunha et al., 2014).

The INFORBIOMARES project is a good example of monitoring and centralization of data, which may serve as an example, not only for the monitoring of MPAs in Portugal but also on how data can be gathered and used in different projects. The aim was to develop and integrate information about biodiversity and human activities, in particular fisheries, to be used to create monitoring, conservation and management models for marine species and habitats. One of the outcomes of the project was the construction of a database to be integrated into the national Information System for the Sea (SNIMar). For that purpose, different specialists and stakeholders were contacted to help get standardized information and ensure monitoring, crossing data with other databases (Frade et al., 2019).

CHAPTER 4

Methodology

To implement an ecosystem services approach, using data from the Marine Strategy Framework Directive, it may be useful to divide geographically the country, using the same approach, as defined at the MSFD assessments (Figure 4.1), which is based in characteristics as bottom topography and granulometry, depth, and upwelling intensity. The assessment areas for Descriptor 3 also included the defined ICES divisions. For the sardine stock assessment, the considered ICES areas were 9a and 8c, due to the broad distribution of the species. This would facilitate a highly detailed and meticulous approach, allowing for the inclusion of ecosystem services and their actors. Apart from this, literature review and analysis of scientific studies, should be done to primarily identify lack of data, information gaps, and initial data trends, as well as next steps to be taken.

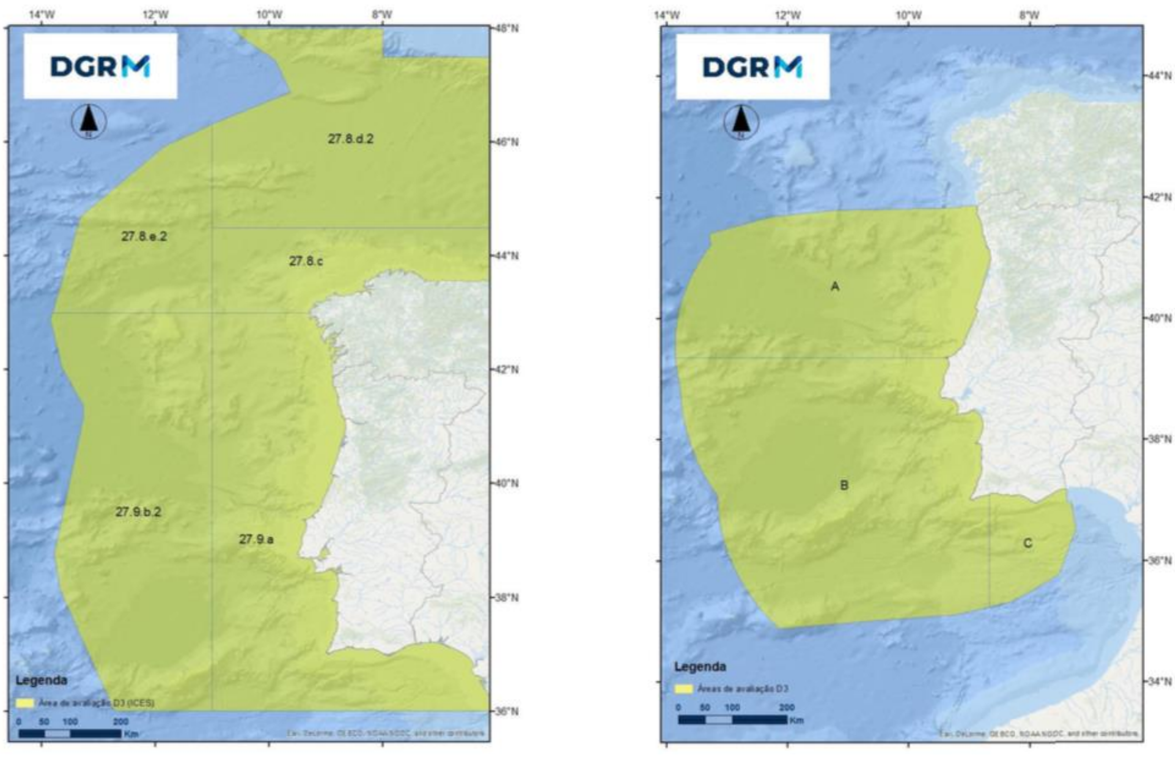

Figure 4.1 – Assessment areas for Descriptor 3 in the framework of the MSFD implementation in mainland Portugal. On the left the divisions considered by ICES. Mainland Portugal is considered under 27 9.a subdivision. This division was used for the species with a wide range of distribution, that are managed under a defined management stock unit. On the right the 3 areas considered for all other species. A - Northwest (Caminha – Nazaré Canyon); B - Southwest (Nazaré Canyon – Lagos); and C – South (Lagos – Vila Real de Santo António). Source: DQEM, 2020.

To create accounts using MSFD data, both modelling and Geographic Information System (GIS) approaches shall be applied. GIS is commonly used as a tool to account for ecosystem extent and condition (Hein et al., 2015).

Regarding the measurement of ES, provision services are the most perceptible of the three considered types of services, since regulation and cultural services account for multiple invaluable factors, driven by people that are difficult to measure and have much larger scales of influence, leading to trade-offs. Thus, provision services, as material contributions, are easily accountable and perceptible, not only regarding the data used, but also by people (Karp et al., 2015).

However, looking up for provision services alone is not enough; false beliefs can be assumed and lead to decision-makers to not account on the entire system, hence believing that the natural capital is improving by being blind on the unseen and unanalysed data referring to declining services that were not accounted for (Karp et al., 2015, Dvarskas et al., 2019).

In order to evaluate the challenges of integrating MES in the System of National Accounts, the proposed methodology is to access national data of INE on Fisheries Statistics from the same temporal scale as of the MSFD, 2012-2016, together with the data reported under the second assessment of the MFSD. The first assessment was excluded due to the fact that D3C2 data was not sufficient to provide any relevant results.

The creation of an ecosystem extent account can be defined for the marine ecosystem of one country by setting the extension of the country's Exclusive Economic Zone (EEZ) (Lai et al., 2018).

The EEZ, is defined in Article 55 of the UNCLOS, as "an area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention". For such reason, it helps identifying the country resources, such as fisheries, that should be included when developing national accounts. Other factors to be considered when creating these accounts are the biophysical indicators such as temperature, oxygen and salinity (Lai et al., 2018).

Considering the example from Lai et al. (2018) on fish stocks, stocks serve as a condition indicator, and species-related indicators are considered ecosystem condition indicators, by considering the spawning stock biomass (SSB) of the fish stocks to be accounted for and included in the condition account, as a first indicator.

There are different types of value sources: the commercial fishing catch, the recreational fishing catch, and the household catch; the three are considered benefits, which means that they count as provision ecosystem services. These dimensions can and should be included when using supply accounts (Anthony et al., 2019). For the present study, only total catches as reported by INE, to the sardine, was used.

Using biomass data represents a baseline for a variety of ecosystem services flows and benefits, not only provision services – food and feed, but also regulating services and cultural services. However, ES measurement uses different methodologies for valuation. For the provision services, the methods include valuing the flows that enter for consumption and production processes, by measuring the physical size of the asset, resorting to catch statistics, survey trawls, modelling, satellites and genetic techniques. (Anthony et al., 2019).

4.1 Account Creation

To create an account to organize and to compile in a structured way ecosystem accounts, some considerations must be taken. The set of variables and indicators used have to be in accordance with the research question and context. Separate indicators can be compiled as indices providing a synthesis of the condition in terms of integrity, health, or naturalness of the assets. The combination of variables and indicators must be done with caution and must include key characteristics for each ecosystem asset.

In the present dissertation, the data selected were the catch statistics data and data from monitoring surveys carried out by the Portuguese Institute for Ocean and Atmosphere (IPMA), that were compiled in the national assessment reports of Descriptor 3 in the framework of the MSFD implementation, and the fisheries statistics provided by the National Statistical Institute Office (INE) in their annual reports on the subject. The choice was based on the open-source characteristics of the data, available online, and is the most direct measure of the flow of biomass (Dvarskas et al., 2019). This method has its weaknesses, as Portugal is a country where 90 % of the fisheries (INE, 2022) are small-scale fisheries, adding uncertainty on the total amount of reported data from landings, discards and jurisdiction (Dvarskas et al., 2019).

The SSB was considered under criterion D3C2. As the availability of this indicator is not wide enough to represent all the species accounted for in the MFSD due to lack of quantitative entries that allow calculation, it was chosen to only analyse the data from sardine (*Sardina pilchardus* (Walbaum, 1792)), because it is ranked as the top valued species in monetary terms in both MSFD assessments (DQEM, 2020, INE, 2022). For Descriptor 3 assessment sardine is included in the population unit comprehending populations with analytical quantitative evaluation and reference biological points that are established/accepted by ICES and ICCAT (DQEM, 2020).

To converge with the SEEA-EA approach and according to Lai et al. (2018), using the criterion D3C2 (SSB) it is possible to create simple extent and condition accounts. The criterion defined under MSFD establishes that if the SSB, per stock of commercially exploited species, is above levels that allow for MSY, GES is achieved. However, for the *Sardina pilchardus*, the adopted method was to use MSY $B_{trigger}$ (breeding biomass "trigger"), as defined in 2015 by ICES, and represents "the lower boundary of the 95% confidence interval of the SSB estimates, assuming an exploitation pattern at FMSY levelfor a long period of time. FMSY is defined under criterion D3C1, and corresponds to the sustainable level of fishing mortality per year. However, it is not available for the species in the assessment, therefore it was not considered. To achieve GES, the premise is SSB ≥ MSY Btrigger ; on the other hand, if SSB < MSY Btrigger, GES is not achieved.

CHAPTER 5

Results and Discussion

To create MES accounts, that can be merged and integrated in the SNA, reliable amounts of data are required. Due to institutional constraints, it was not possible to use all the data required. For this reason, as described in the methodology section, the spectrum of data was the one presented by the Portuguese Institute for Ocean and Atmosphere in the MSFD second assessment report, most specifically in D3C2 criterion, and INE annual Statistical Report on fisheries. The outcome was taken to the maximum possible extent due to the scarcity of the available data.

5.1 Extent Account

An extent account following Lai et al. (2018) and the SEEA (2020) was taken as the base to provide a marine extent account and is presented in Table 5.1. As an extent account for the marine ecosystem of a country can be set by the extension of the country's Exclusive Economic Zone (EEZ), data from the Directorate- General for Natural Resources, Safety and Maritime Services (DGRM) were compiled by regions (Mainland, Azores and Madeira) (Table 5.1).

Table 5**Erro! Não existe nenhum texto com o estilo especificado no documento.**1 - Ecosystem Asset Account – Portuguese Extent Account

Ecosystem Asset Account	Indicator	Value (km^2)	Source
Extent	Area of EEZ cover	1660456	https://www.dgrm.mm.gov.pt/en/web/guest/am-ec-zonas-maritimas-sob-jurisdicao-ou-soberania-nacional
	Mainland	287521	
	Madeira	442248	
	Azores	930687	

5.2 Condition Account

A further step was taken in the construction of a MES condition account and a first attempt to include a monetary value was considered. Using the methodology provided by Lai et al. (2018), data from Descriptor 3, criterion D3C2, as previously defined, from the second assessment of the MFSD were used, values corresponding to the time period 2012-2018. In addition, a temporal series from INE recording total landings of *Sardina pilchardus*, and monetary value from the same temporal scale (2012-2018) were used. Due to the scarcity of data the results are insufficient, as can be observed in Table 5.2; they consist in an output of the average landing of *Sardina pilchardus* for the time period assessed, the average price per ton and kilo (kg), as well as the connection with the two values presented under D3C2 of MSFD.

Table 5**Erro! Não existe nenhum texto com o estilo especificado no documento.**.2 - *Sardina pilchardus* landing profile between 2012-2018 (Source: INE). SSB and MSYtrigger according to the 2nd cycle assessment of MSFD for Descriptor 3, corresponding to the period between 2012-2018 (Source: DQEM, 2020).

Year	Total landings (ton)	monetary value (€)(thousands)	€/ton	€/kg	SSB	MSY_trigger
2012	31326	€ 40 800,00	1 302,43248 €	1,30 €	-	-
2013	27658	€ 39 670,00	1 434,30472 €	1,43 €	-	-
2014	15808	€ 31 583,00	1 997,91245 €	2,00 €	-	-
2015	13690	€ 30 009,00	2 192,03798 €	2,19 €	-	-
2016	13488	€ 27 840,00	2 064,05694 €	2,06 €	-	-
2017	14516	€ 23 790,00	1 638,88123 €	1,64 €	-	-
2018	9662	€ 21 827,00	2 259,05610 €	2,26 €	-	-
Average	18021	€ 30 788,43	1 708,46149 €	1,71 €	136611	446331

Considering the present results, the challenges of including Ecosystem Services in National Accounts are presented in the following sections, which describe the challenges from the literature, that are in the end, transposable to the Portuguese case.

5.3 Challenges of including Ecosystem Services in National Accounts

Austen et al. (2019) provides a science brief on the importance of valuing ecosystem benefits in the Blue economy. It reflects the seven core recommendations on how to value marine ecosystems and how to navigate existing work: for models in marine management decisions and conservation policies, include as integral part ecosystem valuation studies; promote the harmonization of ecosystem service frameworks and classification systems and agree on an international standardized framework to improve the comparability of ecosystem service assessments; improve understanding of the role of services, processes and benefits provided by marine biodiversity; improve quality and availability of valuation data (monetary and non-monetary); set the right scale and boundary for each valuation study; set transdisciplinary teams to develop policy questions and answers; and develop Natural Capital Approach and Natural Capital Accounting. The author describes how these could be achieved, providing clear vision on the challenges faced and how further steps towards the Blue growth can be pursued.

In the Marine Ecosystem Services approaches, there is uncertainty regarding some features, as modelling is performed with limited knowledge of time and spatial measurements.

Consequences regarding this limitation fall on the non-steadiness of marine systems, since they are eminently changeable with different physical factors such as the wind, currents and tides leading to a challenge when mapping by remote sensing. To understand an ecosystem service, it is important to understand where the service is generated, where it is performed, how the locations are connected and who are the beneficiaries (Townsend et al., 2018). Applying the ecosystem services approach, requires the interaction of different ecosystem services (provision, regulating and cultural). Otherwise, if single sector evaluation is applied the output will not reflect a good outcome. The relevance of this type of approach, to be integrated with different services, contrasts with a high representativity of the theme in terrestrial systems (Pendleton et al., 2015).

Besides the dynamic physical challenge, the three-dimensional structure of the Ocean represents a big complex challenge, with different activities taking place in different zones of the water column. Activities can occur in different zones and at the same time be present in more than one, making it harder to value this type of services since accurate data availability is difficult to obtain (Pendleton et al., 2015). For this reason, mapping, accounting and categorizing the services require a deep understanding of the interconnectivity of the Ocean layers (surface, water column, and seabed) and where the different activities and services take place, and how they interact (Townsend et al., 2018). As an example, deep sea mining takes place on the seabed, fishing takes place both in the water column and on the seabed, shipping occurs at the surface, and cable laying on the seabed.

Data centres also play an important role in the challenges of sharing data and on cooperation among centres and users, as 60 % of data centres restrict access to “certain” types of data and only 16 % have no restrictions to access (UNESCO, 2021). In the Portuguese case, some of this information can be found online, for example on the Portuguese Sea Geoportal, available on the DGRM website (https://www.psoem.pt/geoportal_psoem/). In this Geoportal, an online GIS tool gathers information from different national and international entities resulting in a variety of elements of oceanographic characterization and utilization. It allows addition of different layers, being possible to identify features as habitats, cable laying or delineated MPAs. It is a step forward on digitalization, by allowing online access. However, navigation and export of data is limited, as well as complete display of the mentioned data. It can be recognized that the projects on the PMPLS achieved good results due to the type of approached used, bottom up and participatory, this is a really interesting point that can be replicated to further studies. To involve the society and users of such areas, by scaling their responsibilities in the society and turn people part of the process and part of the transition.

It is, unfortunately, evident that not all monitoring goals were achieved under the Marine Strategy Framework Directive implementation, such as the monitoring and the implementation of the programmes of measures, and the development of ecosystem indexes to identify ecological trends (Directive no. 2008/56/EC). Under the FAO statistics database, data on SDG 14, 14.4.1 – Proportion of fish stocks within biologically sustainable levels (% not overexploited) - submitted by Portugal referred to 2018 only, and were classified as "Unreliable" by the Organization, since they passed the first level of Quality Assurance defined, but not the second one. From the 34 stocks considered, 79.4 % are unknown, resulting in a proportion of 85.7 % of stocks not overexploited (https://www.fao.org/faostat/en/#data/SDGB).

The application of the mentioned recommendations in the policy spectrum, and the use of data, which applies transversally to the European Member States, passing by the open database of MAES, which exists in a very incomplete and confusing platform that makes the usage not only time-consuming but also very inconsistent, underlines the perception of data scarcity and knowledge gaps. The UN has also created their own database and online platform to promote partnerships that accommodate data on habitats at a global level, named Ocean+ Habitats (UNEP-WCMC, 2019). Other challenges arise from the national plans and each MS jurisdiction and law, underlining the urge for better governance integration and better use of resources and data..

As the accounting of ecosystem services is on the spotlight and is encouraged by different organizations, monitoring needs to be improved to finely evaluate the stocks and flows, natural capital and ES, respectively (UNSD EEA and the World Bank 2011, UNU-IHDP, UNEP, 2014). As mentioned by Karp et. al. (2015), there is a need for the creation of a platform of ecosystem services.

These mentioned challenges are transposable and comparable to the ones faced in the present dissertation. It is important to note that the focus on the fishing industry and therefore on fishing activities, is a viable starting point for the accounting of MES in Portugal, and therefore a good starting point to integrate these ecosystem services in accounts and in the SNA.

Looking into fishing services, highlights how the economy and the population rely upon direct use of provision services, and indirect use of regulating and cultural services. However, the holistic vision could not be reached due to limited data access, which led to an incomplete output of the initial proposed outcome. With comparable and systematic data, drivers and trends can be detected and help the most correct possible valuation of ecosystem services (Karydis et al., 1996, Leitão, 2019). For this reason, conclusions of the present work are based on the general challenges faced by policymakers, decision-makers and academics on the inclusion of MES in Ecosystem Accounts to be included in SNA.

Conclusions

Scaling up Ocean science must be a priority, aiming at the understanding and evaluation of Marine Ecosystem Services, thus leading to a more sustainable future, whereas we are against the clock to stop and mitigate the destruction of habitats and biodiversity loss. On an even larger scale, there is a need to stop and mind the Ocean, our service provider, indispensable for life on Earth and indispensable to the world we currently live in. Accordingly with E/2021/58, national research, budgets to Ocean science represent on average only 1.2 % (between 2013 and 2017), which is under the value estimated of the Ocean contribution of $ 1.5 trillion by 2100.

Firstly, to correctly establish monetary values for the ecosystem services, linked to the holistic view of the Ocean system, it is possible to step up to an open source, monitoring platform, answering the emblematic measures of the National Strategy for the Sea 2030 – Strategic Objective 1: Combating Climate Change and Pollution and Restoring Ecosystems; Measure no. 1: Implement a National Programme for the Mapping of Habitats and Services of Marine and Coastal Ecosystems including restoration measures.

With the gathering of information and the allowance of entry of data referring to studies on the subject, as in MPAs, a confluent, more comprehensive look at MES can be achieved, overpassing challenges of data gaps and scarcity. The organization among different levels, namely, national organizations, the results and the data collected from academics, non-governmental organizations (NGOs), and scientific studies, can be merged in an Ocean National Account that can be included in the System of National Accounts and steer the upgrading of the current Satellite Account for the Sea. By starting with provision services such as fisheries, mapping ecosystems and habitats, facilitates the accomplishment of SDG 14 by 2030, and orientates the alignment with the agenda of the United Nations Ocean Decade.

Regarding the SAS, it is noteworthy that data analysis and publication can be improved, since there is a disparity of temporal scales. The triennium analysis of the SAS does not allow comparability with other sources of data as in the MSFD assessment cycles, or the INE annual reports on fisheries statistics. Moreover, the time elapsed since the triennium analysis to its publication, was such that when access to the report was available, data were already outdated for scientific and formal analysis. The definition of a shorter period for reporting would beneficiate the Blue Economy as a whole, as the assessment would be more centralized, allowing SNA to be updated and more useful. Taking as an example the SNIMar that is operationalized by the Portuguese Institute for Ocean and Academy, that includes responsibilities on the MSFD implementation in Portugal.

However, to ensure the feasibility of the process these initiatives need to be global. There are slight trends that can be overlooked, such as extreme event occurrences, oil slips or sudden biomass changes, that can only be well interpreted when looking at the Ocean as a whole (i.e., by using international networks). Comparability and the chance to look at a broader scale is imperative, which can benefit of satellite and remote sensing technologies, direct observations, surveys and modelling (Karp et al., 2015).

The framework to create such a platform, highlights the need for more specific orientated professionals and at the same time more multidisciplinary teams, since only with a holistic and expert supported approach, efficiency in the methods can be successful; still, without never forgetting a key factor: funding and investment. Scientific research and specifically Ocean science are in urgent need of a boost in funding and attention to attract investment.

Even with the existing monitoring programmes, none can account for the total stocks of fish or other marine resources. Applying a consistent method and time scale, proved to be a challenge to the ability to evaluate the sustainability of the ecosystem provision service. If that approach was applied, it would result in the analysis of critical trends and adaptation of management plans in a sustainable, cautious and updated manner, more beneficial for a sustainable governance (Kremen, 2005, Winfree et al., 2015, Karp et al., 2015).

Having comparable, descriptive, coherent, and updated data is crucial to organize the information regarding the MES into specific accounts. Hence, decision-makers can use it to be included in the SNA to answer the increasingly urgent needs of our world, outstanding sustainability and good governance of our Ocean.

As a closing remark, it is important to point out that untreated raw data give neither results nor outputs, and for this reason, do not help policymakers to take informed decisions. Hence, working groups with different field experts and an open-source platform would allow joint forces to decide on how to use the available data to get the best possible results and outputs. Artificial Intelligence (AI) is a great tool that can be merged with open-source platforms allowing massive data entries to be treated, as it works to find ways to investigate data in a way humans cannot, simplifying complex data, running algorithms and presenting faster results. Digitalization and innovation are mandatory for a more sustainable and resilient Ocean.

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