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IMPLEMENTING THE SEEA EA FRAMEWORK:
Valuing Portugal's Marine Ecosystems

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Abstract

This study evaluates the integration of marine natural capital into Portugal's Ocean Satellite Account (OSA) using the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) framework. Focusing on the Southwest Alentejo and Vicentina Coast, it analyzes ecosystem services such as carbon sequestration, commercial fishing, and recreational activities. This illustrative exercise highlights the economic value of these services and the challenges in data availability and valuation methodologies. By addressing these gaps, the study underscores the potential of ecosystem accounting to inform sustainable ocean management.

Keywords: SEEA EA; Ocean Economy; Ecosystem Services; Environmental Valuation; Portugal; Ocean Accounting.

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“A terra o sol o vento o mar
São a minha biografia e são meu rosto”

- Sophia de Mello Breyner Andresen in *Poema*

1- Introduction

Oceans cover 70% of Earth, regulate the climate by absorbing 91% of excess heat, produce 50% of oxygen, and host 80% of existing species (NOAA, 2021; UN, 2022). They support nearly 3 billion people and facilitate 80% of global trade (UN, 2021b; World Bank, 2023). Also, coastal areas are home to 40% of the global population, rising to 92% in Portugal (OECD, 2021). These numbers reveal not only Ocean’s role on climate change mitigation, but also the impact of climate change and human activities on marine ecosystems. In this sense, international efforts, like the UN Ocean Decade, OSPAR, the Paris Agreement, and the Lisbon Declaration, highlight oceans as a global priority. Aligned with this view, Portugal reflects this priority in its National Ocean Strategy 2021–2030[1].

Despite the often-overlooked value of blue natural capital, assessing their economic value is essential for sustainable ocean management (GOAP, 2021). In response, the Portuguese government approved incorporating marine natural capital into the Ocean Satellite Account (OSA) by 2026, which will be updated every three years (resolution nº 121/2024). This thesis aims to be an illustrative exercise on how marine natural capital can be integrated into Portugal's OSA, focusing on the UN's *System of Economic-Environmental Accounting Ecosystem Accounting* (SEEA EA), recognized as an international standard (SEEA EA, 2021). The SEEA EA, chosen for its comparability and alignment with the System of National Accounts (SNA, 2008), is the most researched and tested method compared to alternatives such as Emergy/Exergy or Green Accounting (Comte et al., 2022; Appendix 1). Also, it is a complementary model to the SEEA Central

[1] NOS (2021-30): “(...) the development of Experimental Accounts for the Environment and Ecosystem Services (marine) should be considered.” (page 83) free translation.

Framework 2012, however it can be applied independently. In essence, SEEA EA is a critical component of Ocean Accounting, a broader system supporting sustainable ocean management (GOAP, 2021).

In sections 2 and 3, we present the proposed model and review the literature on its application over recent decades. Drawing lessons from this, in section 4 the study proceeds to analyze the case of Portugal, starting with an Ocean Economy (OE) analysis as reflected in the two OSA's published in 2016 and 2020. Following this, the SEEA EA is applied to selected ecosystems and ecosystem services within the Southwest Alentejo and Vicentina Coast (SAVC). Despite their limitations, the results highlight the challenges of assessing the economic and exchange value of environmental goods, as well as gaps in data availability and monitoring systems. Nevertheless, they also underscore the economic significance of ecosystem services that might otherwise remain largely unperceived.

2 - SEEA EA Framework

2.1 - Background

The 2021 SEEA EA is the culmination of decades of efforts to integrate economic valuation of environmental goods and services into economic accounting. Its origins date back to the 1980s, with early recognition of the need to account for resource depletion and environmental degradation. This led to the UN's publication of the *Handbook of National Accounting: Integrated Environmental and Economic Accounting* in 1993, coinciding with the 1992 UN Conference on Environment and Development and Agenda 21 (SEEA EA, 2021).

In 2012, the UN adopted the SEEA CF as an international standard, institutionalizing environmental-economic accounting through the UN Committee of

Experts on Environmental-Economic Accounting (UNCEEA) (SEEA EA, 2021). Recognizing gaps in ecosystem degradation and services, the SEEA Experimental Ecosystem Accounting (SEEA EEA) was introduced in 2013 to link ecology and economics.

The launch of the 2015 Sustainable Development Goals (SDGs) underscored the importance of ecosystems (SDG 6: water, SDG 14: ocean, SDG 15: land) (UN, 2015; Edens et al., 2022). This shifted global narratives, emphasizing biodiversity restoration, and incorporating economic valuation of environmental goods, as highlighted in António Guterres' *Our Common Agenda* (UN, 2021a). Additionally, implementation projects like WAVES, MAES, INCA, and NCAVES revealed strengths and weaknesses in SEEA EEA, prompting a revision.

Starting in 2017, the UNCEEA focused on spatial units, ecosystem conditions, ecosystem services, and monetary valuation (Edens et al., 2022). The final document, SEEA EA 2021, established foundational chapters and governance structures, marking the transition from "experimental" to a comprehensive accounting framework (SEEA EA, 2021) (Appendix 2).

2.2 - Definition and Structure

SEEA EA's definition and structure are brought by a single and fundamental document: *System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA)*, published in 2021. It encompasses all the major guidelines and technical details for different types of ecosystems. It is a very complete document that should be the major guideline source of any entity trying to implement a SEEA EA.

Moving forward, SEEA EA is *a spatially based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and* *assets and linking this information to measures of economic and human activity* (SEEA EA, 2021).

SEEA EA is a statistical framework that specifies a set of ecosystem accounts, designed to meet the demand for efficient public policy on the topics of economic and environmental sustainability by being consistent with the SNA. The SEEA EA framework treats ecosystems as spatial units, each treated as an asset – a provider of a flow of goods and services (ecosystem services, ES) over time which represents the ecosystem's asset value at a given period (e.g, life-support systems), and for which markets do not typically exist due to their public goods' features. This contrasts with produced assets traded in traditional economic markets. The SEEA EA emphasizes both physical and monetary data to ensure comprehensive environmental-economic accounting, while also recognizing that the monetary values of the SEEA do not capture the full *value of nature* (SEEA EA, 2021). In this sense, ecosystems, as assets, (Edens et al., 2022) are, firstly, described by their stock accounts, in terms of size (extent) and changes in integrity (condition).

The measurement of an ecosystem's extent specifies, for a given ecosystem accounting area, the size (spatial area) of its various ecosystems, categorized by ecosystem type as outlined by the IUCN Global Ecosystem Typology international classification (IUCN, 2020; Keith et al., 2020). On the other hand, the condition of an ecosystem is the assessment of its integrity in various levels of biotic and abiotic characteristics, including pollutants and waste, in relation to a reference condition.

Secondly, it is pivotal to assess ecosystem's flows, such as ecosystem services (ES) extending the production boundary in the SNA, adding a set of benefits that ecosystems provide not only to the economy but also to the people. There are three categories of ES: Provisioning services, which include food like fish (biotic) or water abstraction (abiotic); Regulation and Maintenance services such as oxygen production, climate regulation or improved water quality and Cultural services, for instance recreational fishing and coastal tourism (Edens et al., 2022; SEEA EA, 2021). The ES flows account establishes which ecosystem services are provided by each ecosystem type, in physical and/or monetary terms. In this sense, there is a reference list of twenty-five ES plus a flow related to non-use values – the ecosystem and species appreciation, which accounts for the human well-being derived from the value attributed to the existence and protection of such species and ecosystems, whether it is for use or non-use (Appendix 3).

The monetary valuation of ecosystem assets and services is complex and fueled a long debate among the international scientific community, which has culminated in the latest version of the SEEA EA 2021, described in chapters 8 and 9 (SEEA EA, 2021).

In the SEEA EA, ES can be given a monetary value considering different methodologies, using the same principles as the SNA, which includes the concept of exchange value. This means that, unlike other approaches relying on economic welfare values, according to the SEEA EA, ES are valued based on the price they would have if traded in a market, reflecting their value in economic transactions. Given the challenges of studying complex marine ecosystems, the economic valuation of ES might not be as clear as it would be desirable, and only further research and data collection can provide a more robust foundation for the SEEA EA (Addamo et al., 2024).

Lastly, and in broad terms, the ecosystem asset account consists of assessing the capacity of an ecosystem asset to provide services into the future (SEEA EA, 2021). The monetary ecosystem asset account is based on the Net Present Value method (NPV) which determines the value of an asset at a given period by "aggregating the NPV of expected future returns for each ES supplied by an ecosystem asset" (SEEA EA, 2021).

3 - SEEA EA Implementation Globally: key lessons

Since 2021, the global implementation of the SEEA EA for marine ecosystems has made significant strides, with notable advancements in several regions[2]. Although, the application of SEEA EA to oceans is still in its early stages compared to other terrestrial ecosystems (Comte et al., 2022; SEEA EA, 2021; Addamo et al., 2024; Cummins et al., 2023).

Australia has published the second phase of their first National Ocean Account in 2022. However, before that, the application of SEEA EA has been integrated into the management of iconic marine systems, such as the Great Barrier Reef in 2017 (Australian Bureau of Statistics, 2017). This experimental project focused on biophysical metrics and the valuation of ecosystem services (ES) like tourism and fisheries. Nevertheless, challenges persist in addressing uncertainties in valuation methodologies, turning data less transparent (Cummins et al., 2023).

The OSPAR region, encompassing the North-East Atlantic, has demonstrated pioneering endeavors in experimental SEEA EA implementation at a regional scale. This effort involves assessing key ES such as fish provisioning, carbon sequestration rates, and recreational benefits. The project has highlighted critical data limitations, particularly the lack of harmonized, spatially explicit datasets across contracting parties. Despite these challenges, the work provides a foundation for future regional collaboration and identifies strategic areas for improving marine ecosystem accounting, such as technological advancements for the collection of data in situ and via satellite. For instance, one of the main obstacles when accounting for the ocean is that the spatial units provided by SEEA EA do not capture the third dimension, that is, depth, making accurate mapping harder

[2] Since January 2023, the USA is currently developing their Natural Capital Account supported by notable efforts of researchers such as Eli Fenichel (2024).

(Blazquez et al., 2023; UN, 2021). Advancements in marine technology are key to overcoming these obstacles.

In this sense, the European Union (EU) has also made significant progress in advancing SEEA EA through the Knowledge Innovation Project on Natural Capital and Ecosystem Services Accounting (KIP INCA) and MAIA (Mapping and Assessment for Integrated Ecosystem Accounting).

Since 2004, the EU has invested in the establishment of data centers and satellite monitoring techniques, complemented by buoy systems, as demonstrated by the MERSEA-STRAND 1 project and the 2014 Copernicus Marine Service by Mercator Ocean International (MOi). The EU has prioritized ocean forecasting and marine phenomena through initiatives like the Copernicus Marine Service (CMS, n.d.). In June 2024, the Europe Digital Twin of the Ocean (EU DTO) was launched, utilizing advanced AI technologies (Horizon, 2024). Notably, these systems depend on member states' active monitoring of their waters. Additionally, the European Marine Observation and Data Network (EMODnet), established in 2009, integrates over 120 organizations to support sustainable ocean resource management through a unified data framework (EMODnet, n.d.). At the national level, Portugal has made improvements by having recently (December 2024) launched a microsatellite, PoSat-2, to improve maritime communication and monitoring of ocean heat waves (AICEP, 2024).

The Netherlands were one of the participants in the MAIA project, to systematically integrate marine natural capital accounting into decision-making processes under the guidance of SEEA EA. One of the aspects underlined by the MAIA project was the National Ecosystem Typology used, recognizing the need to cross-referencing it with international ecosystem classification systems, such as IUCN GET (proposed by the

SEEA EA) and the European Nature Information System (EUNIS) (Statistics Netherlands, 2022).

From these regional and national examples, several key learnings emerge. First, cross-sectoral collaboration is essential to a successful SEEA EA implementation, as demonstrated by OSPAR's regional coordination. Second, data transparency and harmonization remain critical. Adhering to FAIR (Findable, Accessible, Interoperable, and Reusable) principles has enhanced the credibility and utility of ecosystem accounts, as seen in the EU and OSPAR initiatives (Cummings et al., 2023). Having an open and accessible data network is essential for policy development in the sector, as it strengthens stakeholders' trust and encourages their participation (Cummins et al., 2023; Leap et al., 2023; Konar & Ding, 2023). Furthermore, as documented in a report by the OECD on Belgium, data access has fostered academic work in the marine field, contributing to a greater understanding of the region's ecosystems (Jolliffe & Athar, 2024).

Additionally, it is important to emphasize the significance of transparent monitoring over time and space, as each data collection represents only a snapshot of the ecosystems under evaluation (Ministry of the Sea – working group, 2018). The implementation of systems like SEEA EA requires constant assessment of the condition's evolution and location of ecosystems. This method not only minimizes the uncertainties associated with ES, their quantification, and economic valuation, as it is also essential for ecosystem condition and asset assessments (SEEA EA, 2021).

All goods and services must be valued by considering who benefits from them and whether they are intermediate or final services (EPA, 2009; Barbier, 2010). Services such as carbon sequestration or fish provisioning are examples of final services, with the former benefiting the government (on behalf of citizens) and the latter benefiting the fishing industry (SEEA EA, 2021), for which markets exist. On the other hand, many estuarine regions provide, for example, an intermediate service of regulating the marine environment for which typically markets do not exist and when assessing their economic value, a high risk of double counting persists.

Lastly, but most important, the economic integration of ecosystem accounts, particularly through linking ES with GDP-aligned metrics, has improved policy relevance and utility (Cummings et al, 2023). However, the economic valuation of marine ES remains as one of the most pressing obstacles in marine ecosystem accounting. On this topic, the UK presents one of the most advanced Natural Capital Accounts (Engledew & Watson, 2021).

As previously described, the SEEA EA encompasses various methods for assessing ES. This topic, being one of the most debated throughout the revisions of the SEEA EA, also requires greater standardization and alignment across countries. Given that the SEEA EA is based on the state-of-the-art literature regarding the economic valuation of ecosystem services (ES), it is important to highlight some of these methods.

In its Chapter 9, the SEEA EA Handbook outlines five categories and strategies for the economic valuation of ecosystem services (ES). Firstly, *Methods where the price for the ecosystem service is directly observable*, for instance, in the case of regulated and relatively mature carbon markets where the price per ton of carbon may be applied to the amount sequestered by ecosystems. Secondly, *Methods where the price for the ecosystem service is derived from markets for similar goods and services* when the prices are not observable, and the economic valuation may rely on the market price for related goods. Thirdly, *Methods where the price for the ecosystem service is embedded in a market transaction*, applying to fish provisioning from commercial fisheries where the ES economic value is different from the product market price, implying the use of the resource rent method, where all costs of operations are subtracted to assess the value of the underlying ES. Fourthly, *Methods where the price for the ecosystem service is based on revealed preferences obtained from expenditures (costs) on related goods and services*, applying to recreational activities by assessing expenses from travelling to the recreational site and from doing the activity (Travel Cost), for instance, recreational fishing (Lopez-Rivas et al, 2021). Lastly, *Methods where the price for the ecosystem service is based on expected expenditures or markets* can be considered when the valuation of an ecosystem is based on the cost of the damages that would occur if there was a loss of that ecosystem (Avoided Damage Costs) (SEEA EA, 2021). Additionally, other important methods are included, such as stated preference methods (Rulleau et al., 2012; Ferreira et al., 2017; Cunha-e-Sá et al., 2024).

4 - Case Study: Portugal

Portugal has a land territory of 92,225.20 km² (INE, 2023) and a marine territory divided, according to the Montego Bay Convention (UNCLOS), into Territorial Sea (50,957 km²), Internal Waters (13,415 km²), and the Exclusive Economic Zone (1,660,456 km²) (DGPM, 2024). A quick calculation reveals that the land-to-sea ratio in Portugal is approximately 1:18, meaning that for every square kilometer of land, Portugal possesses around 18 square kilometers of sea. This disproportionality has historically proven to be a source of opportunity. Therefore, it is unsurprising that Portugal is the first country to build an Ocean Satellite Account (INE, 2016), monitoring its maritime-related marketed economic activities (EU Commission, 2020; DGPM, 2024).

Portugal has made significant strides in ocean research through organizations like Portuguese Institute for Sea and Atmosphere (IPMA), the Directorate-General for Maritime Policy (DGPM), Directorate-General for Marine Resources (DGRM), the Hydrographic Institute and numerous academic institutions in Portugal. Key initiatives include the Task Force for the Extension of the Continental Shelf (TFECS), established in 2009, whose methodologies are supporting the extension of Portugal's continental shelf. Projects like SNIMAR (2012) and PSOEM (2018) developed geoportals for marine data, while the SEAMInd project (2014) is advancing monitoring indicators for ocean economic, social, and environmental health.

Despite these efforts, the Marine strategic framework (2008) goal of Good Environmental Status (GES) by 2020 remains unmet, with timelines extended (DGRM, 2020). Portugal faces significant challenges in marine monitoring due to its vast ocean territory, 16 hectares per inhabitant compared to the EU average of 1.3. In this sense, the Portuguese Research Council (FCT) published a report in 2019 highlighting the lack of a sustainable, long-term monitoring system, despite progress in this area (FCT, 2019).

One of the most pressing challenges in establishing robust monitoring systems lies in the fact that different aspects related to ES and the economic valuation of these services have, in general, an important location specific component. In the sense, that people who typically take more advantage (or are more harmed) by ecosystem’s condition are local communities given their livelihood´s dependence on them. Additionally, even though benefit transfer techniques can be used, they require a very careful methodological approach while choosing the potential site(s) to support the underlying analysis.

Furthermore, interdisciplinarity is a cornerstone of ocean research and monitoring (Grilo et al., 2017). This principle was highlighted by the Gulbenkian Ocean Initiative (GOI) (2013–2018), which published several reports on the importance of blue natural capital, with a specific focus on private sector perceptions (Saldanha et al., 2015). Notably, as part of *The Economics of Ecosystems and Biodiversity* (TEEB), the GOI proposed a pilot project to implement the SEEA in the Nazaré region. (GOI & UNEP-TEEB, 2014).

4.1 - Data and Methodology

Portugal's Ocean Satellite Accounts

To analyze the Portuguese context, official data from the two OSAs conducted (2010–2013 and 2016–2018) were consulted, highlighting data such as employment, gross value added, imports, and exports, both in general terms and by group of economic activity. This data provided by The National Statistics Office (INE in Portuguese) and DGPM is crucial for understanding the economic dynamics of the sector; however, there are no regional data available, making it impossible to conduct a more detailed analysis of different areas of the Portuguese coast. Regional analysis is only performed in the second OSA (2016-2018), separating the Azores and Madeira from mainland Portugal. Methodologically, a comparative analysis of the two referred periods will be undertaken, enabling the observation of trends and discrepancies between groups of economic activity.

SEEA EA Pilot Study: Southwest Alentejo and Vicentina Coast (SAVC)

After analyzing the economic dynamics of the maritime sector, the case study will focus on a specific region of the Portuguese coast, the SAVC (Appendix 5). The choice of this location is motivated, on the one hand, because it includes since 1995 a natural park and a protected marine area 2 km from the coastline, demonstrating its significant diversity of habitats and biodiversity interest (Cunha-e-Sá et al., 2024). On the other hand, it is a region close to the port of Sines, one of the main entry points for gas and oil, presenting considerable risks of hazard spills that could harm the condition of ecosystems (Frazão Santos et al., 2013). Given this risk, for the responsible authorities (DGRM) it is key to assess and monitor the impacts of that economic activity on the condition of the regional ecosystems services (ES) provided. For this exercise, the data on the type and extent of local ecosystems are obtained from technical reports produced by the MARSW project, which describes and characterizes some ecosystems of SAVC (especially mobile sediments and reefs – Appendix 6.1) (MARSW, 2020). Furthermore, these data are complemented by the Calouste Gulbenkian "Blue Carbon" 2023 reports, which are based on the most recent data on ecosystem areas such as salt marshes and seagrass beds. In the context of this case study, among the ten sites considered in the report, three were within the area under analysis and, therefore, included in this study: Mira Estuary, Alvor Estuary, and Arade Estuary (Appendix 6.2).

Regarding the classification of ecosystems, the hierarchical EUNIS classification is used, given its adoption in the MARSW report and its broad comparability with OSPAR case, among others. According to EUNIS, the ecosystems considered are A3.2, A3.3, A4.2, A4.3 (Reefs); A5.23, A5.25 (Mobile Sediments – Sand); A2.61 (Seagrass Beds) and A2.5 (Salt Marshes). Concerning ES and given the data available for the region under study, there are three ES accounted for in physical terms: (i) provision of wild fish, mollusks and crustaceans from commercial fishing, (ii) carbon sequestration annual rate, and (iii) recreational fishing. In the absence of spatially defined data, commercial fishing catches in the region are obtained from the DGRM, corresponding to the sum of catches from the Sines and Lagos delegations for 2022 and 2023. Also, recreational fishing license data for the region are obtained from the DGRM for the years 2007–2013, as 2013 was the last year when data were disclosed by region. Accordingly, to account for the SAVC the data retrieved considers not only the regional licenses for Alentejo and Algarve, but also the National licenses which allows recreational fishing along the Portuguese national coast. Also, Carbon sequestration rates are derived from the Calouste Gulbenkian “Blue Carbon” 2023 report.

Two of the ES described in physical units are translated into monetary units: the carbon sequestration rate (corresponding only to salt marshes and seagrass bed ecosystems) and recreational fishing. This monetary analysis also accounts for the value that economic agents attribute to species and ecosystems in SAVC, based on a recent forthcoming study by Cunha-e-Sá et al. (2024), which assesses the individual WTP for investments in defensive measures to prevent oil spills. Based on a choice experiment conducted for a representative sample of the Portuguese population, the attributes considered were biodiversity, coastal protection, and beach use protection in monetary terms (WTP). To assess the value of the region's support for the protection of ecosystems in SAVC data gathered in Cunha-e-Sá et al. (2024) for 2020 is used, based on a five-year time horizon project that aimed at providing better conditions for coastal protection, biodiversity, beach use maintenance, and surfing hotspots. The results showed that the first three attributes were of statistical interest, with an average individual WTP of 42.25 EUR2020 for the five-year time horizon project. Knowing that the adult population of Portugal in that year was 8,299,575 (INE, 2023), the total economic value was estimated by assuming this individual amount for the entire Portuguese adult population. This assessment is attributed to flows related to use and non-use values "Ecosystem and Species Appreciation"[3]. Although SEEA EA does not consider "Ecosystem and Species Appreciation" as an ES, it can still be treated as one in the data gathering, as it reflects both use and non-use aspects (Cunha-e-sá et al., 2024; Barbier, 2010; SEEA EA, 2021) (sources - Appendix 7)[4].

[3] "Ecosystem and Species Appreciation" - "(…) the treatment of non-use values in an accounting setting requires additional considerations. In the context of the environment, non-use values are those values that people assign to ecosystems (including the associated biodiversity), irrespective of whether they use (directly or indirectly), or intend to use, the ecosystems." (SEEA EA Handbook, 137).

[4] Also, the provision of wild marine animals is not translated into monetary units since there is no data available on operation costs and, therefore, it is not possible to apply the resource rent method.

To assess the amount of carbon sequestered, the market price of carbon is used based on the EU Emissions Trading System (EU ETS) market. Given that in 2023 the price of a ton of carbon dioxide (CO2) was traded at 83.60 EUR (European Commission, 2024), and that 1 ton of carbon (C) corresponds to 3.67t of (CO2), each ton of sequestered carbon is worth about 306.81 EUR (Krzemień et al., 2022). To value recreational fishing, the Travel Cost method is applied, widely used to assess the value of recreational activities (Barbier, 2010; SEEA EA, 2021). Thus, aligning temporally with the obtained license numbers, data on travel costs for recreational fishing in the region are derived from the 2008 Sportfish project, detailed in a study conducted by Erzini et al, (2008) in which the cost was estimated to be 22.11 EUR 2008 per person per trip. Adding on the cost of a single trip, Erzini et al. (2008) estimated the average number of days each person went for recreational fishing in SAVC – 65 days (margin of error: ± 2).

Regarding the beneficiaries of ES in physical and monetary units, the approach aligns with the framework outlined in the SEEA EA handbook, as well as in studies conducted in Netherlands (SEEA EA, 2021; Horlings et al., 2020) and the OSPAR case study (Blazquez et al., 2023). Accordingly, the beneficiary of wild marine animals' provision from commercial fishing is the industry (Fisheries, Agriculture, and Forestry). The government, as a representative of society at large, is considered the beneficiary of carbon sequestration and ecosystems and species appreciation values. Finally, households are recognized as the beneficiaries of recreational fishing activities.

Regarding the Ecosystem Asset account, ecosystems are quantified as assets providing services, based on available data. Thus, the asset related to the carbon sequestration service provided by salt marshes and seagrass ecosystems is assessed, firstly in physical terms, using data from the Calouste Gulbenkian "Blue Carbon" 2023 Report II. Secondly, a use value is assigned to the ecosystem as an asset, considering its ability to sequester carbon in the future, using the methodology proposed in SEEA EA, NPV. Following the supplementary material from the OSPAR case, it is assumed that the ecosystem has a lifespan of 100 years, and the discount rate is assumed to decrease over time: 3.5% for the first 30 years and gradually decreasing, that is, 3.0% for the following 45 years and 2.5% for the final 25 years[5] (Joseph Lowe, 2008; Blazquez et al., 2023).

The condition of ecosystems was not integrated into this pilot account, as it will require the use of indicators based on the SEAMind platform, which has yet to be launched. Furthermore, no data were available regarding Good Environmental Status (GES) for which a baseline condition would be required to proceed with such an assessment.

5 - Results

5.1 - Ocean Satellite Accounts (2010-13 & 2016-18)

As of December 2024, Portugal has published two OSA's, the first in 2016, covering the period 2010-2013 (INE, 2016), and the second in 2020, covering 2016-2018 (INE, 2020). Both OSAs resulted from the collaboration between INE and DGPM. These documents outline the structure of Portugal's Ocean Economy (OE) and are methodologically based on ESA (2010). Furthermore, adapting to the national context, INE proposes nine groups of economic activity (OSA, 2016): 1 – Fisheries, aquaculture, processing, wholesale and retail of its products; 2 – Non-living marine resources; 3 – Ports, transports and logistics; 4 – Recreation, sports, culture and tourism; 5 –

[5] The discount rate presented is in accordance with the *Intergenerational wealth transfers and social discounting: Supplementary Green Book guidance* (Joseph Lowe, 2008) from the HM Treasury, UK. This document, used by Blazquez et al., 2023, for the OSPAR case, sets a declining discount rate to account for long-term uncertainties, ensuring fairness to future generations, and reflecting ethical and economic considerations, especially for irreversible impacts like climate change.

Shipbuilding, maintenance and repair; 6 – Maritime equipment; 7 – Infrastructures and maritime works; 8 – Maritime services; and 9 – New uses and resources of the ocean (Appendix 8).

Despite their common framework, there are significant differences between the two OSAs. While the OSA 2010-2013 considers Portugal as a single territory, the OSA 2016-2018 differentiates between Mainland Portugal, the Autonomous Region of Madeira, and the Autonomous Region of the Azores (OSA, 2020). This new approach matters to understand regional conditions and the weight of economic activities in areas that differ from the national continental context. Additionally, the OSA 2016-2018 incorporates the Symmetric Input-Output Matrices System (INE, 2017), allowing for the analysis of the OE's indirect effects, specifically on the Indirect Gross Value Added (GVA), providing a more precise picture of this sector's impact on the country's GDP. Notably, the 2018 data in the OSA 2016-2018 is provisional (OSA, 2020).

Utilizing the data available from these two OSAs, it is evident that the direct GVA of the OE in Portugal has been increasing. In 2010, it accounted for 2.9%, rising to 4.0% in 2018 of the total GVA of the national economy. In the analyzed periods, the OE experienced faster GVA growth compared to the national economy. For the 2010-2013 period, the GVA of the OE increased by 2.1%, while the national economy's GVA decreased by 5.4%. Similarly, for the 2016-2018 period, the OE's GVA rose by 18.5%, whereas the national economy grew by only 9.6%. In absolute terms, it grew from 4,615.8 million EUR (2010) to 7,177 million EUR (2018) (Appendix 9).

Regarding employment in the OE, we observe a slight increase in its share at the national level, rising from 3.5% in 2010 to 4.1% in 2017. In absolute terms, this represents an increase from 162,901 full-time employees (2010) to 189,236 (2017). Average wages in the OE have also followed this upward trend, increasing from 21,500 EUR (2010) to

22,900 EUR (2017) annually. This evolution outpaced the national economy, as OE wages represented 106.3% of the national average (2017) (Appendix 10).

To understand Portugal's OE, it is essential to examine discrepancies and trends among the various economic activity groups. Between the 2010-2013 and 2016-2018 periods, group 4 (recreation, sports, culture, and tourism) GVA increased by approximately 72.3% (Appendix 11), growing its share on the total OE from 35.5% (2010-2013) to 40.4% (2016-2018). Employment in this area exhibited a similar trend, accounting for 36.2% of OE employment in the most recent OSA, compared to only 28.6% in 2010-2013. However, significant wage and productivity disparities exist across the different sectors. For instance, groups 1 and 6 show average wages significantly below the national average, reflecting their labor-intensive and low-skilled condition (Appendix 12). Conversely, groups 3, 8 and 9 have average wages well above the national average, meaning higher productivity, except for group 9, which involves emerging activities with highly specialized human resources (OSA, 2020).

Between 2011 and 2013 (2010, due to the purchase of two submarines is considered an outlier), OE imports accounted for 2.8% of the total economy, increasing to 3.0% in 2018. However, exports show a significant increase, from 3.3% in 2010 to 5.0% in 2018. This translated into an external balance increase, which represented 3.3% of the national economy in 2010-13 and 190.7% in 2018.

In 2016-2018, a deeper analysis was conducted on the OE's representation in national GDP based on the calculation of total GVA (direct GVA + indirect GVA) using the aforementioned Symmetric Matrices System. As such, the OE accounted for 5.1% of total GDP in 2018. Focusing on the products with the greatest impact in this triennium, it is estimated that accommodation services, food products, fisheries, aquaculture products, and related services, as well as restaurant services, collectively represented over 70% of the GDP generated by the OE (OSA, 2020). Therefore, this increase most likely reflects the touristic activity.

5.2 - SEEA EA Pilot Study: SAVC

In the context of the study, the total area of the SAVC considered spans from Sines to Arade Estuary (Appendix 5.2). This area includes a natural park designated as a protected landscape in 1988, recognizing the region's natural, historical, and cultural values and the need for their sustainable protection and utilization. The region was reclassified as a Natural Park in 1995, and in 2011, a Marine Park was established (MARSW, 2020). The ecosystems of reefs (A3.2, A3.3, A4.2, and A4.3), mobile sediments (A5.23 and A5.25), salt marshes (A2.61), and seagrass beds (A2.5) were identified, with their respective areas detailed in Appendix 13. Together, the ecosystem accounting area has a total of 292.93 km².

An assessment of ES is subsequently conducted in both physical and monetary terms, and the results are presented in Appendix 14. A slight increase in commercial fishing yields was observed, reaching 8,720.9 tons of wild marine animals in 2023. Regarding carbon sequestration rates by habitats A2.61 and A2.5, the calculations showed that these ecosystems absorb approximately 101.4 tons of carbon annually, corresponding to a monetary value of 31,110.90 EUR2023 (calculations – Appendix 15).

As for recreational fishing, an average of 90,297 licenses were issued annually between 2007 and 2013. During this period, the average travel cost per fishing trip was 22.11 EUR2008, with each recreational fisherman engaging in the activity for an average of 65 days per year. Consequently, the annual average monetary value of recreational fishing in the SAVC between 2007 and 2013 was 129,770,334 EUR 2008 (163,406,036 EUR2023) (calculations – Appendix16). Additionally, the economic value of SAVC's biodiversity, coastal and beach use protection for a five-year time period was estimated at 350,660,000 EUR2020 (Cunha-e-Sá et al., 2024).

In conclusion, the implementation of the SEEA EA framework included the development of an Ecosystem Asset Account (Appendix 17), which has produced an economic value associated to the future carbon sequestration provided by seagrass bed ecosystems at 100,466.41 EUR2023 and salt marshes at 950,014.02 EUR2023, resulting in a total value of 1,050,480.43 EUR2023 (calculations - Appendix 18).

6 - Discussion

6.1 - Data and Methodology Limitations

Firstly, it is essential to highlight that the absence of an up-to-date monitoring system available for consultation determines these results as illustrative with a considerable degree of uncertainty. Therefore, this serves only as an illustration of what could be done in a more systematic way. Given that the functioning of marine ecosystems is specific to each location, the lack of comprehensive data at the regional level hinders the chance of obtaining more accurate results. In the case of data collection for marine animal catches the aggregation of data from the Sines and Lagos delegations does not provide the ideal spatial accuracy to effectively apply these findings to the SAVC area.

Additionally, regional data on the operational costs of commercial fishermen in Portugal would be crucial, not only for calculating the value of ES but also for understanding the profit margins of this sector. Concerning the lack of available regional data, it is noteworthy that DGRM ceased providing regional data on recreational fishing licenses from 2014 onwards, which further weakens the reliability of the results, since there is no available recent data.

To achieve a better and more accurate economic assessment of ES, monitoring systems reporting local data on ecosystem areas and their associated services are needed. Notably, obtained results underestimate services such as carbon sequestration due to the exclusion of many other ecosystems providing the same service. Furthermore, the temporal discrepancies in data regarding salt marshes and seagrass bed extents also introduce uncertainty. These discrepancies emphasize the necessity of implementing local strategies for frequent granular data collection to accurately account for assets and services with significant economic value. This should drive conservation and restoration policies for ecosystems that benefit society.

Nonetheless, the challenge of economic valuation and the methods to be implemented remains a pressing issue in ecosystem accounting. While the SEEA EA framework provides some examples, it lacks specific valuation methods for certain ecosystem services, leaving room for improvement. For instance, the use of stated preference methods, such as WTP, has been used in the literature for that purpose, showing how individuals value the protection of marine and coastal ecosystems. However, the economic valuation of environmental goods can be obtained using different possible payment vehicles. The choice of the payment vehicle may depend on the circumstances of the country, such as the perceived quality of institutions, among others (Cunha-e-Sá et al., 2024). In fact, when comparing mandatory extra income taxes with crowdfunding with a payback mechanism, they found that respondents are more willing to contribute when presented with the crowdfunding version: "These results suggest the potential of using crowdfunding to support ecosystem services' conservation initiatives." (Cunha-e-Sá et al., 2024, p1).

The use of the carbon market price is another point worthy of discussion, since the market price in the EU ETS does not reflect all sector's emissions and the social cost of carbon, which quantifies the monetary impact of an extra ton of CO2, including reduced agricultural productivity, sea level rise damages, and declines in health and labor productivity (Druckenmiller, 2022). Furthermore, the carbon dioxide market price does not remain stable over time, meaning that the economic value of the different assets may vary significantly, as forecasts predict rising carbon dioxide prices in the coming years (Reuters, 2024).

Also, even though the declining discount rate applied to the ecosystem asset value considers possible scenarios due to climate change, there is still considerable uncertainty regarding the impacts of it on ecosystems' capacity to continue providing their services at a local level. For example, changes in marine acidity may have notable effects on the services provided by marine ecosystems (Garrard & Beaumont, 2014; Gao et al., 2021). This highlights the urgency of monitoring in order to understand upcoming and ongoing environmental changes' effects.

6.2 - Including Ecosystem Accounting in Portugal's OSA

The analysis of both OSA's makes evident the lack of regional data beyond that between mainland and islands, making harder the design of local policies. Particularly in sectors such as coastal tourism, which represents the largest growing of GVA (2010-2018). This example highlights the necessity of integrating ecosystem accounting with the economic data presented in the OSA. Despite the existence of economic data on maritime activities, the impact of these activities on marine ecosystems remains largely unknown, potentially jeopardizing all activities dependent on them.

The importance of coastal tourism in Portugal's OE calls attention to its significant and lasting impacts on marine ecosystems and coastal zones. Coastal tourism contributes to coastal erosion, as its intensification is typically linked to infrastructure development that may degrade beach quality if sustainability is not considered (Semeoshenkova &

Newton, 2015). Moreover, it poses a considerable threat to biodiversity, as evidenced by a study conducted in Algarve. This includes impacts such as land occupation, noise, pollution, the artificial introduction of invasive species, and artificial beach nourishment, all of which exacerbate erosion risks (Nunes et al., 2021).

Finally, increasing the number of economic activity groups included in the OSA is imperative. This update should align with the evolution of activities that are of relevance in the context of the transition to carbon neutrality such as the energy sector. Furthermore, a crucial step toward integrating natural capital, through SEEA EA, into the OSA would be to include expenditures on marine environmental protection, including marine protected areas (MPAs). This approach would allow for the identification of physical and monetary values provided by the ecosystems within those MPAs, fostering their monitoring as a relevant component for improving public policy design implementation.

7- Conclusion

By highlighting data gaps and issues to be addressed regarding the economic valuation methods for ES, this thesis aims to be an illustrative exercise towards the development of environmental goods assessment and for the implementation of accounting systems like the SEEA EA in Portugal. Despite uncertainties, European data platforms like EMDOnet, Copernicus Marine Service, and the upcoming SEAMInd in Portugal, offer a promising foundation for comprehensive monitoring systems. By reducing uncertainty, assessing ES value integrates economic and societal needs with the condition of natural ecosystems, contributing to better public policy design. Incorporating marine natural capital into Portugal's OSA by 2026 will be challenging but needed.

However, Portugal does not start from ground zero. Organizations such as the Oceano Azul Foundation contribute through research and ocean governance, while Forum Oceano fosters sustainable growth by uniting private-sector efforts and supporting initiatives like the INOVAMAR consortium to secure European funding.

In this sense, the SEEA EA, with its broadly consensual framework, stands out as the model to be implemented globally for the inclusion of marine natural capital and thus contributing to a more sustainable ocean governance. As such, Portugal should adopt it, because the urgency of achieving national and international goals requires comparability and standardization, which can be both offered by the SEEA EA.

Assessing marine natural capital, being a measure beyond GDP, is just one of the many steps required for a fully sustainable ocean accounting. Achieving that will imply more research in areas such as maritime governance and risk accounting, always grounded in an interdisciplinary approach. Accounting for the condition of natural ecosystems and assessing their economic value in a systematic way is key to transforming Portugal's Ocean Economy into a Blue Economy.

"Deus ao mar o perigo e o abismo deu,
Mas nele é que espelhou o céu."

-Fernando Pessoa in *Mensagem*

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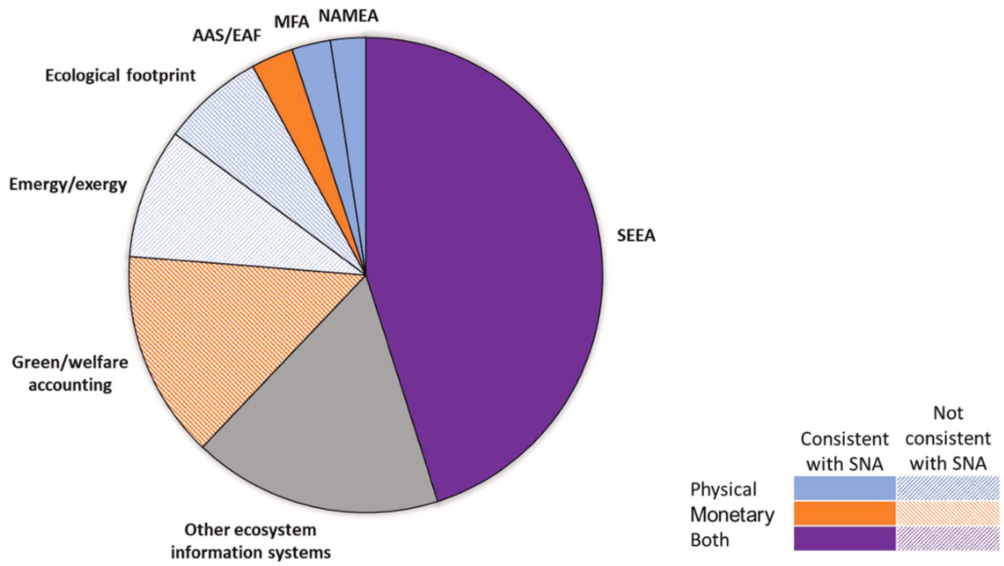
Appendix

1.

1 – Share of different ecosystem accounting conceptual frameworks in the literature; Source: Comte et al., 2022 (page 4)



2.

2.1 – SEEA EA Governance and Structure; Source: Edens et al., 2022 (page 5)

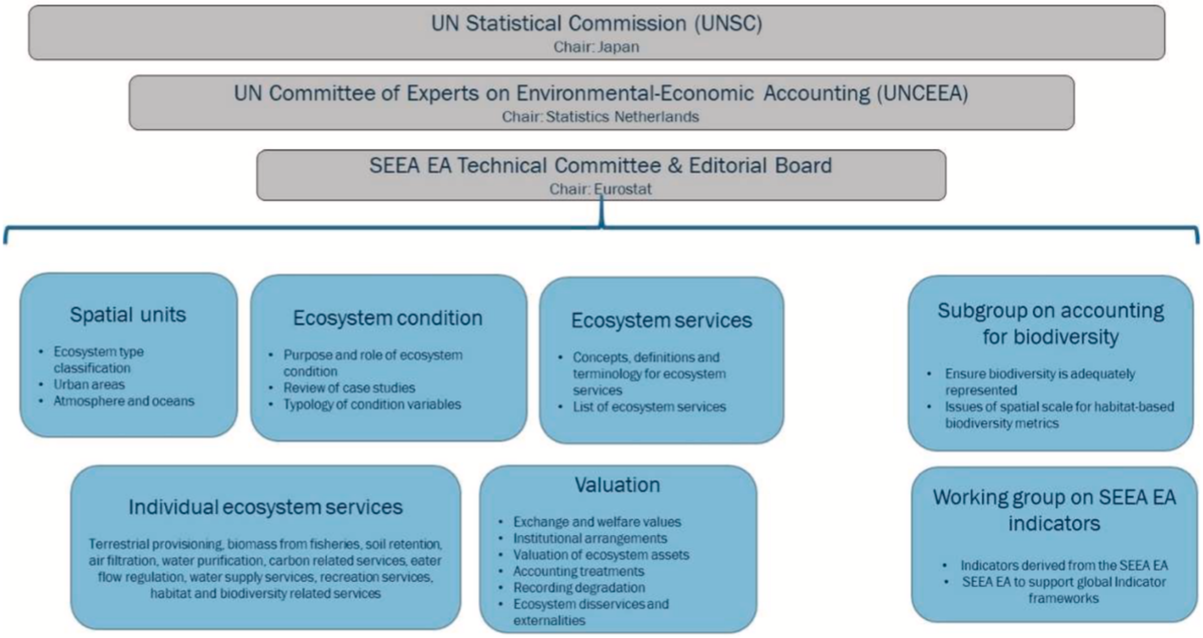
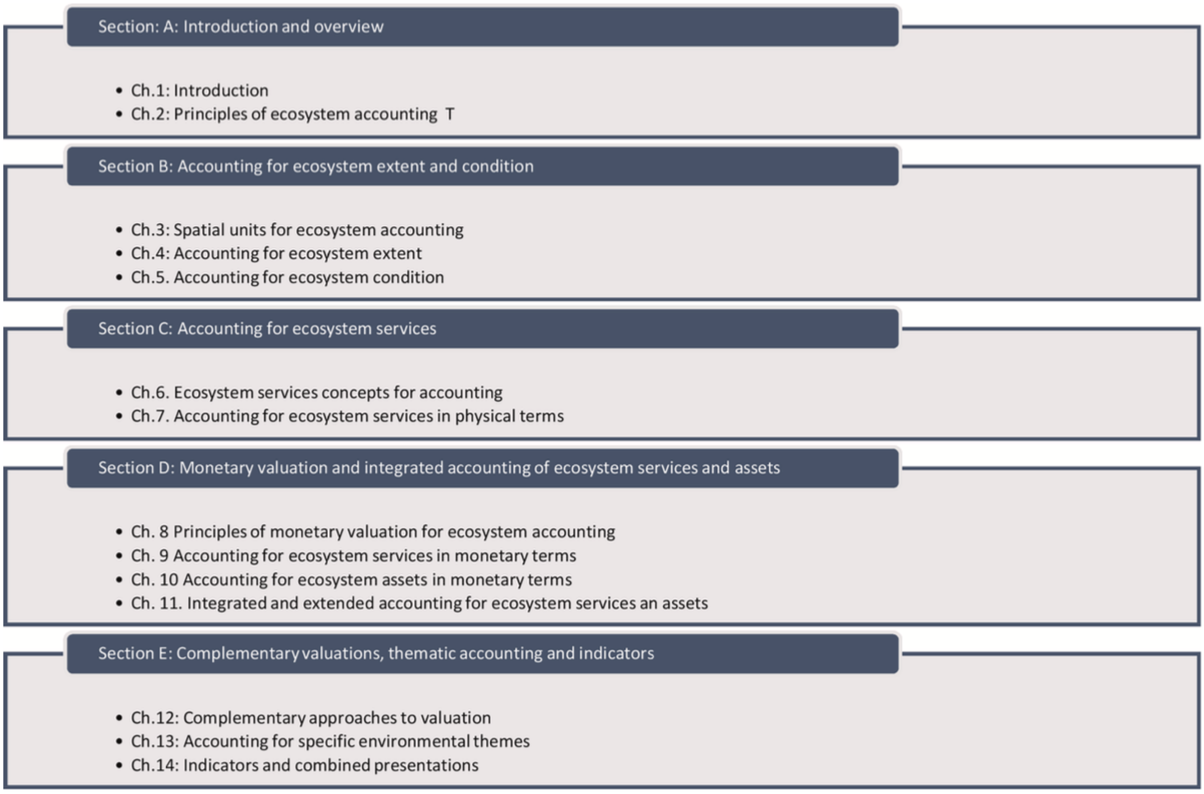
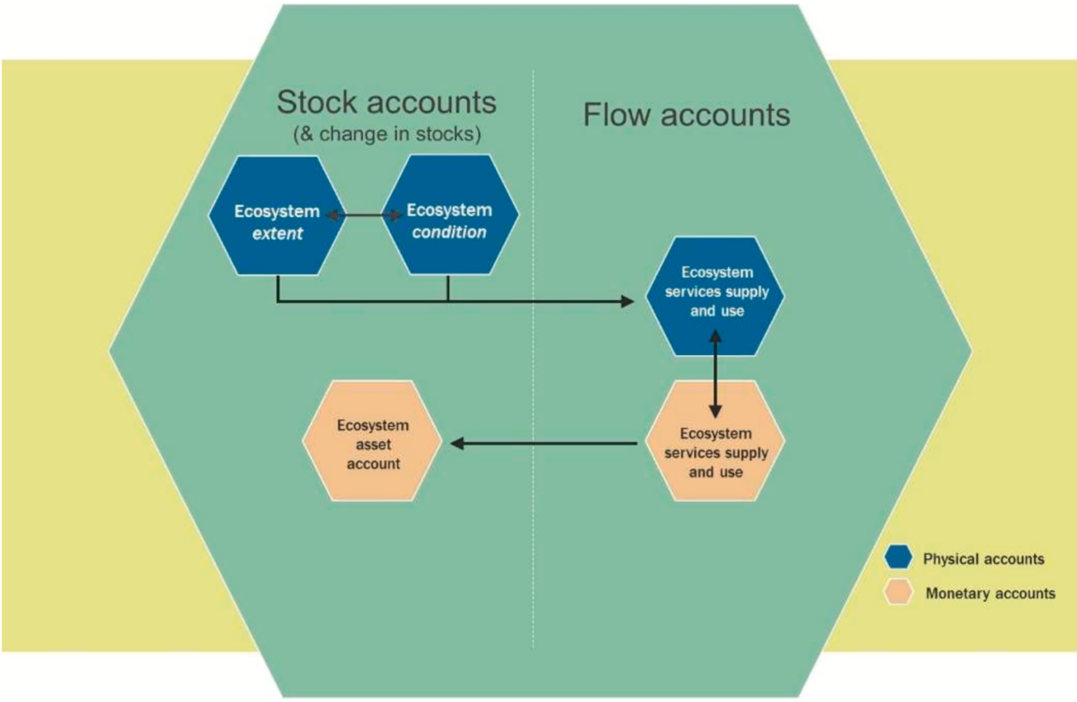


Fig. 2. Governance structure of the SEEA EA revision process (2018–2021).



2.2 – SEEA EA Accounts structure Source: Edens et al., 2022 (page 3)



3.

3 – Ecosystem Services Table; Source: SEEA EA Handbook (131-34)

ECOSYSTEM SERVICE		DESCRIPTION
Provisioning services		
Biomass provisioning services	Crop provisioning services*	Crop provisioning services are the ecosystem contributions to the growth of cultivated plants that are harvested by economic units for various uses including food and fibre production, fodder and energy. This is a final ecosystem service.
	Grazed biomass provisioning services*	Grazed biomass provisioning services are the ecosystem contributions to the growth of grazed biomass that is an input to the growth of cultivated livestock. This service excludes the ecosystem contributions to the growth of crops used to produce fodder for livestock (e.g., hay, soybean meal). These contributions are included under crop provisioning services. This is a final ecosystem service but may be intermediate to livestock provisioning services.
	Livestock provisioning services*	Livestock provisioning services are the ecosystem contributions to the growth of cultivated livestock and livestock products (e.g., meat, milk, eggs, wool, leather), that are used by economic units for various uses, primarily food production. This is a final ecosystem service. No distinct livestock provisioning services to be recorded if grazed biomass provisioning services are recorded as a final ecosystem service.
	Aquaculture provisioning services	Aquaculture provisioning services are the ecosystem contributions to the growth of animals and plants (e.g., fish, shellfish, seaweed) in aquaculture facilities that are harvested by economic units for various uses. This is a final ecosystem service.
	Wood provisioning services	Wood provisioning services are the ecosystem contributions to the growth of trees and other woody biomass in both cultivated (plantation) and uncultivated production contexts that are harvested by economic units for various uses including timber production and energy. This service excludes contributions to non-wood forest products. This is a final ecosystem service.
	Wild fish and other natural aquatic biomass provisioning services	Wild fish and other natural aquatic biomass provisioning services are the ecosystem contributions to the growth of fish and other aquatic biomass that are captured in uncultivated production contexts by economic units for various uses, primarily food production. This is a final ecosystem service
	Wild animals, plants and other biomass provisioning services	Wild animals, plants and other biomass provisioning services are the ecosystem contributions to the growth of wild animals, plants and other biomass that are captured and harvested in uncultivated production contexts by economic units for various uses. The scope includes non-wood forest products (NWFP)[69] and services related to hunting, trapping and bio-prospecting activities; but excludes wild fish and other natural aquatic biomass (included in previous class). This is a final ecosystem service
Genetic material services		Genetic material services are the ecosystem contributions from all biota (including seed, spore or gamete production) that are used by economic units, for example (i) to develop new animal and plant breeds; (ii) in gene synthesis; or (iii) in product development directly using genetic material. This is most commonly recorded as an intermediate service to biomass provisioning.
Water supply*		Water supply services reflect the combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses including household consumption. This is a final ecosystem service.
Other provisioning services		

Regulating and maintenance services		
Global climate regulation services		Global climate regulation services are the ecosystem contributions to reducing concentrations of GHG in the atmosphere through the removal (sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems. These services support the regulation of the chemical composition of the atmosphere and oceans. This is a final ecosystem service.
Rainfall pattern regulation services (at sub-continental scale)		Rainfall pattern regulation services are the ecosystem contributions of vegetation, in particular forests, in maintaining rainfall patterns through evapotranspiration at the sub-continental scale. Forests and other vegetation recycle moisture back to the atmosphere where it is available for the generation of rainfall. Rainfall in interior parts of continents fully depends upon this recycling. This may be a final or intermediate service.
Local (micro and meso) climate regulation services		Local climate regulation services are the ecosystem contributions to the regulation of ambient atmospheric conditions (including micro and mesoscale climates) through the presence of vegetation that improves the living conditions for people and supports economic production. Examples include the evaporative cooling provided by urban trees ('green space'), the role of urban water bodies ('blue space') and the contribution of trees in providing shade for humans and livestock. This may be a final or intermediate service.
Air filtration services		Air filtration services are the ecosystem contributions to the filtering of air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components, particularly plants, that mitigates the harmful effects of the pollutants. This is most commonly a final ecosystem service.
Soil quality regulation services		Soil quality regulation services are the ecosystem contributions to the decomposition of organic and inorganic materials and to the fertility and characteristics of soils, e.g., for input to biomass production. This is most commonly recorded as an intermediate service.
Soil and sediment retention services	Soil erosion control services	Soil erosion control services are the ecosystem contributions, particularly the stabilising effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). This is may be recorded as a final or intermediate service.
	Landslide mitigation services	Landslide mitigation services are the ecosystem contributions, particularly the stabilising effects of vegetation, that mitigates or prevents potential damage to human health and safety and damaging effects to buildings and infrastructure that arise from the mass movement (wasting) of soil, rock and snow. This is a final ecosystem service.
Solid waste remediation services		Solid waste remediation services are the ecosystem contributions to the transformation of organic or inorganic substances, through the action of micro-organisms, algae, plants and animals that mitigates their harmful effects. This is may be recorded as a final or intermediate service.
Water purification services (water quality regulation)	Retention and breakdown of nutrients	Water purification services are the ecosystem contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants by ecosystem components that mitigate the harmful effects of the pollutants on human use or health. This may be recorded as a final or intermediate ecosystem service.
	Retention and breakdown of other pollutants	
Water flow regulation services	Baseline flow maintenance services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and gradually release water during dry seasons or periods through evapotranspiration and hence secure a regular flow of water. This may be recorded as a final or intermediate ecosystem service.
	Peak flow mitigation services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and

		hence mitigate the effects of flood and other extreme water-related events. Peak flow mitigation services will be supplied together with river flood mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Flood control services	Coastal protection services	Coastal protection services are the ecosystem contributions of linear elements in the seascape, for instance coral reefs, sand banks, dunes or mangrove ecosystems along the shore, in protecting the shore and thus mitigating the impacts of tidal surges or storms on local communities. This is a final ecosystem service.
	River flood mitigation services	River flood mitigation services are the ecosystem contributions of riparian vegetation which provides structure and a physical barrier to high water levels and thus mitigates the impacts of floods on local communities. River flood mitigation services will be supplied together with peak flow mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Storm mitigation services		Storm mitigation services are the ecosystem contributions of vegetation including linear elements, in mitigating the impacts of wind, sand and other storms (other than water related events) on local communities. This is a final ecosystem service.
Noise attenuation services		Noise attenuation services are the ecosystem contributions to the reduction in the impact of noise on people that mitigates its harmful or stressful effects. This is most commonly a final ecosystem service.
Pollination services		Pollination services are the ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. This may be recorded as a final or intermediate service.
Biological control services	Pest control services	Biological control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of pests on biomass production processes or other economic and human activity. This is may be recorded as a final or intermediate service.
	Disease control services	Disease control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of species on human health. This is most commonly a final ecosystem service.
Nursery population and habitat maintenance services		Nursery population and habitat maintenance services are the ecosystem contributions necessary for sustaining populations of species that economic units ultimately use or enjoy either through the maintenance of habitats (e.g., for nurseries or migration) or the protection of natural gene pools. This service is an intermediate service and may input to a number of different final ecosystem services including biomass provision and recreation-related services.
Other regulating and maintenance services		
Cultural services		
Recreation-related services		Recreation-related services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. This includes services to both locals and non-locals (i.e., visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service.
Visual amenity services*		Visual amenity services are the ecosystem contributions to local living conditions, in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, including recreation-

		related services and noise attenuation services to underpin amenity values. This is a final ecosystem service.
Education, scientific and research services		Education, scientific and research services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use the environment through intellectual interactions with the environment. This is a final ecosystem service.
Spiritual, artistic and symbolic services		Spiritual artistic and symbolic services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that are recognised by people for their cultural, historical, aesthetic, sacred or religious significance. These services may underpin people's cultural identity and may inspire people to express themselves through various artistic media. This is a final ecosystem service.
Other cultural services		
Flows related to non-use values		
Ecosystem and species appreciation		Ecosystem and species appreciation concerns the wellbeing that people derive from the existence and preservation of the environment for current and future generations, irrespective of any direct or indirect use.

4.

4 – Qualitative descriptors for determining GES; Source: MSF, 2008 (Annex I)

L 164/34 EN Official Journal of the European Union 25.6.2008

ANNEX I

Qualitative descriptors for determining good environmental status

(referred to in Articles 3(5), 9(1), 9(3) and 24)

(1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

(2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.

(3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

(4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

(5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

(6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

(7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

(8) Concentrations of contaminants are at levels not giving rise to pollution effects.

(9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

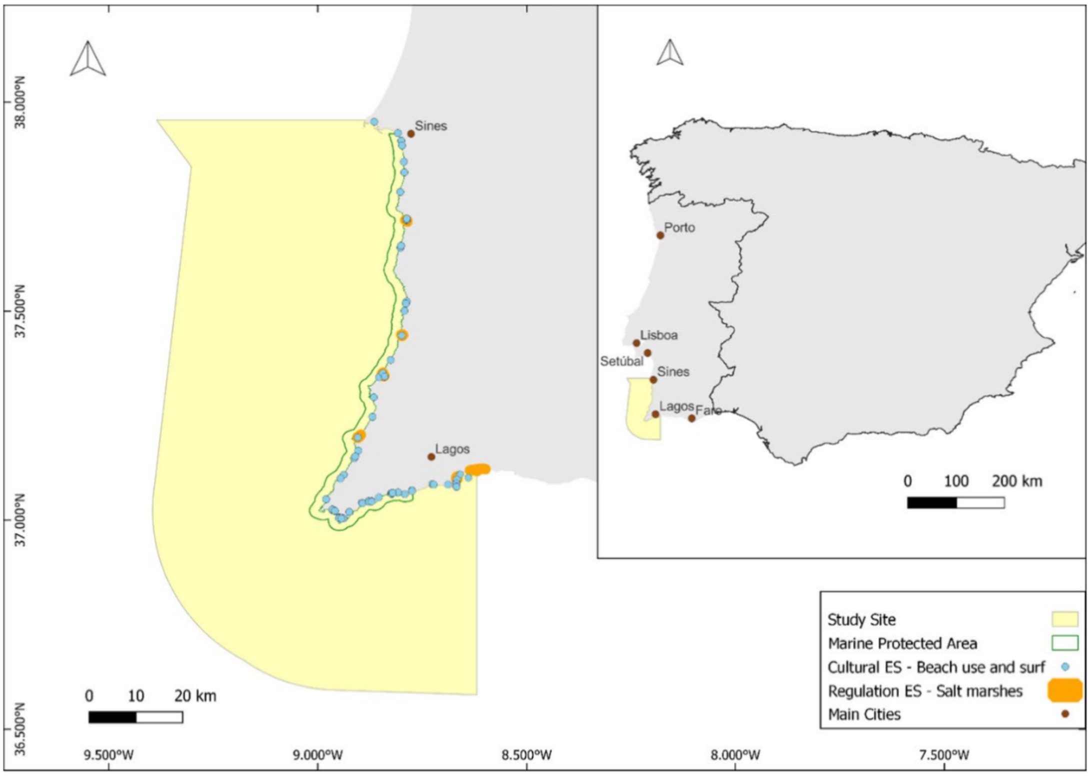
(10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

(11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

To determine the characteristics of good environmental status in a marine region or subregion as provided for in Article 9(1), Member States shall consider each of the qualitative descriptors listed in this Annex in order to identify those descriptors which are to be used to determine good environmental status for that marine region or subregion. When a Member State considers that it is not appropriate to use one or more of those descriptors, it shall provide the Commission with a justification in the framework of the notification made pursuant to Article 9(2).

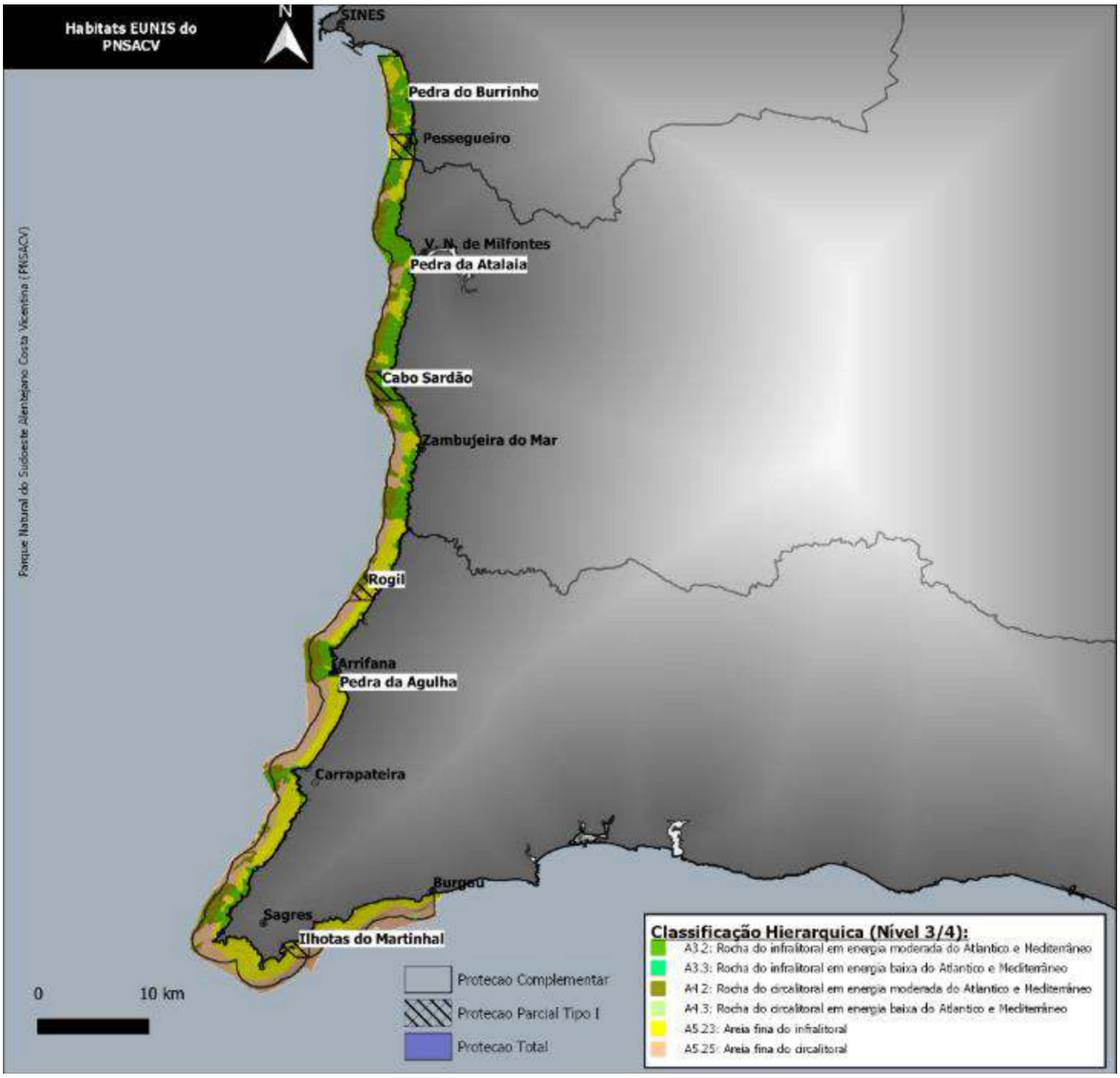
5.

5 – Study site (in yellow); Source: Cunha-e-Sá et al. 2024, page 5



6.

6.1– Reefs and Mobile Sands Map on SAVC; Source: MARSW Report 2021 (page 206)



6.2 – Location of Estuaries under analysis; Source: made by the author.

6.2.1 – Salt Marshes and Seagrass Beds Map, Mira Estuary; Source: Blue Carbon Report (Gulbenkian Foudation, 2023 – page 84)

6.2.2 – Salt Marshes and Seagrass Beds Map, Alvor Estuary; Source: Blue Carbon Report (Gulbenkian Foudation, 2023 – page 95)

6.2.3 – Salt Marshes and Seagrass Beds Map, Arade Estuary; Source: Blue Carbon Report (Gulbenkian Foudation, 2023 – page 107)

7.

7 – Ecosystem Services and Sources; Source: made by the author.

ECOSYSTEM SERVICE SECTION	ECOSYSTEM TYPE EUNIS	ECOSYSTEM SERVICE GROUP (SEEA-EA)	RELEVANCE TO ECOSYSTEM ACCOUNTS	VALUATION METHOD	DATA SOURCE
Provisioning	All (A3.2; A3.3; A4.2; A4.3; A5.23; A5.25:A2.61; A2.5)	Wild fish and other natural aquatic biomass provisioning services	Fish and other aquatic products including from comercial fisheries	--	MARSW Report (2020) DGRM (2024)
Regulation & maintenance	A2.61 and A2.5	Global climate regulation services GHG (Carbon sequestration and capture)	Measuring the carbon sequestered and stored by ecosystems (seagrass beds and saltmarshes)	EU ETS Carbon pricing 2023	Blue Carbon Report (Gulbenkian Foundation, 2023)
Cultural	All (A3.2; A3.3; A4.2; A4.3; A5.23; A5.25:A2.61; A2.5)	Recreation-related services (Recreational fishing)	Measuring the cultural value of recreational fisheries provided by ecosystems	Travel costs	Erzini et al., 2008
Flows related to use & non-use values*		Ecosystem and species appreciation	Measuring how much people value the maintenance or protection of ecosystems (use and non-use)	Willingness to Pay	M. A. Cunha-e-Sá et al. (2024)

8.

8 – Economy activity group description; Source: OSA, INE 2016 and 2020 (page 23)

Groups:

1 - **Fisheries and aquaculture, processing and wholesale and retail of its products** - includes activities related to the value chain of fishery and aquaculture products. The core activities include Fisheries and Aquaculture, with connections upstream to the food industries for animals, namely for aquaculture, and downstream with the transformation industry, such as processing and preserving of fish, crustaceans and mollusks. It also includes the production of ice, cold storage and trade, wholesale and retail trade, of fishery and aquaculture products.

2 - **Non-living marine resources** - includes activities related to the research and exploitation of conventional energy resources (oil and gas), to the research and exploitation of marine minerals and the extraction and refining of salt and production of condiments derived from it. It also includes the desalination of sea water.

3 - **Ports, transports and logistics** - includes activities related to the water transportation value chain, whose main activity is the shipping of goods and passengers. Downstream includes port services and rental of maritime and inland waterway transports and the river transport of goods and passengers.

4 - **Recreation, sports, culture and tourism** - includes the maritime activity of recreation and sport, the maritime dimension of culture and maritime and coastal tourism, including maritime touristic activities operating in water. This group includes the activities related to boating, which are considered recreational boating and nautical sports. Coastal tourism includes housing, imputed rents of second homes, real state promotion of tourist accommodation, restaurants, travel agencies and associated recreational activities and leisure, including the related cultural activities, like the activities considered in the Tourism Satellite Account (but only the ones taking place in coastal areas).

5 - **Shipbuilding, maintenance and repair** - comprises construction activities of ships and floating platforms, including pleasure and sport boats, as well as the repair and maintenance activities of boats and the dismantling of end-of-life vessels.

6 - **Maritime equipment** - comprises diverse manufacturing activities such as, for example, the ones allowing equipping a vessel or a floating platform. It is a heterogeneous group, dedicated primarily to building and repair of relevant equipment for the other activities of the ocean economy. It was decided, therefore, to bring together in one group all the activities identified in the manufacturing industry with the production / repair of marine equipment of support for most of the activities of the other groups.

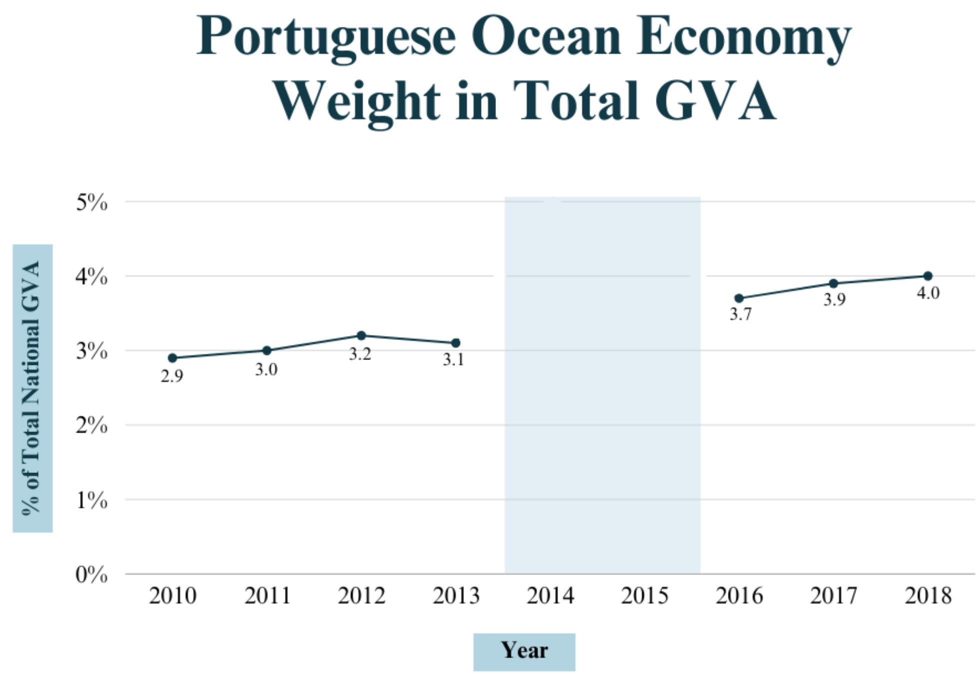
7 - **Infrastructure and maritime works** - includes activities related to construction works and expansion of port terminals in order to develop maritime and land accessibility conditions, namely land corridors for the transport of goods by rail (associated with shipping, by connecting the rail to the main interchanges of intermodal transport). It also includes the construction and repair of ports, marinas, as well as dredging, protection and coastal defense, etc.

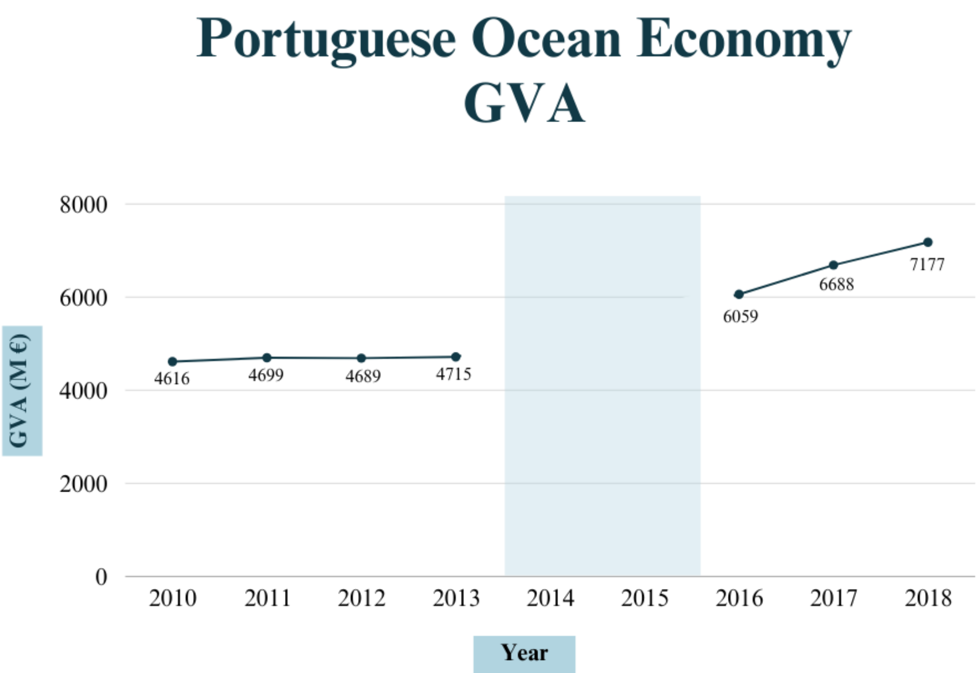
8 - **Maritime services** - includes, as the name indicates, the service activities related to the ocean. Includes education, training and R&D in areas related to the ocean, governance activities, such as defense and maritime security and maritime spatial planning, and a large subgroup of other service activities encompassing maritime information and communication services, consulting and business services in the ocean areas, maritime finance and insurance, trade and distribution activities related to the ocean and others.

9 - **New uses and resources of the ocean** - this group was established in order to quantify a set of emerging activities, yet with little economic importance, which would, otherwise, be "diluted" in other activities. The relevance of this isolated group was evaluated during the work. Includes the marine biotechnology; marine renewable energies; gases storage; research and exploitation of unconventional energy resources (gas hydrates) and the services of earth observation.

9.

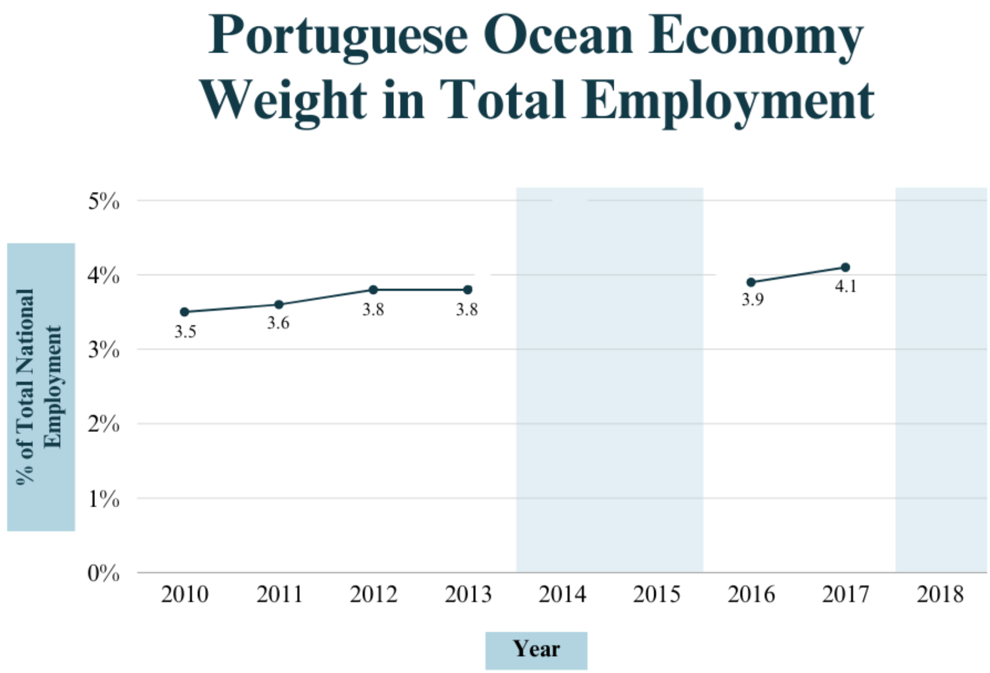
9 – Source: made by the author based on OSA data (INE)

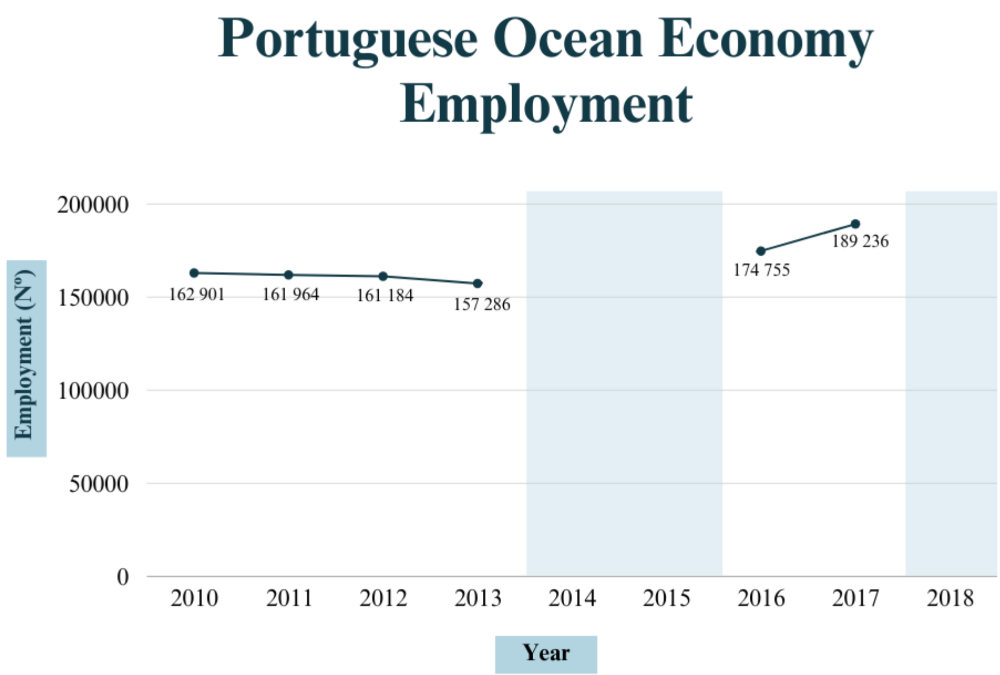




10.

10 – Source: made by the author based on OSA data (INE)





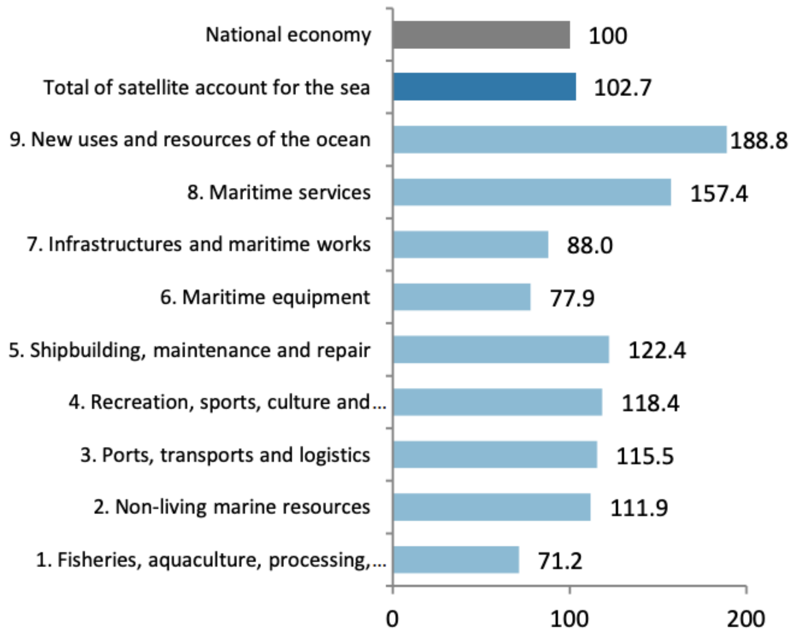
11.

11 – Source: made by the author based on OSA data (INE)

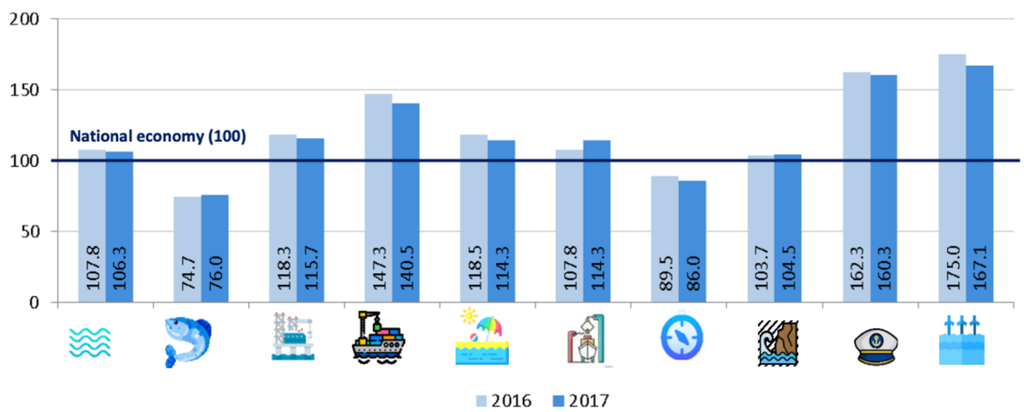
Classification by Group	Units of Economic Activity			GVA			Employment			GVA/Employment			Average Wage		
	Nº			10^6 euros			FTE			10^3 euros			10^3 euros		
	2010-2013	2016-2018	change rate %	2010-2013	2016-2018	change rate %	2010-2013	2016-2017	change rate %	2010-2013	2016-2017	change rate %	2010-2013	2016-2017	change rate %
1. Fisheries, aquaculture, processing, wholesale and retail of its products	10 296	8 531	-17,1%	1 203	1 667	38,6%	62 414	61 595	-1,3%	19,3	27,1	40,4%	15,2	16,1	6,3%
2. Non-living marine resources	83	115	38,6%	49	57	16,3%	2 333	1635	-29,9%	21,0	34,9	66,0%	23,6	25,0	6,2%
3. Ports, transports and logistics	1 092	1052	-3,7%	676	707	4,6%	15 086	12 307	-18,4%	44,8	57,4	28,2%	24,3	30,8	26,5%
4. Recreation, sports, culture and tourism	43 370	39 487	-9,0%	1 660	2 860	72,3%	45 950	72 147	57,0%	36,1	39,6	9,7%	25,0	24,9	-0,2%
5. Shipbuilding	373	411	10,2%	119	156	31,1%	4 404	4 869	10,6%	27,0	32,0	18,6%	25,8	23,8	-7,9%
6. Maritime equipment	495	422	-14,7%	159	206	29,6%	9 028	6 636	-26,5%	17,6	31,0	76,3%	16,4	18,8	14,4%
7. Infrastructures and maritime works	772	738	-4,4%	65	270	315,4%	2 850	6 203	117,6%	22,8	43,5	90,9%	18,5	22,3	20,1%
8. Maritime services	2 235	1 755	-21,5%	741	711	-4,0%	18 615	16 265	-12,6%	39,8	43,7	9,8%	33,2	34,5	4,1%
9. New uses and resources of the ocean	22	81	268,2%	7	8	14,3%	88	340	286,4%	79,5	23,5	-70,4%	39,8	36,6	-8,0%
Total of Ocean Satellite Sccount (OSA)	58 738	52 592	-10,5%	4 679	6 642	42,0%	160 768	181 996	13,2%	29,1	35	20,3%	21,6	22,9	5,6%
National Account (NA)				152 425	169 700	11,3%	4 409 186	4 503 007	2,1%	34,6	36,8	6,4%	21,1	21,4	1,5%
OSA/NA (%)				3,1%	3,9%		3,6%	4,0%		94%	95%		102,7%	106,8%	

12.

12.1 - Average wage per employee, by group of economic activity; Source: OSA 2010-13 (INE)



12.2 – Average wage per employee, by group of economic activity; Source: OSA 2016-18 (INE)



13.

13– Ecosystem Extent; Source: made by the author

ECOSYSTEM TYPE	EUNIS CLASSIFICATION	EXTENT (Square Km)
REEFS	A3.2	65.1
	A3.3	1.5
	A4.2	35.9
	A4.3	1.0
TOTAL		103.4
MOBILE SEDIMENT (SAND)	A5.23	124.3
	A5.25	61.9
TOTAL		186.2
SEAGRASS BEDS	A2.61	0.18
SALT MARSHES	A2.5	3.15
	TOTAL	292.93

14.

14 – Ecosystem Services Use and Supply Table; Source: made by the author

					ACCOUNTING YEAR			
VALUE	ECOSYSTEM TYPE EUNIS	ECOSYSTEM SERVICE GROUP (SEEA-EA)	BENEFICIARIES	UNIT	2007-13 Year Average	2020 (5 year project)	2022	2023
Physical	All (A3.2; A3.3; A4.2; A4.3; A5.23; A5.25:A2.61; A2.5)	Wild fish and other natural aquatic biomass provisioning services	Industry (Fisheries, agriculture and forestry)	tonnes	--	--	8,134.5	8,720.9
	A2.61 and A2.5	Global climate regulation services GHG (Carbon sequestration and capture)	Government	tonnes	--	--	--	101.4
	All (A3.2; A3.3; A4.2; A4.3; A5.23; A5.25:A2.61; A2.5)	Recreation-related services (Recreational fishing)	Households	nº of licenses	90,297	--	--	--
Monetary	A2.61 and A2.5	Global climate regulation services GHG (Carbon sequestration and capture)	Government	ETS market price € (2023)	--	--	--	31,110.90
	All (A3.2; A3.3; A4.2; A4.3; A5.23; A5.25:A2.61; A2.5)	Recreation-related services (Recreational fishing)	Households	€(2008)	129,770,334	--	--	--
		Ecosystem and species appreciation	Government	€(2020)	--	350,660,000	--	--

15.

Total value of Carbon Sequestration annual rate

<u>**DATA**</u>

Annual Carbon Sequestration: 101.4 t(C)/year
Conversion factor: 1 t(C) = 3.67 t(CO2)
ETS market price of t (CO2) (2023): 83.60 EUR2023

Formula

Economic Value = (Annual Carbon Sequestration) x (Conversion Factor) x (ETS Market Price of t(CO2))

Carbon Sequestered to CO2 Equivalent

CO2 Equivalent = 101.4 t(C) x 3.67 t (CO2/t(C)) = 372.14 t(CO2)

Economic Value

Economic Value = 372.14 t(CO2) x 83.60 EUR2023 / t(CO2) = 31,110.90 EUR2023

The economic value of the ecosystem services related to carbon sequestration annual rate (Mira Estuary + Alvor Estuary + Arade Estuary) is

Final Result - 31,110.90 EUR 2023

16.

Total use value of Recreational Fishing (monetary)

DATA

Nº of Recreational fishing licenses: Alentejo (9,601) + Algarve (23 747) + National licenses (56 949) = 90,297

Cost per Travel: 22.11 EUR2008

Average fishing days (year): 65 days

Formula

Total Use Value = (Number of Licenses) x (Travel Cost per Day) x (Average Days per Year)

Total Use Value

Total Use Value = 90,297 x 22.11 EUR2008 x 65 = 129,770,334 EUR2008

The use value of recreational fishing in SAVC is

Final Result - 129,770,334 EUR2008

Converting the Final Result to EUR 2023 (updated value)

Consumer Price Index (CPI): 93.354 (2008) and 118.271 (2023)

Accumulated Inflation Rate

Formula

$$\text{Inflation Rate} = \frac{\text{CPI 2023}}{\text{CPI 2008}} - 1$$

Values

$$\text{Inflation Rate} = \frac{118.271}{93.354} - 1 = 0.2669 \text{ (or 26.69\%)}$$

Adjusting EUR 2008 to 2023

Formula

Value 2023 EUR = Value 2008 EUR x (1+ Inflation Rate)

Values

Value 2023 EUR = 129,770,334 x (1+ 0.2669) = **164 406 036 EUR2023**

17.

17 – Ecosystem Asset Account; Source: made by the author

ECOSYSTEM TYPE (EUNIS)	LOCATION	EXTENT (year) (Square Km)	CARBON SEQUESTRATION (Annual t C)	ORGANIC CARBON Total Stock (t OC)
SEAGRASS BED (A2.61)	MIRA ESTUARY	0.15 (2019)	8.3	1,333
	ALVOR ESTUARY	0.03 (2012)	1.4	233
	ARADE ESTUARY	<0.01 (2010)	<0.1	0.36
TOTAL A2.61		0.18	**9.7**	**1,566.36**
SALT MARSHES (A2.5)	MIRA ESTUARY	1.25 (2019)	36.3	6,402
	ALVOR ESTUARY	0.72 (2010)	21	4,243
	ARADE ESTUARY	1.18 (2010)	34.4	6,953
TOTAL A2.5		3.15	**91.7**	**17,598**

ECOSYSTEM TYPE (EUNIS)	EXTENT (Square Km)	CARBON SEQUESTRATION (Annual t C)	ECOSYSTEM ASSET ACCOUNT (NPV, €2023)	SOURCE
SEAGRASS BED (A2.61)	**0.18**	**9.7**	**100,466.41**	**OSPAR Region Ecosystem Accounts - Suppl. material 2 Maria G. A. Blazquez (2023)**
SALT MARSHES (A2.5)	**3.15**	**91.7**	**950,014.02**	
TOTAL	**3.33**	**101.4**	**1,050,480.43**	

18.

Ecosystem Asset Value (Carbon Sequestration)

Seagrass Beds (A2.61)

Note:
The discount rate presented is in accordance with *Intergenerational wealth transfers and social discounting: Supplementary Green Book guidance* (Joseph Lowe, 2008) from the HM Treasury, UK. This document, used by Blazquez et al., 2023, for the OSPAR case, sets a declining discount rate to account for long-term uncertainties, ensuring fairness to future generations, and reflecting ethical and economic considerations, especially for irreversible impacts like climate change.

DATA

Annual rate of carbon sequestration: 9.7 t (C)
Conversion factor: 1t (C) = 3.67t (CO2)
ETS market price of t (CO2) (2023): 83.60 EUR2023

Discount rate segments (Joseph Lowe et al.,2023):
3.5% for years 1-30
3.0% for years 31-75
2.5% for years 76-100

Carbon Sequestered to CO2 Equivalent

9.7 t(C) x 3.67 t(CO2/t(C)) = 35,599 t(CO2)

Annual Economic Value

35,599 t(CO2) x 83.60 EUR2023/t(CO2) = 2,973.06 EUR2023/year

Segment 1: years 1-30 (3.5% discount rate)

Formula

$$NPV_1 = d \times \frac{1-(1+r)^{-30}}{r}$$

Values

$$NPV_1 = 2,973.06 \times \frac{1-(1+0.035)^{-30}}{0.035}$$

$$NPV_1 = 2,973.06 \times 20.2094 = 60,103.91$$

Segment 2: years 31-75 (3.0% discount rate)

Formula

$$NPV_2 = d \times \frac{1-(1+r)^{-45}}{r} \times (1+r)^{-30}$$

Values

$$NPV_2 = 2,973.06 \times \frac{1-(1+0.03)^{-45}}{0.03} \times (1+0.035)^{-30}$$

$$NPV_2 = 2,973.06 \times 24.9638 \times 0.4120 = 30,525.77$$

Segment 3: years 76-100 (2.5% discount rate)

Formula

$$NPV_3 = d \times \frac{1-(1+r)^{-25}}{r} \times (1+r_2)^{-45} \times (1+r_1)^{-30}$$

Values

$$NPV_3 = 2,973.06 \times \frac{1-(1+0.025)^{-25}}{0.025} \times (1+0.03)^{-45} \times (1+0.035)^{-30}$$

$$NPV_3 = 2,973.06 \times 19.7915 \times 0.4109 \times 0.4120 = 9,836.73$$

Total NVP for Seagrass Beds

$$NPV = NPV_1 + NPV_2 + NPV_3$$

$$NPV = 60,103.91 + 30,525.77 + 9,836.73 = 100,466.41$$

Final Result - 100,466.41 EUR2023

Salt Marshes (A2.5)

Annual rate of carbon sequestration: 91.7 t (C)

Carbon Sequestered to CO2 Equivalent

91.7 t(C) x 3.67 t(CO2/t(C)) = 336,539 t(CO2)

Annual Economic Value

336,539 t(CO2) x 83.60 EUR2023/t(CO2) = 28,117.01 EUR2023/year

Segment 1: years 1-30 (3.5% discount rate)

Formula

$$NPV_1 = d \times \frac{1-(1+r)^{-30}}{r}$$

Values

$$NPV_1 = 28,117.01 \times \frac{1-(1+0.035)^{-30}}{0.035}$$

$$NPV_1 = 28,117.01 \times 20.2094 = 568,171.16$$

Segment 2: years 31-75 (3.0% discount rate)

Formula

$$NPV_2 = d \times \frac{1-(1+r)^{-45}}{r} \times (1+r)^{-30}$$

Values

$$NPV_2 = 28,117.01 \times \frac{1-(1+0.03)^{-45}}{0.03} \times (1+0.035)^{-30}$$

$$NPV_2 = 28,117.01 \times 24.9638 \times 0.4120 = 288,871.07$$

Segment 3: years 76-100 (2.5% discount rate)

Formula

$$NPV_3 = d \times \frac{1-(1+r)^{-25}}{r} \times (1+r_2)^{-45} \times (1+r_1)^{-30}$$

Values

$$NPV_3 = 28,117.01 \times \frac{1-(1+0.025)^{-25}}{0.025} \times (1+0.03)^{-45} \times (1+0.035)^{-30}$$

$$NPV_3 = 28,117.01 \times 19.7915 \times 0.4109 \times 0.4120 = 92,971.79$$

Total NVP for Saltmarhes

$$NPV = NPV_1 + NPV_2 + NPV_3$$

$$NPV = 568,171.16 + 288,871.07 + 92,971.79 = 950,014.02$$

Final Result - 950,014.02 EUR2023

Total NVP (Seagrass Beds and Salt Marshes)

Total NVP - Sum of Final Results

Total NVP = 100,466.41 + 950,014.02 = 1,050,480.43 EUR2023

Total NVP - 1,050,480.43 EUR2023