RWS INFORMATION

Natural capital accounting for the North-East Atlantic area

Preliminary results and first estimates

Colofon

Published by	Rijkswaterstaat Water Verkeer en Leefomgeving
Author	Maria Alarcon Blazquez
Information	Rob van der Veeren
Phone	
E-mail	rob.vander.veeren@rws.nl
Datum	15 August 2021
Version	Final
Status	

Acknowledgements

I would like to express my sincere gratitude to my supervisors, Rob van der Veeren and Xander Keijser, for providing their guidance, comments and suggestions throughout the course of the project. Also, I would like to thank Philip James for his assistance and expertise on this topic. Lastly, I want to thank Adrian Judd, who provided information, suggestions, and feedback on the report.

Finally, I want to communicate my deepest thanks to everyone who shared their time, advice, knowledge and experiences on this subject with me. This work would not have been possible without their help, and they contributed to the quality of the report.

Table of Contents

List of Tables

List of Figures

Executive summary

The contribution of marine ecosystems to human well-being is crucial, even though absolute numbers can vary or the analysis holds potential limitations. Numerous studies targeting marine ecosystem services (at regional, national, or local level) show that a significant proportion of the global economy's gross domestic product (GDP) entirely depends on the flow of goods and services delivered by marine ecosystems. For example, in the European Union (EU) they generate a turnover of EUR 750 billion in 2018.

The **global condition of marine ecosystems has rapidly deteriorated** over the past few decades, leading to a loss of about USD 10.9 trillion per year compared to 1997 values. There are many reasons for this global decline, including excessive exploitation of marine resources, pollutants, and plastics contamination, leading to the loss of coral ecosystems, reduction of seagrass extent and quality, and, more generally, benthic habitats. Environmental issues caused by human pressures are complex problems that are difficult to tackle. There are still many knowledge gaps that need to be filled, and new tools and methodologies are required to respond to these matters.

The steady **decline in the provision of services** by the marine environment has been attributed to the deterioration in the state of ecosystems as a result of the loss or depletion of marine natural capital.

Apparently**, the current management tools and indicators (e.g., GDP) are not enough** to stop the degradation of the marine environment. Therefore, there is a clear and emerging need to seek new forms or tools of marine management.

In March 2021, the new economic and environmental framework, the System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA), was adopted by the UN Statistical Commission. It marks a major step forward beyond the commonly used statistic of GDP. This framework ensures that natural capital is recognised in economic reporting as ecosystems deliver essential services that generate great benefits for people. NCA and ecosystem accounting are on the global and European agenda. It is in this context that OSPAR wants to *'start accounting for ecosystem services and natural capital by making maximum use of existing frameworks in order to recognise, assess and consistently account for human activities and their consequences in the implementation of ecosystem-based management.'* (Strategic objective 7.03 in the new North-East Atlantic Environmental Strategy).

The **marine ecosystems contribute considerably to the countries' economies** that surround **the North-East Atlantic** by providing a large variety of ecosystem goods and services. Therefore, the **conservation, protection, and sustainable management of marine ecosystems' biodiversity, resources, and environmental quality are of great importance**. Furthermore, the ocean does not follow national boundaries. Consequently, ecosystem degradation issues are internationally relevant and can only be dealt with through joint actions, for which joint assessment of marine ecosystems is needed. These facts stress the need and importance of sustainable marine environment management and why OSPAR would like to study whether ecosystem goods and services are used sustainably.

Moreover, given the OSPAR main objectives (environmental management of the marine environment), NCA could be very relevant to support OSPAR decision making. It is an appropriate integrated analysis tool that allows for ecosystem-based management, and it enhances the understanding of the ocean's contribution to society and how human activities impact the marine environment.

NCA can contribute to achieving some of the OSPAR North-East Atlantic Environment Strategy 2030 Strategic objectives. The report is an initial contribution to the Operational objective 7.03. This objective commits OSPAR to start accounting for ecosystem services and natural capital by making maximum use of existing frameworks to recognise, assess, and consistently account for human activities and their consequences in implementing ecosystem-based management.

The **accounts included** in NCA are:

1. **Extent** account – ecosystem type size or extent
2. **Condition** account – state of the ecosystem
3. **Physical supply and use** accounts - flows from that asset in the form of ecosystem services in physical terms
4. **Monetary supply and use** accounts - flows from that asset in the form of ecosystem services in monetary terms
5. **Monetary asset** account - the stock and change in the stock of each ecosystem asset

It is important to **differentiate between marine ecosystem accounts and ocean accounts.** Ocean accounting is a new method that uses international statistical standards to regularly integrate economic activities, social conditions, and environmental characteristics related to the ocean and the use of ocean resources. The ocean account framework is a complex system framework, which includes economic, social, and environmental components. These components allow the identification of stocks within systems and flows between them. Ocean accounts involve economic (e.g., SNA), environmental-economic (e.g., SEEA EA), and social (e.g., Social Accounting Matrix (SAMs)) accounting.

On the other hand, marine natural capital accounts (environmental-economic) record the marine stocks of natural assets. Natural capital includes different contributions from the environments, deriving a wide range of services – ecosystem services, abiotic flows, spatial functions- which make human life possible. In this way, Marine Ecosystem Accounts form part of the ocean accounts and contribute to the measure of a Blue Economy.

There are **initiatives supporting countries' implementation of the SEEA EA from global to regional level.** At the global level, it is worth noting the EU-funded Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) partnership lead by the World Bank, as well as its Global Programme on Sustainability. It is important to remark the work of the Global Ocean Accounts Partnership (GOAP) as the greatest promoter of the ocean accounts globally. At the European level, the EU has led the Knowledge Innovation Project on an Integrated system of Natural Capital and Ecosystem Services Accounting for the European Union (KIPINCA), and more recently, the Mapping & Assessment for Integrated ecosystem Accounting (MAIA).

In the report, information about the state of the accounts within OSPAR contracting parties is collected. It can be observed that the central development is in terms of the terrestrial environment; however, there is an increasing interest and more initiatives regarding the marine environment in the last years. The Netherlands and the UK can be seen as the **leading countries** in terms of marine natural capital accounting. However, it is noted that almost all OSPAR contracting countries are involved to a certain extent in natural capital or ecosystem accounting. The **main policy relevance** points among the countries include monitoring the natural resources and the Sustainable Development Goals (SDGs), inform decision-making, and link economic activities and environmental pressures or impacts. Finally, **major knowledge gaps and difficulties** encountered are a lack of data, resources, and standardization, but this report demonstrates that these should not be seen as a barrier to development. Despite the current data does not fit perfectly to populate the SEEA EA framework, **with the current information, all accounts have been completed** at least in an estimated way.

When recorded regularly, the information detailed in natural capital accounts can support a broad range of decision-making processes concerning ocean management, such as:

- *Understanding the interdependency of the blue economy and the marine environment:* The development of the accounts provides information that can be used to support the formulation of strategies and goals for the sustainable progress of the “sea” or “blue” economy, hence, serving as a strategic development planning tool for decision making.
- *Communication and reporting:* The advantages of using NCA to support communication are the development of a common language and narrative in the greater scope and integrity of engagement in the natural capital community.
- *NCA as a tool to support operational and management decisions (e.g., Marine and Coastal Spatial Planning):* The details that NCA provides about how the condition, health, and integrity of ecosystems and biodiversity is changing over time, or where the main areas of degradation and enhancement are, can serve to guide and support Maritime Spatial Planning.
- *Finance and investment allocation:* NCA of financial flows and the associated changes in social, environmental, or economic conditions provides integrated and holistic information.
- *Regulatory decisions:* The accounts allow informed decision-making in the promulgation of regulatory instruments and granting of conditional permits and licenses for ocean economic activities.
- *Identify trade-offs:* Considering the comprehensive data generated by the accounts, they can provide a better picture of exchanges between different ecosystems services or stakeholders. The identification of additional synergies and trade-offs between ecosystem services inform future policy to ensure optimal outcomes to enhance biodiversity.
- *Monitor status of the marine environment and ocean analysis:* The steady development of the accounts enables to compare and conclude which is the state of the ecosystems, if they are managed sustainably or if they are being depleted.

It is critical to keep in mind that **the value of the ecosystem services is not an absolute value,** and it should not be used for these purposes. They intend to provide indicators to allow comparison over time. In the same manner, the asset value of a natural resource refers to the long-term potential of that resource to provide a service to humans; and gives information on stocks and changes (additions and reductions) of ecosystem assets (in much the same way as GDP is often used: the main focus is not so much on the absolute number, but in the trends over time). Hence, it includes accounting for ecosystem enhancement and degradation.

The different limits, uncertainties, and risks identified during the process underline that there is a **need for further standardisation and data challenges**, but increasing collaboration and harmonisation among countries will improve and facilitate NCA in the future. Although limitations and uncertainties were encountered during the process, the report sets a baseline for future accounts.

In the report, a few ecosystem services accounts were estimated. Some of the conclusions that can be derived from the initial estimation of the accounts are:

- Marine carbon sequestration in 2019 is estimated to be more than half of the value of fisheries in 2018. Carbon sequestration values are likely to be underestimated due to the conservative approach taken, the lower bound estimates, and the limits of extension data for key ecosystems providing this service. Therefore, this significant ecosystem service requires more research to understand it fully.
- The value of marine renewable energy had grown over 25 times from 2008 to 2019.
- Outdoor recreation in coastal and intertidal values increased from 238.53 mill EUR in 2000 to 253.13 mill EUR in 2012 in the OSPAR EU countries.
- The North-East Atlantic marine ecosystem assets for which the initial values are estimated have an asset value of 125.75 EUR billion, of which more than 40% comes from carbon sequestration and outdoor recreation (and these estimates are underestimated).

Finally, some actual and feasible next steps that OSPAR could take to continue developing and improving the marine natural capital accounts for the North-East Atlantic are the following:

1. **Analyse and identify what to do based on this report**. This report can be used as the focal point in terms of where we can progress now and continue the work that has been started. Some improvements are needed in all the accounts.

2. Find and set **priorities**. On the one hand, expand the list of ES to ensure that the coverage of the ecosystem account is as complete as possible and to have something closer to reality. On the other hand, not only decide what should be prioritized but also what should be the process of prioritization.

3. Set some kind of framework or **roadmap for NCA for OSPAR**. A binding and ambitious timetable to move to action is needed. Moving from concepts to implementation, throughout actions to achieve actual improvement of the marine environment.

4. Keep **sharing information and experiences**, and participate in partnerships such as GOAP. Build bridges and linkages with other international organizations working on NCA, such as the OECD or Eurostat. Efforts should be aligned within countries to coordinate and homogenise the process in order to be able to compare between countries.

As a final point, it is crucial to keep in mind and reflect on the initial state where OSPAR and many countries currently are, together with the pieces of evidence and data currently accessible: This report is the first attempt to collect the available data and put things together in a consistent and integrative accounting framework, in a way which is compatible with existing OSPAR workstreams and assessments of quality status.

Samenvatting

De bijdrage van mariene ecosystemen aan het menselijk welzijn is van cruciaal belang, ook al kunnen de absolute cijfers hierover uiteenlopen en kennen de relevante analyses mogelijk beperkingen. Talrijke studies die zich richten op mariene ecosysteemdiensten (op regionaal, nationaal of lokaal niveau) tonen aan dat een aanzienlijk deel van het bruto binnenlands product (bbp) van de wereldeconomie volledig afhankelijk is van de stroom van door mariene ecosystemen geleverde goederen en diensten. In de Europese Unie (EU) bijvoorbeeld genereren zij een omzet van 750 miljard euro in 2018.

De mondiale toestand van de mariene ecosystemen is de afgelopen decennia snel verslechterd, wat heeft geleid tot een verlies van ongeveer 10,9 biljoen USD per jaar ten opzichte van de waarden van 1997. Er zijn veel oorzaken aan te wijzen voor deze wereldwijde achteruitgang, waaronder een buitensporige exploitatie van mariene hulpbronnen, en de aanwezigheid van verontreinigende stoffen en plastics, die leiden tot het verlies van koraalecosystemen, vermindering van de omvang en kwaliteit van zeegras en, meer in het algemeen, van benthische habitats. Milieuproblemen die door menselijke druk worden veroorzaakt, zijn complexe problemen die moeilijk aan te pakken zijn. Er zijn nog veel leemten in onze kennis die moeten worden opgevuld, en er zijn nieuwe instrumenten en methodes nodig om deze problemen aan te pakken.

De **gestage afname van de levering van diensten door het mariene milieu** wordt toegeschreven aan de verslechtering van de toestand van de ecosystemen ten gevolge van het verlies of de uitputting van het mariene natuurlijke kapitaal.

Blijkbaar volstaan de huidige beheersinstrumenten en -indicatoren (bv. BBP) niet om de achteruitgang van het mariene milieu een halt toe te roepen. Daarom is er een duidelijke en opkomende behoefte aan nieuwe vormen of instrumenten ter ondersteuning van het mariene beheer.

In maart 2021 is het nieuwe kader voor economie en milieu, het 'System of Environmental-Economic Accounting Ecosystem Accounting' (SEEA EA), goedgekeurd door de Statistische Commissie van de Verenigde Naties. Dit is een grote stap voorwaarts ten opzichte van de standaard gebruikte statistiek van het BBP. Dit kader zorgt ervoor dat natuurlijk kapitaal wordt erkend in economische rapportages, aangezien ecosystemen essentiële diensten leveren die grote voordelen opleveren voor de mens. Natuurlijk Kapitaal Rekeningen (NKR) en ecosysteemboekhouding staan op de mondiale en Europese agenda. Het is in deze context dat OSPAR *"een begin wil maken met de boekhouding van ecosysteemdiensten en natuurlijk kapitaal door maximaal gebruik te maken van bestaande kaders teneinde menselijke activiteiten en de gevolgen daarvan te erkennen, te beoordelen en consequent te verantwoorden bij de uitvoering van ecosysteem gericht beheer*". (Strategische doelstelling 7.03 in de nieuwe milieustrategie voor het noordoostelijke deel van de Atlantische Oceaan).

De **mariene ecosystemen leveren een aanzienlijke bijdrage aan de economieën van de landen rondom de Noordoost-Atlantische Oceaan** door een grote verscheidenheid aan ecosysteemgoederen en -diensten te leveren. Daarom zijn de **instandhouding, bescherming en het duurzame beheer van biodiversiteit, de hulpbronnen en de milieukwaliteit van de mariene**

ecosystemen van groot belang. Bovendien houdt de oceaan zich niet aan landsgrenzen. Daarom zijn kwesties die verband houden met de aantasting van mariene ecosystemen internationaal relevant en kunnen zij alleen worden aangepakt via gezamenlijke acties, waarvoor een gezamenlijke beoordeling van mariene ecosystemen nodig is. Dit alles onderstreept de noodzaak en het belang van een duurzaam beheer van het mariene milieu, en vormt een belangrijke reden waarom OSPAR wil onderzoeken of ecosysteemgoederen en –diensten op een duurzame wijze worden gebruikt.

Bovendien zou NKR, gezien de hoofddoelstellingen van OSPAR (milieubeheer van het mariene milieu), zeer relevant kunnen zijn ter ondersteuning van de OSPAR-besluitvorming. Het is een geschikt instrument voor geïntegreerde analyse dat een op ecosystemen gebaseerd beheer mogelijk maakt, en het vergroot het inzicht in de bijdrage van de oceanen aan de samenleving en de wijze waarop menselijke activiteiten het mariene milieu beïnvloeden.

NKR kan bijdragen tot het bereiken van een aantal strategische doelstellingen van de OSPAR Noordoost-Atlantische milieustrategie 2030. Dit rapport is een eerste bijdrage aan de operationele doelstelling 7.03. Deze doelstelling houdt in dat OSPAR een begin moet maken met de boekhouding van ecosysteemdiensten en natuurlijk kapitaal door maximaal gebruik te maken van bestaande kaders voor de erkenning, beoordeling en consistente boekhouding van menselijke activiteiten en de gevolgen daarvan bij de uitvoering van ecosysteemgericht beheer.

De **rekeningen die in NKR zijn opgenomen** zijn:

1. Extensie boekhouding – beschrijft de omvang van verschillende ecosysteemtypen
2. Toestand – presenteert de toestand van het ecosysteem
3. Fysieke aanbod- en gebruiksrekening – geven de stromen weer van ecosysteemdiensten in fysieke termen
4. Monetaire aanbod- en gebruiksrekening – idem in monetaire termen
5. Monetaire activarekening - de voorraad en de verandering in de voorraad van elk ecosysteemactivum

Het is belangrijk om **onderscheid te maken tussen mariene-ecosysteemrekeningen en oceaanrekeningen**. Oceaanboekhouding is een methode waarbij gebruik wordt gemaakt van internationale statistische normen om economische activiteiten, sociale omstandigheden en milieukenmerken met betrekking tot de oceaan en het gebruik van de rijkdommen van de oceaan regelmatig te integreren. Het is een complex systeemkader, dat economische, sociale en milieucomponenten omvat. Deze componenten maken het mogelijk om de voorraden binnen systemen en de stromen tussen systemen te identificeren. Oceaanrekeningen omvatten economische informatie (bv. Nationale Rekeningen), milieu-economische informatie (bv. NKR) en sociale indicatoren (bv. Sociale rekeningen).

Mariene natuurlijk kapitaalrekeningen registreren de mariene voorraden van natuurlijke activa en omvat verschillende bijdragen van het milieu, waaruit een breed scala van diensten - ecosysteemdiensten, abiotische stromen, ruimtelijke functies - voortvloeit die het menselijk leven mogelijk maken. Op die manier maken mariene ecosysteemrekeningen deel uit van de oceaanrekeningen en dragen zij bij tot de meting van een blauwe economie.

Van mondiaal tot regionaal niveau zijn er initiatieven ter ondersteuning van landen bij de implementatie van natuurlijk kapitaalrekeningen. Zoals het door de EU gefinancierde project "Natural Capital Accounting and Valuation of Ecosystem Services" (NCAVES), en het door de Wereldbank geleide partnerschap "Wealth Accounting and the Valuation of Ecosystem Services" (WAVES) en haar mondiaal programma inzake duurzaamheid. Het is belangrijk om te wijzen op het werk van het Global Ocean Accounts Partnership (GOAP) als de grootste promotor van de oceaanrekeningen op mondiaal niveau. Op Europees niveau heeft de EU het kennisinnovatieproject "Knowledge Innovation Project on an Integrated system of Natural Capital and Ecosystem Services Accounting for the European Union" (KIPINCA) geleid, en meer recentelijk het project "Mapping & Assessment for Integrated ecosystem Accounting" (MAIA).

In dit rapport is informatie verzameld over de stand van zaken met betrekking tot de implementatie van natuurlijk kapitaal rekeningen en soortgelijke initiatieven bij de verdragspartijen van OSPAR. Er kan worden vastgesteld dat de belangrijkste ontwikkelingen plaatsvinden in relatie tot het terrestrische milieu; de laatste jaren is er echter een toenemende belangstelling en zijn er ook meer initiatieven met betrekking tot het mariene milieu. Nederland en het Verenigd Koninkrijk kunnen worden beschouwd als de **gidslanden** op het gebied van mariene natuurlijk kapitaalrekeningen, hoewel bijna alle OSPAR-landen tot op zekere hoogte bezig zijn met natuurlijk kapitaal- of ecosysteemrekeningen. **De meest beleidsrelevante onderwerpen** voor de landen zijn onder meer het monitoren van de natuurlijke rijkdommen en de Sustainable Development Goals (SDG's), het informeren van de besluitvorming en het leggen van een verband tussen economische activiteiten en milieubelasting of -effecten. Tot slot zijn de **belangrijkste kennislacunes en moeilijkheden** een gebrek aan gegevens, middelen en standaardisatie. Maar dit rapport laat zien dat dit niet als een belemmering voor de ontwikkeling van NKR moet worden gezien. Hoewel de huidige gegevens niet perfect passen om het SEEA EA-kader te vullen, **zijn met de huidige informatie alle rekeningen op zijn minst met schattingen gevuld**.

Wanneer de informatie in de rekeningen over natuurlijk kapitaal regelmatig wordt geregistreerd, kan zij een breed scala van besluitvormingsprocessen met betrekking tot oceaanbeheer ondersteunen, zoals

- *Inzicht in de onderlinge afhankelijkheid van de blauwe economie en het mariene milieu:* De ontwikkeling van de rekeningen levert informatie op die kan worden gebruikt ter ondersteuning van de formulering van strategieën en doelstellingen voor de duurzame ontwikkeling van de "zee"- of "blauwe" economie, en kan dus dienen als een strategisch planningsinstrument voor de besluitvorming.
- *Communicatie en rapportage:* De voordelen van het gebruik van NKR ter ondersteuning van de communicatie zijn de ontwikkeling van een gemeenschappelijke taal en betrokkenheid in de natuurlijk kapitaal gemeenschap.
- *NCA als instrument ter ondersteuning van operationele en beheerbeslissingen (b.v. ruimtelijke ordening op zee):* De details die NKR verschaft over hoe de toestand, de gezondheid en de integriteit van ecosystemen en biodiversiteit in de loop van de tijd veranderen, of waar de belangrijkste gebieden van verslechtering en verbetering zich bevinden,

kunnen dienen als leidraad en ondersteuning voor ruimtelijke ordening op zee.

- *Financiering en toewijzing van investeringen:* NKR presenteert op een geïntegreerde en holistische manier informatie over financiële stromen en de daarmee gepaard gaande veranderingen in de sociale, ecologische of economische omstandigheden.
- *Regelgevingsbesluiten:* Het rekeningenstelsel maakt geïnformeerde besluitvorming mogelijk met betrekking tot de inzet van regelgevingsinstrumenten en de toekenning van voorwaardelijke vergunningen en licenties voor economische activiteiten op zee.
- *Bepalen van afwegingen:* Gezien de uitgebreide gegevens die door de rekeningen worden gegenereerd, kunnen zij een beter beeld geven van afwegingen tussen verschillende ecosysteemdiensten of belanghebbenden. De identificatie van bijkomende synergiën en uitruil tussen ecosysteemdiensten levert informatie op voor toekomstig beleid om optimale resultaten te garanderen ter verbetering van de biodiversiteit.
- *Monitoring van de toestand van het mariene milieu en analyse van de oceanen:* De ontwikkeling van het rekeningenstelsel voor meerdere jaren maakt het mogelijk om de toestand van de ecosystemen te vergelijken en te concluderen of ze duurzaam worden beheerd dan wel uitgeput raken.

Men mag niet uit het oog verliezen **dat de waarde van de ecosysteemdiensten geen absolute waarde is**, en niet voor deze doeleinden mag worden gebruikt. Zij zijn bedoeld als indicatoren die een vergelijking in de tijd mogelijk maken. Op dezelfde manier verwijst de (vermogens)waarde van het natuurlijk kapitaal naar het langetermijnpotentieel van die hulpbron om een dienst aan de mens te leveren; zij geeft informatie over voorraden en veranderingen (toevoegingen en verminderingen) van ecosysteemactiva (op vrijwel dezelfde manier als het BBP vaak wordt gebruikt: de nadruk ligt niet zozeer op het absolute getal, maar op de trends in de tijd). Op deze manier wordt de verbetering en achteruitgang van ecosystemen in beeld gebracht.

De verschillende beperkingen, onzekerheden en risico's die bij het opstellen van de natuurlijk kapitaalrekeningen aan het licht zijn gekomen, onderstrepen dat **er behoefte is aan verdere standaardisatie en dat er uitdagingen zijn** op het gebied van gegevens, maar dat toenemende samenwerking en harmonisatie tussen landen de NKR in de toekomst zal verbeteren en vergemakkelijken. Hoewel er beperkingen en onzekerheden aan het licht zijn gekomen, vormt dit rapport een basis voor toekomstige rekeningen.

In het rapport zijn enkele ecosysteemdienstenrekeningen geraamd. Enkele conclusies die uit de eerste raming van de rekeningen kunnen worden getrokken, zijn:

- De waarde van koolstofvastlegging in het mariene milieu in 2019 wordt geraamd op meer dan de helft van de waarde van de visserij in 2018. De waarde van koolstofvastlegging is waarschijnlijk onderschat als gevolg van een conservatieve benadering, de ramingen van de ondergrenzen en de beperkingen van de uitbreidingsgegevens voor de belangrijkste ecosystemen die deze dienst leveren. Daarom is voor een volledig begrip van deze belangrijke ecosysteemdienst meer onderzoek nodig.

- De waarde van mariene hernieuwbare energie is tussen 2008 en het 2019 meer dan 25 keer zo groot geworden.
- De waarde van openluchtrecreatie in kust- en intergetijdengebieden is in de OSPAR-EU-landen gestegen van 238,53 miljoen euro in 2000 tot 253,13 miljoen euro in 2012.
- De activa van de mariene ecosystemen in het noordoostelijke deel van de Atlantische Oceaan waarvoor de initiële waarden worden geraamd, hebben een vermogenswaarde van 125,75 miljard euro, waarvan meer dan 40% samenhangt met koolstofvastlegging en openluchtrecreatie (en deze waarden zijn onderschat).

Tot slot is er een aantal reële en haalbare volgende stappen die OSPAR zou kunnen nemen om de rekeningen van het mariene natuurlijke kapitaal voor het noordoostelijke deel van de Atlantische Oceaan verder te ontwikkelen en te verbeteren:

1. **Analyseer en identificeer wat te doen op basis van dit rapport.** Dit rapport kan als uitgangspunt worden gebruikt om te bepalen op welke punten we nu vooruitgang kunnen boeken en het aangevatte werk kunnen voortzetten. Alle rekeningen moeten op bepaalde punten worden verbeterd.
2. **Prioriteiten zoeken en stellen.** Enerzijds de lijst van ecosysteemdiensten uitbreiden om ervoor te zorgen dat de ecosysteemrekening zo volledig mogelijk is en om iets te hebben dat dichter bij de realiteit staat. Anderzijds moet niet alleen worden bepaald wat prioriteit moet krijgen, maar ook hoe de prioriteiten moeten worden bepaald.
3. **Stel een soort kader of stappenplan op voor NKR voor OSPAR.** Er is een bindend en ambitieus tijdschema nodig om tot actie over te gaan. Van concepten naar implementatie, in acties om daadwerkelijke verbetering van het mariene milieu te bereiken.
4. **Informatie en ervaringen blijven delen, en deelnemen aan partnerschappen zoals GOAP.** Bruggen bouwen en verbanden leggen met andere internationale organisaties die werken aan NKR, zoals de OESO of Eurostat. De inspanningen moeten binnen de landen op elkaar worden afgestemd om het proces te coördineren en te homogeniseren, zodat vergelijkingen tussen landen mogelijk zijn.

Als laatste punt is het belangrijk om in gedachten te houden en na te denken over de uitgangssituatie waarin OSPAR en veel landen zich momenteel bevinden, samen met de informatie en gegevens die momenteel toegankelijk zijn: Dit rapport is de eerste poging om de beschikbare gegevens te verzamelen en samen te brengen in een consistent en integrerend boekhoudkundig kader, op een manier die verenigbaar is met bestaande OSPAR-werkstromen en beoordelingen van de kwaliteitsstatus.

1 Introduction

The approximate global monetary value of services provided by coastal and marine ecosystems was estimated by Costanza et al. (2014) at about USD 49.7 trillion a year (2011 estimates). Thus, marine ecosystems make a vital contribution to human well-being, even though absolute numbers can vary and the analysis has some potential limitations. Numerous studies targeting marine ecosystem services (ES) (at different levels) show that a significant proportion of the global gross domestic product (GDP) entirely depends on the flow of goods and services delivered by marine ecosystems, e.g., in the European Union (EU) they generate a turnover of EUR 750 billion in 2018 (European Commission, 2020b; Maes et al., 2020).

Nevertheless, the global condition of marine ecosystems has rapidly deteriorated over the past few decades, leading to a loss of about USD 10.9 trillion per year compared to 1997 values (Costanza et al., 2014; Maes et al., 2020). There are many reasons for this global decline, including excessive exploitation of marine resources, pollutants, and plastics contamination, leading to the loss of coral ecosystems, reduction of seagrass extent and quality, and, more generally, benthic habitats. Aside from the complex analysis of trade-offs and synergies in the delivery of services, the sustainable delivery of services is closely associated with the good health of the ecosystems they provide. Thus, the steady decline in the provision of services by the marine environment has been attributed to the deterioration in the state of ecosystems as a result of the loss or depletion of marine natural capital (Maes et al., 2020). The succession of these incidents highlights the fact that current tools are not enough to stop the degradation of the marine environment. Therefore, there is a clear and emerging need to seek new forms or tools to inform marine management.

In March 2021, the new economic and environmental framework, the System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA), was adopted by the United Nations Statistical Commission (UNSC) and marks a major step forward that goes beyond the commonly used statistic of gross domestic product (GDP) that has dominated economic reporting since the 1950s (Eurostat, n.d.-b; UN-SEEA, n.d.-c; United Nations, n.d.-b). This measure would ensure that natural capital—forests, wetlands, and other ecosystems—are recognised in economic reporting that the ecosystem delivers essential services that generate great benefits for people (European Commission, n.d.-c; United Nations, n.d.-b). The adoption of the new framework was welcomed by the UN Secretary-General António Guterres, saying (United Nations, n.d.-a):

"This is a historic step forward towards transforming how we view and value nature. We will no longer be heedlessly allowing environmental destruction and degradation to be considered economic progress."

The marine ecosystems contribute considerably to the economies of the countries that surround the North-East Atlantic by providing a large variety of ecosystem goods and services (OSPAR, n.d.-i). Therefore, the conservation, protection, and sustainable management of the biodiversity, resources, and environmental quality of marine ecosystems are of great importance. The ocean does not follow national boundaries. Consequently, ecosystem degradation issues are internationally relevant and can only be dealt with through joint actions, for which joint assessment of marine ecosystems is needed (Maes et al., 2020; Veretennikov, n.d.). These facts stress the need and importance of the sustainable management of the marine environment, and this is also one of the reasons why OSPAR would like to study whether ecosystem goods and services are used sustainably.

The goal of Natural Capital Accounting (NCA) is to map the relationship between nature, the economy, and well-being in a way that is easy to understand and internationally comparable (*Natural Capital*, n.d.). Subsequently, given the OSPAR main objectives (environmental management of the marine environment), NCA could be very relevant to support OSPAR decision making since it is a relevant integrated analysis tool that allows for ecosystem-based management and enhances the understanding of the contribution from the ocean to society, but also how human activities impact the marine environment.

1.1 Relevance to OSPAR

Maintaining 'natural capital' (i.e., ecosystems and the services they provide) is fundamental to sustain human economic activity and well-being. In recent decades, methods for measuring the stock of natural resources that generate benefits as natural capital have received considerable attention. By providing regular and objective data (which is consistent with broader statistics), NCA can provide the basic evidence necessary to inform economic and environmental decision-making (European Commission, n.d.-c; European Environment Agency, 2019b).

Environmental assets are accounted as raw stocks of natural resources and not as media for ecological health and growth. In asset accounts, an addition to a stock of resources (e.g., growth in stock and discoveries) is contrasted with a reduction in stock (e.g., extraction, natural and catastrophic losses) to calculate how much a total stock has changed at the end of an accounting period (usually one year) (United Nations, 2021). This kind of information is useful to check whether any resource is managed sustainably. Hence, the accounts can be a good addition to the thematic assessments in future OSPAR Quality Status Reports.

Ecosystem accounts permit showing the contribution of natural capital to the economy by linking the economic accounts with the ecosystem accounts. For example, these integrated accounts would show the monetary value of the goods and services related to ecosystems that are produced in a specific year or a specific sector. They will also indicate the spatial location of ecosystem service production and the use of the ES. Therefore, through this interlinked approach, ecosystem accounts will make the contribution of ecosystems and their services to the economy increasingly visible (in addition to human and produced capital) (European Environment Agency, 2019b; United Nations, 2021). Therefore, the accounts are also a viable way to ‘share’ the same language between different disciplines and an easy, fast, and effective way of communication among them.

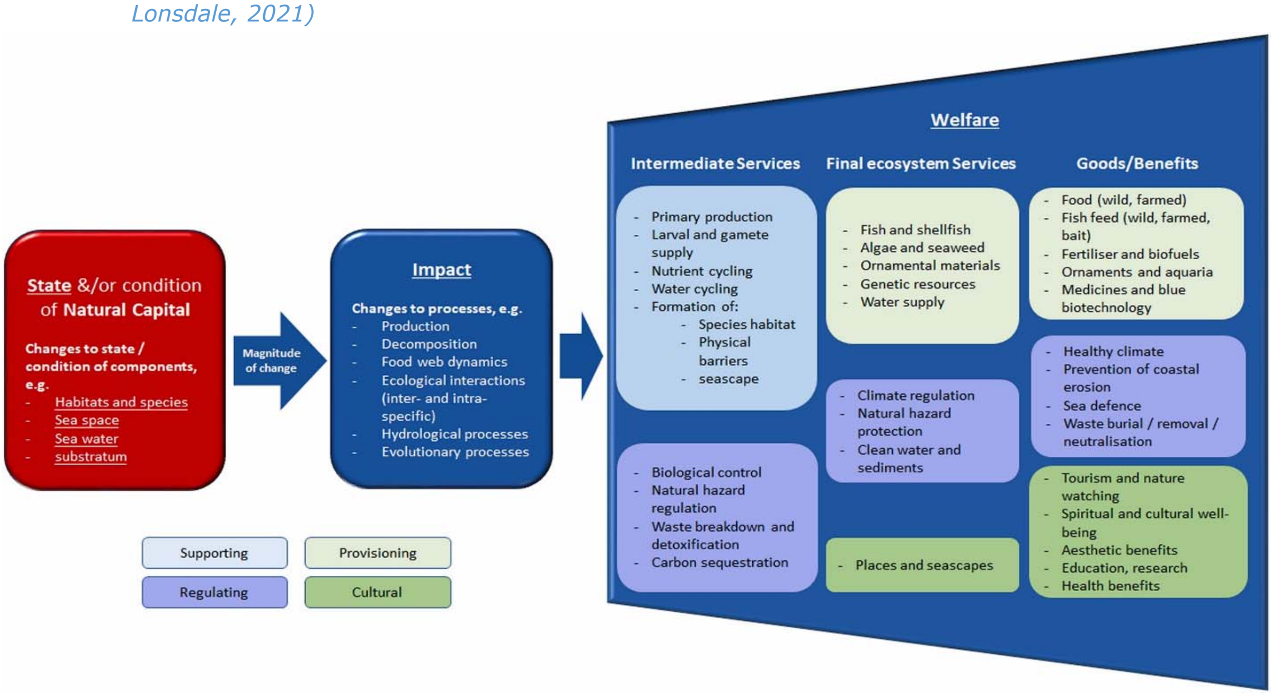
In addition to the above, the need to conserve and enhance natural capital is an explicit policy target in the EU's Biodiversity Strategy. In December 2019, the European Commission proposed the European Green Deal. It puts Europe on the road to achieving climate neutrality by 2050 and determines actions to achieve this goal. Protecting and restoring the ecosystem is essential for the Green Deal (European Commission, 2019). On May 20, 2020, the European Commission adopted the "EU 2030 Biodiversity Strategy" (European Commission, 2020b). The strategy puts forward an ambitious agenda to change the trend of biodiversity loss, with increasing emphasis on the restoration of ecosystems. Ecosystems are seen as solutions that protect biodiversity and improve carbon sequestration and help mitigate climate change and provide basic benefits for humans, agriculture, and the economy (Maes & Jacobs, 2017).

The main objective of the new European "Biodiversity Strategy 2030" is to develop a natural restoration plan for the EU. The plan proposes an impact assessment of the legally binding EU natural restoration goals. These goals should consider baseline data and the baseline level of ecosystem conditions. The impact assessment will also consider the possibility of using EU-level methods to map, assess and achieve good ecosystem conditions to provide benefits such as climate regulation, water regulation, soil health, pollination, and disaster prevention and protection. Thus, NCA contributes to the European Biodiversity Strategy to map and evaluate ES in the marine environment (European Commission, n.d.-a; Maes et al., 2020).

Furthermore, OSPAR is currently implementing the 'Ecosystem Approach', and as concluded by Judd & Lonsdale (2021), there are explicit similarities and synergies between the "Ecosystem Approach" and the "Natural Capital Approach"; therefore, they should not be considered mutually exclusive. Focusing on the synergies helps to develop a common vocabulary and methods among natural, economic, and social scientists and provides efficiency and standardization in data collection and use.

Figure 1 shows a common practical framework that combines the Ecosystem and Natural Capital Approaches in a single system model. Thus, applying a simple unifying schematic representation such as NCA supports the priorities of the UN Decade of the Ocean Science for Sustainable Development as it facilitates collaboration and integration of environmental, social, and economic disciplines.

Figure 1. Expanded State – Impact on Welfare relationships. Source: (Judd & Lonsdale, 2021)



The Natural Capital Approach is increasingly appearing in national and international marine environmental policy. The approach proposed by (Judd & Lonsdale, 2021) aims to facilitate the incorporation of the Natural Capital Approach into marine policies and strategies that originally focused exclusively on the Ecosystem Approach. This incorporation can be seen as a natural extension of the existing data flow and the outcome of the assessment rather than requiring a new assessment strategy (Judd & Lonsdale, 2021). A natural capital approach incorporates the concept of natural capital into decision-making. When natural capital assessments are used for collecting accounts and conduct comparisons over time, these are named NCA (Natural Capital Coalition, n.d.).

Consequently, developing a Natural Capital Approach and NCA is of relevance for OSPAR because it enhances the understanding of the contribution from the ocean to society, but also how human activities impact the marine environment. Moreover, NCA is on the European and global agenda, so the interest and performance of the accounts are increasing among OSPAR contracting parties. Finally, environmental issues are complex problems that are difficult to tackle. There is still a lot of knowledge gaps that need to be filled; more and new tools and methodologies are needed to respond to these matters.

1.2 Aim of the report

This report is the first contribution to accomplish the draft NEAES 2030 Operational objective 7.03, which commits OSPAR to start accounting for ES and natural capital by 2025. The framework presented in this report will be further developed in the future and may be used to contribute to the European Biodiversity Strategy by mapping and to assess ES in the marine environment.

This report aims to explore the use and the value-added of NCA as a tool for marine governance at the OSPAR level. It explores the opportunities of adapting and applying extant datasets generated for OSPAR assessments (e.g., the QSR) in NCA. This methodology considers economic activities and the environmental quality of the marine environment simultaneously and how they affect each other. Thus, NCA allows integrated analyses that are required to support ecosystem-based management.

1.3 Outline

This preliminary study uses available data to estimate the value of specific ES that flow from large-scale marine habitats in OSPAR waters and includes the following:

- Chapter 2 intends to put in context OSPAR and its strategic approach to protecting the North-East Atlantic marine environment.
- Chapter 3 explains the meaning of NCA and the SEEA EA statistical common framework, considering its relevance for OSPAR.
- Chapter 4 includes the added value of NCA for decision-making, highlighting the potential use and applications of the accounts from a marine perspective and especially to the OSPAR Convention. Additionally, it gives an overview of what is happening regarding ecosystem accounting, paying special attention to marine accounting within OSPAR countries.
- Chapter 5 contains the development of a rudimentary form of natural capital accounts for the North-East Atlantic based on publicly available information. This chapter also covers the limits, uncertainties, and risks encountered in the process.
- Chapter 6 comprehends a first exploration of the type of analyses that can be carried out based on the information found.
- The final chapter, chapter 7, examines the use of NCA and, based on a discussion on the feasibility and potential (value-added) of the accounts, advice on what could be done to further develop these initial marine accounts to better support ecosystem-based management at the OSPAR level.

2 Context

This initial attempt of NCA for the OSPAR area has been prepared by the Netherlands in its capacity as a Contracting Party of the OSPAR Convention and convenor of the Intersessional Correspondence Group on Economic and Social Analysis (ICG-ESA). It is the first contribution to the accounting of natural capital in OSPAR by using the recently adopted SEEA EA framework at the OSPAR level.

2.1 OSPAR and the North-East Atlantic Ocean

The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR Convention is the legislative mechanism by which 15 Governments and the European Union (EU) cooperate to protect the marine environment of the North-East Atlantic. The beginning of the Convention was in 1972, with the Oslo Convention for the prevention of marine pollution from dumping or discharges from ships and aircraft. It was later broadened to cover land-based sources of marine pollution in 1992 when it combined with the Paris Convention of 1974. This combination in 1992 resulted in the current OSPAR Convention (OSPAR, n.d.-i; OSPAR Commission, n.d.).

The marine environment of the North-East Atlantic consists of 5 regions:

Figure 2. OSPAR Maritime Area and sub-regions. Source: www.ospar.org

- *Region I: Arctic Waters*
- *Region II: Greater North Sea*
- *Region III: Celtic Seas*
- *Region IV: The Bay of Biscay and Iberian Coast*
- *Region V: Wider Atlantic*

OSPAR regions vary in characteristics and ecosystems composition. The North-East Atlantic contains wide variations in coastal topography and a great variety of marine landscapes such as fjordic sea lochs, salt marshes, dunes, bays, estuaries, wetlands, or numerous sandy beaches. Therefore, there is a large range of habitats supporting diverse fish fauna that are particularly important for migratory birds as well. Furthermore, there have been recent discoveries of several different fragile deep-sea habitats (such as hydrothermal vents, carbonate mounds, coral gardens, and sponge communities) listed as threatened or declining (OSPAR, n.d.-i).

The human population size differs in the various OSPAR regions, and many significant economic activities occur within the North-East Atlantic. Two of the world's largest ports (Rotterdam and Antwerp) are situated on the North Sea coast, and the coastal zone is used intensively for recreation. The main relevant human activities are fishing, aquaculture, maritime transport, offshore activities related to the exploitation of oil and gas reserves, sand and gravel extraction, development of renewable energy generation facilities, and recreation and tourism. In addition, industries of various types, agriculture, and other land-based activities are located along the coasts (OSPAR, n.d.-i).

OSPAR protects and focuses its efforts on the marine environment. Considering the scope of OSPAR, the focus of this report is marine habitats and ecosystems. Although not in the focus of the research, coastal habitats and ecosystems are also considered to be relevant for marine accounting. Therefore, coastal ecosystems and their services are mentioned and considered in some parts of the report.

2.2 Ecosystem approach

OSPAR's activities are guided by the application of the 'Ecosystem Approach' to work coherently towards a holistic approach to the problems addressed by the different OSPAR Strategies[1](OSPAR, n.d.-d). This approach is defined as:

"the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity"

OSPAR ecosystem approach includes conservation and management tactics such as marine protected areas or actions targeted at specific species and habitats. This approach also aids in adapting human activity management to the complex and dynamic nature of marine ecosystems. The ecosystem approach is supported by a general obligation of Contracting Parties to apply the precautionary principle, the polluter pays principle and best available techniques (BAT), and best environmental practice (BEP) (OSPAR, n.d.-h, n.d.-g, n.d.-b).

OSPAR promotes the implementation of the ecosystem approach in the North-East Atlantic within the framework of the Convention on Biological Diversity through programmes and measures developed under its Strategies. OSPAR's work focuses on four elements in particular (OSPAR, n.d.-d):

[1] 1. Biodiversity and Ecosystem Strategy; 2. Eutrophication Strategy; 3. Hazardous Substances Strategy; 4. Offshore Industry Strategy; 5. Radioactive Substances Strategy; 6. Joint Assessment and Monitoring Programme.

1. *Promoting understanding and acceptance by all stakeholders of the ecosystem approach to the management of human activities, and collaboration among the various management authorities in the North-East Atlantic in implementing that approach;*
2. *Monitoring the ecosystems of the marine environment to understand and assess the interactions between and among the different species and populations of biota, the non-living environment and humans;*
3. *Setting objectives for environmental quality, underpinned by monitoring, in support both of the formulation of policy and assessments;*
4. *Assessing the impact of human activities upon biota and humans, both directly and indirectly through impacts on the non-living environment, together with the effects on the non-living environment itself*

Management measures should be developed to ensure the sustainable use of the North-East Atlantic Ocean and its adjoining seas and the balance of the interests of different sectors. This can be achieved only by considering together the ecosystem structures, processes, functions, and interactions relevant to the development of policies on the different issues arising in the managed area (Joint Meeting of the Helsinki & OSPAR Commissions, 2003; OSPAR Commission, 2010a).

OSPAR will implement the Ecosystem Approach taking account of its role within the wider political and legal frameworks, guiding international cooperation on protecting the marine environment of the North-East Atlantic. OSPAR Contracting Parties that are EU Member States have agreed that the OSPAR Commission should be the main platform to coordinate their work to implement the EU Marine Strategy Framework Directive (MSFD) in the North-East Atlantic. Ecosystem goods and services are explicitly mentioned in the ecosystem-based approach to management. They are also included within the EU MSFD concepts of sustainable use of marine resources, therefore it is important to include this type of information in future assessments in a way that integrates the information with other assessments. The MSFD aims to achieve good environmental status for the EU Member States' marine waters by applying the Ecosystem Approach. OSPAR will facilitate the implementation of the MSFD by implementing its North-East Atlantic Environment Strategy and by contributing to the further development of the elements of good environmental status under the MSFD to the extent this is relevant for the respective strategies. Vice versa, the implementation of the MSFD will contribute towards OSPAR's objectives (OSPAR Commission, 2010a, 2021).

2.3 North-East Atlantic Environment Strategy

The North-East Atlantic Environment Strategy (NEAE Strategy) has progressed work related to the implementation of the Ecosystem Approach (NEAE Strategy Part I) and a package of five theme strategies[2] (NEAE Strategy Part II) to tackle the principal challenges identified as related to problems under its jurisdiction. The ecosystem method implemented in OSPAR is based on the integration of the six OSPAR Strategies. Under each theme, work is undertaken concerning the monitoring and assessment of the status of the marine environment, the results of which are used to follow up the implementation of the strategies and the resulting benefits to the marine environment (European Commission, n.d.-d; OSPAR Commission, n.d., 2010a).

[2] 1. Eutrophication, 2. Hazardous substances, 3. Radioactive substances, 4. Offshore oil and gas industry, 5. Biodiversity and ecosystems.

The NEAE Strategy Part I presents the OSPAR Commission's concept for implementing the Ecosystem Approach. The OSPAR Commission's vision is a clean, healthy and biologically diverse North-East Atlantic ocean, used sustainably. To this end, the OSPAR Commission's activities under this Strategy will be guided by applying the Ecosystem Approach (OSPAR Commission, n.d., 2010a).

The NEAE Strategy is implemented to facilitate the delivery and evaluation of progress towards good environmental status as laid down in the Marine Strategy Framework Directive (MSFD), taking account of the national obligations under the Directive. Within the context of the OSPAR Commission, Contracting Parties will have coordinated under the thematic strategies in Part II and the Joint Assessment and Monitoring Programme (OSPAR Commission, n.d., 2010a).

The draft NEAE Strategy 2030 largely mirrors the vision of its 2010 predecessor but emphasises the need for resilience to climate change and ocean acidification. Delivery of the vision has been reorganised under twelve Strategic objectives (see Box 1) and a suite of Operational Objectives. Therefore, NCA can contribute to achieving some of the OSPAR NEAE Strategy 2030 Strategic objectives (OSPAR Commission, 2021). This report is an initial contribution to the Operational objective 7.03.

Operational objective 7.03 commits OSPAR to

'…start accounting for ES and natural capital by making maximum use of existing frameworks to recognise, assess and consistently account for human activities and their consequences in the implementation of ecosystem-based management.'

Box 1. Extract from the draft OSPAR North-East Atlantic Environment Strategy 2030

To achieve clean seas we will:

Strategic objective 1. Tackle eutrophication, through limiting inputs of nutrients and organic matter to levels that do not give rise to adverse effects on the marine environment;
Strategic objective 2. Prevent pollution by hazardous substances, by eliminating their emissions, discharges and losses, to achieve levels that do not give rise to adverse effects on human health or the marine environment with the ultimate aim of achieving and maintaining concentrations in the marine environment at near background values for naturally occurring hazardous substances and close to zero for human made hazardous substances;
Strategic objective 3. Prevent pollution by radioactive substances in order to safeguard human health and to protect the marine environment with the ultimate aim of achieving and maintaining concentrations in the marine environment at near background values for naturally occurring radioactive substances and close to zero for human made radioactive substances; and
Strategic objective 4. Prevent inputs of and significantly reduce marine litter, including microplastics, to reach levels that do not cause adverse effects to the marine and coastal environment with the ultimate aim of eliminating inputs of litter.

To achieve biologically diverse and healthy seas we will:

Strategic objective 5. Protect and conserve marine biodiversity, ecosystems and their services to achieve good status of species and habitats, and thereby maintain and strengthen ecosystem resilience; and
Strategic objective 6. Restore degraded habitats in the North-East Atlantic when practicable to safeguard their ecosystem function and resilience to climate change and ocean acidification.

To achieve productive and sustainably used seas we will:

Strategic objective 7. Ensure that uses of the marine environment are sustainable, through the integrated management of current and emerging human activities, including addressing their cumulative impacts;
Strategic objective 8. Reduce anthropogenic underwater noise to levels that do not adversely affect the marine environment; and
Strategic objective 9. Safeguard the structure and functions of seabed/marine ecosystems by preventing significant habitat loss and physical disturbance due to human activities.

To achieve seas resilient to the impacts of climate change and ocean acidification we will:

Strategic objective 10. Raise awareness of climate change and ocean acidification by monitoring, analysing and communicating their effects;
Strategic objective 11. Facilitate adaptation to the impacts of climate change and ocean acidification by considering additional pressures when developing programmes, actions and measures; and
Strategic objective 12. Mitigate climate change and ocean acidification

3 Natural Capital Accounting

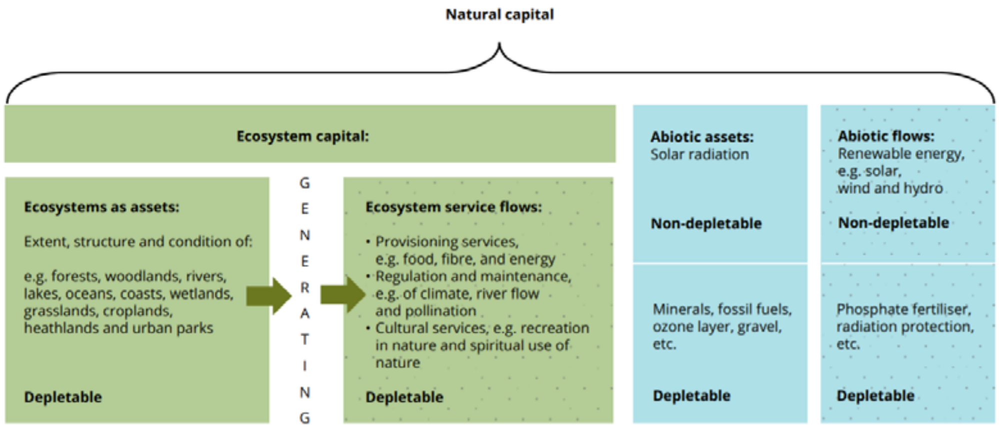
3.1 Natural Capital

David Pearce proposed the term "natural capital" in 1989 to emphasize the role of nature in supporting the economy and human well-being (Pearce, 1989). It is currently recognized that human well-being depends on different resources or assets, which can be classified according to four broad types of capital. Much attention has been drawn to the definition of well-being or wealth. In a recent report, Treasury (2021) discusses the concept of inclusive wealth in a way that is adjusted for demographic changes, the sum of the accounting values of produced capital, human capital, and natural capital. The economy and human well-being are supported by each of these capitals (Ekins & Max-Neef, 1992; European Environment Agency, 2019b; Pearce, 1989):

I. *Manufactured or man-made capital: assets used to produce goods and services- e.g., machines, tools, buildings, and infrastructure. Financial capital includes currency and other financial assets and is sometimes regarded as a separate additional category (Aronson et al., 2007).*
II. *Human capital: assets in the form of knowledge, education, motivation, and work skills, as well as physical and mental health.*
III. *Social capital: Including social trust, promoting social and intellectual interaction, and the norms and networks of methods to solve common problems- e.g., community associations, civic and cooperative organizations, and the political and legal structure of society.*
IV. *Natural capital: includes the ecosystem and non-biological assets that provide usable resources on the earth- e.g., solar radiation, fossil fuels, and minerals- and generate revenue through ecosystem services- e.g., food, climate regulation, and entertainment.*

Although all four types of capital are necessary to sustain human well-being, natural capital is probably the most important because it maintains and supports the other forms of capital (European Environment Agency, 2019b). For example, minerals, metals, wood and fibres, and energy are required to build up components of manufacturing capital. Human and social capital are highly dependent on people’s health, who rely on ES to maintain good health. These services vary from the provision of food and freshwater to the regulation of ES that support water purification, nutrient cycling, and disaster mitigation to the benefits of open landscapes and urban parks that support recreation. The broad definition of natural capital proposed by David Pearce includes biological and non-biological elements and covers all natural resources on which human society depends. Figure 3 illustrates the main components of natural capital as understood by the European Environment Agency and based on natural capital figures from the first Mapping and Assessment of Ecosystems and their Services (MAES) report (European Commission, 2013; European Environment Agency, 2019b). The green elements cover the “ecosystem capital”: the ecosystems that generate ES and are non-renewable. The blue part includes the abiotic assets and flows such as non-renewable resource stocks (e.g., fossil fuels) and renewable natural resource flows (e.g., solar energy).

Figure 3. The components of Natural Capital. Source: (European Commission, 2013; European Environment Agency, 2019b).



Note: Global solar radiation is constant above the atmosphere and hence considered a stable asset.

The 12th Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) recognized that the valuation of biodiversity and ecosystem goods and services is directly related to the Natural Capital concept. Defining Natural Capital as (CBD, n.d.; European Environment Agency, 2019b):

"the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this Natural Capital that humans derive a wide range of services, often called ES, which make human life possible. The most obvious ES include food, water, plant materials used for fuel, building materials and medicines. There are also many less visible ES such as the climate regulation and natural flood defences provided by forests, the billions of tonnes of carbon stored by peatlands, or the pollination of crops by insects. Even less visible are cultural ES such as the inspiration taken from wildlife and the natural environment."

Natural capital covers both ES and abiotic flows. Abiotic flows are contributions to benefits from the environment that are not supported by or dependent on ecological characteristics and processes, such as the capture of wind, solar, tidal, geothermal, and similar sources of energy or the extraction of fossil fuel, mineral, sand or gravel. According to the SEEA EA (United Nations, 2021), ES can be divided into three categories:

1. *Provisioning services: representing the contributions to benefits that are extracted or harvested from ecosystems, e.g., the provision of fish and other aquatic products.*
2. *Regulating and maintenance services: resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles, ergo they maintain environmental conditions beneficial to individuals and society, e.g., global climate regulation or water purification services.*
3. *Cultural services: defining as the experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits, e.g., recreation-related or spiritual, symbolic, and artistic services.*

3.2 The System of Environmental-Economic Accounting- Ecosystem Accounting (SEEA EA) framework

Background

Accounting is a method of organizing information to provide an overview of income and expenditures and gives comprehensive and consistent results. The System of National Accounts (SNA), which is also underpinned by this principle, develops information about a country's GDP, a key indicator for assessing economic progress and understanding a country's economic wealth. Nevertheless, the wealth of a country and the well-being of its people not only depends on economic conditions but also on its natural resources and the services we obtain from the ecosystem. Consequently, since the 1970s, statisticians, accountants, and others have been working to create a supplementary accounting system that includes natural assets and the benefits we derive from them. This is the so-called Environmental-Economic Accounting System (SEEA)(European Environment Agency, 2019b).

In response to the need to internalize the depletion and degradation of natural resources in macroeconomic accounting, work began in the 1980s and ended with the Manual of National Accounts: Complete Table of Environmental and Economic Accounting (SEEA 1993) published by the United Nations Statistics Division (European Environment Agency, 2019b). Since the first publications of Rapport, Daily and Costanza (Costanza et al., 1997) in the 90s, ecosystem accounting is getting more attention, which resulted in various reports and applications: De Groot and Costanza first classification of ES (Costanza et al., 2014), the Millennium Ecosystem Assessment in 2005 (MA, 2005), 'The Economics of Ecosystems and Biodiversity' (TEEB) report (TEEB, 2009) and applications like the land and ecosystem accounts approach (LEAC) by the EEA (EEA, 2006). In these circumstances, the United Nations Statistical Commission (UNSC) supported to further develop the SEEA framework concerning ecosystem accounting, together with great efforts guided by the United Nations Statistical Division (UNSD), the UN Environment Programme (UNEP), the Convention on Biological Diversity (CBD), the World Bank or the Indian Ocean Commission (European Environment Agency, 2019b; Weber, 2018).

The development and application of ecosystem accounting methods require the recording of physical and monetary measurement of (changes in) ES supply and the ability of the ecosystems to provide services in a manner consistent with prescribed national accounting methods (as reflected in the System of National Accounts; SNA) and for environmental-economic accounts (as reflected in the System for Environmental-Economic Accounts Central Framework; SEEA CF). The SEEA CF is, as of 12 February 2012, a global statistical standard for environmental accounting (United Nations et al., 2014). However, neither the SNA nor the SEEA CF was designed for accounting for ES or ecological capital. Recognizing these issues, a consortium coordinated by the United Nations Statistics Division formulated the SEEA Ecosystem Accounting (SEEA EA) Guidelines (Edens & Hein, 2013).

As explained by the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA), in their last draft report (United Nations, 2021), 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".

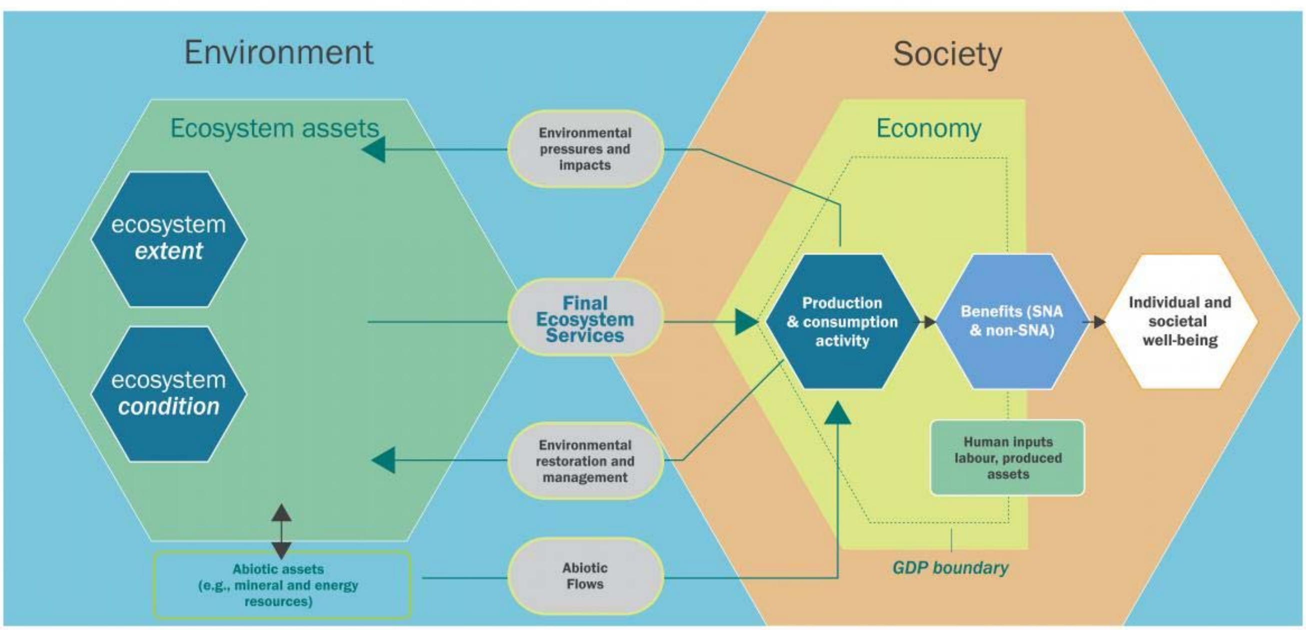
The SEEA EA complements the SEEA CF considering the perspective of ecosystems and their contribution to human well-being in terms of identifiable ecosystem services (Nations, n.d.). The SEEA, including both the SEEA Central Framework and the SEEA EA, provides a system that uses accounting principles to integrate environmental-related physical and monetary measurements so that they can be compared with data in the SNA and thereby complementing the SNA. This framework aims to respond to the various needs and policy challenges with a focus on making nature's contributions to the economy and people visible. In addition to the provision of an integrated, coherent and consistent set of data, the use of accounting methods allows for comparable, periodic and continuous measurement (United Nations, 2021).

The SEEA EA is a new international statistical standard that the UNSC has adopted in March of 2021. The purpose of the SEEA EA statistical framework is to guide the measurement of the different natural capital components of an ecosystem, in terms of the state of the ecosystem and its ability to provide ES, and how to organize the necessary information to estimate the cost of protecting or repairing the damage. The main objective is to create a set of accounts for important stocks of natural capital (ecosystem assets defined by their size and condition) and ecosystem service flow accounts. These flows are first recorded using quantitative physical metrics and then, if possible, expressed in monetary values (European Environment Agency, 2019b; United Nations, 2021).

Conceptual Framework

Figure 4 illustrates the conceptual structure of SEEA EA, picturing the contributions and links between its different components:

Figure 4. SEEA EA Conceptual Structure. Source: (UN-SEEA, n.d.-b)



The core logic of the ecosystem accounting framework is based on the definition of *ecosystem assets*. The definition of an ecosystem asset is a statistical representation of the general description of an ecosystem by the CBD. They are the statistical units of ecosystem accounting, i.e., ecological entities of which information is required and which statistics record.

In ecosystem accounting, the statistical output is most commonly presented in tabular form, with data on ecosystem assets grouped by ecosystem type. Ecosystem types reflect a different set of interactions between abiotic and biotic components. Alternatively, it can be viewed in the form of a map that can display the composition and location of different ecosystem types to identify individual ecosystem assets. A set of ecosystem accounts will cover those ecosystem assets within the defined ecosystem accounting area (EAA). The EAA is the geographic area for which the ecosystem accounting is compiled (United Nations, 2021). Thus, in the case of this report, the EEA is the area covered by OSPAR Maritime Area.

To better understand Figure 4, there are a series of concepts that are key for ecosystem accounting and important to define as well (United Nations, 2021):

- The spatial size of an ecosystem asset is the ***ecosystem extent.***
- The ***ecosystem condition*** is the quality and state of an ecosystem measured regarding its abiotic and biotic features.
- The different ecosystem assets supply a range of ***ecosystem services*** that reflect the different characteristics and processes of the ecosystem, depending on its ecosystem type, extent and condition, and on their location and patterns of use by economic units (including households, businesses and governments).
- Regarding the use of ecosystem services, it integrates direct physical ***consumption***, passive enjoyment and indirect use.
- In addition, economic and human activities cover various forms of interaction between ecosystems and people (environment and society), including in-situ and remote interactions.
- In terms of the ***benefits*** to which ecosystem services contribute, these are defined as the goods and services that are ultimately used and enjoyed by people and society. These benefits may be captured or reflected in current measures of production (e.g., food, water, energy, recreation) or may be excluded from these measures (e.g., clean water, clean air, protection from floods).

SEEA EA Accounts

These concepts constitute the five accounts forming the accounting system, in which the accounts are strongly interconnected and provide a comprehensive and consistent view of the ecosystems. There is no single ecosystem account that covers or encompasses everything. Although it is designed as a system of integrated accounts, each one has its strengths and information (United Nations, 2021). Figure 5 explains the structure and connections of the accounts within the SEEA EA framework, which are defined as (UN-SEEA, n.d.-c):

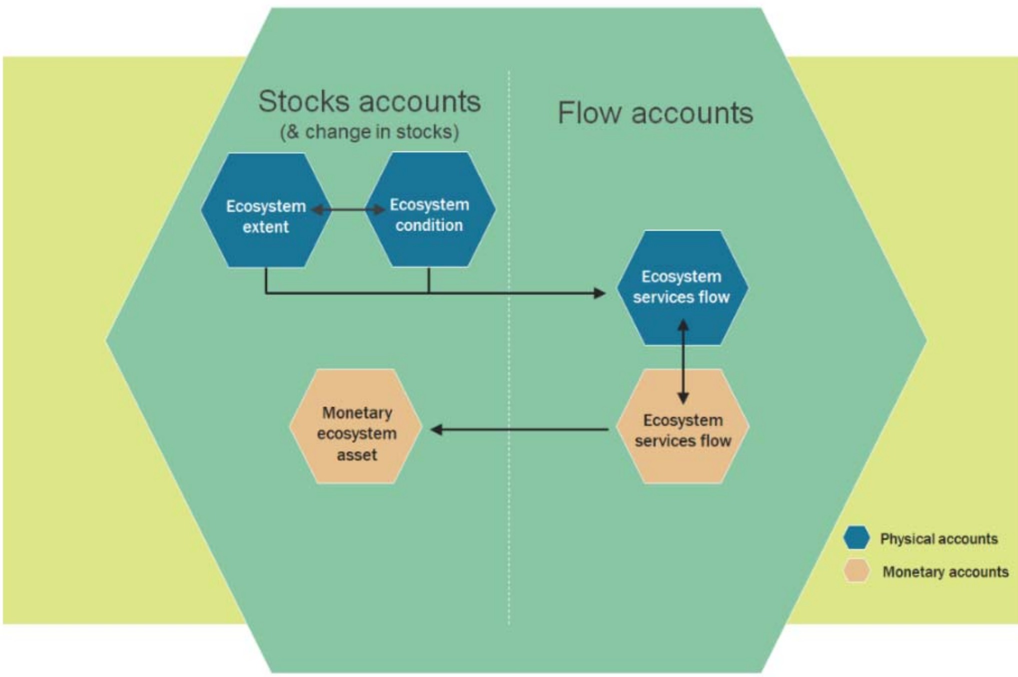
1 ECOSYSTEM EXTENT *accounts record the total area of each ecosystem, classified by type within a specified area (EAA). Ecosystem extent accounts are measured over time in EAA (e.g., nation, province, river basin, protected area, etc.) by ecosystem type, thus illustrating the changes in extent from one ecosystem type to another over the accounting period.*

*2 **ECOSYSTEM CONDITION** accounts record the condition of ecosystem assets in terms of selected characteristics at specific points in time. Over time, they record the changes to their state and provide valuable information on the health of ecosystems.*

*3&4 **ECOSYSTEM SERVICES** flow accounts (physical and monetary) record the supply of ES by ecosystem assets and the use of those services by economic units, including households, businesses and governments.*

*5 **MONETARY ECOSYSTEM ASSET** accounts record information on stocks and changes in stocks (additions and reductions) of ecosystem assets. This includes accounting for ecosystem degradation and enhancement.*

Figure 5. Connections between the SEEA EA ecosystem accounts. Source: (United Nations, 2021).



SEEA EA includes bio-physical accounting modules (physical accounts) and monetary accounting modules (monetary accounts), encompassing accounts in both bio-physical terms (e.g., hectares, tonnes) and in monetary terms, where flows of ES are monetary valued through various market and non-market valuation techniques. The valuation of ES subsequently supports the valuation of ecosystem assets (European Environment Agency, 2019b; United Nations, 2021). The UNSC has not yet adopted the valuation part of SEEA, although the statistical principles and recommendations for the valuation of ES and assets are internationally recognized.

Accordingly with the previous, and as shown in Figure 5, ecosystem accounting includes the following data over an accounting period (United Nations, 2021):

- the stock and change in the stock of each ecosystem asset, incorporating ecosystem enhancement and degradation; and
- flows from that asset in the form of ES. The flows of ES are linked to the ecosystem type, size or extent and its condition or state, as well as features that determine levels of use of the ecosystem.

Like the SEEA framework consist of recording the relationships among ecosystems, people, and economic units, it provides a basis for analysing the role of ecosystems in supporting economic and human activities and understanding the impact of economic and human activities on ecosystems. Thus, the SEEA EA design facilitates the integration of ecosystem information with standard measures of income, production and wealth that can be later used to analyse sustainability and green economy issues. SEEA EA provides a broad and cross-sectional view of the ecosystem at the national or regional level. While many concepts can be applied in detail, their purpose is to provide a broad perspective of integration with the general economy in the national accounts (European Environment Agency, 2019b; Schenau et al., 2019; United Nations, 2021).

3.3 The Ocean accounts and marine natural capital accounts

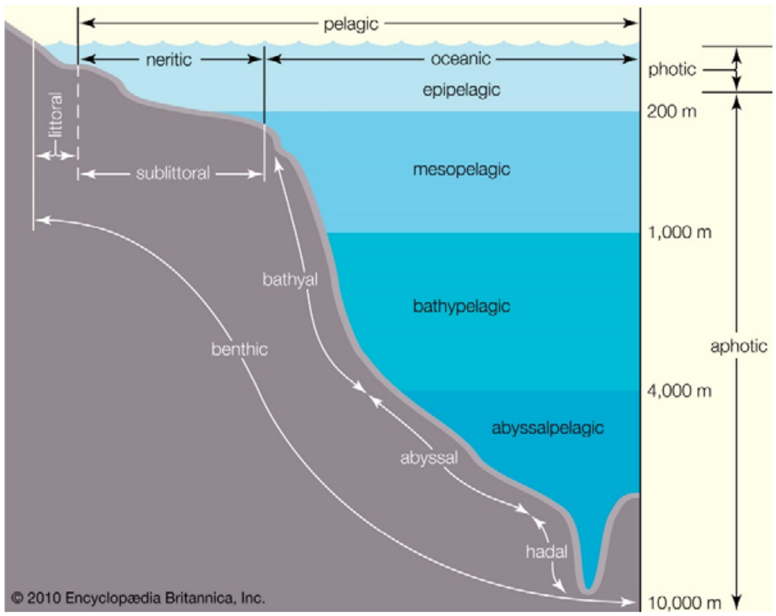
The accounting treatment of marine and coastal assets is very different from the accounting treatment of land-based environmental assets. For instance, the boundaries between land assets and related economic owners or managers are usually clearer. In addition, the services provided by land assets are more easily attributable to the assets themselves and economic owners. This link between economic owners and land assets makes economic-environmental links more transparent to decision-making and policy. The boundaries of marine and coastal ecosystems are more difficult to observe, and ownership is usually assigned to waters rather than areas of marine ecosystems (GOAP, 2020; United Nations, 2021).

It is important to differentiate between marine ecosystem accounts and ocean accounts. Ocean accounting is a new method that uses international statistical standards to regularly integrate records of economic activities, social conditions, and environmental characteristics related to the ocean and the use of ocean resources. The ocean account framework is a complex system framework, which includes economic, social, and environmental components, and these components allow the identification of stocks within systems and flows between them. Ocean accounts involve economic (e.g., SNA), environmental-economic (e.g., SEEA EA), and social (e.g., Social Accounting Matrix (SAMs) accounting (GOAP, 2020, personal communication, July 13, 2021), while NCA focuses on environmental-economic accounting. This report explores only the environmental-economic components; to be more specific marine natural capital accounts for the OSPAR area. Hence, just a part of the ocean accounts is investigated.

Figure 6 shows how marine ecosystems are not concentrated near just one surface (e.g., land or water interface) but extend throughout the water column, including bottom sediments and seabed, which provides natural boundaries for the ecosystem assets. Conceptually, the ecosystem assets of the marine ecosystem can be divided according to vertical stratifications. For instance, considering the ecological differences in the location and depth of the water column and distinguishing the seabed from the overlying water column. However, since describing or depicting ecosystem assets in a vertically stratified way can be challenging, in the first instance, surface-based delineation may be the most practical measurement method for accounting purposes. However, future development of marine NCA should investigate mechanisms to assess the 3-D spatial and temporal characteristics of marine ecosystems. Especially for marine ecosystems on the continental shelf, it is advisable to depict the assets of the ecosystem based on the regions of the various ecosystem types associated with the seafloor (e.g., seaweed grasslands, sandy bottoms and coral reefs) (United Nations, 2021). For the OSPAR area, certain regions (especially II and

III) are relatively shallow. Here neglecting the vertical column may not be that much of a problem than in regions I and V, where there are areas covering deep-sea.

Figure 6. Indicative of the vertical structure of marine. Source: brittanica.com



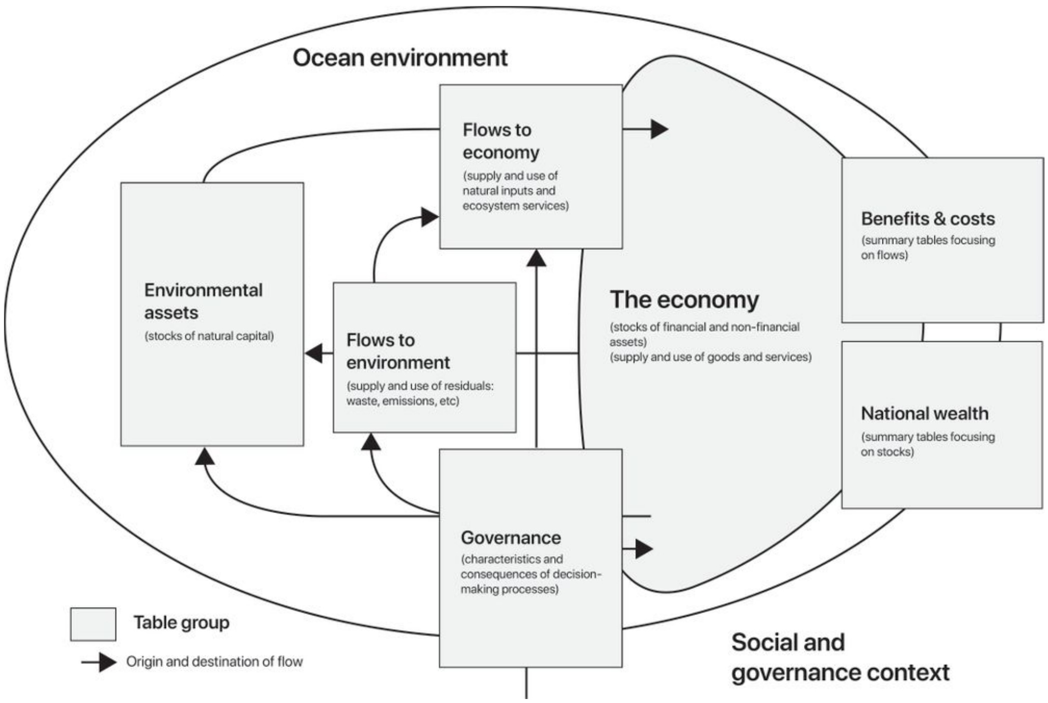
The Global Ocean Accounts Partnership (GOAP) is the greatest promoter of the ocean accounts globally, which aims to respond to today's challenges by establishing a coordination and communication structure for diverse member institutions. They are developing a technical guideline for ocean accounting together with collaborative capacity-building activities that support the development, maintenance, and ongoing use in decision-making, of holistic ocean accounts that link together social, environmental and economic statistics. Consequently, this Ocean Accounts guideline can provide a consistent and agreed information basis for strategic and spatial planning of marine and coastal areas, regulation of marine economic sectors and activities, and related investments decisions. It can provide unbiased evidence to monitor and evaluate marine policy as well. Furthermore, it can be used to identify gaps and focus research efforts on filling those gaps (GOAP, n.d.).

The Ocean Accounts are essentially a compilation of accounts (or modules) organized according to a conceptual framework. These accounts can be selectively implemented based on national priorities, data availability, and technical capabilities. In general, the framework describes:

- the interaction between economy and environment,
- the stock and changes in the stock of environmental assets (natural capital) that bring benefits to people, and
- social and governance factors that affect the status and condition of environmental assets and associated benefits.

Figure 7 illustrates the overall structure and component table of the Ocean Account Framework, which can be found on the GOAP website or in their Technical Guidance (GOAP, n.d., 2020b).

Figure 7. The GOAP Ocean Accounts Framework. Source: oceanaccounts.org



In the SEEA EA last draft, the Ocean Accounts Framework presents a comprehensive framework to link relevant components of the SNA, SEEA CF and SEEA EA to harmonize priority data on the ocean, including economic, ecological, governance and social aspects. Building on the SEEA ecosystem extent, ecosystem condition, and ES flow accounts, the SEEA EA Ocean Accounts Framework include accounts for natural resources and pressures on oceans from the SEEA CF; additionally, it includes accounts relating to the ocean economy and regarding governance, management and technology (United Nations, 2021).

Environmental accounting is a useful tool to assess the biophysical and economic value of natural capital and ES in marine ecosystems. In particular, environmental accounting allows the assessment of multiple aspects dealing with marine ecosystems (Buonocore et al., 2020). The concept of natural capital allows to collect and systematise information on the stocks and flows of natural resources and trends over time, covering non-renewable resource stocks (e.g., fossil fuels, minerals and metals), renewable natural resource flows (e.g., solar and wind energy) and the ecosystems that provide humans with vital ES (e.g., water, forests, wetlands and grasslands) (European Environment Agency, 2019b).

In this way, Marine Ecosystem Accounts form part of the ocean accounts and contribute to the measure of a Blue Economy. Understanding a Blue Economy as parallel to a green economy concept to include pillars of sustainability and inclusivity (personal communication, July 13, 2021). The focus of this report is on Marine Natural Capital Accounts for the North-East Atlantic, therefore considering marine ecosystem and abiotic assets for the accounts.

4 Marine natural capital accounts: practical cases and policy use

4.1 Relevant projects and initiatives

SEEA EA implementation progress has been driven by global, national and regional initiatives (Hein et al., 2020). The United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) carried out the 2020 Global Assessment of Environmental-Economic Accounting and Supporting Statistics. This assessment tracked the status of national implementation of environmental-economic accounting programmes, showing that the number of countries implementing SEEA has increased by 29% in 2020 compared to 2017. The growth rate of developing countries was even higher in the same period, an increase of 47%, while developed countries increased by 14%. Climate change has been the most frequently mentioned policy priority in both developed and developing countries. Other priorities in developed countries include circular economy and green/blue growth (environmentally sustainable economic growth), while biodiversity and protected areas are top priorities in developing countries. The majority of both developed and developing countries say they use SEEA's accounts for both reporting of the Sustainable Development Goals (SDGs) and informing national policies (United Nations Statistics Division, 2021).

Initiatives such as the EU-funded Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project and the World Bank Global Programme on Sustainability have supported country implementation and provided training on the implementation of the SEEA EA. The NCAVES project is funded by the EU through its Partnership Instrument (PI) to help five participating countries: Brazil, China, India, Mexico and South Africa, to advance their knowledge on environmental-economic accounting, especially on ecosystem accounting. It acts as a pilot test SEEA EA to improve the measurement of ecosystems and their services (including physical and monetary); incorporating biodiversity and ecosystems into policy planning and implementation; and promoting the development of internationally agreed methodologies and their use in partner countries (UN-SEEA, n.d.-d).

The World Bank Group is leading a partnership to promote NCA internationally, providing support to many countries around the world at a project level. The Wealth Accounting and the Valuation of Ecosystem Services (WAVES) partnership pursues to advance sustainable development through assuring the integration of natural resources among development planning and national economic accounts (WAVES, n.d.).

Based on WAVES experiences, the World Bank has developed the Global Program on Sustainability (GPS) to enlarge the application of the “sustainable development” perspective in decision-making in developing countries. GPS is built around three interrelated pillars of participation (information, implementation, and incentives) and will contribute to the achievement of the SDGs by supporting developing countries’ efforts to sustainably manage their natural capital (WAVES, n.d.).

Additionally, as explained in section 3.3, GOAP brings together diverse member institutions around the globe who have a common interest to ensure that the values and benefits of oceans are recognized and accounted for in decision-making about social and economic development. GOAP was launched by the United Nations (UN)

Economic and Social Commission for Asia and the Pacific (ESCAP) on behalf of the United Nations in response to many international commitments (GOAP, n.d.)

Another important related work is an exploration of satellite accounting for ocean economic activity carried on by the Organisation for Economic Co-operation and Development (OECD). The satellite accounting framework collects and compiles comparable data on marine economic activities (both supply and use), thus, providing opportunities for a better understanding of the marine economy and improved evidence-based decision-making. The OECD is currently working alongside several pilot countries to develop OECD ocean economy supply and use tables to produce internationally comparable statistics on ocean economic activities. The benefits of using satellite accounting to measure the marine economy are enormous. A better understanding of the interconnections between internal and external activities in the marine economy, of the use of marine goods and services, and reliable management of economic data are other major benefits. Because of these advantages, more and more countries, including Portugal and the United States, have established or are in the process of establishing marine economic satellite accounts. Experiments using the OECD's international satellite accounts for marine economic activities can be transformative for comparable statistical data across countries, allowing for several economic analyses that are currently difficult to achieve. Over time, accounting for marine natural assets and relevant marine ES will be feasible and real, at least on the physical side. Hence, the satellite accounts by providing regular, reliable and comparable statistics on both maritime economic activity and the relationship between maritime environment and economy will become a powerful tool for measuring aspects of the sustainability of maritime economic activities (Jolliffe et al., 2021).

In addition, at the European level, the EU has led the Knowledge Innovation Project on an Integrated system of Natural Capital and Ecosystem Services Accounting for the European Union (KIPINCA), and more recently, the Mapping & Assessment for Integrated ecosystem Accounting (MAIA). The KIPINCA project aims to provide a versatile tool that can be used for various policy decisions at various stages of the policy cycle and can be accessed by national authorities and research centres. It allows for a clear description of the ecosystem and the scope of its services and to demonstrate the benefits of investing in sustainable management of nature and resources in monetary terms (European Commission, n.d.-c).

The MAIA project aims to promote the integration of NCA in the EU Member States and Norway. It is conducted by a consortium that includes partners with expertise in statistics, ecological modelling and environmental economics. MAIA’s partners are involved in initiatives, such as the London Group of Environmental Accounting, MAES, IPBES and KIP INCA. The project has adopted a cooperative approach in which countries will exchange experiences and methods, improving coordination between ongoing initiatives (MAIA, n.d.).

Interest in marine ecosystem accounting or environmental-economic accounts is increasing in similar organizations to OSPAR, such as HELCOM. This can be seen in actions taken, namely a Marine Ecosystem Accounting Workshop and various projects related to this topic developed around the Baltic Sea (HELCOM, 2019). One of these projects is the MAREA project (From marine ecosystem accounting to integrated governance for sustainable planning of marine and coastal areas), which is a collaboration between SYKE, Pellervo economic research (Finland), University of Tarto and Baltic Environmental Forum Latvia. The aim is to develop modelling and accounting of ES in the Baltic Sea, an indicator-based sustainability compass for sustainability assessment of different management actions in the sea, and a web portal for modelling and valuation results. The focus of the MAREA project is on the valuation and accounting of coastal blue carbon and its trade-offs with other services, cultural/recreational ES, and provisional and regulating (also blue carbon) services related to common reed. Also, one of the objectives is to include emerging/potential marine sectors/economic activities in the assessment, such as ferromanganese extraction, algae and bladderwrack cultivation, as well as the use of common reed for bioenergy and other purposes (MAREA, n.d., personal communication).

4.2 Marine ecosystem accounting programmes in the OSPAR area

This section of the report includes an overview of the state and active development of natural capital or ecosystem accounts within OSPAR countries. Table 1 gives a summary of the accounts progress, the main interest points from the countries to develop the accounts and the knowledge gaps or difficulties encountered during the process.

Table 1.Overview information on the state, policy relevance and gaps of the OSPAR contracting parties natural capital accounts.

Country	State of the accounts	Policy relevance	Knowledge gaps and difficulties
Belgium[i]	The environmental policy is regionalised. Main initiative in **Flanders**. In Flanders, **extent** account and **ES supply and use** accounts **published.** The **ES supply and use** account are in **physical and monetary terms**, including wood production in forests, carbon storage in above-ground biomass, water availability and health benefits of green and blue areas in the living environment. A **condition** account and a **biodiversity account** are **being developed**. **SUMES project** ongoing, the **modelling** impact of **human-induced changes** on the **marine** ecosystem**.**	**Climate-related aspects** such as water availability, storage and infiltration, carbon storage and climate regulation by green and blue spaces in an urban environment. Increasingly demand **better information on health-related aspects** of natural capital. The use of NCA as a basis for **monitoring the Sustainable Development Goals** and to support the evolution towards a Green Economy **beyond GDP-indicators**. **Monitoring land-use change** as a driver of biodiversity loss.	**Data challenges** concern carbon storage in biomass; the health effects of green space; functional biodiversity and its contribution to the supply of ES as well as the **accuracy of the base layers** of the land use/land cover map. The relevant data, knowledge, skills, resources are **scattered across different entities**, this impedes building appropriate ES models.
Denmark[ii]	**Green National Accounts** previously called "Environmental-Economic Accounts for Denmark" **supplement** the traditional **National Accounts**. Statistics Denmark does not have any current activities in ecosystem accounting. However, they produce and publish environmental-economic accounts according to the SEEA Central Framework – which **includes accounts for natural resources (stocks).**	Highlighting the **importance of nature** to **economic activities** and how those affect or create **pressures** on the environment. Describing **how stocks of natural resources** and land cover/use have **developed**. Nature or "green" activities part of the economy and Danish national wealth in the broad sense. **SDG indicators** for Denmark based on data from these accounts.	**No natural capital accounts**
Finland[iii]	Multiple **frameworks** and multiple **academic exercises developed** in NCA but **no official accounts published**. **Marine ecosystem accounts** under development - Pilot on **marine ecosystem extent** and **condition** account - **Pilot test in accounting for fish resources** considering food web interactions and including reactional fishing - Other related **projects** such as **MERIAVAIN** and **MAREA** related to marine accounting **A pilot account** for Recreation supply and use in physical and monetary terms was **recently published**. Thematic accounts for most advances made in **freshwater accounting**.	The Eurostat initiative to update Regulation (EU) 691/2011 and the SEEA EA are expected to **increase policy- demand for NCA**. Improve **monitoring of biodiversity and ecosystems** (including ES). **Investigating the trade-offs** between relevant ES in monetary terms such as timber (increasing demand) and other important ES such as carbon sequestration is **critical.** The **need for methodologies** to generate regional accounts on water assets and water abstraction **to allow sustainability analyses** on varying sub-national scales, due to resources are unevenly distributed.	**Lack of mandate** barrier for the development and implementation of ecosystem accounts. **The common language** between natural scientists, economists and statisticians take time. Development of **harmonized**, IUCN GET-compliant hierarchical ecosystem **classification**. Data-based quantification of fresh water assets currently not possible, **data** fully/partly **missing**. The Marine condition account needs refining. Some problems linked to **contradictory or non-feasible guidelines**.

France[iv]	**Methodological framework** for the **Marine ecosystem** extent, condition and monetary asset account (accounts expected in the following years). **Forest ecosystem monetary asset account** developed on a national scale. **Cultural ES** supply and use account in **monetary terms** developed on a local scale. Theoretical framework **under construction** to **calculate the unpaid ecological cost for an ecosystem** (complementary approach to valuation according to SEEA EA framework).	- Enables the formulation of strategic questions, and useful to inform coastal and marine **spatial planning**, - Facilitate **budget allocation** on natural amenities, - Follow the **state of ecosystems** through time and space, - Set **new wealth indicators**, - Inform on the **environmental costs of human activities** to better inform decision-makers for different impactful activities, - To **include ecological** debts and credits in **national accounts** - **Inform impact** of different sectors and firms on the environment **to set ecological taxation.**	**Infrequent and inconsistent data** of **marine and coastal habitats** affecting both extent and condition accounts. The **overseas territories lack data** overall except for coral reefs. The account for **unpaid ecological cost** still **needs** conceptual and technical **refinements** to become operational.
Germany[v]	Ecosystem **extent** account **available** on a regional and national scale and **condition** account **in progress**. **ES accounts in biophysical and economic terms developed:** - Natural soil fertility of cropland and grassland, - amenity value of public urban green spaces, - Appreciation of species and habitats services, - Timber and carbon sequestration of woodlands. Biophysical ES accounts done for Soil erosion mitigation, Pollination service potential and Recreation services. Accounts of Climate gas mitigation and recreation economic accounts ongoing. **Ongoing project** on monitoring, evaluation and monetization of **marine ES** in the German sea.	Some **ecosystem accounts already incorporated** into the Statistical System related to the National Sustainable Development Strategy of Germany. Focus on **biodiversity conservation targets** in urban and rural areas. **Inform policy** on the full range of ecological and economic effects of policy decisions by: - Creating a harmonized database - Elucidating the intersectoral physical and economic relations between nature, economy and society - Providing data for land use decisions and environmental policies; including scenarios for alternative policy programs (e.g. on renewable energy, infrastructure and forest and agricultural policies).	Differences in **accuracy and quality** of the available **data sources** for the extent account. Some **additional research** o better disentangle the contribution of soils from the contributions of anthropogenic factors to production. The calculation of amenity values of urban green space should be recalculated based on **more recent and harmonised data**, and there are still many questions regarding the methods and data for an **economic evaluation** for some ES accounts. **Little awareness of the importance** of integrating natural capital and ES into economic accounting and related government reports.
Iceland[vi]	There are **not yet clear and concrete** aims regarding **NCA** and no defined plans for the issues of inclusive wealth accounting, formally defined indicators or water accounting. In 2016, the ministry for the environment and natural resources started a still-**ongoing** primary phase **project mapping the natural resources** for NCA.	Especially important areas to **focus on** the **fishing sector and** targeting **ecosystem degradation**. **Volcanic activity** and related ash deposits, which can be a threat to some ecosystems. Economic **sectors with impacts on biodiversity**: energy industry, fishing, and agriculture; and infrastructure development.	**No natural capital accounts.**

Ireland[vii]	Irish NCA for Sustainable Environments **(INCASE) project** ongoing. INCASE is testing NCA principles in **four river catchments** in Ireland. Institute for the Development of Environmental-Economic Accounting (**IDEEA Group**), **developing demonstration accounts**, to see how NC approaches can be utilised by the **seafood sector**.	Environmental management, develop **decision-support tools** for policy-makers. Conduct **economic impact assessments** to analyse food production policies on NC. **Inform integrated economic and political decision-making**, sectoral policies, responsible business strategies and support evidence-based investment, rural development, health and sustainability outcomes.	**Finding and gathering the data needed**: - Coverage of spatial data, datasets available at different scales and time series. - Different resolutions and coordinates for mapping units, troubling match and compare datasets. - Data gaps, the majority in terms of condition. - Working and matching up with the catchment boundaries.
Netherlands[viii]	**High** level of **expertise and** number of **accounts published.** **Extent** and **condition** account **available** on a regional and national scale. **Wide variety of ES** incorporated in their ecosystem asset, **biophysical and monetary** ES **supply and use accounts** (currently updating). Thematic accounts: **carbon and biodiversity account published**, **first version** of the Physical **marine NCA for Dutch Sea developed**.	NCA as a **source of information** for the parliament and to **monitor SDGs**. NCA **already contributed to policy-making** on peatlands (a major issue related to **farming and climate change** in the Netherlands). **Contribution to specific policy areas** such as: - forest strategy - policies around nitrogen, - biodiversity, - nature-inclusive and circular agriculture, area development, - urban living environment - carbon storage and climate change adaptation. Not only used by policy, but **also private parties** are working with it	**Key indicators** and **usage** of the accounts in relevant policy debates and questions. **Marine and biodiversity** accounts **need further development** and still have some data gaps. **Trade-offs** between **economic use and biodiversity**, whether need to value biodiversity in monetary terms or not How to use condition account to calculate the **sustainable use of ES**
Norway[ix]	Ecosystem **extent accounts developed**, including thematic accounts for forests, agriculture and some urban areas. Ecosystem **condition** for all ecosystems **except urban** and **agricultural ecosystems**, both on a national scale, for urban recreation areas and an urban tree inventory on a regional scale. National **monetary asset** account **for agricultural ecosystems** and a regional account for **urban ecosystems** ongoing. The **Nature Index for Norway** equivalent to a **biodiversity account**. MAREA project - **MARine Ecosystem Accounting for integrated coastal planning** in the Oslofjord (local scale)	**Land use and land-use change** provide useful information to the municipalities to support their goal of "land use neutrality". Municipal **"Land use accounts" as a starting point** to introduce ecosystem accounting concepts. Focus on **land cover use of infrastructure**, especially wind power, holiday homes, road and rail. **Monetary accounting data**, in particular **restoration** and **compensation** and **infrastructure** projects. Research is needed to have tested solutions available if/when policy windows arise. Facilitate **sustainable ecosystem-based management**	The national **classifications** historically used for NCA, are **not compatible** with the new IUCN classifications used in SEEA extent accounts. There are **insufficient resources** to test the new classification methods at national scale. Until now there has **been limited national policy support** and a lack of demand for implementing a system of ecosystem accounts.
Portugal[x]	Statistics Portugal (INE), the national statistical office in Portugal, has already implemented a **Sea/Ocean Satellite Account on a routine basis**, accounts for 2010-2013, released in 2016; and 2016-2018, release in November 2020. They are harmonized with National Accounts.	Ocean Satellite Account allows having **adequate information** in the context of the **Integrated Maritime Policy (IMP).** **Measure** the **relevance** of **Ocean Economy,** and **support decision** concerning coordination of national policies for the ocean. **Monitor** National Ocean Strategy, in its economic component.	- **Different concepts** and methodological approaches. - **Identifying** and classifying Ocean Economy **entities**. - **Comparing** results. - **Insufficient** economic information / **data**. - Innovation challenges, Environmental impact and ES. - **Growing demand** for satellite accounts.

Spain[xi]	Developed on **two levels**: national level and regional level for Andalusia. At the **national level**, ecosystem **extent** and a **forest condition** account developed. **Multiple ES** and **biodiversity** accounts **ongoing** and planning to develop ecosystem asset accounts. At the **regional level**, in **Andalusia,** focus on **forest asset accounts** in monetary terms, along with **ES accounts**, **carbon** and **biodiversity** accounts. **Marine NCA** project in a **MPA in the Mediterranean area** (Marilles Foundation in the Balearic Islands)	**NCA complementary** to policy needs: SEEA EA, European Environmental-Economic Accounts (EEA) and EU and Spanish Biodiversity strategy. Focus on the **Environmental-Economic Accounts** (rolled out in Spain) and integrated into their national statistics. **Contributed** to accomplish some of the EU and Spanish B**iodiversity Strategy targets**. Discussions to **connect** the accounts to the **economic sector**.	Lack of **specific frameworks** to measure the accounts in a replicable and scalable manner. Evaluation and quantification of **some ES** (regulating and some cultural). **Marine** and other ecosystems account for **additional difficulty**. The institutions interested **lack time** and **resources**. More **political** and **legislative support** is needed. Participation and political and legislative actions challenges.
Sweden[xii]	The ecosystem accounts are still being developed in Sweden. Two ecosystem accounting **projects**: - Developing the methodology of **connecting land cover (1) and forestland (2)** data with **economic** actors. Develop of **'Symphony', an assessment tool** that calculates the **cumulative impact of human activities on the marine environment**, planners are informed of the baseline conditions and the potential effect of various planning options on the cumulative impact in different areas.	Combine statistics about ES in a way that can build on already existing environmental accounts and provide a picture of **how the economy affects the environment**, and **vice versa**. Assess the **cumulative impact** on the marine environment. Use to **support** ecosystem-based Marine Spatial Planning (**MSP**) and as a support tool for **environmental impact assessment**.	Focus on **testing land use accounts** as a way to approach ecosystem accounts. Challenges on including ecosystem **condition** information and assess the **value of ES.** **Symphony** provides a **simplified** but holistic **picture** of environmental impacts in the sea, which makes it also **less exact**.
United Kingdom[xiii]	**High** level of **expertise and** number of **accounts published.** **NCA developed and published**, keep improving and updating their methodology. **Marine natural capital accounts published** by the Office for National Statistics (ONS).	Monitor **losses and gains in NC** over time. **Identify priority areas** for investment and **inform** resourcing and management **decisions**. Highlight **links** with **economic activity** and **pressures** on NC. UK's Marine Natural Capital Ecosystem Assessment (**mNCEA**) **programme** which aims to **incorporate** all of **nature's values into decision making.**	Some **specific technical issues** such as: - Particular classification or defining issues for certain services. - Appropriate approach to valuing assets without an asset market value; or an appropriate discount rate to generate a (net) present value.

* In the countries where it is not explicitly remarked, information about marine natural capital accounts have not been found.

From the table, it can be observed that the main development is in terms of the terrestrial environment; however, there is an increasing interest and more initiatives arising regarding the marine environment in the last years. The Netherlands and the United Kingdom can be seen as the leading countries in terms of marine NCA. However, it is noted that almost all OSPAR contracting parties are involved to a certain extent in natural capital or ecosystem accounting. The main policy relevance points among the countries include monitoring the natural resources and the Sustainable Development Goals (SDGs), inform decision-making and link economic activities and environmental pressures or impacts. Finally, major knowledge gaps and difficulties encountered are lack of data, resources and standardization.

4.3 NCA pilots and first experiences outside OSPAR

Experiences from pilot cases serve as examples and guidance towards the successful development of the accounts. This section intends to illustrate the application of the accounts and the type of information that can be expected from the accounts. Two pilot projects are used as examples: the pilot project for Geographe Marine Park in Australia and the pilot ocean accounts developed in southern Thailand. These pilots were selected due to their relevance and the information revealed. These projects show and quantify the importance of the ecosystem and raise awareness of the many benefits provided by the ecosystem assets, as well as the human impact on those. The information about the experiences of Australia and Thailand was provided by GOAP (GOAP, 2020a).

Australia

In November 2020, an ocean accounting pilot project was completed for Geographe Marine Park in Commonwealth waters off Western Australia. This was part of Australia's participation in the High-Level Panel for a Sustainable Ocean Economy. This pilot includes the extent and condition of those ecosystems, the services and benefits they provide, and potential pressures. The information gathered covers commercial and recreational fishing, marine recreational activities, carbon exploration and storage, and shipbuilding and parking. The Australian pilot revealed the following:

- The Geographic Marine Park ecosystems accounted for approximately AUD 316,000 of the total operating surplus of the regional economy in 2019 through whale watching (AUD 254,000) and commercial fishing (AUD 62,000).
- With over 12,000 fishing trips in 2018, recreational fisheries services are valued at AUD 2.2 million.
- Graphic Marine Park's seagrass meadows were estimated to store about 6.2 million tons of carbon in the soil, with about 27,569 tonnes (net) additional separated each year. Based on estimates from 2014.
- The annual amount sequestered in these seagrass meadows is equivalent to the average carbon emissions of 1,500 households per year, estimated at AUD 443,865 (assumed AUD 16.10 per tonne).

The information developed as part of the project raises awareness of the many benefits provided by Geography Marine Park assets, expands existing understanding, informs risk assessment, and helps to prioritise monitoring activities in the future. The accounting process also identifies information gaps, providing methods that can be enhanced. The standardisation of ecological data collection and transformation methods result in better-informed management of Australia's oceans.

Thailand

Thailand aims to manage better maritime and marine resources, guided by its national strategy and development plans. Their national plan and strategies include promoting interdependent and balanced development in the economic, environmental, land and maritime sectors, as well as considering aspects of quality of life. Thailand recognizes the tourist area as the main driver of inclusive growth, but at the same time, it is one of the main contributors to the unbalanced use of natural resources and environmental degradation, especially in the coastal provinces.

In 2019, in response to the need for integrated environmental and economic data for the sustainable planning and management of tourist sustainability, pilot ocean accounts were developed in the main tourist destinations in southern Thailand (Phuket, Krabi, Phang Nga, Trang, and Saturn or so-called Andaman Tourism Cluster). Thailand has created Tourism Satellite Accounts (TSA) regularly but no previous SEEA integration. Thus, the objective of the pilot study was to integrate tourism and environmental statistics and produce integrative maps to locate areas with high risks of exceeding carrying capacity for accommodating tourism activities. The information from the pilot showed that:

- Although only one out of nine persons in the five provinces were tourists, tourism-related activities used:
    - 21% of the water,
    - 57% of the energy
- and was responsible for:
    - 26% of the waste and
    - 28% of the greenhouse gas emissions.
- Additionally, the high-risk areas and proposed sites for conservation were identified.

Regarding the current progress in the implementation of marine accounts, the methods used in the pilot study are being replicated in other tourism groups across the country. In addition, and thanks to knowledge gained from the pilot, Thailand is involved in a new project, integrating ocean accounts, Ocean Health Index Plus (OHI+) and MSP in Phang Nga Bay. This new project aims to create an integrated decision support system to inform Thai policymakers and programs for the sustainable management and protection of coastal and marine resources.

Other countries experiences

Finally, other examples where the UN highlighted the actual policy use of the SEEA EA framework are the following (UN-SEEA, n.d.-a, n.d.-b):

- In Indonesia, carbon accounts have been used to assess the impacts of changes in peatland ecosystems. The analysis revealed that 52% of peat forests in Sumatra and Kalimantan had been converted to other land uses during the period 1990-2014, with greater losses occurring in Sumatra. The accounts reveal that conversions were associated with significant oil palm production increases, generating high monetary value. However, they also resulted in a 31% loss of carbon stocks from 1990 to 2014 and a 74% increase in net carbon emissions during the same period, making degraded peatland a significant source of Indonesia’s GHG emissions (UN-SEEA, n.d.-a; World Bank, 2018);

- In South Africa, ecosystem extent and condition accounts for rivers have informed the National Water and Sanitation Master Plan. The key finding from the river accounts was that the ecological condition of South Africa's rivers declined by 10% from 1999 to 2011 (Nel & Driver, 2015; UN-SEEA, n.d.-a);

- In Uganda, species accounts have demonstrated the economic importance of the indigenous Shea tree. The accounts revealed the important potential for sustainable Shea butter tree nut harvesting outside of protected areas, although there is a significant decrease in coverage between 1990 and 2015 (Experimental Ecosystem Accounts for Uganda); and

- The use of data from ecosystem extent and condition accounts has been used to monitor progress towards the UN Sustainable Development Goals and the Strategic objectives of the UN Convention to Combat Desertification. Hence, NCA will provide relevant information for monitoring the Post-2020 Global Biodiversity Framework (UN-SEEA, n.d.-a).

4.4 NCA potential decision-making use and applications

Due to the current urgent necessity of new tools to support decision-making, the natural capital accounts can provide comprehensive, structured, consistent, coherent, spatially referenced, and adaptable information. Moreover, NCA has several key features that allow it to support, complement and extend other measurement frameworks and initiatives. Consequently, when recorded regularly, the information detailed in these accounts can support a broad range of decision-making processes concerning ocean management (Eurostat, n.d.-a; GOAP, 2020b; IDEEA Group, 2020; UN-SEEA, 2014, personal communications), such as:

Understanding the interdependency of the blue economy and the marine environment: The development of the accounts provides information that can be used to support the formulation of strategies and goals for the sustainable progress of the "sea" or "blue" economy, hence, serving as a strategic development planning tool for decision making. In this way, the accounts inform about who benefits and who is negatively impacted from the current use of natural resources, what are the impacts on the state of the environment and specific sectors of the economy, what is the size of environmental investment in the economy or how many 'blue' jobs the economy generates. On the one hand, the accounts support results-oriented reporting. SEEA shifts the focus from inputs, the current area of sustainability measurement, to results. On the other hand, the accounts can be used to combine stories about economic growth and sustainability in a jointly and coherent manner.

Communication and reporting: The advantage of using NCA to support communication is the development of a common language and narrative in the greater scope and integrity of engagement. In addition, communication can also be external by communicating the information to the interested parties, thus becoming reporting. The objective of the external reporting is to communicate information to those who depend on the marine ecosystems and their functions, to those who regulate the activities occurring and to those who have an indirect impact by demanding goods and services on the marine ecosystems.

NCA as a tool to support operational and management decisions (e.g., Marine and Coastal Spatial Planning): The details that NCA provides about how is the condition, health and integrity of ecosystems and biodiversity changing over time or where are the main areas of degradation and enhancement can serve to guide the ocean space management. A broad understanding of the current and past extent, condition and value of ocean assets (including ecosystems) and flows of benefits associated with those assets can help on the designation and monitoring of protected areas, marine/maritime spatial planning (MSP) and integrated coastal zone management (ICZM), and regulatory approvals and conditions for ocean activities and infrastructure.

Finance and investment allocation: NCA of financial flows and the associated changes in social, environmental or economic conditions provides integrated and holistic information. Different projects and initiatives can be compared quantitatively, potentially strengthening assessments that inform capital allocation. This can then be used to design and allocate taxes, subsidies and public investment related to oceans for specific economic sectors, social groups or locations.

Regulatory decisions: The accounts allow informed decision-making in the promulgation of regulatory instruments and granting of conditional permits and licenses for ocean economic activities. Decision-makers are informed by making use of developed integrated indicators which can be understood by stakeholders from different disciplines. A standardized set of information, such as NCA, can be useful to achieve recognised schemes to drive the needs of the different certifications of different buyers and markets.

Identify trade-offs: Considering the comprehensive data generated by the accounts, they can provide a better picture of trade-offs between different ecosystems services or stakeholders. The identification of different synergies and trade-offs between ES inform future policy to ensure optimal outcomes to enhance biodiversity.

As an example and combining this application with financial allocation uses, the return on investment is a measure used by organizations to allocate financial capital. In this way, the accounts can be used to identify trade-offs across projects and used to assist in the development of some industries and to allocate capital effectively.

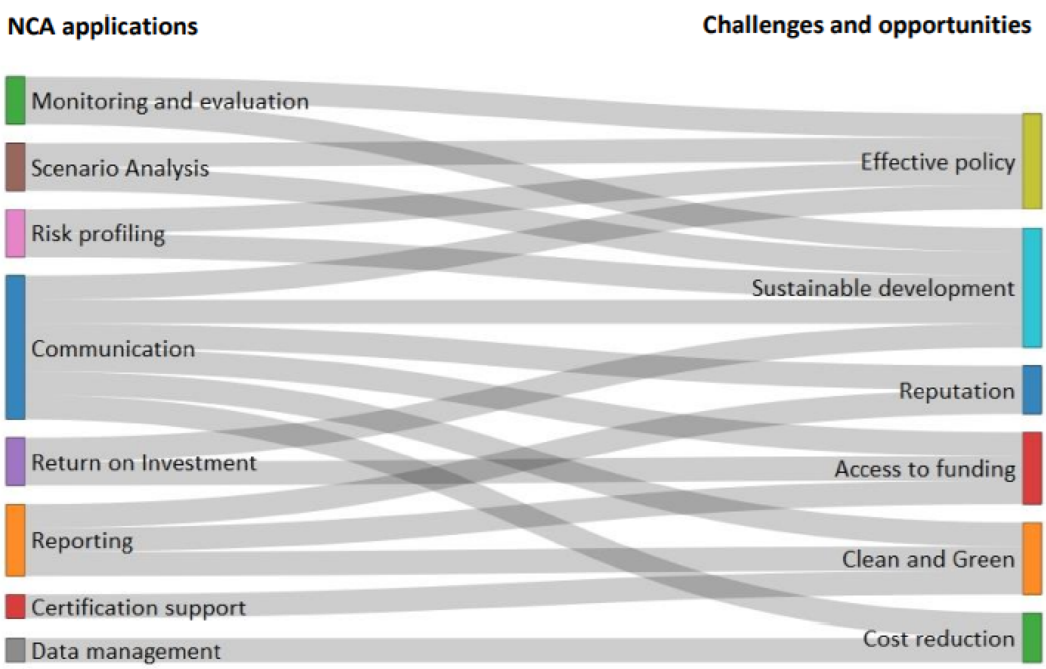
Monitor status of the marine environment, ocean analysis and policy evaluation: The regular development of the accounts enables to compare and conclude which is the state of the ecosystems, if they are managed sustainably or if they are being depleted. The time series of integrated economic and environmental information recorded in the accounts can inform and contextualize impact assessment, strategic impact assessment, and benefit-cost analysis.

Monitoring and evaluating are central elements of effective policy at all levels of government. NCA facilitates the evaluation and improvement of policies, programs and investments to add value through multiple paths (human capital and natural capital) using internationally agreed performance metrics. This allows for more informed and evidence-based policy development based on consistent monitoring and evaluation approaches across governments.

Thus, NCA can be potentially used in the MSFD analyses of marine waters and cost-of-degradation. Additionally, indicators derived from the accounts can be used for monitoring EU progress towards sustainable development goals. For instance, the use of the ecosystem accounts in scenario analysis can provide policymakers with a better understanding of the links that exist between society, economy and the environment, and hence lead to better decisions. The accounts support scenario analyses as they reflect business as usual and provide a framing to describe and collect information for the scenario. In this sense, NCA can serve as guidance focusing on the use of backwards-looking data in forward-looking policy scenario analyses that allows policymakers to assess the possible impacts of their choices.

The following figure (Figure 8) illustrates how the different NCA applications can be connected to different challenges and opportunities in a pilot case in Ireland. For this pilot case, Bord Iascaigh Mhara (BIM) - the agency of the Irish state with responsibility for developing the Irish marine fishing and aquaculture industries-engaged IDEEA Group in 2019 to assess how NCA could support BIM and the aquaculture and fisheries operators within the seafood industry. Figure 8 is extracted from the pilot report and shows how NCA has a significant added value for marine-related decision making.

Figure 8. Linking NCA applications and challenges and opportunities faced by marine fishing and aquaculture industries. Source: (IDEEA Group, 2020)

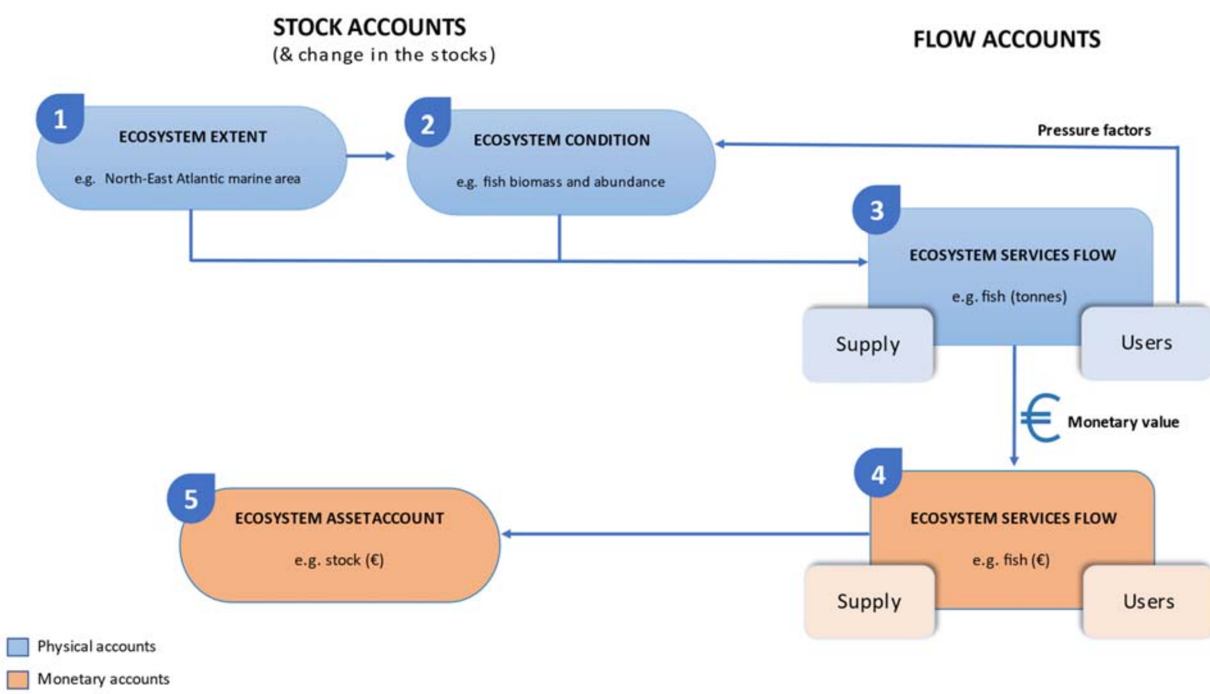


5 Exploring natural capital accounts for OSPAR

In this chapter, available information is examined to fill a set of initial marine capital natural accounts for the North-East Atlantic. To start using NCA as a tool, the most practical approach would be to customize a 'quick-start guide' with a few ES and gradually improve the methodology as accounts are constructed. OSPAR has a large database at its disposal and conducts periodic assessments of the status and activities that occur in the North-East Atlantic area (odims.ospar.org, oap.ospar.org). This information will be the main source for the development of the accounts. In this way, it is also possible to identify what information is already available to OSPAR and what is not available to focus future efforts in those areas or to search for alternative sources. Due to the international relevance of the SEEA EA framework and its adoption by the UN, this statistical framework, explained in section 3.2., is used to compile the accounts along with the GOAP recommendations.

The sections in this Chapter will follow the various steps in the SEEA EA framework illustrated in Figure 9. The five accounts constituting the framework can be seen below. Accounts 1,2, and 5 are stock accounts, and the ES ones (3 and 4) are flow accounts. The blue boxes refer to the physical accounts, and the orange ones indicate the accounts expressed in monetary terms. It can be observed how the different accounts need information from the previous ones, and therefore, they are interconnected and integrated with each other. The users of the ES may exert pressure factors, which are included in the condition account, creating feedback between the accounts.

Figure 9. SEEA EA framework followed in this study



5.1 Ecosystem type and extent account

The basis of all the accounts is the extent account. Ecosystem extent accounts organize data about the extent or area of the various ecosystem types, differentiating between the different ecosystem assets present in the ecosystem accounting area (EAA) (United Nations, 2021).

Extent accounts data describe the composition and change in ecosystem types, including content related to conversions between different ecosystem types within a country. Hence, it can provide a common basis for discussion among stakeholders. The compilation of this account is also relevant in determining the appropriate ecosystem types that will underpin the structure of other accounts (United Nations, 2021). Due to the three-dimensional characteristics and complexity of delineating marine ecosystem assets in a vertically stratified manner, for this report, delineation based on the areas of different ecosystem types associated with the seabed is the most practical measurement pathway for accounting purposes.

Both SEEA EA and GOAP recommendations agreed to consider the IUCN Global Ecosystem Typology (GET) as a "reference classification". GET is an advised starting point and a reference for international comparison in the absence of an agreed national classification of ecosystems. The IUCN GET was developed by the IUCN Red List of Ecosystems Thematic Group. It combines a global process-based and biogeographical approach. The goal is to develop an extensible framework that supports the generalization of functionally similar ecosystem groups and recognizes the different expressions defined by the composition of contrasting organisms in these groups. Since marine accounts need to establish ecosystem types, GOAP suggests that it may be more useful to classify them in functional groups (IUCN GET level 3). At this level, IUCN GET has identified 22 marine functional groups (e.g., seagrass beds) and 12 transitional functional groups (e.g. intertidal forests and shrubs (mangroves) (GOAP, 2020b; United Nations, 2021).

Although the IUCN GET is the recommended ecosystem classification, it is not available at the OSPAR level. Therefore, following the example from the Initial natural capital accounts for the UK marine and coastal environment report (Thornton et al., 2019), as well as other countries such as France or Bulgaria (MAIA, n.d.), in this report, the broad habitat definitions based on the European Nature Information System (EUNIS) is used.

The EUNIS classification combines a hierarchical structure to define habitats from very broad scales (level 1) to fine, species-specific scales (level 4, 5, or 6). In this report, levels 2, 3 and 4 are used as these were available. The EUNIS classification is based on substrate types that contain some unique and clear biological characteristics that are important for providing specific ES (European Environment Agency, n.d.). To account for the maximum extension of the OSPAR area, the EMODnet broad-scale seabed habitat map for Europe (also known as EUSeaMap 2019) is used (EMODnet, n.d.).

The EUSeaMap is a broad-scale seabed habitat map for Europe. It is a comprehensive, free and readily available map that harmonizes mapping procedures and promotes a common understanding among European seabed mappers. EUSeaMap's broad-scale predictive mapping method is repeatable, ensuring that maps can be continuously improved in the future. The EUSeaMap 2019 covers EUNIS Category A (Marine Habitats) (EMODnet, n.d.; Vasquez et al., 2020). However, the associated seabed data cannot be used to accurately predict the extent of such dynamic habitats as littoral habitats. Consequently, the extent of Littoral habitat for EUNIS categories A1 (Littoral rock and other hard substrata) and A2 (Littoral sediment) are missing.

The broad-scale seabed habitat map is adapted to cover only the OSPAR area by intersecting the EUSeaMap and the OSPAR region files. The OSPAR region file covers the area within OSPAR boundaries as defined by the OSPAR Convention text, so only the Maritime Area[3] (OSPAR, 1998). The map produced by these actions illustrates the OSPAR ecosystem accounting area (Figure 10). Subsequently, Table 2 can be generated, providing the details of the extent (ha) for each EUNIS level 2 or 3[4] habitats used for the extent accounts. Appendix I includes an extended version of the table generated incorporating level 4 where possible.

[3] "Maritime area" means the internal waters and the territorial seas of the Contracting Parties, the sea beyond and adjacent to the territorial sea under the jurisdiction of the coastal state to the extent recognised by international law, and the high seas, including the bed of all those waters and its sub-soil (OSPAR, 1998).

[4] EUNIS classification incorporates a hierarchical structure to define habitats from a very broad scale (level 1) down to fine, species specific, scale (level 4, 5 or 6). Here we use levels 2 and 3, which are based on substrate type incorporating some distinctive, defining biological features important to the delivery of the specific ecosystem service of interest (European Environment Agency, 2019a; Thornton et al., 2019).

Figure 10. OSPAR seabed habitat map based on EUSeaMap 2019 (EUNIS classification).

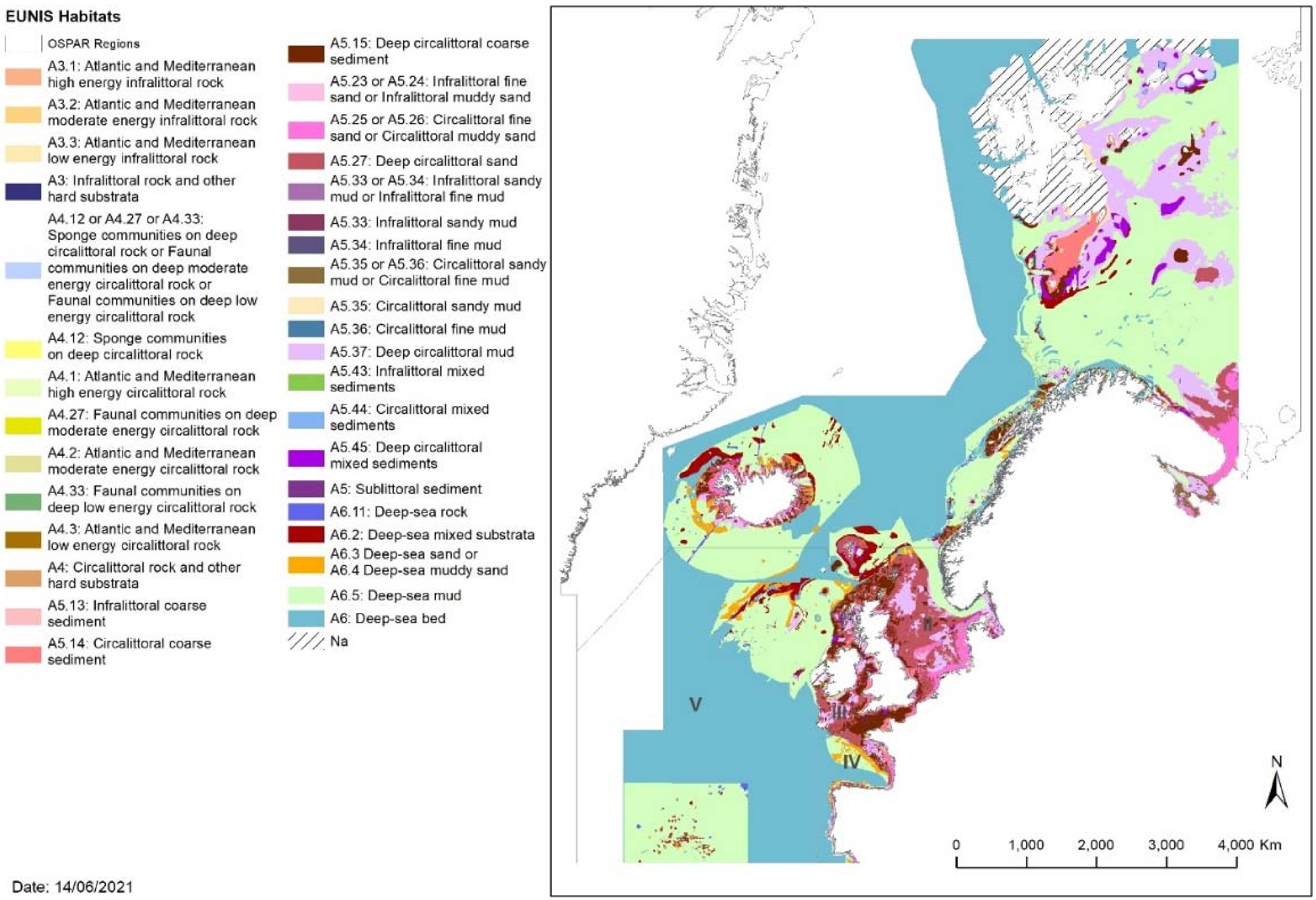


Table 2. The extent of OSPAR marine habitats (EUNIS classification levels 2 and 3)

EUNIS Habitat		Extent Area (km2)	Extent Area (ha)
Level 2	Level 3		
A3: Infralittoral rock and other hard substrata		2,429.59	242,959.40
	A3.1: Atlantic and Mediterranean high energy infralittoral rock	3,768.38	376,837.57
	A3.2: Atlantic and Mediterranean moderate energy infralittoral rock	1,293.70	129,369.70
	A3.3: Atlantic and Mediterranean low energy infralittoral rock	1,490.00	148,999.60
A4: Circalittoral rock and other hard substrata		2,850.93	285,092.77
	A4.1: Atlantic and Mediterranean high energy circalittoral rock	18,696.42	1,869,642.19
	A4.2: Atlantic and Mediterranean moderate energy circalittoral rock	11,143.75	1,114,375.20
	A4.3: Atlantic and Mediterranean low energy circalittoral rock	31,067.48	3,106,747.69
A5: Sublittoral sediment		6,784.75	678,475.40
	A5.1: Sublittoral coarse sediment	373,680.92	37,368,092.26
	A5.2: Sublittoral sand	683,052.59	68,305,259.10
	A5.3: Sublittoral mud	453,612.14	45,361,213.77
	A5.4: Sublittoral mixed sediments	55,398.25	5,539,825.10
A6: Deep-sea bed		4,200,112.73	420,011,273.35
	A6.1: Deep-sea rock and artificial hard substrata	46,089.16	4,608,916.40
	A6.2: Deep-sea mixed substrata	147,561.10	14,756,109.53
	A6.3 Deep-sea sand or A6.4 Deep-sea muddy sand	150,385.88	15,038,588.17
	A6.5: Deep-sea mud	3,033,135.36	303,313,536.47
	Na	170,298.02	17,029,801.74
	Total Area	**9,392,851.15**	**939,285,115.43**

As previously explained, two important levels are missing regarding littoral habitats, levels A1 and A2. Therefore, crucial habitats are missing and not covered in the extent account. Some of the ecosystems missing provide important benefits to society; thus, these benefits cannot be assessed without further research or the use of more sources. Among these ecosystems, it is possible to remark the absence of particularly important ones as coral reefs (genetic material storage and educational and scientific research), mangroves (nursery and breeding habitat, storm protection) or saltmarshes (regulating and recreation) (Barbier, 2017). For this reason, the Ecosystem Extent Accounts published by the European Environment Agency (EEA) is used to complete the extent account as much as possible. Table 3 contain *'Saltmarshes'*, *'Salines and intertidal area'* and *'Coastal waters'* ecosystem types extension covered by the EEA Ecosystem Extent Accounts for the North-East Atlantic zone and only for the OSPAR contracting countries. Saltmarshes, Intertidal flats and Salines are related to the EUNIS A2 level missing (European Environment Agency, 2021).

Table 3.Extent of marine habitat included in the EEA Ecosystem Extent Accounts. Source: (European Environment Agency, 2021).

Ecosystem type	**Extent area (km2)**	**Extent area (ha)**
Saltmarshes	1,239	123,905
Salines and intertidal area	10,592	1,059,206
Coastal water (coastal lagoons and estuaries)	3,158	315,794

Most of the information collected by OSPAR is distinguish and classified per region. Appendix I comprehend five figures (Figure I – Figure V) that display the percentages of the different ecosystem types' presence per region. Some of the conclusions that can be derived from these figures are:

Region I: Artic Waters

The most abundant habitats in Region I are *Deep-sea mud* with 38% and *Deep-sea bed* occupying 35% of the habitats data available for Region I; followed by *Sublittoral sand* and *Sublittoral mud* with 8% and 6%.

Region II: Greater North Sea

In the case of Region II, it is possible to observe more variety of habitats abundance. *Sublittoral sand* is present in 47% of the data available for Region II. *Sublittoral coarse sediments* and *Sublittoral mud* are the following habitats that occupy more extension in this region for which data is available, with a percentage of 18% and 16%.

Region III: Celtic Seas

In Region III, the largest habitats found were *Sublittoral coarse sediment*, *Sublittoral sand* and *Sublittoral mud* with 34%, 31% and 16%, respectively. There is 9% of the area included in the EUSeaMap for this region that is classified as Not available (Na), so that area is not classified as any habitat type.

Region IV: The Bay of Biscay and Iberian Coast

Deep-sea bed occupy 49% of the area covered by the EUSeaMap for Region IV. Deep-sea mud and Sublittoral sand with 16% and 10% are the habitats more abundant identified in the other 51% of data available for Region IV.

Region V: Wider Atlantic

Finally, in Region V, the greater habitats are Deep-sea bed and Deep-sea mud, constituting 60% and 37% of the area.

Limits, uncertainties and risks

Regarding the database used for this report, it should be noted that EUNIS classes A1 and A2 are missing. Therefore key habitats providing crucial ES are missing (such as seagrass, intertidal salt marsh, reefs or kelp forests). Additionally, the use of the EUNIS classification has been criticised because it does not include the water column and is thus more a seabed classification than a classification of ecosystem types. The IUCN GET is a better classification but not available yet in a database (GOAP, 2020b; United Nations, 2021).

The database used was the EUSeaMap of 2019, which was the only option found that covers more than one country Exclusive Economic Zone, and it has been used in other NCA examples. The EUSeaMap was constructed in different phases and is not available over time. Therefore, comparisons to the previous extent of habitats are not possible. Although this extent account can be used as a baseline for future NCA, it is worth mentioning that there is a clear challenge concerning the available data that fits the NCA framework. It would be desirable to produce EUSeaMaps for different years, e.g., have a freeze every 5 or 6 years, so that one can see the changes over time or find another way to get that information.

This report focused on natural capital accounting for the OSPAR area. OSPAR boundaries include only the Maritime Area, so in this report, only the Maritime OSPAR area was included. However, some activities that take place on land are relevant to the ecological status of the sea. Also, some human activities that use the sea do so from land. Therefore, also in this study, for some activities (e.g., recreation), coastal areas were included in the analyses as well. Since it is difficult to fix and use uniform boundaries, it is recommended to have further discussion within OSPAR about the spatial scope that has to be used in any future versions of the NCA.

Only increasing spatial resolution is not sufficient to enhance the legitimacy and utility of maps. In many cases, stakeholders do not participate in choosing the ES that are mapped or in the selection of the modelling methodology. More credibility and acceptance of ES maps is expected if models are co-produced with the active participation of the end-users: considering that the model aims to inform, understand the level of spatial heterogeneity that needs to be captured, and jointly evaluate the quality of the indicators and data available (Zulian et al., 2018).

5.2 Ecosystem condition account

A core feature of ecosystem accounting is the organization of biophysical information about the conditions of different types of ecosystems. The Ecosystem Condition Account organizes data on the characteristics of selected ecosystems and the distance to a reference condition to provide information about the ecological integrity of the ecosystem. It will also organize relevant data to measure the ecosystem's ability or capacity to provide or supply different ES (United Nations, 2021).

Ideally, an integrated ecosystem-level assessment should cover as many ecosystem components as possible (physical, biological and social). However, there may be trade-offs between understanding the overall complexity and functioning of marine ecosystems and balancing the size of the project (size of the region, project collaboration), or research capacity (funds and time) and the ecological data capacity. By simplifying complex ecosystem-level data and returning it to indicators that are easy to interpret, indicators help to communicate ecological outcomes and inform policy. The indicators depend on how the state of a particular ecosystem is defined and the availability of services and data that the ecosystem is expected to provide. These indicators can vary from simple (e.g., indices of single-species population parameters) to more complex (e.g., trophic models and indicators of ecosystem resilience). Comparison among assessment of ecosystem status, knowing what indicators to use and how to apply them best has become more and more difficult as a result of lack of standardisation and consistency among studies (Smit et al., 2021; United Nations, 2021).

OSPAR developed a set of Ecological Quality Objectives (EcoQOs) which intend to define the ecosystem health of the North Sea (first set of EcoQOs has been tested and evaluated by North Sea countries, OSPAR Region II, in the period 2002- 2009) and could be used as a reference condition (OSPAR, 2010; OSPAR Commission, 2010b). The Quality Status Report 2023 and the EU MSFD EcoQOs have been replaced by a more comprehensive suite of environmental indicators. Some of the key condition variables that would inform multiple ocean-related concerns based on the GOAP technical guidance are acidity, eutrophication, species diversity, ecosystem diversity, concentration, sea surface temperature, coral condition, seagrass and mangrove cover, fish stocks state or grade of minerals (GOAP, 2020b). Several of these indicators have already been assessed by OSPAR in the Quality Status Reports (QSR), where the quality status of the North-East Atlantic is evaluated for taking forward OSPAR’s vision of a clean, healthy and biologically diverse sea (OSPAR Commission, 2010b). Hence, the assessments tools developed by OSPAR could be considered consistent with the SEEA EA framework regarding some aspects. However, the indicators currently presented at the OSPAR level cannot be directly linked to the various ecosystems since they are related only to the different OSPAR regions.

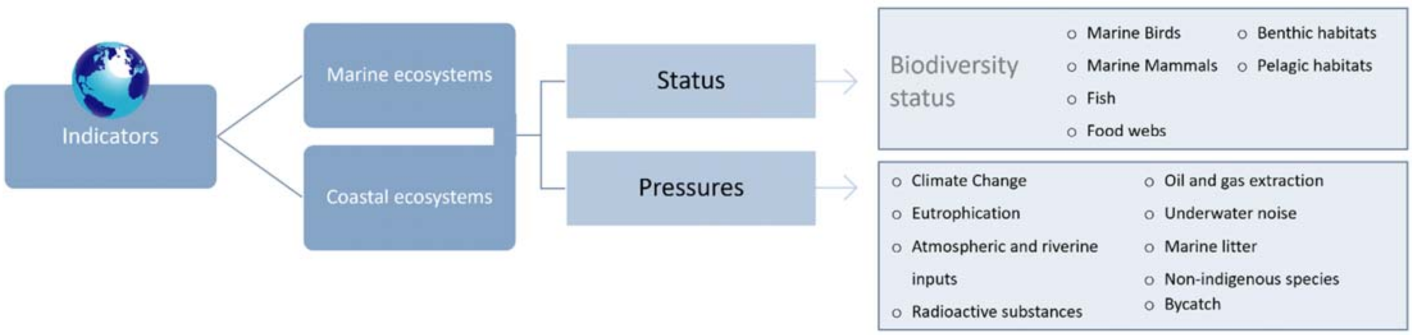
Theoretically, the condition account for OSPAR would be an overview of the state of the ecosystem types by using indicators for measuring the environmental or quality status of the ecosystem, together with indicators of the pressures exerted on them. As a first step, this report gives an overview of the quality status, and pressures indicators (formerly Ecological Quality Objectives) that OSPAR has already used in assessments such as the QSR2010, IA2017 or that will be used in the QSR2023. This approach is compatible with the Pressure, State Change and Impact (on Welfare) components of the DAPSIR framework being applied in the QSR2023 thematic assessment templates (OSPAR, n.d.-a, 2019).

The main intention here is to synthesise rather than replace existing monitoring data, in this case, that is relevant for OSPAR. The tables included in this section organize OSPAR indicators following the SEEA ecosystem condition typology (ECT)[5], hence,

[5] The SEEA ECT is a hierarchical typology used to organize data about the characteristics of ecosystem conditions. By describing a meaningful sequence and range of attributes, it can be

providing an idea of what indicators OSPAR could use to build the condition account. Figure 11 illustrates the actions undertaken for generating Tables 4, 5, 6 and 7, which provide an overview of the indicators available at the OSPAR level that can be used in the future to build the condition account for the North-East Atlantic.

Figure 11. Actions followed to give an overview of OSPAR indicators organized and categorized based on SEEA Ecosystem Condition Typology (ECT)



OSPAR indicators are distinguished between coastal or marine environment-related. Later, these indicators are also classified between status quality or state change indicators and pressures indicators, following the SEEA ECT.

Therefore, the following tables classify the indicators per 'Thematic Assessment', which will form core chapters in the QSR 2023. The 'Thematic Assessments' are related to the theme strategies mentioned in sections 2.2 and 2.3. These assessments gather several indicator assessments, other assessments (both OSPAR- and third party assessments), data products and other relevant information to evidence conclusions and statements on progress for status, pressures and implemented measures (QSR 2023 Guidance Document, n.d.). The extended version of these tables can be found in the Appendix, which also includes information about indicators units, the OSPAR group leading the work, the state of the different assessments and source of information.

The tables below (Table 4 - 7) summarise the results after following the procedure explained above and shown in Figure 11.

used as a template for selecting variables and indicators, and provide a structure for aggregation. The ECT establishes a common language to support increased comparability among different ecosystem condition studies as well (United Nations, 2021).

Quality status indicators for **marine ecosystems**:

Table 4. OSPAR Quality status indicators for marine ecosystems.

Thematic Assessment	State change Indicator
A. Abiotic ecosystem characteristics	
A.1. Physical state characteristics	
A.2. Chemical state characteristics	
Marine Birds	• Marine bird habitat quality (B7)
Benthic habitat	• Condition of benthic habitat communities: the common conceptual approach (BH2)*
	• Benthic multimetric index quality assessment (BH2b) Condition of benthic habitat communities (BH2-B): Subtidal Habitats of the Southern North Sea
B. Biotic ecosystem characteristics	
B.1.Compositional state characteristics	
Marine Birds	• Marine bird abundance (B1)
Marine Mammals	• Seal abundance and distribution (M3)
	• Abundance and distribution of marine mammals (M4) - Abundance and Distribution of Cetaceans - Abundance and Distribution of Coastal Bottlenose Dolphins - Pilot Assessment on Abundance and Distribution of Killer Whales
Fish	• Distributional range (FC7)
	• Fish distributional pattern (FC8)
	• Recovery in the population abundance of sensitive fish species (FC1)
	• Proportion of large fish (Large Fish Index) (FC2)
Food webs	• Fish biomass and abundance of dietary functional groups (FW7)
	• Biomass trophic spectrum (FW8)
	• Ecological network analysis diversity (FW9)
Benthic habitats	• Typical species composition (BH1)
Pelagic habitats	• Plankton biomass &/or abundance (PH2)
B.2. Structural state characteristics	
Food webs	• Production of phytoplankton (FW2)
	• Biomass, species composition and spatial distribution of zooplankton (Candidate) (FW6)
B.3. Functional state characteristics	
Marine Birds	• Breeding success of Kittiwake (B2)
	• Marine bird breeding success (B3)
Marine Mammals	• Grey seal pup production (M5)
Food webs	• Mean maximum length of demersal fish and elasmobracnchs (FC3)
	• Size composition in fish communities (FW3)
	• Change in average trophic level of marine predators in the Bay of Biscay (FW4)
Benthic habitats	• Size frequency distribution of bivalve or other sensitive/indicator species
Pelagic habitats	• Changes in plankton functional types (life form) index ratio (PH1/FW5)
	• Changes in biodiversity index(s) (PH3)
C. Landscape level characteristics	
C.1. Landscape and seascape characteristics	

Candidate indicator

Pressures indicators for **marine ecosystems**:

Table 5. OSPAR Pressures indicators for marine ecosystems.

Thematic Assessment	Pressure Indicator
Climate Change and physical pressures	
Climate change	(no indicator found but relevant)
Ocean acidification	(no indicator found but relevant)
Temperature changes	Sea Surface Temperature (no indicator found but relevant)
Salinity changes	salt content of the sea water (no indicator found but relevant)
Hydrological changes	Sea level changes (no indicator found but relevant)
Pollution and other chemical pressures	
Atmospheric and riverine inputs	• Waterborne & atmospheric nutrient input trends • Inputs of heavy metals via water and air • Status and trends in the concentrations of polycyclic aromatic hydrocarbons (PAHs) in shellfish & sediment • Status and trends of polychlorinated biphenyls (PCB) in fish and shellfish & sediment • Trends in concentrations of polybrominated diphenyl ethers (PBDEs) in fish and shellfish &sediment • Status and trends in the levels of imposex in marine gastropods (TBT in Shellfish) • Status and trends of TBT in sediments • Status and trends for heavy metals (mercury, cadmium and lead) in fish and shellfish & sediment
Radionuclide contamination	β – activity discharges levels of radioactive substances
Eutrophication	• Winter nutrient concentrations • Growing season concentrations of chlorophyll-a • Concentrations of dissolved oxygen near the seafloor
Other physical pressures	
Marine birds	• Marine bird bycatch (B5)
Marine Mammals	• Marine mammal bycatch (M6)
Litter	• Beach litter • Seabed litter • Ingestion by Fulmars • Ingestion plastic particles by turtles
Underwater noise	• Impulsive noise impacts (Candidate) • Ambient noise (candidate) • Impulsive noise pressure
Oil and gas discharges	Number and total quantities of oil spilled
Biological pressures	
Non-indigenous species	• Trends in New Records of Non-Indigenous Species Introduced by Human Activities (NIS3)

Candidate indicator

Quality status indicators for **coastal areas**:

Table 6. OSPAR Quality status indicators for coastal areas.

Thematic Assessment	State change Indicator
A. Abiotic ecosystem characteristics	
A.1. Physical state characteristics	
A.2. Chemical state characteristics	
Marine Birds	• Marine bird habitat quality (B7)
Benthic habitat	• Condition of benthic habitat communities: the common conceptual approach (BH2)*
	• Assessment of coastal habitats exposed to nutrient and organic enrichment (BH2a)
B. Biotic ecosystem characteristics	
B.1.Compositional state characteristics	
Marine Birds	• Marine bird abundance (B1)
Marine Mammals	• Seal abundance and distribution (M3)
	• Abundance and distribution of marine mammals (M4) - Abundance and Distribution of Coastal Bottlenose Dolphins
B.2. Structural state characteristics	
B.3. Functional state characteristics	
Marine Birds	• Breeding success of Kittiwake (Candidate) (B2)
	• Marine bird breeding success (B3)
Marine Mammals	• Grey seal pup production (M5)
C. Landscape level characteristics	
C.1. Landscape and seascape characteristics	

Candidate indicator

Pressures indicators for **coastal areas**:

Table 7. OSPAR Pressures indicators for coastal areas.

Thematic Assessment	Pressure Indicator
Other physical pressures	
Litter	• Beach litter

OSPAR can use these tables to discuss and decide which indicators and in which scale are more convenient to include in the condition account. This will guide condition accounting (aligned with the quality status assessment) in the future; for instance, some indicators may not be deemed essential and other relevant indicators may be missing so they could be developed for inclusion. Ultimately, after discussing and deciding which indicators are more appropriate, the indicators can be calculated per ecosystem type and generate the OSPAR condition account.

Limits, uncertainties and risks

The main challenge that hindered the construction of a condition account in this report is the fact that OSPAR collects the condition information per region instead of per ecosystem type. This means that with the available information, it is unfortunately not possible to relate the condition indicators to ecosystem types.

It is also important to point out that the list of OSPAR condition indicators seems to be somewhat unbalanced; more weighted towards animal or species indicators, which inherits the risk of being a bit misleading as these animals and species tend to be quite mobile. It is therefore recommended that the indicators used are either more selective or combined in some way.

Furthermore, as stated before, the EUNIS classification does not take into account the differential nature of the water column, which might be more relevant for the condition accounts than the sea bed itself. Good environmental status is monitored under the WFD or MSFD (Spaans, 2020). A possible solution could be to combine other databases, e.g., the database for coastal and marine water quality.

As mentioned before, the coastal areas are also relevant for ocean accounting. Because of their potential importance, condition indicators related to coastal areas are included but shown separately.

The above facts could end up in the absence of some condition indicators specific to particular ecosystem types, which would be worth including.

5.3 Key Ecosystem Services for the OSPAR area

The ecosystem service concept is used in various cases, resulting in a range of different ES classification schemes. In the absence of an internationally agreed classification of ES, the last SEEA EA report has developed a reference list of selected ES by combining the findings from the CICES, MA, TEEB and IPBES-NCP, among other works. The ES included in the so-called reference list of selected ES are those services considered to constitute ES with significant relevance in many countries and contexts. The list is structured in three large categories: provisioning, regulating & maintenance and cultural services (United Nations, 2021). MA and TEEB also include a fourth category, namely 'supporting services' (MA, 2005; TEEB, 2009). In CICES, this category is considered to be included in the other categories (Noordegraaf, 2020). Since this report follows SEEA EA and GOAP guidance, only the three categories previously mentioned are considered.

Following SEEA EA and GOAP recommendations, ES are considered to be distinct from abiotic flows while both reflect contributions from the environment (GOAP, 2020b; United Nations, 2021). Nevertheless, the SEEA EA framework includes 'Spatial Functions' also as a component of contributions from the environment. When doing NCA, both abiotic flows and ES are encouraged to be recorded since their consideration could enhance environmental trends assessments for spatial areas (particularly for water flows) (United Nations, 2021).
Table 8 illustrates how SEEA EA frames the mentioned contributions from the environment to people, adapted to the marine environment and including the relevance of ES to Ocean Accounts as explained in the technical recommendation of GOAP.

Table 8. Contributions from the environment: SEEA Reference list of selected ES, abiotic flows and spatial functions, edited to focus on relevant marine ES. Source: (GOAP, 2020b; United Nations, 2021)

Ecosystem service		**Relevance to Ocean Accounts**	**Services included in this report**
Provisioning services			
Biomass provisioning services	Fish and other aquatic products provisioning services	including from coastal aquaculture and capture fisheries and marine fisheries	Fisheries Aquaculture
Water supply (Purification and regulation)		may apply to mangroves, tidal flats, estuaries and coastal vegetation in terms of purifying inland water flows to the ocean	
Genetic material services		Applies as well to materials supplied from coastal and marine ecosystems	
Regulation and maintenance services			
Global climate regulation services		Including carbon sequestration and storage by phytoplankton, mangroves, and seagrasses	Carbon sequestration
Rainfall pattern regulation services (at subcontinental scale		intended for tropical forests, but ocean temperature and cycles will contribute substantially	
Local (micro and meso) climate regulation services		also intended for terrestrial, but applicable to coastal ecosystems (especially mangroves)	
Air filtration services		including mangroves, coastal vegetation	
Soil quality regulation services		decomposition of biological materials also occurs in marine ecosystems	
Soil erosion control services (includes also sediment retention services)		applies to flood protection by mangroves, coral reefs and seagrasses	
Water purification services (water quality amelioration)	Retention and breakdown of organic pollutants including excess nutrients	may apply to mangroves, tidal flats, estuaries and coastal vegetation in terms of purifying inland water flows to the ocean	
	Retention and breakdown of inorganic pollutants		
Water regulation services	Baseline flow maintenance	applies to flow/wave regulation by mangroves, coral reefs and seagrasses	
	Peak flow mitigation		
Flood mitigation services	Seawater (Tidal) surge mitigation (Coastal protection services)	applies to flood protection by mangroves, coral reefs and seagrasses	
	River flood mitigation		
Storm mitigation services		applies to storm mitigation by coastal	
Noise attenuation services		may apply to mangroves, coastal dunes	
Pollination services		gamete dispersal in marine environments	
Pest control service		applies to coastal and marine ecosystems	
Nursery population and habitat maintenance services		applies to coastal and marine ecosystems	
Solid waste remediation		applies to coastal and marine ecosystems	
Cultural services			
Recreation-related services	Tourism recreation-related services	applies to coastal and marine ecosystems	
	Local recreation-related services		Outdoor recreation
Amenity services		applies to coastal and marine ecosystems	
Education, scientific and research services		applies to coastal and marine ecosystems	
Spiritual, symbolic and artistic services		applies to coastal and marine ecosystems	
Ecosystem and species appreciation services		applies to coastal and marine ecosystems	
Abiotic flows			
Geophysical sources	Abstraction of water (including groundwater)		

	The capture of wind, solar, tidal, geothermal and similar sources of energy.		Renewable electrical energy
Geological resources	Extraction of fossil fuel, mineral ores, sand & gravel.		Extraction of oil and gas Extraction of minerals
Spatial functions			
Flows related to the use of the environment as the location for transportation and movement, and buildings and structures			
Flows related to the use of the environment as a sink for pollutants and waste (excluding the mediation of pollutants and wastes recorded as ES).			

To ensure the most comprehensive scope of the accounts, the SEEA EA framework recommends including as many types of ES as possible. However, because of time and resources limitations, this study cannot present data on all ES. The ES included in this report can be seen in Table 8: Fisheries, Aquaculture, Carbon sequestration and outdoor recreation. The selection of these ES is based on relevance, data availability and time limitations. There are some other relevant services excluded but important to capture in future marine accounts, such as natural hazard protection or waste remediation (Office for National Statistics, 2021a). This is left for future research. In this way, over time, a gradual expansion of the range of services will be possible depending on the availability of data and resources and the relative importance of those services.

As in the initial marine accounts for the UK and The Netherlands, abiotic flows of wind for energy electricity generation and aggregate extraction are included. They are included due to the impact that abiotic services may have on marine habitats. The UK initial marine accounts (Thornton et al., 2019) or Noordegraaf (2020) explain some of these possible impacts: for example, the location of wind turbines on the seabed or physical changes on the benthic habitat and associated biological community because of aggregate extraction causes.

The broader benefits of the marine environment, for example, as a means of transportation, could be considered in future iterations of the assessment of marine ES and natural capital accounts. These impacts can be managed to ensure greater sustainability of marine ES overall by using the information made available by marine NCA.

5.4 Ecosystem services and abiotic flows physical supply and use accounts

This section illustrates and explains the methodology and data used to obtain the set of initial marine natural capital accounts in physical terms for the North-East Atlantic. The marine natural capital accounts published by the Netherlands and UK are used as main guidance since they are the accounts available at the moment within the North-East Atlantic zone (Jongh et al., 2021; Office for National Statistics, 2021a; Schenau et al., 2019; Thornton et al., 2019; Van Berkel et al., 2021). Each of the ES and abiotic flows selected for this study are described regarding both supply and use for the OSPAR area. Lastly, the physical supply and use tables are displayed.

The ES flow accounts in physical terms include, by definition, the supply of final ES by ecosystem type and the use of the services selected by economic units. The economic units distinguish between households, enterprises and government and constitute one of the central features of ecosystem accounting (United Nations, 2021). As explained in the SEEA EA report (United Nations, 2021), the supply and use table intends to record the flows of final ES supplied by ecosystem assets, and used by

economic units during an accounting period; while permitting the recording of intermediate service flows between ecosystem assets.
Given these points, this section will describe in more detail the following ES and abiotic flows:

Table 9. Ecosystem services and abiotic flows included in this report.

Provisioning services	- Fisheries - Aquaculture
Regulating & maintenance ecosystem services	- Carbon sequestration
Cultural services	- Outdoor recreation
Abiotic flows	- Generation of electricity from wind power - Oil and gas - Minerals extraction
Spatial function	-

For each of these ES and abiotic flows, the trends and developments in the size of the various ES will be described at the OSPAR level. Based on the SEEA EA and GOAP guidance and the example of the UK and the Netherlands, what information is used to calculate the ES and abiotic flows is also explained. In addition, the potential impacts of the ES related to human activities are specified. Finally, some of the limitations encountered during the process are mentioned.

5.4.1 Provisioning services

Fisheries

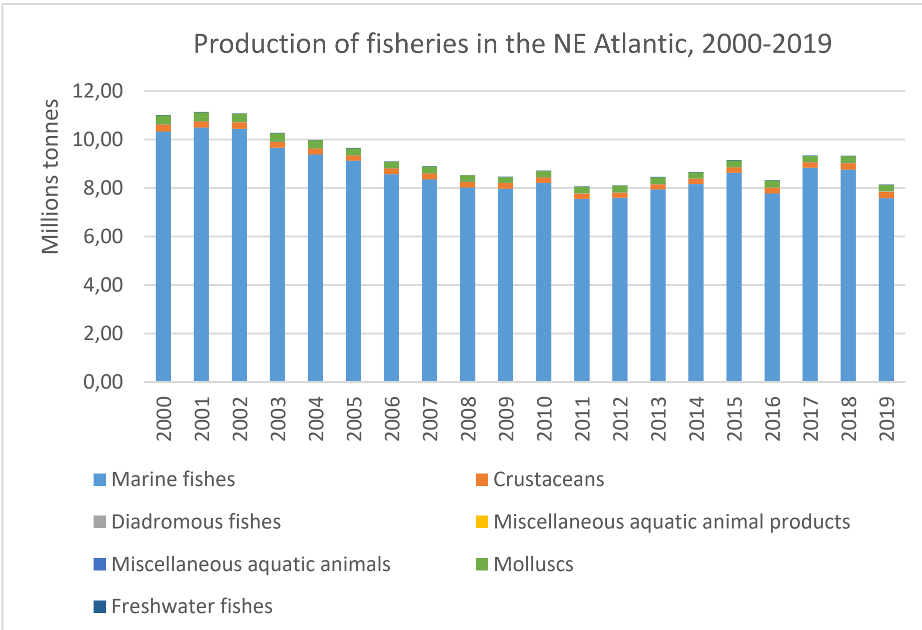
Fisheries is one of the most important economic activities within the OSPAR area, distributed substantially across all OSPAR regions other than Region V. This account includes commercial fisheries since recreational fisheries would be considered cultural services and covered by tourism or recreation services. Regarding biotic provisioning services, marine fishing (biomass by wild animals for nutrition) can be considered the most important (OSPAR EIHA, 2021c).

As in the UK marine natural capital accounts: "*The overall fish capture provisioning service physical flow presented in this article represents landings (tonnage)*" from OSPAR waters (Office for National Statistics, 2021a). To quantify the physical flows associated with the provisioning service of fisheries biomass[6], catch statistics available for the North-East Atlantic are used. Figure 12 represents the trend of fish

[6] Total tonnes includes FAO categories of marine fishes, diadromous fishes, freshwater fishes caught in marine areas, crustaceans, molluscs, miscellaneous aquatic animal products, miscellaneous aquatic animals. Does not include aquatic plants or aquatic mammals. Includes capture from recreational fisheries if provided. Data is for FAO Area 27; includes Baltic and some far north areas not in OSPAR convention area. Detailed breakdown in (FAO, 2021b).

landings over time (FAO, 2021b), where it is possible to observe how fisheries in OSPAR waters have slightly decreased since 2000, and it is established around 8-9 mill tonnes.

Figure 12. Production of fisheries in the NE Atlantic, 2000-2019



As in the case of the condition indicators, OSPAR collects the information about the activities occurring in the North-East Atlantic per region instead of relating them per ecosystem type. Accordingly, the information about fisheries is reported in this report per region, but ideally, ES should be reported per ecosystem type in NCA.

The UN Food and Agriculture Organisation (FAO) communicated that total reported marine fisheries landings in the North-East Atlantic in 2018 was 9.32 million tonnes, around 11% of the global figure of 84.4 million tonnes. The majority of stocks, but not all, are now being fished at or approaching levels consistent with maximum sustainable yield (MSY) (OSPAR EIHA, 2021c). As a consequence, there have been declines in fishing pressure from previous peaks in most of the regions. Table 10 summarizes the intensity of the fisheries activity per region, including its trends since 2010 and the forecast trend to 2030.

Table 10. Summary table of fisheries activity within the OSPAR area per region. Source: (OSPAR EIHA, 2021c)

	OSPAR REGIONS				
	I	II	III	IV	V
Relative intensity	H	H	H	M	L
Trend since 2010	↓	↑	↑	↔	↔
Forecast trend to 2030	?	?	?	?	?

QSR 2010 noted that measures such as long-term management plans, quota-based systems, closed areas and abolition of financial subsidies had been put in place. It called for cooperation to achieve reductions in fishing pressure, to address discarding, to take account of the special vulnerability of deep-water species and habitats, and to keep by-catch of marine mammals, sharks, seabirds and turtles to a minimum, and preferably eliminated (OSPAR EIHA, 2021c).

The IA 2017 showed signs of recovery in some areas, which may continue if fisheries pressures do not increase again. Physical disturbance from bottom trawling remained significant: 86% of the assessed areas in the Greater North Sea and the Celtic Seas were physically disturbed, of which 58% was highly disturbed; and consistent fishing pressure occurred in 74% of all assessed areas, which was very likely to affect the ability of habitats to recover. The EIHA fisheries report briefly analyses specific pressures, impacts and measures ongoing in the OSPAR regions. The environmental impacts of fisheries identified are litter, bycatch, and damage to habitats (OSPAR EIHA, 2021c).

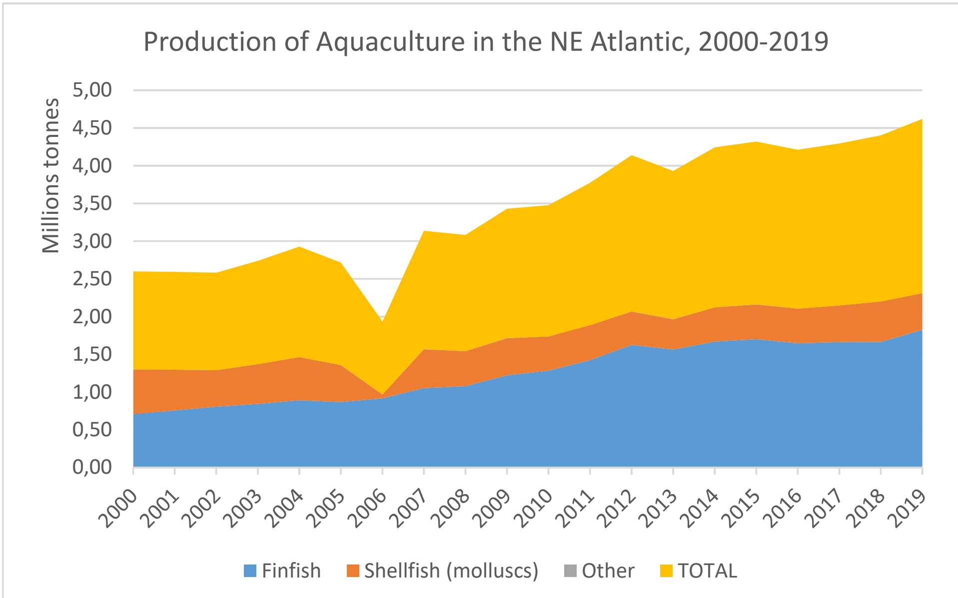
Aquaculture

Aquaculture is the provisioning service of biomass by reared animals. In this case, the UK example is not possible to follow since they expressed that: *"Aquaculture or farmed fish, like farmed livestock, have been removed from estimates as farmed fish are viewed as a produced asset and not a natural asset"* (Office for National Statistics, 2021a).

However, following the fisheries example, to quantify the physical flows associated with the provisioning service of aquaculture, production statistics available for the North-East Atlantic are used (FAO, 2021a). As for the EIHA report on Aquaculture, the aquaculture account covers the production of finfish, molluscs, crustaceans, aquatic plants, and miscellaneous aquatic products in the FAO North-East Atlantic area in marine waters.

The QSR2010 reported that almost 1.5 million tonnes of farmed fish and shellfish were produced in the OSPAR region in 2006. It noted that production of finfish had grown by over 50% in the previous decade, mainly in Regions 1 and 2, while shellfish farming had remained stable. Production by weight in the OSPAR region increased from around 1.5 million tonnes to around 2.2 mt between 2008 and 2018, although trends among countries vary. Norway remained by far the largest producer. Norwegian production accounted for well over half of total OSPAR production weight and the bulk of the overall increase since the QSR 2010 analysis. In other countries, including France, Netherlands, Germany and Ireland, aquaculture production in the early-mid 2010s was lower than 10-15 years previously (OSPAR EIHA, 2021a). Figure 13 shows the mentioned trends of aquaculture production over time and manifests the rapid increase of production this activity is having in the OSPAR area.

Figure 13. Production of aquaculture in the NE Atlantic, 2000-2019



Finfish aquaculture in OSPAR is dominated by salmon production, particularly from Norway. In 2018, Norwegian production from all marine aquaculture (fish, shellfish and other organisms) was over 1.35 million tonnes, mainly of salmon, around 60% more than in 2008, though relatively little changed since 2012. The largest producers of shellfish were Spain in Region 4 (mainly mussels) and France in Regions 2, 3 and 4 (predominantly oysters) (OSPAR EIHA, 2021a). The Scientific, Technical and Economic Committee for Fisheries (STECF) analysis noted the impact of factors such as shellfish mortalities, weather conditions and diseases(Scientific, 2018). The EU's 2020 Blue Economy report referred to impacts of disease and lack of seed on mussels and other shellfish in 2013, although production had recovered subsequently (European Commission, 2020a). Other marine aquaculture products are small (OSPAR EIHA, 2021a).

As for fisheries, Table 11 gives an overview of the regional presence of this activity.

Table 11. Summary table of fisheries activity within the OSPAR area per region. Source: (OSPAR EIHA, 2021a).

	OSPAR REGIONS				
	I	II	III	IV	V
Relative intensity	H	H	M	M	L
Trend since 2010	↑	↑	↔	↑	↔
Forecast trend to 2030[7]	↑	↑	↑	↑	↔

[7] Trend is in volume of production

The Aquaculture EIHA report explains that there are several environmental issues linked to marine aquaculture outlined by the QSR 2010 (OSPAR EIHA, 2021a), such as:

- genetic interactions between farmed fish and wild stocks;
- transfer of parasites and diseases;
- the spread of non-indigenous species;
- the dependence on industrial catches of wild fish to feed fish in aquaculture;
- eutrophication as a result of nutrient enrichment from feeds and effluents;
- competition between escaped farmed fish and wild stocks for spawning grounds;
- release of chemicals used to prevent equipment fouling or to treat parasites and diseases;
- displacement of bird and seal populations as a result of scaring devices;
- impacts from shellfish harvesting and mussel seed collection;
- litter.

5.4.2 Regulating & maintenance services

Carbon sequestration

In line with the definitions used by Thornton et al. (2019) (based on SEEA EEA (2012)), the carbon sequestration service presented in this report is defined as the net accumulation of carbon in an ecosystem due to both growths of the vegetation and accumulation in below-ground carbon reservoir.

In 2007, the OSPAR Commission took decisive action towards reducing the negative effects of climate change by adopting amendments to the Annexes of the Convention to allow the storage of carbon dioxide in geological formations under the seabed following OSPAR's 2006 report on ocean acidification (OSPAR, n.d.-c). Next, following up the conclusions and recommendations of the QSR2010, OSPAR is giving further consideration to how to take forward the development of monitoring and assessment capacities for climate change and ocean acidification at the regional scale, including tools to assess the rate of change (OSPAR, 2011). Hence, accounting for carbon sequestration is of interest and relevant for OSPAR and included in the marine natural capital accounts.

The calculation of the flow of the carbon sequestration service provided by marine habitats for climate regulation is based on the procedure used in the UK marine natural capital accounts. Therefore, in line with Thornton et al. (2019), the sub-habitats selected for the calculations of the ecosystem service were: A2.5 (Coastal salt marshes and saline reedbeds), A5.2 (Sublittoral sand), and A5.3 (Sublittoral mud).

Saltmarshes are included because, in the case of vegetated systems, plants capture CO_2 from the atmosphere. Then, they provide long-term storage of that carbon through the root systems into the sediments, which is sometimes known as 'blue carbon'. Regarding the selection of littoral, sublittoral and deep-sea sediments, Thorton et al. (2019) explain that carbon capture/fixation without carbon burial/accumulation in the sediments do not raise the welfare benefit; the benefit comes with carbon burial when the CO_2 is locked away long-term. Due to data limitations, for economic valuation and natural accounting purposes, they focused on particulate organic carbon (POC). Within the water column, to avoid double-counting, they only valued the POC deposited and then stored it in the shelf sea sediments using the lowest estimates. Further explications can be found in Thornton et al. (2019).

The data for coastal salt marshes and saline reedbeds is not included in the EUSeaMap2019, used for calculating the extent account in this report (EMODnet, n.d.). The extent of coastal salt marshes and saline reedbeds is derived from the European Environment Agency 'Ecosystem extent accounts Tier 2 / level 2' within the environmental zones of Arctic, Atlantic Central, Atlantic North and Macaronesia, which report an area of 123 905 ha for saltmarshes (European Environment Agency, 2021). Table 12 includes the extent of salt marshes in the OSPAR area according to the previous.

Table 12. First estimates of the extent of salt marshes in the OSPAR area. Source: (European Environment Agency, 2021)

Environmental zone	**Salt marshes extent (km2)**	**Salt marshes extent (ha)**
Artic	28	2 890
Atlantic Central	556	55 607
Atlantic North	655	65 458
Macaronesia	-	-
TOTAL	1 239	123 905

For saltmarshes, the carbon sequestration rate from Luisetti et al. (2019) is extrapolated and used, which is equal to 0,86 t/ha/yr or 3,14 tCO2e/ha/yr (Thornton et al., 2019). To estimate the ecosystem service flow of carbon sequestration and storage, the calculations rely on the estimates of carbon burial rates. The different carbon burial rates can be seen in table 13.

Table 13. Carbon burial rates. Source: (Thornton et al., 2019)

Habitat type	**Carbon burial rates Tonnes/ha/yr**
A5.1 Sublittoral coarse sediment	Not known
A5.2 Sublittoral sand	0,08
A5.3 Sublittoral mud	0,12

Thus, the carbon sequestration service is determined by:

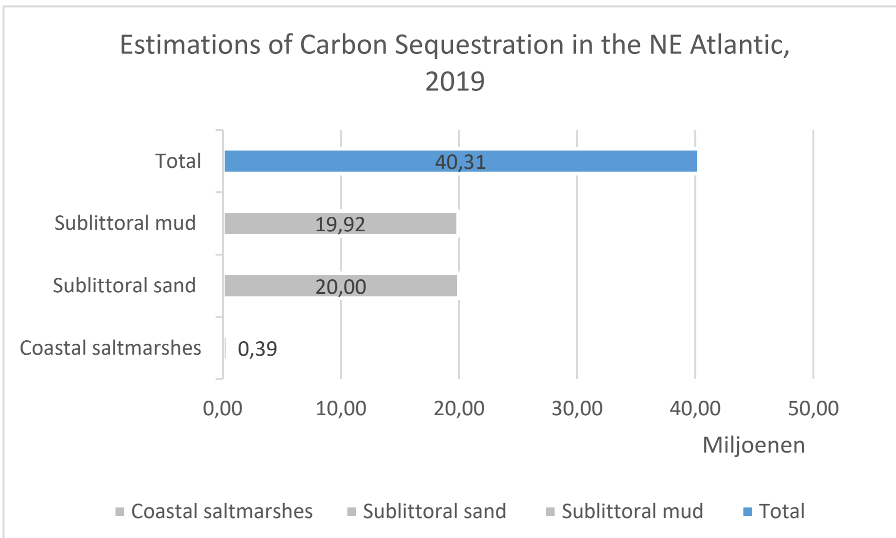
$$St = at\ c{,}m * Cbt$$

that is, the total area extent of the coastal or marine ecosystem considered ($at\ c{,}m$) (i.e., saltmarshes and seabed sediments) multiplied by the carbon burial rate (Cbt) measured in tonnes of carbon or tonnes of CO2 equivalent per unit area at time t. Given the uncertainty surrounding the carbon burial estimates, a conservative approach is taken, and the lower bound estimates per each habitat type of the marine sediments and for saltmarshes are used. To obtain estimates in tCO2e, tonnes of carbon estimates are multiplied by 3.66 (Thornton et al., 2019).

After carrying out the explained calculations, it is possible to obtain the estimated total volume of carbon sequestration, which is 40.31 million tCO2 for 2019. The amount of carbon sequestration provided by the different marine habitats can be seen in figure 14. It is important to keep in mind that these estimates are downward estimates since some vegetated systems are missing, and only the available extension of the habitats mentioned is used, which may not be the total extension.

OSPAR's 2006 report on ocean acidification indicated that high levels of carbon dioxide (CO2) in the atmosphere were changing ocean carbon chemistry at least 100 times faster than at any time in the last 100,000 years and that capturing CO2 at source and transporting for storage in sub-sea geological formations could help mitigate climate change over the long term (OSPAR, n.d.-c). This type of statement highlights the importance of understanding and considering non-economic-based contributions of nature to people.

Figure 14. Estimations of Carbon Sequestration in the NE Atlantic, 2019



5.4.3 *Cultural services*

Outdoor recreation

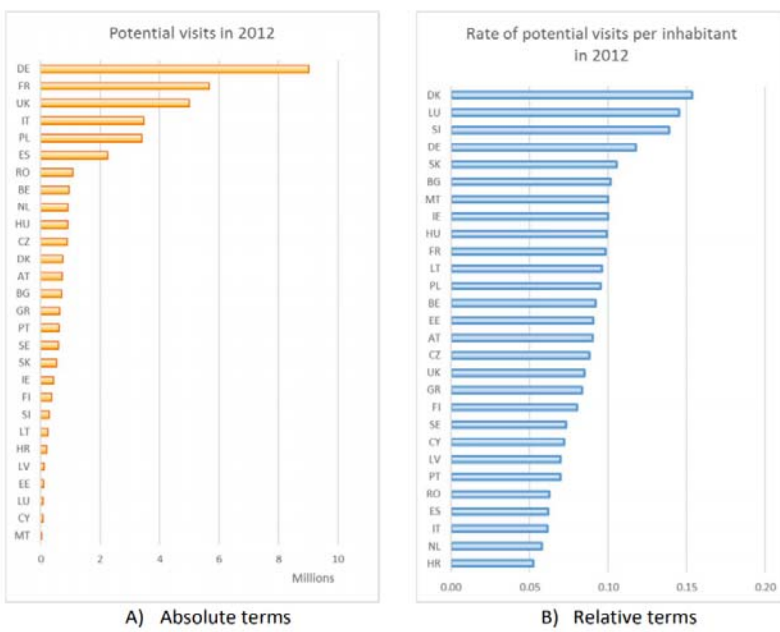
Cultural services for the North Sea area mainly relate to recreation and tourism (physical and experimental interaction with the environment); the intellectual, spiritual and symbolic interactions with the environment are more difficult to define and measure. Recreation and tourism are activities occurring on and along the North-East Atlantic Ocean. This is a relevant activity both because of its economic relevance and because of its dependence on the marine ecosystem (Pachernegg, 2020).

There is a lack of collection of relevant recreation and tourism data in a uniform matter. Therefore, KIP-INCA estimates by the Joint Research Centre (JRC) for recreation are used to show how accounting for cultural services could look like for OSPAR. The outdoor recreation estimates are based on the potential number of local trips to the sea and then calibrating actual use by reference to UK sources (S. Vallecillo et al., 2018). Only the estimations for the OSPAR countries are shown for the supply and use of the ecosystem service in this report. It is important to emphasize that this is not a complete outdoor recreation account for OSPAR, but it serves as an illustration of what type of information is needed and how this service has been accounted for in the KIP-INCA project.

As defined by Vallecillo et al. (2018): *"Outdoor recreation is a cultural ecosystem service that includes all physical and intellectual interactions with biota, ecosystems, land-/seascapes"*. In their report, outdoor recreation includes the biophysical characteristics or ecosystem attributes that are viewed, observed, experienced, or enjoyed in a passive or active way by people on a daily basis. KIP INCA built a short-distance recreation account, which estimates the value of ecosystems with a high recreation potential for daily use recreation. The JRC modelled this ES applying an adapted version of the outdoor recreation model employed in the ESTIMAP toolbox[8] due to lack of data on outdoor recreational use at the EU level (S. Vallecillo et al., 2018).

Figure 15 shows how the ES calculated by the JRC is distributed among the different EU countries (European Commission, n.d.-b). By comparing the different countries included in Figure 15, it can be observed that the actual flow of outdoor recreation in 2012 at the country level shows that countries with the highest population present the largest actual flow, as measured by the potential number of visits in 2012. Then, Vallecillo et al. (2018) explains that the actual flow needs to be expressed in relative terms for a more significant comparison of the actual flow between countries.

Figure 15. 'Actual flow' of outdoor recreation at country level in 2012. Source: (S. Vallecillo et al., 2018)

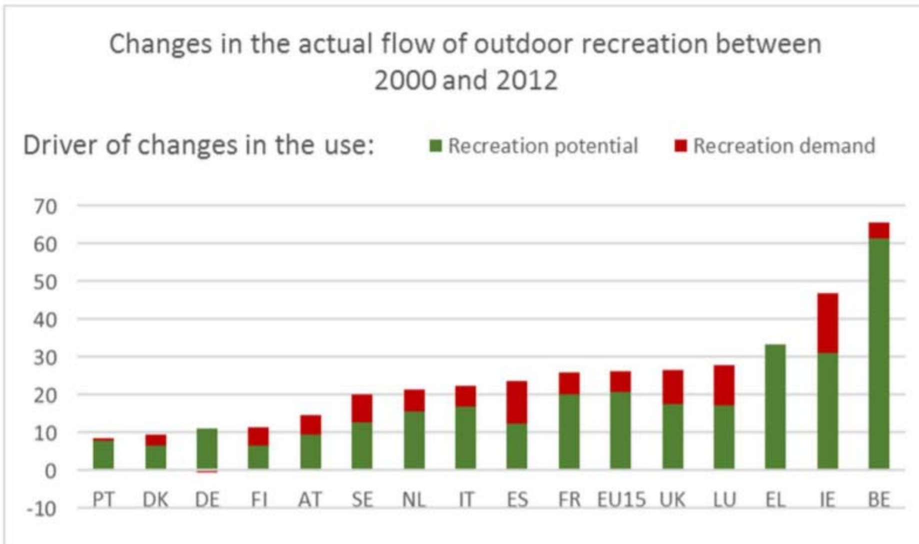


Figures 16 shows how the actual flow of outdoor recreation (potential visits to the 'areas for daily recreation', the number of visits) has increased in the EU by around 26% between 2000 and 2012. Based on the JRC report, Belgium and Ireland are the countries showing the largest increase in the actual flow of the service. Vallecillo et al. (2018), however, describe that whilst in Belgium, the main driver of change in the use of the service was due to an expansion of recreational areas, in Ireland, this

[8] The model provides a spatially explicit assessment of the ecosystems potential to provide nature-based outdoor recreational and leisure opportunities (Paracchini et al., 2014; Zulian et al., 2017). More explanations also in Vallecillo et al. (2018) Appendix I

expansion was not as significant. Instead, the growth in the actual flow is also due to higher demand.

Figure 16. Changes in the actual flow of outdoor recreation 2000-2012. Source: (S. Vallecillo et al., 2018)



A wide range of recreation and tourism activities are taking place along the North-East Atlantic, all exerting different kinds of pressures on the marine environment. The recreation and tourism EIHA feeder report outline the contribution of recreation to physical disturbance, physical damage, and physical loss. It also mentions that some recreation activities can also cause contamination by hazardous substances through various pollution-types, or nutrient and organic matter enrichment. Additionally, the introduction of invasive species can induce biological disturbance (Pachernegg, 2020).

5.4.4 Abiotic flows

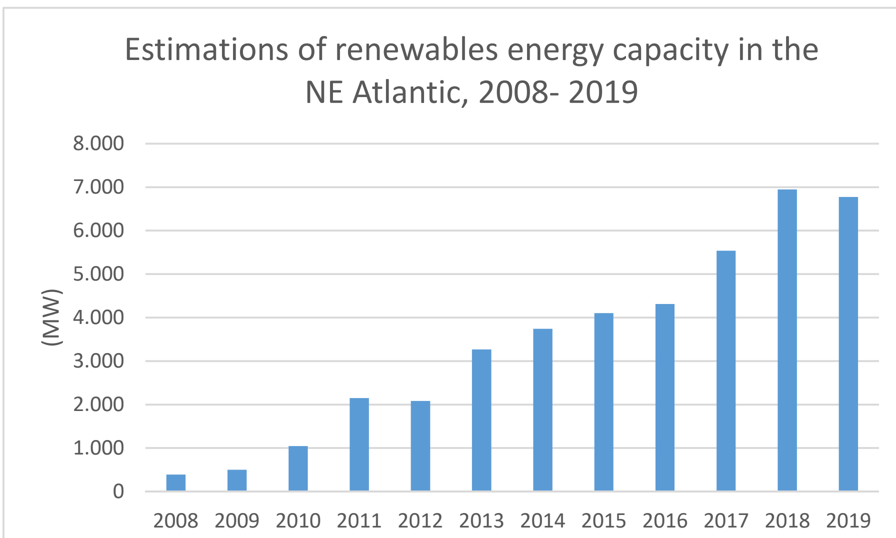
Generation of electricity from wind power

The EU's aspiring plan to tackle climate change is taking shape in renewable energy policy. Its objective is to decarbonize the energy system by expanding the development of offshore wind farms (OWF). It is a positive development due to the reduction of greenhouse gas emissions. In contrast, a substantial increase in OWF may have an increasingly worse impact on the marine ecosystem and its ability to provide ecosystem products and services that contribute to human well-being. Therefore, the OWF upscale must be managed sustainably. The EU's goal is to reach a renewable energy share of 32% by 2030 and achieve energy neutrality by 2050 (Noordegraaf, 2020).

To account for this abiotic service, OSPAR facilitated the data available for OSPAR Offshore Renewable Energy Developments between 2008-2019 within the OSPAR area. The data reports the capacity in MW, and as the reporting format changed in 2013 to encompass all renewable energy developments, also commercial-scale tidal and wave expansions are considered from 2013 onwards. To avoid overestimating the generation of energy, load factors from the UK were used, which indicate, on average, the percentage of renewable energy used every year, following the example of the UK accounts (Office for National Statistics, 2021a).

Figure 17 illustrates the trend and the rapid increase of this source of energy during the last decade.QSR2010 remarked that energy production by offshore wind farms has appeared as a new use of coastal and shallower offshore waters from 2000 to 2010. The whole expansion was in OSPAR Regions II and III (OSPAR EIHA, 2021d). In 2019, there was 22 072 MW of installed offshore wind capacity in Europe, generated by more than 5000 turbines (WindEurope, 2020). The 99% of this capacity was in five countries: the United Kingdom (45% of all installations), Germany (34%), Denmark (8%), Belgium (7%) and the Netherlands (5%). On the other hand, the OSPAR countries with small volumes of offshore wind production were Spain, France, Sweden, Norway, Ireland and Portugal. The North Sea reported 77% of Europe’s installed capacity, and the Irish Sea 13% (OSPAR EIHA, 2021d).

Figure 17. Estimations of renewable energy capacity in the NE Atlantic, 2008- 2019



In 2019, the newly net installed offshore wind capacity added 3,632 MW (which is the highest annual increase), of which almost half was in the UK. At the end of 2019, Europe represented around 75% of the world's installed offshore wind capacity. Not only is the number of turbines installed in European OWF increasing, but so is the size of the wind turbines themselves. The energy efficiency of wind turbines increases as their size increases, reducing costs (OSPAR EIHA, 2021d).

The North Sea has the largest offshore capacity installed compared to the other sea basins in Europe, probably since it is the shallow-water part of the North-East Atlantic region. Whilst the majority of renewable energy developments in the OSPAR maritime area are large scale wind farms, commercial-scale tidal and wave developments are now also being considered and implemented. OSPAR has therefore expanded its offshore renewables database to include all marine renewable developments (OSPAR, n.d.-f).

Table 14 summarizes the trends in the amount of offshore wind energy capacity installed per region.

Table 14. Summary table of offshore wind energy capacity installed within the OSPAR area per region. Source: (OSPAR EIHA, 2021d)

	OSPAR REGIONS				
	I	II	III	IV	V
Relative intensity	L	H	M	L	L
Trend since 2010	↑	↑	↑	↑	↔
Forecast trend to 2030	↑	↑	↑	↑	↔

Impacts arise throughout the life cycle of marine renewable developments, including site selection, construction, operation, decommissioning and removal. Impacts include the effects of underwater noise on marine mammals and fish, disturbance and loss of habitats, bird collisions and visual intrusion. Marine renewables can also interfere with other uses of the sea – causing hazards to shipping and the servicing of the offshore industry and displacing fishing activities and recreational boating. There may also be a conflict with marine conservation objectives (OSPAR EIHA, 2021d).

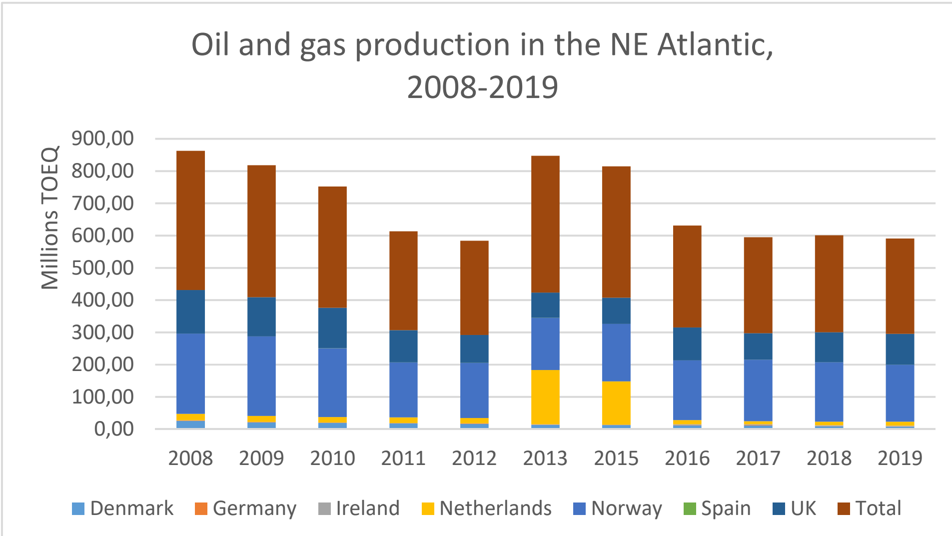
Oil and gas

Offshore oil and gas activities have developed in the OSPAR area over the past 40 years (OSPAR Commission, 2010b). Nowadays, it is a mature oil and gas production area (OSPAR, n.d.-e). As with the provision ES, oil and gas production in the North-East Atlantic is used to built this abiotic flow account. Data regarding the tonnes of oil extracted in tonnes of oil equivalent was facilitated by OSPAR. Figure 18 presents the production of oil and gas production in the OSPAR area between 2008-2019, differentiating by country.

The total production of oil and gas trend in the North-East Atlantic has been steadily falling over the last decades. Since 1998, the dumping, and leaving wholly or partly in place, of disused offshore installations within the OSPAR maritime area is prohibited under OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations. However, following assessment, the competent authority of the relevant Contracting Party may permit to leave installations or parts of installations in place for some specific cases. At present more than 1,350 offshore installations are operational in the OSPAR maritime area, most of them sub-sea steel installations and fixed steel installations. So far, around 170 have been decommissioned, and ten derogations have been granted ((OSPAR, n.d.-e, OSPAR Commission, 2010b).

Contracting Parties with an offshore oil and gas industry include Denmark, Germany, Ireland, the Netherlands, Norway, Spain and the United Kingdom. Figure 18 shows that Norway and UK are the primary producers, followed by the Netherlands. The mentioned constant fall can also be observed in figure 18.

Figure 18. Estimations of oil and gas production in the NE Atlantic, 2008- 2019



Environmental impacts occur throughout the lifecycle of these activities, including during the exploration, production and decommissioning phases. Exploration includes seismic surveys and the drilling of exploratory wells. Production includes the drilling of production wells and the construction, placement and operation of infrastructure (e.g., platforms, pipelines). Decommissioning, the final phase of an oil and gas field development, involves activities such as the plugging of wells and removal of infrastructure. Finally, the transport of oil and gas by pipeline or tanker has the potential to cause impacts outside the area of production (OSPAR Commission, 2010b).

As a result of the reduction of offshore oil and gas activities, the IA2017 indicated a general downward trend for several indicators. For example, the amount of dispersed oil discharged in produced water decreased by 18% between 2009 and 2014, the use of chemicals on OSPAR's List of Chemicals for Priority Action (LCPA) has reduced by over 90% since 2009, and in 2014 no LCPA chemicals were discharged. Additionally, there has been a 30% decrease in the use of chemicals carrying substitution warnings and a 40% decrease in their discharge between 2009 and 2014 (OSPAR, 2017).

OSPAR works under the Offshore Oil and Gas Industry Strategy to establish environmental goals and measures to prevent pollution and protect the marine environment, consistent with the objectives set by OSPAR, especially those for hazardous substances and radioactive substances (OSPAR Commission, 2010b). Many of the downward trends have been achieved as the direct result of measures adopted by OSPAR and their subsequent implementation by the offshore oil and gas industry (OSPAR, 2017).

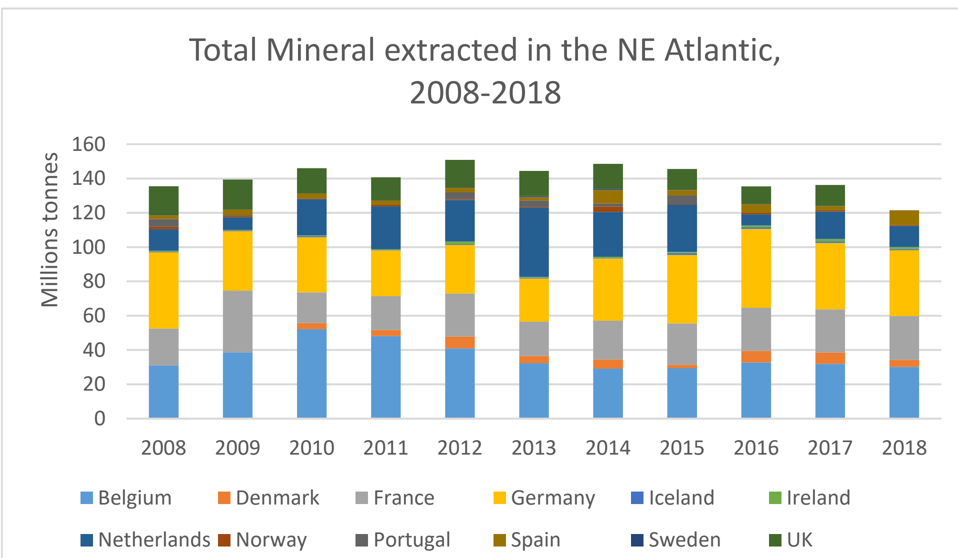
Minerals extraction

The EIHA report about aggregates extraction states that the current extraction of non-living resources in the OSPAR area is dominated by sand and gravel. The report also explains how these deposits may be relict or fossil, formed when the sea level was lower than at present and parts of the modern sea bed were exposed, glaciated or crossed by major rivers; or formed under modern marine processes, such as sandbanks in the southern North Sea. Sand and gravel are used as a source of aggregate or contract fill material for the construction industry and as material for coastal works such as land reclamation, beach replenishment and coastal defence (OSPAR EIHA, 2021b).

Since the 1970s, marine sediment extraction in the North Atlantic has increased substantially, reaching quantities of more than 140 million tonnes during the last decade. The 2010 OSPAR QSR reported that extraction of marine sand and gravel in the OSPAR area had augmented by around 30% in the previous decade. The total area of extraction had been relatively stable as new areas had been offset by activity stopping elsewhere. The QSR anticipated that demand to supply construction projects and coastal protection schemes would continue to increase (OSPAR EIHA, 2021b).

To account for minerals extraction, the total amount of minerals extracted per year is used. The data needed has also been facilitated by OSPAR. The extraction trend between 2008 and 2018 can be seen in Figure 19. The highest mineral extracting point during this period is a bit more than 150 million tonnes in 2012 with a decreasing trend since then.

Figure 19. Total Mineral extracted in the NE Atlantic, 2008-2018



There exist a certain concern about future marine mineral extraction in deep-sea areas. A technical report for OSPAR highlighted the increasing demand for resources such as copper, cobalt, nickel, lithium, silver, rare earth elements and critical metals, with a doubling of global demand anticipated by 2050-2060 (OSPAR 2021). The EU's blue economy report 2020 described the role that marine minerals might play in the future supply of raw materials. It states that further research and knowledge on the deep-sea environment and its resilience are required to move from exploration to exploitation. The EU is also supporting the International Seabed Authority's development of a regional environmental management plan for areas beyond national jurisdiction in the North Atlantic by funding a project on areas of particular environmental interest in the Atlantic (European Commission 2020).

The regional intensity assessment of volumes of sand and gravel extracted within the OSPAR area is presented in Table 15. The information does not cover deep-sea mining, which is currently largely at a conceptual/experimental phase.

Table 15. Summary table of sand and gravel extraction within the OSPAR area per region. Source: (OSPAR EIHA, 2021b).

	OSPAR REGIONS				
	I	II	III	IV	V
Relative intensity	L	H	M	M	L
Trend since 2010	↔	↓	↔	↑	↔
Forecast trend to 2030	?	?	?	?	?

The environmental impacts of these activities are explained in both the QSR 2010 and IA2017 (OSPAR EIHA, 2021b), including:
- loss of the materials themselves
- impacts on benthic fauna (few of which will survive the extraction process)
- sand coverage on the seabed in the vicinity
- suspended matter in the water
- noise

Regarding the impacts of the possible increasing activity of deep-sea mining, loss of substrate, changes to seabed integrity, the impacts of plumes, increases in light and noise levels, and release of toxic metals into the water column are identified in the EIHA extraction aggregates report (OSPAR EIHA, 2021b).

Limits, uncertainties and risks

For fisheries, the supply is calculated following other accounts examples, and it is based on landings reported by the FAO. This could be misleading since it does not account for the entire fish stock.

Regarding carbon sequestration, it is worth mentioning that important rooted vegetated marine systems are not included. Consequently, the carbon sequestration included in this report is underestimated.

In this study, outdoor recreation is based on the results of the KIP-INCA project published by the JRC, which uses potential visits to coastal recreational areas per year (daily use) to account for this service. It is important to emphasize that the values included serving just as an illustration of this service for the North-East Atlantic. Only some OSPAR areas are included since only the countries that are a member of the EU are included, and the values presented in this study should therefore be considered as an underestimation and therefore be used with caution. In various studies on NCA, cultural services tend to be the service with the highest monetary value, but in this case, it is really low due to the previous facts. Other limitations regarding this service are the weak distinction between coastal and marine recreation and the use of "Potential visits". SEEA calls that the "capacity", whereas SEEA uses the "actual visits" as an indicator for use. Finally, it is important to mention that there are also various limitations encountered in the KIP-INCA project, which, by using their data, also apply to the results of this report (S. Vallecillo et al., 2018; Sara Vallecillo et al., 2019).

With respect to the abiotic flows, there are also uncertainties and limitations in the calculations of those. For instance, for renewable energy from wind power, due to a change in the reporting format, from 2013 onwards, commercial-scale tidal and wave expansions are also included in the numbers. Therefore, there may be a lack of comparability over time. Additionally, full capacity reported is not the actual use. For this reason, load factors from the UK are used to calculate it (Office for National Statistics, 2021b, personal communication). Load factors serve to estimate what percentage of energy that is used on average every year to avoid overestimating the energy generated. Finally, capacity is reported in MW and converted into GW hours for using it in benefit transfers, which carries the risks of overestimations.

In addition to the previous limitations, in this report, the condition of the ecosystems was not incorporated in the calculations of the physical ecosystem supply and use. The connections between the accounts and how to include them in the calculations need further research for future accounts.

5.4.5 Spatial function

The SEEA EA framework distinguishes between two main types(United Nations, 2021):

- Flows related to the use of the environment as the location for transportation and movement, and for buildings and structures.
- Flows related to the use of the environment as a sink for pollutants and waste (excluding the mediation of pollutants and wastes recorded as ES).

As the SEEA EA last draft explains (United Nations, 2021), there is no expectation that compilers of ecosystem accounts will record abiotic flows from deep geological resources or flows relating to spatial functions. However, in case of interest for OSPAR, they already have data available regarding, e.g., shipping activities (OSPAR EIHA, 2021e). The inclusion of shipping or provision of space could then be explored by OSPAR to decide if they want to better understand this contribution of the environment by making use of the NCA framework.

5.4.6 Physical supply and use tables

The physical supply and use tables for ES, ideally, record the flows of ES supplied by ecosystem assets (classified by ecosystem type) and used by economic units during an accounting period. Data in the tables relate to a given ecosystem territory (United Nations, 2021).

In this report, ES supply could not be linked to the different ecosystem types. Nevertheless, with the aid of the login chains conducted in the UK initial marine accounts (Thornton et al., 2019), the ES and abiotic flows are related to some of the EUNIS habitats to give an idea of these connections, when possible.

The supply table records which ecosystem types provide biophysical quantities of ES. This gives insight into the wide range of services that are offered by marine ecosystems (United Nations, 2021).

The use table records which economic sectors (corporations, households, government, exports) benefit from the ES, identified by the review of login chains in the literature (United Nations, 2021). Defining who are stakeholders and who are the end-users and beneficiaries of ES and abiotic flows will help decision-makers, especially policy-makers but also resource managers, to guide investment for the most cost-effective impact. The development of the use table requires linking the ES provided with the different user categories (Thornton et al., 2019).

There are some challenges identified by the UK when doing these linkages, which are worth noting (Thornton et al., 2019):

1. *The link between ES and users is not always directly related to a well-defined spatial area*
2. *The basic users' categories could be further disaggregated, spatially or by sector, allowing wider policy use*
3. *The disaggregation of ES supply between different users' types is often made difficult by the lack of suitable data*

Consequently, the initial compilation of use tables only shows the contribution to those sectors or population segments representing the first direct users of the ES. This is the same approach followed by Thornton et al. (2019) for the initial natural capital accounts for the UK marine and coastal environment. Table 16 illustrates how different economic activities benefit from the ES provided by the marine ecosystems of the North-East Atlantic included in this report.

Ideally, the information presented in the tables would show the information for various years as well broken down into ecosystem types if data would have been available. For these preliminary estimations of marine natural capital accounts for the North-East Atlantic, the information and data described throughout chapter 5, specifically section 5.4, is used to build the ES and abiotic flows supply and use tables (Table 16 and 17).

Table 16. North-East Atlantic marine ES initial physical supply account estimates.

ES	EUNIS Habitat	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
PROVISIONING														
Fisheries	A2, A3, A4, A5, A6	**mill. t**	8,54	8,46	8,72	8,07	8,11	8,46	8,66	9,15	8,33	9,34	9,32	8,14
Aquaculture		**mill. t**	1,73	1,88	2,07	1,96	2,12	2,16	2,10	2,15				
REGULATION & MAINTENANCE														
Carbon sequestration	A2,A5,A6	**mill. tCO2**												40,31
CULTURAL														
Outdoor Recreation*	A1,A2,B1,B2,B3	**no. visits**					200,778							
Abiotic flows														
Generation of electricity from wind power	A5	**MW**	386.82	498.54	1,043.64	2,148.44	2,081.18	3,267.55	3,742.46	4,105.03	4,312.69	5,536.16	6,946.97	6,773.65
Minerals extraction	A5	**mill. t**	135.53	139.35	146.05	140.72	150.89	144.45	148.55	145.54	135.41	136.19	121.42	135.53
Oil and gas extraction	A5	**mill. TOEQ**	431.44	409.17	376.19	306.68	292.02	423.66		407.38	315.42	297.65	300.26	295.49

Table 17. North-East Atlantic marine ES initial physical use account estimates. Example for 2019.

ES	Units	Industry								Households	Government	Export
		Agriculture, forestry, fisheries	Mining and quarrying	Manufacturin g	Electricity and gas supply	Construction wholesale and transportatio	Water collection and treatment	Tourism and recreation	Other industries			
PROVISIONING												
Fisheries	mill. t fish landings	8,14										
REGULATION & MAINTENANCE												
Carbon sequestration	Mill tCO2e carbon captured										40,31	
CULTURAL												
Outdoor recreation	No. visits									200,778		
Abiotic flows												
Generation of electricity from wind power	MW				6,773							
Minerals extraction	mill. t		46,09									
Oil and gas extraction	mill. TOEQ		295.49									

5.5 Ecosystem services and abiotic flows monetary supply and use accounts

The marine environment physical accounts are the basis for the monetary accounts' calculations. This section explains the different methodologies used to obtain the monetary accounts for this report.

Commonly, estimates of ES in monetary terms are based on estimating prices for individual ES and multiplying through by the physical quantities recorded in the ES flow account in physical terms (United Nations, 2021). Due to time constraints and the initial nature of this report, the estimations included in this report are calculated by benefit transfer from other studies conducted within the OSPAR area.

Benefit transfer is the projection of benefits from one place and time to another time at the same place or to a new place. Thus, benefit transfer includes the adaptation of an original study to a new policy application at the same location or the adaptation to a different location (Richardson et al., 2015). Brander (2013) stresses that decision-making often requires information quickly and at a low cost, and benefit transfer is both less expensive and time consuming compared with primary valuation methods.

Benefit transfer of resource rent unit from UK marine natural capital accounts provided by the Office of National Statistics (ONS) is applied to the following ES and abiotic flows: Fisheries, Generation of electricity from renewables, Oil and gas extraction and Minerals extraction. In the case of Aquaculture, basic unit estimates were also transferred. The values used are based on the results of a master thesis about Resource Rent in the Norwegian Aquaculture Industry (Flatebø et al., n.d.).

Resource rent provides a gross measure of the return on the environmental asset. In other words, it aims at isolating the surplus value added to the marketed output from the environmental asset after considering other operational costs and normal returns. This approach to the calculation of the resource rent is acknowledged to produce low estimates of the monetary contribution that environmental assets and ES provide to the national economy. Nevertheless, it is considered to be suitable for this specific application, and, generally, it has been advised as an appropriate methodology in several previous natural capital and ES accounting guidelines (Office for National Statistics, 2021a; United Nations, 2021). The resource rent can be obtained by using a residual value approach. The methodology guide report produced by ONS can be used to find more information on how the calculation of the basic unit estimates can be done by using resource rent.

As previously explained, the outdoor recreation service shown in this report is just an estimation adapted from the outdoor recreation account developed by the JRC (S. Vallecillo et al., 2018). Only OSPAR contracting parties are considered for coastal and intertidal areas. The valuation method used by JRC was Travel Costs. The results should be used with some caution and make clear that these are just published estimates for at least some of the OSPAR area as an illustration of coastal and intertidal recreation services.

Table 18 gives an overview of the benefit transfer sources used for estimating each of the ES and abiotic supply and use accounts in monetary terms.

Table 18. Sources used for calculating the monetary accounts

Ecosystem service	Source
Fisheries	Benefit transfer of resource rent unit (Office for National Statistics, 2021a)
Aquaculture	Benefit transfer of resource rent unit (Flatebø et al., 2019)
Carbon Sequestration	Efficient Carbon price from the low reduction scenario (Horlings et al., 2020)
Outdoor recreation	Monetary accounts used from INCA project only for OSPAR contracting parties (European Commission, n.d.-b)
Abiotic flows	
Generation of electricity from wind power	Benefit transfer of resource rent unit (Office for National Statistics, 2021a)
Minerals extraction	Benefit transfer of resource rent unit (Office for National Statistics, 2021a)
Oil and gas extraction	Benefit transfer of resource rent unit (Office for National Statistics, 2021a)

Limits, uncertainties and risks

In general, benefit transfer is used because it comprehends ease of use and minimal data needs. In general, as Brander (2013) notes, the reliance on value transfer can be legitimate for first-cut experimental Natural Capital or Ecosystem accounts, as its practical application will help improve understanding of its limitations.

Johnston et al. (2015) explain that prospects for future use appear strong because the government is increasingly evaluating options for managing resources (time and budget for these evaluations are limited), and the number of available evaluation studies has grown steadily. At the same time, benefit transfer is often the least accurate method of estimating theoretically reasonable welfare estimates. Therefore, when feasible, the primary study is preferred (Johnston et al., 2015).

Furthermore, the use of resource rent as a valuation method produces low estimates of the monetary contribution that environmental assets and ES provide to the national economy (sometimes even negative). Nevertheless, it is considered to be suitable for this specific application, and, generally, it has been advised as an appropriate methodology in several previous natural capital and ES accounting guidelines (Office for National Statistics, 2021b; United Nations, 2021).

Moreover, there is some risk and controversial discussion regarding the valuation of ES in monetary terms. It is important to keep in mind that the values in NCA are not meant to be absolute numbers, but they can give the importance and magnitude to the environment that is not accounted for at the moment.

Despite its critics, ES valuation has the potential to inform policy decisions by highlighting the benefits of sustainable ecosystem management. Although it must be taken into consideration that the valuation techniques suffer from serious limitations, and some ES may not be amenable to valuation by the techniques available.

There is a need for further standardization of NCA at the OSPAR level, for example, by increasing collaboration and harmonisation among countries, to improve and facilitate NCA in the future.

5.5.1 Monetary supply and use tables

Tables 19 and 20 displays an overview of the information that the NCA monetary supply and use accounts can provide for OSPAR.

Table 19. North-East Atlantic marine ES initial monetary supply account estimates (€ million)

ES	EUNIS Habitat	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
PROVISIONING													
Fisheries	A2, A3, A4, A5, A6								1,727.6	2,846.5	2,641.3	2,165.1	
Aquaculture		1,626.5	476.9	-149,2	1,416.6	1,391.7	1,248.2	4,215.1	3,684.3				
REGULATION & MAINTENANCE													
Carbon sequestration	A2,A5,A6												1,612.5
CULTURAL													
Outdoor Recreation	A1,A2,B1 ,B2,B3					253.13							
Abiotic flows													
Generation of electricity from wind power	A5	25.5	49.9	46.6	62.1	124.5	168.3	227.8	475.2	359.6	388.1	763.3	
Minerals extraction	A5											147,2	
Oil and gas extraction	A5	137,610	63,898	76,379	87,934	82,429	80,795		-13,442	-294,129	17,527	41,374	24,845

Table 20. North-East Atlantic marine ES initial monetary use account estimates (€ million). Example for 2018.

ES	Industry								Households	Government	Export
	Agriculture, forestry, fisheries	Mining and quarrying	Manufacturing	Electricity and gas supply	Construction wholesale and transportation	Water collection and treatment	Tourism and recreation	Other industries			
PROVISIONING											
Fisheries	2,165.1										
REGULATION & MAINTENANCE											
Carbon sequestration										1,612.5*	
CULTURAL											
Outdoor recreation									253.13**		
Abiotic flows											
Generation of electricity from wind power				763.3							
Minerals extraction		147,2									
Oil and gas extraction		41,374									

* Estimations for 2019 (included for illustrating purposes)

**Estimations for 2012 (included for illustrating purposes)

5.6 Monetary asset account

The asset account records the monetary value of the opening and closing stocks of all ecosystem assets within an ecosystem accounting area and presents the additions and reductions in those stocks. Therefore, the value of an ecosystem asset can be determined by calculating the net present value (NPV) of the future flows of income associated with the different ES (Schenau et al., 2019; United Nations, 2021).

Following the UK and the Netherlands procedure (Horlings et al., 2020; Office for National Statistics, 2021b), the following is assumed:

Assumption 1: The future flow of income for each ES is constant and equal to the flow observed most recently. Where you have projections of the future service available, you would discount based upon these, but this is not the case.

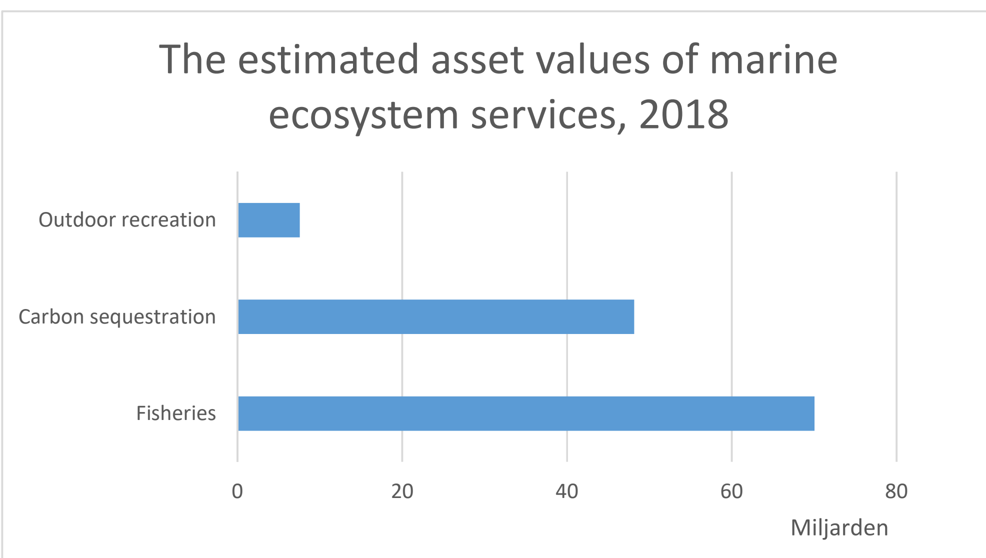
Assumption 2: The discount rate equals 3 per cent (using the green book social discount rate).

Assumption 3: The asset life is 100 years for all ecosystem assets and 25 for non-renewables abiotic assets.

Also, so-called abiotic services, such as wind and solar energy and the extraction of sand and gravel, are not included in the calculations, consistent with the SEEA EA guidelines (Jongh et al., 2021; United Nations, 2021). The first monetary asset account estimates can be seen in the following graph.

Figure 20 shows the first estimated asset values of marine ES for the North-East Atlantic. The North-East Atlantic marine ecosystem assets for which the initial values are estimated have an asset value of 125.75 EUR billion, of which more than 40% comes from carbon sequestration and outdoor recreation (where these estimates are considered underestimated).

Figure 20. The asset estimates values of marine services, € millions, 2019 prices, 2018



According to SEEA EA last draft (United Nations, 2021):

"An ecosystem asset is considered to supply a number of ecosystem services (e.g., timber provisioning services, air filtration services, recreation-related services) to different users (e.g., businesses, households, government). Each ecosystem asset will have a different capacity to supply ecosystem services that is closely linked to its extent and condition but will also be linked to existing and expected patterns of ecosystem management and use and to the influence of wider environmental factors such as weather and extreme events".

Based on the previous, the great potential of calculating the monetary asset account is to indicate if an ecosystem asset is managed sustainably or not. When also projections can be included in the calculations of the ecosystem asset, this account can show the capacity or ability of the asset to continue providing the service or services in the future. This account can also give magnitude and importance to the environment since, by giving a monetary value, it is more likely to scale the importance of the ecosystem. NCA intends to calculate the true value and not only the market value so that, by sharing a common language, more people can also understand its importance and give it the attention needed.

As valuing ES in monetary terms, the monetary asset account presents limitations, uncertainties, and risks. For this reason, future progress requires a deep understanding of the links between the various disciplines of economics, ecology, and accounting. It is crucial that economists, ecologists, and accountants can work together to integrate their different perspectives to address these challenges better (Obst et al., 2015).

As explained by (Van Berkel et al., 2021):

"Valuation is, however, considered essential for communicating the economic value and scarcity of nature. It should be recognized that monetary values always have to be presented and analysed together with information from the other ecosystem accounts. [...]. Thus, the SEEA EA monetary values should not be considered to provide, and do not intend to estimate, a complete 'value of nature'."

6 Possible analyses and applications of NCA by OSPAR

Chapter 4 presented some practical cases and potential policy uses of marine natural capital accounts. This part of the report intends to explain how the information included in the accounts can be used to support decision-making. It also proposes a series of analyses that can be of interest and, therefore, could be conducted in the future by OSPAR using the information from the different accounts.

One of the strengths of NCA is that the accounts are quite versatile and provide information both separately and combined. Since the accounts included and presented in the previous chapter are very first and partly incomplete estimates, only very first draft analyses will be presented in this chapter (see textbox below), mainly to illustrate what one can be done with the type of data that are available at this moment. Therefore, the focus of this chapter is subsequently on a series of analyses that can be of interest and could be conducted in the future by OSPAR using the information from the different accounts. There are some main points that can be derived based on these first estimates of the marine natural capital accounts for the North-East Atlantic:

Based on the information presented in the previous chapter, some conclusions can be derived from the initial estimation of the accounts:

- Marine carbon sequestration in 2019 is estimated to be more than half of the value of fisheries in 2018. Carbon sequestration values are likely to be underestimated due to the conservative approach taken, the lower bound estimates and the limits of extension data for key ecosystems providing this service. Therefore, this significant ecosystem service requires more research to fully understand it.
- The value of marine renewable energy had grown over 25 times from 2008 to 2019.
- Outdoor recreation in coastal and intertidal values increased from 238.53 mill EUR in 2000 to 253.13 mill EUR in 2012 in the OSPAR EU countries.
- The North-East Atlantic marine ecosystem assets for which the initial values are estimated have an asset value of 125.75 EUR billion, of which more than 40% comes from carbon sequestration and outdoor recreation (and these estimates are underestimated).

Section 4.4 presented different ways in which NCA could support decision-making. The accounts organize and present the following relevant data that can be used for this:

- *Extent account and condition account*

If extent and condition accounts are updated regularly, it is possible to use them to track changes in the extension or size of the different ecosystem types and the state of those, both spatially and over time This can be used to identify which ecosystem types are the most affected ones. And since the ecosystem type can be related to ecosystem use, it is possible to identify which activity has the most important impact on the ecosystem.

- *Ecosystem Services*

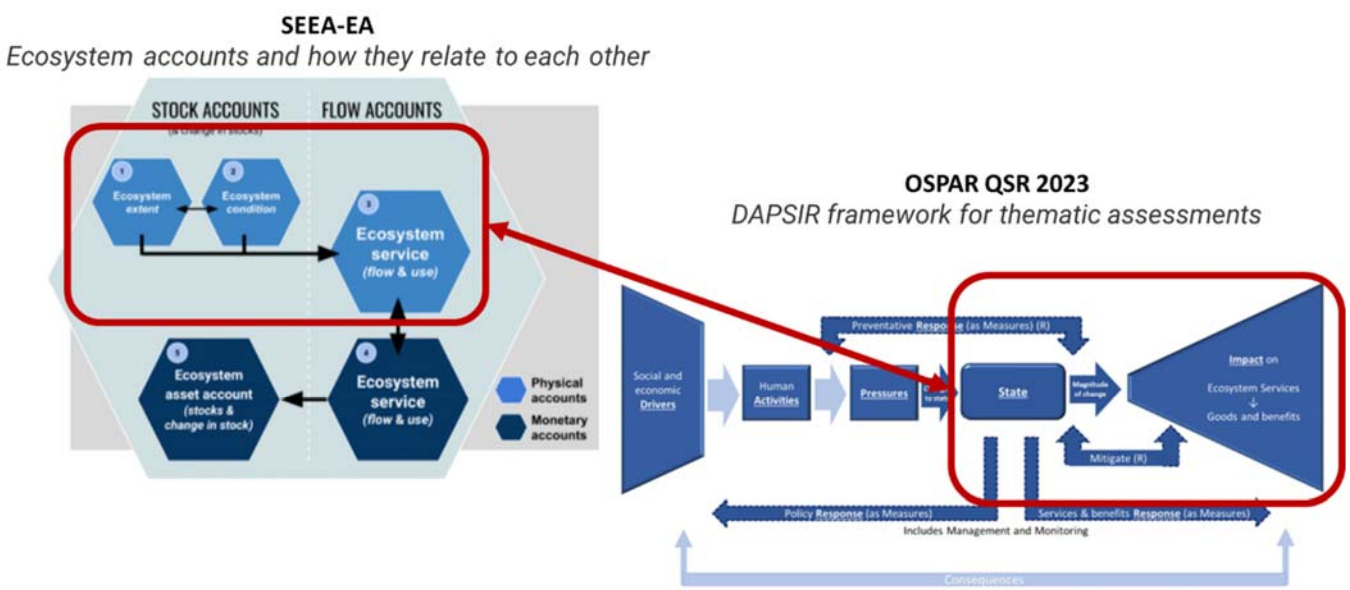
The provision of the different ES and their changes can be tracked as well, in both physical and monetary terms. In terms of monetary valuation, the so-called logic chains can be used to link the ES supplied by ecosystem assets to the benefits and their specific beneficiaries or economic users. The links between these components have also been identified in the NC accounts of the UK and the Netherlands.

When looking at Tables 17 and 18, the different changes in the supply of the ES can be identified. These trends give an idea of how much an ecosystem service is supplied and used over time. However, it is difficult to compare the information regarding different ES if they are only expressed in physical terms. This is where the use of monetary accounts is really helpful. The accounts, when expressed in monetary terms, improve the comparability among ES (Tables 19 and 20).

Implementing and using system thinking frameworks such as the DAPSIR framework, which is already implemented in the QSR, can create synergies between DAPSIR and Natural Capital Approach, as illustrated in Figure 21. Thus, the DAPSIR framework may help to build OSPAR logic chains and facilitate the connections between the natural capital accounts or ES and its users.

Figure 21 shows the compatibility of the basic structure of physical accounts in the SEEA EA to the State → Impact on Ecosystem Services aspects of the DAPSIR framework being applied in the thematic assessments for the OSPAR Quality Status Report (QSR) 2023[2].

Figure 21. The synergy between the SEEA EA physical accounts components[9] and the OSPAR DAPSIR framework for QSR 2023 thematic assessments[10].



---

[9] Source: https://seea.un.org/ecosystem-accounting (accessed 20/06/2021)

[10] Source: https://www.ospar.org/site/assets/files/44049/qsr_guidance_thematic_assessments_updated_25may2021_final_1.pdf (accessed 20/06/2021)

The connection of the different accounts can inform on the impacts of human activities related to ES on the ecosystem condition and, subsequently, the ecosystem, but also, on how the condition of the ecosystems, in turn, affects the supply of the ES and therefore on how changes in the marine environment affect human activities.

Human activities are at the base of the several pressures acting on the marine environment, degrading the condition of its ecosystems (Maes et al., 2020). There is a need to understand future trends, including impacts of climate change on the spatial distribution of human activities and their pressures on the marine ecosystem. NCA can be used to provide a better understanding of how the environment and economic activities are interconnected. In the EIHA reports, OSPAR already includes for various human activities the linkages between individual human activities and the quality status and pressures indicators. Thus, these linkages can be used to analyse how human activities may affect or impact the condition of the ecosystems and subsequently the ecosystems over time and space. The EIHA reports do this for each individual human activity in isolation. NCA offers the opportunity to perform integrated analyses for various human activities simultaneously.

Table 21. Pressures related to different human activities that are included in this report as ecosystem services or abiotic flows. Source: OSPAR EIHA feeder reports

Human activity	**Pressures related**
Fisheries	Habitat destruction-/Physical disturbance Food webs changes Litter Bycatch of animals
Aquaculture	Genetic interactions between farmed fish and wild stocks; Transfer of parasites and diseases Spread of non-indigenous species Eutrophication (nutrient enrichment from feeds and effluents) Competition between escaped farmed fish and wild stocks for spawning grounds Release of chemicals Displacement of bird and seal populations Litter
Recreation	Physical disturbance Contamination by hazardous substances Nutrient and organic matter enrichment. Invasive species
Renewables	Habitat loss (Sea birds, Mortality/population impacts) Collision (Sea birds, Migrating birds, Mortality/population impacts) Underwater noise (Marine mammals, Population impacts)
Oil and gas	Hazardous substances and radioactive substances

Minerals extraction	Loss of the materials themselves Impacts on benthic fauna Sand coverage on the seabed in the vicinity, Suspended matter in the water Noise Loss of substrate, Changes to seabed integrity Impacts of plumes, Release of toxic metals into the water column

- *Monetary supply and use accounts and the asset account*

Traditionally, economics has been concerned with direct use values, focussing on quantifying and analysing goods and services that produce tangible benefits. Economists, however, have broadened their scope in recognition of the growing appreciation for the indirect use, non-use, existence, bequest, and option values of ecosystems and have developed techniques to extend monetary valuations to these ES (Chee, 2004). It is important to keep in mind that the value of the ES is not meant as an absolute value, and it should not be used as such.

The intention of the valuation of ES is to provide a uniform measure to allow comparison over time. In the same manner, the asset value of a natural resource refers to the long-term potential of that resource to provide a service to humans; and gives information on stocks and changes (additions and reductions) of ecosystem assets (in much the same way as GDP is often used: the main focus is not so much on the absolute number, but in the trends over time). Hence, it focuses on accounting for ecosystem enhancement and degradation.

Other relevant analyses that could be performed with NCA

Some of the analyses that could be of special interest and potentially be performed by OSPAR by using more extended versions of the natural capital accounts are the following:

- *Connect the accounts to policy themes to help to quantify and analyze those and evaluate the effectiveness of measures.*

  Section 2.3 described how NCA is directly related to OSPAR Operational objective 7.03. The accounts can not only contribute to the achievement of this Operational objective but can also be relevant to compile or evaluate other NEAES 2030 Objectives (OSPAR Commission, 2021), as described in Box 1 in chapter 2, such as:

- Monitor the compliance of the nutrients and organic matter limits and the adverse effects of the substances and concentrations related to the Strategic objectives 1-4, related to achieving clean seas.
- In order to achieve biologically diverse and healthy seas, the marine natural capital accounts can be used to support spatial planning and evaluate the effectiveness of MPAs. This relates the accounts to the Strategic objective 5: Protect and conserve marine biodiversity, ecosystems and their services to achieve good status of species and habitats, and thereby maintain and strengthen ecosystem resilience.
- In the same way, NCA can be used to identify habitats suitable for restoration and to monitor the effectiveness of the methods used for restoration. Therefore, they can also be used to evaluate Strategic objective 6: Restore degraded benthic habitats in the North-East Atlantic when practicable to safeguard their ecosystem function and resilience to climate change and ocean acidification.

- Strategic objectives 7, 8 and 9 are related to achieving productive and sustainably used seas. Considering that one of the main strengths of the natural capital accounts is the opportunity to analyse how sustainable the ocean economy is using the marine environment, these accounts can be directly related to Strategic objective 7 and more indirectly to Strategic objectives 8 and 9. These objectives intend to achieve productive and sustainably used seas.
- The final Strategic objectives of the NEAES 2030 are to achieve seas that are resilient to the impacts of climate change and ocean acidification. With respect to Strategic objective 10, the accounts can directly assist in monitoring, analysing and communicating the effects of climate change and ocean acidification to raise awareness. For Strategic objective 11, the accounts may identify additional pressures of climate change and ocean acidification, which will facilitate adaptation to the impacts when developing programmes, actions and measures. Finally, Strategic objective 12 plan to mitigate climate change and ocean acidification by contributing to global efforts, including by safeguarding the marine environment's role as a natural carbon store. The accounts can be used to understand how oceans serve as a natural carbon sink and to communicate their role in this respect.

- *Trade-offs analysis between ecosystem services.*

Accounts could help to identify the most profitable level of an activity or ecosystem service, in the long run, taking into account the effect on other ES and within the boundaries of the marine environment. Vondolia et al. (2020) show how analyses of trade-offs between ES are relevant to support management decisions. In their study, they developed a bio-economic model of habitat-fisheries interaction and analysed the ecosystem interaction between kelp forest and fisheries.

Kelp forests are necessary to provide ES in the form of commercial products like biofuels, feed for aquaculture and livestock, and alginate. They also provide other ES, such as supporting ES in the form of habitat for coastal cod fisheries and regulating ES in the form of carbon storage for climate change mitigation. In their model, social planners maximise the mutual or co-benefits of those interactions when the habitat: is 1) a consumable marine resource, 2) it serves as a home for commercial fish enhancing the growth of the fish stock, and 3) delivers regulating ES as a carbon sink for climate change mitigation (Vondolia et al., 2020).

Optimal management that internalizes the co-benefits of kelp forests, especially based on recent estimates of carbon content, will provide a clearer understanding of the economic and climate mitigation consequences of alternative kelp management systems. In the regulations on the harvest of kelp forests in Norway, it was tried to consider the interactions between kelp forests and fisheries for a long time. The transformation in optimal kelp stocks (caused by the incorporation of carbon storage co-benefits in the management of cod and kelp) contributes to the accumulation of an additional 300,000 tonnes of carbon in the kelp forests of Norway (Vondolia et al., 2020).

- *Marine Spatial Planning analysis*

A research study conducted by the Norwegian Institute for Water Research (NIVA) and the Norwegian Institute for Nature Research (NINA) presents an exploratory assessment of the role of monetary valuation in ecosystem accounting to support integrated coastal zone planning (ICZP), using the Oslofjord as an example. The study emphasizes that the ES supply and use tables and the monetary accounts in SEEA EA have a significant capacity to boost the ICZP of the Oslofjord, such as Environmental Impact Assessments, Strategic Environmental Assessments and Cost-Benefit Analysis. The requirements on the resolution and scale of NCA depend on who is the user of the accounts and what are the policy targets (Chen et al., 2021).

The monetary valuation of the ES part of SEEA EA has not been widely used in coastal and marine decision-making in Norway, but there are many purposes for which monetary valuation could be of importance. One example is the trade-off between coastal zone real estate development and public access to the coast. Chen et al. (2021) contemplate how SEEA EA can create a shared data platform that may provide information on biophysical indicators of environmental impacts as well as recreational usage values, demonstrating both negative and positive consequences of new estate development. Municipalities, which are in charge of planning and issuing building permits, could use the data to weigh the financial gain from new estate development against the potential loss of recreational value and public use. Where there are significant conflicts between public access to the coastal zone and private estates, ecosystem use and value accounts can provide decision support on whether to purchase the private estate to safeguard "the coast for all", which is one of the primary Norwegian policy goals. These accounts could also serve as a foundation for an ecological fiscal transfer from the national budget to municipalities to support nature conservation at the local level (Chen et al., 2021).

Another application of the monetary supply and use accounts in marine NCA is to support prospective cost-benefit analysis (CBA) of policy measures for coastal planning (Chen et al., 2021). The use of such accounts as a basis for water management plans that include an action plan with measures to ensure GES following the WFD is exemplified in Chen et al. (2021) study. The reduction of eutrophication caused by sewage and agricultural run-off is a major challenge in the Oslofjord. Municipalities will have to spend lots of money to clean up the sewage. Likewise, farmers will incur high costs to construct, for example, retention basins or set aside cultivatable land as buffer zones. The monetary supply and use accounts for ES can provide data on historical costs incurred in sewage cleaning and agricultural runoff reduction measures to achieve previous eutrophication levels. In order to analyse various prospective policy scenarios, exchange values of measures recorded in the accounts can be supplemented in CBA with welfare measures of willingness to pay to achieve water quality objectives (Chen et al., 2021).

Finally, chapter 14 of the SEEA EA describes many other examples in which data from the ecosystem accounts can be used to originate indicators and combined with other environmental-economic accounting data and national accounting data to prove the relations between the economy and the environment and to compare trends over time (United Nations, 2021).

7 Discussion, conclusions and next steps

This final chapter discusses the added value of using NCA at the OSPAR level and provides some suggestions on what could be done to further elaborate natural capital accounts in the future. The discussion and recommendations presented in this chapter are based on the information gathered in this report together with the information that was shared and the discussions that took place during a workshop about NCA that was organized by the OSPAR group on Economic and Social Analyses (ICG-ESA) on the 13th of July of 2021. During this event, people from different disciplines and countries from all around the globe were brought together to talk about NCA and their experiences[11].

Ocean accounts and ocean or marine natural capital accounts are different concepts. Ocean Accounting is frequently described in policy communications in terms of its potential to provide aggregate indicators that transform management at the scale of progress towards sustainable development. The Global Ocean Accounting Partnership (GOAP) and the High-Level Panel for a Sustainable Ocean Economy (Ocean Panel) often explain that for something as complex as the ocean, one single indicator of progress, such as an ocean-related GDP or GVA, should not be used. Instead, multiple indicators of progress should be used in combination because of the inherent complexity of a system like the ocean. Those indicators are classified into three broad domains:

1. GDP or ocean economy growth indicators. These are the standard economic indicators.

2. Sustainability or environmental-economic indicators. Here is where NCA forms part of Ocean Accounting. In this way, the environment is treated as an asset and not as an externality or something that needs to be regulated in opposition to economic drivers.

3. Social accounts describe the equity dimension in terms of who is or is not benefitting from the ocean economy and the ocean economic sectors.

Accounting systems need to support indicators that can be aggregated according to policy needs, and politicians and policy-makers can use them to announce short and informative messages, for instance, that the economy is growing at the expense of environmental assets. In this way, it is possible to perceive marine NCA as a subset of a much broader agenda.

What type of decisions can be supported by NCA?

Different decisions can be supported by NCA that are of particular interest to OSPAR, for example:

- **Sustainable use** of marine resources, maritime **spatial planning**, consider and identify **trade-offs.**

[11] Tables II, III and IV included in the Annex outline the main messages discussed in the different breakout rooms during the workshop. More information and the summary of the OSPAR Special Meeting on Marine Natural Capital Accounting held on the 13th of July of 2021 can be found here.

- **Understanding** the different options around the use of ecosystem services.

- In terms of **funding decisions**, whether funds should be invested in development or conservation objectives or research.

- Environmental **assessment**, better **communication**, policy **prioritization** and marine **protected areas**.

NCA can be of great importance when it comes to **separate between the costs and the benefits**; costs often fell at the local level and benefits at the regional or national level. NCA can give you, hopefully, an insight into that dichotomy between local and national impact. It can also give insight into the broader benefits and competing priorities within the marine environment for things like offshore wind energy, fisheries, habitat preservation, etc.

In addition, NCA can be used to **inform** the whole range of **policies and objectives included in the NEAE Strategy**. Not only focusing on the ones specifically related to natural capital. The different objectives have environmental, social, and economic components that can be examined, connected, evaluated, or compared. Thinking about the future NEAE Strategy, NCA can help on how to incorporate climate change or establish a clear baseline to look at and to measure change against.

What type of analyses could be relevant for OSPAR to conduct based on the information collected by the accounts?

Regarding the type of analyses that could be of interest or relevance for OSPAR that can be conducted based on the information gathered in the accounts, the following can be mentioned:

- The most notable analyses are **MSP, MPA,** and **cost-benefits analyses**. Additionally, some other analyses could be:
    - Valuation of different strategic options for ecosystem-based management (e.g., at sea basin level)
    - Gap analysis
    - Supporting cumulative effects assessment
    - Analyses of changing values over time
    - Valuation of recovery vs restoration measures
    - Identifying parameters to value and how they should be valued (e.g., intrinsic vs economic)

- **Time-series analysis** is a very interesting and relevant type of analysis that can be conducted with NCA. For this type of analysis, it is important to have and use indicators and data that are available for longer time series. In this case, very regional explicit and detailed project data that have been performed once or available for one year cannot be used over time. Thus, this type of data is not desirable even though it may be very accurate. Indicators need to be available over time to identify trends and developments. By conducting time-series analyses, the status of the environment can be monitored as well as measures can be evaluated and examine whether they are effective.

When performing integrated analyses, there are **advantages at the regional level** as opposed to the country level or the local-pilot type of level. Because from the regional level point of view, it is possible to look at the coherence of the MPA network and deal with mobile and transboundary impacts (not only mobile species but also chemicals, waste, etc.). Another advantage of having NCA at the regional level is that smaller countries, which do not necessarily have the full capacity to produce their own marine accounts, can be supported in understanding the marine environment more effectively.

What are the next steps that OSPAR could take in terms of NCA?

Some actual and feasible next steps that OSPAR could take to continue developing and improving the marine natural capital accounts for the North-East Atlantic are the following:

1. **Analyse and identify what to do based on this report**. This report can be used as the focal point in terms of where we can progress now and continue the work that has been started. Some improvements are needed in all the accounts:

    - The database used is a key point since the extent account is the basis of the accounts. In this report, the EUSeaMap 2019 was used since there is 70% of the OSPAR area classified in EUNIS habitats. Therefore, a great part of the North-East Atlantic can be classified, and the EUNIS classification has been found in other relevant NCA studies.
      The great limitation of using the EUNIS habitats is that this classification is more a sea bed classification than an ecosystem classification. It does not consider the water column or vertical stratification, so it does not take into account the three-dimensionality of the ocean. OSPAR must enhance the classification of ecosystem types and databases. It is not the methodology that is **limited** but the **data availability**. With perfect or improved data, many decisions could be improved as well. There are data problems, and data are sometimes not available at the level of ecosystems at the OSPAR level, so it is not regionally explicit enough to be able to use the information the way we would like to, yet.

    - Condition indicators need to be of both types: very specific and general indicators. OSPAR uses a lot of indicators related to the status change or pressures exerted on the North-East Atlantic marine and coastal environment. These indicators could be used to build the condition account. However, these indicators are not compiled by per ecosystem type, and they are too weighted towards animal or species indicators. In this report, OSPAR indicators are shown and classified based on the SEEA Ecosystem Condition Typology to give an overview of what is available and can be used for this account. OSPAR needs to decide which indicators are the most relevant for them and which are better to use and include in the marine natural capital accounts for the OSPAR area.

    - In this report, only a few ecosystem services and abiotic flows are included in the accounts. OSPAR has to determine which ES and abiotic flows are more important to prioritize. Climate regulation services such as blue carbon are really relevant, and it is getting more attention from OSPAR. Ecosystem services related to the deep sea may also be important to prioritise, for example, due to concerns over the potential impacts of deep-sea mining.

    - The accounting process included in this report, as well as the future accounting methods selected, are crucial. An important limitation is the **difficulty of including everything**; for instance, fish stocks accounted are expressed in landing values instead of the value of the whole stock.

    - Moreover, efforts need to be focused on how to link ecosystems with ecosystem services and then with the society, making spatially explicit where this is possible and recognizing that there are certain data limitations.

- Benefit transfer is a good starting point because unit value transfers include ease of use and minimal data requirements. However, valuation methods need to go beyond benefit transfer because well-structured primary valuation studies should always provide more reliable estimates than benefit transfers, even if they generate the same information gains (Johnston et al., 2015). This valuation method was considered sufficient for the first estimates of the NCA, but other valuation methods should be used for future accounts. The SEEA EA guidance and examples from other countries (like the Netherlands or the UK) can be used to assist the methodology selection. The analyses need to be done consistently with the traditional economic accounts so that we can compare the accounts both across countries but also within-country in terms of looking at GDP growth versus natural capital growth.

It is advisable to continue and promote system thinking frameworks such as the DAPSIR framework and try to use already existing frameworks to create synergies, which is already implemented in the QSR between DAPSIR and Natural Capital Approach.

2. Find and set **priorities**. On the one hand, expand the list of ES to ensure that the coverage of the ecosystem account is as complete as possible and to have something closer to reality. On the other hand, not only decide what should be prioritized but also what should be the process of prioritization. There are different possibilities such as:
   - A process of prioritisation led by decision-makers, policy, environmental NGOs, stakeholders, people of influence, etc., where areas of risk, vulnerability or high value are identified and tackled first.

3. Set some kind of framework or **roadmap for NCA for OSPAR**. A binding and ambitious timetable to move to action is needed. Moving from concepts to implementation, throughout actions to achieve actual improvement of the marine environment.

4. Keep **sharing information and experiences**, and participate in partnerships such as GOAP. Build bridges and linkages with other international organizations working on NCA, such as the OECD or Eurostat. Efforts should be aligned within countries to coordinate and homogenise the process in order to be able to compare between countries.

As a final point, it is important to keep in mind and reflect on the initial state where OSPAR and many countries currently are, together with the pieces of evidence and data currently accessible: This report is the first attempt to collect the available data and put things together in a consistent and integrative accounting framework, in a way which is compatible with existing OSPAR workstreams and assessments of quality status. This report explored whether such a NCA framework can be useful and workable at the OSPAR level and what steps OSPAR can take in the coming years to make the best use of this method to support decision making for ecosystem-based management of the marine environment. Therefore, the content of this report is just a first step rather than the endpoint, i.e., it is better to have a functional NCA system with gaps than to defer progressing NCA until all gaps can be filled.

8 References

Barbier, E. B. (2017). Marine ecosystem services. In *Current Biology* (Vol. 27, Issue 11, pp. R507–R510). Cell Press. https://doi.org/10.1016/j.cub.2017.03.020

Brander, L. (2013). Guidance Manual on Value Transfer Methods for Ecosystem Services. In *Guidance manual on value transfer methods for ecosystem services*. Publishing Services Section, UNON.

Buonocore, E., Donnarumma, L., Appolloni, L., Miccio, A., Russo, G. F., & Franzese, P. P. (2020). Marine natural capital and ecosystem services: An environmental accounting model. *Ecological Modelling*, *424*, 109029. https://doi.org/10.1016/J.ECOLMODEL.2020.109029

CBD. (n.d.). *Natural Capital*. Retrieved May 27, 2021, from https://www.cbd.int/business/projects/natcap.shtml

Chee, Y. E. (2004). An ecological perspective on the valuation of ecosystem services. *Biological Conservation*, *120*(4), 549–565. https://doi.org/10.1016/J.BIOCON.2004.03.028

Chen, W., Barton, D. N., & Sander, G. (2021). *Coastal-Marine ecosystem accounting to support Integrated Coastal Zone Management Norwegian institute for Water Research (NIVA) Norwegian Institute for Nature Research (NINA) Corresponding author : wenting.chen@niva.no*.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature 1997 387:6630*, *387*(6630), 253–260. https://doi.org/10.1038/387253a0

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, *26*(1), 152–158. https://doi.org/10.1016/J.GLOENVCHA.2014.04.002

Edens, B., & Hein, L. (2013). Towards a consistent approach for ecosystem accounting. *Ecological Economics*, *90*, 41–52. https://doi.org/10.1016/j.ecolecon.2013.03.003

EEA. (2006). Land accounts for Europe 1990–2000: Towards integrated land and ecosystem accounting. In *Europe* (Vol. 11, Issue 11). http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Land+accounts+for+Europe+1990?2000#0

Ekins, P., & Max-Neef, M. A. (1992). *Real-life economics : understanding wealth creation*. 147–155.

EMODnet. (n.d.). *EMODnet Seabed Habitats - EUSeaMap broad-scale maps*. Retrieved August 2, 2021, from https://www.emodnet-seabedhabitats.eu/about/euseamap-broad-scale-maps/

European Commission. (n.d.-a). *Biodiversity strategy for 2030*. Retrieved May 27, 2021, from https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en

European Commission. (n.d.-b). *Integrated System for Natural Capital and Ecosystem Services Accounting (INCA) project, Map*. Retrieved August 14, 2021, from https://ecosystem-accounts.jrc.ec.europa.eu/map/recreation-actual-flow

European Commission. (n.d.-c). *Natural Capital Accounting - Environment - European Commission*. Retrieved May 31, 2021, from https://ec.europa.eu/environment/nature/capital_accounting/index_en.htm

European Commission. (n.d.-d). *OSPAR - Marine Policy - Environment - European Commission* (pp. 1–13). Retrieved August 13, 2021, from https://ec.europa.eu/environment/marine/international-cooperation/regional-sea-conventions/ospar/index_en.htm

European Commission. (2013). *Mapping and Assessment of Ecosystems and their Services*. https://doi.org/10.2779/12398

European Commission. (2019). *The European Green Deal*. https://ec.europa.eu/info/sites/default/files/european-green-deal-communication_en.pdf

European Commission. (2020a). 2020 Blue Economy Report: Blue sectors contribute to the recovery and pave way for EU Green Deal. *European Commission - Press Release - IP/20/986*, *June*, 2. https://ec.europa.eu/commission/presscorner/detail/en/IP_20_986

European Commission. (2020b, May 20). *Reinforcing Europe's resilience: halting biodiversity loss and building a healthy and sustainable food system*. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_884

European Environment Agency. (n.d.). *EUNIS habitat classification — European Environment Agency*. 2018. Retrieved August 13, 2021, from https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification

European Environment Agency. (2019a). *Habitat types search*. https://eunis.eea.europa.eu/habitats.jsp

European Environment Agency. (2019b). *Natural capital accounting in support of policymaking in Europe — European Environment Agency*. https://www.eea.europa.eu/publications/natural-capital-accounting-in-support

European Environment Agency. (2021). *Ecosystem Extent Accounts — European Environment Agency*. https://www.eea.europa.eu/data-and-maps/data/data-viewers/ecosystem-extent-accounts

Eurostat. (n.d.-a). *Environmental accounts - establishing the links between the environment and the economy - Statistics Explained*. Retrieved August 13, 2021, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental_accounts_-_establishing_the_links_between_the_environment_and_the_economy#Policy_relevance_and_uses_of_environmental_account

Eurostat. (n.d.-b). *UN adopts a new statistical standard to measure the value of ecosystems - Products Eurostat News - Eurostat*. Retrieved August 12, 2021, from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/cn-20210311-1

FAO. (2021a). *Fishery Statistical Collections - Global Aquaculture Production*. http://www.fao.org/fishery/statistics/global-aquaculture-production/en

FAO. (2021b). *Fishery Statistical Collections - Global Capture Production*. http://www.fao.org/fishery/statistics/global-capture-production/en

Flatebø, S., Supervisor, S., & Nøstbakken, L. (2019). *Resource Rent in the Norwegian Aquaculture Industry A bottom-up approach*.

GOAP. (n.d.). *About the Global Ocean Accounts Partnership*. Retrieved August 13, 2021, from https://www.oceanaccounts.org/about-the-global-ocean-accounts-partnership/

GOAP. (2020a). *Global Inventory of Accounting in Countries. Global Progress Assessment, Ocean Accounting for Sustainable Development*.

GOAP. (2020b). *Technical Guidance on Ocean Accounting- Version 0.9, pre-release consultation draft*. https://www.oceanaccounts.org/technical-guidance-on-ocean-accounting-2/

Hein, L., Bagstad, K. J., Obst, C., Edens, B., Schenau, S., Castillo, G., Soulard, F., Brown, C., Driver, A., Bordt, M., Steurer, A., Harris, R., & Caparrós, A. (2020). Progress in natural capital accounting for ecosystems. *Science*, *367*(6477), 514–515. https://doi.org/10.1126/science.aaz8901

HELCOM. (2019). *Baltic Marine Environment Protection Commission Key messages from the International Marine Ecosystem Accounting Workshop in terms of HOLAS III and continuation of HELCOM work on economic and social analyses Code 5-3 Category INF Agenda Item 5-Activities of relevant HELCOM projects or processes Submission date*. http://maiaportal.eu/home/

Horlings, E., Schenau, S., Hein, L., Lof, M., Jongh, L. de, & Polder, M. (2020). *Monetary valuation of ecosystem services for the Netherlands*. https://www.cbs.nl/en-gb/background/2020/04/monetary-valuation-of-ecosystem-services-for-the-netherlands

IDEEA Group. (2020). *Natural Capital Accounting for Bord Iascaigh Mhara. Accounting assessment report, Prepared for Bord Iascaigh Mhara (BIM)*. www.ideeagroup.com

Johnston, R. J., Rosenberger, R. S., Rolfe, J., & Brouwer, R. (2015). *Benefit Transfer: The Present State and Future Prospects*. 553–574. https://doi.org/10.1007/978-94-017-9930-0_24

Joint Meeting of the Helsinki & OSPAR Commissions. (2003). *Statement on the Ecosystem Approach to the Management of Human Activities*.

Jolliffe, J., Jolly, C., & Stevens, B. (2021). *Blueprint for improved measurement of the international ocean economy: An exploration of satellite accounting for ocean economic activity*. https://doi.org/10.1787/aff5375b-en

Jongh, L. de, Jong, R. de, Schenau, S., Berkel, J. van, Bogaart, P., Driessen, C., Horlings, E., Lof, M., Mosterd, R., & Hein, L. (2021). *Natural Capital Accounts Netherlands 2013-2018. CBS publication in collaboration with Wageningen University & Research (WUR)*. https://www.cbs.nl/nl-nl/longread/aanvullende-statistische-diensten/2021/natuurlijk-kapitaalrekeningen-nederland-2013-2018?onepage=true

Judd, A., & Lonsdale, J. A. (2021). Applying systems thinking: The Ecosystem Approach and Natural Capital Approach – Convergent or divergent concepts in marine management? *Marine Policy*, *129*, 104517. https://doi.org/10.1016/j.marpol.2021.104517

Luisetti, T., Turner, R. K., Andrews, J. E., Jickells, T. D., Kröger, S., Diesing, M., Paltriguera, L., Johnson, M. T., Parker, E. R., Bakker, D. C. E., & Weston, K. (2019). Quantifying and valuing carbon flows and stores in coastal and shelf ecosystems in the UK. *Ecosystem Services*, *35*, 67–76. https://doi.org/10.1016/J.ECOSER.2018.10.013

MA. (2005). *Millennium Ecosystem Assessment*. https://www.millenniumassessment.org/en/index.html

Maes, J., & Jacobs, S. (2017). Nature-Based Solutions for Europe's Sustainable Development. *Conservation Letters*, *10*(1), 121–124. https://doi.org/10.1111/conl.12216

Maes, J., Teller, A., Nessi, S., Bulgheroni, C., Konti, A., Sinkko, T., Tonini, D., & Pant, R. (2020). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment . Supplement (Indicator fact sheets). In *JRC Science for Policy Reports. European Commission*. https://doi.org/10.2760/519233

MAIA. (n.d.). *MAPPING AND ASSESSMENT FOR INTEGRATED ECOSYSTEM ACCOUNTING*. Retrieved May 31, 2021, from https://maiaportal.eu/

MAREA. (n.d.). *MAREA – From marine ecosystem accounting to integrated governance for sustainable planning of marine and coastal areas*. Retrieved June 1, 2021, from http://marea.balticseaportal.net/

Nations, U. (n.d.). *An Introduction to Ecosystem Accounting Key Concepts and Policy Applications*.

Natural Capital. (n.d.). Retrieved July 20, 2021, from https://www.cbs.nl/en-gb/society/nature-and-environment/natural-capital

Natural Capital Coalition. (n.d.). *What is a Natural Capital Approach?* Retrieved August 2, 2021, from https://naturalcapitalcoalition.org/wp-content/uploads/2019/06/NCC-WhatIs-NaturalCapitalApproach-FINAL.pdf

Nel, J. L., & Driver, A. (2015). *National River Ecosystem Accounts for South Africa. Discussion document for Advancing {SEEA} Experimental Ecosystem Accounting Project*. http://opus.sanbi.org:80/jspui/handle/20.500.12143/5642

Noordegraaf, I. (2020). *Application of Ecosystem Services to support decision- making in OSPAR activities . Colofon* (Issue February).

Obst, C., Hein, L., & Edens, B. (2015). National Accounting and the Valuation of Ecosystem Assets and Their Services. *Environmental and Resource Economics 2015 64:1*, *64*(1), 1–23. https://doi.org/10.1007/S10640-015-9921-1

Office for National Statistics. (2021a). *Marine accounts, natural capital, UK*. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/marineaccountsnaturalcapitaluk/2021

Office for National Statistics. (2021b). *Marine natural capital accounts, UK methodology guide* . https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/marinenaturalcapitalaccountsukmethodologyguide

OSPAR. (n.d.-a). *Assessment templates* . Retrieved August 14, 2021, from https://www.ospar.org/work-areas/cross-cutting-issues/qsr2023/assessment-templates

OSPAR. (n.d.-b). *Best Available Techniques (BAT) & Best Environmental Practices (BEP) | OSPAR Commission*. Retrieved August 13, 2021, from https://www.ospar.org/convention/principles/bat-bep

OSPAR. (n.d.-c). *Carbon Capture and Storage*. Retrieved June 10, 2021, from https://www.ospar.org/work-areas/oic/carbon-capture-and-storage

OSPAR. (n.d.-d). *Ecosystem Approach | OSPAR Commission*. Retrieved August 12, 2021, from https://www.ospar.org/convention/principles/ecosystem-approach

OSPAR. (n.d.-e). *Offshore Installations* . Retrieved August 14, 2021, from https://www.ospar.org/work-areas/oic/installations

OSPAR. (n.d.-f). *Offshore Renewables*. Retrieved June 15, 2021, from https://www.ospar.org/work-areas/eiha/offshore-renewables

OSPAR. (n.d.-g). *Polluter Pays Principle | OSPAR Commission*. Retrieved August 13, 2021, from https://www.ospar.org/convention/principles/polluter-pays-principle

OSPAR. (n.d.-h). *Precautionary Principle | OSPAR Commission*. Retrieved August 13, 2021, from https://www.ospar.org/convention/principles/precautionary-principle

OSPAR. (n.d.-i). *The North-East Atlantic | OSPAR Commission*. Retrieved August 12, 2021, from https://www.ospar.org/convention/the-north-east-atlantic

OSPAR. (1998). *1992 OSPAR Convention for the protection of the marine environment of the North-East Atlantic*. https://www.ospar.org/site/assets/files/1290/ospar_convention-1.pdf

OSPAR. (2010). *The OSPAR system of Ecological Quality Objectives for the North Sea, a contribution to OSPAR's Quality Status Report 2010.* 15 pp. www.ospar.org

OSPAR. (2011). *Ratification of OSPAR carbon capture and storage measures*. https://www.ospar.org/news/ratification-of-ospar-carbon-capture-and-storage-measures

OSPAR. (2017). *Offshore Oil and Gas, Trends in discharges, spills and emissions from offshore oil and gas installations. Intermediate Assessment 2017*. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-

2017/pressures-human-activities/trends-discharges-spills-and-emissions-offshore-oil-and-gas-inst/

OSPAR. (2019). *QSR 2023 Guidance Document*. https://www.ospar.org/documents?v=40951

OSPAR Commission. (n.d.). *North-East Atlantic Environment Strategy*. Retrieved May 27, 2021, from https://www.ospar.org/convention/strategy

OSPAR Commission. (2010a). The North-East Atlantic Environment Strategy. *Ministerial Meeting Of The Ospar Commission*, *Summary Re*, 22. http://www.ospar.org/html_documents/ospar/html/Revised_OSPAR_Strategies_2003.pdf#nameddest=biodiversity

OSPAR Commission. (2010b). *The Quality Status Report*. https://qsr2010.ospar.org/en/index.html

OSPAR Commission. (2021). *North-East Atlantic Environment Strategy 2020-2030. Draft – unpublished.*

OSPAR EIHA. (2021a). *OSPAR Quality Status Report: feeder report on aquaculture [EIHA DRAFT]*.

OSPAR EIHA. (2021b). *OSPAR quality status report: feeder report on extraction of non-living resources (e.g. sand and gravel) [EIHA draft]*.

OSPAR EIHA. (2021c). *OSPAR quality status report: feeder report on fisheries [EIHA draft]*.

OSPAR EIHA. (2021d). *OSPAR Quality Status Report: feeder report on offshore renewable energy generation [EIHA draft]*.

OSPAR EIHA. (2021e). *OSPAR Quality Status Report: feeder report on shipping and ports [EIHA DRAFT]*.

Pachernegg, P. (2020). *Recreation and Tourism in the Northeast Atlantic Ocean [EIHA draft]*.

Pearce, D. W. (1989). *Blueprint for a green economy, Earthscan, London*.

QSR 2023 Guidance Document. (n.d.). Retrieved August 4, 2021, from https://www.ospar.org/documents?v=40951

Richardson, L., Loomis, J., Kroeger, T., & Casey, F. (2015). The role of benefit transfer in ecosystem service valuation. *Ecological Economics*, *115*, 51–58. https://doi.org/10.1016/J.ECOLECON.2014.02.018

Schenau, S., Rietveld, H., & Bosch D. (2019). *Natural capital accounts for the North Sea: The physical SEEA EEA accounts- Final report* .

Scientific, T. and E. C. for F. (STECF). (2018). *The 2018 Annual Economic Report on the EU Fishing Fleet (STECF 18-07)*. https://doi.org/10.2760/56158

Smit, K. P., Bernard, A. T. F., Lombard, A. T., & Sink, K. J. (2021). Assessing marine ecosystem condition: A review to support indicator choice and framework development. In *Ecological Indicators* (Vol. 121, p. 107148). Elsevier B.V. https://doi.org/10.1016/j.ecolind.2020.107148

Spaans, M. (2020). *Marine Protected Areas in Europe, An assessment of the current status and the representation of benefits in socio- economic analyses in order to support decision-making*. http://www.marbef.org/wiki/Marine_Protected_Areas_in_Europe

TEEB. (2009). *The Economics of Ecosystems and Biodiversity for National and International Policy Makers – Summary: Responding to the Value of Nature 2009*. UNEP. www.teebweb.org

Thornton, A., Luisetti, T., Grilli, G., Donovan, D., Phillips, R., & Hawker, J. (2019). *Initial natural capital accounts for the UK marine and coastal environment. Final Report. Report prepared for the Department for Environment Food and Rural Affairs. June*.

Treasury, H. (2021). *The Economics of Biodiversity: The Dasgupta Review Abridged Version*. www.gov.uk/official-documents.

UN-SEEA. (n.d.-a). *An Introduction to Ecosystem Accounting, Key Concepts and Policy Applications*.

UN-SEEA. (n.d.-b). *Introduction to SEEA Ecosystem Accounting | System of Environmental Economic Accounting*. Retrieved August 13, 2021, from https://seea.un.org/Introduction-to-Ecosystem-Accounting

UN-SEEA. (n.d.-c). *Methodology | System of Environmental Economic Accounting*. Retrieved July 21, 2021, from https://seea.un.org/ecosystem-accounting

UN-SEEA. (n.d.-d). *Natural Capital Accounting and Valuation of Ecosystem Services Project*. System of Environmental Economic Accounting 2012. https://doi.org/10.1787/9789210562850-en

UN-SEEA. (2014). System of Environmental Economic Accounting 2012. In *System of Environmental Economic Accounting 2012*. https://doi.org/10.1787/9789210562850-en

United Nations. (n.d.-a). *Ecosystem Accounting in the News | System of Environmental Economic Accounting*. Retrieved August 12, 2021, from https://seea.un.org/content/ecosystem-accounting-news

United Nations. (n.d.-b). *UN adopts landmark framework to integrate natural capital in economic reporting | United Nations*. Retrieved August 13, 2021, from https://www.un.org/en/desa/un-adopts-landmark-framework-integrate-natural-capital-economic-reporting

United Nations. (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting: Final Draft* (Vol. 3, Issue March).

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, & The World Bank. (2014). *System of Environmental-Economic Accounting 2012 Central Framework - final, official publication.*

United Nations Statistics Division. (2021). *Global Assessment of Environmental-Economic Accounting and Supporting Statistics 2020*. https://unstats.un.org/unsd/statcom/44th-session/documents/doc13/BG-SEEA-Implementation-E.pdf;

Vallecillo, S., La Notte, A., Polce, C., Zulian, G., Alexandris, N., Ferrini, S., & Maes, J. (2018). *Ecosystem services accounting: Part I - Outdoor recreation and crop pollination*.

Vallecillo, Sara, La Notte, A., Ferrini, S., & Maes, J. (2019). How ecosystem services are changing: an accounting application at the EU level. *Ecosystem Services*, *40*. https://doi.org/10.1016/j.ecoser.2019.101044

Van Berkel, J., Bogaart, P., Driessen, C., Hein, L., Horlings, E., De Jong, R., De Jongh, L., Lof, M., Mosterd, R., & Schenau, S. (2021). Natural Capital Accounting in the Netherlands-Technical report. Statistics Netherlands (CBS) and Wageningen University and Research (WUR) Natural Capital Accounting in the Netherlands. *Statistics Netherlands and WUR*, *May*.

Vasquez, M., Manca, E., Inghilesi, R., Martin, S., Agnesi, S., Al Hamdani, Z., Annunziatellis, A., Bekkby, T., Pesch, R., Askew, N., Bentes, L., Castle, L., Doncheva, V., Drakopoulou, V., Gonçalves, J., Laamanen, L., Lillis, H., Loukaidi, V., Mcgrath, F., … Virtanen, E. (2020). *EUSeaMap 2019, A European broad-scale seabed habitat map, technical report* (Issue July). https://archimer.ifremer.fr/doc/00636/74782/

Veretennikov, P. (n.d.). *Report on possibilities of application of Ecosystem Services and Natural Capital approaches in OSPAR activities*.

Vondolia, G. K., Chen, W., Armstrong, C. W., & Norling, M. D. (2020). Bioeconomic Modelling of Coastal Cod and Kelp Forest Interactions: Co-benefits of Habitat Services, Fisheries and Carbon Sinks. *Environmental and Resource Economics*, *75*(1), 25–48. https://doi.org/10.1007/S10640-019-00387-Y

WAVES. (n.d.). *Wealth Accounting and the Valuation of Ecosystem Services - Natural Capital Accounting*. Retrieved May 31, 2021, from https://www.wavespartnership.org/en/natural-capital-accounting

Weber, J.-L. (2018). Environmental Accounting. In *Oxford Research Encyclopedia of Environmental Science*. Oxford University Press. https://doi.org/10.1093/acrefore/9780199389414.013.105

WindEurope. (2020). *Offshore wind in Europe - key trends and statistics 2019* . https://windeurope.org/intelligence-platform/product/offshore-wind-in-europe-key-trends-and-statistics-2019/

World Bank. (2018). Pilot Ecosystem Account for Indonesian Peatlands. *World Bank*, 10–11. http://documents1.worldbank.org/curated/en/280931564033874140/pdf/Pilot-ecosystem-account-for-Indonesian-peatlands-Sumatra-and-Kalimantan-islands.pdf

Zulian, G., Stange, E., Woods, H., Carvalho, L., Dick, J., Andrews, C., Baró, F., Vizcaino, P., Barton, D. N., Nowel, M., Rusch, G. M., Autunes, P., Fernandes, J., Ferraz, D., Ferreira dos Santos, R., Aszalós, R., Arany, I., Czúcz, B., Priess, J. A., … Viinikka, A. (2018). Practical application of spatial ecosystem service models to aid decision support. *Ecosystem Services*, *29*, 465–480.

https://doi.org/10.1016/J.ECOSER.2017.11.005

8.1 References Table 1

[i] Belgium
- https://maiaportal.eu/storage/app/media/MAIA_BE_Factsheet_Final.pdf
- https://www.blauwecluster.be/project/sumes

[ii] Denmark
- https://www.dst.dk/en/Statistik/Publikationer/VisPub?cid=27468

[iii] Finland
- https://maiaportal.eu/storage/app/media/MAIA_FI_Factsheet_Final.pdf
- syke.fi
- Information from OSPAR Special Session on Marine Natural Capital Accounting held on 13 July 2021

[iv] France
- https://maiaportal.eu/storage/app/media/MAIA_FR_Factsheet_Final.pdf

[v] Germany
- https://maiaportal.eu/storage/app/media/MAIA_DE_Factsheet_Final.pdf

[vi] Iceland
- http://norden.diva-portal.org/smash/get/diva2:1282581/FULLTEXT01.pdf

[vii] Ireland
- www.incaseproject.com
- https://ideeagroup.com/

[viii] Netherlands
- https://maiaportal.eu/storage/app/media/MAIA_NL_Factsheet_Final.pdf

[ix] Norway
- https://maiaportal.eu/storage/app/media/MAIA_NO_Factsheet_Final.pdf
- Information from OSPAR Special Session on Marine Natural Capital Accounting held on 13 July 2021

[x] Portugal
- https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=459804030&DESTAQUESmodo=2
- https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=261968449&DESTAQUESmodo=2
- https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_docmetodsec2010_cn&contexto=cs&perfil=220677460

[xi] Spain
- https://maiaportal.eu/storage/app/media/MAIA_SP_Factsheet_final.pdf
- https://recaman.agenciamedioambienteyagua.es/VICAF/visor.html

- Information from OSPAR Special Session on Marine Natural Capital Accounting held on 13 July 2021

[xii] Sweden

- Land accounts for ecosystem services (scb.se)
- Investigating new data sources for land and ecosystem accounts (scb.se)
- https://www.msp-platform.eu/practices/symphony-tool-ecosystem-based-marine-spatial-planning

[xiii] United Kingdom

- http://sciencesearch.defra.gov.uk/Document.aspx?Document=14642_JNCCCefasmNCAreport.pdf
- https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/marineaccountsnaturalcapitaluk/2021#measuring-the-data
- Information from OSPAR Special Session on Marine Natural Capital Accounting held on 13 July 2021

Appendix

I. Extent Account

Table I: Extent of OSPAR marine habitats (EUNIS classification 2, 3, and 4)

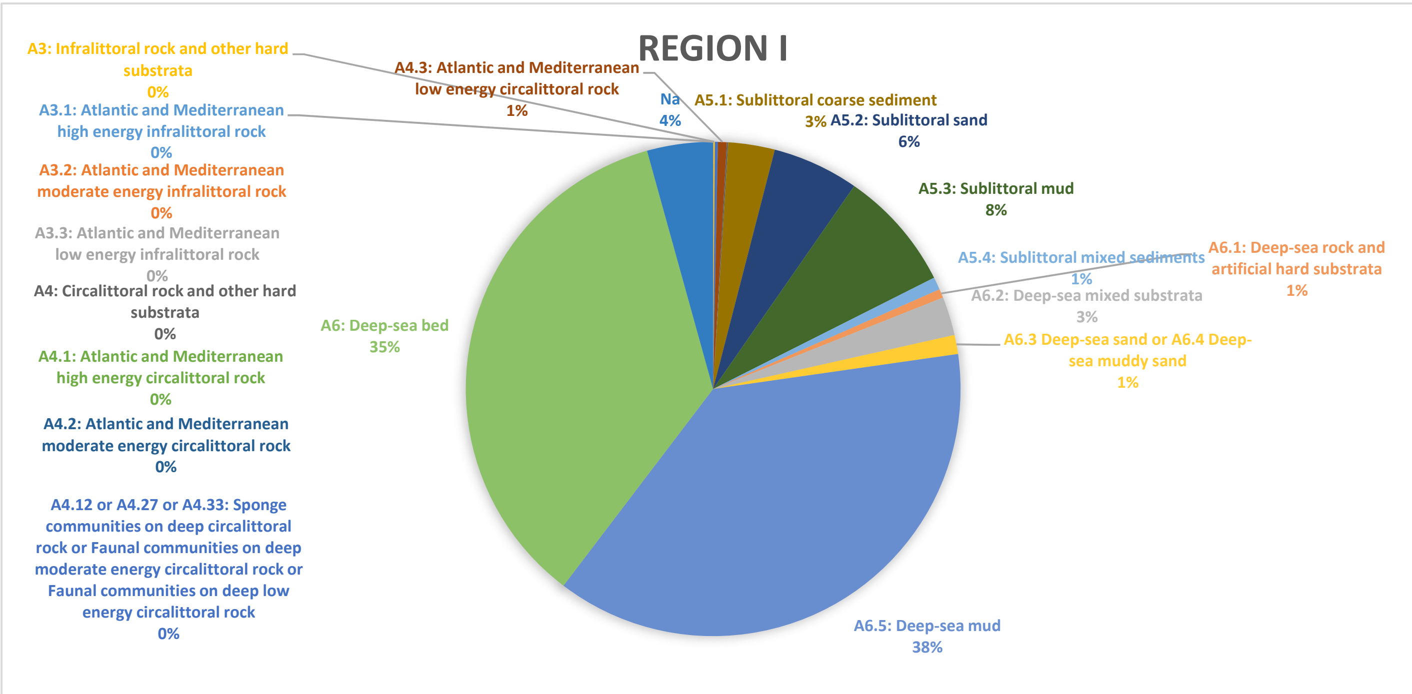
EUNIS Habitat			Extent (km2)	Extent (hectares)
Level 2	Level 3	Level 4		
A3: Infralittoral rock and other hard substrata			2,429.59	242,959.40
	A3.1: Atlantic and Mediterranean high energy infralittoral rock		3,768.38	376,837.57
	A3.2: Atlantic and Mediterranean moderate energy infralittoral rock		1,293.70	129,369.70
	A3.3: Atlantic and Mediterranean low energy infralittoral rock		1,490.00	148,999.60
A4: Circalittoral rock and other hard substrata			2,850.93	285,092.77
	A4.1: Atlantic and Mediterranean high energy circalittoral rock		12,463.82	1,246,381.74
		A4.12: Sponge communities on deep circalittoral rock	5,150.85	515,085.12
		A4.12 or A4.27 or A4.33: Sponge communities on deep circalittoral rock or Faunal communities on deep moderate energy circalittoral rock or Faunal communities on deep low energy circalittoral rock	1,081.75	108,175.33
	A4.2: Atlantic and Mediterranean moderate energy circalittoral rock		5,118.76	511,875.67
		A4.27: Faunal communities on deep moderate energy circalittoral rock	6,025.00	602,499.54
	A4.3: Atlantic and Mediterranean low energy circalittoral rock		4,937.43	493,743.40
		A4.33: Faunal communities on deep low energy circalittoral rock	26,130.04	2,613,004.30
A5: Sublittoral sediment			6,784.75	678,475.40
		A5.13: Infralittoral coarse sediment	6,275.64	627,564.39
		A5.14: Circalittoral coarse sediment	86,053.06	8,605,306.09
		A5.15: Deep circalittoral coarse sediment	281,352.22	28,135,221.78

		A5.23 or A5.24: Infralittoral fine sand or Infralittoral muddy sand	25,244.82	2,524,482.06
		A5.25 or A5.26: Circalittoral fine sand or Circalittoral muddy sand	154,639.61	15,463,960.94
		A5.27: Deep circalittoral sand	503,168.16	50,316,816.10
		A5.33: Infralittoral sandy mud	3,048.95	304,895.47
		A5.33 or A5.34: Infralittoral sandy mud or Infralittoral fine mud	2,844.61	284,461.29
		A5.34: Infralittoral fine mud	1,328.75	132,875.39
		A5.35: Circalittoral sandy mud	15,921.93	1,592,193.40
		A5.35 or A5.36: Circalittoral sandy mud or Circalittoral fine mud	22,730.74	2,273,074.39
		A5.36: Circalittoral fine mud	3,864.58	386,458.18
		A5.37: Deep circalittoral mud	403,872.56	40,387,255.65
		A5.43: Infralittoral mixed sediments	2,167.70	216,769.52
		A5.44: Circalittoral mixed sediments	10,556.43	1,055,642.52
		A5.45: Deep circalittoral mixed sediments	42,674.13	4,267,413.06
A6: Deep-sea bed			4,200,112.73	420,011,273.35
		A6.11: Deep-sea rock	46,089.16	4,608,916.40
	A6.2: Deep-sea mixed substrata		147,561.10	14,756,109.53
	A6.3 Deep-sea sand **or A6.4** Deep-sea muddy sand		150,385.88	15,038,588.17
	A6.5: Deep-sea mud		3,033,135.36	303,313,536.47
Na			170,298.02	17,029,801.74
TOTAL			9,392,851.15	939,285,115.43

Region I

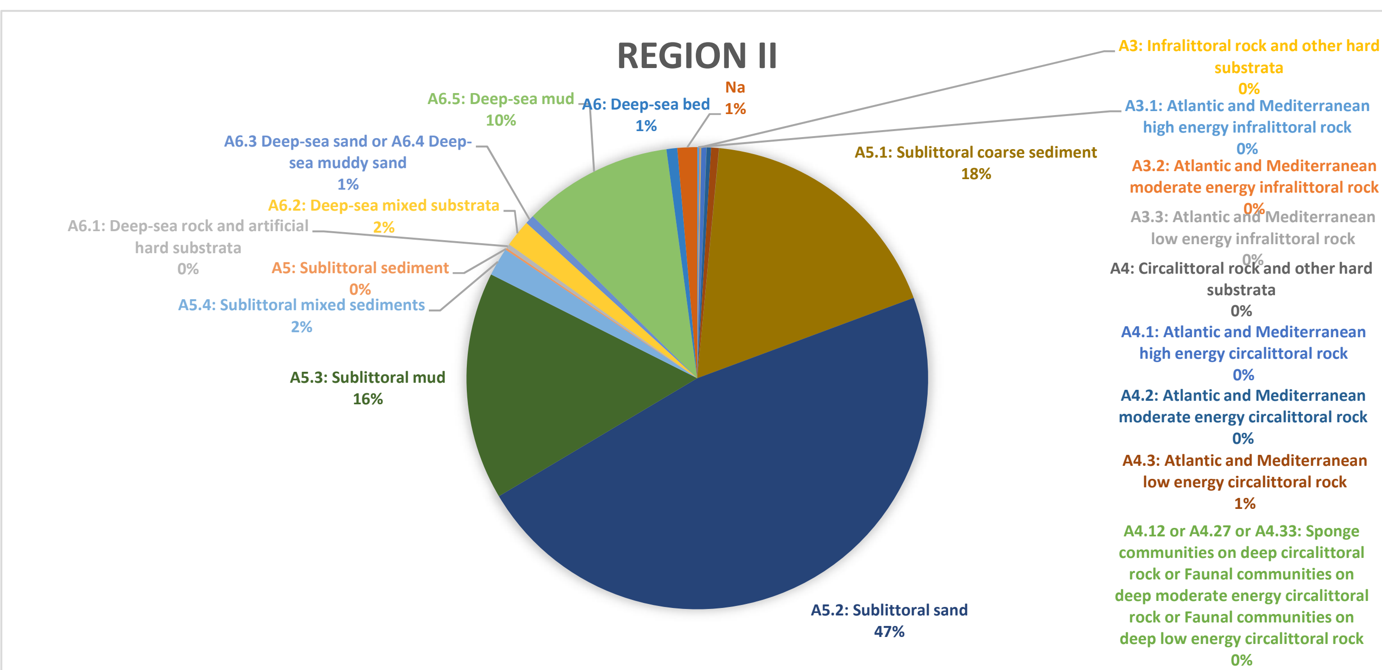
Figure I – EUNIS Habitats abundance in OSPAR Region I. Source: Author's own elaboration

- *0% does not mean that the habitat is not present but that the size is very small in comparison with the rest (this apply to all the graphs of this appendix)*



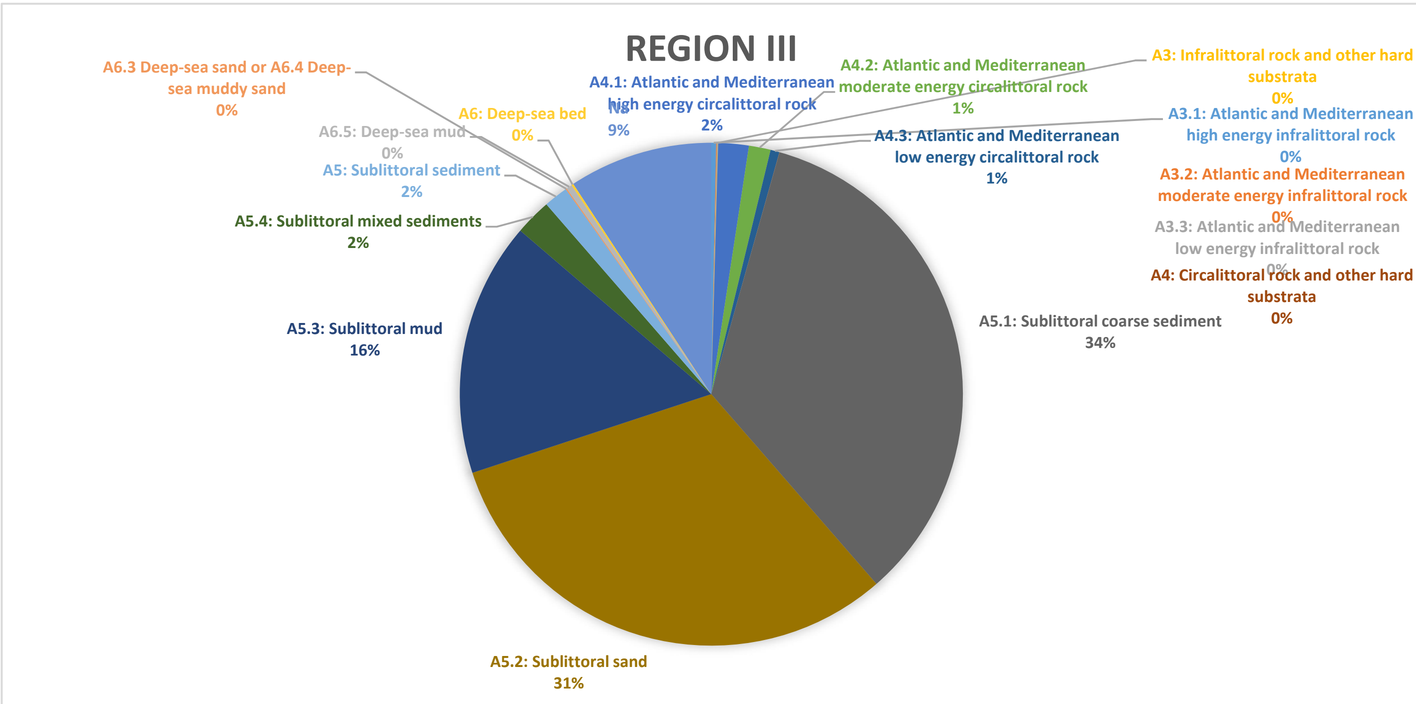
Region II

Figure II – EUNIS Habitats abundance in OSPAR Region II. Source: Author's own elaboration



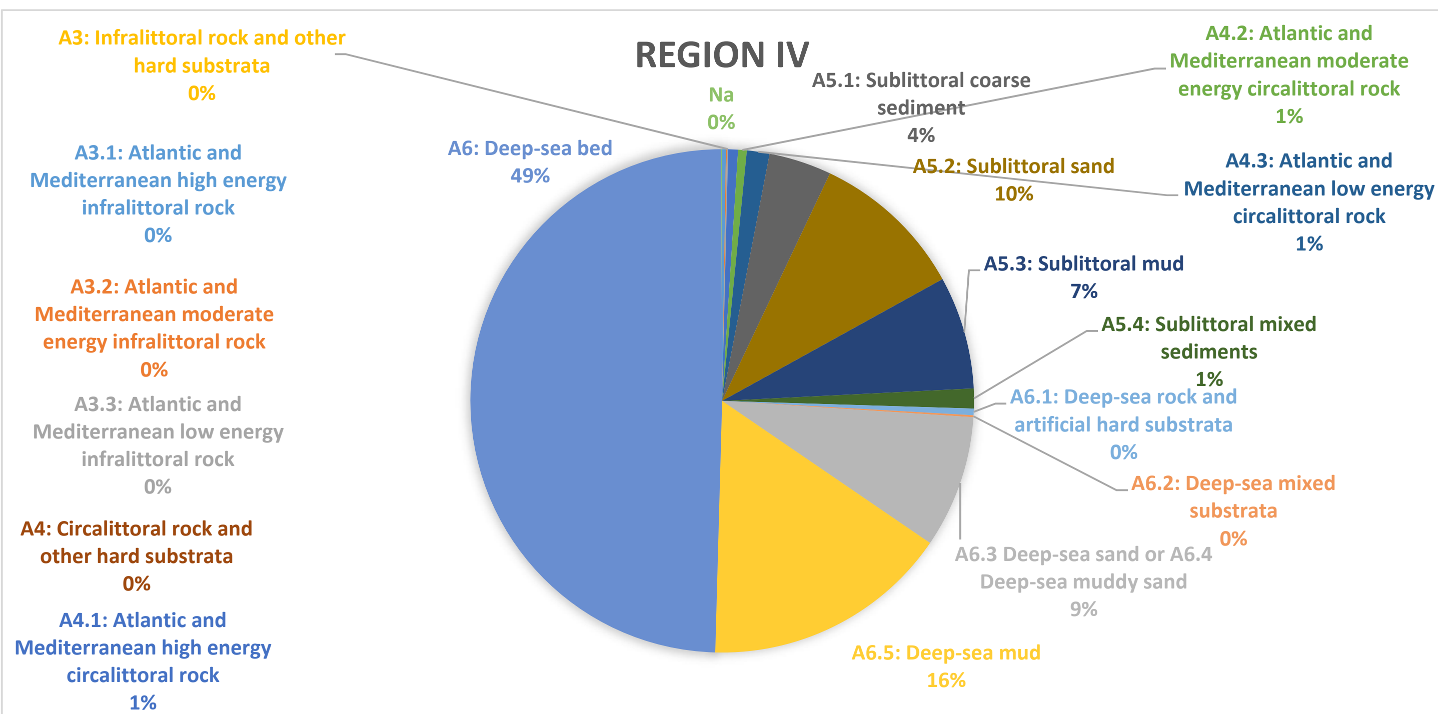
Region III

Figure III – EUNIS Habitats abundance in OSPAR Region III. Source: Author's own elaboration



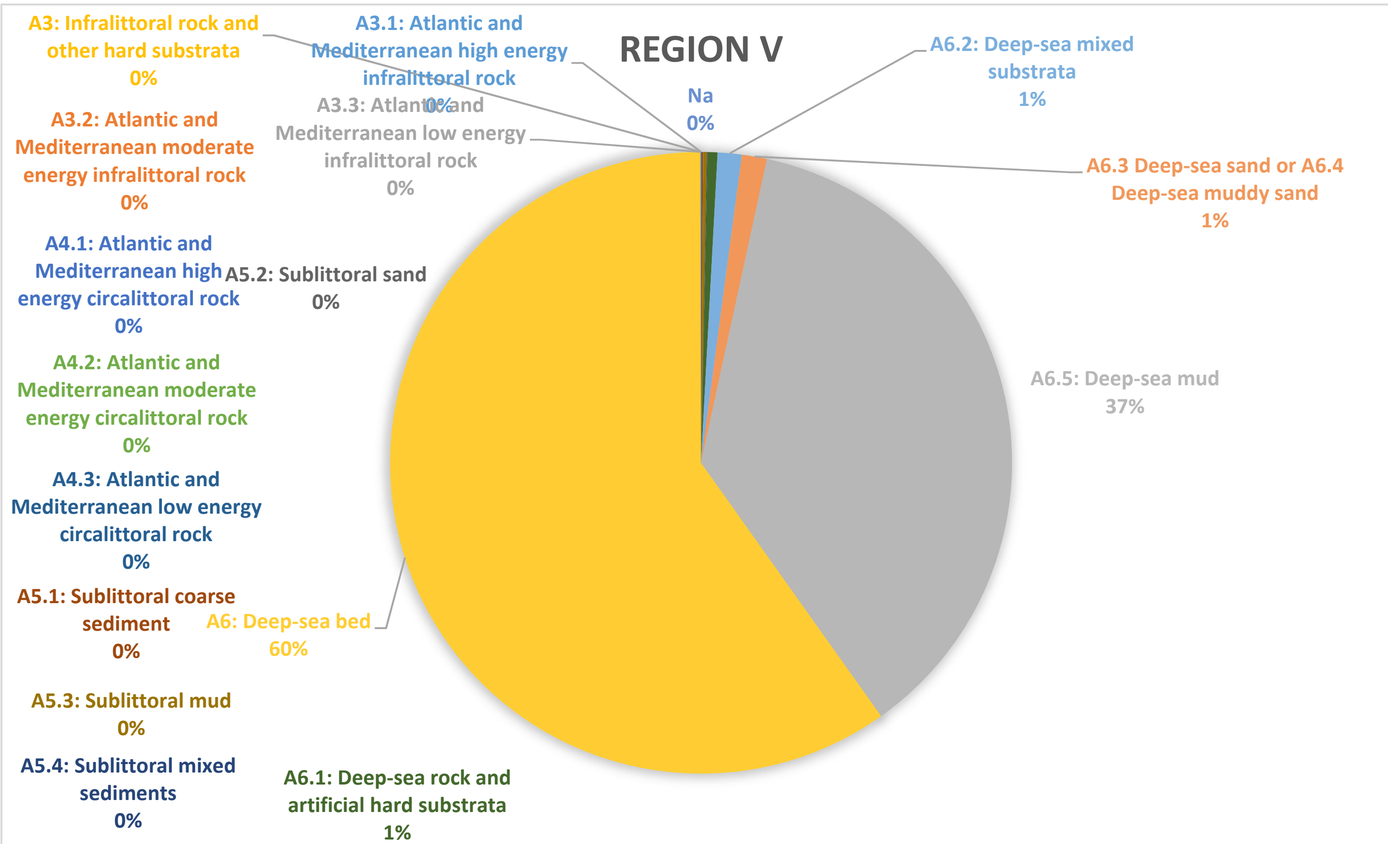
Region IV

Figure IV – EUNIS Habitats abundance in OSPAR Region IV. Source: Author's own elaboration



Region V

Figure V – EUNIS Habitats abundance in OSPAR Region V. Source: Author's own elaboration



II. Condition account

☐ Candidate indicator (the unit used not established or not available yet)

- units content extracted from the latest information from QSR and IA2017
- where units or sources not included, not information found

Quality status indicators for **marine ecosystems**:

Thematic Assessment	State change Indicator	Unit	OSPAR Group leading the work	Assessment state	Source
A. Abiotic ecosystem characteristics					
A.1. Physical state characteristics					
A.2. Chemical state characteristics					
Marine Birds	• Marine bird habitat quality (B7)	% of the area with good condition	JWGBIRD	Candidate indicator pilot assessment	
Benthic habitat	• Condition of benthic habitat communities: the common conceptual approach (BH2)*	Ecological Quality Ratio (EQR) value (0-1)	BiTA/OBHEG	Thematic Assessment	[12]
	• Benthic multimetric index quality assessment (BH2b) Condition of benthic habitat communities (BH2-B): Subtidal Habitats of the Southern North Sea	Index: Bottom fishing abrasion in terms of swept area ratio EQR – value (0-1)	BiTA/OBHEG	Thematic Assessment	[13]
B. Biotic ecosystem characteristics					
B.1.Compositional state characteristics					
Marine Birds	• Marine bird abundance (B1)	No. of individuals Proportion of: - No. of birds per species per site per year that are counted from land or from the air	BiTA/JWGBIRD	Thematic Assessment	[14]
Marine Mammals	• Seal abundance and distribution (M3)	No. seals on land when they are moulting or breeding	BiTA/OMMEG	Thematic Assessment	[15]
	• Abundance and distribution of marine mammals (M4) - Abundance and Distribution of Cetaceans - Abundance and Distribution of Coastal Bottlenose Dolphins - Pilot Assessment on Abundance and Distribution of Killer Whales	No. of individuals - Population abundance estimates from large-scale aerial and shipboard surveys	BiTA/OMMEG	Thematic Assessment	[16]

[12] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/condition-of-benthic-habitat-defining-communities/common-conceptual-approach/
[13] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/condition-of-benthic-habitat-defining-communities/subtidal-habitats-southern-north-sea/
[14] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/bird-abundance/
[15] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/seal-abundance-and-distribution/
[16] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/

		- Records of sightings and strandings			
Fish	• Distributional range (FC7)	%	BiTA/FishWS	Candidate indicator	
	• Fish distributional pattern (FC8)	No unit	BiTA/FishWS	Candidate indicator	
	• Recovery in the population abundance of sensitive fish species (FC1)	No of individuals No of each species of fish sampled in each trawl sample, measured to defined length categories Or species population abundance density (Ns / km2) in each year for each survey	BiTA/FishWS	Thematic Assessment	[17]
	• Proportion of large fish (Large Fish Index) (FC2)	average density (N), of each species (s) and length category (l), in each year,	BiTA/FishWS	Thematic Assessment	[18]
Food webs	• Fish biomass and abundance of dietary functional groups (FW7)		BiTA/Foodweb EG	Candidate indicator	
	• Biomass trophic spectrum (FW8)		TBC (Foodweb EG)	Candidate indicator pilot assessment	
	• Ecological network analysis diversity (FW9)		BiTA/Foodweb EG	Candidate indicator	
Benthic habitats	• Typical species composition (BH1)	Proportion of biomass/number of individuals above specified length/ size		Typical Species Composition indicator under development	ICES Advice 2015, Book 1
Pelagic habitats	• Plankton biomass &/or abundance (PH2) (Continuous Plankton Recorded (CPR) samples averaged/ Ecohydrodynamic zones/ OSPAR sub-region)	T	IA 2017 – EcApRHA project	Thematic Assessment	[19]
B.2. Structural state characteristics					
Food webs	• Production of phytoplankton (FW2)		Foodweb EG	Candidate indicator pilot assessment	
	• Biomass, species composition and spatial distribution of zooplankton (Candidate) (FW6)			Candidate indicator pilot assessment	
B.3. Functional state characteristics					
Marine Birds	• Breeding success of Kittiwake (B2)	No. chicks fledged per pair at colonies of black-legged kittiwake	ICG-POSH or JWGBIRD	Candidate indicator	[20]

[17] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/fish-and-food-webs/recovery-sensitive-fish/

[18] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/fish-and-food-webs/proportion-large-fish-large-fish-index/

[19] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/changes-phytoplankton-and-zooplankton-communities/

[20] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/marine-bird-breeding-success-failure/

	• Marine bird breeding success (B3)	No chicks being produced by a seabird colony in a single breeding season	BiTA/JWGBIRD	Thematic Assessment	21
Marine Mammals	• Grey seal pup production (M5)	No. of grey seal pups born at breeding sites	BiTA/OMMEG	Thematic Assessment	22
Food webs	• Mean maximum length of demersal fish and elasmobracnchs (FC3)	% of fish larger than the mean size of first maturation (cm)	BiTA/Foodweb EG or BiTA/FishWS	Candidate indicator pilot assessment	23
	• Size composition in fish communities (FW3)	% of fish larger than mean size of first maturation The Typical Length indicator - average length of fish catched (bony fish and elasmobranchs) in cm	BiTA/Foodweb EG	Thematic Assessment	24
	• Change in average trophic level of marine predators in the Bay of Biscay (FW4)	Mean Trophic Level (MTL) calculated using species biomass data (low trophic level=1) (T)	BiTA/Foodweb EG	Thematic Assessment	25
Benthic habitats	• Size frequency distribution of bivalve or other sensitive/indicator species	(EQR)	OBHEG	Candidate indicator pilot assessment	
Pelagic habitats	• Changes in plankton functional types (life form) index ratio (PH1/FW5)	Index (1.0 = no change)	BiTA/Pelagic EG	Thematic Assessment	26
	• Changes in biodiversity index(s) (PH3)	Plankton biodiversity indexes based on: diversity, species richness, evenness, or dominance	BiTA/Pelagic EG	Thematic Assessment	
C. Landscape level characteristics					
C.1. Landscape and seascape characteristics					

For the Intermediate Assessment (IA) 2017 only two condition versus pressure interactions have sufficiently developed methodologies and data availability to undertake assessments in the line with the common conceptual approach. These are coastal habitats in relation to nutrient and / or organic enrichment and species diversity in subtidal sediments in the Southern North Sea versus abrasion (by bottom trawling fisheries).

21 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/marine-bird-breeding-success-failure/

22 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/grey-seal-pup/

23 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/fish-and-food-webs/mean-maximum-length/

24 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/fish-and-food-webs/size-fish-composition/

25 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/fish-and-food-webs/mtl-bay-biscay/

26 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/changes-phytoplankton-and-zooplankton-communities/

Pressures indicators for **marine ecosystems**:

Thematic Assessment	Pressure Indicator	Unit	OSPAR Group leading the work	Assessment state	Source
Climate Change and physical pressures					
Climate change	(not indicator found but relevant)		ICG-QSR	Thematic Assessment	
Ocean acidification	(not indicator found but relevant)	% area with acidification pH of sea	ICG-OA	Other Assessment	
Temperature changes	Sea Surface Temperature (not indicator found but relevant)	ºC increase			
Salinity changes	salt content of the sea water (not indicator found but relevant)	promille			
Hydrological changes	Sea level changes (not indicator found but relevant)	m			
Pollution and other chemical pressures					
Atmospheric and riverine inputs	• Waterborne & atmospheric nutrient input trends • Inputs of heavy metals via water and air • Status and trends in the concentrations of polycyclic aromatic hydrocarbons (PAHs) in shellfish & sediment • Status and trends of polychlorinated biphenyls (PCB) in fish and shellfish & sediment • Trends in concentrations of polybrominated diphenyl ethers (PBDEs) in fish and shellfish &sediment • Status and trends in the levels of imposex in marine gastropods (TBT in Shellfish) • Status and trends of TBT in sediments • Status and trends for heavy metals (mercury, cadmium and lead) in fish and shellfish & sediment	umol/L ug/L ug/kg ww; mg/kg ww; pg/g ww	-OSPAR Coordinated Environmental Monitoring Programme (CEMP) -OSPAR Comprenhensive Study on Riverine Inputs and Direct Discharges (RID)? -INPUT	Thematic Assessment	QSR 2023 Resources
Radionuclide contamination	β – activity discharges levels of radioactive substances	ug/L		Thematic Assessment	QSR 2023 Resources
Eutrophication	• Winter nutrient concentrations • Growing season concentrations of chlorophyll-a • Concentrations of dissolved oxygen near the seafloor	umol/L ug/L mg/L	Common Procedure ICG-Eut	Thematic Assessment	QSR 2023 Resources
Other physical pressures					
Marine birds	• Marine bird bycatch (B5)	No. of drowned waterbirds in fishing gear	JWGBIRD	Candidate indicator pilot assessment	ICES | JWGBIRD 2019 (joint OSPAR HELCOM ICES Working group on seabirds

Marine Mammals	• Marine mammal bycatch (M6)	No. of drowned mammals in fishing gear	BiTA/OMMEG	Thematic Assessment	[27]
Litter	• Beach litter • Seabed litter • Ingestion by Fulmars • Ingestion plastic particles by turtles	No. of items collected items/100m items/km2 items/kg items/kg dw	OSPAR pilot project on monitoring marine beach litter OSPAR/UNEP/KIMO report on marine litter in the NEA Region	Thematic Assessment	QSR 2023 Resources
Underwater noise	• Impulsive noise impacts (Candidate) • Ambient noise (candidate) • Impulsive noise pressure	dB re 1 μPa2 Noise level (dB)/ frequency (Hz)		Thematic Assessment	QSR 2023 Resources
Oil and gas discharges	Number and total quantities of oil spilled	no. of oil spills D/y		Thematic Assessment	QSR 2023 Resources
Biological pressures					
Non-indigenous species	• Trends in New Records of Non-Indigenous Species Introduced by Human Activities (NIS3)	No. of individuals	BiTA/NIS EG	Thematic Assessment	QSR 2023 Resources

Quality status indicators for **coastal areas**:

Thematic Assessment	State change Indicator	Unit	OSPAR Group leading the work	Assessment state	Source
A. Abiotic ecosystem characteristics					
A.1. Physical state characteristics					
A.2. Chemical state characteristics					
Marine Birds	• Marine bird habitat quality (B7)	% of area with good condition	JWGBIRD	Candidate indicator pilot assessment	
Benthic habitat	• Condition of benthic habitat communities: the common conceptual approach (BH2)*	Ecological Quality Ratio (EQR) value (0-1)	-IA 2017 – EcApRHA project BiTA/OBHEG	Thematic Assessment (Initial assessment results available for two pressure types)	[28]
	• Assessment of coastal habitats exposed to nutrient and organic enrichment (BH2a)	EQR	-IA 2017 – EcApRHA project -BiTA/OBHEG	Thematic Assessment	[29]

[27] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/harbour-porpoise-bycatch/

[28] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/condition-of-benthic-habitat-defining-communities/common-conceptual-approach/
[29] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/condition-of-benthic-habitat-defining-communities/subtidal-habitats-southern-north-sea/

B. Biotic ecosystem characteristics					
B.1.Compositional state characteristics					
Marine Birds	• Marine bird abundance (B1)	No. of individuals Proportion of: - counts of breeding pairs /species /colony /year - No. of birds /species /site /year that are counted from land or from the air	BiTA/JWGBIRD	Thematic Assessment	30
Marine Mammals	• Seal abundance and distribution (M3)	No. seals on land when they are moulting or breeding	BiTA/OMMEG	Thematic Assessment	31
	• Abundance and distribution of marine mammals (M4) - Abundance and Distribution of Coastal Bottlenose Dolphins	- Records of sightings and strandings	BiTA/OMMEG	thematic assessment	32
B.2. Structural state characteristics					
B.3. Functional state characteristics					
Marine Birds	• Breeding success of Kittiwake (Candidate) (B2)	No. chicks fledged per pair at colonies of black-legged kittiwake	ICG-POSH or JWGBIRD	Candidate indicator	33
	• Marine bird breeding success (B3)	No chicks being produced by a seabird colony in a single breeding season	BiTA/JWGBIRD	Thematic Assessment	34
Marine Mammals	• Grey seal pup production (M5)	No. of grey seal pups born at breeding sites	BiTA/OMMEG	Thematic Assessment	35
C. Landscape level characteristics					
C.1. Landscape and seascape characteristics					

For the Intermediate Assessment (IA) 2017 only two condition versus pressure interactions have sufficiently developed methodologies and data availability to undertake assessments in the line with the common conceptual approach. These are coastal habitats in relation to nutrient and / or organic

30 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/bird-abundance/
31 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/seal-abundance-and-distribution/
32 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/
33 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/marine-bird-breeding-success-failure/
34 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-birds/marine-bird-breeding-success-failure/
35 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/grey-seal-pup/

enrichment and species diversity in subtidal sediments in the Southern North Sea versus abrasion (by bottom trawling fisheries).

Pressures indicators for **coastal areas**:

Thematic Assessment	Pressure Indicator	Unit	OSPAR Group leading the work	Assessment state	Source
Other physical pressures					
Litter	• Beach litter	No. of items collected items/100m	OSPAR pilot project on monitoring marine beach litter	Thematic Assessment	QSR 2023 Resources

Annexe

i. Breakout rooms overview from OSPAR Special Meeting

Table i. Overview answers to the first question in the breakout rooms from the workshop of the 13th of July about Natural Capital Accounting. Source: Author's own elaboration

1. What type of **decisions can be supported** by NCA?
- NCA can help in defining which costs are reasonable when implementing measures on a river basin. - NCA can help to find and finance the most cost-effective combination of measures to reach "good status" (WFD/MSFD) - In Germany (Federal states) we often have the problem that costs and benefits are locally separated. For example, there are polluted sediments in the upper reaches that are very expensive to clean up. The benefits, however, accrue to the downstream riparians and ultimately to the North Sea. NCA can help to estimate the "total package". - For comparisons among countries (as based on GDP). - For valuation of environmental and resource costs required by the Water Framework Directive, as well as for valuation of costs of degradation as per the Marine Strategy Framework Directive. - Assisting in prioritisation exercises by modelling trade-offs between conflicting policies (.e.g. seabed use/conservation) - Improve effectiveness and efficiency on reporting on the state of the marine environment, to inform conservation and sustainable resource use - Managing marine conflicts - Marine conflicts and conflict in the use of the marine environment for economic or conservation purposes
- Marine Spatial Planning - which areas to protect in view of the 30% MPA commitments under the Biodiversity Strategy 2030 & upcoming updated CBD commitments - Cost-effectiveness of pollution reduction versus remediation - Consideration of trade-offs in making marine management decisions - Sustainable use and management of marine resources - Promotion of whole sites approach - Not just protecting designated features but those other areas such as muds that may be good carbon sinks
- Sustainable use of the marine environment (but how do we determine whether the use level is "sustainable"? - if there is no decrease in condition?) - Marine planning decisions (e.g. impact assessments of MPAs) - Analysis of tradeoffs between different uses (e.g. wind vs fishery) - Analysis of (options for) synergie between ecosystem service use (e.g. wind -> fish nursery) - Where to invest to maximise biodiversity gains / opportunities - Funding decision - Spatial planning Which activities where? - Biodiversity Strategy 2030
- It depends on the detail and granularity of the data. If we can value esoteric things like seabed organisms, and we know where everything is, then it can be a general statement of ecosystem health AND an policy planning tool. Problem is that, only have good data for some components (fish) , and in some cases these data do not mesh well with more local planning decisions (e.g. at what level does the localised destruction of the seabed noticeably impact on demersal species) . So to answer the question- a further indicator of ecosystem health in monetary terms (with caveats attached to what it doesn't include) - Environmental assessment - Better communication and policy prioritisation - Licencing, Marine Protected Areas management... - better decisions related to marine environment - assess in issuing permits for derogations of decommissioning - Pressure state response relationship is key. If the metric is invariant to the decision framework (ie.. local planning framework) then it is not suited to that particular decision

- If the data is perfect - and it isn't - then it is informative to all decisions. It's not the approach that is limiting but data and parametrisation.
- Selection of protected areas - Decision on allowing deep-sea mining - Expansion in offshore wind capacity - Trade-offs between activities - Decision on coastal protection, habitat restoration vs dyke etc - Decision on the effect of measures and for the selection of the most promising measures - Regulatory decisions (granting permits)

Table ii. Overview answers to the second question in the breakout rooms from the workshop of the 13th of July about Natural Capital Accounting. Source: Author's own elaboration

2. What type of **analyses** could be of **relevance for OSPAR** to conduct based on the information collected by the accounts?
- Cross-country analyses on issues such as migratory species or network of MPAs - Regional level analyses would be of particular interest for considering ecosystem components, such as highly mobile species, or wide ranging/circulatory pressures like non-native species or marine litter - Regional analyses are in particular useful for smaller countries which do not have sufficient amount of researches/analysts to work on these issues (this is perhaps more relevant to HELCOM countries, which I represent) - studies about the toxicity of the approximately 100,000 chemical substances in the EU and how they impact on biodiversity
- Study of how existing OSPAR biodiversity indicators can be developed to incorporate ecosystem services. Such as BH3 Extent of Physical Damage indicator - Further understanding of links between assets and services, and also impacts of activities on services. A gap analysis would be needed to determine which areas need to be researched.
- See 1): identification of synergies / trade-offs - QSR 2040 - implementation of NEAES Strategic objectives (across the system) - How climate change will impact natural capital assets - The current status and historical trend of natural capital assets and ecosystem in the region - what baseline do we work from?
- Movement of expressing value from landings to all stocks. The warning here should be that not everything that supports stocks is included (the value of nursery areas, for example?)
- Monitoring the status of the marine environment (trend analysis)

Table iii. Overview answers to the third question in the breakout rooms from the workshop of the 13th of July about Natural Capital Accounting. Source: Author's own elaboration

3. What are **next steps that OSPAR should take** in terms of NCA?		
What can be done to improve the initial NCA estimates for the North-East Atlantic?	*Which other ecosystem services or abiotic flows should be prioritised?*	*Other*
Test other economic valuation methods to build more robust estimates of ES flows (such as Simulated Exchange Values for benefits, and maintenance costs for reaching policy objectives) Regional valuations of prioritised ecosystem services. Address issue of sustainable flows of ecosystem services	Those which are most affected by human beings (economic activities) Elements where market-value and ecosystem function/health are in conflict i.e. help us figure out sustainability thresholds, special sites of conservation interest, areas of prime economic value etc.	Establish and disseminate where NCA is going to be integrated into assessments and reporting, so that CPs can prepare for data calls and consider their local decision making options and opportunities Binding and ambitious time steps for implementation Test that this is working
Find data gaps and gather more data Spatial explicit analyses	All other ecosystem services that differ from those that have been mainly analysed so far (i.e. fishery, recreation, carbon sequestration)	Harmonize work among MS Explore if links can be made between the OSPAR Socio-economic and biodiversity indicators
Create a NCC data base for OSPAR region Make it spatial explicit At least at a coarse ecosystem-type based donation; but preferentially a gridded approach Add some more ecosystem services based on societal relevance What fills the newspaper columns? agree spatial reporting units for NCA	The first step may be focus on the accounts where we have good data. Waste mediation i.e. breakdown of pollutants due to (a)biotic processes; *not* dilution Maintenance of ecosystem processes Fish nursery; reef habitat preservation etc. flood protection	Read Maria's report and identify *from that* the most relevant next steps, e.g. by performing a ga analysis for some components it might not be appropriate to monetise them - can/should we include this, if we do how do we ensure cohesion? Work out good methodology to disaggregate ecosystem service (value) into contributions by economy vs by nature
Expand the list of ES that have been looked at (at the moment it was only for fisheries, carbon sequestration and outdoor recreation) Better habitat maps based on biological groups (not geological features) and perhaps ecosystem function. This could be based on community traits and modelled within a HMSC framework	Blue carbon does allow some benthic features to be included that don't yet have a realised value (due to the presence of carbon markets and better information about the degradation of BC functioning. This would be a good next step when widening out the usual suspects of tourism (which is very inshore), fishing, aquaculture etc.	Improve communication concerning benefits of NCA Datasets available and where there are gaps. Gaps should focus on what components are missing out (e.g. benthic?) Define what is the most important message to communicate. E.g. What is the value of our NE Atlantic asset, and how has it changed? BUT ... will inflation make it a loss look gain? We could correct for inflation, but really

Identify the relevant datasets continuing the work started by Maria and ensure a common and broadly based database Work both on stock accounts (natural capital) and flow accounts (ecosystem services) and try to connect the two! We need to be careful when constructing wider accounts, even for things like fish. It might seem holistic, but often key forage fish (where there is no market) or habitat (e.g. nursery) is missed out. It needs to look at the whole ecosystem component as far as it is possible		this should be corrected to individual commodity price. Ask - how can NC help the messaging come out of OSPAR in order to garner better public traction? What biological concerns are coming out of BDC, for instance, and can MC messaging help Articulation with other international organizations, namely OECD and Eurostat Use already existing framework of system thinking in order to create synergies (thinking of the DAPSIR here)
Agree on a seabed map and some common ecosystem services Well defined monitoring programme for longer term	Depends on the data which exists - i.e. cultural services would be good Coastal protection Regulating services	If natural capital accounting means building an inventory of what is there (in terms of services and biodiversity) - yes, then it is a good basis. But if monetarisation is meant, I wonder how the abundance of e.g. humpback whales can be put into a monetary value (except whale watching) - it is value as such.