Exploring the possible setup and uses of natural capital accounts for the Dutch North Sea area

Final report

8-11-2017

Cor Graveland, Roy Remme and Sjoerd Schenau

Index

Summary

Natural capital accounting (ecosystem accounting) is an approach to systematically measure and monitor ecosystem services and ecosystem condition over time for decision making and planning. In this study we have examined whether and how natural capital accounts could be compiled and implemented for the Dutch continental shelf (DCS).

Marine and coastal ecosystems provide a range of 'ecosystem services', from fisheries to carbon storage and flood protection. Yet pollution, overfishing, climate change and habitat destruction cause adverse effects and may lead to degrading several of the ecosystems at the DCS, effecting the wealth of the country and sustainability of cities and communities, water quality and livelihoods. Natural capital accounting (NCA) can be used to monitor and analyse the locations, magnitude in area and condition of ecosystem and the benefits that are derived from ecosystems in a coherent and consistent way.

Nationally and internationally there is much interest to test and implement Natural capital accounts. Focus thus far has been on the terrestrial environment and there is still little experience with the accounts compilation for the marine environment globally. Ecosystem accounts for marine areas such as the DCS are thus still very experimental, and much still has to be developed, tested and learned. The Netherlands is in an excellent position to start a pilot compilation of marine natural capital accounts. First, many different data source are available for the North Sea that are needed for the compilation of the accounts, in physical terms but also in economic terms. Second, Statistics Netherlands (and Wageningen University and Research, WUR) are currently doing a three year project to compile natural capital accounts for the terrestrial part of the Netherlands. This experience could be used for a first pilot compilation of marine natural capital accounts for the DCS.

As a possible next step, it is recommended to initiate a pilot project with a small set of accounts which have also a limited scope with regard to the number of condition indicators and the number of ecosystem services. In addition it is recommended to make it a multi-year project in order to keep the process manageable with respect to budget and required capacity.

1. Introduction

Natural capital accounting (ecosystem accounting) is an approach to systematically measure and monitor ecosystem services and ecosystem condition over time for decision making and planning. Under the auspices of the United Nations, the System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA EEA) has been developed to guide the implementation of ecosystem accounting (UN et al., 2014). One of the main objectives of the SEEA EEA is to measure ecosystem services in a way that is aligned with the System of National Accounting (SNA).

The implementation of Natural capital accounts in countries has focused on the terrestrial environment. At the same time, there have been a few studies applying ecosystem accounting to coastal and marine areas. These studies include work in South Africa (Driver et al., 2012), Canada (Statistics Canada, 2013), Mauritius (Weber, 2014b), United Kingdom (UK) (eftec, 2015) and Australia (Australian Bureau of Statistics, 2015 and 2017; Eigenraam et al, 2016). The importance of accounting for marine areas is well recognised and further research is required to fully consider the spatial framework in these contexts (UNSD 2017, SEEA EEA technical recommendations).

The aim of this study is to examine whether and how natural capital accounts could be compiled and implemented for the Dutch part of the Dutch continental shelf (DCS).

1.1 Project context

This study is part of the research project in 2017 aiming to update the economic description of the marine environment in the Dutch continental shelf and accompanying coastal zone, which constituted of two elements. The first part of the 2017 project was dedicated to update the economic description of the use of the Dutch part of the North Sea. The second part is dedicated to explore whether natural capital accounting could be developed for the Dutch part of the North Sea area, the Dutch Continental Shelf. This report focuses on the (economic) activities and ecosystem goods and services on the Dutch Continental Shelf (DCS), which is the area of the North Sea where the Netherlands has exclusive rights.

The Ministry of Infrastructure and Environment (IenM) and / Rijkswaterstaat has the task of implementing the Marine Strategy Framework Directive (MSFD). In addition to the Dutch legislation, the implementation includes the preparation of several reports on the Dutch part of the North Sea. In 2012, the Netherlands established the Marine Strategy Part 1 (Initial Assessment) and reported this to the European Commission. One of the components of this is the economic description of the Dutch part of the North Sea. On behalf of – and in cooperation with – Rijkswaterstaat in the past (in 2010, 2011 & 2014) Statistics Netherlands developed and reported based on the so-called NAMWA (National Accounting Matrix including Water Accounts) of the North Sea, which describes economic activities related to the North Sea in conjunction with the National Accounts.

By 2018, an update of this initial assessment is required and has to be sent to the European Commission. One of the requirements of the initial assessment is the update of the economic description on the use of the North Sea. The results will also serve as input for discussions in

and publications by the OSPAR Commission, which is the 'Convention for the Protection of the Marine Environment of the North-East Atlantic'.

1.2 Research question

In June 2016, Statistics Netherlands started the development of Natural Capital Accounts (ecosystem accounting) for the whole of the Netherlands. These accounts are based on spatially explicit data and models for determining ecosystem services, ecosystem condition and ecosystem classification. These data and analyses were limited to (exclusively) the terrestrial area of the Netherlands and comply with international UN directives in this area, such as the SEEA-EEA, the System of Environmental Economic Accounts, Experimental Ecosystem Accounting. This study therefore explores whether it is possible to apply the principles and methodology of SEEA-EEA to the Dutch part of North Sea.

The explorative study will consist of two activities and subsequent sub-elements:

1. Inventory of North Sea data within Rijkswaterstaat and Statistics Netherlands (CBS), with:
    a. Demarcation of the different ecosystem types within the North Sea region (in consultation with Rijkswaterstaat), analysis of (especially economic) data available at Statistics Netherlands;
    b. Inventory of the suitability and capabilities of the spatially explicit data provided by Rijkswaterstaat.
2. To draw up a research plan in order:
    a. To generate an overview of the possible types of accounts based on available data, and to what extent they are in line with International Accounting Directives of the SEEA EEA;
    b. To provide an overview of the most important data that are missing, which would be required for a full account of the supply and use of ecosystem services (physical and monetary).

Section 2 explains briefly the main concepts, definitions and scope issues of ecosystem accounting. In section 3 the main typologies and classifications relevant for the marine environment are discussed. In section 4 the results from the data inventory are presented. In section 5 some important policy applications will be discussed. Finally, in section 6 the possible accounts that could be complied are discussed and a potential research plan is presented for the compilation of natural capital account for the DCS.

2. SEEA-EEA: Concepts, definitions and boundaries

This chapter discusses some key conceptual, classification and definition issues with regard to Natural capital accounting according to the guidelines of the SEEA EEA.

2.1 The SEEA – EEA: objective and implementation

The SEEA - Experimental Ecosystem Accounting 2012 (SEEA-EEA, 2012), describes what Ecosystem Accounting is and deals with objectives and approaches for the implementation. In brief according SEEA-EEA, par. 1.4:

".. the System of Environmental-Economic Accounting 2012 - Experimental Ecosystem Accounting (SEEA-EEA, 2012) constitutes an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activities. The perspective of SEEA Experimental Ecosystem Accounting is complementary to that of the accounting approaches described in the System of Environmental-Economic Accounting 2012 - Central Framework (SEEA Central Framework), although it does not have the status of an international statistical standard."

A prime motivation for ecosystem accounting is awareness of the fact that distinct analyses of ecosystems and the economy do not encompass the vital relationship between people and the environment in which we live. The standard approaches to the measurement of the economy focus largely on economic and other human activities, as reflected in the activity of markets. Ecosystem accounting aims to shed light on the non-market activity associated with ecosystems and to integrate the information obtained with relevant market-related data. It is anticipated that individual and societal decisions concerning the use of the environment will be better informed through the use of information sets that are developed based on recognition of the relationship between ecosystems and economic and other human activities (SEEA EEA par. 1.3).

The aim of linking Ecosystem Accounts with more general statistical accounts (following SEEA-EEA (2012) is the integration of environmental and economic information for application in policy discussions. Within this context, the more specific objectives in establishing an accounting structure are:

a) Organizing information on the environment from a spatial perspective, describing, in a coherent manner, linkages between ecosystems and economic and other human activities;
b) By applying a common, coherent and integrated set of concepts, classifications and terminology, the accounting structure provides a platform for the organization of data and research, allowing for systematic comparison and indicator production and providing the common international language and opportunity for comparison;
c) Allowing connections to be made to environmental-economic information compiled following the guidelines of the SEEA Central Framework. This should aid in the understanding of (i) the contribution of ecosystem services to economic production, consumption and accumulation, (ii) the attribution of degradation, restoration and enhancement of ecosystems to economic units and (iii) the development of more comprehensive measures of national wealth;
d) Identifying information gaps and key information requirements.

In 2016 Statistics Netherlands and Wageningen University started to work on a three year project 'Natural capital accounts for the Netherlands' funded by the Dutch Ministries of Economic Affairs and Infrastructure and the Environment. The aim of this project is to test and implement SEEA EEA ecosystem accounting for the Netherlands. The choice was made to develop the core accounts as described in the SEEA EEA and include carbon and biodiversity as thematic accounts. The carbon account has been published recently (Lof et al., 2017), the physical supply and use tables for ecosystem services will be published shortly. The remaining core accounts and the biodiversity account will be developed and published during the course of 2017 and 2018.

The focus of the set of accounts so far has largely been on terrestrial ecosystems, i.e. only inland waters are included, but the marine domain is excluded. A further extension to the current work would be to develop Ecosystem Accounts beyond the ones determined on the shore and to identify and assess also those ecosystem services and assets observable off-shore on the Dutch continental shelf. That is exactly the aim of this study.

The methods for compiling the experimental ecosystem accounts are still being developed, and only a limited number of countries have started to test it, mostly on land. For marine areas compiling SEEA EEA is even more experimental, only a few countries have done some first and limited exercises in compiling such accounts (e.g. Australia (i.e. for Great Barrier Reef), United kingdom) It is therefore emphasised that this work is highly experimental.

2.2 Accounts of the SEEA EEA

In SEEA EEA five core ecosystem accounts are distinguished:

1. The ecosystem extent account (the area that represents the different ecosystem types);
2. The ecosystem condition account (the state or the quality of the ecosystems, measured by different indicators);
3. The physical ecosystem services supply and use accounts (what and how much services do the ecosystems provide and who is using that and how much?);
4. The monetary ecosystem services supply and use accounts (showing the monetary value of the goods and services provided by the ecosystems, after valuing those);
5. The ecosystem monetary asset account (for tracking stocks and changes therein (additions and reductions) of ecosystem assets in monetary terms, based on valuation of the (future) ecosystem services).

In addition there are so-called thematic ecosystem accounts that could be developed, such as the carbon account and the biodiversity account, which gives an explicit description of certain parts of the ecosystem that, might be of particular interest to policy makers

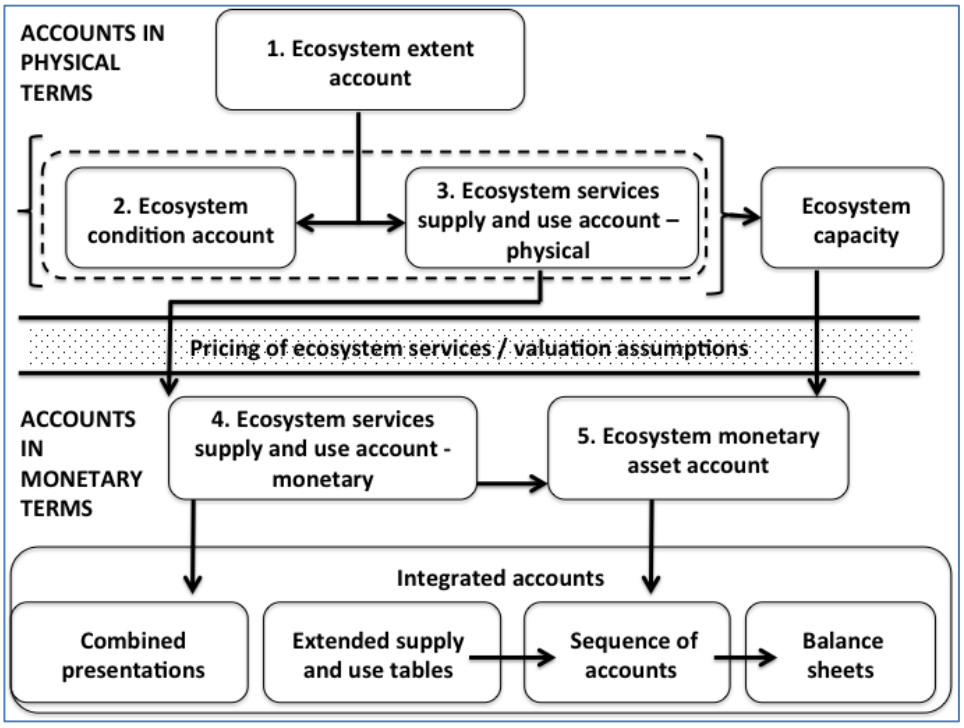
This set of ecosystem accounts reflects the complete coverage in accounting terms for all ecosystem assets and ecosystem services for a given ecosystem accounting area in both physical and monetary terms. However, these accounts and the information they contain will not function in isolation. Two connections with other accounts are relevant. The first link concerns the integration of ecosystem accounting information with the standard economic accounts, following SNA, in monetary flow accounts and balance sheets. The second link is to

various kinds of the 'classic accounts' with some longer history, the SEEA Central Framework (CF) accounts. These SEEA-CF accounts and other thematic accounts, focus on particular resources and flows such as water, energy, timber, fish, soil and land. Since these components are present within ecosystems, from an accounting perspective, consistency between these SEEA-CF, thematic and ecosystem accounts need to be achieved.

Finally the aspect of *ecosystem capacity* is important. This is about the ability of an ecosystem to sustainably generate ecosystem services in the future. The concept of capacity can serve to integrate measurements of ecosystem condition, ecosystem services and ecosystem degradation. Causes and scores of negative impacts on these ES-capacities are potentially relevant for the management of ecosystems in general, and in the context of this study for the North Sea in particular.

The linkages between the various ecosystem accounts are shown in Figure 2.1. These can and need to be linked to other SEEA-CF accounts such as land and water accounts, and other thematic accounts such as carbon accounts. A range of ways for compilation of these accounts can be undertaken, depending on the research, analytical and policy questions one focuses on (SEEA-EEA, 2012; SEEA-EEA-Technical Recommendations, 2017).

Figure 2.1 Connections between the different ecosystem accounts

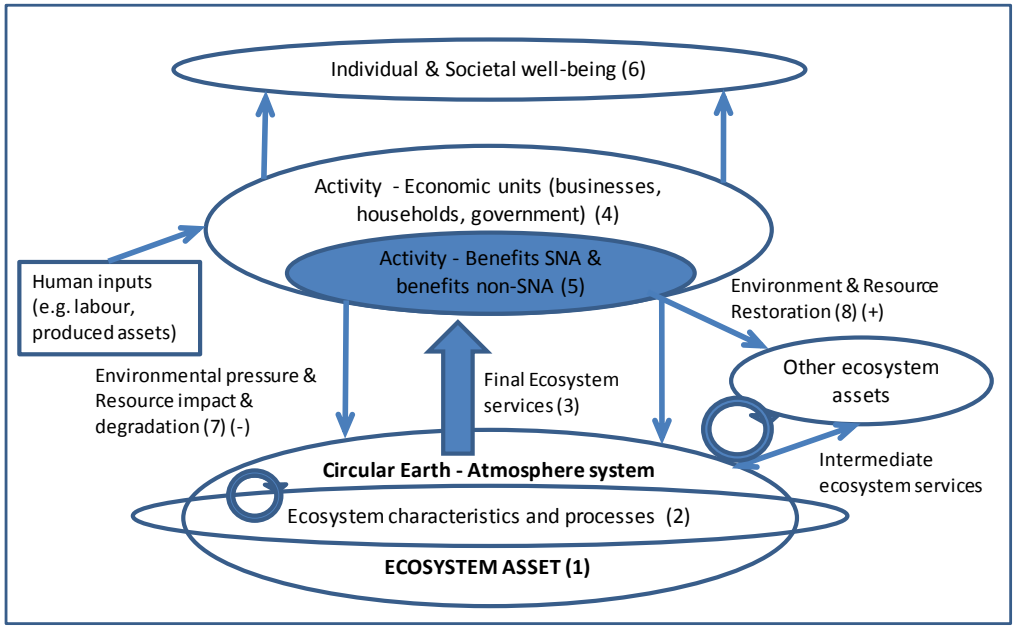


Source: SEEA-EEA-Technical Recommendations (draft), 2017; slightly adjusted.

2.3 SEEA – EEA Accounting framework

The ecosystem accounting framework from the SEEA-EEA (2012) provides a framework for placing information on ecosystem assets, ecosystem services, the benefits generated from ecosystem services and human well-being *(anthropocentric),* in context, and has eight main elements (Figure 2.2).

Figure 2.2 Ecosystem accounting framework



Source: Adapted from SEEA EEA Figure 2.2, UN et al 2014; extended with from SEEA-Central Framework modules, the pressures and restoration (with environmental protection and resource management activities).

Remark: SNA: System of National Accounts, the detailed description of the national economy.

The framework is based around accounting for the various *biotic* and *abiotic components* within an **ecosystem asset (1)** that is defined as a spatial area comprising a combination of biotic and abiotic components and other elements which function together. Possible ecosystem assets include forests, agricultural areas, wetlands, rivers and coral reefs. In land cover class 'marine ecosystems' there may be scope to differentiate between, for example, reefs, sandbanks, continental shelf and deep sea.

A delineation of the area that defines an ecosystem asset is required for accounting purposes and simultaneously should be considered a statistical representation of ecosystems, which by their nature are not discrete systems that align to strict spatial boundaries. There will be different types of ecosystem assets within a territory (e.g. forests, marshlands) which will need to be distinguished, as for the North Sea. Several approaches for the delineation of spatial areas for ES-accounting can be followed. Some of the biotic and abiotic components mentioned can be accounted for individually using the asset accounting descriptions of SEEA CF, such as timber, water or soil (SEEA-EEA-Technical Recommendations. 2017).

Each ecosystem asset has a range of relevant **ecosystem characteristics and processes (2)** that together describe the functioning of the ecosystem. While each ecosystem asset is uniquely defined, ecosystem processes generally will operate both within and across individual ecosystem assets, compared to terrestrial ecosystems. Thus, while in Figure 2.2 ecosystem assets are shown as discrete areas, the associated ecosystem processes are considered to be unbounded and hence extend beyond the asset boundaries.

The accounting framework proposes that the stock and changes in stock (i.e. resources allowing to generate renewable flows as well return flows) of ecosystem assets is measured by assessing

the ecosystem assets' **extent and condition**, using indicators of the relevant ecosystem asset's area, characteristics and processes. The extent (area per ecosystem asset) and condition (quality measured in different indicators) of an ecosystem asset will be affected by natural changes as well as by human activities in that area or outside. While for accounting purposes, each ecosystem asset is considered separable, there will obviously be links with **other ecosystem assets** reflecting both the transfer of water, energy, air and materials and also mutual supply and use of ecosystem services. The measurement of ecosystem extent and ecosystem condition for the North Sea is described later.

Each ecosystem asset generates a set or basket of **ecosystem services (3)** which, together with other human induced (SNA and non-SNA) inputs (see arrow), like produced capital and human capital allow for activities that in turn, contribute to human and economic **activity and production (4)** and add to individual and societal wellbeing (either in a positive or a negative way).

These activities generate human **benefits (5)**. Benefits may be goods or services (products), either private or public, and currently included in the economic production boundary of the SNA (e.g. fish products) - referred to as SNA benefits - or they may be benefits received by individuals that are not produced by economic units (e.g. clean air). The latter are referred to as non-SNA benefits. Further distinction can be made between use and non-use values (i.e. bequest values or option value) can be made. Both SNA and non-SNA benefits (both use values), as well as non-use values, contribute to **individual and societal well-being (6)**.

The activities that contribute to the production of (human) benefits can also cause pressures and have adverse effects onto ecosystems, which are denoted as **Environmental pressure, resource impact & degradation (-) (7)**, indicating negative impacts to ecosystem assets and its ecosystem services, leading to degradation / degeneration. One can try to mitigate or compensate these negative impacts by implementing particular additional measures (arrows pointing back to the ES-Assets). From the SEEA-CF modules like the air emission accounts (AEA), water emission accounts, waste accounts and other, these pressures from economic activities from residents are described. In some cases, data on emissions caused at the nations' territory, as for example collected and described in the Pollutant Release and Transfer Register (PRTR), may add further information on the pressures caused to the ecosystems and (potential) services at the territory.

Furthermore, society causes numerous pressures to the environment while adverse impacts from (human) production and consumption activities are exerted to the scarce natural resources. In an attempt to mitigate and combat those pressures one can undertake activities to promote **Environment & Resource Restoration (+) (8)**. Dedicated measures, policies and (government) expenditures can be applied to change human behaviour and to improve the environmental state. This prevention and restoration is supported by policy instruments like environmental and resource taxes, environmental and resource subsidies, government investments and command & control type of instruments and so forth. Several SEEA-CF modules such as the Environmental Taxes by Economic Activity (ETEA), environmental protection expenditure accounts and statistics (EPEA & EPE), environmental goods and services sector (EGSS) can provide the relevant information in a consistent manner of the different accounts.

To comply with the accounting principles, the supply and use of **ecosystem services (3)** recorded in ecosystem accounts need to be equal. For final ecosystem services, i.e. those services that flow directly to economic units (businesses, households and governments), this implies that the supply of ecosystem services cannot be higher than the quantity of service consumed or otherwise used. Recording supply and use as a 'matching pair' of accounting entries reflects that flows of ecosystem services are transactions (or exchanges) between *ecosystem assets* and receiving economic units or agents from an accounting perspective. Measurement of the relevant ecosystem services is described later.

Ecosystem assets in the ***ecosystem capital***, which is the biotic part of ***natural capital***, are the basis of the supply of ecosystem services and associated benefits. A key motivation for ecosystem accounting is to understand the potential for ecosystem assets to provide ecosystem services into the future and hence contribute to sustainable individual and social well-being. Consequently, it is relevant to consider measurement of ecosystem capacity, degradation and possibly restoration, measures which deal with the potential of ecosystem assets to supply services in the future. (SEEA-EEA, 2012; SEEA-EEA-Technical Recommendations, 2017).

2.4 Treatment of negative externalities and ecosystem disservices

In the context of the Marine Strategy Framework Directive (MSFD) one clear wish is to be able to assess the environmental status and evaluate influencing factors. The objective of the MSFD is to achieve the Good Environmental Status (GES) for the marine environment. The state of the marine environment, in context of possible Marine Ecosystem Accounts for the DCS, can be monitored using the condition account, showing the quality of the ecosystem assets. One set of indicators that can be included in the condition account is environmental pressure indicators, for example deposition levels of acidifying compounds versus critical loads for such compounds.

Ecosystem disservices arise in cases where the interaction between ecosystems and humans is considered to be 'bad'. Usually this refers to the effects of phenomena such as pests and diseases that emerge from ecosystems and negatively affect economic production and human life. The SEEA EEA recognises the discussions on the measurement of ecosystem disservices but so far has not proposed a treatment in accounting terms since, within an accounts-based framing, this would require recording negative production by an ecosystem asset and this is currently not a possible accounting entry. In principle the impacts of ecosystem disservices however, can and should be shown in reduced condition of other assets, for example reduced human capital through poorer health or in reduced condition of (other) ecosystem assets, where relevant.

Related to this is the treatment in ecosystem accounting of environmental pressures and negative externalities, such as emissions, where economic and human activity leads to declines in the condition of ecosystems. So, while any associated environmental flow, i.e., pollutants, emissions, etc. are not considered as ecosystem disservices and their negative impacts on welfare are not captured directly in the accounting for ecosystem services, they are captured differently. These negative impacts are captured in accounting for ecosystem condition and hence, through the accounting system, the effect of negative environmental externalities should emerge in reduced flows of ecosystem services in the future, indicating reduced capacity. For both disservices and negative externalities, work is on-going to outline the

appropriate treatment in the context of the ecosystem accounting framework. (see SEEA – EEA Technical Recommendations, 2017).

Obviously, several of the SEEA Central Framework accounts provide information on reduced or impacted flows of ecosystem services. For example, extractions from the environment in various forms are recorded in the energy flow accounts, water flow accounts and material flow accounts whereas emissions of greenhouse gasses and a series of pollutants (residuals) to air, water, soil are recorded in various accounts such as the air emission accounts. So the SEEA-CF accounts can support the measurement of the required flows in these areas.

The aim of the European Union's ambitious Marine Strategy Framework Directive (MSFD) is to protect more effectively the marine environment across Europe. More precisely, the Marine Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. In order to achieve GES by 2020, each Member State is required to develop a strategy for its marine waters. Because the Directive follows an adaptive management approach, the Marine Strategies must be kept up-to-date and reviewed every 6 years. The Directive, in a legislative framework, applies the ecosystem approach to the management of human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use. In order to achieve its goal, the Directive establishes European marine regions and sub-regions on the basis of geographical and environmental criteria.

The aim of the MSFD among other purposes is to avoid degradation of the marine environment, by taking measures and putting dedicated regulations in place. This also holds for the DCS. For reaching that goal a programme of measures has been debated and is implemented. A number of indicators (Qualitative descriptors) are in place to determine the good environmental status (GES) for the MSFD. Examples of indicators are Biological diversity, Marine food webs, Commercially exploited fish and shellfish, eutrophication, Sea floor integrity, Concentration of contaminants, Contaminants in fish and other seafood or Marine litter, these are ‘pressures’ or ‘state’ indicators or combinations.

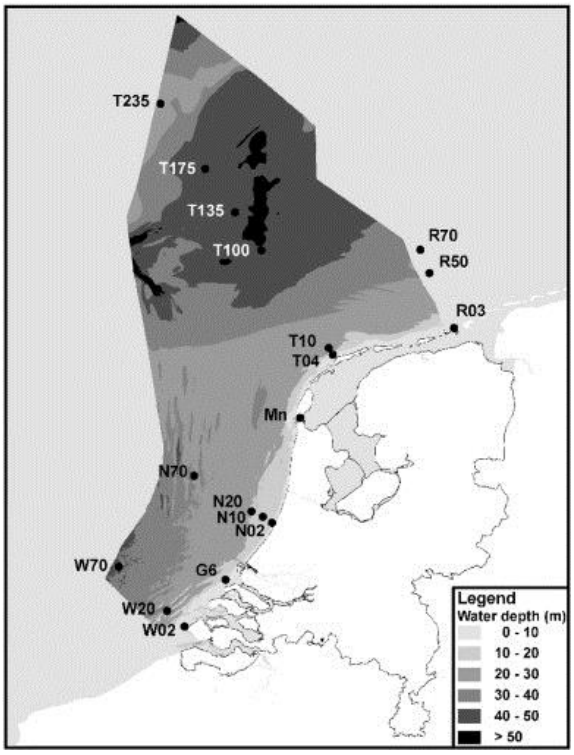
2.5 Geographical boundaries

This study considers ecosystem services and ecosystem conditions which relate to the Dutch part of the North Sea. Accordingly, natural capital accounting for the North Sea is limited to the Dutch part of the Continental Shelf. The study area with the DCS covers only that part of the North Sea, adjoining the Dutch coast, where the Netherlands claims exclusive rights for example to the various mineral resources such as sand, gravel and natural gas. The Dutch part of the continental shelf in the North Sea is also regarded as part of the national economic territory (see figure 2.3).

There are some geographical boundary issues that need to be discussed. Although part of the Water Framework Directive (WFD) and not for the Marine Strategy Framework Directive (MSFD), it is proposed here to include the Wadden Sea up till the Afsluitdijk. The inclusion of the Wadden Sea is necessary in order to align in the best way with the project ‘Natuurlijk Kapitaalrekeningen’ (Natural Capital Accounts). That project aims to asses and quantify a list of about 14 ES services limited to the terrestrial part of the country, including the (fresh) inland water part of aquatic ecosystems (but excluding the Wadden Sea). It is recommended to make a split between the assessment of the DCS and the area of the Wadden Sea allowing combining

the result for both aggregates, with and without the Wadden Sea. Similar, the Westerschelde estuary and possibly also the Oosterschelde could be included in the marine natural capital accounts.

Figure 2.3 Map indicating the study area of the DCS, including the Wadden Sea



Source: Engeland, et al. 2010. Excluding Lake Ijsselmeer beneath Afsluitdijk (Fresh).

A second boundary issue is whether to include the coastal area. In principle, only ecosystem services provided by the marine area are relevant for marine natural capital accounts, thus without considering land. However, the delineation of the ecosystem services provided by either land or water will not always be straightforward. For example, tourism and recreation with regard to the North Sea will be land based (i.e. beach recreation etc.). Also it may be very relevant to include flood protection by the dunes in the marine natural capital accounts. Presumably it is more a matter of trying to get the picture for the country more complete without putting too much effort in finding the perfect demarcation of services stemming from the sea or from the shore. Obviously, we need to prevent double accounting here.

3. Ecosystem typologies and classifications

In this chapter the possible ecosystem typologies and classifications relevant for the North Sea are discussed and embedded in existing national and environmental accounts.

3.1 Ecosystem types

Ecosystem accounting requires delineation of areas within a country, including its terrestrial, coastal and marine areas, into mutually exclusive units that represent ecosystem assets (EAs). These EAs represent contiguous areas covered by a specific ecosystem (e.g. a deciduous forest or a tidal marsh). Ecosystem assets are contiguous areas representing individual ecosystems that form the conceptual base for accounting and the integration of relevant statistics. In practice, given that accounts are normally developed at aggregated scales such as countries, large watersheds and so on, it may be difficult to analyse, record and report data for each individual EA. It is therefore relevant to analyse accounting variables, such as ecosystem condition and ecosystem service supply, at a more aggregated level reflecting information for EAs of the same type, the Ecosystem Type (ET). *Ecosystem Types* (ETs) thus show aggregations of individual Ecosystem assets (EAs) representing a specific type of ecosystem (e.g. marshlands).

Experiences to date with the development of ecosystem accounts for coastal and marine areas are limited. However, given that different marine areas provide different ecosystem services, it will be appropriate to distinguish specific ecosystem types within the land cover class 'coastal ecosystem' (e.g. seagrass meadow, coral reef, oyster/mussel bank, mangrove, rocky substrate, sandy substrate). The land cover class 'marine ecosystems' may be further differentiated in, for example, reefs, sandbanks, continental shelf and Deep Sea (Technical recommendations par. 3.29).

The Land cover and ecosystem functional unit type classification presented in Annex I is the SEEA – EEA standard classification for both terrestrial and the marine areas of aquatic ecosystems. The table below shows two categories, numbers 16 and 17 from the list in the Annex that are relevant for coastal water, sea and marine areas. In table 3.1 the main classes for 'land cover' and connected Ecosystem types are shown with a possible further breakdown for the North Sea.

Table 3.1: The Land (cover) and ecosystem functional unit type classification, with a proposal for further disaggregation for marine (aquatic) ecosystems

Description of classes	Ecosystem types, for instance
16. Coastal water bodies and intertidal areas	Sea grass meadows Barriers islands Sandy shores Rocky shores Estuaries Intertidal areas (for example the Wadden Sea) Lagoons Beaches Port entrance / harbour mouth Flood / coastal defences (Dykes, dams, other)

17. Sea and marine areas	Coastal Shelf Open ocean

Table 3.2 shows an additional ecosystem mapping format based on MAES that could guide the classification of ecosystems and create the base map that shows the delineation and distribution of the relevant ecosystem types at the DCS. This is a generally applied format for marine biotic ecosystems. Depending on future policy demands, this may need further detailing.

Table 3.2 General Ecosystem mapping format (based on MAES)

Ecosystem type for mapping and assessment	Representation of habitats (functional dimension by EUNIS)/MSFD for marine ecosystems)
Marine ecosystems	
Marine inlets and transitional waters	Pelagic habitats: Low/reduced salinity water (of lagoons) Variable salinity water (of coastal wetlands, estuaries and other transitional waters) Marine salinity water (of other inlets) Benthic habitats: Littoral rock and biogenic reef Littoral sediment Shallow sub littoral rock and biogenic reef Shallow sub littoral sediment
Coastal	Pelagic habitats: Coastal waters Benthic habitats: Littoral rock and biogenic reef Littoral sediment Shallow sub littoral rock and biogenic reef Shallow sub littoral sediment
Shelf	Pelagic habitats: Shelf waters Benthic habitats: Shelf sub littoral rock and biogenic reef Shelf sub littoral sediment
Open ocean	Pelagic habitats: Oceanic waters Benthic habitats: Bathyal (upper, lower) rock and biogenic reef Bathyal (upper, lower) sediment Abyssal rock and biogenic reef Abyssal sediment

Source: MAES – EU Ecosystem mapping (http://biodiversity.europa.eu/maes/typology-of-ecosystems).

3.2 Classification of ecosystem services

In ecosystem accounting, the ecosystem services are defined as 'contributions by ecosystems to benefits used in economic and other human activities'. It is therefore important to distinguish clearly between ecosystem services and benefits to humans.

CICES classification

CICES (Common International Classification of Ecosystem Services) was developed as an international classification system for ecosystem services. Initially, CICES focused on defining final ecosystem services that depend on living systems. This was not to say that many of the physical characteristics of physical systems that are part of nature are unimportant to people, but rather to emphasise the fundamental contribution that biodiversity makes to human well-being. In that respect, CICES followed the tradition of the Millennium Ecosystem Assessment (MA, 2005) and other like The Economics of Ecosystems and Biodiversity (TEEB) and the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES).

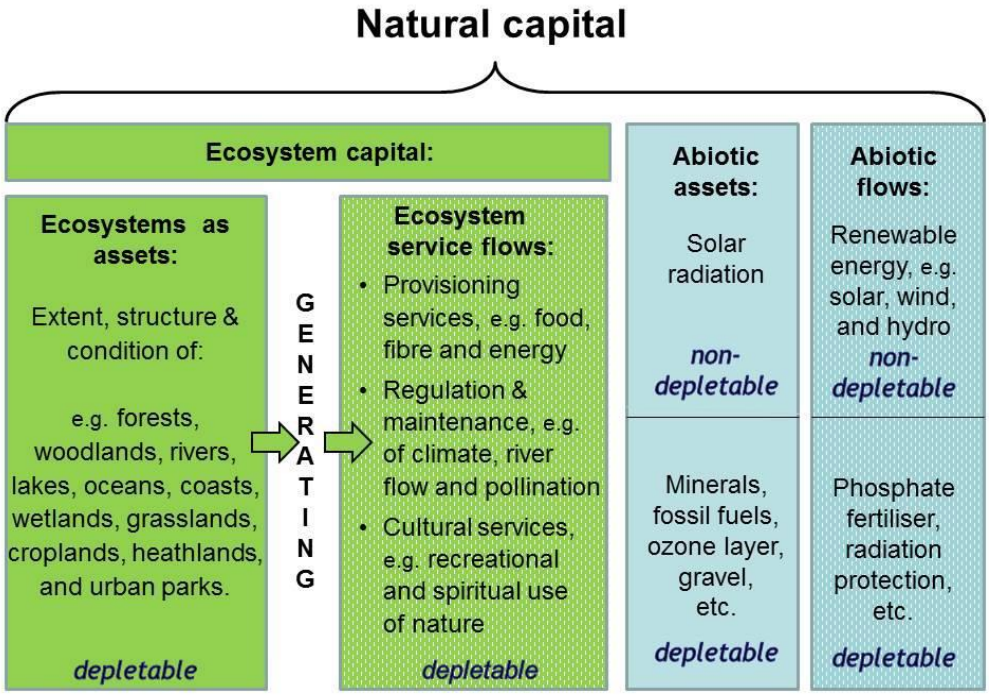
With the CICES V4.3 release, only a rudimentary table of abiotic ecosystem outputs was provided using the same classification logic as for those ecosystem services that depend on living systems (and water). This approach is also followed for the new CICES version V5.1.

However, now this has been extended, and a tool is available to allow users to integrate biotic and abiotic categories into the same table if they need it (Haines-Yong, R. and Potschin, M. 2017).

So, although CICES primarily is intended as a classification of the ways that living systems can contribute to human well-being, it has made a move and now acknowledges that the boundary between *biotic* and *abiotic* ecosystem services is difficult to define in practice. The move to include *abiotic ecosystem outputs* more formally in the structure of CICES also reflects recent discussions about what constitute *natural capital*, which has also been defined in a number of different ways. The approach used in developing CICES V5.1 follows the EU MAES process which considers *natural capital* to include all natural resources that human society draws upon, i.e. both earth's ecosystems and the underpinning geo-physical systems (see Figure 3.3).

The latest version of CICES (CICES V5.1), now makes the distinction between *ecosystem capital* and *abiotic resources*, as shown in figure 3.3, although for some cases there is no clear-cut boundary between biotic and abiotic components. However, this distinction helps to identify and classify different types of natural capital, which is important in the context of developing the *natural capital accounts* and apply both in terrestrial areas as well as for marine areas.

Figure 3.3: Components of natural capital, both for biotic and abiotic ecosystem services



Source: Haines-Yong, R. and Potschin, M. 2017); Following CICES Version 5.

Remark: This overview is developed from the natural capital figure in the EU MAES report on Mapping and assessment of ecosystems and their services (European Commission, 2013).

Two conceptual types of ecosystem services are distinguished, namely intermediate (supporting) services and final ecosystem services. Generally, the primary focus in ecosystem accounting is on final ecosystem services. All final ecosystem services have a direct link between ecosystems and economic units. Intermediate ecosystem services are important for understanding relationships and dependencies between ecosystems and can be incorporated

into the ecosystem accounting model, but thus far they are not (yet) a priority area for measurement (SEEA-EEA-Technical Recommendations (draft), 2017).

Table 3.4: Classification of ecosystem services as intermediate or final service

Intermediate (supporting) Services		Final Services	
Service type	***Example of service***	***Service type***	***Example of service***
Supporting services	Nutrient provision	Provisioning services	Fish catch
		Regulating services	Carbon storage
Regulating services / Ecological processes	Water buffering Soil nutrient recycling		
		Cultural services	Recreational fishing

SEEA-EEA-Technical Recommendations (draft), 2017; Mace & Bateman, 2011.

Ecosystem classification with provisioning, regulating and cultural services

The CICES classification recognizes ecosystem outputs to be provisioning, regulating and cultural services, but it does not cover the so-called 'supporting services' originally defined in the Millennium Ecosystem Assessment. The Intermediate (supporting) Services are treated as part of the structures, processes and functions that characterise ecosystems, are indirectly used, and facilitate the 'final outputs', the final services. CICES describes these 'final ecosystem services', using a five-level hierarchical structure: 1.Section (e.g. Provisioning), 2.Division (e.g. Nutrition), 3.Group (e.g. aquatic plants and fish for food), 4.Class (e.g. sea crops) and 5. Class type (e.g. herring) (see table 3.5).

Table 3.5 Structure of CICES

Section	Provisioning																		
Division	Nutrition														Non-nutritional biotic materials				
Group	Biomass							Water							…			…	
Class	Cultivated crops			Sea crops				…		…					…			…	
Class type	Cereals	…	…	…	…	…		…	…	…					…	…	…	…	

Source: Haines-Yong, R. and Potschin, M. (2012; 2017) CICES Version 4 and version 5.

Avoid double counting

To avoid double counting in economic valuation, only the final services are usually included in the ecosystem accounting framework. By focusing on only the final ecosystem services, the ecosystem services are the final outputs or products from ecosystems that are directly consumed, used (actively or passively) or enjoyed by people (SEEA EEA, 2015). For further analysis of the ecosystem services, also intermediate services may prove to be highly relevant.

In the tables below we will show how the CICES classification can be used in possible future assessment of the Ecosystem Accounts / Natural Capital Accounts for the Dutch part of the North Sea. Table 3.6 in the left part of the table shows the CICES structure for the upper three tiers in the biotic classification, and the recently adopted structure for abiotic services (Right part table) of CICES V5.1. For the biotic classification three tiers are shown, with 1.Section, 2.Division and 3.Group, but two more can be made with 4.Class and 5.Class type. This extension for both biotic and abiotic is made in tables 3.7 and 3.8.

Table 3.6 CICES main structure (3 out of 5-Tier) classification for Biotic (Left), and draft structure (only 3 out of 5-Tier is filled) for Abiotic outputs services (Right) [1)]

Biotic Ecosystem Services							Abiotic outputs from ecosystems		
Section	*Division*	*Group*	*Class*	*Class type*	*Class type*	*Class*	*Group*	*Division*	*Section*
Provisioning services	Nutrition	Biomass	..	..	..	..	Mineral	Nutritional abiotic substances	**Abiotic Provisioning**
		Water					Non-mineral		
	Materials	Biomass, fibre					Metallic	Abiotic materials	
		Water					Non-metallic		
	Energy	Biomass-based energy sources					Renewable abiotic energy sources	Energy	
		Mechanical energy					Non-renewable energy sources		
Regulating services	Mediation of waste, toxics and other nuisance	Mediation by biota	..	..	..	..	By natural chemical and physical processes	Mediation of waste, toxics and other nuisances	**Regulating & Maintenance services by natural physical structures and processes**
		Mediation by ecosystems							
	Mediation of flows	Mass flows					By solid (mass), liquid and gaseous (air)flows	Mediation of flows by natural abiotic structures	
		Liquid flows							
		gaseous / air flows							
	Maintenance of physical, chemical, biological conditions	Lifecycle maint, habitat & gene pool protection					By natural chemical and physical processes	Maintenance of physical, chemical, abiotic conditions	
		Pest and disease control							
		Soil formation and composition							
		Water conditions							
		Atmospheric composition and clim. regulation							
Cultural services	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes (env. Settings)	Physical and experimental interactions	..	..	..	..	By physical and experiential interactions or intellectual and representational interactions	Physical and intellectual interactions with land-/seascapes (physical settings)	**Cultural settings dependent on abiotic structures**
		Intellectual and representative interactions							
	Spiritual, synthetic and other interactions with biota, ecosystems, and land/seascapes (env. Settings)	Spiritual and/or emblematic					By type	Spiritual, symbolic and other interactions with land/seascapes (physical settings)	
		Other cultural outputs							
Habitat services [2)]	..	..					..	..	**Abiotic structure supports Habitat**

Source: https://cices.eu/cices-structure/; with adjustments.

[1)] Column heads 'Class' And 'Class type' show the tier 4 and 5, are kept empty to limit the size of the table. It has room for examples of the particular ecosystem services and goods that can be found.

[2)] Category 'Habitat services' is optional, as it is not part of the standard SEEA-EEA classification of ecosystem services.

Table 3.7 CICES Structure for the (five Tier) classification of Biotic ecosystem services [1)]

Section	*Division*	*Group*	*Class type (V)*
Provisioning services	Nutrition	Biomass	1 Food provision: a) Wild capture sea food b) Farmed sea food
		Water	
	Materials	Biomass, fibre	2 Biotic raw materials (non- food): a) Genetic resources b) Medicinal resources c) Ornamental resources d) Other biotic raw materials
		Water	
	Energy	Biomass-based energy sources	
		Mechanical energy	
Regulating services	Mediation of waste, toxics and other nuisance	Mediation by biota	3 Air purification 4 Climate regulation
		Mediation by ecosystems	5 Disturbance prevention or moderation
	Mediation of flows	Mass flows	6 Regulation of water flows 7 Waste treatment and assimilation
		Liquid flows	7 Waste (water)treatment and assimilation
		gaseous / air flows	
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	9 Biological control
		Pest and disease control	9 Biological control
		soil formation and composition	8 Coastal erosion prevention
		Water conditions	
		Atmospheric composition and climate regulation	
Cultural services	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes	Physical and experimental interactions	12 Leisure, recreation and tourism
		Intellectual and representative interactions	15 Cultural heritage
	Spiritual, synthetic and other interactions with biota, ecosystems, and land/seascapes	Spiritual and/or emblematic	13 Aesthetic experience
		Other cultural outputs	14 Inspiration for culture, art and design 16 Cultural diversity 17 Spiritual experience 18 Information for cognitive development
Habitat services[2)]			19 Migratory and nursery habitat 20 Gene pool protection

Source: CICES-structure, with customisations.

See table 4.1, Annex III and Annex IV for background in classification and some of the RWS data.

[1)] Column heads show the full 5-Tier classification and include examples of the particular biotic ecosystem services and goods (ESS).

[2)] Category 'Habitat services' is optional, as it is not part of the standard SEEA-EEA classification of ecosystem services.

Table 3.8 (CICES derived) draft Structure for the (Five Tier) Abiotic classification of ecosystem services

Section	*Division*	*Group*	*Class (IV)*
Abiotic Provisioning	Nutritional abiotic substances Abiotic materials	Mineral Non-mineral Metallic	Salt (from cavern, mining under seabed)
		Non-metallic	Sand (type of sand) Gravel Clay Other minerals (i.e. ocean mining)
		Non-metallic (Water)	Water for cooling purposes (in-stream) Water as a transport medium (i.e. relevant as in maintenance of particular routes by dredging of the channels) Water intake in vessel operations (NL & Non-NL Vessels) Ballast water? Water for use in processes (incl. in agriculture) Water for use after 'seawater desalination', via either 'Reverse osmosis (RO)', Electro dialysis reversal (EDR), Nano filtration (NF), or else
	Energy	Renewable abiotic energy sources	Wind energy to wind turbine Wind energy to propulsion (seagoing vessels versus sailboats) Solar Energy Tidal energy Wave Energy Blue Energy (salt - fresh) Collect and process the 'plastic soup of oceans', for energy purposes (or else?) Seawater as a heating or cooling medium (often together with heat pump) Heat & cold storage in land underneath the (North) sea Geo-energy gained underneath the (North) sea
		Non-renewable energy sources	Mineral Oils Coal Other ?
		Infrastructure	Water as a transport medium (i.e. relevant as in maintenance of particular routes by dredging of the channels) Seabed: Medium for energy infrastructure (i.e. electric wires or oil & natural gas pipes) Seabed: Medium for cable infrastructure apart from energy, like telecom cables Natural Gas storage Pumped' Storage (future atolls?)
Regulating & Maintenance services by natural physical structures and processes	Mediation of waste, toxics and other nuisances	By natural chemical and physical processes	CO2 - Capture & Storage (CCS) from energy plants in empty gas field Storage of gaseous (non-hazardous) wastes in empty gas fields? CO2 - Dissolved in the seawater (partly autonomous, partly induced capture in the water by particular measure) Dumping of sludge Dumping of wastes (limited polluted soil particles) Discharge of waste water directly from industry and/or see-going vessels

			Discharge of waste water (effluent), possibly of different quality compared to discharge in inland waters(?) Discharge of large volume with limited loads of pollutants (nutrients and heavy metals that are processed …
	Mediation of flows by natural abiotic structures	By solid (mass), liquid and gaseous (air)flows	
	Maintenance of physical, chemical, abiotic conditions	By natural chemical and physical processes	Sand for dunes / protective islands in front of the coast Dynamic coastal management Recreation & sports Habitat & space for animals: fish, birds, mammals, etc. Habitat & space for plants: ….
Cultural settings dependent on abiotic structures	Physical and intellectual interactions with land-/seascapes (physical settings)	By physical and experiential interactions or intellectual and representational interactions	Sand for dunes / protective islands in front of the coast Recreation & sports
	Spiritual, symbolic and other interactions with land/seascapes (physical settings)	By type	
Abiotic structure supports Habitat services			

Source: https://cices.eu/cices-structure/, with customisations.

See table 4.1, Annex II and Annex III for background in classification and some of the RWS data.

[1)] Column heads show the full 5-Tier classification and include examples of the particular a-biotic ecosystem services and goods (ESS).

[2)] Category 'Abiotic structure supports Habitat services' is optional fourth class, as it is not part of the existing SEEA-EEA classification of ecosystem services.

4. Data inventory

For this study, a data inventory for the North Sea was done within Rijkswaterstaat and Statistics Netherlands, with the latter analysis focussing (especially) on economic data available at Statistics Netherlands.

The Rijkswaterstaat data was obtained from an inventory of available data within the institute (See Annex II). The inventory of the data contained the distinct ecosystem services at the DCS together with links to the spatial data in maps, both within Rijkswaterstaat itself and from external sources (Table 4.1), as well as relevant data for a condition account and biodiversity account (Table 4.2).

Most available data relate to both condition and biodiversity indicators, and relatively few available datasets are directly useful to quantify ecosystem services. However, there are several datasets available for each ecosystem service category, including several abiotic datasets.

Table 4.1 Ecosystem Service data Inventory categorised by types of *biotic* and *abiotic* ecosystem services on the Dutch Continental Shelf, data available at Rijkswaterstaat (RWS)

No[1)]	Indicator (Source)	Location	Proposed account	Type of ecosystem service
36	Fisheries statistics Landings (ton) (ICES)	NCP	ecosystem supply and use tables	provisioning service
37	Monitoring shellfish files Harvest (ton/a) (ICES)	NCP	ecosystem supply and use tables	provisioning service
9	Mineral extraction in sea - extraction areas shells (Delfstofwinning op zee - Wingebied schelpen) (DANK)	NCP	ecosystem supply and use tables	provisioning service
7	Protection against flooding (Bescherming tegen overstroming) (DANK)	NZ kust	ecosystem supply and use tables	regulating service
11	Water zuiverende werking bodemorganismen Waddenzee (DANK)	NZ Waddenzee	ecosystem supply and use tables	regulating service
8	Distribution of recreational fishing in fresh water , thus not in marine water (Verspreiding sportvisserijactiviteiten in zoet water, dus niet in zeewater) (DANK)	aquatisch	ecosystem supply and use tables	cultural service
38	Recreational fishery Landings (ton) (ICES)	NCP	ecosystem supply and use tables	cultural service
2	Mineral extraction in sea: sand - ecotype's (Delfstofwinning op zee: zand - ecotopen) (DANK)	NCP	ecosystem supply and use tables	abiotic service
4	Transport routes over water - sea (Transportroutes over water - zee) (DANK)	NCP	ecosystem supply and use tables	abiotic service
	Mineral extraction in sea: Oil and natural gas (Delfstofwinning op zee: Olie- en gasvelden) (Koolwaterstoffen uit DINO)	DCS	ecosystem supply and use tables	abiotic service
	Mineral extraction in sea: mining licences (research, extraction and storage) (Delfstofwinning op zee: Mijnbouwwet-vergunningen (opsporing, winning en opslag)) (DINO)	DCS	ecosystem supply and use tables	abiotic service

[1)] Numbering refers to the inventory list provided by Rijkswaterstaat, See Annex II.

Table 4.2 Ecosystem accounting data Inventory for *condition* and *biodiversity indicators* on the Dutch Continental Shelf, available at Rijkswaterstaat (RWS)

No[1)]	Indicator (Source)	Location	Proposed account
17	Commercial fish, shellfish and crustaceans (biomass spawing stock) - Commerciële vis, schaal en schelpdieren (biomassa paaibestand) (KRM)	NCP	condition account, biodiversity account
18	Commercial fish, shellfish and crustaceans (size distribution) - Commerciële vis, schaal en schelpdieren (Grootteverdeling) (KRM)	NCP	condition account, biodiversity account
19	Commercial fish, shellfish and crustaceans (discards) - Commerciële vis, schaal en schelpdieren (discards) (KRM)	NCP	condition account, biodiversity account
3	Macro algae production in North sea (Macroalgen productie in de Noordzee): Laminaria digitata (DANK)	NCP	condition account, biodiversity account
23	Demersal fish Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
24	Pelagic fish Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
25	Norway lobster and shrimp Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
26	International Bottom Trawl Surveys (IBTS) Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
27	Mackerel and horse mackerel Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
28	Blue whiting acoustic survey Abundance and richness - at age (ton/a)	NCP	condition account, biodiversity account
29	Herring larvae surveys (IHLS)Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
30	Herring echo surveys (NHAS) Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
31	Atlantic Scandic herring survey (ASH) Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
32	Flatfish surveys –BTS Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
33	Flatfish surveys -SNS Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
34	Flatfish surveys –DFS Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
35	Monitoring by-catch Abundance and richness - at age (ton/a) (ICES)	NCP	condition account, biodiversity account
1	Wind capacity North Sea (Windvermogen Noordzee) (DANK)	NCP	condition account
5	Swimming water coast and aquatic (Zwemwater kust en aquatisch) (DANK)	NZ kust	condition account
6	Energy generation inhibited by cooling capacity of surface water (Energieopwekking, beperkt door koelcapaciteit oppervlaktewater) (DANK)	NZ kust	condition account
10	KRW assessment framework for potential relevant acreage of macro fauna (KRW toetsingskader potentieel relevant areaal macrofauna) (DANK)	NZ kust	condition account
21	Eutrophication (Eutrofiering) (KRM)	NCP	condition account
22	Distribution of recreational fishing in fresh water (Verspreiding sportvisserijactiviteiten in zoet water) (DANK)	NCP	condition account
	Geothermal heating potential of the Netherlands (Aardwarmtepotentiekaarten van Nederland) (DINO)	DCS	condition account

No[1)]	Indicator (Source)	Location	Proposed account
12	Benthos in (KRM)	NCP	biodiversity account
13	Fish (Vissen) (KRM)	NCP	biodiversity account
14	Birds - Vogels (KRM)	NCP	biodiversity account
15	Sea mammals - Zeezoogdieren (KRM)	NCP	biodiversity account
16	Number of exotic species - Aantal exoten in (KRM)	NCP	biodiversity account
20	Food webs - Voedselwebben (KRM)	NCP	biodiversity account

[1)] Numbering refers to the inventory list provided by Rijkswaterstaat, See Annex II.

With regard to the data from Statistics Netherlands (CBS), a number of data sources were identified. Important sources of (economic) data obviously are the studies recurrently done for Rijkswaterstaat (often on biennial basis). These studies build upon NAMWA methodology (National Accounting Matrix including Water Accounts), which was developed by Statistics Netherlands for and in cooperation with Rijkswaterstaat. Further the recurring study on the Economic description of the Dutch North Sea and Coast, including economic activity on a strip on the shore and in seaports, for a series of years (Statistics Netherlands 2017).

In this Economic description, a number of (economic) activities is described that are potentially of use. The descriptions are primarily dealing with economic data and performance. However, to facilitate the calculations for a number of activities elements of the underlying physical data had to be used. The assessed activities at sea are:

1. Oil and gas extraction;
2. Fisheries (a wide variety);
3. Sea Shipping (excl. sea port);
4. Hydraulic engineering (broad group of activity);
5. Wind energy Offshore;
6. Sand and gravel extraction;
7. Tourism and recreation (to be separated / delineation from activity on land).

These economic data are particularly relevant with regard to the valuation of certain ecosystem services. For example, for the valuation of oil and gas reserves the macroeconomic data from the National accounts for the oil and gas industry is needed.

In addition to the economic data, Statistics Netherlands has several other data sources that could be used to compile natural capital accounts for the marine environment, which include data on marine and coastal fisheries, energy (wind, fossil fuels), tourism and recreation (number of visitors etc.). Furthermore, Statistics Netherlands together with partner institutes and agencies and NGO's collect data on species on land, but also for the marine areas of the DCS. These data sources could also be used to model certain ecosystem services.

This first inventory presented in Annex II and after some processing shown in Table 4.1 and 4.2, shows that a lot of different datasets are available that can be used to construct natural capital accounts for the North Sea area. In addition, we know from earlier exchange and other cooperation projects with RWS (inland assessment of areas managed by RWS), that other useful data sets exist (for example data on water quality etc.) that have not yet been investigated. We therefore conclude that data availability will not obstruct a first compilation of experimental pilot accounts.

5. Possible (policy) uses of the Ecosystem Accounts

In this chapter we present in brief some important uses of the Marine Ecosystem Accounts. A strong feature of the SEEA and SEEA EEA accounting type of approach is that is fully consistent with other Accounts, such as the National Accounts describing the nations' macro- and meso-economic performance, as well as with the SEEA-CF type of Environmental Accounts. Another strong element of the SEEA – EEA approach is the combination of physical and monetary information, while information is generated at different scale levels, such as on national, regional, and local level. Further the information generated and indicators that are derived from the SEEA EEA information system are to be compiled according to international guidelines, which make the outcomes and resulting indicators internationally comparable. This makes the accounts particularly suitable as the basis for international reporting. These general features make the SEEA – EEA a powerful instrument for policymaking.

5.1 Possible policy applications of the marine Ecosystem Accounts

Ecosystem accounts provide several important pieces of information in support of policy and decision making relating to environment and natural resources management. The overview below of important policy uses is based on par. 1.4 from the SEEA EEA technical recommendations (UNSD, 2017).

1) Detailed, spatial information on ecosystem services supplied by the marine environment.
Ecosystem service supply accounts provide information on the quantity and location of the supply of ecosystem services. This gives insight in the wide range of services that are offered by the marine environment. This information is vital to monitor the progress towards policy goals such as achieving a sustainable use of ecosystem assets and preventing further loss of biodiversity. Defining and quantifying ecosystem services and the factors that support or undermine them is needed to highlight the importance of all types of ecosystems. Protection of the natural environment is highly important not just because of its (potentially incalculable) intrinsic value, but also because of the services that provide clear economic benefits to businesses, governments and households.

The information from the accounts should also be highly relevant for the spatial planning of for instance, infrastructure projects. For example, the potential impacts of different locations for wind farms on the overall supply of ecosystem services can be easily observed.

2) Monitoring the status of ecosystems
The set of ecosystem accounts provide detailed information on changes in status of the marine environment. The condition account reveals the status using a set of physical indicators. These indicators could be aligned with the list of 'descriptors used to determining Good Environmental Status (GES) in the Marine Strategy Framework Directive (MSFD).

The monetary accounts provide an aggregated indicator of ecosystem asset values. Although this indicator does not indicate the 'total economic value' of ecosystems, it does provide an indication of the value of the contribution of ecosystems to consumption and production, as measured with exchange values – for the ecosystem services included in the accounts. The

overall value may be of less relevance for supporting decision making, but *changes* in this value would be a relevant indicator for assessing overall developments.

3) Highlighting ecosystems and ecosystem services of particular concern for policy makers.
The accounts, when implemented over multiple years, clearly identify the specific ecosystem assets (e.g. the Doggersbank, the Waddenzee), ecosystem types (e.g. estuaries or intertidal areas) and ecosystem services (e.g. fish production or water cleansing by benthic organisms) that are changing most significantly. In the case of negative trends, the accounts would thus provide information to determine priorities for policy interventions. Since a number of causes for ecosystem change (e.g. nutrient loads, certain economic activities taking place on the North Sea) are also incorporated in the accounts, there is baseline information to identify relevant areas of focus for effective policy responses.

4) Monitoring the status of biodiversity and indicating specific areas or aspects of biodiversity under particular threat.
Compared to existing biodiversity monitoring systems, the accounting approach offers the scope – when biodiversity accounts are included – to provide information on biodiversity in a structured, coherent and regularly updated manner. Aggregated indicators for administrative units including for countries and continental scale (e.g. Europe) provide information on trends in biodiversity as well as species or habitats of particular concern. In this context, the biodiversity account can include information on species important for ecosystem functioning (e.g. 'key-stone' species indicative of environmental quality), and species important for biodiversity conservation (e.g. the presence and/or abundance of rare, threatened and/or endemic species). Where biodiversity accounts are presented as maps of biodiversity indicators, specific areas of concern or improvement can be identified, as well as areas of particular importance for biodiversity conservation both inside and outside protected areas.

Changes in biodiversity can be monitored from a list of indicators that relate to particular species are groups of species described for example by the Living Planet Index (LPI) in CBS (see: Statistics Netherlands, 2017; and Environmental Data Compendium (2017), Living Planet Index North Sea, with Marine fauna, 1990-2015).

5) Quick response to information needs.
To support ongoing reporting requirements as well as providing information to support discussion of emerging issues, the accounts provide information that is:

- Comprehensive - covering ecosystem services and assets, maps and tables, physical and monetary indicators, covering a wide range of ecosystem types and services;
- Structured - following the international framework of the SEEA aligned with the SNA;
- Coherent - integrating a broad range of datasets to provide information on ecosystem services and assets;
- Spatially referenced – linking data to the scale of ecosystems and allowing the integration of data across difference accounts.

Ideally, accounts should be updated on a regular basis, e.g. bi-annual or annual, taking into account source data availability and user needs. This means that a structured, comprehensive and up-to-date database is available to respond to policy demands for specific information. An integrated assessment, for example an environmental *cost benefit analysis* of a proposed policy or, say, an assessment of new investment in infrastructure, can typically take anytime from half a year to several years. Ecosystem accounts present a ready-to-use database that can

significantly shorten the time needed to address this information need. Assessment of specific policies or investments will likely require additional information beyond that presented in the ecosystem accounts, but, in many cases, a wide range of environmental and economic impacts can be modelled through a combination of information included in the accounts and relevant additional data. Further, different assessments can be based on a common underlying information set. This allows more focus on the outputs from reviews, rather than evaluating the data inputs. This is analogous to the way in which a common, core set of economic data underpins economic modelling.

6) Monitoring the effectiveness of various policies.
The accounts are an important tool to monitor the effectiveness of various regional and environmental policies, by allowing the tracking of changes in the status of ecosystems and the services they provide over time in a spatially explicit manner. The spatial detail of the accounts allow comparing developments in areas influenced by policies with areas with less or no influence of specific policy decisions. In particular, the notion of return on investment may be applied by assessing the extent to which expenditure on a specific program or a particular piece of regulation has made a material impact on the condition of relevant ecosystems or the flows of ecosystem services.

7) Use in economic and financial decision making.
Ecosystem accounting is designed to support the use of environmental information in standard economic and financial decision making. In this context, the measurement of the value of ecosystem services in exchange values supports direct integration with standard financial and national economic accounting data. Consequently, the data can be used to extend standard economic modelling approaches and to enhance broad indicators of economic performance such as national income, savings and productivity. While these measures and applications are different from the more common applications of ecosystem services valuations, the ability to consider ecosystems through multiple analytical lenses appears a strong motivation to continue development of valuations for accounting purposes.

5.2 Main users of the accounts

There are many potential users of the marine Natural Capital Accounts,. First, the information from the accounts, including the maps, can be used to support the Netherlands central government for monitoring purposes, spatial planning, and international reporting. For example, the data from the account can be used to decide where to allocate new wind farms or recreational activities. This builds upon already existing information, for example from the 'Economic description of the Dutch North Sea and Coast'. The SEEA EEA type of Marine Accounts allow to also include all sorts of other, i.e. ecosystem quality information, as can be derived from the 'condition account'. The Ministry of the environment and infrastructure expectedly can use the information in the different stages of the policy cycle, both in the design phase up till the evaluation phase, and can provide input to both ex-ante and ex-post analysis.

The information from the SEEA EEA is also very relevant for the European policy makers that decide upon usage and strategies on the use and efforts for the protection of the marine water environment and to develop and safeguard its resources. One can think of monitoring its relevant biodiversity aspects (i.e. via the Living Planet Indicator, LPI) and alike but also on water quality aspects and fish resources. All relevant in context of a range of policies, among which

the MSFR might be the most important. With the combine physical an monetary information of a fully developed system of the Marine Natural Capital Accounts, it allows to compare physical information with economic values and relevance and look for what are implications in terms of trade-offs between the different uses.

As the oldest governing body for the country, water boards are one way or another connected to the North Sea. Using information from the marine ecosystem accounts they may be better informed to understand what are the main implications for the overall water quality form their discharges to the sea.

Research institutions, such as PBL, Rijkswaterstaat, Imares (WUR), Deltares, TNO, Alterra, and Universities performing research in the marine areas, the GUIS communicates working on marine areas, etc., may well benefit from the detailed systematically organised information, combined and comprehensive physical and economic information, coherent with the National Accounts' meso- and macro-economic information).

The private sector can equally benefit from the gained detailed information in the marine accounts. It can help to determine particular opportunities at the DCS for example being part of development of the 'blue economy', to look for opportunities for renewable energy, for seabed mining, recreational activity and so on.

5.3 Possible use of marine Ecosystems Accounts as part of wider reporting on sustainability

Indicators from the marine Ecosystems Accounts can also be used as input for the monitoring and reporting on sustainability issues. Examples include monitoring and reporting on: i. The Sustainable Development Goals (SDG's), ii. Green Growth following OECD formats, iii. Well-being (In the monitor of 'well-being in the Netherlands) using a number of environmental and ecosystem indicators as input.

Natural capital clearly is an important domain for each of these themes and provides indicators for monitoring and evaluation. Developed Natural capital accounts / ecosystem accounts can provide such indicators, both macro totals at the national level and the underlying partly spatially explicit information needed for in-depth analysis and regional indicators.

6. Research plan

In this chapter we present a proposal to set up a pilot ecosystem accounts for the Dutch part of the continental shelf. Based on data availability, literature study and our experience with the Natural capital accounting project for the Netherlands, we propose that a number of accounts could be compiled step-by-step for the marine environment. First, we will discuss the accounts that could be set up for ecosystem accounting for the North Sea area and show how these accounts could look like. Next, we will present a research plan and propose some next steps.

6.1 Possible ecosystem accounts for the marine environment

At this moment we perceive 6 possible accounts that could be compiled for the marine environment. These are the 5 core accounts as presented in the SEEA EEA technical recommendations (UNSD, 2017) and one thematic account, the biodiversity account (see Table 6.1). For the other thematic accounts, such as the carbon account, it needs to be seen, depending on the data availability, whether these can be developed for the marine environment.

Table 6.1 possible ecosystem accounts for the marine environment

No.	Type of Ecosystem Account, physical / monetary
1	Ecosystem extent account – physical terms
2	Ecosystem condition account – physical terms
3	Ecosystem services supply and use account – physical terms
4	Ecosystem services supply and use account – monetary terms
5	Ecosystem monetary asset account – monetary terms
6	Biodiversity account – physical terms

Below, these possible accounts are briefly described.

1) Ecosystem type map and extent account

The extent account is the start of the sequence of a full set of ecosystem accounts. It aims to organise information on the area, or extent of the different ecosystem types in a country, here primarily aimed at the continental shelf. A good balance is needed between scale of analysis, data availability and derivable (policy) questions. Compilation of this account should start with making a functional classification and zoning for the North Sea. A proper linkage with other mapping initiatives dealing with the North Sea is needed to obtain well aligned accounts. Examples are the Atlas Natural Capital, EU-initiative on Mapping and assessment of ecosystems and their services (EU MAES), and the tasks and monitoring under the Biodiversity convention (COM/2011/0244, 2015).

The structure of a basic ecosystem extent account is shown in Table 6.2. The structure of the rows reflects the basic logic of asset accounts as described in the SEEA Central Framework with an opening extent (showing the sum of the delineation areas / marine zones for each particular ecosystem type at the DCS, expressed in hectares or km^2), a closing extent, additions and reductions.

The extent account is based on an agreed ecosystem type map, which is to be compiled and decided upon during the initial phase of the proposed project as a follow-up. As discussed in section 3.3, this map is essential for ecosystem accounting. The choice and delineation of the different ecosystem types is central to construct this map. Table 6.2 shows some possible ecosystem types that may be relevant for the DCS. The choices for the ecosystem type categories can only be made and negotiated with stakeholders that will use these marine accounts in the future.

In Box 1 it is described how this map was constructed for the terrestrial part of the Netherlands.

Table 6.2 Possible extent account for the marine environment (in ha)

	Ecosystem type											
	Dunes with permanent vegetation	Active coastal dunes	Beaches	Coastal wetlands	Estuaries	Intertidal areas	Port entrance / Harbour mouth	Coastal	Shelf	Open ocean	Etc.	Total
	1	2	3	4	5	6	7	8	9	10	11 …	…
Opening extent												
Additions to extent												
Managed expansion												
Natural expansion												
Upward reappraisal												
Reductions to extent												
Managed regression												
Natural regression												
Downward reappraisal												
Net change in extent												
Closing extent												

However, it is very well possible that the extent of the chosen ecosystem types for the marine environment will not change much over time. Only after new priorities are set on the DCS by policy makers, i.e. in the case of new plans and areas designated for wind energy or the like. Then of course it is not advisable to compile extent account on a regular basis and the Ecosystem Type map will suffice.

An example of the way the ecosystems accounts are implemented can be found in Australia. What is called an Experimental Ecosystem Account for the Great Barrier Reef Region has been compiled, for 2015. Starting from SEEA Ecosystem Accounts formats they have created a map of the Great Barrier Reef zoning and in conjunction reported the accompanying areas. For the Great Barrier Reef marine park a more detailed 'marine zoning (use) account' was developed,. See also ABS (2014; 2015a; 2015b, 2017).

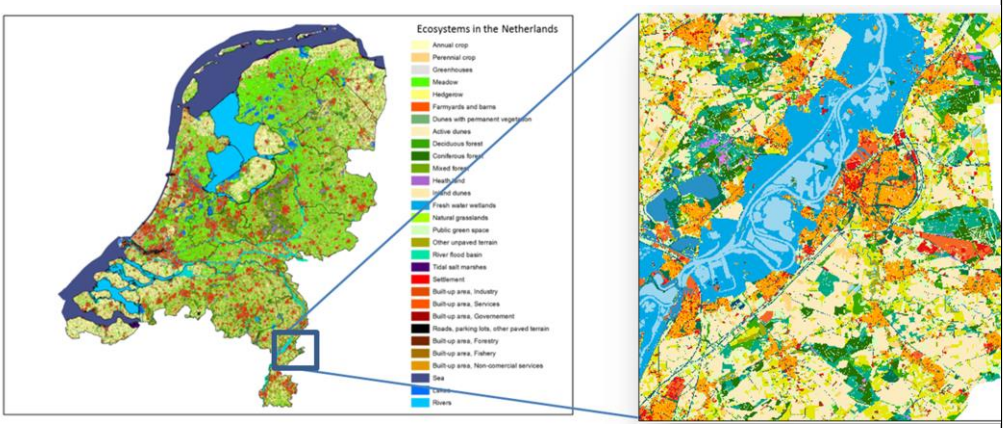
Box 1: Development of an ecosystem extent account in the Netherlands

In 2015, Statistics Netherlands, in a project carried out in collaboration with Wageningen University (WUR), developed an ecosystem extent account for the Netherlands. The account comprised a detailed map of ecosystem assets in the Netherlands, plus a table specifying the number of hectares in each ecosystem type. The map was produced for only one year (2013) and no changes in ecosystem assets were analysed.

The map classified ecosystem assets on the basis of land cover and ecosystem use. Mapping was done, as far as possible, consistent with the MAES and the SEEA EEA ecosystem types. In line with the SEEA EEA, ecosystem use was defined on the basis of the management of the ecosystems as well as on the basis of the services provided by ecosystems. In low-lying, flood-prone areas in the Netherlands, key ecosystem services are water retention and storm protection. Therefore, in addition to the main ecosystem types of the SEEA EEA, dunes and flood plains were distinguished as ecosystem types. Flood plains along rivers are used as water retention areas which are critical for controlling flood risks. The land cover in these flood plains is mostly grassland. This classification is also helpful for the ecosystem services supply and use account, where water retention is linked to flood plains but not to other types of grassland such as pastures. A correspondence table was provided that enables reclassifying the ecosystem types to those of both the SEEA EEA and of MAES.

The ecosystem extent map was produced on the basis of a combination of a number of maps and datasets covering the Netherlands: the cadastral map, a map of agricultural crops grown, the address based business register, addresses of buildings, the basic topographical registry and land use statistics for the Netherlands. Maps were combined following a strict hierarchical approach. For built up areas, the cadastral unit was taken as the base unit. However, where cadastral parcels were dissected by roads, water or railways, the smaller parcels were taken as the ecosystem asset.

The map illustrates the range of ecosystem and land use types that are present in the Netherlands. Natural and semi- natural areas were classified in detail (e.g. wetlands, deciduous forests, heathlands), whereas the same level of detail was applied to intensely managed and paved areas (e.g. different types of perennial crops, non-perennial crops, greenhouses, roads). This high level of detail allows for precise assessments of e.g. land use intensity and temporal changes in land use. The figure below presents the map at national scale, with the 31 ecosystem types at the highest hierarchical level. At the next level (not shown), 80 different types of ecosystems are distinguished including different types of forest and different types of perennial crop. At this 2nd level, the map becomes very suitable for analysing the supply of ecosystem services. Development of an ecosystem service supply and use account in the Netherlands is ongoing.



Source: CBS and WUR, 2015. Ecosystem Accounting Limburg Province, the Netherlands. Part I: Physical supply and condition accounts. To download the full report: https://www.cbs.nl/nl-nl/publicatie/2016/09/maatwerk-rapport-natuurlijk-kapitaalrekeningen

2) Condition account

The condition account provides insight into how the biophysical condition of ecosystems change, and how those changes may influence the flows of ecosystem services supplied by those ecosystems. The ecosystem condition account is compiled in physical terms using a variety of indicators for selected characteristics. Indicators in the ecosystem condition account reflect the general condition or state of an ecosystem and the relevant trends in that condition. These indicators may reflect such aspects as the occurrence of species, soil characteristics, water quality, and ecological processes (e.g. net primary production). The indicators selected should be relevant for policy and decision making, for instance because they reflect policy priorities (e.g. preservation of native habitat); pressures on ecosystems (e.g. deposition levels of acidifying compounds versus critical loads for such compounds) or the capacity of ecosystems to generate one or more services (e.g. attractiveness of the ecosystem for tourism). Generally, different ecosystem types require different indicators (SEEA EEA technical recommendations, 2017, par. 4.5). For the Marine environment

The structure of the ecosystem condition account (Table 6.3) is focused on recording information at two points in time, i.e. it presents information on the condition of different ecosystem types at the opening and closing of the reference accounting period (e.g. one year). Ecosystem condition accounting is particularly useful when accounts are developed for multiple years in order to record trends/changes in ecosystem condition (and, as relevant, the spatial variability of these trends). In the columns are the ecosystem types, in the rows are different indicators for condition. Here some examples of possible indicators are shown.

All indicators should be assessed/quantified in relation to a reference condition for the ecosystem type concerned. Where possible, the reference condition is the natural or near-natural condition in the absence of significant modification by human activity. If this is not possible, an alternative stable reference condition can be selected (e.g. condition at a particular baseline date).

The condition account for the marine environment can be populated with the monitoring data that is collected from the monitoring efforts done as required by the Marine Strategy Framework Directive. The list of (Qualitative) descriptors for determining Good Environmental Status (GES) in the MSFD (WER, 2017) may function as a starting point to determine the relevant condition indicators. Starting from the Business as usual (BAU) these can be monitored to see the progress from BAU to GES over time.

Table 6.3 Possible set up of the condition account for the marine environment (physical units)

		Ecosystem type										
Example indicators of condition		Dunes with permanent vegetation	Active coastal dunes	Beaches	Coastal wetlands	Estuaries	Intertidal areas	Port entrance / Harbour mouth	Coastal	Shelf	Open ocean	Etc.
		1	2	3	4	5	6	7	8	9	11	…
Average temperature	opening condition											
	closing condition											
Turbidity	opening condition											
	closing condition											
Water quality	opening condition											
	closing condition											
Net primary productivity	opening condition											
	closing condition											
Biodiversity	opening condition											
	closing condition											
Overal index of condition	opening condition											
	closing condition											

The main challenge with regard to the condition account is to find the most useful condition indicators based on policy need and data availability. So also this account has to be constructed in close collaboration with RWS and the ministry of Environment and Infrastructure.

As an example and part of the Experimental Ecosystem Account for the Great Barrier Reef Region also elements of the 'condition account', following SEEA EEA formats have been compiled. See ABS (2014; 2015a; 2015b).

3) Physical supply and use tables for ecosystem services

The supply of ecosystem services by ecosystem assets and the use of these services by economic units, including households, is one of the central features of ecosystem accounting. These are the flows that reflect the link between ecosystem assets and economic and human activities. Their measurement is thus central to the ambition to integrate environmental information fully into the existing national accounts.

The structure of the supply and use account is shown in table 6.4. This basic structure is the physical supply and use tables (PSUT), as used in the SEEA Central Framework (UN et al., 2014a). The supply table records which ecosystem types provide biophysical quantities of ecosystem services. This gives insight into the wide range of services that are offered by natural and semi-natural habitats, as well as human dominated ecosystems. The locations of supply can be traced in detail, as the supply account is based on ecosystem service maps. The use table records which economic sectors (including households) benefit from the ecosystem services, following the classifications used in the national accounts. By convention, total supply and use should always be equal in the PSUT. The physical units may be different for each ecosystem service. For example, fish production may be expressed in kton/year, whereas recreation may be expressed as number of visits per ha.

Table 6.4 Possible Ecosystem supply & use tables for the marine environment (physical units)

ECOSYSTEM SUPPLY TABLE

	Measurement units (kg, €/kg/ha, 100, ...)	Type of Ecosystem Unit: Dunes and beaches	Coastal wetlands	Estuaries	Intertidal areas	Port entrance / Harbour mouth	Coastal	Shelf	Etc.	TOTAL SUPPLY
		1 - 3	4	5	6	7	8	9	.. ..	.. ..
Ecosystem services										
Provisioning services										
Regulating services										
Cultural services										

ECOSYSTEM USE TABLE

	Measurement units (kg, €/kg/ha, 100, ...)	Type of Ecosystem Unit: Agriculture, forestry and fisheries	Electricity and gas supply	Water collection, treatment & supply	Other industries	Households	Accumulation	Rest of the world - exports	TOTAL SUPPLY
Ecosystem services									
Provisioning services									
Regulating services									
Cultural services									

Based on our first data inventory (see chapter 4) the following ecosystem services (biotic and abiotic) could be included in the physical supply and use tables for the North sea area:

Table 6.5 List of possible ecosystem services to be explored

Ecosystem services	
Provisioning services	
Fish	biotic
Fossil energy (oil and natural gas)	abiotic
Renewable energy (wind)	abiotic
Minerals (sand, etc.)	abiotic
Regulating services	
Water cleaning by benthic organisms	
Protection against flooding	
Cultural services	
Recreation	
Tourism	

Some of these services could be further disaggregated (i.e. fish species, oil and natural gas, different types of recreation etc.). In addition, it may be worthwhile to investigate the following services with regard to data availability and policy relevance:

1. Carbon sequestration;
2. Bioremediation chemical detoxification/breakdown of pollutants by plants;
3. Dilution, filtration and sequestration of pollutants – water, removal of organic materials from wastewater by biogeochemical processes, filtration of particulates, sequestration of pollutants in organic sediments.

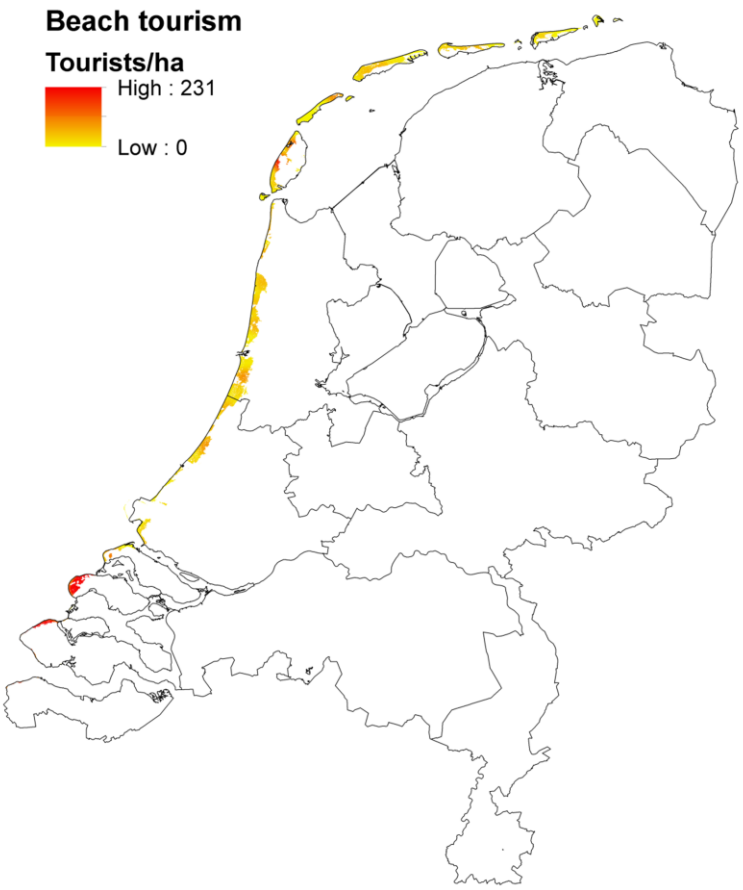
As indicated, data for some services are already available, for example nature / beach tourism (see box 2).

Box 2: The ecosystem service nature tourism

Nature tourism is an important ecosystem service in the Netherlands, as many areas of the country are frequently used for various leisure activities. Nature tourism is also an important component of the overall tourism sector, that accounts for around 4% of Dutch GDP (Statistics Netherlands, 2017b).

The ecosystem service nature tourism was modelled based on Dutch tourism statistics for provinces and tourism areas (NTBC-NIPO, 2015a). Statistics were available for three main types of nature tourism: nature and active tourism, beach tourism, and water sports. It can be assumed that these types of tourism are directly dependent on the of presence of (semi-)natural ecosystems. Tourism statistics were combined with data on densities of beds (for land activities) and marinas (for water sports) for spatial disaggregation. Tourist activities were assumed to take place in the vicinity of accommodations and marinas.

Amount of beach tourists per ha in the Netherlands in 2015.



Beaches and dunes are important ecosystems for tourism in the Netherlands with a mean density of 22 tourists per ha. In 2015 there were over 1 million beach tourists in the Netherlands (visits including an overnight stay, excluding day trippers). Especially the province of Zeeland has a high density of beach tourists (Figure), with up to 231 beach tourists per ha.

Source: NTBC-NIPO, 2015a; Statistics Netherlands and WUR, 2017.

4) Monetary supply and use tables for ecosystem services

Monetary valuation is essential to determine and aggregate the contribution of ecosystems to the economy. Based on the physical supply and use tables experimental monetary values could be calculated for the different ecosystem services using different methodologies, these need to generate outcomes that are consistent with the National accounts There is a list of methodologies that potentially can be applied to make the valuation of the ecosystem services, such as: i. Unit resource rent; ii. Hedonic pricing; iii. Replacement cost; iv. Damage costs avoided; v. Averting behaviour; vi. Travel cost and; vii. Payment for Ecosystem Services (PES) schemes. Each ecosystem service has a preferred methodology for valuation, often only one or two valuation methods can be applied or have the data available for the assessment. These methods are described in the SEEA EEA (2014) and SEEA EEA technical recommendations (2017). In 2017 and 2018 Statistics Netherlands and WUR will compile the monetary supply and use tables for the terrestrial environment of the Netherlands. Based on this experience also the valuation of ecosystem services for the marine environmental could be undertaken. For abiotic services data for certain services are already available (oil and gas reserves) or have been investigated in the past (wind energy etc.). The monetary supply and use tables have the same structure as the physical supply and use tables but has monetary units instead of physical units (see Table 6.4).

5) Monetary asset account

The ecosystem monetary asset account records the monetary value of the opening and closing stocks of all ecosystem assets within an ecosystem accounting area and additions and reductions in those stocks. In most cases, monetary values of assets are estimated based on the net present value (NPV) of the expected future flows of all ecosystem services generated by an ecosystem asset. This requires an understanding of the likely pattern for the supply and use of each ecosystem service and recognition that the pattern of supply among different ecosystem services from a single ecosystem asset is likely to be correlated. In principle, the asset account will show the 'total' value of the ecosystem assets. Figure 6.6 shows the basic structure of the asset account.

Table 6.6 Possible Ecosystem asset account for the marine environment (currency units)

	Ecosystem type											
	Dunes with permanent vegetation	Active coastal dunes	Beaches	Coastal wetlands	Estuaries	Intertidal areas	Port entrance / harbour mou	Coastal	Shelf	Open ocean	etc	Total
Opening stock of ecosystem assets												
Additions to stock												
Reductions in stock												
Revaluations												
Closing stock of ecosystem assets												

Compiling asset accounts for ecosystems is still very experimental. Based on the experience with the Natural capital project for the terrestrial environment in the Netherlands referred to above, an experimental monetary asset account for the DCS may be constructed.

6) Biodiversity account

The relationship between ecosystem services and biodiversity is complex. Biodiversity could be seen as a direct ecosystem service, providing cultural, amenity and provisioning services (harvesting species for food or energy). On the other hand, biodiversity is a fundamental characteristic of ecosystems, underlying ecosystem service supply. Changes in biodiversity frequently result in changes in ecosystem extent and condition. In the SEEA-EEA, biodiversity is considered a characteristic of ecosystems rather than an ecosystem service.

Compiling a biodiversity account enables connecting biodiversity with other accounts. For example, linking biodiversity accounts with land-use, land-cover and environmental protection expenditure accounts of the SEEA Central Framework can support analysis of the cost-effectiveness of expenditures on habitat and species conservation and the assessment of returns of investment. The biodiversity account can also be used to track progress towards achieving policy targets, such as those concerning the protection of threatened species or ecosystems, the maintenance and improvement of ecosystem condition and the location of the benefits arising from the use of biodiversity.

With regard to the compilation of marine biodiversity accounts, the same approach as currently undertaken for the terrestrial Netherlands could be used, which also has a part of the marine area and its ecosystems included (i.e. Wadden Sea), and add the marine accounts to it. In the current biodiversity account only two aquatic ecosystems are distinguished: salt and fresh water. We think of a further break down of these ecosystems, for instance into wetlands, marsh and North Sea, but alternative break downs are possible, for example a distribution following habitats with biodiversity hotspots (For options, see for example: Imares WUR (2011).

6.2 Research plan and possible next steps

In this final section we present a research plan for the pilot compilation of Natural capital accounts for the DCS. Key elements of this plan are:

a) To follow the guidelines of SEEA EEA and the SEEA EEA technical recommendations;
b) To make use of and benefit from the knowledge at Statistics Netherlands (and WUR) that has been gained with respect to natural capital accounting over the past years;
c) To make most efficient use of possible data sources both at RWS, Statistics Netherlands and other institutes;
d) To set up a project with different phases running for several years, rather than one large project for one year. In total, this project may take two or three years. The main advantages are that this will keep the project manageable with regard to the required capacity and budget. Also, this will allow to learn from new insights gained from the current Natural Capital Accounts (Natuurlijk Kapitaal Rekeningen) for the terrestrial part of the country, but also to take account of new international developments. After each phase there could be a go/no go moment where it will be decided to continue with the project or not.

To set up Natural Capital accounts for the DCS, we envisage four phases (0-3). Following the Ecosystem Accounts for terrestrial part of the Netherlands, we learned that given the challenges, both with regard to methodology and data and the sequence of accounts, a split and proper phasing of such a large project is required. We would start with the first phase, organising and deciding on 'the map of the marine zoning and extent account', followed by the 'condition account', the 'Physical supply and use tables for ecosystem services' and possibly followed by the different monetary type of Ecosystem Accounts. This eventually would be supplemented by thematic accounts such as the marine biodiversity accounts. This setup can only be done in close contact and communication with the Ministry of Infrastructure and the Environment (IenM) and with Rijkswaterstaat. First we need to discover their needs en together define their priorities and the magnitude of the project and later on required budget. In the following we discuss the different phases in detail.

Phase 0: Discussion with Rijkswaterstaat / Ministry of Infrastructure and the Environment and other key stakeholders to determine the scope of the project and the way forward

During discussions between the Ministry of Infrastructure and Environment and the Ministry of Economic Affairs, various branches of Rijkswaterstaat and other relevant stakeholders, some key issues have to be answered:

- What are the key policy (and research) questions that need to be answered by the Marine Ecosystem accounts;
- What is the regional scope of the accounts: Inclusion or exclusion of the Wadden Sea, Westerschelde. Inclusion or exclusion of the terrestrial coastal zone (Dunes and beaches), etc.;
- What are the most adequate ecosystem types for the DCS?
- Identify data sources and maps not yet investigated;
- For what year(s) should the pilot accounts be constructed?
- Is there a need from the ministry to deal and incorporate aspects such as negative externalities and ecosystem disservices?

Phase 1: Compilation of a first set of physical accounts

a) Construction of an Ecosystem Type map (marine zoning) of the DCS. In close collaboration with RWS the map will be constructed based on available data and policy relevance;
b) Test compilation of physical supply and use tables for a selection of ecosystem services. This selection of services could be based list presented in table 5.5 with some possible additions depending on the needs to be discussed and priorities set by the stakeholders;
c) Test the setup and compilation of a condition account for the marine environment and populate with the relevant data.

Phase 2 Compilation of a second set of accounts (primarily monetary account)

a) Test compilation of the monetary supply and use tables for the selected number of ecosystem services;
b) Test compilation of the monetary asset account;
c) Test compilation of the biodiversity account.

Phase 3: Evaluation and finalising the accounts

a) Evaluation of the accounts compiled so far with Rijkswaterstaat, the Ministry and key stakeholders;

b) Based on the evaluation and gained insights from the exchange and discussions, improve / extend some of the accounts;
c) Possibly update the accounts for a recent year;
d) Show how the accounts can be used (case study, in depth analysis etc.).

7. Conclusions and recommendations

Marine and coastal ecosystems provide a range of 'ecosystem services', from fisheries to carbon storage and flood protection. Yet pollution, overfishing, climate change and habitat destruction cause adverse effects and may lead to degrading several of the ecosystems at the DCS, effecting the wealth of the country and sustainability of cities and communities, water quality and livelihoods at risk. Natural capital accounting (NCA) can be used to monitor and analyse the condition of ecosystem and the benefits that are derived from ecosystems in a coherent and consistent way.

Nationally and internationally there is much interest to test and implement Natural capital accounts. Focus thus far has been on the terrestrial environment and there is still little experience with the marine environment globally. Ecosystem accounts for marine areas such as the DCS are thus still very experimental, and much still has to be developed, tested and learned. The Netherlands is in an excellent position to start a pilot compilation of marine natural capital accounts. First, many different data source are available for the North Sea that are needed for the compilation of the accounts, in physical terms but also in economic terms. Second, Statistics Netherlands (and Wageningen University and Research, WUR) are currently doing a three year project to compile natural capital accounts for the terrestrial part of the Netherlands. This experience could be used for a first pilot compilation of marine natural capital accounts for the DCS.

As a possible next step, it is recommended to initiate a pilot project with a small set of accounts which have also a limited scope with regard to the number of condition indicators and the number of ecosystem services. In addition it is recommended to make it a multi-year project in order to keep the process manageable with respect to budget and required capacity.

The results of this project may be used by the international community to advance natural capital accounting for the marine environment.

References

ABS (2015b). Information Paper: An Experimental Ecosystem Account for the Great Barrier Reef Region, 2015 (4680.0.55.001).

ABS (2014). Towards Experimental Ecosystem Accounts for the Great Barrier Reef. Paper prepared for Annual WAVES Partners Meeting, 15---16 May 2014. Washington DC, United States of America. John Power, Sean Lawson and Michael Vardon. Centre of Environment Statistics. Australian Bureau of Statistics.

ABS (2015a). Information Paper (Excel): An Experimental Ecosystem Account for the Great Barrier Reef Region, 2015.

ABS (2017). Experimental Environmental-Economic Accounts for the Great Barrier Reef, 2017.

Compendium Leefomgeving (Environmental Data Compendium) (2017) … nieuwe soorten biodiversity data voor de Noordzee …

CBS (Statistics Netherlands) (2017). *Biodiversiteit Noordzee achteruit*. Web-article: 3-11-2017 Den Haag/Heerlen.

EEA (2015). State of Europe's seas. EEA Report No2/2015.

Engeland, van T., K. Soetaert, A. Knuijt, R.W.P.M. Laane, and J.J. Middelburg. Centre for Estuarine and Marine Ecology (CEME), (2010). Dissolved organic nitrogen dynamics in the North Sea: A time series analysis (1995-2005). Netherlands Institute of Ecology (NIOO), Yerseke, The Netherlands. Deltares, Delft, The Netherland. Faculty of Geosciences, Utrecht University, The Netherlands.

Engeland, van T., K. Soetaert, A. Knuijt, R.W.P.M. Laane, and J.J. Middelburg. Centre for Estuarine and Marine Ecology (CEME), (2010). *Dissolved organic nitrogen dynamics in the North Sea: A time series analysis (1995–2005)*. Available from: https://www.researchgate.net/publication/223358852_Dissolved_organic_nitrogen_dynamics_in_the_North_Sea_A_time_series_analysis_1995-2005 [accessed Sep 8, 2017]. In: Estuarine Coastal and Shelf Science 89(1):31-42 · September 2010.

European Commission (2010). Economic and social analysis for the initial assessment for the Marine Strategy Framework Directive (MSFD): a guidance document.

Ecorys (2013a). Baseline scenario's KRW Update sociaaleconomische ontwikkeling t.b.v. analyse Kaderrichtlijn Water.

Ecorys (2013b) Blue Growth in EU sea basins: methodology for data gathering and processing for the North Sea and Atlantic Arc.

Statistics Netherlands (2014). Economic description of the North Sea for the Netherlands, Den Haag/Heerlen.

European Commission (2013). EU MAES report on Mapping and assessment of ecosystems and their services.

Haines-Young, R. and Potschin, M. (2017). *Common International Classification of Ecosystem Services (CICES) V5.1. Guidance on the Application of the Revised Structure*. Fabis Consulting Ltd, Nottingham, UK.

Haines-Yong, R. and Potschin, M. (2012) CICES Version 4: Response to Consultation. Centre for Environmental Management, University of Nottingham.

Imares WUR (2011). *Biodiversity hotspots on the Dutch Continental Shelf. A Marine Strategy Framework Directive perspective*. O.G. Bos, R. Witbaard, M. Lavaleye, G. van Moorsel, L.R. Teal, R. van Hal, T. van der Hammen, R. ter Hofstede, R. van Bemmelen, R.H. Witte, S. Geelhoed & E.M. Dijkman Report number C071/11. IMARES - Institute for Marine Resources & Ecosystem Studies. Report number: C071/11. BO-11-011.04-009. Publication date: 29 June 2011.

MA, Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Mark Eigenraam, Freya McCormick and Dr Zaida Contreras. Marine and Coastal Ecosystem Accounting: Port Phillip Bay. 2016.
https://www.environment.vic.gov.au/__data/assets/pdf_file/0025/49813/Marine-and-Coastal-Ecosystem-Accounting-Port-Phillip-Bay.pdf

Rijkswaterstaat, 2017. Inventory on ecosystem services on the North Sea, both biotic and abiotic aspects (Informatie overzicht over ecosysteem services op de Noordzee van zowel biotisch als abiotische aspecten). By: Cor Schipper, vr 21 April 2017.

SEEA-CF, 2014. UN, EC, FAO, OECD, World Bank, 2014. System of environmental-economic accounting 2012, Central Framework. United Nations, New York, USA.

SEEA-EEA-Technical Recommendations (draft), 2017. SEEA Experimental Ecosystem Accounting: Technical Recommendations. Consultation Draft V4.1: 6 March 2017. Prepared as part of the joint UNEP / UNSD / CBD project on Advancing Natural Capital Accounting funded by NORAD.

SEEA-EEA, 2014. UN, EC, FAO, OECD, World Bank, 2014. System of environmental-economic accounting 2012, experimental ecosystems accounting. United Nations, New York, USA.

SNA, 2008. UN (United Nations), EC (European Commission), IMF (International Monetary Fund), OECD (Organisation for Economic Co-operation and Development) and World Bank (2008). System of National Accounts 2008, New York, USA.

Statistics Netherlands / Wageningen University & Research (WUR) (2017a). The SEEA EEA carbon account for the Netherlands. Marjolein Lof, Sjoerd Schenau, Rixt de Jong, Roy Remme, Cor Graveland, Lars Hein.

Statistics Netherlands / Wageningen University & Research (WUR) (2017b). The biodiversity account for the Netherlands, first results. Elze Polman, Roy Remme, Rixt de Jong, Sjoerd Schenau. 19-06-2017.

Statistics Netherlands / Wageningen University & Research (WUR) (2017c). The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands, in prep.
Statistics Netherlands (2014). Economic description of the North Sea for the Netherlands, 2005, 2008, 2010, 2011. Den Haag/Heerlen.
Statistics Netherlands (2017a). Economic description of the Dutch North Sea and Coast: 2005, 2010, 2014. Den Haag/Heerlen.

Statistics Netherlands (2017b) https://www.cbs.nl/nl-nl/nieuws/2017/34/toerismesector-blijft-groeien.

Tide, Tidal River Development. Ecosystem Service Assessment of TIDE Estuaries.
Sander Jacobs, Wouter Van den bruwaene, Dirk Vrebos, Olivier Beauchard, Annelies Boerema, Kirsten Wolfstein, Tom Maris, Sonja Saathoff and Patrick Meire. Ecosystem Management Research group (ECOBE), University of Antwerp, Belgium. Flanders Hydraulics, Flemish department of mobility and public works, Belgium. Netherlands Institute for Sea Research (NIOZ), the Netherlands. Antwerp Port Authority, Belgium. Hamburg Port Authority, Germany. Flussgebietsmanagement Übergangs-/Küstengewässer, Germany. The Interreg IVB North Sea Region Programme.

Voet, L. and B. Budding (2008). Verkenning van economische en ruimtelijke ontwikkelingen op de Noordzee. Available in Dutch at: http://www.noordzeeloket.nl/Images/Verkenning%20van%20economische%20en%20ruimtelijke%20ontwikkelingen%20op%20de%20Noordzee%20(VERON)_tcm14-3836.pdf

WER (2017). The cost of degradation of the Dutch North Sea environment (CONCEPT). An updated overview including an analysis of its Ecosystem Services. Strietman, W.J.; Blaeij, A.T. de; Reinhard, S.; Zaalmink, B.W. Wageningen Economic Research (WER). Study commissioned by the Dutch Ministry of Infrastructure and the Environment. Den Haag, November 2017.

Internet Sources:

Statline: http://statline.cbs.nl/statweb/?LA=en
Environmental Data Compendium (Compendium Leefomgeving) (2017) *LPI Noordzee: Mariene fauna, 1990-2015*. Indicator. 30 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) LPI Noordzee: Zeevissen, 1990-2016. Indicator 30 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *Beschrijving van de Noordzee*. 30 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *LPI Noordzee Kustzone: Fauna in de kustzone, 1990-2015*. Indicator. 27 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *LPI Noordzee Kustzone: Fauna in de Waddenzee, 1990-2015*. Indicator. 30 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *LPI Noordzee Kustzone: Fauna in de Oosterschelde, 1990-2015*. Indicator. 30 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *LPI Noordzee Kustzone: Fauna in de Westerschelde, 1990-2015*. Indicator. 26 October 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2017) *Kokkels in Waddenzee en Zeeuwse Delta, 1990-2016*. Indicator. 25 October 2017.

Environmental Data Compendium (Compendium Leefomgeving) (2017) *Bodemfauna Noordzee en bodemvisserij*. Indicator. 26 January 2017.
Environmental Data Compendium (Compendium Leefomgeving) (2016) *Inzet visserijtechnieken Nederlandse kottersector, 2014*. Indicator. 07 September 2016.
Environmental Data Compendium (Compendium Leefomgeving) (20127) *Monitor Infrastructuur en Ruimte: Ruimtelijke verdeling biodiversiteit in de Noordzee, 1991-2010*. Indicator. 25 september 2012.
Atlas Natural Capital: https://www.atlasleefomgeving.nl/en/web/ank/home
COM/2011/0244 final (2015). *Biodiversity strategy to 2020. Last review: 21-09-2015*. European Legislation. EUR-LEX, Access to European Union law: Document 52011DC0244.
Statistics Netherlands, 2017. *Bossen en bodems stoten meer CO_2 uit dan ze vastleggen (Forests and soils expel more CO_2 than they sequester)*. Web article: 06-11-2017.

National Ports Council: http://www.havenraad.nl/english
Port of Rotterdam Authority: http://www.portofrotterdam.com/en

European Commission: http://ec.europa.eu/environment/water/marine/index_en.htm
Helpdesk water: http://www.helpdeskwater.nl/

Personal communication:
Cor Schipper, Deltares, 21 April 2017.

Annexes

Annex I Land cover classes and ecosystem functional unit types

Description of classes	Ecosystem types, for instance
1. Artificial areas (including urban and associated areas)	Urban / Residential Urban park Industrial Road infrastructure Waste deposit sites
2. Herbaceous crops	Irrigated rice Other irrigated crops Rain fed annual croplands
3. Woody crops	Fruit tree plantations Coffee and tea plantation, Oil palm plantation Rubber plantation
4. Multiple or layered crops	Two layers of different crops (e.g. wheat fields with olive trees in the Mediterranean area) One layer of natural vegetation (mainly trees) that covers one layer of cultivated crops (e.g. coffee grown under shade trees)
5. Grassland	Natural grasslands Improved pastures Steppe Savanna
6. Tree-covered areas (forests)	Deciduous forest Coniferous forest Plantation (planted) forest
7. Mangroves	Inland mangroves Near shore mangroves
8. Shrub-covered areas	Natural dry land shrub land Degraded dry land shrub land
9. Shrubs, and/or herbaceous vegetation, aquatic or regularly flooded	Wetland shrub land
10. Sparsely natural vegetated areas	Periglacial vegetation
11. Terrestrial barren land	Sandy dunes
12. Permanent snow and glaciers	
13. Inland water bodies	Lakes Rivers
14. ***Coastal water bodies and intertidal areas***	***Coral reefs*** ***Sea grass meadows***
15. ***Sea and marine areas***	***..***

Source: SEEA Central Framework Table 5.12 (UN et al., 2014), and ecosystem types added (from: SEEA-EEA - Technical recommendations, 2017).

Annex II Data Inventory on biotic and abiotic ecosystem services on the Dutch North Sea from RWS

(in Dutch)

	ecosystem services (Source)	Internetlink	Web Features services	Location
1	Windvermogen Noordzee (DANK	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/8e7bf8df-e637-4252-8b6d-3ae0d90f6fd0	http://geoservices.rijkswaterstaat.nl/noordzee_windenergiegebieden?&request=GetCapabilities&service=WFS	NCP
2	Delfstofwinning op zee: zand -ecotopen (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/17df8684-f57f-4b09-902d-ce687d6886d0	http://deltaresdata.openearth.nl/geoserver/DANK/wfs?&request=GetCapabilities&service=WFS	NCP
3	Macroalgen productie in de Noordzee : Laminaria digitata (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/0332f1bf-53a8-46d7-8638-bde94ee94640	http://deltaresdata.openearth.nl/geoserver/DANK/wfs?&request=GetCapabilities&service=WFS	NCP
4	Transportroutes over water - zee (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/0fe67481-c1b7-4968-9a0b-ab6bf143d545	http://geodata.nationaalgeoregister.nl/verkeersscheidingsstelsel/wfs?&request=GetCapabilities&service=WFS	NCP
5	Zwemwater kust en aquatisch (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/42938379-5971-4a57-9536-b58a4f36f282	http://deltaresdata.openearth.nl/geoserver/DANK/wfs?&request=GetCapabilities&service=WFS	NZ kust
6	Energie-opwekking, beperkt door koelcapaciteit oppervlaktewater (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/74bffc68-baa4-4aa1-8062-859661179b43	http://deltaresdata.openearth.nl/geoserver/DANK/wfs?&request=GetCapabilities&service=WFS	NZ kust
7	Bescherming tegen overstroming (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/2da4f090-c800-4834-9f13-1d6da3a9fe2b	http://deltaresdata.openearth.nl/geoserver/DANK/wfs?&request=GetCapabilities&service=WFS	NZ kust
8	Verspreiding sportvisserijactiviteiten in zoet water (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/c1d2bc8e-3e77-44e3-ade8-ebf425a0f503?tab=general	http://deltaresdata.openearth.nl/geoserver/DANK/wms?&request=GetCapabilities&service=WMS	aquatisch
9	Delfstofwinning op zee - Wingebied schelpen (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/34d2133e-8856-4868-94f2-368e9f85e2e6	http://geodata.nationaalgeoregister.nl/noordzeewingebieden/wfs?&request=GetCapabilities&service=WFS	ncp
10	KRW toetsingskader potentieel relevant areaal macrofauna (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/149e2329-980d-4caa-bd5b-b426a57b900h	http://geoservices.rijkswaterstaat.nl/waterdienst_potentieel_areaal?&request=GetCapabilities&service=WMS	NZ kust
11	Water zuiverende werking bodemorganismen Waddenzee (DANK)	http://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/67db9af0-c702-4c7a-8219-69861a6bdff2	http://al-ng008.xtr.deltares.nl/atom/DANK013_waterzuivering_zeewater_service.xml	NZ Waddenzee
12	Benthos in (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
13	Vissen in (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
14	Vogels (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP

15	Zeezoogdieren (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
16	Aantal exoten in (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
17	Commerciële vis, schaal en schelpdieren (biomassa) (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
18	Commerciële vis, schaal en schelpdieren (Grootteverdeling) (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
19	Commerciële vis, schaal en schelpdiere, (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
20	Voedselwebben (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
21	Eutrofiering (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
22	Zeebodemintegriteit (KRM)	http://www.informatiehuismarien.nl/krm/viewer/	http://marineproject.openearth.nl/geoserver/ihm_krm/ows	NCP
23	Demersal fish Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
24	Pelagic fish Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
25	Norway lobster and shrimp Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
26	International Bottom Trawl Surveys (IBTS) Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
27	Mackerel and horse mackerelAbundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
28	Blue whiting acoustic survey Abundance and richness - at age (ton/a)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
29	Herring larvae surveys (IHLS)Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
30	Herring echo surveys (NHAS) Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP

31	Atlanto-Scandic herring survey (ASH) Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
32	Flatfish surveys –BTS Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
33	Flatfish surveys -SNS Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
34	Flatfish surveys –DFS Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
35	Monitoring by-catch Abundance and richness - at age (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
36	Fisheries statistics Landings (ton) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
37	Monitoring shellfish files Harvest (ton/a) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP
38	Recreational fishery Landings (ton) (ICES)	http://ices.dk/marine-data/dataset-collections/pages/default.aspx	https://datras.ices.dk/WebServices/Webservices.aspx	NCP

Source: Rijkswaterstaat, 2017. Inventory on ecosystem services on the North Sea, both biotic and abiotic.

Annex III Classification of marine ecosystem services

Possible classification of marine ecosystem services, from Dogger Bank study

Ecosystem service	*Description*	*Relevance to the Dogger Bank*
Provisioning services		
1 Food provision:		
a) Wild capture sea food	All available marine flora and fauna extracted from unmanaged marine environments for consumption by humans	U, extensive fishing (trawling)
b) Farmed sea food	Food from aquaculture for consumption by humans	X, no aquaculture in the area
2 Biotic raw materials (non-food):		
a) Genetic resources	The provision/extraction of genetic material from marine flora and fauna for use in non-medicinal contexts	?, unknown
b) Medicinal resources	Any material that is extracted from or used in the marine environment for its ability to provide medicinal benefits	?, unknown
c) Ornamental resources	Any material that is extracted for use in decoration, fashion, handicrafts, souvenirs, etc.	U, growing market for mammoth and other Mesolithic remains
d) Other biotic raw materials	Extraction of all other renewable biotic resources	U, harvesting of sandeels for animal feed and fertilisers
Regulating services		
3 Air purification	Influence of a marine ecosystem on concentration of pollutants from the atmosphere	U, extent unknown
4 Climate regulation	The contribution of a marine ecosystem to the maintenance of a favourable climate through impacts on the hydrological cycle, temperature regulation, and the contribution to climate-influencing substances in the atmosphere	U, extent unknown
5 Disturbance prevention or moderation	The contribution of marine ecosystem structures and functions to the dampening of the intensity of environmental disturbances such as storm floods, tsunamis, and hurricanes	X, area too far from the coast
6 Regulation of water flows	The contribution of marine ecosystems to the maintenance of localized coastal current structures	?, unknown

Ecosystem service	*Description*	*Relevance to the Dogger Bank*
7 Waste treatment and assimilation	The removal of contaminant and organic nutrient inputs to marine environments from humans	U, extent unknown
8 Coastal erosion prevention	The contribution of marine ecosystems to coastal erosion prevention	X, area too far from the coast
9 Biological control	The contribution of marine ecosystems to the maintenance of population dynamics, resilience through food web dynamics, disease and pest control	U, extent unknown
Cultural services		
12 Leisure, recreation and tourism	The provision of opportunities for tourism, recreation and leisure that depend on a particular state of marine ecosystems	U, limited to some sailing, diving and recreational angling
13 Aesthetic experience	The contribution that a marine ecosystem makes to the existence of a surface or subsurface lanDCSape that generates a noticeable emotional response within the individual observer. This includes informal spiritual individual experiences but excludes that covered by service 17	U, limited to those who go there
14 Inspiration for culture, art and design	The contribution that a marine ecosystem makes to the existence of environmental features that inspire elements of culture, art, and/or design. This excludes that covered by services 2c, 13, and 16	U, extent unknown
15 Cultural heritage	The contribution of marine ecosystems to the maintenance of cultural heritage, and providing a `sense of place'	U, extent unknown but links to Palaeolithic man
16 Cultural diversity	The contribution of marine ecosystems to social and cultural values and adaptations that pertain to living at coasts and exploiting marine resources	U, extent unknown
17 Spiritual experience	The contribution that a marine ecosystem makes to formal and informal collective religious experiences. This excludes that covered by services 13 and 14	U, extent unknown
18 Information for cognitive development	The contribution that a marine ecosystem makes to education, research, and individual and collective cognitive development	U, extent unknown
Habitat services		
10 Migratory and nursery habitat	The contribution of a particular marine habitat to migratory and resident species' populations through the provision of critical habitat for feeding, or reproduction and	U, extent unknown

Ecosystem service	*Description*	*Relevance to the Dogger Bank*
	juvenile maturation	
11 Gene pool protection	The contribution of marine habitats to the maintenance of viable gene pools through natural selection/evolutionary processes which enhances adaptability of species to environmental changes, and the resilience of the ecosystem	U, extent unknown

Codes on Relevance: U: relevant, X: not relevant,?: relevance unknown.
Source: C. Hattam et al. / Ecological Indicators 49 (2015) 61–75 65; This was modified from de Groot et al. (2010a) and Böhnke-Henrichs et al. (2013).

Annex IV Possible mapping and Assessment of Ecosystems and their Services

Mapping and Assessment of Ecosystems and their Services (MAES)

Table: Correspondence between Corine Land Cover (CLC) classes and ecosystem types following MAES

CLC Level 1	CLC Level 2	CLC Level 3	Ecosystem types level 2
1. Artificial surfaces 2. Agricultural areas 3. Forests and semi-natural areas 4. Wetlands	..	..	
4. Wetlands	4.1. Inland wetlands	4.1.1. Inland marshes Wetlands 4.1.2. Peatbogs	Wetlands
	4.2. Coastal wetlands	4.2.1. Salt marshes Marine inlets and transitional waters 4.2.2. Salines 4.2.3. Intertidal flats	Marine inlets and transitional waters
5. Water bodies	5.1. Inland water	5.1.1. Water courses Rivers and lakes 5.1.2. Water bodies	Rivers and lakes
	5.2. Marine waters	5.2.1. Coastal lagoons Marine inlets and transitional waters 5.2.2. Estuaries	Marine inlets and transitional waters
		5.2.3. Sea and ocean Marine	Marine

http://biodiversity.europa.eu/maes/correspondence-between-corine-land-cover-classes-and-ecosystem-types

Annex V Glossary

BAU	Business as usual
BSU	basic spatial unit
C	carbon
CBD	Convention on Biological Diversity
CICES	Common International Classification of Ecosystem Services
EA	ecosystem asset
EAA	ecosystem accounting area
EAU	ecosystem accounting unit
EC	European Commission
EEZ	exclusive economic zone
ET	ecosystem type
EU	European Union
Eurostat	Statistical Office of the European Union
FAO	Food and Agriculture Organization of the United Nations
FDES	Framework for the Development of Environment Statistics
FEGS-CS	Final Ecosystem Goods and Services Classification System
GDP	gross domestic product
GES	Good Environmental Status
GHG	greenhouse gas
GIS	geographic information system
HRU	hydrological response units
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification of all economic activities
ISO	International Organization for Standardization
IUCN	International Union for the Conservation of Nature
km2	square kilometre
LCCS	Land Cover Classification System
LCEU	land cover / ecosystem functional unit
LPI	Living Planet Index
LUCAS	Land Use and Cover Area Survey
LULUCF	land use, land use change and forestry
m2	square metre
m3	cubic metre
mm	millimetre
MA	Millennium Ecosystem Assessment
MAES	Mapping and Assessment of Ecosystems and their Services (EU-initiative)
MEGS	Measuring Ecosystem Goods and Services
MIMES	Multiscale Integrated Model of Ecosystem Services
MMU	minimum mapping unit
N	nitrogen
NAMWA	National Accounting Matrix including Water Accounts (developed for Rijkswaterstaat in cooperation with Statistics Netherlands (CBS)
NBSAP	National Biodiversity Strategic Action Plan

NEP	net ecosystem productivity
NESCS	National Ecosystem Services Classification System
NPP	net primary productivity
NPV	net present value
NSDI	national spatial data infrastructure
NSO	national statistical office
OECD	Organisation for Economic Cooperation and Development
PIM	perpetual inventory model
PSUT	physical supply and use table
SCBD	Secretariat for the Convention on Biological Diversity
SDG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SEEA EEA	System of Environmental-Economic Accounting Experimental Ecosystem Accounting
SIDS	small island developing states
SNA	System of National Accounts
SUA	supply and use accounts
SWAT	Soil and Water Assessment Tool
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP WCMC	UNEP World Conservation Monitoring Centre
UN REDD+	UN Reducing Emissions from Deforestation and forest Degradation
UNSD	United Nations Statistics Division
UNU-IHDP	University of the United Nations / International Human Dimensions on Poverty Programme
USLE	Universal Soil Loss Equation
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WUR	Wageningen University
WWF	World Wildlife Fund

Source: SEEA – EEA Technical Rec. (2017); with additions.