

The cost of degradation of the Dutch North Sea environment - Update 2024

A study into the cost of avoiding degradation and the applicability of the Ecosystem Services approach

W.J. Strietman, F.D.M. Roos, O.M.C. van der Valk, S. Reinhard



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This report provides an insight into the cost of degradation of the marine environment of the Dutch part of the North Sea by calculating the annual current (2022) costs of measures that avoid or minimise degradation. In addition to this, insight is provided into the potential applicability of the ecosystem services approach to calculate ecosystem benefits gained when Good Environmental Status is reached, in comparison to a Business-as-Usual scenario. The total costs of measures that avoid degradation of the Dutch North Sea environment have been calculated to be in the range of approximately at least €7.19-2.02bn in 2022. In terms of the applicability of the Ecosystem Services Approach methodology, it is concluded that the methodology and empirical application are not mature enough yet and that the data needed are too limited to be applied within the context of the Marine Strategy Framework Directive.

Dit rapport geeft inzicht in de huidige (2022) jaarlijkse uitgave om aantasting van het mariene milieu van het Nederlandse deel van de Noordzee te voorkomen of te minimaliseren. Daarnaast wordt inzicht gegeven in de potentiële toepassing van de ecosysteembenadering als methode om de waarde te berekenen van extra ecosysteemdiensten bij een scenario waarbij de Goede Milieutoestand (GMT) gerealiseerd is ten opzichte van een Business as Usual-scenario. De jaarlijkse totale kosten van maatregelen die aantasting van het Nederlandse Noordzeemilieu voorkomen, zijn voor 2022 berekend op ten minste €7,19-2,02 mld. Voor wat betreft de toepassing van de ecosysteemdienstenbenadering is geconcludeerd dat de methodologie en empirische toepassing nog niet ontwikkeld genoeg zijn en er nog niet voldoende benodigde gegevens beschikbaar zijn om deze binnen de context van de Kaderrichtlijn Mariene Strategie toe te passen.

Key words: Marine Strategy Framework Directive, Costs, North Sea, Ecosystem Approach

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P.O. Box 29703, 2502 LS The Hague, The Netherlands, T +31 (0)70 335 83 30,
E communications.ssq@wur.nl, <http://www.wur.eu/economic-research>. Wageningen Economic Research is part of Wageningen University & Research.



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Summary

This report provides an insight into the cost of degradation of the marine environment of the Dutch part of the North Sea by calculating the annual current costs of measures that avoid or minimise degradation. In addition to this, insight is provided into the potential applicability of the ecosystem services approach to calculate ecosystem benefits gained when Good Environmental Status (GES) is reached, in comparison to a Business-as-Usual scenario.

Given the assumptions used and bearing in mind the measures for which no data or partial data are available, the total cost of avoiding degradation to the Dutch North Sea environment has been calculated to be in the range of approximately at least €7.19-2.02bn, and as such a lower bound for the actual cost of degradation. The majority of these costs (circa 25-50%) are incurred through land-based measures.

The summary table for the cost of avoiding degradation (Table S.1) is shown below.

Table S.1 Summary table of the minimum current total costs of degradation and the costs for each sector
a)

Sector	Minimum total costs (million euros)
Fisheries and aquaculture	36-40
Shipping	52
Oil and gas extraction	207
Sand extraction	(no data available)
Wind energy	32-86
Sea ports	(no data available)
Coastal zone activities	24-33
Government	161-365
Agriculture	2-11
Urban and industrial activities	183 - 1.098
Other activities	22-123
Total estimates	> 719-2,015

a) Please note that all numbers presented above are minimum costs. For some sectors, a minimum range of costs has been calculated.

In this study we also looked into the feasibility of applying the Ecosystem Services methodology as an alternative method to calculate the cost of degradation of the Dutch part of the North Sea. It is concluded that the Ecosystem Services methodology cannot yet be applied to calculate both the benefits of achieving Good Environmental Status and the Cost of Degradation. This is because the methodology has not yet been developed far enough and crucial data are missing.

Samenvatting

Dit rapport geeft inzicht in de kosten van aantasting van het mariene milieu van het Nederlandse deel van de Noordzee door de jaarlijkse huidige (2022) kosten te berekenen van maatregelen die aantasting voorkomen of minimaliseren. Daarnaast wordt inzicht gegeven in de mogelijke toepasbaarheid van de ecosysteemdienstenbenadering voor het berekenen van de behaalde ecosysteemvoordelen bij het bereiken van de Goede Milieutoestand, in vergelijking met een Business-as-Usual-scenario.

Gegeven de gehanteerde aannames en rekening houdend met de maatregelen waarvoor geen of gedeeltelijk gegevens beschikbaar zijn, zijn de totale kosten om aantasting van het Nederlandse Noordzeemilieu te voorkomen berekend op minimaal € 7,19-2,02 mld. Deze berekende kosten zijn een ondergrens voor de werkelijke kosten van degradatie. Het merendeel van deze kosten (25-30%) betreft maatregelen voor activiteiten die op land plaatsvinden.

De overzichtstabel voor kosten om degradatie te voorkomen (tabel S.2) is hieronder weergegeven.

Tabel S.2 *Samenvattende tabel met de huidige minimale kosten om aantasting van het mariene milieu te voorkomen - per sector en gebruiksfunctie a)*

Sector	Minimale kosten (in miljoenen euro's, afgerond)
Visserij & aquacultuur	36-40
Scheepvaart	52
Olie- en gaswinning	207
Zandwinning	(no data available)
Windenergie op zee	32-86
Havens	(no data available)
Activiteiten in de kustzone	24-33
Overheid	161-365
Landbouw	2-11
Stedelijke en industriële activiteiten	183-1.098
Overige activiteiten	22-123
Total estimates	> 719-2,015

a) Alle hierboven weergegeven getallen zijn minimumkosten. Voor sommige sectoren is een minimale bandbreedte aan kosten berekend, voor andere een enkel getal.

In deze studie hebben we ook gekeken naar de haalbaarheid van het toepassen van de Ecosystem Services-methodiek als alternatieve methode om de kosten van aantasting van het mariene milieu van het Nederlandse deel van de Noordzee te berekenen. Er wordt geconcludeerd dat de Ecosystem Services-methodiek nog niet toegepast kan worden voor het berekenen van zowel de baten bij het halen van een Goede Milieutoestand (GMT/GES) als de kosten van degradatie. Dit komt doordat de methodologie nog niet ver genoeg is ontwikkeld én omdat cruciale gegevens ontbreken.

1 Introduction

1.1 Background

The aim of the Marine Strategy Framework Directive (MSFD) is to protect the marine environment across Europe. It aims to achieve Good Environmental Status (GES) of the EU's marine waters and to protect the resource base upon which marine-related economic and social activities depend. Good Environmental Status means that the overall state of the environment in marine waters provides ecologically diverse and dynamic oceans and seas which are healthy and productive (European Parliament, Council, 2008).

The MSFD requires that the use of the marine environment must be kept at a sustainable level that safeguards potential uses and activities by current and future generations. This means the structure, functions and processes of marine ecosystems have to be fully considered, marine species and habitats must be protected, and human-induced decline of biodiversity prevented (European Parliament, Council, 2008).

Each EU Member State - cooperating with other Member States and non-EU countries within a marine region - is required to develop strategies for their marine waters. These must contain a detailed Initial Assessment of the state of the environment, *including the cost of degradation of the marine environment*, a definition of 'good environmental status' at regional level and the establishment of clear environmental targets, a Programme of Measures and monitoring programmes (European Parliament, Council, 2008).

The European Working Group on Social and Economic Analysis (WG ESA) presented two approaches to assess the state of the marine environment in their 'guidance document', which was published in 2011 and updated in 2018 (EU com, 2011; EU com, 2018):

1. The 'cost-based approach' (see Section 4.3 in the guidance document), where the annual costs of measures that avoid (reduce or minimise) degradation are calculated.
2. The 'Ecosystem Services Approach', (see Section 4.1 of the guidance document), where the potential value of ecosystem services of the Good Environmental Status is calculated. This value is then compared to value in the Business-as-Usual scenario. The difference between these two values, is the value of forgone ecosystem services benefits to be gained if GES is reached.

In 2023, an update of the Initial Assessment, including the 'cost of degradation', needs to be completed and submitted to the European Commission by each Member State. Therefore, an update and elaboration on the earlier studies that have been carried out in 2011 and 2018 is needed.

During the first, second and (current) third round of the Initial Assessment, the Netherlands has chosen to apply the cost-based approach to assess the state of the marine environment. The first study into the cost of degradation, was carried out by Wageningen Economic Research (formerly known as LEI) (Walker et al., 2011). An update of this study was carried out by Wageningen Economic Research in 2018 (Strietman et al., 2018).

In line with its methodological approach in 2011 and 2018, the Netherlands has chosen to apply the same approach in 2023 and is interested in the possibility of applying the Ecosystem Services Approach as a methodology to calculate these costs. Accordingly, the Ministry of Infrastructure and Water Management has asked Wageningen Economic Research to provide an updated overview of the current (2022) annual cost of degradation of the Dutch North Sea environment based on the earlier assessment carried out in 2018.

This is done by calculating the annual current (2022) costs of measures that avoid (reduce or minimise) degradation. Next to this, insight is provided into the potential applicability of the Ecosystem Services Approach methodology to calculate ecosystem benefits gained when Good Environmental Status is reached.

2 Methodology

2.1 Introduction

In this chapter, the methodology and approach to calculate the cost of degradation is elaborated. To calculate the cost, two methodological approaches can be applied: a cost-based approach, where the cost of *avoiding* degradation are calculated (in other words: the cost of measures aimed at preventing further degradation to the marine environment). And the Ecosystem Services Approach, where the ecosystem benefits gained when Good Environmental Status is reached are calculated.

2.2 The cost of avoiding degradation

2.2.1 Introduction

The 'cost-based approach' to calculate the cost of avoiding degradation is a quantitative analysis of the (financial) current annual expenditures on measures that are taken to realise and maintain the state of the marine environment. This approach and the underlying methodology applied in this study has also been discussed and by Walker et al. (2011) and Strietman et al. (2018) and is in line with the cost-based approach described in Chapter 4.3 of the guidance document of WG ESA (European Commission, 2018).

2.2.2 General approach

The calculation of the cost of *avoiding* degradation does not estimate the losses in profit and environmental value (=cost of degradation) directly. Instead, it considers the costs of measures aimed at preventing further degradation to the marine environment and uses these to make inferences about how much the current state of the marine environment is valued by society. The reason supporting this is that through the decision-making process, society (assuming decision makers accurately represent society) reveals (part of) the value it places on the marine environment (see e.g., Hueting, 1974). In this way, this method can be seen as a 'revealed preference' approach, where the willingness to pay for existing measures to prevent further degradation is revealed.

Despite the money that is spent on avoiding degradation, a certain level of degradation (compared to a 'pristine' situation) still exists. Accordingly, the actual cost of degradation is not calculated. As such, this method can only calculate the cost of degradation to the extent that society is currently spending money (public and private spending) to avoid degradation (including spendings that contribute to reaching Good Environmental Status/GES).

Since potential or hypothetical additional measures to reach a pristine status are not taken into account, the costs of current measures taken to avoid degradation therefore represent the 'certain' part (or: lower bound) of the actual cost of degradation. Since data on costs of current measures are not always available or measures might not have been identified, the lower bound calculated in this study should also be considered to be a 'lower bound of the lower bound'.

Figure 2.1 shows these relationships. The lower section of the right-hand side shows the 'certain' actual cost of avoiding degradation (that which is calculated in this report). The 'possible' area is a schematic representation of what the actual cost of degradation could be. This is purely diagrammatic as it is not possible to know what the size of the 'possible' area is. The 'possible' area suggests, figuratively, a representation of the actual cost of degradation which is not reflected by the current cost of avoiding degradation.

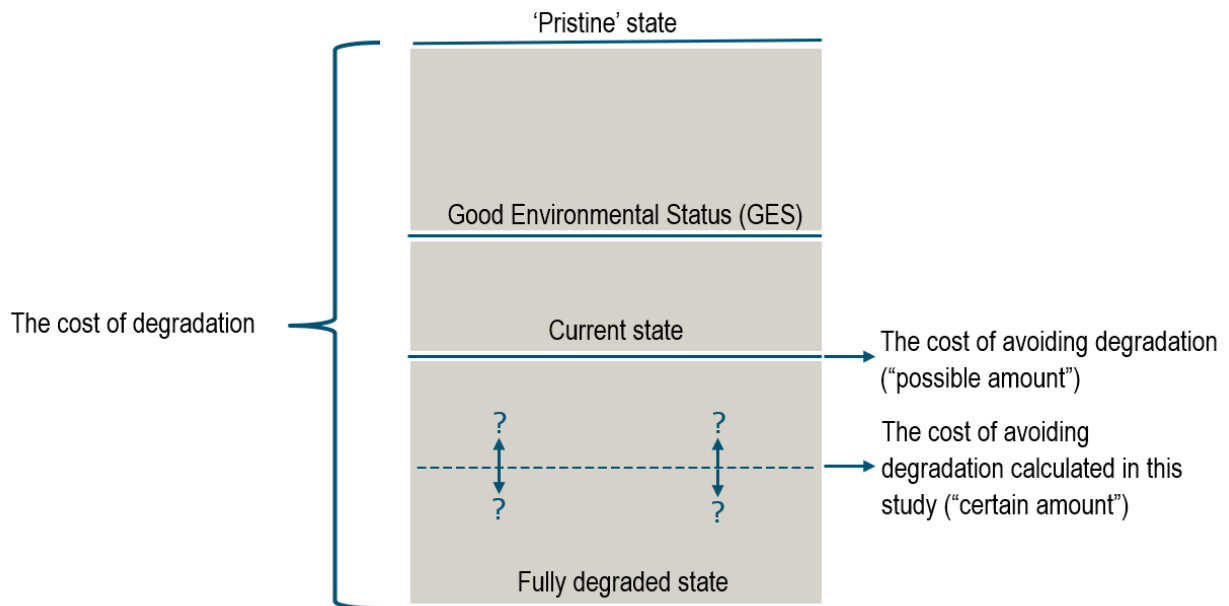


Figure 2.1 A schematic diagram showing the relationship between the cost of degradation, the cost of avoiding degradation and the cost of avoiding degradation calculated in this study

An important source of information used to delineate what measures should be considered as 'current' in this study is the current version of the Dutch Programme of Measures for the MSFD (Ministerie van Infrastructuur en Waterstaat, Ministerie van Economische Zaken, 2022). This programme contains a list of measures that are currently taken or will be taken in the future to reach the targets set for Good Environmental Status.

Since the Programme of Measures for the MSFD does not include all measures taken by society to prevent (avoid) degradation of the Dutch part of the North Sea, costs incurred for other relevant measures will also be included in the calculation. Examples of such measures are sewage treatment and other land-based measures. Accordingly, the costs calculated in this study cannot be equalled to the costs of measures taken in relation to the Marine Strategy Framework Directive and as such to the costs of measures in the Dutch MSFD Programme of Measures.

2.2.3 Additional costs vs. ordinary costs and costs related to the Dutch North Sea

For this study, all additional costs of measures which reduce or minimise the environmental impact of the North Sea are considered. An important issue in this regard is defining where ordinary costs of operating a business end, and where additional costs for measures that reduce or minimise environmental impact begin. Additional costs are attributed to those costs that have a positive effect or mitigate negative effects on the Dutch part of the North Sea environment. Accordingly, effort will be put into separating costs to avoid degradation from ordinary costs.

Isolating when a cost is actually directed at avoiding degradation is not always possible. The definition of additional costs varies between industries (and) in practice. For example, normal regulations relating to construction standards for windfarms may be harder to identify as costs incurred due to environmental concerns or due to regulations regarding the required efficiency of windfarms, the safety of windfarms or other planning restrictions. However, the extra costs for measures such as bubble curtains for use during construction are easy to separate from normal costs. The costs of measures which may have a different main purpose than marine environmental concerns, but which do reduce or minimise marine environmental impact ('avoiding degradation'), will also be accounted as additional costs in this study

2.2.4 Costs and measures related to the Dutch North Sea

This study covers both sea-based and land-based costs. The sea-based costs require consideration of the variety of sectors that operate on the Dutch part of the North Sea, which is the Dutch part of the Continental Shelf (DCS), otherwise called the Exclusive Economic Zone or EEZ. The Dutch part of the North Sea excludes areas like the Wadden Sea, Western Scheldt and Eastern Scheldt. A challenge in the calculation of sea-based costs is that the Dutch part of the North Sea is used by companies based all over the world and by ships registered all over the world. Another challenge is that Dutch vessels also operate both in the Dutch part of the North Sea and across the rest of the world's oceans. Careful thought is required to decide how to deal with this fact.

In this study, the following percentages are used to quantify the proportion of costs which can be allocated to the Dutch part of the North Sea:

- For measures related to Dutch shipping, a percentage of 10% is used for the time spent in the Dutch part of the North Sea by Dutch-flagged vessels. Accordingly, it is assumed that 10% of the costs of measures taken by the Dutch shipping sector can be allocated to the North Sea environment. This estimate stems from Ecorys (2007) and considered to be a suitable estimate for use in this report. It was also used in the previous reports (2011 and 2018) on the Cost of Degradation.
- For fisheries, it is assumed that the time spent fishing by Dutch fishing vessels in the Dutch part of the North Sea is 60-70% (Wageningen Economic Research, internal information, 2022). It is therefore assumed that 60-70% of the costs of measures relating to the Dutch fisheries sector can be allocated to the North Sea environment.
- For land-based measures it is assumed that 5-30% of the costs can be allocated to the North Sea environment. The reasoning behind this assumption is, that 5-30% of all harmful emissions (i.e. nitrates, pollutants and litter) will eventually reach the North Sea, through water bodies such as the 'Nieuwe Waterweg', and the 'IJsselmeer'. This assumption is based on expert opinion by Rijkswaterstaat and was also applied in the 2018 report (Strietman et al., 2018).

2.2.5 Costs to the public sector

The Dutch government is directly involved in policy work, management, monitoring of the North Sea environment and economic activities, and the improvement of the knowledge about- and further understanding of the North Sea environment. The costs involved include costs for policy preparation and coordination, subsidies and project outsourcing to research institutes or consultants, permit licensing, coastguard and inspection, as well as other overhead costs such as buildings (property) and transportation.

In this study, the costs to the government include the (estimated) number of FTEs (Full Time Equivalent) involved in the management and protection of the North Sea, spending on research and consultancy work, subsidies and monitoring. Information related to other overhead costs such as property and transportation costs could not be obtained and require further study. In this report the cost of an FTE includes the cost of facilities and equipment as well as the salary for the employee. Based on internal information from the Ministry of Infrastructure and Water Management, it is assumed that this amounts to €100.000 per year on average.

For the purpose of this study, it is also considered not to be relevant whether a (policy) measure has been (fully) implemented or not as the main purpose of this study is to calculate the current annual costs, regardless of the status of its implementation.

2.2.6 Current costs and costs over time

In this report, *current* annual costs are the relevant numbers; 2022 is chosen as it is the most recent year of for which (most) data are available. If data for 2022 was not available at the time of writing, data for 2021 or earlier is provided. Throughout the report different case-specific assumptions are made about the best way to deal with the time element. The basic principle is that current costs do not have to be incurred in 2022 per se but must be incurred within a definable and relevant period which includes 2022. In case only total project costs for a certain time period are available, costs are averaged over each of the years covered.

Due to inflation, costs may also change over time. During the 2011-2018 time period, hardly any inflation took place, however an increase took place afterwards, in particular during 2021-2023. For pragmatic reasons, the effects of inflation are not taken into account when calculating the costs of measures. Taking inflation into account may be an aspect to consider in future economic analyses.

2.2.7 This study calculates the costs of both MSFD measures and non-MSFD measures

For this study, all measures are considered that could prevent the degradation of the Dutch North Sea environment. An important source for the measures described in this study is the Dutch Programme of Measures for the MSFD, which contains a list of measures, categorised according to so-called descriptors (e.g., biodiversity or eutrophication). This programme contains a list of measures referred to as category 1A, 1B, 2A or 2B measures, where category 1A consists of measures which have already been implemented, category 1B of measures that have been set but not yet (fully) implemented, category 2A of extra (i.e. stricter) measures that could be taken as an addition to 1A and 1B measures, category 2B of measures that are fully new and not related to any of the 1A, 1B or 2A measures. In this study we will look into the costs related to 1A measures and, if data is available, on 1B measures.

In this study, other (non-MSFD) measures are also considered, provided these measures have the effect of avoiding degradation of the Dutch North Sea environment. Such measures are included in the chapters with the corresponding theme/descriptor. *Accordingly, this study goes beyond only calculating the costs of measures included in the Dutch MSFD Programme of Measures.*

2.2.8 Categorisation of all measures by MSFD Descriptor and by economic sector

Even though this study calculates the costs of both MSFD measures and non-MSFD measures, for the purpose of this study, the grouping of measures is done according to the categorisation used in the Dutch Programme of Measures for the MSFD, by so-called 'descriptor': biodiversity, non-indigenous species, commercial fish, crustaceans and shellfish, eutrophication, seabed protection, hydrographic properties, pollutants, contaminants in fish, marine litter and energy including underwater noise (Ministerie van Infrastructuur en Waterstaat, Ministerie van Economische Zaken, 2022).

Apart from this categorisation in descriptors, the costs for each measure will also be assigned to economic sectors where applicable. These economic sectors are a combination of those used in the Dutch Marine Strategy Part 3 (Ministerie van Infrastructuur en Waterstaat, Ministerie van Economische Zaken, 2022) and several additional sectors relevant to assign costs to, such as Urban and industrial activities. The sectors are fisheries & aquaculture, shipping, oil and gas extraction, sand extraction, wind energy, seaports, coastal zone activities (i.e. recreation, tourism), government, NGOs, agriculture, urban and industrial activities (i.e. sewage treatment).

2.2.9 Costs for each descriptor are summarised in a table

At the end of each section that describes the costs of measures for each descriptor, a table is shown, which provides a summary of the results. Where costs are calculated, numbers are provided. Where costs are expected but could not be obtained as part of this study, the abbreviation 'n.a.' ('not available') is used in each of those cells. Where costs are not expected, cells are left blank.

2.3 The Ecosystem Services Approach

As part of this study, the feasibility of using the Ecosystem Services Approach is discussed. The Ecosystem Services Approach is mentioned in Section 4.1 of the guidance document of WG ESA (EU com, 2018). It provides information on the value of the extra ecosystem goods and services that would be provided if Good Environmental Status (GES) would be achieved, compared to a 'Business as Usual' scenario. By calculating the difference between these two values, insight is gained into the value of forgone ecosystem services benefits to be gained if/when GES is reached.

2.4 The relationship between both approaches

Figure 2.2 shows the relationship between the 'cost approach' and the 'ecosystem services approach'. On the left-hand side, the cost of measures to avoid degradation are shown, as calculated in Chapter 3 of this report. The right-hand side shows an overview which is relevant for Chapter 4, which deals with the value of additional ecosystem services, using the 'ecosystem services approach'.

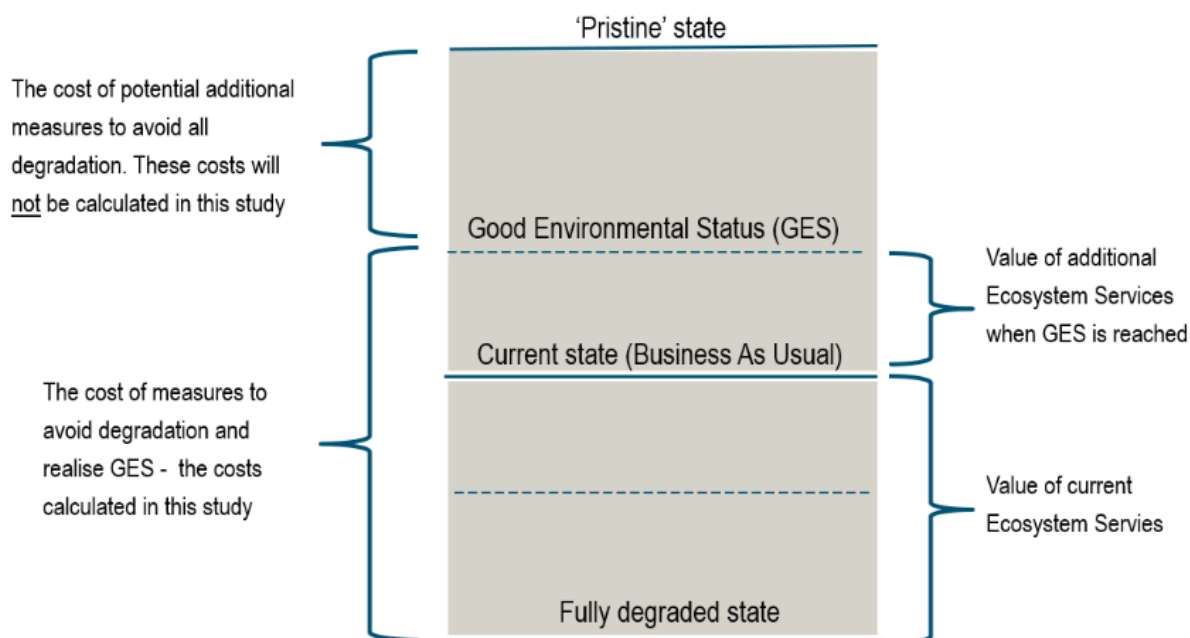


Figure 2.2 The relationship between the 'cost of (avoiding) degradation approach' and the 'ecosystem services approach'

3 The cost of avoiding degradation

3.1 Introduction

In the following sections, the measures aimed at avoiding degradation of the Dutch part of the North Sea are discussed, including their costs (where data on costs are available). The measures are sorted in line with the categorisation in the Dutch Programme of Measures for the MSFD, which are categorised by Descriptor (Ministerie van Infrastructuur en Waterstaat, Ministerie van Economische Zaken, 2022).

Since the Programme of Measures does not include all measures taken by actors in the Dutch society to avoid degradation of the North Sea environment, which is the focus of this study, other measures not officially designated as MSFD measures will also be included in the analysis. Such measures will be categorised as such under the descriptor that thematically links best with those measures.

Apart from the categorisation in descriptors, the costs for each measure will also be assigned to the following economic sectors: fisheries & aquaculture, shipping, oil and gas extraction, wind energy, seaports, coastal zone activities, government, agriculture, urban and industrial activities, and other activities.

3.2 Biodiversity & food webs

In this section, the following measures will be described:

- Assessment of (large-scale) interventions and relevant compensation
- Restriction on fishing in the coastal zone
- Zoning and phasing of activities along the coast
- Regulation of other activities within the coastal zone
- Implementation of OSPAR List of threatened species and habitats
- Haringvliet Locks Management Decree on the partial opening of the Haringvliet locks
- Conservation measures at the Frisian Front and Brown Ridge (designated as Birds Directive areas in 2021) and possible other areas that qualify under the Birds Directive
- Measures relating to birds, bats and marine mammals and vulnerable species protection.

3.2.1 Assessment of (large-scale) interventions and relevant compensation

Hydrographic interventions include activities which can affect the hydrographical conditions such as the construction of coastal defence works, land reclamation, damming big rivers, large-scale sand extraction and installing structures in coastal waters or open sea, such as large-scale aquaculture farms or wind turbine parks and other installations for energy generation.

The cumulative effects of the construction of wind farms in combination with sand extraction and sand replenishment could have significant negative effects. These effects must be studied in Environmental Impact Assessments (EIAs), as prescribed at the European level, specifically in relation to the Birds and Habitats Directive. If this shows that the effects of the intervention do not cause permanent large-scale and irreversible changes to the ecosystem, no further action need be taken. Otherwise, mitigation or compensation for negative effects is required.

The costs of all EIAs produced in 2022 are unknown. However, for the offshore windfarm for which such costs were made in 2022, Hollandse Kust Zuid-West, the total costs of the Environmental Impact Assessment (EIA) and so-called location studies are known. These preparatory costs were originally incurred by the government but are borne by the company to whom the permit was granted (in 2022). These costs amount

to approximately €13.5m (Rijksoverheid, 2021). The costs for other EIAs relating to other large-scale interventions in 2022 are unknown and thus require further study. The costs for this measure should therefore be treated as a lower bound.

3.2.2 Restriction on fishing in the coastal zone

The Nature Conservation Act stipulates the designation of protected Birds Directive and Habitats Directive areas (Natura 2000 areas) for species of birds and marine mammals. In designated Natura 2000 areas, human activities are restricted, partly to prevent and to mitigate significant effects on protected bird and marine mammal species and habitats.

Within the Dutch North Sea coastal zone and the 'Voordelta', certain conditions are in place in five specific seabed protection areas to prevent and mitigate for significant effects of fisheries on Birds & Habitat Directive Species and habitats. In those areas, bottom trawl with vessels >260 hp is prohibited. The additional costs for the fisheries are the costs to avoid these areas and to fish in other areas for such specific vessels. These additional costs can consist of extra fuel, less time to fish (it takes longer to reach the fishing grounds) and possibly less earnings (due to being forced to fish in less favourable fishing areas). The annual costs of these measures were estimated to be around €11.5m in 2011 (van der Veeren and Keijser, 2012). The current costs of this measure are unknown. For the purpose of this report, it is assumed that these are similar to the costs in 2011.

3.2.3 Zoning and phasing of activities along the coast

The management plans for the Natura 2000 areas along the coast stipulate that the presence of nesting locations must be taken into account during coastal (beach) sand replenishment, maintenance on cables and pipelines, and beach management. Zoning and phasing should help to improve the quality of the habitat for birds and seabed habitats. The annual costs for communication, monitoring and maintenance are around €1.1m (Rijkswaterstaat, internal information, 2023).

3.2.4 Regulation of other activities within the coastal zone

Other activities in the coastal zone are also regulated by means of exemption conditions, permit conditions and mitigating measures such as codes of conduct. Areas can also be temporarily closed - partially or entirely - for certain activities. The costs of this measure are unknown and require further study.

3.2.5 Implementation of OSPAR List of threatened species and habitats

This measure concerns the implementation of measures aimed at achieving the objectives of OSPAR's North-East Atlantic Environmental Strategy for 16 animal species and five habitat types. In 2022, the Ministry of Agriculture, Nature and Food Quality commissioned the following research and/or implemented the following measures (Ministry of Agriculture, Nature and Food Quality, internal information):

- *Harbour Porpoises*

The Conservation Plan for the Harbour Porpoise was updated in 2020 to contribute to the good environmental status of the porpoise. In 2022, an evaluation was launched as part of the North Sea Agreement, in which all species conservation plans need to be evaluated every two years. Measures and actions carried out in 2023 as part of the plan included population size and distribution monitoring, monitoring of contaminants, pathology of stranded animals, starting a pilot project on tagging porpoises and work on an EU-wide project on by-catch prevention (CIBBRiNA). The total costs of these actions and measures in 2022 were around €0.666m.

- *Seals*

Measures and actions related to seals include the development of the Seal Agreement (2020), which was initiated to professionalise seal rehabilitation in the Netherlands. Specific actions are to develop an improved stranding registration procedure and research on lung worms. Additional actions include population monitoring and international policy work, including in the Trilateral Seal Agreement. The total costs of these actions and measures in 2022 were around €0.3m.

- *Sharks and rays*

Measures and actions taken in 2022 related to sharks and rays include the development and coordination of the Shark and Ray Action Plan, and the funding of EU-wide projects and scientific research. The total costs of these actions and measures in 2022 were around €0.4m.

- *Cetaceans other than harbour porpoises*

Measures and actions include pathological research and veterinary work. The total costs of which in 2022 were around €0.02m.

Some costs may not have been identified for this measure. As such, the minimum cost of this measure is estimated to be €1.4m.

3.2.6 Management Decree on the partial opening of the Haringvliet locks

To restore the migration of diadromous fish species (living in both seawater and freshwater), as from 2018, the Haringvliet locks are set ajar at moments when the water level in the Haringvliet estuary is lower than the seawater level. At these moments, seawater is allowed to flow into the estuary through the locks. Because the Haringvliet Locks Management Decree also stipulates that sufficient fresh water is to remain in the area, compensatory measures are required to facilitate agriculture and the supply of drinking water.

The initial total budget for this project was €80m and was funded by the national government (Rijkswaterstaat), the regional water authority (Hollandse Delta) and a drinking water company (Evides). The project was completed by 2018. After completion, annual monitoring is required. The annual monitoring costs are estimated to be around €0.3m (Ministerie van Infrastructuur en Milieu, 2017). As such, the costs of this measure are assumed to be €0.3m in 2022.

3.2.7 Conservation measures at Birds Directive areas

The Frisian Front and Brown Ridge are designated Natura 2000 areas. In those areas, fisheries restrictive measures are being prepared to be implemented in 2025 under the Article 11 procedure of the Common Fisheries Policy. Since 2023, fisheries restrictive measures have been in place for Frisian Front (BD and MSFD). In the Bird Directive area of Frisian Front, a half year ban on gillnet fisheries is in place, from 1 June to 30 November (including some exceptions). In the MSFD area Frisian Front a ban on bottom contacting gear is in place. The costs to the Dutch government in 2022 are (next to FTE) related to scientific support and approximately €0.1m (Ministry of Agriculture, Nature and Food Quality, internal information). Potential costs for the fisheries sector in 2022, related to preparatory actions in anticipation of this measure are unknown and require further study.

3.2.8 Measures relating to birds, bats and marine mammals

The Nature Conservation Act regulates, among other things, generic protection of species of birds and mammals, including the prohibition on killing and disturbing animals. Species protection plans are developed and implemented for vulnerable species, including birds, marine mammals, fish, and benthic animals that are identified on the basis of international guidelines and the Ecology and Cumulation Framework ('KEC'). Threatened bird species will be protected by measures described in protection plans, of which some of them are expected to be operational by 2024 (Ministry of Agriculture, Nature and Food Quality, internal information).

The costs of measures related to marine mammals are covered in the measure 'Implementation of OSPAR List of threatened species and habitats'. The costs in 2022 related to measures for birds and bats could not be obtained and require further study.

3.2.9 Vulnerable species protection

As of 2020, independent research is being conducted into the abundance and distribution of honeycomb worm reefs. If that research leads to applicable conclusions, relevant locations will be protected via spatial protection measures under the Habitats Directive or Marine Strategy Framework Directive. For this measure, the costs in 2022 could not be obtained and require further study.

Table 3.1 shows the final minimum cost estimate of approximately €27.7m in 2022 for measures related to biodiversity.

Table 3.1 Biodiversity

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Assessment of (large-scale) interventions and relevant compensation	1A			n.a.		>13.5	n.a.	n.a.	n.a.			n.a.
Restriction on fishing in the coastal zone	1A	11.5							n.a.			
Zoning and phasing of activities along the coast	1A								1.1			
Regulation of other activities within the coastal zone	1A							n.a.	n.a.			
Implementation of OSPAR List of threatened species and habitats	1A								1.4			n.a.
Haringvliet Locks Management Decree on the partial opening of the Haringvliet locks	1A								0.3			
Conservation measures at the Frisian Front and Brown Ridge (designated as Birds Directive areas in 2021) and possible other areas that qualify under the Birds Directive	1A	n.a.							0.1			
Measures relating to birds, bats and marine mammals	1A								0.1			
Vulnerable species protection	0								n.a.			
Total	28	11.5				13.5			3			

3.3 Non-indigenous species

After the introduction in 2015 of the EU regulation (1143/2014) on the prevention and management of the introduction and spread of invasive alien species, the Netherlands submitted an Action Plan to the European Commission (2020) to tackle the routes along which alien species are introduced. Several of these measures are covered in this section, along with some additional measures:

- Management of Natura 2000 areas (non-indigenous species)
- Conditions attached to permits to prevent the spread of non-indigenous species
- Regulation on the prevention and management of invasive species
- Countering the spread of species via ballast water
- Implementation of Hull Fouling Guidelines against growth of non-indigenous species on ships' hulls
- Implementation of protocols for exemptions after the Ballast Water Convention comes into force

3.3.1 Management of Natura 2000 areas (non- indigenous species)

The management programmes for the Natura 2000 areas include measures geared towards preventing the import of non-indigenous species and combating the presence of invasive non-indigenous species. The type of measures differs for each Natura 2000 area and depend on the objectives for each of these areas. This measure thematically overlaps with the measure 'Conditions attached to permits to prevent the spread of non-indigenous species' (Section 3.3.2, see below). As such, no costs are included for this measure.

3.3.2 Conditions attached to permits to prevent the spread of non-indigenous species

To prevent the introduction of non-indigenous species (plants and animals) in North Sea waters, the Dutch aquaculture sector is obliged to take measures when importing shellfish from abroad and when transporting shellfish within the Netherlands.

To prevent non-indigenous species from getting introduced into Dutch waters through import, the transport and dumping of non-indigenous species is banned. In addition, the transport of musselseed from the Eastern Scheldt estuary to the Wadden Sea is also banned to prevent the introduction of the Asian rapa whelk and other non-indigenous species. The cost of this measure is related to monitoring, legal advice, permit application and quarantine measures. The administrator can intervene if invasive non-indigenous species are seen to be introduced. As such, the risk of introduction of invasive non-indigenous species is minimalised.

The costs related to measures to prevent the introduction of non-indigenous marine plants and animals from entering the Eastern Scheldt and North Sea are estimated to be around €260,000 a year. These costs include monitoring, legal advice, permit application and quarantine measures (Walker et al., 2011). The costs related to the measure to prevent the introduction of non-indigenous species through the transport between the Eastern Scheldt and the Wadden Sea are unknown and require further study.

3.3.3 Ballast water management

In 2017, the Netherlands implemented the IMO Ballast Water Management Convention in national legislation. This convention requires ship owners to treat their ballast water. In order to meet this requirement, it is expected that most ships will be equipped with a ballast water treatment system. The costs of these treatment systems for each single ship are estimated to be around €0.3 to €1.5 m, depending on the total ballast water capacity and the ballast water flow rate of the ship. It is not known to which extent the 1,094 ships sailing under Dutch flag, were equipped with such a treatment system in 2022 (KVNR, 2023, pers. comm). As such, the costs could be significant, but the exact amount requires further study.

3.3.4 Implementation of Hull Fouling Guidelines against growth of non-indigenous species on ships' hulls

This measure concerns the limitation of growth of non-indigenous species on ships' hulls. On the international level (IMO), the Netherlands has made efforts to secure an international agreement about hull fouling. This agreement is still voluntary and is being evaluated in IMO context. The additional annual cost of Tributyltin (TBT) free anti-fouling material taken by the Dutch shipping industry are unknown and require further study.

3.3.5 Implementation of protocols for exemptions after the Ballast Water Convention comes into force

This measure is aimed at minimising the possibilities for introducing new non-indigenous species imports within 5 years of the Ballastwater Convention coming into force. Since this measure is similar to the measure 'Ballast water management', the costs of which are unknown and require further study.

Table 3.2 shows the final minimum cost estimate for measures related to non-indigenous species of >€0.3m in 2022.

Table 3.2 *Non-indigenous species*

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Management of Natura 2000 areas (non- indigenous species)	1A										n.a.	
Conditions attached to permits to prevent the spread of non-indigenous species	1A	0.3									n.a.	
Ballast water management	1A		n.a.								n.a.	
Implementation of Hull Fouling Guidelines against growth of non-indigenous species on ships' hulls	1A		n.a.								n.a.	
Implementation of protocols for exemptions after the Ballast Water Convention comes into force	1B		n.a.								n.a.	
Total		0.3	0.3									

3.4 Populations of commercial fish, crustaceans, and shellfish

In this section, the following measures will be described:

- Commercial fishing catch management
- Minimising and phasing out of discards (landing obligation)
- Encouraging alternative fishing gear
- Sustainable Seafood Certification

3.4.1 Catch management of commercial fish species

In the current situation, the fisheries sector is both legally restricted and financially supported by the EU and The Netherlands. The main management tools are the Common Fisheries Policy (CFP) and the European Maritime, Fisheries and Aquaculture Fund (EMFAF; previously called European Maritime and Fisheries Fund, or EMFF).

The CFP sets rules for managing European fishing fleets and for conserving fish stocks. It aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. The costs related to the CFP include costs for administrative staff involved in the policy preparation and coordination, projects outsourced to research institutes (Statutory Research Tasks-WOT and information about fish stocks in the North Sea for international quota management (TAC & Quota)), permit licensing, coastguard, and inspection, etc. Costs for the sector include measures that are required under the technical measures policy.¹ These combined costs are unknown and require further study.

The EMFAF provides support for developing innovative projects ensuring that aquatic and maritime resources are used sustainably. The fund has four priorities:

1. Fostering sustainable fisheries and the restoration and conservation of aquatic biological resources.
2. Fostering sustainable aquaculture activities and processing and marketing of fisheries and aquaculture products, thus contributing to food security in the Union.
3. Enabling a sustainable blue economy in coastal, island and inland areas, and fostering the development of fishing and aquaculture communities.
4. Strengthening international ocean governance and enabling seas and oceans to be safe, secure, clean and sustainably managed.

Most of the financial support granted through the EMFAF can be assumed to be spent to prevent degradation of the marine environment. The contribution of the government (which is funded for 70% by the EU and 30% by the Netherlands) to EMFAF-related measures amounts to €139.9m for the period 2021-2027 (about € 20m annually). Of the €139.9m, around €40m (or €5.7m annually) is made available to the fisheries sector, for which on average 50% co-financing is needed. This means that the fisheries sector contributes another €5.7m on an annual basis). The total annual costs are therefore estimated to be €25.7m (€20m + €5.7m).

The amount of €25.7m has to be adjusted for the fact that the benefits of subsidies for the fisheries sector will not just be felt in the Dutch part of the North Sea but also in any area outside of that where Dutch fishing vessels operate. It is assumed that the time spent fishing by Dutch fishing vessels in the Dutch part of the North Sea is 60-70% (Wageningen Economic Research, internal information, 2022). As such, the final value of EMFAF-related costs is estimated to be between €15.42-17.99 for the government and €3.42-3.99 for the fisheries sector, making a total of €18.8-22.0m in 2022.

¹ One could argue that there may also be costs to the sector in terms of lost revenue due to quota as there could potentially be lower landings than could theoretically be caught if no quota would be in place. However, an unregulated fishery will most likely result in overfishing and thus lower catches in the long-term. It is therefore assumed that quota management results in stable commercial fish stocks and thus sustained revenue in the long term. As such, costs due to lost income due to quota management are not included in the calculations.

In some cases, the costs of EMFAF-related measures can be counted as real costs to society. In some cases they cannot. This is because the costs can be considered as an investment which the private sector makes in order to increase its revenues. The private sector will only make this investment if the revenues are higher than the costs. In this way, not all costs are 'real costs' (Walker et al., 2011). Therefore, the figures mentioned above are considered to be an upper bound.

3.4.2 Minimising and phasing out of discards (landing obligation)

The discard ban has been fully implemented. In 2022, the Scientific, Technical and Economic Committee for Fisheries (STECF) concluded that there is little change in fishing practices due to the Landing Obligation so far thus there are most likely also very limited socioeconomic impacts solely from the Landing Obligation (STECF, 2022). The costs can likely be attributed to the fisheries sector and government. These costs are, given the current insignificant change in fishing practice, likely negligible.

3.4.3 Encouraging the use of alternative fishing gear

This measure relates to the development of alternative and innovative methods enabling more selective fishing and causing less damage. The costs of this measure are mentioned at 'Catch management of commercial fish species'.

3.4.4 Sustainable Seafood Certification

This measure concerns the adoption of criteria for an eco-label for fisheries and aquaculture at the national level and the efforts of the Dutch government to implement criteria for an eco-label for fisheries and aquaculture at EU level.

The certification costs relate to the costs for assessments, setting up and running a monitoring system, and annual audits. One of the largest certification bodies is the Marine Stewardship Council (MSC). The costs related to MSC certification differ for each type of fisheries and type of fish. On average, these costs can be around 0.25 eurocents per kg of certified fish. In 2015, the annual costs for the Dutch fisheries were estimated to be €350,000 for plaice and €350,000 for grey shrimp (Hans Nieuwenhuis, MSC, pers. comm. 2017). In total this is €700,000. For this study, it is assumed that these costs are similar in 2022.

Table 3.3 shows the final minimum cost estimate of <€19.5-22.7m in 2022 for measures related to commercial fish, crustaceans and shellfish.

Table 3.3 Commercial fish, crustaceans and shellfish

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)											
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Aquaculture	Agriculture	Urban and industrial activities	Other activities
Commercial fisheries catch management	1A	3.4-4										15.4-18	
Minimising and phasing out of discards (landing obligation)	1A	n.a.										n.a.	
Encouraging alternative fishing gear	1A	n.a.										n.a.	
Sustainable Seafood Certification	1A	0.7										n.a.	
Total		19.5-22.7	4.1-4.7									15.4-18	

3.5 Eutrophication

In this section, the following measures will be described:

- The implementation of Annex V MARPOL Convention
- Mandatory manure Processing (Nitrates directive)
- Urban wastewater treatment
- Action Programme of the Nitrates Directive
- Delta Plan Agricultural Water Management
- Private onsite wastewater treatment
- Measures relating to the Water Framework Directive (WFD)

Please note that most of the measures described in this section are taken on land. As described in Section 2.2.3, land-based activities can also have significant indirect effects on the marine environment. For measures taken on land, it is assumed that 5-30% of the costs of measures taken on land to protect water quality can be attributed to (having an effect on) the North Sea environment.

3.5.1 Implementation of Annex V MARPOL Convention

The aim of the implementation of Annex V MARPOL Convention is the prevention of discharge of hazardous substances into water. MARPOL lays down rules for the prevention of discharges of harmful substances into water and air. These discharges include mineral oils, harmful bulk liquids, sewage, flue gases and other emissions into the air, remnants of solid bulk materials and the discharge of domestic waste. The MARPOL Convention is implemented through the Dutch Prevention of Pollution by Ships Act, which is also meant to lead to a reduction in nitrogen pollution. In relation to eutrophication, measures relating to sewage treatment onboard vessels are relevant. These costs could not be obtained and require further study.

3.5.2 Mandatory manure processing (Nitrates directive)

Measures relating to agriculture are included in the Fifth Action Programme Nitrate Directive (2022-2025). These measures are included in the Dutch Manure Law. As part of this law, farms are limited in the number of cattle and are required to have any surplus amount of manure processed and treated.

In the period 2006-2020, several standards have gradually become stricter. Since 2015, stricter standards for nitrate apply for crops on the sand- and loess grounds in southern areas of the Netherlands (e.g. measures were implemented to reduce the drainage of nitrates into 34 areas vulnerable to groundwater pollution). Besides conditions on the use of fertiliser, other measures have been put into place or have become stricter (Lukács et al., 2020). Information about the costs of these measures could not be obtained and require further study.

3.5.3 Urban wastewater treatment

The collection and transport of wastewater from households to sewage treatment plants happens through sewage systems (the public sewers). The Netherlands has more than 90,000 kilometres of sewer lines. This falls under the responsibility of the municipal governments. At the sewage treatment plants, the wastewater is treated and purified. This is the responsibility of the district water boards. The Netherlands has 25 district water boards that together manage 350 sewage treatment plants (Rijksoverheid, 2023).

The total annual cost related to the collection and transport of wastewater in the Netherlands were estimated to be €1,800m in 2022 (CBS, 2022a), the cost related to the treatment of this water €1,459m (Unie van Waterschappen, 2023). In total, the annual cost of collection, transport and treatment of wastewater amounted to €3,259m in 2022. For this study it is assumed that 5-30% of these costs can be attributed to the North Sea environment. Accordingly, the cost of this measure is estimated to be €163-978m.

3.5.4 Delta Plan for Agricultural Water Management

To supplement the Fifth Action Programme of the Nitrates Directive, the agricultural and horticultural sector developed the Delta Plan Agricultural Water Management. It is a collaboration project between LTO (the Dutch Federation of Agriculture and Horticulture), the regional water authorities, and the ministry of Infrastructure and Water Management and the ministry of Agriculture, Nature and Food Quality. The programme is aimed at (significantly) reducing the amount of phosphorus and nitrogen in management areas. The Delta Plan is carried out on a voluntary basis but is not free of obligation since the Netherlands does currently not comply with the European Nitrate Directive.

In 2020, approximately €39m was reserved by the government to achieve this goal by 2027. Additional co-financing would be funded by the provinces, regional water authorities, EU development programmes (including the Rural Development Programme (POP3)) and agricultural sector. According to the government, it is difficult to estimate which part of the support could be directly attributed to the improvement of (sea) water quality (Ministerie van Infrastructuur en Waterstaat, 2022). As such, the costs related to this measure requires further study.

3.5.5 Private onsite wastewater treatment

The annual costs of private sewer treatment installations were estimated to be around €400m in 2019 (Ministerie van Infrastructuur en Waterstaat, 2022). This relates to measures to prevent emissions of wastewater to surface water. It is assumed that this estimate is similar for 2022. For emissions to surface water the assumption is used that 5-30% would find its way to the North Sea. Therefore, it is assumed that 5-30% of this measure can be attributed to having a potential effect on the North Sea environment, the cost of which would be €20-120m.

3.5.6 Measures relating to the Water Framework Directive (WFD)

The European Water Framework Directive (WFD) sets, amongst others, standards for the quality of the surface water (coastal water, rivers and lakes, drainage ditches) and the ground water. In the Netherlands, a substantial number of measures are in place to meet these standards.

The total costs for these measures in the period 2016-2021 were equal to €1,200m. We assume that those costs are equally distributed over each year and similar for 2022, thus $\text{€}1,200\text{m}/6 = \text{€}200\text{m}$ (Ecorys, 2021, p. 12). For emissions to surface water the assumption is used that 5-30% of this water will finally end up in the North Sea. Therefore, it is assumed that 5-30% of this measure can be attributed to having a potential effect on the North Sea environment. As such, the costs of this measure are estimated to be €10-60m.

Table 3.4 shows the final minimum cost estimate of €213-1.119m in 2022 for measures related to eutrophication.

Table 3.4 Eutrophication

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)											
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Aquaculture	Agriculture	Urban and industrial activities	Other activities
Implementation of Annex V MARPOL Convention	1A												
Mandatory manure Processing (Nitrates directive)	1A								n.a.	n.a.			
Urban waste water treatment	1A								n.a.		163-978		
Action Programme of the Nitrates Directive	1A								n.a.	n.a.			
Deltaplan Agricultural Watermanagement	1A								n.a.	n.a.			
Private onsite wastewater treatment	O										20-120		
European Water Framework Directive (WFD)									10 - 60	n.a.			
Total	193-1,158	19.6-22.7							10 - 60		183-1,098		

3.6 Seafloor integrity

In this section, measures will be described that relate to seafloor integrity: Extending conservation measures at Cleaver Bank, Dogger Bank and Frisian Front, extending seabed protection in the Frisian Front, Central Oyster Grounds and Borkum Reef Grounds, conservation measures in still to be determined areas, amendment of areas with conservation measures North Sea coastal zone areas, sand extraction in specified areas and avoiding turbidity.

3.6.1 Extending conservation measures (including seabed protection) in the Frisian Front, Central Oyster Grounds and Borkum Reef Grounds and Cleaver Bank, southern Dogger Bank

For the MSFD-appointed conservation areas Central Oyster Grounds and the Frisian Front, regionally focused seabed conservation measures based on article 11 of the Common European Fisheries Policy (CFP) are in place since 2023 (not in 2022) through a delegated act of the European Commission. These measures include restrictions on fishing with bottom contacting gear to protect the benthic habitat in these areas. In addition, similar measures are in place for the Borkum Reef Grounds and the southern Dogger Bank since 2023 as well as extension and enlargement of the Central Oyster Grounds, Frisian Front. The costs of these measures to the government (in 2022) relate to coordination and planning and include three FTEs and scientific support, the costs of which are already included in the measure 'Conservation measures Frisian Front and Brown Ridge (designated as Birds Directive area in 2021) and possible other areas that qualify under the Birds Directive'.

3.6.2 Conservation measures in still to be determined areas

This measure relates to conservation measures to be taken in still to be determined areas of the North Sea, as part of the 'North Sea Agreement'. Such measures were not in place in 2022. The costs related to this measure (such as research work in preparation of this measure) are unknown and require further study.

3.6.3 Amendment of areas with conservation measures in the North Sea coastal zone

The specific areas in which only seabed-affecting fisheries are banned and the areas in which all fisheries are banned will be amended. This has been agreed upon in 2018 in the so-called 'VIBEG-2'-agreement. The conservation measures will be implemented following national legislation. The costs of this measure in 2022 are unknown and require further study.

3.6.4 Sand extraction in specified areas

Extraction of sand and shells are the only two mining activities occurring in the Dutch area of the North Sea. Of these two, sand extraction is the most important. In 2021, around 27-30m m³ of sand was extracted from several specified mining locations (Rijkswaterstaat, 2022). Due to environmental concerns, the government only issues permits for certain specified locations. Since these are not all located at the economically most optimal locations there is a cost involved.

The sector estimates that it spends approximately 5% more than in an 'ideal' situation where it is allowed to mine sand and shells in every suitable location (Ecorys, 2007). The turnover (Gross Value Added) in 2021 is €82.3m (the latest year for which numbers are available) (CBS, 2023). As such, the additional costs (5%) are estimated to be €4.1m.

3.6.5 Avoiding turbidity

Another measure that relates to sand and shell mining relates to avoiding turbidity. Turbidity refers to the suspension of material from the seabed in the water. Higher levels of suspended material interfere with aquatic species metabolism and can interfere with spawning. Certain types of dredging equipment reduce the turbidity but may be more costly. These costs are unknown and require further study.

Table 3.5 shows the final minimum estimate of €4.1m in 2022 for measures related to seabed protection.

Table 3.5 Seabed protection

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Extending conservation measures (including seabed protection) in the Frisian Front, Central Oyster Grounds and Borkum Reef Grounds and Cleaver Bank, southern Dogger Bank	1B	n.a.										
Conservation measures in still to be determined areas (covering 1,333% of the Dutch part of the North Sea)	1B											
Amendment of areas with conservation measures North Sea coastal zone areas	1B	n.a.							n.a.			
Sand extraction in specified areas	0									4.1		
Avoiding turbidity	0								n.a.			
Total	4.1									4.1		

3.7 Hydrographical conditions

This section describes the following measure:

- The assessment of hydrographic interventions and compensation for effects.

3.7.1 Assessment of hydrographic interventions and compensation for effects

Hydrographic interventions include the construction of coastal defence works, land reclamation, damming big rivers, large-scale sand extraction and installing structures in coastal waters or open sea, such as large-scale aquacultures or offshore wind parks and other installations such those related to oil and gas production.

The effects of new large-scale hydrographic interventions must be studied in the environmental impact assessments, as prescribed at European level. In the Netherlands, this EU policy is implemented in Section 7 of the Environmental Management Act and in the EIA Decree. If this shows that the effects of the intervention do not cause permanent large-scale and irreversible changes to the ecosystem, no further action need be taken. In this procedure, it is important to study cumulative effects and the effects outside the coastal waters. In the coastal waters, the requirements of the Water Framework Directive must be fulfilled.

The cumulative negative effects of the construction of wind farms in combination with sand extraction and sand replenishment could be significant. Compensation for negative effects is required, specifically in relation to the Bird and Habitat Directive.

The costs for this measure are unknown and require further study.

Since no cost data could be obtained for measures related to the descriptor 'hydrographical conditions', the total costs are unknown (Table 3.6).

Table 3.6 Hydrographical Conditions

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)											
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Aquaculture	Agriculture	Urban and industrial activities	Other activities
Assessment of hydrographic interventions and compensation for effects	1A					n.a.		n.a.					
Total	n.a.					n.a.		n.a.					

3.8 Pollutants

This descriptor includes the following measures:

- Ban on TBT
- Reduction of pollution by reducing shipping incidents
- Reduction of discharges of pollutants from oil and gas installations
- Preventing and limiting industrial emissions
- Reduction of environmental risks ensuing from major accidents
- Pilot projects at municipal water treatment plants for further removal of pharmaceutical and other polluting chemicals
- Ban on discharging ships' waste from inland shipping vessels
- Action Plan for Sustainable Plant Protection
- Preparation, cooperation and coordination of disaster and incident control at sea, international cooperation in case of disasters and incidents
- Green Deal Sport Fishing Lead Free
- Training programme for permit-providers
- Insurance to cover the impact of disasters at sea
- Contribution to the IOPC fund
- Prevention of contaminated dredged material entering the North Sea
- Implementation of the Bathing Water Directive
- Decommissioning of oil and gas platforms

3.8.1 Ban on TBT

This regulation prohibits the use of certain harmful substances in paints that prevent fouling on hulls and underwater structures, such as TBT (tributyltin). The aim is to achieve a reduction of hazardous substances in the marine environment. This measure is similar to the following measure: 'Implementation of Hull Fouling Guidelines against growth of non-indigenous species on ships' hulls' (see Section 3.3). The costs are unknown and require study.

3.8.2 Reduction of pollution by reducing shipping incidents (rerouting of shipping lanes)

Shipping lanes increase the efficiency of shipping and reduce the chances of shipping accidents (and thus pollution). Such reroutings have resulted in additional distances for commercial traffic and associated costs. The total annual cost having a shipping lane in place of this measure to all (Dutch and non-Dutch owned vessels) was calculated to be €19.3m per year; a distinction between the costs for these two types of vessels has not been made (IMO sub-committee on safety of navigation, 2012). It not known which share of these costs can be attributed to reducing the chances of pollution by Dutch flagged vessels. Therefore, the annual €19.3m should be considered as an upper bound.

3.8.3 Reduction of discharges of pollutants from oil and gas installations

The aim of this measure is to achieve a reduction of pollutants discharged into the marine environment. As a result of the process of extracting oil and gas from water-bearing formations, water is discharged by oil and gas installations. This water usually contains oil, heavy metals and Polycyclic aromatic hydrocarbons (PAHs). Because of this, this water must be treated and tested prior to being discharged overboard. This measure is mandatory for all platforms within the Dutch EEZ.

To calculate the cost of these measures, the same assumptions are used as in the 2011 study as they are likely still valid. The annual investment cost of treatment plants for produced water on all oil and gas platforms in Dutch waters were estimated to be €6.5m (Walker and Strietman, 2011). This figure consists of two separate elements. The cost of running the treatment plants were estimated to be €5.8m per year. In addition to the day-to-day costs of treatment, research is also carried out into the process at a cost of €0.7m per year. These costs apply to all platforms operating in the Dutch EEZ.

3.8.4 Preventing and limiting industrial emissions

This measure is intended to prevent and limit environmental pollution due to industrial activities and intensive farming. Under the Directive Industrial Emissions measures are taken relating to permit requirements, application of technical standards, application of regulations as included in the European reference documents (BREFs), and application of an emission test when judging the emissions to the surface waters. These measures reduce industrial emissions to surface water. The costs of these measures could not be obtained and require further study.

3.8.5 Reduction of environmental risks ensuing from major accidents

This measure aims to reduce the amount of hazardous substances in the marine environment due to major accidents. Companies must at least have a safety policy and a safety management system. Companies and plants that operate with large quantities of hazardous substances must also draw up a Safety report. The EU 'Seveso Directive' relating to this measure applies to more than 10,000 industrial establishments in the European Union where dangerous substances are used or stored in large quantities, mainly in the chemical, petrochemical, logistics and metal refining sectors (European Commission, 2017). The costs of these measures could not be obtained and require further study.

3.8.6 Pilot projects at municipal water treatment plants for further removal of pharmaceutical and other polluting chemicals

In addition to the existing requirements for water treatments plants, measures have been taken to reduce certain polluting chemicals even further. These measures are aimed at reducing residues from medicines and so called 'emerging chemicals', such as PFAS. These modifications of the water quality policy are aimed at minimalising (with priority) the impact of emissions of new chemicals and chemicals that pose a problem for the water quality, through the permit procedures. In total €300m is being spent by the Ministry of Infrastructure and Water Management and the Water Boards during the 2019-2027 period (Ministry of Infrastructure and Water Management, internal information). As such, the annual costs in 2022 are estimated to be €33.3m.

3.8.7 Ban on discharging ships' waste from inland shipping vessels

This measure aims to achieve a reduction of pollutants discharged from inland shipping into rivers (which eventually flow into the North Sea). Under the (Rhine and Inland Waterways) Ships' Waste Decree and Regulation, all passenger and hotel ships with a capacity of more than 50 people are prohibited from discharging domestic wastewater into surface water since 1 January 2012. The Ships' Waste Decree is the implementation of the 2009 Convention on the collection, deposit and reception of waste produced during navigation on the Rhine and inland waterways. The Ships' Waste Decree is divided into three components. Part 1 focuses on the discharge of oil and grease waste. Part 2 focuses on waste of the load and part 3 focuses on remaining waste.

In 2021 all ships were required to contribute €8.50 per 1,000 litres of gasoline (CDNI, 2022). Ships can subscribe to SABni (Stichting Afvalstoffen & Vaardocumenten Binnenvaart), which takes care of the discharge of ships' waste in return for a certain contribution. In 2021, the total contribution of ships that were subscribed to SABni equalled €7.5m for the discharge of oil and grease waste (SABni, 2021).

3.8.8 Action Plan for Sustainable Plant Protection

This measure refers to sustainable use of plant protection products, soil contamination and the reduction of pesticides (Action Plan for Sustainable Plant Protection). It leads to a reduction of contamination due to pesticides. The annual total cost related to this measure was estimated to be €18m for agriculture and €18m for greenhouse horticulture in 2013 (De Koeijer et al., 2015). More recent numbers could not be obtained as part of this project. It is therefore assumed that these numbers are similar for 2022. Of this measure, 5-30% is attributed to the Dutch part of the North Sea environment. The total costs that are attributed to this measure are therefore estimated to be in the range of €1.8-10.8m.

3.8.9 Preparation, cooperation and coordination of disaster and incident control at sea

This measure concerns the coordination of disaster and incident control (i.e., preparedness, clean-up, exercises, international cooperation) in the North Sea by the Dutch government (Rijkswaterstaat). The costs of this measure were estimated to be <€2m (Rijkswaterstaat, 2015). It is assumed that these costs are similar in 2022.

3.8.10 International cooperation in case of disasters and incidents

BE-AWARE was carried out as part of the Bonn Agreement for the purpose of acquiring a common shipping and offshore risk analysis for the entire region. The measure intends to achieve a coordinated emergency response and incident control in the North Sea. The cost of this measure could not be obtained and would require further study.

3.8.11 Green Deal Recreational Fishing Lead Free

The Green Deal Recreational Fishing Lead Free is a covenant and aimed to reduce the emissions of fishing lead to the marine environment. Different organisations are working together to increase the availability of attractive and sustainable alternatives for lead and to gradually phase out the use of lead in recreational fishing gear by 2028. The covenant was signed in 2018 by stakeholders in the recreational fishing industry and several ministries. As a result, the number of recreational fishers using alternatives to lead has also increased since the covenant was signed (WUR, 2021). The costs related to this measure for the government are estimated to be around 0.03m annually (Ministerie van Infrastructuur en Waterstaat, internal information). The costs related to the recreational fishing sector could not be obtained and would require further study.

3.8.12 Training programme for permit-providers

The ministry of Infrastructure and Water Management organised a training programme for permit providers of Rijkswaterstaat, regional water authorities, Environmental Services and Drinking Water companies which ran until 2022. The aim was to have higher quality permits, resulting in better quality of water and thus less harmful emissions into the sea. The costs related to this programme could not be obtained and would require further study.

3.8.13 Contribution to the IOPC fund

This measure refers to both the insurance costs to cover the impact of disasters at sea (i.e. cleaning up oil spills due to collisions) and the costs of contributing to the International Oil Pollution Compensation Funds (IOPC Funds).

The insurance costs for an average Dutch ship are between €125,000 and €150,000 for a 10,000 GT (gross tonnage) ship (Ecorys, 2007). This figure is used because approximately 10,000 GT is the average size of a ship under a Dutch ownership (Ecorys, 2007). According to expert opinion (Ecorys, 2007), 25% of the total insurance amount can be attributed to avoiding degradation of the marine environment. For this report, it is also assumed that this proportion is the same for 2022. Based on the number of ships in 2021, the figure is estimated to be €34-41m. This figure must then be adjusted to account for the fact that the fund covers all oceans not just the North Sea. To do this, the 10% assumption is used. As such the final annual average is between €3.4-4.1m.

In addition to the costs related to insurance, the Dutch oil industry contributes to the International Oil Pollution Compensation Funds (IOPC Funds). These funds are part of an international regime for liability and compensation for oil pollution damage caused by oil spills from tankers. Under the regime, the owner of a tanker is liable to pay compensation up to a certain limit for oil pollution damage following a leak. If that amount does not cover all the admissible claims, further compensation is available from the '1992 Fund' if the damage occurs in a state which is a member of that fund. Additional compensation may also be available from the Supplementary Fund if the state is a member of that fund as well. The IOPC Funds are financed by levies on certain types of oil transported by tankers. The annual contributions of the IOPC members varies depending on the amount which the fund needs to pay out.

In 2021, the Netherlands (including Bonaire, Sint Eustatius and Saba) contributed €993,714.40 to the '1992 Fund' (calculating with an annual average conversion rate in 2021 of 1.16 euros per pound), which is 7% of the total contributions. In 2021, no levies were made in respect of contributions to the 'Supplementary Fund' (IOPC, 2022). Again, the 10% assumption is used as cost related to the North Sea. As such, the costs in 2022 are estimated to be around €100,000.

3.8.14 Prevention of contaminated dredged material entering the North Sea

Marine sediments accumulate through tidal action mainly in the western port areas, whereas the eastern port areas are mainly influenced by fluvial sediments, transported by the Rhine. On average, about 30m m³ of material is dredged every year from all Dutch seaports and seaways. In the port of Rotterdam alone, some 20m m³ of sediment is dredged each year (Vellinga and Eisma, 2005).

The relocation of dredged material from harbour basins to the North Sea is regulated by a set of chemical criteria. Heavy metals such as zinc and copper, as well as Polycyclic Aromatic Hydrocarbons (PAHs) and Tributyltin (the toxic part of anti-foul paints which was previously applied to ship hulls), are commonly found in port sediments. Although disposal to the North Sea is the preferred and cheapest option, due to the high levels of contaminations a certain part of the dredged material has to be disposed of in confined (land-based) sites (in the case of Rotterdam: the 'Slufter') to prevent degradation of the North Sea environment.

Most of the dredged material (about 28m m³ on an annual basis) is returned to the North Sea, but around 0.9m m³ of dredged material exceeds certain limits of heavy metals. The costs of processing the contaminated dredged material are estimated to be around €20 per m³ (Kirichek et al., 2018). The annual additional costs are therefore estimated to be around 0.9m m³ * €20 per m³ = €18m.

3.8.15 Implementation of the Bathing Water Directive

This measure focuses on the quality that the bathing water, which means also of the swimming locations that the provinces have designated in the coastal waters, must meet. The main risks for exceeding the swimming water quality norms are pollutants from the land, such as sewage overflows and the presence of dogs and horses on the beach. In some instances, however, commercial vessels and pleasure craft also pose a risk.

In total there are 800 bathing water locations, 80 of which are at North Sea beach locations or in direct contact with the sea. To improve water quality and to inform the public, measures are being taken such as water quality monitoring, sources of pollution determination and developing and running a website with monitoring results of all swimming locations.

The total costs of these measures in 2022 were estimated to be €2,4m. for all 800 locations. If we assume that 10% of the total costs of all activities with respect to bathing water locations can be attributed to this measure, the costs equal €240,000 in 2022.

3.8.16 Decommissioning of oil and gas platforms

In Dutch offshore waters, around 150 platforms with some 700 wells are present. Below the sea bed, approximately 3,500 kilometres of pipelines are in operation for the transport of oil and gas between the platforms and to the Dutch coast.

International agreements are in place regarding the removal of offshore mining installations at the end of their economic life. OSPAR Decision 98/3 regulates the removal of mining installations after use. The specific requirements are set out in the Dutch Mining Decree (article 5.2.3) (Nexstep, 2022).

In case of suspension of mining works, including wells, it is required to decommission installations unless these are eligible for re-use/repurpose. In 2022, two underwater installations, two satellite platform and 35 offshore wells were decommissioned, the costs of which were around €200m. Approximately 75% of these costs were related to well abandonment (Nexstep, 2022).

The final total cost estimate for measures related to pollutants, in 2022 is approximately €348-457m. The derivation of this is shown in Table 3.7.

Table 3.7 Pollutants

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)									
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities
Ban on TBT	1A		n.a.						n.a.		
Reduction of pollution by reducing shipping incidents	1A		19.3						n.a.		
Reduction of discharges of pollutants from oil and gas installations	1A			6.5					n.a.		
Preventing and limiting industrial emissions	1A								n.a.		
Reduction of environmental risks ensuing from major accidents	1A		n.a.						n.a.	n.a.	
Pilot projects at municipal water treatment plants for further removal of pharmaceutical and other polluting chemicals	1A								33.3		
Ban on discharging ships' waste from inland shipping vessels	1A								n.a.		7.5
Action Plan for Sustainable Plant Protection	1A								n.a.	1.8-10.8	
Preparation, cooperation and coordination of disaster and incident control at sea	1A		n.a.						<2		
International cooperation in case of disasters and incidents	1A								n.a.		
Green Deal Sport Fishing Lead Free	O	n.a.							0.03		n.a.
Training programme for permit-providers	O								--		
Insurance to cover the impact of disasters at sea	O		n.a.								
Contribution to the IOPC fund	O		3.5-4.2								
Prevention of contaminated dredged material entering the North Sea	O							18	n.a.		
Implementation of the Bathing Water Directive	O								0.24		
Decommissioning of oil and gas platforms	O			200					n.a.		
Total	328-337		22.8-23.5	206.5				18	71.1	1.8-10.8	7.5

3.9 Contaminants in fish

This descriptor includes one measure: standards for contaminants in fish and fish products.

3.9.1 Standards for contaminants in fish and fish products

Levels of contaminants in fish and fish products must meet the norms set by national and international legislation (European legislator). OSPAR has shown that the doses in fish products are far below the international norms for human exposure to contamination. High levels of contaminants do not occur in the Netherlands. The costs related to this measure are monitoring costs, which are unknown and require further study.

Since no cost data could be obtained for measures related to the descriptor 'Contaminants in fish', the total costs are unknown (Table 3.8).

Table 3.8 Contaminants in Fish

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Standards for contaminants in fish and fish products.	1A											n.a.
Total	n.a.											n.a.

3.10 Marine litter

This section describes the following measures:

- Green Deal for Clean Beaches
- Clean Beaches programme
- Beach clean-up initiatives by stakeholders
- Beach cleaning by municipalities
- Clean Meuse Limburg Approach
- River basin-oriented litter policy
- Putting riverine litter on the agenda of area managers
- Putting litter on the agenda of stakeholders and in education
- Fishing for Litter programme
- Green Deal Fishery for a Clean Sea
- Fishing for a Clean Sea programme
- Phasing out the use of dolly rope in bottom trawl fisheries
- Green Deal for Ships' Waste Supply Chain
- Implementation of the EU Directive 2019/883 on port reception facilities for the delivery of waste from ships
- Ban on the discharge of garbage by ships (MARPOL Annex V)
- Implementation of the release obligation of persistently solidified cargo residues
- Marine environmental awareness course
- Nationwide Waste Management Plan 3
- Prevention, cleaning up and processing of litter (nationwide)
- 'The Netherlands Circular 2050' initiative
- Making packaging more sustainable
- Plastic Pact
- Reducing the use of plastic bags
- Promoting the reduction of balloons
- EU-ban on emissions from microplastics in cosmetics and detergents

3.10.1 Green Deal for Clean Beaches

The Green Deal Clean Beaches covenant was initiated in 2014 and lasted until 2022, when it was replaced by the Clean Beaches programme. The Green Deal Clean Beaches is a collaborative strategy with measures, signed and agreed upon by the signatories who all assist intensively with cleaning up the Dutch part of the North Sea beaches and keeping them clean. Next to 19 coastal municipalities, the signatories included a range of companies, volunteers, interest groups and civil society organisations.

The Green Deal is aimed at improving coordination and collaboration between these actors, preventing duplication of work, and enabling the Green Deal partners to learn from each other's experiences. And finally, proper attitude and behaviour of beach goers is stimulated, so that beach goers leave less waste behind on the Dutch North Sea beaches. In addition, new specific actions are documented, in which these partners make an additional contribution to clean beaches (Ministerie van Infrastructuur en Milieu, 2014).

Measures agreed upon by the actors who signed the Green Deal Clean Beaches include behavioural influence of beach visitors, Green Key certification, cigarette butts measures, the distribution of ash trays, and monitoring. The cost of these measures in 2021 were calculated to be €650,000 (Ecorys, 2014).

Since the Green Deal Clean Beaches covenant was replaced by the Clean Beaches programme in 2022 (see below), no costs are calculated for this measure in 2022.

3.10.2 Clean Beaches programme

The Green Deal Clean Beaches was replaced by the Clean Beaches programme in 2022. This follow-up programme is aimed at a reduction of litter coming from people visiting the beach. The programme is

focused on the exchange of knowledge, support of collaboration projects and improvement of local cooperation between entrepreneurs and municipalities along the Dutch coast. The annual costs of this programme relate to coordination and the funding of smaller projects by Rijkswaterstaat (and is therefore different to the 'Green Deal for Clean Beaches'). The costs of the Green Beaches programme are estimated to be around €100,000 on an annual basis (Rijkswaterstaat, internal information).

3.10.3 Beach clean-up initiatives by stakeholders

Volunteer organisations remove significant amounts of litter from (mostly non-bathing) beaches, which suggests that the total cost of voluntary action to remove marine litter could add considerably to the cost of municipal beach cleaning campaigns.

Most of the time spent and costs involved is paid for by the volunteers involved. Costs related to coordination, monitoring, waste transport and disposal are usually funded by charities and governmental organisations. These costs are estimated to be around 2-2.5m a year (Ministerie van Infrastructuur en Waterstaat, internal information).

3.10.4 Beach cleaning by municipalities

Beach litter originates from various sources, including fisheries, shipping, untreated sewage and inland sources (the latter two as a result of inflow from rivers) from the Netherlands but also neighbouring countries. Municipalities along the Dutch coast have measures in place to remove beach litter. For most municipalities, the importance of clean beaches for tourism provides the principal motivation for removing such litter. The city of The Hague, for example, spent around €1.3m annually on its beach cleaning programme (Mouat et al., 2010).

The total annual cost that municipalities in the Netherlands spent on the removal of beach litter was estimated to be between €3.7m and €5.3m in 2012, 70% of which is spent on beach cleaning and 20% and 10% respectively on the management of waste facilities and waste disposal (Ecorys, 2012). It is assumed that these costs were similar in 2022. In addition, volunteer organisations and NGOs collectively also remove a significant amount of litter from (mostly non-bathing) beaches, which suggests that the total cost of voluntary actions to remove marine litter could add a considerable number to the cost of municipal beach cleaning. Therefore, the cost range of €3.7-5.3m should be treated as a lower bound.

3.10.5 Clean Meuse Limburg Approach

A part of the litter that ends up on the beaches originates from the rivers. The Clean Meuse/Clean Rivers initiative was setup as a cooperation between volunteers, NGOs and the government to collect litter from riverbanks. The measure aims to prevent and remove waste from the River Meuse. The costs of this initiative consist of coordination of annual cleaning actions, collection of flood debris and litter transportation and processing. The annual costs were calculated to be €0.28-0.33m in 2014 (Ecorys, 2014). It is assumed that these costs are similar in 2022.

3.10.6 River basin-oriented litter policy

This measure consists of two sub-measures (Rijkswaterstaat, internal information):

1. Both in the Wadden Sea and Rijn-Maas delta region (in and around the city of Rotterdam), Communities of Practice Plastics have been initiated. In such communities, stakeholders from managing authorities, water Authorities, municipalities, NGOs, and business work together on the removal and prevention of riverine litter. The role of the (central) government is to encourage and facilitate effective and systematic cooperation between the stakeholders active in the Communities of Practice. The total costs for this measure could not be obtained and requires further study.

2. In 2018 Rijkswaterstaat started with the Litter Collection Scheme (ZOR). This scheme aims to support Clean River collaborations and initiatives by facilitating the collection and processing of litter from river basins by third parties. The costs to the government of coordinating and implementing this scheme are around €0.13m on an annual basis (Rijkswaterstaat, internal information). There are also costs related to the actions undertaken by third parties and municipalities. Those costs are not known and require further study.

As such, the minimum costs for this measure are €0.13m, on an annual basis. The actual costs are higher.

3.10.7 Putting riverine litter on the agenda of area managers

This (governmental) measure is aimed at increasing awareness on the issue of riverine litter and provide (by Rijkswaterstaat) support to implement structural measures by managing authorities and other stakeholders along rivers. Such measures should be aimed at reducing and preventing litter. This measure runs from 2015-2022 and costs €8m. The annual costs are estimated to be €1m (€8m. over 8 years) (Rijkswaterstaat, internal information 2023).

3.10.8 Putting litter on the agenda of stakeholders and in education

This measure refers to a specific project, co-funded by the EU (European Fund for Maritime Affairs and Fisheries) called 'Afval op School' ('Litter at School'), which was carried out under the coordination of Rijkswaterstaat during the period 2017-2019. The aim of the project was to raise awareness on the themes of waste and litter and the consequences of marine litter at primary and secondary schools and to provide advice to those schools about waste reduction, waste separation and waste prevention. During the project period, around 140 schools were involved in the project.

As no costs for this measure were incurred in 2021 or 2022, these costs will not be included in the calculation.

3.10.9 Fishing for Litter programme

Within the Fishing for Litter programme, fishers can deliver waste they get on board as by-catch during fishing operations to ports. After delivery, removal and processing takes place on land free of charge. The annual cost of the Fishing for Litter programme (which is paid for by the government) was €0.19m in 2022 (Ministerie van Infrastructuur en Waterstaat, internal information).

3.10.10 Green Deal Fishery for a Clean Sea

The Green Deal Fishery for a Clean Sea was signed in 2014. As part of this deal, the signatories commit themselves to tackle the waste issue by taking measures such as: Fishing for Litter, more effective waste management, developing alternatives for dolly rope. The signatories included the fisheries sector, the Ministry of Infrastructure and Water Management, ports and litter disposal organisations. Since this measure is not active in 2022, no costs are included for this measure.

3.10.11 Fishing for a Clean Sea programme

This programme is the follow-up of the Green Deal Fishery for a Clean Sea. The aim is to continue the decline in fisheries litter at beaches in 2027 relative to 2021. Information on costs incurred in 2022 could not be obtained and requires further study.

3.10.12 Phasing out the use of dolly rope in bottom trawl fisheries

Dolly rope is the name for blue or orange rope that are used to protect bottom trawling nets against wear and tear. During fishing operations or maintenance work on the net, threads or bundles of dolly rope threads may end up in the sea.

Since 2013 the fishing industry, NGOs, research institutes and governments work together to find sustainable alternatives to dolly rope. The aim is to stimulate the use of alternative solutions and gradually phase out the use of conventional dolly rope by 2027. A possibility to stimulate the phasing-out of conventional dolly rope and promoting alternatives would be through financial (fiscal) stimuli to make sustainable alternatives more financially attractive. The costs of this measure in 2022 could not be obtained and requires further study.

3.10.13 Green Deal for Ships' Waste Supply Chain

The Green Deal Ship Generated Waste was signed in 2014 by 15 parties and was a voluntary agreement (covenant) between private/societal parties and the central government. The signatories include port authorities, ship owners, ship suppliers, port reception facilities, enforcement authority and NGOs. The covenant is a collaborative strategy with measures, signed and agreed upon by all signatories. It aims at closing the maritime waste cycle by means of waste prevention and delivering waste in ports. Furthermore, it aims to help close the plastic cycle by collecting plastic waste separately and making it suitable for recycling. Measures focus on waste prevention of ships' supplies, waste inspections, separate disposal and the alignment of procedures in the ports, among other things (Ministry of Infrastructure & Water, pers. comm. 2017). Since this measure is not active in 2022, no costs are included for this measure.

3.10.14 Implementation of the EU Directive 2019/883 on port reception facilities for the delivery of waste from ships

This measure is aimed to prevent marine pollution from ships by ensuring that waste generated on ships are returned to land and adequately managed. The Directive aims to protect the marine environment against the negative effects from discharges of all waste from ships (including cargo residues and 'Fishing For Litter' waste) using ports located in the European Union, while ensuring the smooth operation of maritime traffic, by improving the availability and use of adequate port reception facilities and the delivery of waste to those facilities.

The costs of this measure relate specifically to waste fees that are charged to vessels and the implementation of port waste plans. This measure requires the presence of adequate port reception facilities (PRFs) in Dutch ports. The total costs to shipping (all ships visiting Dutch ports, excluding fisheries ports) for ship generated waste and cargo residues in 2021 were estimated to be €28.7m (Ministry of Infrastructure and Water Management, internal information).

For fisheries specifically, the cost of this measure relates to three different waste categories: 1. Household waste 2. chemical waste, and 3. 'Fishing for Litter' waste. Annual costs related to household waste collection are estimated to be between €56,000 and €336,000 (280 vessels, 40 weeks of fishing, €5-30 per week per vessel) (Wageningen Economic Research, 2023; Kruft and Strietman, 2017). The collection of MARPOL Annex II waste (chemical waste and oil/bilge waste) is carried out by 'Stichting Financiering Afvalstoffen Visserij' (SFAV) and is financed by membership fees. Total membership fees collected in 2015 were €350,000 (SFAV, internal information, 2017) and are assumed to be slightly lower in 2022 due to a decline in the number of fishing vessels. The membership fee for 2022 is therefore likely a slight overestimate. The costs related to Fishing for Litter waste could not be obtained and require further study. The total estimated amount for the Dutch fisheries sector is therefore estimated to be at least 0.4m-0.7m.

3.10.15 Ban on the discharge of garbage by ships (MARPOL Annex V)

This measure concerns a ban on ships discharging garbage at sea, with the – conditional – exception of food waste to reduce pollutants discharged into the marine environment. In 2013, the revised MARPOL Annex V regulations came into force. Since this measure concerns adequate collection, storage and disposal of waste, the costs are included in the measure 'Implementation of the EU Directive 2019/883 on port reception facilities for the delivery of waste from ships'.

3.10.16 Implementation of the release obligation of persistently solidified cargo residues

Since 1 January 2021, all ships that transport their cargo to a European port and navigate through certain demarked sea areas (as stipulated by MARPOL Annex II, Regulation 13), are required to deposit washing water with persistent solidified cargo residues, like paraffin wax, at shore. For certain chemicals with high viscosity additional pre-washing requirements after unloading at a reception port are set. The costs of this measure are unknown and require further study.

3.10.17 Marine environmental awareness course

Having basic knowledge of the impact of shipping on the marine environment and the effects of operational or accidental pollution are an international IMO requirement for seafarers in 'Standards of Training, Certification and Watchkeeping' (STCW). This requirement also means that attention for these topics need to be included in the education programmes of future seafarers in the Netherlands. Some maritime institutes in the Netherlands discuss these topics, mostly related to the IMO's MARPOL-regulations, themselves. However, some maritime institutes hire ProSea (in)directly to provide the IMO model course '1.38 Marine Environmental Awareness' to meet the STCW training requirements.

This model course was developed by the Dutch foundation ProSea Marine Education and aimed at creating knowledge and awareness of pollution to the marine environment and the need for prevention among (future) seafarers. Those who have successfully completed the course will be able to demonstrate knowledge and understanding of the importance of preventing pollution to the (marine) environment and receive a certificate stating to have completed the 'IMO model course 1.38'. This course is being offered at various Dutch maritime institutes, but also in maritime institutes of other (EU member) states (e.g. Jade Hochschule Germany).

ProSea also provides the IMO model course 1.38 (or variations of it) to the private sector. However, private sector organisations mostly request tailor-made trainings including attention for internal experiences and policies. If these tailor-made trainings cover all learning objectives mentioned in the IMO model course 1.38, certificates of having completed the model course will be handed to participants.

The number of trainings, and the type of clients (both maritime institutes and private sector parties), vary from year to year. As such, the total cost of this 'measure' in 2022 was estimated to be €250,000 for the North Sea basin (ProSea, internal information, 2023).

3.10.18 Plastic Pact

As a spin-off to 'The Netherlands Circular 2050' initiative, the European Plastic Pact was initiated. It was signed in February 2019 by 13 countries and 66 European Companies. The Plastic Pact is aimed at stimulating the re-use of plastics and reducing the unnecessary use of plastics. Information on the potential effect of this measure on the North Sea environment and its costs could not be obtained and require further study.

3.10.19 Nationwide Waste Management Plan 3

The National Waste Management Plan 3 ('LAP 3') concerns the policy for waste prevention, waste management (collection, recycling, incineration, and landfill) and monitoring. In 2018, the costs incurred by municipalities were estimated to be €157m. The costs incurred by other area managers were estimated at €36m. As such, the total costs were estimated to be €193m (KplusV, 2020). It is assumed that these costs were similar in 2022 and that 5-30% of this measure can be attributed to having a potential effect on the North Sea environment. As such, the cost of this measure is estimated to be €9.7-57.9m.

3.10.20 Prevention, cleaning up and processing of litter (nationwide)

According to a recent study by Tauw (2022), the total costs for preventing, cleaning up, monitoring and processing litter in the Netherlands amount to €304m in 2021. For this study, it is assumed that 5-30% of the costs for land-based measures can be allocated to the North Sea environment. As such, the total costs of this measure are estimated to be €15.2-91.2m in 2022. These costs also include the costs of beach cleaning by municipalities (see 'Beach cleaning by municipalities', described above). It is not known to which extent these costs are included into this estimate. But since a range was used to calculate this estimate, this takes into account this aspect.

3.10.21 National programme circular economy

This programme outlines the transition to a circular economy by 2050. The programme includes the adoption of a mix of pricing, standard-setting and stimulus measures.

The transition to a fully circular economy requires both public and private funding. To this end, central government has various financing options at its disposal. Legislative measures, both national and European, will impact enforcement, implementation and oversight, including financial supervision. As an envisioned result in 2050, no plastics should end up in the environment anymore.

Information on the costs of activities and measures within this initiative that are specifically aimed at the prevention of plastics ending up in the environment (and thus the marine environment) could not be obtained and require further study.

3.10.22 Making packaging more sustainable

In the area of making packaging more sustainable, the Packaging Framework Agreement regulates producer responsibility for the take-back and recycling of packaging. In addition to these measures, a deposit on small plastic bottles was introduced in July 2021 and it was decided to also introduce a deposit on (aluminium) cans in March 2023. With the implementation of the Single Use Plastics Directive in 2022, producers also become responsible for the costs of measures related to (raising) awareness on the issue of litter and the need for prevention. The producers of single-use plastic food and drink packaging, light plastic carrier bags, wet wipes, balloons and tobacco filters are also obliged to contribute to the costs incurred by public area managers in cleaning up litter.

As part of the Extended Producer Responsibility (EPR), such producers are also required to take awareness-raising measures aimed at preventing litter. Such measures are in addition to communication and awareness activities by the government and societal organisations. Many of these stakeholders participate in the 'Schouders onder Schoon' platform initiative. This platform was established in 2020 to improve knowledge exchange, coordination and collaboration amongst its members.

Information on the costs for all individual measures mentioned above could not be obtained. However, CE Delft carried out a study that looked into the cost of a deposit scheme and the costs related to prevention, cleaning up, monitoring and processing litter. Starting on 1 July 2021, a deposit scheme is in place for plastic beverage bottles. The deposit is €0.15 for each small bottle. The expectation is that 70-90% of the nearly 90m bottles will be returned on an annual basis. CE Delft estimated the costs of a deposit system for beverage bottles to be between €10m to €110m per year, paid for by manufacturers, importers and supermarkets (of which the costs of extra deposit machines in supermarkets make up the largest share). The exact annual costs of this scheme after its implementation in 2022 are unknown and require further study. As such, for this measure, an annual cost estimate range is chosen of €10-110m (CE Delft, 2018).

3.10.23 Reducing the use of plastic bags

Since 1 January 2016, it is no longer allowed to provide free plastic bags to customers. This has led to a reduction of 80% of the usage of plastic bags and a reduction of 60% of plastic bags that are found as litter (I&O Research, 2019). The costs related to this measure are unknown and require further study.

3.10.24 Promoting the reduction of balloons releases

This measure focuses on a reduction in the number of balloon releases and use of environment friendly alternative materials for ribbons: there is considerable opposition to, and legislation against, balloon releases, due to environmental concerns. Most activities related to this theme were carried out in the 2013-2021 period by several actors, including the Dutch government, municipalities, political parties and NGOs, specifically the North Sea Foundation. The costs of these activities in 2022 could not be obtained and require further study.

3.10.25 EU ban on emissions from microplastics in cosmetics and detergents

The government of the Netherlands is involved in negotiations at EU level aimed at developing policies to ban products to which microplastics have been deliberately added. The position of the government of the Netherlands is to implement restrictions that are as ambitious as possible, without unnecessary exceptions or unnecessarily long transitional periods. As this measure is not in place yet, no costs are calculated for this measure.

Table 3.9 shows the final minimum cost estimate of €49-278m in 2022 for measures related to Marine Litter.

Table 3.9 *Marine Litter*

Measure	MSFD Programme of Measures category type	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Green Deal for Clean Beaches	1A							--	--			
Clean Beaches programme	1A							n.a.	0.1			
Beach clean-up initiatives by stakeholders	1A							n.a.	2-2.5			n.a.
Beach cleaning by municipalities	1A							n.a.	3.7-5.3			
Clean Meuse Limburg Approach	1A								n.a.			0.3
River basin-oriented litter policy	1A								0.13			
Rivers: putting riverine litter on the agenda of area managers	2A											
Putting litter on the agenda of stakeholders and in education	1A								1			
Fishing for Litter programme	1A	n.a.							0.19			
Green Deal Fishery for a Clean Sea	1A	--							--			
Fishing for a Clean Sea programme	1A	n.a.										
Phasing out the use of dollyrope in bottom trawl fisheries	2A	n.a.							n.a.			
Green Deal for Ships' Waste Supply Chain	1A	--							--			

Measure	MSFD Programme of Measures category type	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Implementation of the EU Directive 2019/883 on port reception facilities for the delivery of waste from ships	1A	0.4m-0.7m	28.7							n.a.		
Ban on the discharge of garbage by ships (MARPOL Annex V)	1A		n.a.							n.a.		
Implementation of the release obligation of persistently solidified cargo residues	2A		n.a.							n.a.		
Marine environmental awareness course	1A		0.3									
Nationwide Waste Management Plan 3	1A						1.8-10.8	7.9-47.1				
Prevention, cleaning up and processing of litter	1A							15.2-91.2				
The Netherlands Circular 2050 initiative	1A								n.a.			
Making packaging more sustainable	1A											10-110
Plastic Pact	1A								n.a.			
Reducing the use of plastic bags	1A								n.a.			n.a.
Promoting the reduction of balloons	1A								n.a.			n.a.
EU-ban on emissions from microplastics in cosmetics and detergents	1A								n.a.			n.a.
Total	49-278	0.4-0.7	3.0				1.8-10.8	30.2-147.5				14-115.6

3.11 Introduction of energy (including underwater noise)

This section describes the following measures:

- Licensing procedure for wind farms
 - Code of Conduct for explosive ordnance disposal
 - Regulations on sonar use
 - Research into the possibilities to amend regulations on seismic surveys
 - Implementation of the IMO-guidelines regarding the reduction of underwater noise of commercial ships
 - Limitation of platform lighting on oil and gas platforms
 - More actively implement IMO-guidelines regarding the reduction of underwater noise of commercial ships
- Reducing the effects of underwater noise during seismic surveys

3.11.1 Licensing procedure for wind farms

In 2022, five offshore wind farms were in operation in the Dutch part of the North Sea: Egmond aan zee (108 megawatt (MW), located near Egmond aan Zee), the Princess Amaliawindpark (120 MW, located near IJmuiden), Eneco Luchterduinen (129 MW, located near Zandvoort), Borssele 1 & 2 (752 MW, located near Westkapelle) and Borssele 3 & 4 Blauwwind (732 MW, located near Westkapelle). In addition, a total of 5 wind farms (Hollandse Kust Noord and Hollandse Kust 1, 2, 3 & 4) were going through the planning process (4C Offshore, 2022).

The period when wind farms are constructed is considered to be the time when the largest effects on the marine environment take place, mainly due to impulsive noise because of pile-driving. As part of the licensing procedure, significant negative effects on Bird & Habitat Directive species and their habitats should be avoided during operations. For this purpose, several measures are being implemented by offshore wind operators, such as a 'soft start' and 'bubble curtains'.

Information on the costs of such measures carried out in 2022 could not be obtained as part of this study. However, in 2015, as part of a study looking into such measures, Royal HaskoningDHV calculated that the annual costs of such measures are estimated to be €18-72m (Royal HaskoningDHV, 2015). For the purpose of this study, it is assumed, that similar costs were made in 2022.

3.11.2 Reducing impulse noise by means of the Code of Conduct for explosive ordnance disposal

A regulation was implemented in 2016 to restrict possible harmful effects of explosives clearance and to introduce feasible alternative techniques or mitigating measures to minimise negative effects on the maritime environment. The current status of this measure and its costs could not be obtained and would require further study.

3.11.3 Regulations on sonar use

The Ministry of Defence invests in knowledge to minimise the harmful effects of anti-submarine sonar signals on marine mammals. As part of that policy-process, the Ministry of Defence commissioned several studies. Since 2004, approximately €1.6m was spent on this research programme, which is around €200,000 annually (René Dekeling, pers. Comm. 2017). The current status of this measure and its costs could not be obtained and would require further study.

3.11.4 Reducing the effects of underwater noise during seismic surveys

Currently, permit requirements are in place to reduce the effects of underwater noise during seismic surveys: application of soft start and acoustic deterrent devices (ADDs) and production of an EIA. In addition, the Netherlands is considering introducing a noise budget for seismic surveys. As part of that policy-process, Rijkswaterstaat commissioned Royal HaskoningDHV to carry out a study to assess the possibilities to amend

regulations on seismic surveys (Barbé et al., 2021). The current status of this measure and its costs could not be obtained and would require further study.

3.11.5 Implementation of the IMO-guidelines to reduce underwater noise of commercial ships

The IMO adopted guidelines to reduce underwater noise by new commercial ships. This is a voluntary guideline, not a national (Dutch EEZ) restriction or mandatory measure. Based on recommendation at IMO, international guidelines might be developed in the future. The cost for this voluntary guideline are unknown and require further study.

3.11.6 Limitation of platform lighting on oil and gas platforms

This measure concerns the shielding of light sources and automatically disconnecting light sources in places on the platform where no work is being carried out. The aim is to reduce the negative effects of offshore platform lightning on migratory birds. The assumption is that this measure does not lead to significant extra costs.

Table 3.10 shows the final minimum cost estimate of >€18-72m in 2022 for measures related to underwater noise.

Table 3.10 Underwater Noise

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
Licensing procedure for wind farms	1A					18 - 72			n.a.			
Reducing impulse noise by means of the Code of Conduct for explosive ordnance disposal	1A								n.a.			
Regulations on sonar use	1A								n.a.			
Research into the possibilities to amend regulations on seismic surveys	1A			n.a.					n.a.			n.a.
Implement IMO-guidelines regarding the reduction of underwater noise of commercial ships	1A		n.a.						n.a.			
Limitation of platform lighting on oil and gas platforms	1A			0								
Total	18-72		n.a.	0		18-72						n.a.

3.12 Other measures and costs

Next to the measures that could be categorised in the sections before, some other measures are described in this section:

- Costs to the government
- Tax measures

3.12.1 Government costs: FTE

The Dutch government is directly involved in policy work, management, monitoring of the North Sea environment and economic activities, and the improvement of the knowledge about- and further understanding of the North Sea environment. The costs involved include costs for policy preparation and coordination, subsidies and project outsourcing to research institutes, permit licensing, coastguard and inspection, as well as other overhead costs such as buildings (property) and transportation.

Some of these costs have previously been provided as part of the measures presented earlier. In this section, the costs to the government are presented in terms of the (estimated) number of FTEs (Full Time Equivalent) involved in the management and protection of the North Sea. The estimate was made by Rijkswaterstaat based on internal information (Table 3.11). Information related to other overhead costs such as property and transportation costs could not be obtained and require further study.

Table 3.11 FTE government

Estimated number of FTEs involved in North Sea management related work (2023)	
Government Body (total FTEs)	FTEs
Ministry of Infrastructure and Water Management/RWS/ILT	200
Ministry of Economic Affairs and Climate Policy	15
Ministry of Agriculture, Nature and Food Quality	15
Ministry of Education, Culture and Science	2
Ministry of Defence	10
Total	242

Source: Rijkswaterstaat – internal information (2023).

An FTE is assumed to cost €100,000 per year. This number includes salary and other costs such as overhead, housing, etc. As a result, the final costs for 2022 are estimated to be €24m.

3.12.2 Tax measures

This measure concerns fiscal incentives for environmentally friendly technologies (Environmental Investment Rebate (MIA) scheme/Arbitrary Depreciation of Environmental Investments scheme (VAMIL).

In 2021, €114m was allocated for the Environmental Investment Rebate Scheme (MIA) and €25m for the Arbitrary Depreciation of Environmental Investments scheme (VAMIL) (RVO, 2021). Both of these measures are aimed at lowering the taxes for environment related investments. Thus, the cost of these measures can be attributed to the government. The investments relate to measures to lower the impact of emissions to the air and surface- and groundwater. If we again assume that 5-30% would have an effect on the North Sea environment, the total amount on an annual basis would be €7-41.7m.

Table 3.12 shows the final minimum cost estimate of €31-66m in 2022 for other measures.

Table 3.12 *Other Measures*

Measure	MSFD Programme of Measures category	Average annual cost per economic sector (in million €)										
		Fisheries & aquaculture	Shipping	Oil and gas extraction	Sand extraction	Wind energy	Sea ports	Coastal zone activities	Government	Agriculture	Urban and industrial activities	Other activities
FTE government									24			
Tax measures	1A								7-41.7			
Total	31-66								31-65.7			

4 The Ecosystem Services Approach to determine the cost of degradation

4.1 Introduction

In this chapter, we explain what the Ecosystem Services approach is, how it differs from the methodology applied in the first part of this report, and to which extent it can be used to calculate the cost of degradation in the context of the Dutch part of the North Sea.

4.2 Ecosystem Services Approach

The Ecosystem Services approach links ecological information to economic studies. Ecosystem services can be defined as the benefits natural ecosystems provide to human well-being. Three groups of benefits can be distinguished: provisioning ecosystem services (e.g., fish for human consumption), regulating services (e.g., CO₂ regulation) and cultural services (e.g. sailing or diving), see the previous report (Strietman et al., 2018). The methodology can be used to quantify the ecosystem effects of policies or measures. As such it provides a powerful tool for communicating the value of ecosystems to the public, policymakers, and other stakeholders.

4.3 Calculating the cost of degradation by applying the Ecosystem Services Approach

The Ecosystem Services approach can be used to calculate the cost of degradation as the (ecosystem) benefits of reaching Good Environmental Status. This can be calculated as the change in the provision of Ecosystem Services between those services at a Business-As-Usual scenario and Good Environmental Status. The following steps characterise this approach (EU com, 2011:36):

1. Define the status of two or more ecosystem states.
 - a. Define GES using the qualitative descriptors.
 - b. Assess the environmental status in a Business as Usual (BAU) scenario.
2. Describe the gap, the differences in qualitative and, if possible, quantitative terms between the GES and the environmental status in the BAU scenario, i.e., the degraded state of the marine environment.
3. Describe the consequences to human well-being of this gap.

4.4 The applicability of the Ecosystem Services Approach to calculate the cost of degradation in the Dutch North Sea

In our previous report (2018), we concluded that the Ecosystem Services methodology is not evolved enough to be applied in the context of calculating the cost of degradation, and that, due to a lack of data, its empirical application is currently considered to be too challenging to be applied for this purpose in the context of the Dutch North Sea environment (Strietman et al., 2018). Even though more studies were carried out into this issue, specifically the 2019 study by CBS into Natural capital accounts for the North Sea (Schenau et al., 2019), we believe that this conclusion still holds, based on the following observations:

- The main challenge is in the quantification of the changes in ecosystem services when GES is reached (compared to a Business-as-Usual scenario) because most GES descriptors and/or criteria are only described qualitatively. As such, no quantification of the effects can be given. And as long as the effects

cannot be quantified, the benefits cannot be monetised. Qualitative links were made in several studies though, such as the recent Rijkswaterstaat commissioned study by Cornacchia (2022). However, these impact relations were not quantified.

- The objective to achieve a Good Environmental Status has been developed to improve marine environmental conditions, and not to maximise the provision of ecosystem services. It is not clear how the provision of ecosystem services is affected if GES is reached. In other words, there is no clear quantitative link between changes in the marine environment (due to taking measures) and the provision of ecosystem services provided by the marine environment. Accordingly, improved marine environmental conditions may or may not have a positive effect on the provision of ecosystem services. For example, restricting fishing could be an option to improve GES. But the benefits (and ecosystem services) depend on the fish caught. Hence, the value of ecosystem services may decrease if fishing is restricted, even if marine environmental conditions improve.
- The relevant relations between measures and potential changes in the marine environment and the impacts of those changes on the provision of ecosystem services are not known sufficiently to quantify *the changes* in ecosystem services.
- There is a limited understanding of the functioning of the North Sea marine ecosystem. In other words, the effects of linkages between different components are not always understood. These linkages affect the impact relation (from measure to ecosystem/GES) in an unknown way.
- An extra complicating factor is that monetary valuation of non-market goods is not widely accepted by policymakers in the Netherlands.

Based on these observations and the value added of applying the ecosystem services approach transparently, in line with scientific evidence, we recommend the Dutch government to discuss and coordinate the following topics with respect to the MSFD further on a European level, to align the Ecosystem services approach and to expand its scientific base:

- Different views on ecosystem services exist, ranging from purely ecologic (focussing on ecosystems) to economic (focusing solely on human welfare). Hence, the application of the ecosystem services approach to determine the costs of degradation starts with a transparent delineation of the methodology applied.
- Both the quantity and value of ecosystem services depend on the input of human derived capital (HDC), for instance fishing vessels to catch fish, and dredging equipment to extract sand. However, most studies do not incorporate the costs of this human derived capital into their analyses. If HDC is ignored, the value of ESS will be overestimated. Including the costs of HDC into the analysis may be something to consider, in cooperation with other EU Member States.
- Ecosystem services consist of both biotic and abiotic services. However, most studies focus solely on biotic services. Since the MSFD also contains abiotic descriptors, it is recommended to include abiotic services in the analysis e.g. the extraction of sand and gravel, as regulating ecosystem service(hence, sand and gravel are considered to be part of the ecosystem).
- Studies that use willingness to pay (WTP) in their Ecosystem Services approach often do not use ecosystem services as attributes in the WTP analysis. WTP studies for the MSFD should link their attributes directly to the GES indicators (or their related welfare effect), to be sure the preferences values obtained are directly linked to the cost of degradation.
- The additional value of the ecosystem services depends on the demand market conditions for these ecosystem services. The marginal value of additional ecosystem services may decrease if supply increases. This potentially reduced marginal value may affect the value of the extra ecosystem services supply. Currently, due to a lack of data, it is not known to which extent such a reduction may occur in the context of the MSFD.

5 Discussion

5.1 Introduction

This report has given insights, where possible, into who bears the cost for the various measures related to the MSFD. It has taken a broad approach (covering as many issues as possible) to collect data on the cost of avoiding marine environmental degradation of the North Sea. Hence, a wide variety of measures and costs has been covered, with a variation in the accuracy or availability of these figures. Given these issues some aspects of the data will be discussed in terms of whether these issues may have a significant impact on the total figure for the cost of avoiding degradation.

5.2 Accuracy and availability of the data

An important source for this study was the Dutch Programme of Measures for the MSFD. This programme contains a list of measures, categorised according to so-called descriptors (e.g., biodiversity or eutrophication). For each of these measures, and other relevant measures which are not in the programme, information on costs was gathered, based on literature and expert opinion. Shortages of data meant that this was not always or only partially possible, resulting in an incomplete overview of all costs involved for the measures identified. In the summary tables at the end of each chapter, 'n.a.' is mentioned at sectors where costs are suspected but where data on those costs could not be obtained or was not available. Most of such missing data on costs are related to the government.

In addition to this, it is reasonable to assume that not all potential measures which have the effect of avoiding degradation of the North Sea environment have been included in the scope of this study. In other words: there are likely more measures that could have been included in this study, but which were not identified as such during (the preparation phase of) this study. Accordingly, extra work outside the scope of this project would be required to fill in the gap of missing data on costs.

5.3 Validity of the assumptions

Land-based measures account for the majority of the costs in this report. Making assumptions on the extent to which such measures affect the North Sea environment was an important step in linking land-based measures to the North Sea environment. For this study, it is assumed that 5-30% of such costs can be attributed to the North Sea environment, the range of which was determined based on expert judgment by Rijkswaterstaat.

In this study, these percentages were not reviewed, but they are the only ones which are available. It is important to remember that the percentages are subjective and that another panel of experts, may produce different outcomes. In any case, our method is consistent with the two previous studies on the cost of degradation (Walker et al., 2010 and Strietman et al., 2018). However, more information on the relationship between land-based measures and their effect on the Dutch North Sea environment issue would be very useful and could have a significant effect on the final results.

5.4 Comparison of the results with the previous reports

This report is the third report where the same methodological approach was applied to calculate the cost of degradation. Due to differences in data availability, the results of this study and the previous two differ. As such, the results of the three studies should not be interpreted as a time series nor that the total value has changed over time. The new value in this study replaces the old values.

5.5 Applicability of the data

The applicability of the cost data which is collected needs to be considered:

- For wider application, users of the data should take care in using the final, total figure because it consists of various types of costs, on land and on sea, which are collected from various sources and refers to various types of environmental improvements.
- Other uses may not be practical. Using this cost data to infer benefits of new measures for use in a Cost Benefit Analysis (CBA) would be difficult to justify. This is because the data does not refer to changes in costs which would result from new policies or measures and is therefore of limited use within a Cost Benefit Analysis.
- However, the insight into who is paying which costs to avoid marine environmental degradation can be useful when discussing affordability and/or the disproportionality of the costs of additional measures for the MSFD. The information provided on the current costs by sector can be used as the baseline to calculate the percentage change in the costs which is useful information to determine whether an increase in costs is disproportional or not.

6 Conclusion

In conclusion, this report has provided insight into the cost of avoiding degradation of the marine environment. This in turn can be used to indicate a lower bound on the costs of environmental degradation in the North Sea. However, the results need to be considered given the discussion described in Chapter 5.

Several key conclusions are now highlighted:

- Most costs (25-50%) are incurred through land-based measures. The percentages which are used to allocate a share of land-based costs to avoiding degradation of the marine environment are therefore key in evaluating the results of this report.
- In this study we also investigated the feasibility of applying the Ecosystem Services methodology as an alternative method to calculate the cost of degradation. We concluded that both crucial data needed to calculate the costs and benefits are missing and that this methodology is currently not adequately suited to be applied in the context of calculating the cost of degradation of the Dutch part of the North Sea.
- The insight into who is paying which costs to avoid marine environmental degradation can be useful when discussing affordability and/or the disproportionality of the costs of additional measures for the MSFD. The information provided on the current costs by sector can be used as the baseline to calculate the percentage change in the costs which is useful information to determine whether an increase in costs is disproportional or not.

Given the assumptions used and bearing in mind the measures for which no data or partial data is available, the total cost of avoiding degradation to the Dutch North Sea environment has been calculated to be in the range of approximately €7,19-2,02bn at a minimum, and as such a lower bound for the actual cost of degradation. The summary table below shows the minimal costs attributed to each sector (Table 6.1).

Table 6.1 Summary table of the minimum current total cost of degradation and the costs for each sector

Sector	Minimum total costs (million euros)
Fisheries and aquaculture	36-40
Shipping	52
Oil and gas extraction	207
Sand extraction	(no data available)
Wind energy	32-86
Sea ports	(no data available)
Coastal zone activities	24-33
Government	161-365
Agriculture	2-11
Urban and industrial activities	183-1.098
Other activities	22-123
Total estimates	> 719-2,015

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Wageningen Economic Research
P.O. Box 29703
2502 LS The Hague
The Netherlands
T +31 (0)70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

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Wageningen Economic Research
P.O. Box 29703
2502 LS Den Haag
The Netherlands
T +31 (0) 70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

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