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Framework for Assessing Ecological and Cumulative Effects 3.0 for the roll-out of offshore wind energy 2030

Sub-report A: Methods

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TNO 2014

A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea;
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Memorandum: Adding OWEZ and PAWP to the KEC 3.0 calculations, Dr. A. Gyimesi & J.L. Leemans, Bureau Waardenburg, 2018

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Relationship between parts A, B and C

Part A of the KEC report provides the conceptual framework for the approach to ecology and accumulation, and describes its implementation for offshore wind energy. Part A replaces previously published versions. The substantive reports (in Part B) further elaborate the substantive methods and models used, and include the calculations for the roadmap as made with the models. New reports have been added to Part B.

Part C provides an executive summary of the substantive reports and states the conditions required for the implementation of the 2030 Roadmap. Part C is new by comparison with previous versions.

1 Introduction

1.1 Background

There has been a need to describe and assess the effects of human activities on natural ecosystems since at least the 1970s. In the 1980s it was realised that it is not enough to describe and assess the effects of specific proposals and activities, but that it is also necessary to examine whether the effects of various different activities can accumulate to produce larger or more damaging ecological or environmental impacts.
Despite the difficulties, the importance of properly describing and addressing the issue of cumulative effects was acknowledged and incorporated into the legislation. This can be clearly seen in the wording of the EU Birds Directive (1979) and EU Habitats Directive (1992).
These directives require that the ecological values, in terms of natural habitat types, species habitats and species, should not only be protected from the possible adverse effects of each separate human activity in and around protected areas on the ecological and environmental values in these areas, but also from the cumulative effects of all human activities. In the Netherlands the implementation of these directives in national law has created an explicit requirement under the 1998 Nature Conservation Act (Natuurbeschermingswet (Nbw)) to assess not only the effects on ecological values of individual initiatives with potentially significant adverse effects but also their cumulative effects in combination with other plans and projects in the area provisions of the Act. The Nature Conservation Act also takes cumulative effects into account in the provisions relating to species. However, it does so more implicitly by assessing effects in terms of favourable conservation status at various spatial scales.

Since 2005, the Dutch government has received development consent applications for offshore wind farms that require a decision about how to assess not only the effects on the marine ecosystem of the separate wind farms but also the cumulative effects with other wind farms and in combination with other activities.
Given a number of issues, including knowledge gaps about the cause–effect relationships, the presence of marine species and the resulting mandatory application of the precautionary principle, the assessment led to the imposition of restrictions on the development of offshore wind power and to a number of mitigation measures.

On the basis of the knowledge gaps identified, research programmes have been established (Ecological Monitoring Shortlist 2010-2011, Follow-up to Implementation of Master Plan 2012-2015, Offshore Wind Energy Ecological Programme (WOZEP[1]). Other countries have also recognised the problem of identifying and assessing the effects (cumulative and otherwise) of offshore wind farms and have completed extensive research in recent years.

The 2030 Offshore Wind Energy Roadmap was published in March 2018[2]. In addition to the wind farms that will be built in the period up to and including 2023, it also includes the timetable and location of the wind farms at sea up to and including 2030.

[1] https://zoek.officielebekendmakingen.nl/kst-33561-26.html (in Dutch) and https://www.noordzeeloket.nl/en/functions-and-use/offshore-wind-energy/
[2] https://zoek.officielebekendmakingen.nl/kst-33561-42.html (in Dutch)

The North Sea Policy Document 2016-2021, which is an integral part of the National Water Plan 2016-2021[3], has been included:

> *Future development decisions, such as site decisions, for offshore wind energy will be assessed using the Framework for Assessing Ecological and Cumulative Effects. Focus areas include the effects (cumulative or otherwise) of wind farms on the Lesser Black-backed Gull and harbour porpoises.*

Accordingly, the national government has committed itself to drawing up and applying a framework for ecology and cumulative effects. This underlying Framework for Ecological and Cumulative Effects fulfils that commitment. Since January 2017, the inclusion of cumulative effects in plans and projects has also been implemented in Dutch legislation in Article 7.23(1)(f) of the Environmental Management Act.

1.2 Development of offshore wind energy

In September 2013, it was agreed in the SER Energy Agreement for Sustainable Growth to raise the proportion of energy generated from renewable sources in the Netherlands to 14% in 2020 and 16% in 2023. Specifically for offshore wind farms, it has been agreed that a total of 4,450 megawatts (MW) of installed capacity must be in place by 2023. In the Energy Agenda in December 2016, the government set out its decision that the offshore wind energy project would be expanded after the construction of the wind farms already planned in the North Sea.

On 27 March 2018, the government announced, through the Minister of Economic Affairs and Climate, that the '2030 Offshore Wind Energy Roadmap' includes plans for wind farms in the wind energy areas Ten Noorden van de Waddeneilanden, Hollandse Kust (west) and IJmuiden Ver (see below) in the period from 2024 to 2030.

[3] https://zoek.officielebekendmakingen.nl/kst-31710-45.html (in Dutch)

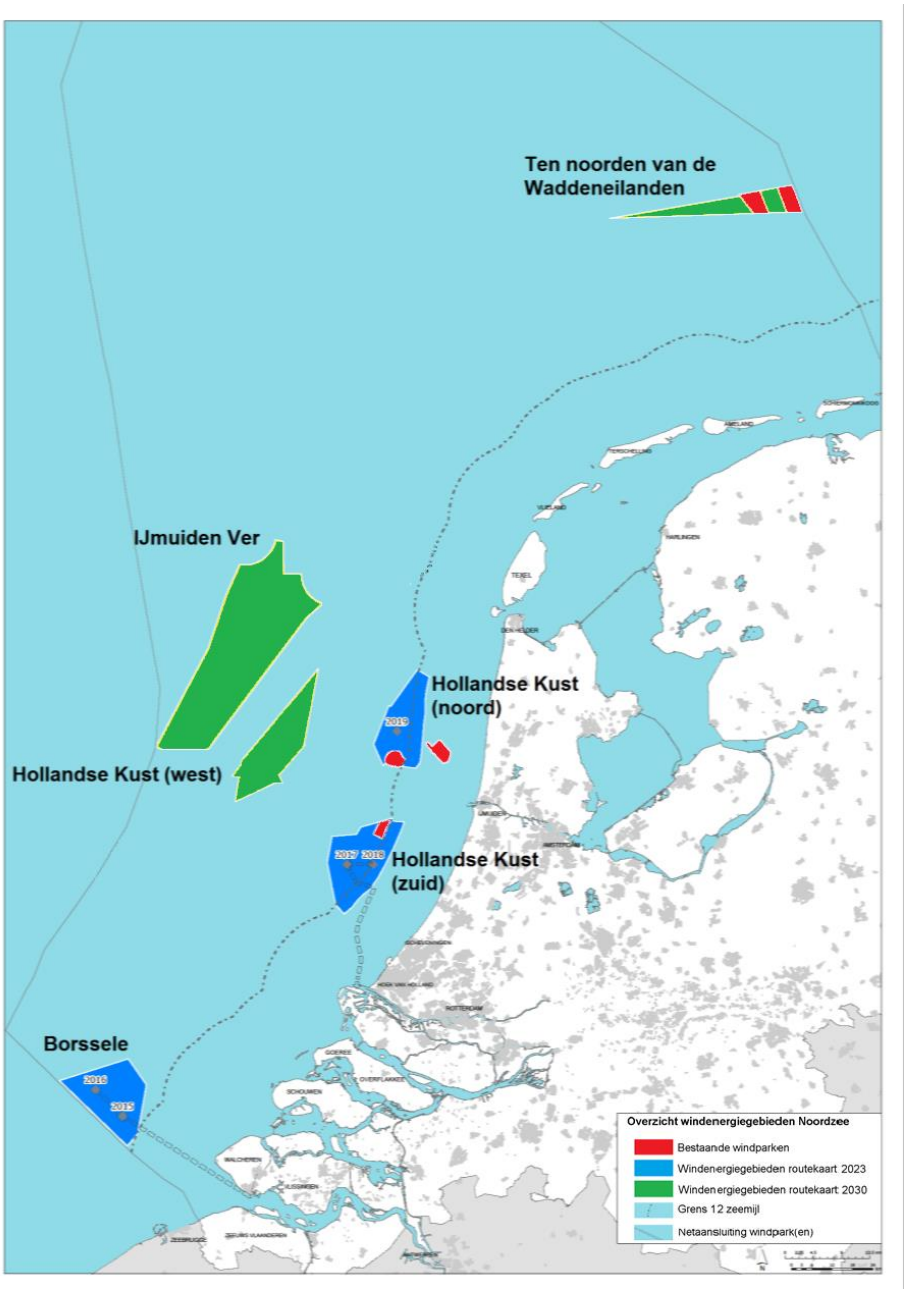

Figure 1: location of wind energy areas prior to 2030

1.3 Wind farm size

The 2030 Offshore Wind Energy Roadmap provides for wind farms with a combined size of approximately 6.1 GW. The areas in question are:

- Hollandse Kust (west) with a capacity of 1.4 GW; operations are expected to begin in 2024-2025;
- Ten Noorden van de Waddeneilanden with a capacity of 0.7 GW; operations are planned to begin in 2026;
- IJmuiden Ver, the largest wind energy area with approximately 4.0 GW; operations will begin in the period 2027-2030.

The offshore wind energy roadmap provides for a minimum of 3.5 GW (in 2023) and 6.1 GW (in 2030) on top of the existing wind farms (1 GW). Together, therefore, this represents a minimum of 10.6 GW. As a result of changes resulting from the further spatial concentration of the turbines, total wind energy capacity is expected to be slightly higher in 2030 at approximately 11 GW. The KEC 3.0 sets out the calculations for the capacities listed above in bullets 1 to 3.

Offshore Wind Energy Act

The Offshore Wind Energy Act (2015) provides a comprehensive legal framework for the large-scale development of offshore wind farms. It introduces a 'site decision' in which the government designates the areas where offshore wind farms may be built and in which the Ministers of Economic Affairs and of Climate, Agriculture, Nature and Food Quality state the locations and the conditions for the development of wind farms and where the connections to the national grid are to be made. In an SDE+ tendering process a developer will be selected for each site and granted the rights to build the wind farm on the site and the connection to the grid. The developer will also be granted a licence giving exclusive rights to build and operate a wind farm on the site.

Steps were made in 2018 towards amending Offshore Wind Energy Act. The essence of the Act will remain unchanged. The proposed amendments in the new bill consisted of establishing the new division of powers for the ministers and making the Act suitable for the further future for energy carriers other than electricity. Finally, the procedure for granting licences through the comparative assessment has been improved and the possibility of auctioning licences has been added to the Act. The bill mainly affects the wind sector. The amendment to the Act relates to the granting of licences and not the designation of wind energy areas or site decisions. Other stakeholders in the North Sea such as the shipping sector, the fisheries sector, the mining sector and nature conservation organisations are not affected by the bill, or only to a lesser extent.

An important part of the site decision is the assessment of ecological impacts. After 1 January 2014, activities in the Exclusive Economic Zone (EEZ) were subject to the provisions of the 1998 Nature Conservation Act (Nbw) 1998 and the Flora and Fauna Act (Ffw). Since 1 January 2017, these two acts have been incorporated in the Nature Conservation Act, which implements the Birds Directive and the Habitats Directive. The area provisions of the Nature Conservation Act provide for the protection of natural habitats and habitats of species in certain special protection zones with special natural values, the Natura 2000 sites, which together form a European network. The species provisions of the Nature Conservation Act provide for the protection of certain animal and plant species throughout the national territory. In the Offshore Wind Energy Act, this assessment, which is required by the Nature Conservation Act, is included in the site decision.

The site decision is a decree as referred to in Article 7.1(2)(c) and (b) of the Environmental Management Act. This means that an environmental impact assessment (EIA) must be carried out when preparing a decision to designate a site. In the event that a wind farm could have significant effects on a Natura 2000 site, an appropriate assessment (AA) must also be made. The EIA and the AA must also investigate what the cumulative effects will be.

The second version of the Framework for Assessing Ecological and Cumulative Effects (KEC; 2016) contains an estimate of the cumulative effects of all the wind farms planned through to 2023 (both Dutch and foreign wind farms) in the study area (see Chapter 5). The third version of the Framework for Assessing Ecological and Cumulative Effects (KEC; 2019) contains an estimate of the cumulative effects of all the national and international wind farms built and planned in the period leading up to 2030. The best available scientific knowledge has been used to make an assessment of whether the cumulative effects exceed the acceptable limits for three species groups: marine mammals, birds and bats.

If the EIA and AA indicate that unacceptable adverse effects may occur, a study is mandatory to determine whether these effects can be sufficiently mitigated by taking additional measures. These mitigation measures must be included in the site decision as a set of conditions.

The allocation of responsibilities in the Offshore Wind Energy Act and the position of the Framework for Ecological and Cumulative Effects (KEC) in that context are explained below.

Wind farm sites are designated only in zones reserved for this purpose in the National Water Plan (NWP). The National Water Plan for 2016-2021 continues the designation of the wind energy areas Borssele, IJmuiden Ver, Hollandse Kust and Ten Noorden van de Waddeneilanden from the earlier National Water Plan. The Hollandse Kust wind energy area has been extended by two strips 18.5 km offshore by means of a partial amendment of the National Water Plan for 2016-2021.[4]

How exactly cumulative effects should be addressed is an issue that people have also been struggling with on land, certainly since the passing of the Flora and Fauna Act and the 1998 Nature Conservation Act, and later the Nature Conservation Act. The mapping out of cumulative effects is therefore a complex issue that may, in principle, include the consideration of large numbers of species and effects. Two studies have been completed in this area for the purposes of the energy transition.[5] In practice, decisions have to be made about which effects and species are relevant. Decisions also have to be made about how exactly these effects should be described and evaluated. Because specific field data are still often lacking, obtaining the best available scientific knowledge will actually always require modelling, expert evaluation or combinations of these two approaches since it is not possible to measure situations that are still only in the planning stages.

This Framework for Assessing Ecological and Cumulative Effects (KEC) shows how the decisions were made about the species, populations and activities to be included in the assessment of cumulative effects and how these effects should be identified and described (and, where appropriate, the models to be used to do this).
It includes generic information on the accumulation of effects and more specific information on how cumulative effects of offshore wind power activities should be incorporated into environmental assessments. Calculations were made relating to the requirements for offshore wind energy from the 2030 Roadmap in accordance with the methodology described in this framework.

1.4 The KEC as a living instrument

This Framework for Assessing Ecological and Cumulative Effects (KEC) has been drawn up by Rijkswaterstaat (the part of the Ministry of Infrastructure and the Environment responsible for the design, construction and maintenance of the country's main infrastructure facilities) for the Ministry of Agriculture, Nature and Food Quality, with assistance from an interdepartmental steering group of representatives from various departments of the Ministry of Economic Affairs and Climate and the Ministry of Infrastructure and Water Management.
Rijkswaterstaat conducted two impact studies for use in the preparation of the first version of this assessment framework (version 1.1, 2015):

- Cumulative effects of impulsive underwater sound on marine mammals. Conducted by a consortium led by TNO;
- A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea, carried out by a consortium led by IMARES.

[4] https://zoek.officielebekendmakingen.nl/kst-33561-37.html (in Dutch)

[5] Ecological studies of species that are vulnerable to energy infrastructure in the Netherlands carried out by Wageningen Environmental Research *et al*. The report was published on: https://www.rijksoverheid.nl/documenten/rapporten/2018/05/01/kwetsbare-soorten-voor-energieinfrastructuur-in-nederland and an international comparative legal study of the application of the Birds and Habitats Directives to sustainable energy projects in the Netherlands, the United Kingdom, Belgium, Denmark and Germany was carried out by the Utrecht Centre for Water, Oceans and Sustainability Law (UCWOSL), which is affiliated to Utrecht University. The report was published on: https://www.rijksoverheid.nl/documenten/rapporten/2018/05/28/projecten-voor-hernieuwbare-energie-en-soortenwetgeving---een-juridisch-vergelijkend-onderzoek

There has been an update since. The following reports have been amended:

- Framework for Assessing Ecological and Cumulative effects for the roll-out of Offshore Wind Energy, Part A - Methods - 2016 update Chapters 1.5 and 5.6;
- Framework for Assessing Ecological and Cumulative Effects and the roll-out of Offshore Wind Energy, Part B - Description and assessment of the cumulative effects assuming the implementation of the Offshore Wind Energy Roadmap - Version 2.0 26 May 2016.

The 2030 Offshore Wind Energy Roadmap[6] was published in March 2018. In addition to the wind farms that will be built in the period leading up to 2023, this also includes the planning and locations for the offshore wind farms until 2030.
In addition to the new scenarios for wind farms (both national and international), new knowledge was developed in the period between the first KEC calculations and 2018, for example in WOZEP. It was possible to amend this KEC given changes in the insights in terms of knowledge (such as improved measurements of the flight heights of birds and more up-to-date data on the international status of populations) as well as in terms of needs (the inclusion of the need for mitigation measures in the KEC calculations) because the KEC is a living instrument.

New developments that may lead to revisions include:

- Follow-up analyses of collision victims among the large gull species;
- Redefining the acceptable limit for harbour porpoises or (in the future) for other species or habitats;
- Decisions about the use of mitigation measures.

The first KEC (1.1, 2015) indicated that the construction and operation of wind farms in line with the 2023 Roadmap could have significant impacts on a range of protected species if mitigation measures were not taken. The main species affected were the harbour porpoise, Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull and possibly also Nathusius's pipistrelle and even two other bat species. However, there was already a need at that time to define mitigation measures on the basis of the site decision (for Borssele, for example) for birds, bats and underwater sound.
At the time it was decided for birds, on the basis of the quality of the distribution data, to consider only the effects on the Dutch Continental Shelf (DCS) and to assess these effects on the 'Dutch' population for the purposes of decision-making. In addition, the use of mitigation measures – in other words, changes to the number of turbines and therefore the turbine size – was needed in order to limit any significant negative effects.
For harbour porpoises, it was decided to use a different approach to assess the effects (a maximum reduction of 5% of the current population as a result of the construction of offshore wind farms). In addition, the effects including the use of mitigation measures – in other words, a flexible sound standard – were considered. This information has been included in KEC 2.0 (2016).

[6] https://www.rijksoverheid.nl/documenten/kamerstukken/2018/03/27/kamerbrief-routekaart-windenergie-op-zee-2030

Reasons for the drafting of KEC 3.0
The present document, KEC 3.0 (2019), and the new calculations develop KEC 2.0 (2016) further. The new KEC calculations were considered to be necessary given new insights from, among other sources, WOZEP:

- birds: a different selection from the database, an update with more recent survey data and other calculations for population size
- bird collisions: new information about seagull flight heights
- bats: new information about relationships between bat numbers and weather influences
- underwater sound: new information from Aquarius
- underwater sound: new information about disturbance duration for harbour porpoises
- underwater sound: new information about the energetics of harbour porpoises
- general: inclusion of mitigation

Furthermore, as indicated above, the 2030 Offshore Wind Energy Roadmap was published in March 2018. In addition to the wind farms that will be built in the period leading up to 2023, this also includes the planning and locations for the offshore wind farms until 2030. Calculations had to be made for these new farms on the basis of the cumulative ecological effects.
Annex 6 shows the differences between KEC 1.1 & 2.0 and KEC 3.0.

Structure of KEC 3.0
The present report, Part A, sets out the conceptual framework for addressing ecological and cumulative effects, and how to interpret them for offshore wind energy. It replaces previous versions of Part A. The substantive reports (Part B reports) provide further details of the changes with regard to the calculations in KEC 3.0 (2019) by comparison with KEC 2.0 (2016). The Part B reports consist of the substantive reports from the KEC 1.1 and 2.0 and the new reports from KEC 3.0. Part C provides an executive summary of the substantive reports and states whether implementation of the 2030 Roadmap is possible and subject to which conditions.

Part B reports
KEC 1.1 and 2.0:

- Cumulative effects of impulsive underwater sound on marine mammals; TNO 2014;
- A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea; Imares 2015.

KEC 3.0

- Framework for Assessing Ecological and Cumulative Effects – 2018. Cumulative effects of offshore wind farm construction on harbour porpoises. F. Heinis, HWE, C.A.F. de Jong, S. von Benda-Beckmann & B. Binnerts, TNO, 2018;
- Cumulative effects of offshore wind farms: loss of habitat for seabirds. Update for five seabird species until 2030. J.T. van der Wal, M.E.B. van Puijenbroek, M.F. Leopold, WMR 2018;
- Mitigation measures for bats in offshore wind farms. Evaluation and improvement of curtailment strategies. M. Boonman, Bureau Waardenburg, 2018;
- Update of KEC bird collision calculations in line with the 2030 Roadmap.

Dr. A. Gyimesi, *ir.* J.W. de Jong, Dr. A. Potiek, E.L. Bravo Rebolledo MSc, Bureau Waardenburg 2018;
- Memorandum: Adding OWEZ and PAWP to the KEC 3.0 calculations. A. Gyimesi & J.L. Leemans, Bureau Waardenburg, 2018;
- Workshop Memorandum, 12 July 2018. E.L. Bravo Rebolledo & A. Gyimesi, Bureau Waardenburg, 2018.

Part C
Framework for Assessing Ecological and Cumulative Effects: Description and assessment of the cumulative effects resulting from the implementation of the 2030 Offshore Wind Energy Roadmap
Part C: Summary

1.5 Inclusion of mitigation

Mitigation measures had not yet been included in KEC 1.1. It emerged from the assessment of the effects as calculated in KEC 1.1 that the construction and operation of wind farms in line with the Roadmap could have significant impacts on a range of protected species if mitigation measures were not taken.

The KEC update, version 2.0, did consider this aspect on the basis of a number of developments.

Mitigation has been included in the present KEC 3.0. Basic mitigation has been considered for the various components. Where necessary (for example if there are new insights or new scenarios), this mitigation approach can be adjusted on the basis of calculations in the EIA and AA for the relevant site decision.

1.6 Structure of the report

The present Part A describes the approach used to describe and assess cumulative effects. Parts B and C look in further detail at the substantive approach, and the description and assessment of the cumulative effects of implementing the Roadmap.

Chapter 2 of this Part A examines the purpose and intended audience of the assessment framework and describes its scope and underlying principles. It contains an explanation of how cumulative effects are dealt with in the Dutch nature conservation legislation and the basic approach chosen in this assessment framework.
Chapter 3 describes the generic approach for identifying and describing cumulative effects and Chapter 4 explores the aspects specific to offshore wind energy. Both Chapters 3 and 4 give an answer to the question of how to address cumulative effects and which aspects should be included in the assessment and which should not. The factors that need to be considered, from an ecological and a legal point of view, are identified in a step-by-step process.
Chapter 5 examines the methodological steps that are specifically important in terms of calculating the effects of rolling out the Roadmap.
Chapter 6 discusses important points to be considered in the subsequent stages.

2. Scope and legal basis

2.1 Purpose and scope

Purpose

This document is a generic framework for identifying, describing and assessing the cumulative ecological effects of development decisions, particularly in relation to the development of offshore wind farms.

It describes a methodology for calculating cumulative effects. Given the reason for preparing this framework, it focuses mainly on offshore wind energy. The framework has been applied to the Offshore Wind Energy Roadmap as described in Chapter 1. The reason is to check in advance whether, and in which ecological conditions, the entire roadmap can be implemented. The framework will also have to be used when drawing up environmental impact assessments (EIAs) and appropriate assessments (AAs) for the specific site decisions and, where appropriate, when designating new areas for offshore wind farms. The use of the methodology for calculating the effects of implementing the Roadmap, including the results of the underlying research reports, is described in Part C. The calculated effects will be used as generic input for the EIAs/AAs for the site decisions.

To make the framework more widely applicable in the longer run, a generic approach was adopted (which is broadly applicable and possibly applicable in the future to a broader area than offshore wind energy) and it is being worked up specifically for assessing the effects of offshore wind farms. This report also identifies possibilities for mitigating the effects of developing offshore wind farms as proposed in the Roadmap.

Who are the intended users of the KEC?

The framework was drafted primarily for use by all government departments and agencies involved in the decision-making relating to offshore wind energy, such as strategic planning documents (*structuurvisies*) and site decisions (*kavelbesluiten*). Because it provides transparent information on how the cumulative effects of these developments should be identified and assessed it is also relevant for consultancies preparing EIAs/AAs in support of these decisions and for stakeholders in offshore wind energy.

Scope

When adapting the KEC specifically for offshore wind power, a decision was made to include only those impacts that could lead to significant adverse consequences, either on their own or in combination with other activities. Calculations for the Roadmap drew on a scenario that includes virtually all national and international wind farms that are expected to be built in the period leading up to 2030 (see the 2018 Part B reports for more information about the scenarios). It must also be made clear that the assessments of the effects on conservation status or the population level have been made at least at the national level. As the exact locations of the wind farm sites are not yet known, it cannot be excluded that more detailed calculations in project EIA/AA will identify specific effects. These types of effects will have to be determined more precisely during location-specific EIAs/AAs for the relevant site decisions.

In addition, calculations have not been made for all species because the previous KEC showed that the effects on the population of many other species did not appear to be moving in the direction of unacceptable levels.

The acceptability of the effects is determined in the KEC (2015, 2016, 2019) for birds and bats on the basis of Potential Biological Removal (PBR). PBR uses population size and a recovery factor to determine the order of magnitude of a

possible decline or reduction in the population that is acceptable from the perspective of the population dynamics. The smaller the recovery factor used in this PBR, the more sensitive a population is and the lower the number of individual victims. The use of PBR as an acceptable measure has been criticised (for example by O'Brien *et al.* 2017) for not being sufficiently cautious. However, as yet, there is no adequate alternative. Until that is the case, PBR will be used cautiously.

In the case of harbour porpoises, PBR cannot be used a measure of acceptable effects because the issue with harbour porpoises is not solely direct mortality but also reduced reproduction. The most relevant question when assessing the consequences of impulsive underwater sound for harbour porpoises is whether it endangers the conservation status of the population. In order to set acceptable limits for the effects on harbour porpoises, it is important to bear in mind that the conservation status of harbour porpoises on the DCS has been assessed as moderately unfavourable (Camphuysen & Siemensma 2011). It was therefore decided that the harbour porpoise population must not fall below 95% of the current population as a result of the construction of wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of the construction of the wind farms. Under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the interim target that has been set for harbour porpoises is that the population should not fall below 80% of the carrying capacity. It is not known what this capacity is on the DCS. Maintaining the population with a high degree of certainty at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period 2016 - 2030 can be considered a safe choice.

In one of its recommendations, the Netherlands Commission for Environmental Assessment asked how the KEC dealt with the report by Buij *et al.* (2018). This report was drawn up for the Energy Transition and Nature project on behalf of the Ministry of the Interior and Kingdom Relations and the Ministry of Agriculture, Nature and Food Quality.[7] It did not calculate vulnerability in the same way as the KEC. The differences between the KEC approach and the Buij approach are easy to explain. This will be discussed further in Annex 5.

2.2. Status and follow-up

The National Water Plan for 2016-2021 states that the KEC must be used to support decision-making about the boundaries and exploitation of future wind farms in the designated areas. For the purposes of decisions about the development of offshore wind farms, such as designating wind energy areas and site decisions, the KEC will be used to determine whether it is possible to exclude the possibility that the combination of a wind farm with other wind farms will have any significant ecological effects.
The Dutch government is therefore committed to using the KEC in decision-making procedures for the development of offshore wind farms. In addition, the inclusion of cumulative effects in plans and projects has also been implemented in the Environmental Management Act since January 2017.

The KEC is a living document: it draws on of the knowledge and expertise currently available and so new developments may require the revision of the document.

[7] 'Species vulnerable to energy infrastructure in the Netherlands; overview of the effects of renewable energy infrastructure and high-voltage lines on the most vulnerable species of birds, bats, marine mammals and fish, and possible solutions for a nature-inclusive energy transition' (Buij *et al.* 2018), see also footnote 5.

These revisions may reflect advances in knowledge (such as population changes, understanding of cause–effect relationships, effects on species about which little was known, new information about population sizes), and changes in the activities included in the assessment or the techniques used for that purpose, but also changes in the legislation (including the relevant case law) or a broadening of the field of application of the KEC (beyond offshore wind energy, for example). The EU Marine Strategy Framework Directive (MSFD) merits particular mention here. In the future, if possible, the MSFD should also be included this Framework for Ecological and Cumulative Effects, together with the indicators of ecological quality that it contains. Ongoing research into the effects of offshore wind energy, such as WOZEP, will provide new input in phases for this KEC.

2.3. Underlying principles

The description of effects in KEC 3.0 (2019) is based on the most recent publicly available knowledge and the following underlying principles:

- transparency about knowledge gaps and assumptions;
- use of the precautionary principle assumes a realistic worst-case approach within the range of expected developments;
- absolute clarity about the geographical scale and time horizon of the calculated effects;
- use of substantiated expert judgements to address knowledge gaps;
- an emphasis on possible adverse effects;
- only for those species that suffer the most significant negative effects.

2.4 National and international conservation requirements in law for plans and projects

The inclusion of cumulative effects in the assessment of plans and projects is required under international conventions and EU directives. This requirement has also been implemented in Dutch legislation since January 2017 in Article 7.23(1)(f) of the Environmental Management Act[8]. These legal obligations have been taken into consideration during the drafting of the KEC.

International conservation legislation

A brief review of the relevant international conventions and laws and their requirements regarding cumulative effects is given below. These international conventions have been implemented in Dutch legislation.

The aim of the OSPAR Biodiversity and Ecosystem Strategy, the EU Birds and Habitats Directives, the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) is to protect or restore generic ecosystem qualities or specific habitats and species. The Birds Directive and the Habitats Directive have been implemented in the Netherlands in the Nature Conservation Act (in the area provisions and species provisions). This Act also applies to the entire Dutch section of the Continental Shelf. All this legislation places certain requirements on marine and other activities with the aim of achieving the specific objectives stated in this Act.

[8] Environmental Management Act, Article 7.23(1) An environmental impact assessment shall include in any event: … f. any additional information referred to in Annex IV to the EIA directive that is relevant to the specific characteristics of a given activity or type of activity and to the environmental aspects likely to be affected; Directive 2014/52/EU of 16 April 2014 amending Directive 2011/92/EU, ANNEX IV, 5. A description of the likely significant environmental effects of the project as a result of, among other things:
… e) the accumulation of effects with other existing and/or approved projects, taking into account all existing environmental problems relating to areas of particular environmental interest which may be affected by the project or taking into account the use of natural resources;

The aim of the EU EIA/SEA Directives, UNECE (United Nations Economic Commission for Europe) Espoo Convention and the OSPAR Strategies on Offshore Oil and Gas, Hazardous Substances and Radioactive Substances is to reduce the environmental impacts of activities. They require a full assessment of the effects of plans, projects and activities on the whole ecosystem. The Espoo Convention, the MSFD and the WFD require a Cumulative Effect Assessment (CEA). The WFD takes the ecological status of the coastal waters as its starting point, whereas the MSFD adopts an ecosystems approach. The Espoo Convention is an important tool for bringing all stakeholders together before any environmental impacts occur and it obliges parties to assess the environmental impact of certain activities at an early stage of the planning process. It also lays down a general obligation on parties to notify and consult each other about activities that are expected to have significant adverse effects across borders. The only directives that require a CEA are the EU EIA/SEA Directives and the Birds Directive and Habitats Directive. CEA is a mandatory part of the EIA in these cases.

National nature conservation legislation
The Nature Conservation Act (Wnb) implements the EU Birds and Habitats Directives. The area provisions of the Act provide for the protection of natural habitats, species habitats and species in the key sites for the habitats and species designated specifically for that purpose. These Natura 2000 sites together form the international Natura 2000 network of protected areas. The species provisions of the Act provide for the protection of named plant and animal species and the specific habitats of these species, both inside and outside the Natura 2000 sites, in other words throughout the Netherlands.

The Offshore Wind Energy Act states that the ecological impacts of offshore wind energy projects must be assessed in the context of the drafting of a site decision, which means that no separate consent or discretionary permit is required under the Nature Conservation Act. For practical reasons, the present document refers to the Nature Conservation Act because the substantive assessment of the site decisions is in line with the Nature Conservation Act.

Cumulative effects assessment
The Nature Conservation Act requires a specific *ex ante* assessment of projects and plans which are not directly connected with or necessary to the management of the area and which, on their own or in combination with other plans or projects, could have adverse effects on the quality of the natural habitats and species habitats in a Natura 2000 site, or result in significant disturbance of the species for which the Natura 2000 site in question has been designated. This also applies to activities that take place outside a Natura 2000 site but which may have consequences for protected habitat types, species habitats or protected species in Natura 2000 sites. In this case, an assessment must be made of whether the activities concerned will have consequences for the ecological values requiring protection in the Natura 2000 site. These are referred to as external impacts on Natura 2000 sites.

If consent is required under the Nature Conservation Act, the project or plan must be appropriately assessed, including an assessment of the cumulative effects in combination with other projects and plans. The assessment is required to include only projects in which construction has been approved and not yet taken place or projects that have been built but for which the consequences have not yet been incorporated into the background situation.

All protected species enjoy a generic level of protection under the species provisions of the Nature Conservation Act, which also applies outside Natura 2000 sites. An initiative with potentially adverse effects on these species (mortality or the destruction/disturbance of permanent resting places or essential habitats) can only be granted a discretionary permit under the Nature Conservation Act if the requirements of the Act are met. The requirement for most species is that their favourable conservation status must not be endangered. However, there are additional requirements for some strictly protected species such as the existence of a legitimate interest. When determining the consequences of the activities for the favourable conservation status of a species, the assessment under the species provisions of the Nature Conservation Act must also take into account, albeit implicitly, possible cumulative effects resulting from other activities. This also follows from the Birds and Habitats Directives[9]. This topic is examined in more depth in Section 2.5 (under the heading Species provisions and cumulative effects).

2.5 Legal and ecological approaches

The KEC makes a distinction between a legal and an ecological approach because compliance with the legal requirements of the Nature Conservation Act does not necessarily mean that a favourable conservation status will also be achieved in ecological terms. In the Netherlands, the Nature Conservation Act implements the Birds and Habitats Directives by the designation and subsequent explicit protection of the Natura 2000 sites (the special protection areas under the Nature Conservation Act: the Natura 2000 sites). The intention is that all the habitats and species for which a conservation objective has been designated for these areas will acquire national favourable conservation status as a result of the contribution made by all these areas to the protection of those habitats and species.

This area protection policy works well for the terrestrial ecosystems in the Netherlands, including the inland lakes, rivers and coastal waters. However, this approach is less appropriate for protecting species in the North Sea, which are generally distributed over areas that extend far beyond the boundaries of the designated Natura 2000 sites and even far beyond national borders.

Differences between 'land' and 'sea'

The natural functioning of the North Sea ecosystem is characterised by a large variation in the spatial and temporal distribution of species. The system is driven to a large extent by short-lived and local hydrogeographical conditions (such as weather fronts) to which animals respond. As a result, many species are highly mobile and not confined to the Natura 2000 network of protected areas. They include marine mammals (in particular, the harbour porpoise, common seal and grey seal) and seabirds but also some larger fish species (such as sharks and rays).

This means that, under the EU Birds and Habitats Directives, the favourable conservation status of these species effectively has to be maintained at the biogeographical population level. However, because the distribution of species varies considerably within and between seasons and years, the value for certain species of specific areas within the North Sea by comparison with the rest of their range is hard to predict or establish, which limits the possibilities available to the Netherlands to establish good conservation status. For many species the best available knowledge is insufficient to identify any areas which fulfil a specific ecological function over any prolonged period of time.

[9] See page 65 of the 'Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC' from 2007.

For example, the harbour porpoise protection plan (Camphuysen & Siemensma 2010) states that the areas of special ecological value (*GBEW*, Lindeboom *et al.* 2005) are not home to higher numbers than the surrounding areas. We may conclude that the level of protection in all these areas is insufficient to establish a favourable conservation status for these migratory species. These species require protection throughout the North Sea. This is recognised in the designation decisions for Natura 2000 areas in the North Sea.
Although the harbour porpoise is mentioned specifically, the same also applies to many marine species, such as the various species of seabirds, dolphins and seals. The KEC therefore assesses the effects on the populations in the study area in order to implement the objectives in Natura 2000 areas, which have a direct bearing on the presence of the species in those areas.

This does not alter the fact that, for initiatives near Natura 2000 sites that have already been designated or are close to being designated with an additional or special function for some species (such as breeding grounds for seabirds such as the Sandwich Tern and Lesser Black-backed Gull; resting, moulting and nursery habitats of common and grey seals; and moulting or foraging habitats of Common Guillemots, Razorbills and Northern Gannets), the assessment of effects under the provisions of the Nature Conservation Act continues to require particular attention. Location-specific assessments will also remain necessary under the species provisions. These site-specific assessments will have to be conducted for the purposes of the site decisions.

Dutch legislation
More specifically, the following aspects of Dutch nature conservation legislation are relevant in relation to the points discussed below:

1. The Nature Conservation Act applies only to activities on Dutch territory and the exclusive economic zone in the North Sea (Article 1.2(1) of the Nature Conservation Act). However, species and their habitats are not confined by national borders. Animals can migrate across borders and can live in areas that extend across many countries and so, when considering the ecology of a species, the area relevant for the whole population must be considered. The long-term conservation of a species depends on the quality of different habitats in different areas. A legal assessment of the acceptability of activities is therefore logically demarcated by the national borders of the Netherlands but it should also consider the effects on protected species outside the territory of the Netherlands.

2. Under the Nature Conservation Act it is necessary to establish beyond doubt that the effects of an activity or development are not significant and/or that the quality of a protected habitat will not deteriorate. Only then can a licence be issued, where appropriate subject to conditions that safeguard compliance with this requirement. The ecological reality is that the environment is complex, species and habitats are influenced by a great variety of factors and it is seldom possible to determine exactly the magnitude of the effect of an activity, which is why there is always a range of uncertainty for the identified effects. When there is too much uncertainty, the precautionary principle must be used. The precautionary approach, either on its own or in combination with adaptive management, brings together the legal and ecological approaches.

3. The protection of sites requires that activities be assessed for any adverse effects on the integrity of Natura 2000 sites as defined by the conservation

targets set out in the designation decisions. If the range of a species extends far beyond the boundaries of a Natura 2000 site or beyond the borders of the Netherlands, it may still become extinct, even though the quality of the sites in the territory of the Netherlands is good. This may happen, for example, as a result of the effects of human activities in other parts of the species' range (such as the British coast for species that breed there but return to the Dutch Continental Shelf (DCS) in the autumn). From an ecological perspective and in the interests of species protection, therefore, activities and developments should be assessed for their effects on the conservation status of the species.

4. Plans, projects and other interventions: A project or plan may have no significant consequences, either on its own or in combination with other plans or projects. Article 6(3) of the Habitats Directive requires a specific *ex ante* assessment of projects and plans which are not directly related to or necessary for the management of a Natura 2000 site and which, individually or *in combination with other plans or projects*, could have significant implications for the site.

In addition to Article 6(3) of the Habitats Directive, Article 2.7 of the Nature Conservation Act requires an assessment of the cumulative consequences of plans and projects. This means that the cumulative consequences of 'other interventions' – as referred to in Article 2.7 of the Nature Conservation Act – do not, *in principle*, from a legal point of view, have to be included because they have already been included in the current situation. However, as these 'other interventions' could well have a major ecological impact (an example being seismic surveys), it would be relevant to take these 'other interventions' into account from an ecological point of view.

Species provisions and cumulative effects
As described in Section 2.4, the species provisions of the Nature Conservation Act do not state specifically the approach required to address the cumulative effects of different projects. From a strictly legal point of view, one could therefore argue that the assessment on the basis of the species provisions does not have to take cumulative effects into account. However, case law indicates that cumulative effects do have to be included in the assessment. This also follows from the Birds and Habitats Directives[10].

It is unclear how cumulative effects should be assessed. This assessment is necessary because the assessment of the impact of a project must include its effect on the favourable conservation status of the relevant plant or animal species. If other projects that have been implemented or are going to be implemented also affect these plant or animal species, they will also have to be assessed in order to estimate the effects on the conservation status of these species properly. If this is not done, there is a risk that species will not be adequately protected.

[10] See 'Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC' (2007) page 65: (60) Such monitoring could also be seen as a part of the general surveillance obligation under Article 11 of the Directive. It would be reasonable for such surveillance to be sensitive to the effects (including cumulative effects and the effects of compensation measures) of derogations implemented for species for which derogations are regularly granted or which are in an unfavourable conservation status (and are nevertheless the subject of derogations).

A good example is the impact of offshore wind farms on bats. Natura 2000 sites have been designated for three bat species: the pond bat, Geoffroy's bat and the greater mouse-eared bat. These are not species expected to be found at sea, which means that an assessment of the effect of development of offshore wind farms on all other bat species protected by the species provisions of the Nature Conservation Act need only consider the effects of each individual wind farm. There is only a low probability that a single wind farm would cause so many bat deaths that the favourable conservation status of any bat species would be endangered. However, it is possible that all the wind farms together, as planned in the Offshore Wind Energy Roadmap (and certainly if they are considered in combination with all other existing and planned wind farms in the rest of the international areas of the North Sea), could cause so many victims that there will be an adverse effect on the favourable conservation status of the relevant bat species that migrate across the sea.

The aim of the Nature Conservation Act, and the underlying Birds and Habitats Directives, is to maintain the favourable conservation status of the designated species. A failure to take cumulative effects into account would not do justice to this aim. Although cumulative effects are not explicitly mentioned in the wording of the law, an assessment of them does follow from the Birds and Habitats Directives, and the conclusion must be that cumulative effects should be included in the assessment because otherwise a sound estimate cannot be made of the effects of the project concerned on conservation status.

Ecological and legal approaches: flexible application
Meeting the legal requirements makes it possible to issue development consent or a discretionary permit, or – specifically for offshore wind energy – to adopt a site decision. To ensure that nature conservation objectives are met, however, a purely legalistic approach to cumulative effects will not always be adequate. Adopting an approach of that kind could eventually lead to a legal risk if certain agreed nature conservation objectives cannot be met after all.

The KEC therefore primarily assesses the cumulative effects on non-location-specific species at the biogeographical population level. In the event of a positive assessment, this implies compliance with both the species provisions and the area provisions of the Nature Conservation Act because specific effects that affect the populations of these species will also affect the sub-populations in the protected areas. Not only does this meet the nature conservation objectives, it also provides adequate latitude for the development of offshore wind energy.

In legal terms, the assessment is based on the conservation objectives of the Natura 2000 sites. Effects on sub-populations of species restricted to specific protected areas (such as some breeding colonies) may differ from the effects at the biogeographical population level. In those cases, the project EIAs/AAs for the site decisions must include a specific consideration of these effects.

The ecological effects are assessed at the level of the biogeographical population. KEC 3.0 (2019) focuses in that respect on:

- assessing effects at biogeographical scales;
- assessing effects on the conservation status instead of at the scale of one or more individual Natura 2000 sites;
- including transboundary effects;
- excluding uncertainties by applying the precautionary principle;
- including the complete Offshore Wind Energy Roadmap as far as it is known, even if permits have not yet been granted for those farms;

- including foreign offshore wind farms which are expected to be built in the period leading up to 2030 (see Part B (2018) for the scenarios included for national and international wind farms).

In practice, the KEC assesses the population on the DCS or the southern North Sea.

2.6 DPSIR model for assessing cumulative effects

The description and assessment of the cumulative effects of plans and projects in the KEC is a step-by-step procedure based on the DPSIR method. This method systematically identifies the drivers, pressures, state, impacts and responses in six steps (see Annex 2).[11]

The first two steps are iterative and are carried out together.

- Step 1: Identify the relevant pressures the envisaged activity could cause.
- Step 2: Identify the habitats and species that may be affected by these pressures.
- Step 3: Describe all other drivers that could affect the same species.
- Step 4: Describe the nature and scale of the cumulative effects of all the activities selected in Step 3 on the selected habitats and species for the relevant[12] populations of those species (*impacts*).
- Step 5: Evaluate the significance, through comparison with the legally established conservation targets, of both the *state* (e.g. conservation objectives) and the *impact* (on ecosystem biodiversity, for example) of the effects on the selected habitats and species.
- Step 6: If necessary, adapt the activity by taking mitigation or compensatory measures (*response*) so that it does not contribute to any significant effects.

The procedure is represented schematically in the diagram below. The diagram also shows that, as activities, pressures and species are added, the number of operational steps or calculations that have to be made in the process increases exponentially. This makes it necessary to select only the most relevant species and pressures in order to keep the calculations required within manageable proportions.

[11] This 'conservation status' (which corresponds to the term *state*) can, of course, be 'poor', 'moderately unfavourable' or 'favourable' in the DPSIR approach, in which case the aim will be to achieve 'favourable' status through the *response*.

[12] In this context, the 'relevant' population is understood to mean the population of the total geographical area in which the intended activity will take place.

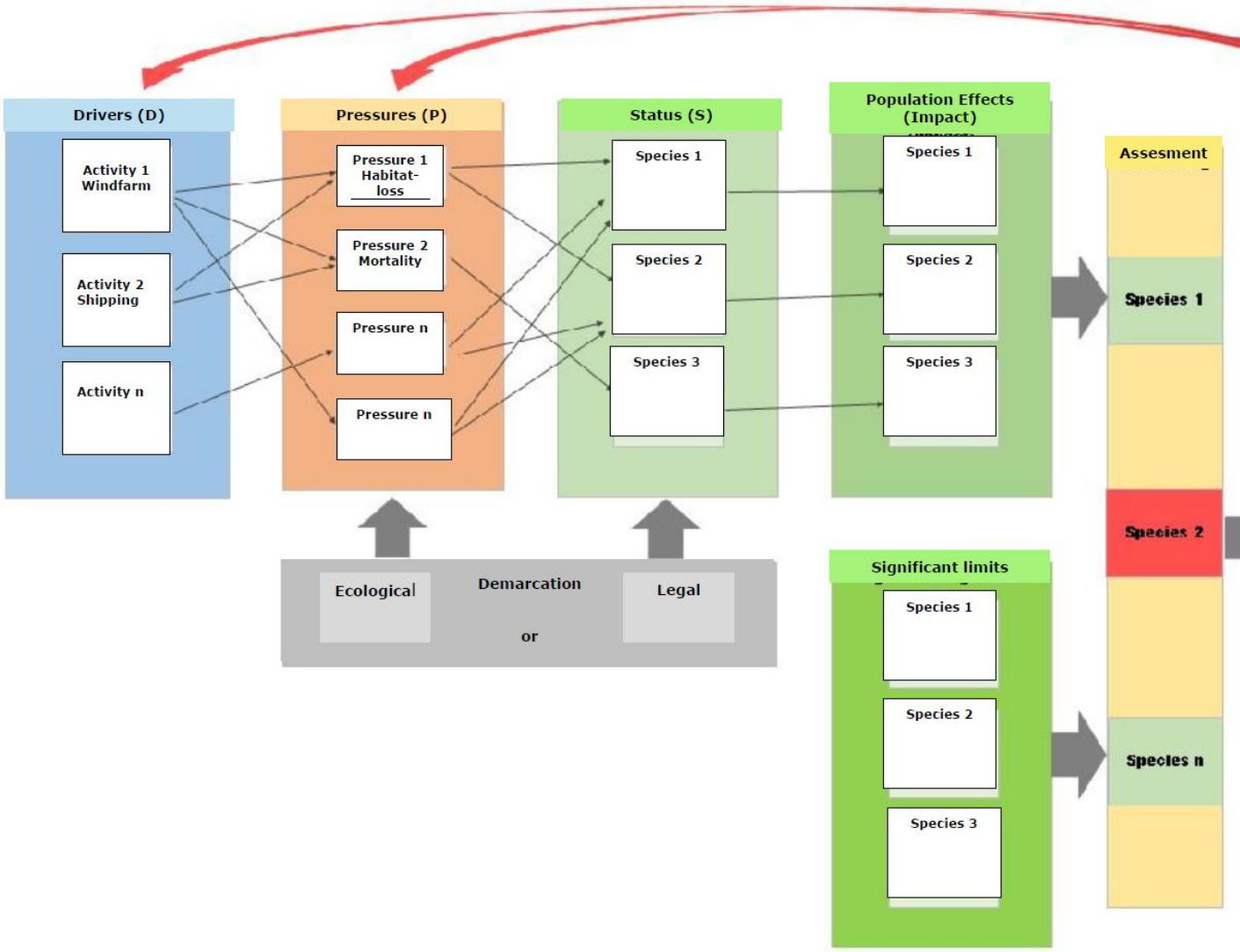

Figure 2: Schematic diagram of the DPSIR steps

3 Generic approach to the assessment of cumulative effects

This chapter describes the steps to be taken at the generic level to make an adequate assessment of the cumulative effects of proposed developments. The following sections describe the steps to be taken in the DPSIR approach at a generic level. The corresponding sections in the subsequent chapters examine these steps specifically for offshore wind farms. Each step contains a description of what is necessary from a legal and an ecological point of view (to the extent that these differ).

3.1 Identification of pressures from the activities to be assessed (Step 1)

The pressures from the activity to be assessed are described in conjunction with Step 2 and that description is dependent on the same step, the identification of sensitive species and habitats. The activity to be assessed is the human activity that may have an impact on the species, habitats or other ecological values of prime concern for the assessment. Pressures are those aspects of the activities that cause impacts.
Examples of pressures are:

- disturbance caused by mechanical activities and obstacles;
- disturbance caused by light;
- disturbance caused by sound;
- habitat loss;
- toxic effects of contamination;
- animal mortality or injury;
- changes in species composition through the introduction of species or new habitats.

Pressures are only relevant if there are species and/or habitats sensitive to them in the area. Identifying the pressures starts with a detailed description of the proposed activity, its physical characteristics, dimensions and duration for all phases: preparation, construction, operation, and decommissioning and removal.
Different activities occur during each of these phases (for offshore wind farms: shipping movements, excavation, construction, operations and maintenance, and finally decommissioning) and these activities exert different pressures. The spatial dimensions of these pressures must then be identified and this cannot be seen in isolation from the sensitivity of species. For example, if a species is affected by sound above a certain level, the spatial dimension of this pressure is the area within which the sound is louder than the maximum level acceptable to the species. The level of detail required when identifying and describing the pressures must be determined in conjunction with Step 2.

3.2 Identification of sensitive species and habitats (Step 2)

3.2.1 Ecological

The next step is the identification of species and habitats that could be affected by the pressures from the activities under consideration. In this step a list should be made of the species present within the sphere of influence of the pressure and the species that are sensitive to the pressures identified in Step 1. These pressures are only significant in relation to what they can disturb. In other words, they are dependent on how sensitive a certain species or habitat is to a given pressure, and on whether there is any overlap in space and time between the presence of a pressures and the species sensitive to that pressure.

3.2.2 Legal

The first point to note from the legal perspective is that not all species enjoy the same level of protection. In the Netherlands, species habitats are protected by the area and species provisions of the Nature Conservation Act (see Section 2.4). The various species and habitats protected by this Act enjoy different protection regimes. The species provisions of the Nature Conservation Act provide different levels of protection. Species listed in Annex I of the Birds Directive and Annex IV of the Habitats Directive enjoy the highest level of protection.

This step involves consideration of those species on the list of sensitive species drawn up in 3.2.1 that are protected under area or species provisions. However, care should be taken to consider any indirect effects on protected species resulting from adverse effects on non-protected species (e.g. via the food web). The abiotic structure and ecological function of habitats are also protected. These are not described as clearly as the above-mentioned species lists (albeit to a certain degree in the Natura 2000 profile documents) but they are just as relevant.

3.3 Inventory of other relevant activities with effects (Step 3)

3.3.1 Ecological

This step identifies all the other relevant activities in or in the vicinity of the plan area. It is important to realise that proximity to the plan area is not necessarily as significant for the inventory of other relevant activities as the area within which the relevant effects on the species or habitats concerned could occur. For highly mobile animals, such as birds and harbour porpoises, the areas within which relevant effects could occur are large. Effects and populations do not stop at national borders, which means that the assessment should be made from an international perspective.

Only those activities that lead to cumulative effects are considered in this step. The activities to be included should be identified on the basis of their ecological effects and the relevance of those effects, not on the basis of their legal status. Activities are relevant only if they can exert an influence on the habitats and species identified in Step 2, either via the same pressures identified earlier or via entirely different pressures (or even entirely different *drivers*). For example, when assessing the effects of the construction of a wind farm (the activity to be assessed from Step 1) on sea mammals, it is important to consider not only the influence of the construction of other wind farms but also the influence of other activities (such as fishing or seismic surveys) in the areas where sea mammals live. Effects on habitats or species populations other than those identified in Step 2 will not be considered.

3.3.2 Legal

The legal requirement in the Nature Conservation Act is that, when assessing plans and projects, the cumulative effects of their combined impacts with other plans and projects must be taken into consideration. More detailed requirements are provided for in the case law of the Dutch Council of State and the Court of Justice of the European Union. As the species provisions of the Nature Conservation Act do not mention cumulative effects, they also contain no requirements relative to what should or should not be included in a cumulative effect assessment. However, because it is necessary to make an assessment of effects on the favourable conservation status, each activity which could have an adverse effect on the favourable conservation status must be included in the assessment unless it can be considered to have been already incorporated into the estimated conservation status used for the assessment.

3.4. Determination of the cumulative effects of all activities (Step 4)

This phase describes the effects of all the activities selected in Steps 1 and 3 that could affect the species and habitats selected in Step 2. However, it is advisable here to draw up a list of priorities first based on expert judgement. The initial selection should be based on a qualitative assessment of the cause–effect relationships between pressures and species/habitats that could lead to significant adverse cumulative effects, the key criterion being the protection of the most sensitive species. Other, less sensitive, species will often benefit from the mitigation measures required for the most sensitive species. After a list of priorities (which must be made explicit) has been established in this way, a more detailed study will have to be made of those aspects that could lead to significant adverse effects, including those where significance is questionable.

This more in-depth study, where possible based on quantitative research or modelling studies, should indicate for each activity the extent of the effect that each pressure has on each habitat or species. If this is not possible, the extent of the effect should be determined qualitatively by expert judgement.
The set of effect assessments determined for each pressure by species or habitat forms the basis for the analysis to determine whether, and if so to what degree, the various effects of the pressures act enhance or weaken each other. For instance: a seabird that experiences a loss of habitat resulting from the presence of a wind farm will avoid the area and therefore be less affected by collisions. An example of effects that could enhance each other is when habitat loss and a barrier effect occur at the same time: not only is the habitat reduced in area, but the remaining area is less accessible.

3.5. Assessment of cumulative effects (Step 5)

3.5.1 Ecological

This step involves assessing the effects. The determination of the size or scale of the effects, which took place in Step 4, is a value-free exercise. An objective assessment is made of whether effects actually occur; there is not yet any assessment of the severity of those effects. The latter assessment takes place in Step 5. Step 5 assigns a value to an effect. In other words, the changes in the status of the protected species at the population level and the reduction in the size or quality of protected habitats is measured against a threshold value (limit of acceptable change). This threshold is determined for species on the basis of population change in line with the principle that there should be no structural decline in population numbers. The threshold for habitats is based on the favourable conservation status; there must be no reduction in the size and/or quality of habitat in relation to the conservation objective of a site. If there is an objective for improving a habitat type, this objective must not be endangered as a result of individual or cumulative effects. In legal terms, if such a decline or deterioration is probable, the effect will be described as 'potentially significant'.

The ecological assessment of the effects seeks to establish the extent to which the adverse effects of the activity can have a significant influence on a conservation objective (such as the area or quality of a habitat or the population of a species). The natural size of a healthy species population is limited mainly by the amount of food and other environmental factors, such as the area of safe reproduction and roosting habitats required and the presence of natural predators. A temporary increase in the mortality rate may be compensated for by higher survival rates of the remaining animals and the ability to raise more offspring (density-dependent factors). Additional mortality in animal populations (due to a virus infection, for example) may be caused by unexpected temporary or permanent changes in

environmental factors. The likelihood of a population recovering from a disturbance depends on the magnitude of the disturbance and the speed at which it occurs.

The mechanism described above gives the population a certain degree of 'resilience' against additional mortality resulting from individual or cumulative effects of human activities. But if the increase in mortality continues year on year, the natural carrying capacity will be affected. If recovery is not possible, the species will eventually become extinct or disappear from part of its range and, if a population is already under pressure from human influences such as pollution and disturbance, additional, cumulative, adverse effects will produce a significant effect sooner. The 'resilience' argument is only valid for direct adverse effects on the size and/or quality of a species' habitat if such a loss is offset by positive effects, such as a richer environment in the remaining areas, natural migration or habituation.

The outcome of this step is an assessment of whether the cumulative effects on a habitat or species are within the limits of acceptability or not. If the cumulative effects act to permanently reduce the size of a species population or pose a structural threat to the favourable conservation status of a habitat (expressed as area and/or quality), the activity in its proposed form is not permissible.

From an ecological perspective, the thresholds (limits of acceptable change) must ensure that the conservation status of the habitat is not adversely affected (in other words, size and/or quality are not impaired) and the population does not decline as a result of the cumulative effects of the initiative in combination with all other influences of human activities. The carrying capacity of the ecosystem for the populations of the protected species must be maintained at the level of the favourable conservation status.

In the KEC, effects on birds are assessed for the time being with respect to potential biological removal (PBR). The PBR is a measure of the maximum number of individuals of a species that may be removed from the population in addition to natural mortality and emigration as a result of the cumulative effects, expressed as a virtual annual additional mortality, without the population undergoing a structural decline. Population characteristics such as capacity for growth and recovery and the trend in population size are included in this measure. As long as the PBR is not exceeded, there will be no significant – and therefore unacceptable – effects. The PBR is an approach based on the principle of equilibrium population size.

The PBR was developed by Wade (1998) to calculate the acceptable level of mortality among sea mammals (cetaceans and seals) as a result of human activities. The population dynamics of many seabird species are, like those of seals and cetaceans, characterised by a high life expectancy, relatively late sexual maturity and a relatively low rate of reproduction. Wade's model is therefore also applicable to seabirds (Dillingham & Fletcher 2008; Richard & Abraham 2013). Moreover, the findings of Milner-Gulland & Akçakaya (2001) show that the PBR concept can be applied to other, more shorter-lived, bird species as well. The PBR approach as applied by Lebreton (2005), Niel & Lebreton (2005) and Dillingham & Fletcher (2008) can also be used to describe and assess cumulative effects on bats. The results of these studies underline the fact that the PBR is a useful instrument for predicting whether the impact of a source of additional mortality will remain within acceptable limits or not, and for identifying vulnerable populations and/or situations in which mortality reduction (i.e. mitigation) measures should be introduced (Wade 1998; Neil & Lebreton 2005).

The use of PBR as an acceptable measure has been criticised (for example by O'Brien *et al.* 2017) for not being sufficiently cautious, particularly in the case of smaller populations. However, as yet, there is no adequate alternative. Until that is the case, PBR will be used cautiously. WOZEP is working on the development of a better assessment method. However, no population models or a new method for an acceptable measure are yet available.

A different approach has been used to assess effects on harbour porpoises. In the case of harbour porpoises, PBR cannot be used a measure of acceptable effects because the issue with harbour porpoises is not solely direct mortality but also reduced reproduction. The most relevant question when assessing the consequences of impulsive underwater sound for harbour porpoises is whether it endangers the conservation status of the population. In order to set acceptable limits for the effects on harbour porpoises, it is important to bear in mind that the conservation status of harbour porpoises on the DCS has been assessed as moderately unfavourable (Camphuysen & Siemensma 2011). It was therefore decided that the harbour porpoise population must not fall below 95% of the current population as a result of the construction of wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of the construction of the wind farms. Under the ASCOBANS (Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas) Convention, the interim target for harbour porpoises is that the population should reach, and remain at, a minimum of 80% of carrying capacity. It is not known what this capacity is on the DCS. Maintaining the population with a high degree of certainty at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period 2016 - 2030 can be considered a safe choice. This approach is in line with the spirit of the PBR approach: maintaining the population at a level that ensures enduring survival and even a return to the natural carrying capacity after the cessation or reduction of human activities.

Individual and cumulative effects of proposed activities on habitats should be assessed in terms of whether, and to what extent, they cause a measurable reduction in the total area of the relevant habitats (the relevant criteria are provided in the guidance document on significant effects (Leidraad significantie) published by the former Ministry of Economic Affairs, Agriculture and Innovation in 2009) and/or a measurable decline in the quality of those habitats (expressed in terms of abiotic characteristics, presence of typical species, etc.). This approach has not yet been included in the KEC.

3.5.2 Legal

From a legal point of view it is important to assess the effects of activities on the favourable conservation status of protected species or on the conservation objectives as set out in the designation decisions for Natura 2000 sites under the Nature Conservation Act.

The Nature Conservation Act has defined *favourable conservation status* as follows:
Favourable conservation status of a species:
'conservation status of a species, which implies:

a. that data relating to population dynamics for the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
b. the natural range of the species is neither being reduced or likely to be reduced within the foreseeable future, and

c. there is, and will probably continue to be, a habitat that is large enough to maintain the populations on a long-term basis';

Conservation objectives are defined in the Nature Conservation Act as follows:
conservation objectives:
'conservation objectives as referred to in Article 2.1(4)';
'Article 2.1(4): A decision as referred to in paragraph 1 shall include conservation objectives for the area. This shall include in any event the conservation objectives related to:

a. the habitats for bird species, in so far as they are required for the implementation of the Birds Directive, or
b. the natural habitats and species habitats to the extent necessary to implement the Habitats Directive.'

And *conservation* as:
conservation:
'set of measures required for the conservation or restoration of natural habitats and populations of wild fauna and flora at a favourable conservation status';

The conservation objectives themselves have been further elaborated for:

- Bird species: in terms of the 'size and quality of a habitat with a carrying capacity for a population of a certain number of birds (seasonal average)'[13]
- Species covered by the Habitats Directive: in terms of the 'size and quality of the habitat for the population';
- Habitat types: in terms of 'area and quality'.

The conservation objectives may be targets for the maintenance, expansion or improvement in the quality of a habitat. The minimum requirement for all bird species is a maintenance target but there may be an improvement requirement in some cases.

The consequences of activities for species can be assessed using rules of thumb such as the ORNIS criterion established by case law. The ORNIS criterion means that, if the effect of an initiative causes less than 1% of the annual mortality of the species, there is no demonstrable effect on the size of the population of the species and therefore no adverse effect on the favourable conservation status of the species. In this regard it is important to realise that, as soon as a better assessment method becomes available for the effect assessment, the ORNIS criterion will no longer be mandatory. It will always be possible to use the best available set of criteria at any time as long as sufficient evidence can be provided to demonstrate that those criteria provide sufficient safeguards for the conservation objectives. The guidance document on significant effects from 2009 can be used for the assessment of the effects on habitats[14].

3.6 Reduction of cumulative effects (Step 6)

3.6.1 Ecological

If the outcome of Step 5 indicates that the project or plan may have significant adverse effects, this should lead to a *response* in which measures are taken that will either reduce or eliminate the effects of the activities (*mitigation*) or otherwise ensure the maintenance of the conservation status of the affected species (*compensation*).

[13] For some bird species (for which fewer quantitative data are available) a target number of this kind has not been explicitly included in the designation decisions.

[14] Ministry of Agriculture, Nature and Food Quality, Nature 2000 Policy Research Centre, 2009

3.6.2 Legal

If there is a likelihood that a project will have significant adverse effects on a conservation objective that could endanger the favourable conservation status of a protected species or habitat (either as a result of the effect of the project or of cumulative effects produced in combination with other projects or plans), the next step is to investigate whether the consequences of the project can be limited to such an extent that the adverse effects are no longer significant and that the favourable conservation status is therefore no longer endangered. This step is called mitigation.

If, despite mitigation measures having been taken, significant adverse effects on the conservation objectives cannot be ruled out, Article 2.8 of the Nature Conservation Act requires an 'AIC' assessment. The first step is to examine whether there are alternative solutions (A) for the activity concerned. If there are no alternatives, the next step is to examine whether there are imperative reasons of overriding public interest (I). If there are none, the final step is to determine whether compensatory measures (C) can be taken. These are measures that offset the adverse consequences of the activity, for example by creating new areas of habitat to meet the objectives for the relevant species or habitats. In principle, compensation should be completed before the initiative is implemented.

Although the species provisions of the Act do not specifically mention mitigation or compensation, these are both possible under the Act when the possibility of the activity having an adverse effect on the favourable conservation status of a species cannot be ruled out. When an application is made for a discretionary permit involving a strictly protected animal species, the Act requires an assessment to be made in all cases of whether there are other satisfactory solutions that have a less adverse effect on the species in question. A discretionary permit of this kind is granted only when there is an interest in the development or activity designated by law. Mitigation measures follow from the Nature Conservation Act. An examination will also be required of whether there are alternatives or solutions for the project and how the project will be implemented, if there is the possibility of an infringement of a prohibition, so that the damage can be limited. In addition, mitigation measures are required by the duty of care set out in Article 1.11(1) and (2) of the Nature Conservation Act. Article 1.11(1) and (2) of the Nature Conservation Act states that everyone must take adequate precautions to care for wild animals and plants, and their immediate living environment. That duty of care implies in any event that anyone who knows or can reasonably be expected to suspect that adverse consequences may be caused to wildlife by his actions or failures to act should refrain from such actions or, if refraining from those actions cannot be reasonably required, take the measures required to prevent those consequences or, insofar as those consequences cannot be prevented, limit or rectify them as much as possible. Should the above-mentioned mitigation and compensatory measures not reduce the adverse effects to an adequate degree, it would be theoretically possible to look for possible reductions in other pressures.

4 Cumulative effects of offshore wind energy

The discussion now turns to the same steps as those covered in Chapter 3 but this time specifically for offshore wind energy.

4.1 Identification of the relevant pressures caused by the activity

To establish a picture of the relationships between the relevant pressures and the vulnerable habitats or species to be considered, it is helpful to distinguish between the construction phase, the operational phase and the decommissioning phase of the wind farms.

The main pressure in the construction phase is underwater sound from piling the foundations. The following pressures are also relevant in this phase:

- disturbance caused by mechanical activities, such as vibration and sound;
- attraction to and disturbance caused by light;
- disturbance caused by intensive shipping activity during construction;
- disturbance caused by excavation;
- disturbance caused by depositing material (scour protection for foundations with riprap).

In the operational phase, it is primarily the wind turbines themselves and the total marine area taken up by the wind farms that can have adverse effects on animals. The following pressures are relevant in this phase:

- habitat loss, possibly resulting in habitat fragmentation;
- disturbance of the migration routes of birds and bats;
- vibrations and sound;
- attraction to and disturbance caused by light (lighting);
- disturbance caused by maintenance vessels;
- contamination caused by the release of substances such as anti-corrosion and antifouling products;
- change in hydromorphological processes (such as currents and sedimentation);
- death or injury caused, for example, by collisions or near-collisions with turbines;
- change in species composition and food availability or competition for food through the introduction of new habitats (hard substrate), such as foundation piles and riprap around piles;
- effects of certain uses in wind farms (such as certain types of fishing);
- electromagnetic fields generated by cables.

In the decommissioning phase, the most important pressure is again most likely to be underwater sound and excavation. As yet, little or no experience has been acquired with this phase and so it is not yet possible to include the effects in this framework.

4.2 Identification of sensitive habitats and species

4.2.1 Ecological

For the protection of the marine habitats on the DCS required by the Nature Conservation Act, it will in all probability be sufficient to avoid the Natura 2000 sites there when planning the locations for offshore wind energy. For the time being, no wind farms will be planned in the protected Natura 2000 sites and the quality of the values in these sites will not be endangered by wind farms built outside those sites.

The issue is more complicated when it comes to the protection of species covered by the Nature Conservation Act. The Netherlands on its own does not have enough possibilities to safeguard the national favourable conservation status of typical marine species or their habitats through the designation and protection of Natura

2000 sites. This is because the relevant species are distributed throughout the North Sea and so no distinction can be made between populations in the Dutch Natura 2000 areas and those elsewhere (and neither is this possible for the DCS and the rest of the southern North Sea). The presence of these species in the marine Natura 2000 areas is therefore not an adequate safeguard to ensure that a national favourable conservation status can be attained and maintained for them, as a result of which the species protection provisions will be invoked more emphatically. This does not alter the fact that international coordination of the protection, management and use of Natura 2000 sites remains essential. This species protection is enshrined in Dutch law in the species protection provisions of the Nature Conservation Act, which include protection for these 'marine species' on the DCS and which now also explicitly include the consideration of cumulative effects.

Approach
The effects on the marine species have been assessed in the KEC on the basis of the biogeographical population (in the KEC, the populations on the DCS and in the southern North Sea respectively) so that a picture is obtained of the effect on the conservation status of the species concerned. Any significant effects on the populations in the Dutch North Sea can then be allocated proportionally to the relevant Natura 2000 sites.

New activities with potentially adverse effects on the species, such as the construction of wind farms, should be assessed in any event everywhere on the DCS to determine the scale and severity of these effects on any species considered to be potentially susceptible. The current environmental impact assessments and other studies for the development of offshore wind farms have shown that underwater sound in the construction phase in particular may have adverse effects on marine mammals and that, in the operational phase, it is primarily the wind turbines that may have adverse effects on birds and bats.

In the group of marine mammals, the most relevant species are the harbour porpoise, the common seal and the grey seal. In addition to these species, the white-beaked dolphin, common minke whale, humpbacks and common bottlenose dolphin are occasionally present on the DCS. It has been assumed for the time being, until evidence emerges to the contrary, that the harbour porpoise is the species in the group of marine mammals found in the North Sea that is most sensitive by far to the possible effects of piling sound during the construction of offshore wind farms.

The North Sea contains large numbers of saltwater fish and migratory fish species. All these species of fish are expected to be affected by underwater sound during the construction of the wind turbines.
However, as yet, there are still major knowledge gaps relating to the effects of underwater sound on fish. Their behaviour may be affected and that may in turn affect their availability as a source of food for other animals or influence the distribution of those predator species.

The birds found in the North Sea area can be divided into three main groups:
1. 'true' seabirds, which spend all of their time at sea outside the breeding season;
2. coastal birds, which breed or rest on or near the coast and fly over the Dutch North Sea every day during either the breeding period or the whole period they are present in Dutch coastal waters;

3. migratory land birds and water birds, which in general are not ecologically bound to the coast or the sea but display migratory tendencies in spring and autumn, either parallel to the coast in a NE–SW direction or in an E–W direction, or both, between the European mainland and the British Isles.

All three groups should be taken into account when assessing effects. Fewer species have been included in this KEC 3.0 (2019) than in KEC 1.1 (2015). In the case of the third category of birds, for example, only a few migratory species of water birds have been included and various species of songbirds have been disregarded. The bird species selected for inclusion in KEC 3.0 (2019) were the species that were near to or at the PBR in KEC 1.1.

Research has shown that bats (in wind farms) are more common at sea than previously assumed. For a number of years now, it has been known with certainty on the basis of various recaptures of ringed bats that, among others, Nathusius's pipistrelles also cross the North Sea to the United Kingdom. During this migration across the North Sea, the bats pass offshore wind farms and so there is a risk of collision. The bats in question are primarily Nathusius's pipistrelles.

As stated in 2.1, different interpretations are possible with respect to the relevant species to be considered. For example, the report by Buij *et al.* (2018) argues that a number of species are relevant other than those chosen for the KEC. Annex 5 provides further substantiation of the difference between the species selection made by Buij and the species considered in the KEC Part B reports.

4.2.2 Legal

In the Dutch sector of the North Sea (including the coastal waters) there are three habitat types for which special conservation zones (Habitats Directive areas) have been or are in the process of being designated. These are sandbanks which are slightly covered by sea (H1110), mudflats and sandflats not covered by seawater at low tide (H1140) and reefs (H1170). On the DCS, three areas that include these habitat types have been designated (Vlakte van de Raan, Voordelta and North Sea coastal zone), together with two other areas in the open sea (Dogger Bank and Cleaver Bank). In addition to these areas protected under the Habitats Directive, the Frisian Front has also been designated for the protection of the Common Guillemot under the Birds Directive. A decision has yet to be taken on the possible designation of Brown Ridge as a Natura 2000 site under the Birds Directive. So far, these seven areas have not been nominated for the development of wind farms and the protected habitats within them will therefore not be adversely affected by the wind farms planned in the Roadmap. In addition, with regard to habitats, there is also no question of external factors that affect designated Natura 2000 sites (in other words, factors outside a Natura 2000 area that affect a conservation objective for that area). As far as species and their habitats are concerned, effects are conceivable as a result of barrier effects, the loss of external habitat and/or the structural decline of populations as a result of a structural increase in annual mortality.

The harbour porpoise enjoys the highest level of legal protection under the Nature Conservation Act. It is now covered by Articles 3.5 and 3.8 of Section 3.2. The protection status of common and grey seals is less strict: these animals are now covered by Section 3.3 (Articles 3.10 and 3.11) of the Nature Conservation Act. There are extra protections for the harbour porpoise, common seal and grey seal in the marine Natura 2000 sites and along the coast: conservation objectives have been set explicitly for these species under the Habitats Directive.

All the bird species found at sea also enjoy the highest level of legal protection under the species provisions of the Nature Conservation Act and a number of species are also covered by additional protection provisions under the designation of specific Natura 2000 sites where they are covered by conservation objectives set explicitly pursuant to the Birds Directive.

All bat species also have a strict protection status under the Habitats Directive (at the European level) and the Nature Conservation Act (pursuant to Articles 3.5 and 3.8 of Section 3.2). Among other things, the species covered by Section 3.2 may not be killed or disturbed 'deliberately'. Species in Section 3.3 may not be killed 'deliberately'. 'Deliberately' means that a person knows (or can suspect) that effects may occur. Initiatives with effects of this kind can only be allowed under a discretionary permit or exemption which can only be granted if an assessment shows that the conservation status of the species will not be compromised.

The EC adopted the position that the framework of the Common Fisheries Policy is also the appropriate framework for restricting fishing activities in the marine areas in the Exclusive Economic Zone to comply with the Birds and Habitats Directives. Pursuant to the 1963 Fisheries Act, regulations can be introduced for sea fishing in the interests of nature conservation. Article 1.2(2) of the Nature Conservation Act states that the act does not apply to activities covered by the common fisheries policy, as referred to in Article 38 of the Treaty on the Functioning of the European Union, insofar as they are located in the Exclusive Economic Zone.

Only a few species of fish are protected by the Nature Conservation Act. Both species protection and area protection may apply to fish depending on the species. N2000 areas have been designated for the allis shad, twaite shad, houting, river lamprey, salmon and sea lamprey. In addition, pursuant to Article 3.5 of the Nature Conservation Act, a strict protection regime applies for sturgeons and houting. On the basis of Article 3.7, additional regulations may be introduced for the allis shad, twaite shad, river lamprey and salmon. Finally, Article 1.11 of the Nature Conservation Act[15] establishes a general duty of care for all animals living in the wild.

4.3 Inventory of other relevant activities

4.3.1 Ecological

Step 3 identifies all the relevant activities that can exert pressure on the species described in the previous step. The production of sound (in space and time) by seismic surveys and military activities (sonar and shooting exercises and the clearance of unexploded ordnance) and for the purposes of geophysical surveys (studies of the structure of the bed) for the wind farms are additional sources of underwater sound that can be taken into account during the determination of the cumulative effects. For the purposes of the 2018 calculations for the 2030 Roadmap, only the geophysical surveys have been included for the sound calculations. Underwater sound from seismic surveys, military activities, shipping, etc. is not included.
Other factors are also important for marine mammals, examples being mortality due to by-catch in certain types of fishing, disturbance by and possible collision with vessels, pollution and, for seals, disturbance as a result of coastal leisure activities.

[15] Article 1.11 (1): All persons shall exercise adequate care with respect to Natura 2000 sites, special national nature sites, and wild fauna and flora and their immediate living environment. Article 1.11 (3): The first paragraph shall not apply to acts or omissions in accordance with the provisions of, or pursuant to, this Act or the provisions of the 1963 Fisheries Act.

These factors have not been included either in these KEC calculations for 2018. Annex 3 contains a brief overview of the main activities at sea and their associated pressures.

Factors here that may cause the diminution of the size/quality[16] of the habitat and other forms of additional mortality resulting from human activities (such as collisions, but also hunting, poisoning, traffic, or other forms of indirect disturbance or loss of habitat) for birds are primarily: other wind farms, including those on land, professional shipping (which also results in disturbance in parts of the area where the birds live), professional fishing (as a result of disturbance and the impact on available food) and perhaps to a certain extent mining (including sand and shell extraction) and marine activities involving the Armed Forces. Pollution in the form of oil, microplastics and bioaccumulation of microcontaminants also play a role. These activities have not been included in the KEC.

4.3.2. Legal

The case law shows that only certain activities need to be included in the assessment of cumulative effects. Future activities do not have to be included if it is not certain that these activities will indeed be carried out. Neither do existing uses have to be included, because the effects of these should already be incorporated into the background situation (in other words: the current conservation status). The activities which must be included are the Dutch and foreign wind farms in the North Sea, as well as other licensed activities that have not yet been carried out (because their net effects cannot already have been incorporated into the current conservation status of the selected species), such as mining, sand extraction and seaweed cultivation. Legally speaking, 'other interventions' (such as seismic surveys) do not need to be included in the cumulative effects. The concept of 'other interventions' is challenging. Generally speaking, as long as there is no actual change in the physical environment, something will be considered to be another activity. For example, on land, larger livestock herds represent another activity.

Recently started activities that have not yet had an effect on the current conservation status may nevertheless also affect ecological values. This is particularly relevant for series of successive projects in a short period of time: the installation and subsequent operation of wind farms is an example here[17].

4.4 Determination of the cumulative effects of all activities

A description is given in this section of the approach to determining the cumulative effects of underwater sound on marine mammals and the cumulative effects for birds and bats associated with the operation of wind farms. Very little is known about how the different effects can interact to reinforce or weaken the overall effect, so nothing can be said about those effects in this assessment framework.

Underwater sound and marine mammals

For the time being, unless any further research indicates otherwise, research has shown that the harbour porpoise is the most sensitive of the marine mammals in

[16] The quality of the habitat in a wind farm could probably also improve as a result of an improvement in the food situation but, as long as seabirds do not become accustomed to the presence of wind farms and avoid those areas, it will obviously not be possible for them to benefit from this. It is not yet possible on the basis of the existing research data to determine whether habituation of this kind occurs. In addition, habituation in the case of Northern Gannets, for example, could suddenly lead in turn to an increased risk of collision because foraging individuals do indeed fly regularly at rotor height and, in addition, they are predominantly looking downwards at such times…

[17] For interesting case law on cumulative effects in wind farms (species protection), the reader may wish to consult, for example, the decision of 21 July 2010 (Sabina Polder) http://www.raadvanstate.nl/uitspraken/zoeken-in-uitspraken/tekst-uitspraak.html?id=46630 (in Dutch).

the southern North Sea to disturbance by underwater sound. It is therefore assumed that adequate protection measures for the harbour porpoise will also provide adequate protection for the other species of marine mammals. The sound disturbance contours from the construction of wind farms (both in the Netherlands and in the other North Sea countries) were determined in order to establish a picture of the total area disturbed by piling sound (impulsive sound) for a certain period of the year for the species considered to be most sensitive to this sound, the harbour porpoise. These contours can be compared with information on the distribution of the harbour porpoise to obtain an estimate of the number of harbour porpoises that will be disturbed, and for how many days, by the construction of the proposed wind farms (harbour porpoise disturbance days).

The cumulative effect of underwater sound on the harbour porpoise was calculated in Step 4 using the expert model developed for this purpose: Interim PCoD (*Population Consequences of Disturbance*). This model can state the consequences of disturbance of the numbers of harbour porpoise determined in Step 3 as the consequences for the population of this species compared with the situation without the proposed activity. A more detailed explanation of how this PCoD model is used in the KEC can be found in the Annex to Part B (Heinis *et al.* 2018).

Fish
As far as is known, fish are only affected by sound levels higher than those affecting harbour porpoises. It is therefore assumed that, if protective measures are adequate for the harbour porpoise, the protected fish species or the fish species that form an important source of food for protected mammals or birds will also be adequately protected. This assumption could change in the light of new research and insights.

Birds
Wind farms affect birds in four ways:
1. Avoidance of the areas where the wind turbines are situated. This leads to the displacement of certain species which no longer 'recognise' the wind farm as part of their habitat. As long as there is no habituation, this results in the diminution of the area in which these species live.
2. Barrier effects of wind farms. If wind farms are located in places situated on the routes taken daily by birds from their resting or breeding areas to their foraging areas at sea, the birds may be forced to go around or through the farms (with the risk of collisions as a result). In addition to natural factors such as wind strength and direction, this may lead to greater energy use, loss of foraging time, loss of condition and/or a much higher risk of collision with rotating turbine blades (see 3).
3. Collision fatalities or injuries. These mainly involve birds that fly through areas with wind farms, either while foraging or during seasonal migration in spring and autumn along the coast and/or over the southern North Sea.
4. Attraction of bird species that see enhanced foraging opportunities, resting opportunities and food supplies ('better habitat quality').

The first three ways birds are affected during the operational phase of the wind farms were cumulated for each species for each individual wind farm. The fourth effect (attraction) will be left out of the equation for the time being because concrete evidence for this effect has only been found in the case of the Great Cormorant. If it should later emerge that, for whatever reason, wind farms provide a higher-quality foraging habitat for seabirds and that the species that now avoid wind farms start to become accustomed to the presence of those farms, this factor

could become more significant. The effects per species of all the Dutch wind farms and all wind energy initiatives in the southern North Sea were then cumulated and the virtual mortality was calculated.
KEC 3.0 (2019) does not include the effects of other plans, projects and activities in the southern North Sea on the same species or groups of species. Ideally, of course, this should be done.
The cumulative pressures in Step 3 that lead to a loss of habitat (for seabirds) or direct mortality due to collisions are stated for each species as population loss (annual 'extra' mortality or leaving the study area of the southern North Sea or DCS).

Two models are available for quantifying collision mortality. They are described below. More details on these models can be found in the background report accompanying Part B.

1. Bradbury model
   An expert model was developed to calculate the combined effects of habitat loss and collision mortality (Bradbury *et al.* 2014) and this model can be used in any event for seabirds and coastal birds.
   The Bradbury model uses data on the presence of seabird species and their species-specific sensitivity indices to wind farms to map the relative sensitivity of marine waters to offshore wind farms. This makes it a suitable tool for marine spatial planning.

   This model assumes, for the time being[18], that loss of habitat for seabirds and coastal birds will lead to a 10% increase in mortality (or definitive emigration) for the birds affected. This assumption is based on WMR's interpretation of Bradbury *et al.* (2014), in which this factor is not further explained[19]. The assumption must therefore be considered to be an arbitrary choice. The part played by density effects on the development of populations has hardly been investigated at all and is largely unknown. Unfortunately, no other estimates are known. In a worst-case scenario, 100% displacement (mortality or definitive removal from the population) could be justified, but this does not reflect the current reality and has no basis in the literature. In any case, it is safe to assume that the 'additional mortality' as a result of habitat loss will increase as a percentage if wind farms take up a much greater share of the marine area than is proposed for the period through to 2030, at least as long as there is no structural habituation. That is why, conversely, the additional mortality could be reduced almost to zero if the species that avoid turbines become habituated to the presence of operational wind farms.

   It has been argued that this model can also be used to calculate the increase in collision mortality for the same species of seabirds and coastal birds. The model draws on assumptions based on expert judgement about the species-specific

[18] If the proportion of the habitat that has become unsuitable as a result of a further increase in, for example, wind farms becomes much higher and the avoidant seabird species do not become accustomed to the presence of those farms, then that 'mortality/emigration rate' will obviously increase considerably at some point. This aspect begins to play a role from the point at which the remaining areas at sea either become too small to provide sufficient carrying capacity for these seabirds or become inaccessible because of the barrier effect of the wind farms.

[19] Leopold *et al.* (2014) have the following to say in this respect: "In the analyses in this report, we follow the suggestion given by Bradbury et al. (2014) to use a factor of 0.1 (or 10%) for mortality of displaced birds. …….For the present study, we have extended their methods by introducing a scaling factor, which allows us to estimate absolute mortalities, per seabird species and per individual wind farm based on quantitative information on densities of seabirds..'.

behaviour of the different species (such as the proportion of time spent flying/swimming, flight height, micro-avoidance, etc.). Each bird species was assigned to categories for the various parameters. This means that the values for the proportion of time spent flying/swimming were not specific to each individual species but that each species was assigned to one of five categories.

2. Band model
   The Crown Estate's Strategic Ornithological Support Services (SOSS[20]) group published a model in 2012 to quantify bird collisions with offshore wind farms (Band 2012[i]). This 'Band model' originated from the theoretical model of collision risk of birds with wind turbines first described by Tucker (1996) and later by Band (2000) and Band *et al.* (2007).

   This model can be used for all bird species (including migratory land birds) and is based on existing data on bird fluxes per species per place, data on flight heights and flight velocities per species, the sizes of the individual bird species, data on the wind turbines themselves (lowest point of the rotor, total height, rotor diameter, rotor speed, etc.) and indices for macro-avoidance (of wind farms) and micro-avoidance (of wind turbines). The Band model can be used to make calculations for all selected species if the correct assumptions are plausible and feasible for each species.

The table below shows the effects on bird species groups and the model used to obtain these effects in the KEC (- = not calculated, + = calculated).

		Band model	Bradbury model
seabirds	avoidance/habitat loss	-	+
	barrier effect	-, because effect is local	
	collisions	+	
	attraction	-	
coastal birds	avoidance/habitat loss	-	-
	barrier effect	-, because effect is local	
	collisions	-	-
	attraction	-	
migratory birds	avoidance/habitat loss	not applicable	
	barrier effect	-, because effect is local	
	collisions	+	-
	attraction	-	

Table 1: Characteristics of effect models for birds

The applicability of the Band model depends on the availability of location-specific data about wind turbines and bird presence, which is why the Band model is more detailed than the Bradbury model (2014), making it suitable for use in project EIAs.

None of the models have been validated on the basis of actual measurements of collision victims at sea because it has proven to be extremely difficult to make reliable measurements of the numbers of actual collisions between rotating turbine blades and flying birds (or bats). This is difficult primarily because it is impossible to recover carcasses, which in turn makes it extremely difficult to identify the species of bird or bat concerned. Many techniques are being developed to record collisions –

[20] Group established by the Crown Estate (UK) to identify important ornithological issues for the English offshore wind sector. At the time, Bureau Waardenburg from the Netherlands was an SOSS secretariat partner.

indeed, some are already being applied – but clear results have not yet been published. As long as we still do not know how many actual victims there are among the various species of birds and bats, the Band model would seem, for the time being at least, to provide the most realistic estimates of the numbers of collision victims, especially given the fact that this model contains the best descriptions of the characteristics of wind turbines. The Band model, however, is very sensitive to certain parameters such as avoidance rates. A difference of a few tenths in avoidance percentages can lead a difference in the calculated number of collision victims amounting to percentages in multiples of ten.

There are models to determine energy loss in some bird species as a result of the barrier effect of wind farms. These show that offshore wind farms result in negligible effects for long-distance migrants (such as the eider duck) (Masden *et al.* 2009[ii]). For other birds it also appears unlikely, given the scale of the southern North Sea in relation to the location of the wind farms currently planned and the flexibility of the usual migration routes, that the barrier effect will lead to structural avoidance behaviour that could cause any more than negligible effects.

It is thought that barrier effects can result in significant effects only at specific sites (for example in the immediate vicinity of breeding colonies, exactly on the main routes to the main foraging sites). However, even there, collisions would appear to pose a more serious risk. These types of effects should be described and assessed in site-specific EIAs and AAs.

Bats
There are still many knowledge gaps relating to bats, examples being population size and behaviour in relation to the presence of operational wind farms. Furthermore, there is no reliable model for estimating the number of collision victims at sea for this species group. Estimating effects at the population level is not yet possible because there are not yet any reliable population estimates.

The conclusion is that there is still insufficient knowledge available to produce estimates of numbers of bat victims that can be used in a CEA other than by expert judgement.

4.5 Assessment of results

This section discusses the standards for evaluating whether the effects are acceptable or not.

4.5.1 Ecological

Birds and bats
For the time being, the preferred standard in this assessment framework for assessing cumulative mortality is the PBR. The underlying theory is that, as long as the additional annual mortality due to the cumulative effects does not exceed the PBR, the population will not decline.

The use of PBR as an acceptable measure has been criticised (for example by O'Brien *et al.* 2017) for not being sufficiently cautious, particularly in the case of smaller populations. However, as yet, there is no adequate alternative. Until that is the case, PBR will be used cautiously. WOZEP is working on the development of a better assessment method. However, no population models or a new method for an acceptable measure are yet available.

Harbour porpoises
The most relevant question when assessing the consequences of impulsive underwater sound for harbour porpoises is whether it endangers the conservation status of the population. Calculations by Scheidat *et al.* (2013) show that, according to the PBR method, the threshold of acceptable mortality for the DCS is 272 animals/year for all activities. However, this value refers to direct mortality and does not take into account the possible indirect effect of reduced reproduction. In order to set acceptable limits for the effects on marine mammals, it is important for the conservation status of harbour porpoises on the DCS to be assessed as unfavourable-inadequate (Camphuysen & Siemensma 2011). On the basis of the interim recommendations of the Netherlands Commission for Environmental Assessment on the draft EIA for sites I and II of the Borssele wind energy area, it has therefore been decided that the harbour porpoise population must not decline below 95% of the current population after the construction of offshore wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of the construction of the wind farms. On the basis of the data from Geelhoed *et al.* (2011, 2014), it has been estimated that the population on the DCS consists of 51,000 animals (Scheidat, personal communication). This means that the total population should exceed 48,450 animals.

Under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the interim target that has been set for harbour porpoises is that the population should not fall below 80% of the carrying capacity. It is not known what this capacity is on the DCS. Maintaining the population with a high degree of certainty at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period 2016 - 2030 can be considered a safe choice.

In addition to the possible effects of offshore wind power facilities, the harbour porpoise population is also affected by other factors. Major influences are by-catch during fishing and disturbance by underwater sound, especially from seismic surveys for oil and gas extraction. Estimates of shipping effects, explosions[21] and other anthropogenic sources cannot be made at present. The Conservation Plan for the Harbour Porpoise Phocoena phocoena in the Netherlands assumes that 150 to 250 animals are killed by fishing activities each year. The effects of seismic surveys may well be much more substantial. It is not clear to what degree the effects of these activities and fisheries have already been incorporated into current population trends. In this KEC, none of the other activities that may have an effect on the harbour porpoise have been included in the calculations.

Birds
The preferred standard in this assessment framework for assessing cumulative bird mortality is the PBR. The idea is that, as long as the additional annual mortality due to the cumulative effects does not exceed the PBR, the population will not decline. In that case, the cumulative effects will not be significant and they will therefore be acceptable.

Bats
The rough estimates of the cumulative effects of collisions and barotrauma on bats are also compared with the (equally roughly estimated) PBR for the three species in

[21] A study of explosions is currently ongoing. After that study has been completed, it may be possible to say more about the effects of explosions.

question. However, the population data on Nathusius's pipistrelle, common noctule and parti-coloured bat are still so rudimentary that this assessment is at best indicative. Further studies have been made of Nathusius's pipistrelle looking at numbers in relation to weather conditions (Lagerveld *et al.* 2017, Boonman 2018).

4.5.2 Legal

Marine mammals

Harbour porpoises are covered by the ASCOBANS agreement, which contains provisions for the protection of all toothed whales, with the exception of the sperm whale. For the harbour porpoise, ASCOBANS contains a 'best efforts' standard.

Bats

There are no standards as yet for determining adverse effects on bats in national or international legislation. The standard for assessing the effects on bats in the KEC is also the PBR.

Birds

Two methods are used at present to determine the threshold for significant effects on birds.

1. ORNIS criterion

According to this criterion, which was drawn up by the ORNIS Committee, each increase in mortality of less than one per cent of the annual natural mortality rate[22] of the population concerned (average value) may be considered to be not significant in the absence of any contrary scientific evidence. The Court of Justice uses this criterion as its benchmark for assessing whether an effect is significant or not (e.g. case C-79/03 (Commission/Spain)). In this regard it is important to realise that a better assessment method should be used as soon as it becomes available, also from a legal point of view. In practice, when adequate data are available on the mortality rate of a population, this criterion can be used to determine whether it is possible to rule out the occurrence of any significant effects. If the extra mortality rate of a species due to the effects remains below the threshold, it no longer has to be considered in the assessment. If the extra mortality exceeds the 1% threshold, the effect may be significant and a more detailed investigation of possible population effects will be necessary.

2. Potential biological removal (PBR)

The PBR method (see Section 3.5.1) draws on scientific information about the populations of the relevant species. This makes it a generally applicable method that nevertheless provides enough confidence about maintaining actual population levels while providing more latitude for initiatives. The PBR method has been criticised (for example by O'Brien *et al*. 2017), among other things for not being cautious enough, particularly when small areas and populations are being considered, because density dependence is implicitly built into the method. However, as yet, there is no adequate alternative. Until that is the case, PBR will be used cautiously. WOZEP is working on the development of a better assessment method.

Legislative requirements

Under the species provisions of Nature Conservation Act, the effects on the animal species listed above must be assessed at the level of their biogeographical populations to obtain an indication of the effect on the conservation status of the

[22] It should be noted that it will be possible to determine the annual mortality of a species only if enough population-dynamic parameters for that species have been measured in the field.

species in question. The assessment on the basis of Natura 2000 conservation objectives can be carried out in two ways:

1. Effects on populations in the southern North Sea. These have a direct bearing on the presence of the species in the Natura 2000 areas. This applies specifically to mobile species that move across national borders and for which protection in Natura 2000 sites does not safeguard the continued survival of the populations (see Section 2.5). This means that, in the event of the expected effects exceeding the acceptable standards (such as, for the time being, PBR), significant negative effects on conservation objectives cannot be excluded.
2. For initiatives near Natura 2000 sites that have an additional or special function for some species (such as breeding grounds of the Sandwich Tern and Lesser Black-backed Gull, resting, moulting and nursery habitats of the common and grey seals, and Common Guillemot moulting habitats), a location-specific assessment must be made under the Nature Conservation Act (in project-related EIAs and appropriate assessments). This assessment must include a determination of whether the cumulative effects of the initiative inside the boundaries of Natura 2000 sites impinge on the integrity of the sites with respect to the size, quality and carrying capacity of the habitat types and species habitats in the Natura 2000 sites that are covered by conservation objectives.

Because of its location-specific nature, the second approach should be elaborated in project EIA/AAs in site decisions and the designation of new wind energy areas.

4.6 Reduction of cumulative effects

4.6.1 Ecological

If adverse effects cannot be ruled out, mitigation measures will have to be taken to reduce the effects on the species of the construction and/or operation of the new wind farms to such a degree that the cumulative effects can no longer damage the conservation status of the selected species and so will no longer increase the risk of not meeting the conservation objectives for these species in the relevant Natura 2000 sites[23].

4.6.2 Legal

As described in Section 3.6.2, mitigation measures are mandatory when adverse effects on Natura 2000 sites and their protected habitats or species cannot be ruled out.

If, after an assessment has been made of the effects of the initiative with mitigation measures on Natura 2000 sites, the effects in question have not been sufficiently reduced, the Nature Conservation Act requires the rejection of the initiative (which will therefore not be considered eligible for a permit), unless it can still be implemented on the basis of the AIC criteria. In any event, the alternatives will have to be located in other areas designated for offshore wind farms (if the significant effect on the Natura 2000 site will be eliminated by doing so). The production of renewable energy can be seen as an imperative reason to override public interest. Compensation can only be considered if there are no alternatives.

[23] If negative effects cannot be prevented and mitigation measures are required, this is an area that will be assessed as part of a satisfactory alternative solution (and not in the context of a duty of care or the conservation status). The alternative must be chosen that combines solving the problem with the best possible protection for the species (see pages 58-60 of the Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC). This may involve taking mitigation measures that are not solely designed to maintain a favourable conservation status.

Pursuant to the species provisions of the Nature Conservation Act, compensation may also be considered a solution that justifies the granting of a discretionary permit after all if mitigation measures are inadequate.

5 Determination of effects and assessment of the 2030 Offshore Wind Power Roadmap

Whereas Chapter 4 describes a general method for determining the cumulative effects of offshore wind energy, this chapter takes a more detailed look at several options for drawing up a final calculation of the cumulative effects for the 2030 Roadmap. The calculations themselves can be found in the Part B reports.

5.1 Identification of relevant pressures

For the calculation of effects it was decided to take all the wind farms in the 2030 Roadmap, as well as the farms that have already been built, with the exception of OWEZ and PAWP, as the starting point for the assessment of cumulative effects when preparing the first site decisions. A supplementary memorandum has been produced for collisions in OWEZ and PAWP because the latest site decisions will have to take the previous site decisions into account. The aim here is, therefore, to provide as accurate a picture as possible of the total cumulative effect in order to maximise the chances of completing the 2030 Roadmap without running up against constraints that may arise in connection with possible cumulative effects. This approach also takes into account the comments made by the Netherlands Commission for Environmental Assessment on the national spatial strategy for offshore wind power (Rijksstructuurvisie Windenergie op Zee). All the future wind farms planned in the period leading up to 2030 were therefore included in the assessment of the 2030 Roadmap. During that process, the bandwidth and measures were included in the cumulative effects for the parks for which it was already known (because of a permit or a site decision) which requirements were in place with regard to bandwidths and measures. Logically, the future farms will be included as more generic units. The site boundaries for the various farms are not yet known and therefore existing restrictions with regard to, for example, mining, cables and pipelines, and the distances between them have not yet been taken into account.

The key pressures that determine the cumulative effects are, for the construction phase, underwater sound caused by pile-driving and, for the operational phase, bird and bat mortality resulting from collisions and loss of habitat. The decommissioning phase has not yet been included. New innovative techniques have not been taken into account.

5.2 Identification of sensitive habitats and species

On pragmatic grounds, it was decided to define a study area for birds and bats during the identification of effects at the level of biogeographical regions. This area is the southern North Sea. The decision was based primarily on the characteristics of the area and the functions it has for the relevant species. This area is a relatively shallow (predominantly less than 200 m deep), warm and sheltered part of the North-East Atlantic region. Further north the North Sea 'bottleneck' becomes wider, the water becomes deeper and colder and the direct impact of the Atlantic Ocean is felt more strongly, making this a habitat for other species. The southern North Sea is a highly varied area with influences of cold Atlantic water and eutrophic water from the land. Gulls, terns, divers and Common Guillemots are the most relevant birds in this area; harbour porpoises, common seals and grey seals are the most relevant marine mammals. Moreover, the south of the North Sea is an important flyway between the European mainland and the United Kingdom and it acts as a bottleneck for a number of north–south migration routes, mainly for land birds. In consultation, WMR and Rijkswaterstaat drew the boundaries of the southern North Sea (see Figure 3) in such a way that the whole of the Dogger Bank is included in

the study area. It now consists of the southern North Sea between 51°N (about the latitude of Calais) to 56°N (just to the north of the point where the three national continental shelves meet at the northern tip of the DCS, and from the British coast to the European coastline (excluding the Wadden Sea and the Zeeland sea inlets behind the delta barrier).

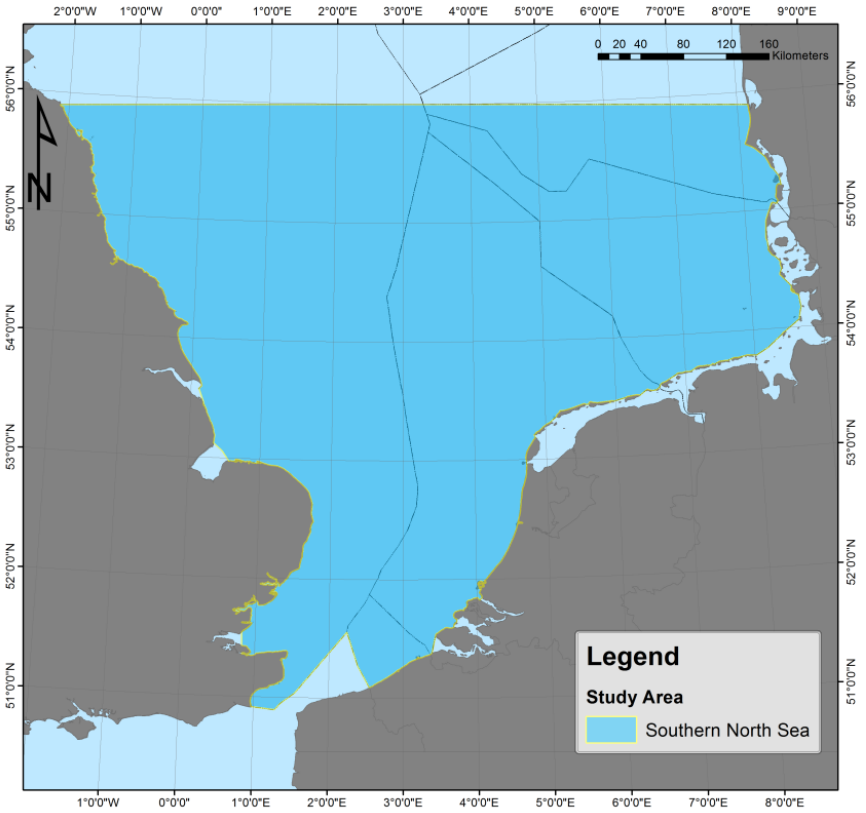

Figure 3: Study area for birds and bats

The effects on the harbour porpoise appear to be the key factor for underwater sound. The management units defined by ICES at the request of the European Commission and the OSPAR Commission (see Figure 4) were adopted as a relevant sub-population for the harbour porpoise. This allocation to sub-populations is therefore internationally recognised. As the DCS population of the harbour porpoise is part of the population in the NS management unit, this sub-population was adopted as the basis for the calculation of international scenarios.

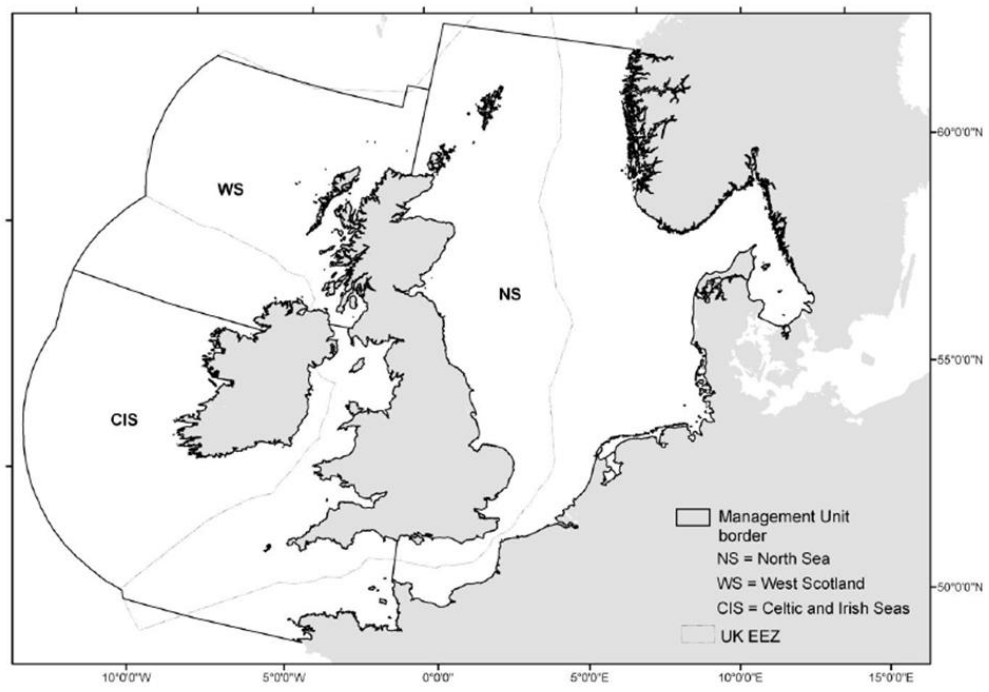

Figure 4: Study area for harbour porpoises

5.3 Inventory of other relevant activities

The calculation of the effects of underwater sound on harbour porpoises is based on activities from the offshore wind energy sectors (national and foreign wind farms in the North Sea in the study area). The information available about military activities (particularly clearing unexploded ordnance) was inadequate for its inclusion in the calculation of cumulative effects. Seismic surveys were not included because one could argue that this sound resulting from oil and gas prospecting has been present for many years and, given the decision to adopt population dynamics parameters, this factor has already been taken into account implicitly in the Interim PCoD model. However, it is assumed here that prospecting activities are, on average, comparable in all years. Additional activities should therefore be included. However, it is not clear which activities and at what level will be deployed by the sector in the period leading up to 2030. The calculations of the effects for the 2030 Roadmap do include the geophysical surveys for the Dutch wind farms that will be built from 2024 onwards (see Part B report, TNO, HWE 2018).

The calculations for birds and bats included the effects of national and foreign wind farms in the study area of the North Sea to the extent that they are almost certain to be built. Disturbance caused by major shipping lanes has not been included in KEC 3.0. It was found in KEC 1.1 that this added little to the total effect of habitat loss.

5.4 Calculation of the cumulative effects for the 2030 Roadmap

Harbour porpoises

The effects of underwater sound on the harbour porpoise population were calculated in a series of stages:

1. Sound propagation per piling strike;
2. Disturbance area;
3. Number of disturbed animals;
4. Animal disturbance days per offshore project and total;
5. Population development over the years (using the Interim PCoD model).

The final model results are presented as a reduction in the harbour porpoise population in the years leading up to 2030. The exact steps taken and assumptions made in this project are described in the background report to Part B. The calculations are based on scenarios with different assumptions for the number of farms considered. The reports in part B describe the scenarios.

Birds
The calculation of cumulative effects on birds included the habitat loss resulting from the presence of the wind farms and the effects of bird collisions with wind turbines. The loss of habitat is based on the assumption that 10% of the 'displaced' birds die or that the animals that suffer this loss of habitat emigrate definitively, or in any event are removed from the population of the southern North Sea. This assumption is based on WMR's interpretation of Bradbury *et al.* (2014), which does not contain any further discussion of this factor. The Band model was used to calculate collision victims.

Bats
A lot is still not known about the presence and behaviour, and therefore the sensitivity of, bats at sea to operational wind farms. Expert judgement, in combination with the analyses of the relationships between weather conditions and bat observations offshore, were used to produce indicative estimates of possible effects. Mitigation measures were then proposed in line with the precautionary principle.

5.5 Assessment of results

5.5.1 Ecological

Harbour porpoises
The results of the model calculations for wind farms must be assessed on the basis of the thresholds (limits of acceptable change) derived from the ASCOBANS interim objective. Under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the interim target that has been set for harbour porpoises is that the population should not fall below 80% of the carrying capacity. However, it is not known what this level is on the DCS. The government has therefore decided that the harbour porpoise population must not fall below 95% of the current population as a result of the construction of wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of the construction of the wind farms.
Maintaining the population with a high degree of certainty at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period 2016 - 2030 can be considered a safe choice.

Birds
The results of the model calculations for wind farms must be assessed against the thresholds (limits of acceptable change) obtained using the PBR approach.

Bats

Too little is known about bats to be able to make any sort of reliable calculation of cumulative effects. However, on the basis of the assumptions made, it has been estimated that the favourable conservation status of Nathusius's pipistrelle could be endangered. Given the precautionary principle provided for by the Nature Conservation Act, mitigation measures must therefore be prescribed to limit the number of bat victims. A proposal for a mitigating measure can be found in Part C.

5.5.2. Legal

Underwater sound

In addition to the determination of the effects at the population level for harbour porpoises, an EIA still has to make an assessment based on the conservation objectives for the Natura 2000 sites. This issue will require more detailed investigation in the project EIAs and AAs. Significant adverse effects may also occur due to the location of specific wind farm sites, such as the disturbance of seals on sandbanks near the shipping lanes used by maintenance vessels. These site-specific matters are not discussed in greater detail in this version of the KEC but they should be further investigated in the project EIAs.

Birds

Natura 2000 sites that have an additional or special function for some species and that are near/relatively near to planned wind energy initiatives should be the focus of particular attention in the assessment made pursuant to the Nature Conservation Act (see Section 2.4). For birds, these are the Natura 2000 sites where seagoing birds such as the Sandwich Tern and Lesser Black-backed Gull breed. During the breeding season these birds regularly go on foraging flights within a certain distance of the nesting areas. Significant consequences due to external effects on for example swans, ducks, geese and waders will also have to be considered in the project EIAs.

Bats

The available information on bats is too limited to be able to make a sufficiently reliable calculation of the cumulative effects. Given the precautionary principle in the Nature Conservation Act, measures for bats must be implemented on the basis of assumptions. In addition, a study is being carried out as part of, among other initiatives, the WOZEP.

6 Knowledge gaps and follow-up actions

6.1 Knowledge gaps and additions to the models and methods used

There are still a considerable number of knowledge gaps relating to both methodological aspects (process, ecological, legal) and ecological aspects. Some of these gaps have been filled by assumptions based on expert judgement; others have been remedied by making pragmatic assumptions and setting up and conducting research, as in the WOZEP. However, the assumptions made will have to be validated in due course where possible, preferably on the basis of the results of future research. In addition, the ecological knowledge gaps are covered in the research reports in Part B.

The research community is not standing still. Research is underway into the effects of offshore wind farms on marine life, both in the Netherlands and elsewhere. These studies will deliver partial answers to the research questions. In addition, research into the knowledge gaps mentioned in this Framework (WOZEP) began in 2016. A number of studies have resulted in changes to the assumptions for the calculations made in Part B of this KEC 3.0 (2019).

6.2 Ecological latitude after 2030

This Framework for Assessing Ecological and Cumulative Effects has been developed to ensure that the effects of the development of offshore wind farms do not exceed the ecological latitude for the use of the North Sea ecosystem. This means that, if the effects of an initiative remain within the limits of acceptable change, the initiative can be permitted from both an ecological and a legal point of view. However, this also means that when a subsequent initiative is assessed, the remaining ecological latitude in the ecosystem will be less; its resilience will have decreased. This is why it was decided to assess the development of offshore wind farms as set out in the Roadmap. The KEC was used to identify and assess the total cumulative effects of the whole Roadmap, despite the fact that, strictly speaking, there is no legal reason to take into account planned wind farms that have not yet been granted a permit. Adopting this approach makes it possible, when designing and building all wind farms, to ensure that the latest wind farms can also be built and operated without causing any ecologically or legally significant effects.

The KEC 3.0 does not look further ahead than the year 2030. It is clear that the North Sea ecosystem must still maintain sufficient ecological latitude, even after 2030, for either offshore wind energy or other initiatives. It therefore makes sense to take this into account from the outset when rolling out the Roadmap. One way to do this would be to deploy mitigation measures for each wind farm site to avoid damage to ecological values as far as possible. The initial high levels of investment this may involve can be recouped over the longer term in the form of the benefits of maintaining ecological latitude in the North Sea ecosystem.

The generic approach taken by the KEC as described in Chapter 3 will also be applicable to very different interventions in other places but other options should be used for the defining pressures, species, calculation models and assessment frameworks.

Annex 1 Concepts and definitions

Netherlands Commission for Environmental Assessment
The Netherlands Commission for Environmental Assessment is an independent advisory body that gives advice on all environmental impact assessments (with or without an accompanying appropriate assessment) prepared for plans or projects.

Cumulative effects
Effects are described as changes in the physical, natural or cultural environment caused by a development project that fall outside the natural range of events. Cumulative effects are all the effects on the environment resulting from an activity or project in combination with the overlapping effects of other, earlier, current or future projects and activities.

Biogeographical region
Europe is divided into areas called biogeographical regions within which species and habitats are protected. These regions are found both on land and at sea. The Netherlands is located in the Atlantic region. This large region is divided into smaller sub-regions, often derived from international agreements and protocols. For example, OSPAR works with different sub-regions than the Marine Strategy Framework Directive. The region used in this document covers the southern North Sea biogeographical region, which falls within the exclusive economic zones of the UK, the Netherlands, Germany, Denmark and Belgium.

Significant effect
An effect of human activities on a legally protected ecological value (such as a conservation objective for a Natura 2000 site or the conservation status of a protected species) is considered significant, in the legal meaning of the word in European nature conservation legislation, if the realisation of that conservation objective or favourable conservation status cannot be guaranteed as a result of that effect.

Good/favourable conservation status
The population size of every species in a specific area is always influenced by a balance of factors. If the population size exceeds the carrying capacity, numbers will inevitably decline due to insufficient food and competition for resources between the individuals because the reproduction rate will be lower than the mortality rate. A minimum number of individuals, depending on the species and the area concerned, are needed to maintain the population, prevent inbreeding and to absorb the effects of disease and natural calamities. A good/favourable conservation status is the minimum number of individuals needed to maintain the population in that specific area on a long-term basis. It is advisable not to work from this minimum number but to increase it by a certain number as a reserve capacity so that the population can cope with any unforeseen additional effects or accumulation of effects in the future without the population collapsing.

Mitigation
Mitigation measures are measures aimed at minimising or removing the disturbance or damage caused by a project or activity by altering or amending the proposed activity. Examples of measures of this kind include sound abatement systems, such as bubble curtains around the places where pile driving operations are held to construct the foundations of the wind turbines to reduce the propagation of sound from pile-driving. Mitigation measures can also include choosing alternative methods that make it unnecessary to drive piles at all and so reduce or eliminate the

underwater sound such as the use of other types of foundations for the wind turbines. Prescribing larger turbines, for example, can also be a mitigation measure.

Compensation
Compensatory measures are measures designed to offset the negative effects of an activity by taking measures not included in the proposed activity. Compensatory measures may be taken only when mitigation measures have already been taken but have not eliminated the disturbance or damage, when there are no alternatives available to the proposed activity and when there are imperative reasons of overriding public interest for carrying out the proposed activity. Compensation involves either creating a new or enlarged area of habitat or improving the habitat quality of part of the site. Choosing between these options depends on the location of the damaged area, its legal status, the species affected and the possibilities for compensation. If no compensation is possible and significant effects cannot be excluded, the proposed activity cannot proceed.

Annex 2: DPSIR method

DPSIR introduction
Drivers, Pressures, States, Impact, Response model - Netherlands (TNO for EEA)

The European Environmental Agency (EEA) established the DPSIR system in 1999 with the aim of developing a shared language/approach for visualising cumulative effects (see literature). The relationships between activities, effects on species and the policy response are schematically mapped out in a number of steps (*drivers*, *pressures*, *states*, *impacts* and *responses).*
Originally, the DPSIR method was designed to assess cumulative effects at a relatively high level of abstraction (Figure 1). However, it is also very useful for a systematic approach at a concrete level to planned interventions/projects.

DPSIR development
The abbreviation DPSIR stands for *Drivers, Pressures, States, Impact* and *Response.*
In the DPSIR method, the *drivers* represent economic and social policy goals of governments (for example, society needs electricity as an energy source). These *drivers* lead to *pressures* on the environment and the *state* of the environment changes as a result (examples being health, availability of resources and biodiversity). In turn, this *state* change has a certain *impact* on both human health and ecosystems. Subsequently, this can generate a certain social *response*, causing *drivers*, *pressures* or *states* to change as a result of changes or solutions.
See the next section for a more detailed discussion of the various components of DPSIR in relation to the effects of offshore wind energy.

Figure 1: A generic representation of the DPSIR model
http://www.eea.europa.eu/publications/92-9167-059-6-sum

DPSIR in the Framework for Assessing Ecological and Cumulative Effects
The DPSIR model, as applied in the KEC, works on an abstraction level that is slightly different from the original DPSIR abstraction level. DPSIR looks at cause-effect relationships between anthropogenic pressures and different species.

The level of *drivers* is defined as human activities that can have an impact on the environment, such as offshore wind turbines, but also very different factors such as sand extraction, gas and oil production, professional shipping, fishing, etc. In the original DPSIR system, this would be at a higher abstraction level: the *driver* considered is 'society needs electricity as an energy source'.
The main use function (*driver*) that will also be processed quantitatively in the KEC as much as possible is offshore wind energy. The most important *pressures* that result are underwater sound, collision victims and habitat loss. However, these *pressures* can also be generated by other *drivers* such as:

- Seismic surveys (*pressure* = underwater sound);
- Explosives (*pressure* = underwater sound);
- Shipping (*pressure* = displacement and underwater sound).

These *drivers* will not be discussed in the KEC.

The *pressures* on the environment resulting from these *drivers* may include loss of habitat, (excessive) underwater sound and mortality among birds or bats due to collisions with the rotor blades of a turbine. The next step is to look at the effect of these *pressures* on the *state* of a species or groups of species. The *state* is the condition of the species or species group as it would be in natural, undisturbed

conditions. The *impact* on that *state* as a result of the *pressures* caused by the *drivers* is, for example, a decline in the population (due to collisions) or impaired fitness (due to habitat loss caused by factors like underwater sound). The subsequent human *response* is what people can/will/must do to prevent or counteract the *impact* in the future. This includes mitigation measures during the installation of wind turbines (noise barriers, bubble curtains etc.). A *driver* can cause multiple *pressures* but a given *pressure* can also result from multiple *drivers*. Multiple *pressures* can then have a cumulative *impact* on the same species or groups of species.

In summary, the *drivers* in this case are the types of use, and *pressures* are the consequences of that use that have an effect on the ecological/natural parameters (in other words the species or groups of species). The *state* is the description of the ecological/natural parameters in their desired, undisturbed condition. The *impact* for each species at the population or sub-population level is then described, together with the possible *response*.

DPSIR as used in the KEC is therefore a systematic approach in which models and/or expert judgement can be used for the further quantitative interpretation of the relationships.

References:

Band, W. (2012) *Using a collision risk model to asses bird collision risk for offshore wind farms.* Guidance document, SOSS Crown Estate.

Annex 3: Overview of pressures and estimate of cumulative effect

Activity	**Pressure**	**Marine mammals & fish**	**Seabirds**	**Coastal birds**	**Migratory land birds**	**Bats**
Operational wind farms	Mortality as a result of collisions and/or barotrauma	None	Moderate	Moderate	Moderate	(much still unknown)
Professional fishing (especially gillnetting)	Mortality due to by-catch (in gillnets)	Moderate - large	Moderate	Moderate	None	None
Professional shipping (discharges and calamities)	Mortality due to pollution/oil pollution	Moderate	Moderate - large	Moderate - large	None	None
Oil and gas platforms	Mortality resulting from attraction/blinding by lights followed by collision/burning	None	Mild	Mild - moderate	Moderate	Possible mild (not known)
Operational wind farms	Permanent loss of habitat due to failure to recognise	Possibly mild (for now)	Mild (for now)	Possibly mild	None	None
1. Piling for wind turbines 2. Seismic surveys for oil and gas extraction 3. Military exercises 4. Clearance of ordnance (Armed Forces) 5. Professional shipping	Temporary (but long-term) loss of habitat due to underwater sound	Severe	Probably mild at most (not yet known)	Probably none	None	None
1. Professional shipping 2. Operational wind farms 3. Oil and gas platforms	Temporary (but frequently repeated) loss of habitat caused by disturbance from: 1. Busy shipping lanes 2. Construction, management and maintenance of wind farms and oil and gas platforms	Possibly mild	Mild	None	None	None
Professional fishing	Negative impact on	Possibly	Possibly	Possibly	None	None

Activity	**Pressure**	**Marine mammals & fish**	**Seabirds**	**Coastal birds**	**Migratory land birds**	**Bats**
	food availability due to damage to benthic fauna and/or overfishing of small fish	mild (and local)	mild (and local)	mild (and local)		
Sand extraction and/or sand replenishment	Negative impact on food availability due to sludge plumes (reduction in primary production)	Probably none	Possibly mild (and local)	Possibly mild (and local)	None	None

The table above provides an overview of pressures caused by offshore activities, their relationship with that activity and their estimated qualitative contribution to the cumulative effect on five groups of species that are sensitive to aspects of offshore wind farms. The table was drawn up at a generic qualitative level. Local effects can differ significantly from the generic assessment and they are also species-dependent. The above table should therefore be interpreted with due care.

Annex 4: Assumptions for the Framework for Assessing Ecological and Cumulative Effects

General

- It is assumed that the most important effects identified in the EIAs and/or AAs for the site decisions are indeed the priority effects that can result in problems as they accumulate. Other effects are not considered.
- The selection of foreign farms to be included in the calculation of cumulative effects is based on all farms to be built during the planning period or that are already under construction. In the case of Germany and Belgium, the framework assumes the underwater sound reduction standards in force there. It is assumed for the other farms that no mitigation measures will be applied. This is a worst-case approach.
- It is assumed that the main effects will occur during the construction (underwater sound) and operational (habitat loss of birds and collisions of birds and bats) phases. No information is yet available about the decommissioning phase and it is assumed that cumulative effects will not cause problems.

Birds

Populations and fluxes

- It was not possible to include all existing count data in the study: count data for some seasons are missing. It is assumed that the data used constitute a representative picture of the bird species present in the southern North Sea. Experts have stated that there is variation over the seasons and over the years.
- In the case of migrating birds, knowledge about areas of origin and the dangers there is very fragmented and this has therefore not been taken into account.
  Density maps are based on numbers taken from the MWTL surveys and the ESAS database that were extrapolated using Inverse Distance Weighing (IDW). The underlying data come from different studies, and different methods have been used. The data may be distorted by zero counts or precisely by counts that are very high on occasion, as a result of which the IDW approach cannot level them out enough. Count data for the period 2014-2017 have been added to the densities of seabirds. Densities of seabirds for the national scenario were determined over the period 2000-2017 instead of 1991-2014 to improve reliability.

Collisions

The following assumptions were used in the collision probability models:

- For each bird species, a single flight speed was used regardless of the location or weather conditions (speeds from Alerstam *et al.* 2007, Pennycuick 1997, Guilford *et al*. 2008, Welcker *et al.* 2009, Gyimesi 2017 (a) and (b)). When no speed was known for a species, the speed of a closely related species was used. Data on the flight behaviour of the Lesser Black-backed Gull and Herring Gull have been updated on the basis of the study by Gyimesi *et al.* (2017a) in the WOZEP. Data on flight behaviour and migration routes of the Bewick's Swan and Brent Goose have been updated on the basis of the study by Gyimesi *et al.* (2017b) in the WOZEP;
- Birds fly at one fixed height regardless of location or weather conditions (flight heights from Johnston *et al*. 2014 or Gyimesi 2017a and (b);
- Birds fly at an angle of 90 degrees (in other words, perpendicular) to the rotor swept area.
- Wind turbine sizes in the calculations are wind farm-specific rather than a worst-case scenario of 3 MW in each wind farm and 10 MW for future farms;

- The worst case was determined on the basis of seabirds (on the grounds that land birds fly much higher and are not affected by turbines);
- It is assumed that the distance between the turbines is not a factor;
- Avoidance is a very important factor when determining collision victims. However, little is still known about it. Avoidance rates are based on estimates from three studies: Maclean *et al*. 2009, Cook *et al*. 2012, Wright *et al.* 2012a,b. Avoidance data are based on daytime visual observations in good conditions. The extent to which these values change in poor visibility conditions is not known;
- The Band model is used to estimate collisions. However, this model has not yet been validated with 'real' bird victims in the field because there is still no adequate method for this purpose.

Avoidance

- For the avoidance of wind farms, it is assumed that this loss of habitat results in the loss of 10% of the birds from the population (on the basis of Bradbury *et al.* 2014). This is an estimate based on expert judgement. Quantitative data on the effects of habitat loss on bird populations are lacking;
- For the time being, it is assumed that there will be no habituation;
- The largest surface area is assumed to result in the highest avoidance rate;
- The expected farm boundary layout is assumed. Not all wind energy areas are used for the 2030 Roadmap.

Bats

- Very little is known about the numbers, behaviour, or flight routes and heights of bats migrating over the North Sea. On the basis of expert judgement, the number of bat victims is estimated very roughly at one bat per turbine per year;
- Population data for the relevant bat species are very limited. A PBR cannot therefore be determined.

Underwater sound

Sound propagation

- The Aquarius 4.0 model developed by TNO was used to calculate the piling sound on the basis of detailed data about the pile-driver, hammer and the locality.

Threshold values for disturbance/changes in behaviour

- The calculated effect distances are highly dependent on the discrete threshold value selected. The information about the dose-effect relationship used for harbour porpoises is limited to a laboratory study (SEAMARCO) and a number of German field studies;
- For the time being, the calculations for harbour porpoises do not take hearing sensitivity as a function of the frequency into account. The unweighted threshold values used at present are based on studies of piling sound and airguns; they therefore apply to the relevant low-frequency impulsive signals. The effect of the form of the signal and the frequency content (this depends on factors such as the distance to the piling location) on the dose-effect relationship needs to be investigated further.

Threshold values for hearing threshold shifts

- Because it is not ethical to conduct experiments to determine threshold values for PTS onset, these values are currently estimated on the basis of the limited data available about rising threshold shifts in line with increasing exposure levels. On the basis of data about land animals, it is cautiously assumed that, at an auditory threshold shift of 40 dB, the risk of permanent damage is such that this can be adopted as an approximate value for 'PTS

onset'. Data about rising threshold shifts in the presence of exposure to piling sound are lacking for the time being;
- It is assumed that the onset of an auditory threshold shift depends on the total exposure dose, SELCUM. A range of studies have now found that the 'duty cycle' for exposure (continuous sound as opposed to a single pulse or series of pulses) is an important factor here. In addition, it will probably also be necessary to take an 'effective silent' threshold value into account, below which sound levels do not contribute to the SELCUM that results in an auditory threshold shift;
- For the time being, the calculations for harbour porpoises, like those for disturbance, do not take hearing sensitivity as a function of the frequency into account. The effect of the signal form and frequency content on the dose-effect relationship needs to be investigated further. Linking threshold values for avoidance and TTS/PTS to the hearing threshold in the way proposed by Tougaard *et al.* (2014) may have an effect on the estimate of the number of affected animals.

Number of disturbed animals and animal disturbance days
- The number of disturbed animals is calculated by multiplying the estimated disturbance area by the estimated population density of animals in that area for the time of the year in which the disturbance takes place;
- In the case of harbour porpoises, the estimated densities are highly uncertain (the 95% confidence interval for the average estimates used here is between approximately -50% and +100% [Geelhoed *et al.* 2011, 2014]). Furthermore, almost nothing is known about any possible season-dependent migration patterns, site fidelity, and possible sex- and age-specific variations in these factors. This makes it difficult to provide a more precise estimate of the number of animals affected at different times of the year;
- The total number of animal disturbance days is calculated by multiplying the number of animals that may be disturbed on one day by the duration of the disturbance. A disturbance duration of 6 hours emerged from the expert elicitation (Heinis *et al.* 2018);
- The accuracy of the number of estimated animal disturbance days also depends on the accuracy of the available information about the timetable for the future construction of wind farms. At present, that timetable is highly uncertain with respect to the numerous international projects in the North Sea. The accuracy of the number of estimated animal disturbance days also depends on the accuracy of the available information about developments in seismic surveying in the North Sea, which is equally uncertain, if not more so.

Vulnerable sub-population
- For calculations with the Interim PCoD model, the user must define a 'vulnerable sub-population'. This is the proportion of the total population – in the case of the harbour porpoise, the animals living in the North Sea – that may be affected by the activity producing the sound. The size of the population is highly dependent on the extent to which the animals are bound to a particular area (this may depend on age and sex, and the time of the year). No information is available about this factor.

Extrapolation of animal disturbance to vital rates
- A more important assumption is that the response level described as 'disturbance' matches the interpretation of disturbance by the experts consulted for the Interim PCoD model. The model assumes a statistical relationship between the number of days on which an animal demonstrates a significant behavioural response and the vital rates of that animal. This relationship was estimated on the basis of expert elicitation. In addition, it was suggested to the experts that a significant behavioural response corresponds to level 5 on the scale used in Southall *et al.* (2007). It was

concluded in the ecologists' workshop – with the approval of John Harwood, one of the authors of the Interim PCoD model – that the interpretation of avoidance/disturbance used in the staged procedure resides on basic principles that are comparable with the definition of 'significant behavioural response' supplied to the experts by SMRU.

Interim PCoD model

- The Interim PCoD model assumes that the harbour porpoise population is stable and that demographic development does not depend on the population density. This means that, after the one-off inclusion of an effect on the population, in other words a fall in numbers as a result of the activities, the population in the model outcomes will not recover after the activities cease. This is probably not realistic. We need to know more about the population-density-dependent effects on population developments in order to arrive at a more realistic estimate of changes in the population in the years when there is disturbance, but above all after the disturbance ceases: has the carrying capacity been reached and, if so, what are the factors limiting population growth? Does competition for food play a role if animal population density increases when the animals are driven out of a particular area by underwater sound?

General

- For the time being, the assumption is that porpoises are more sensitive to underwater sound than seals. Recent research appears to suggest that the situation is less simple and that porpoises, seals and fish react to different 'segments' of underwater sound. As a result, their physical condition and behaviour respond differently. Until greater clarity is achieved in this area, it is assumed that there will be no effect on seals as long as there is no effect on harbour porpoises. Following the same reasoning, it is assumed that there are no significant effects on fish species either.

Annex 5 Report by Buij *et al.* (2018) relating to KEC 3.0, Update KEC and energy transition report

The Energy Transition and Nature project housed with the Ministry of the Interior and Kingdom Relations and the Ministry of Agriculture, Nature and Food Quality has produced various reports, one of which is 'Kwetsbare soorten voor energie-infrastructuur in Nederland; overzicht van effecten van hernieuwbare energie infrastructuur en hoogspanningslijnen op de kwetsbaarste soorten vogels, vleermuizen, zeezoogdieren en vissen, en oplossingsrichtingen voor een natuurinclusieve energietransitie' (*Species vulnerable to energy infrastructure in the Netherlands: overview of the effects of renewable energy infrastructure and high-voltage lines on the most vulnerable species of birds, bats, marine mammals and fish, and possible solutions for a nature-inclusive energy transition*) by Buij *et al.* 2018.[24]

Following the preliminary assessment recommendations of the Netherlands Commission for Environmental Assessment in the procedure for the site decisions V and VI Hollandse Kust (north)[25], this update of the KEC looks at the approach that should be adopted to working with this publication.

Birds

Comparison of the methods used in Buij *et al.* 2018 and the KEC

For the analysis of birds, the authors broadly follow the analyses as carried out in the first version of the KEC (2015) and its updates, in which sensitivity is determined on the basis of, among other things, the Bradbury method.

Buij *et al.* (2018) determine vulnerability using two factors:

- Sensitivity
  For seabirds, this is determined on the basis of the Bradbury method, which was applied in the KEC and its updates;
- Population vulnerability
  For seabirds, this is determined on the basis of the Dutch Red List Status (van Kleunen *et al.* 2016).

The Bradbury method determines the sensitivity of birds using different parameters that are scored on a scale from 1 to 5. This results in an index of sensitive species. Alongside the Bradbury method, the KEC uses the Band model to determine the sensitivity of birds and seabirds. This model calculates the number of victims on the basis of the flux or density of birds and various behavioural parameters such as flight speed and avoidance.

The acceptability of the effects is determined in the KEC (2015, 2016, 2019) on the basis of the potential biological removal (PBR), with a cautious approach being adopted to the PBR. The PBR is a measure of the maximum number of individuals of a species that may be removed from the population in addition to natural mortality and emigration without the population undergoing a structural decline. Population characteristics such as capacity for growth and recovery and the trend in population size are incorporated into this measure. The PBR is an approach based on the principle of equilibrium population size. In broad terms, this measure (the PBR) can be seen as a measure of population vulnerability because it includes a recovery factor (comparable with the Red List Status). The recovery factor in the latest KEC update (2018) is based on the IUCN population status.

[24] https://www.rijksoverheid.nl/documenten/rapporten/2018/05/01/kwetsbare-soorten-voor-energieinfrastructuur-in-nederland (in Dutch)

[25] http://www.commissiemer.nl/adviezen/3228 (in Dutch)

The different methods from both reports are compared for seabirds and land birds in what follows.

Seabirds	Buij *et al.* 2018	KEC, Bradbury	KEC, Band (collisions only)
Sensitivity	Bradbury method Index score based on categories	Bradbury method Index score based on categories	Band model (2012) - Main, Extended model Quantitative modelling of number of victims
Population vulnerability	based on red list (Kleunen *et al.* 2016).	PBR method, with RF based on IUCN status and scaling	PBR method, with RF based on IUCN status
Assessment of acceptability of effects	-	Number of victims in relation to PBR value (scale)	Number of victims in relation to PBR value

Land birds	Buij *et al.* 2018	KEC, Band (collisions only)
Sensitivity	Index based on numbers of victims observed, corrected for population size & probability of observation (family level)	Band model (2012) - Migrant, Basic model Quantitative modelling of number of victims
Population vulnerability	based on red list	PBR method, with RF based on IUCN status
Assessment of acceptability of effects	-	Number of victims in relation to PBR value

<u>Selection of vulnerable seabird species</u>
The selection of the most vulnerable species was determined in Buij *et al.* (2018) for both breeding and non-breeding birds:

- Breeding birds: according to Buij, there are five species that travel more than 10 nautical miles offshore. These are the Great Black-backed Gull, Lesser Black-backed Gull, Herring Gull, Sandwich Tern and Great Cormorant.
- Non-breeding birds (migratory and winter birds): according to Buij, 24 species out of a total of 36 considered account for 90% of total vulnerability. However, this is the case without spatial overlap between the areas where species are found and the Dutch wind energy areas. If this spatial overlap is taken into account, 13 species account for 90% of the total vulnerability. These are the Arctic Skua; Northern Gannet; Great Black-backed Gull; Herring Gull, Lesser Black-backed Gull; Common Gull; Little Gull; Black-headed Gull; Black-legged Kittiwake; Sandwich Tern; Common Tern; Red-throated Diver & Black-throated Diver.

Only the Arctic Skua and Sandwich Tern have a status on the red list, as a result of which the population vulnerability will count towards the overall vulnerability. In the case of the other species, total vulnerability is equal to the sensitivity based on the Bradbury. As far as collision is concerned, the sensitive species identified using the Bradbury method are a close match with the Band method.

According to this report, the conclusion with regard to the species spectrum (seabirds) that is vulnerable to offshore wind energy hardly differs, if at all, from the KEC conclusions. In the case of non-breeding birds, it may be important to pay more attention to the Arctic Skua and Sandwich Tern.
Although the Great Cormorant can certainly reach the offshore wind farms from the colonies, there are no indications that these birds are negatively affected. On the contrary, since the arrival of offshore wind farms, they have been seen in large numbers in and on the wind farms.

In the case of land birds (migratory birds), the comparison is less easy to make because of the difference in the methods used: Buij *et al.* (2018) determine the sensitivity of species on the basis of victims actually found, while the KEC assumes a theoretical sensitivity. The KEC is based on bird species that migrate regularly across the sea. The vulnerable migratory bird species identified by Buij *et al.* (2018) are mainly predatory birds, plovers, larks, buntings and terns. The KEC - on the basis of the ratio of victims to PBR - identifies the following species as vulnerable: Bewick's Swan, Brent Goose, Common Shelduck, Black Tern, Curlew, Bar-tailed Godwit, Red Knot, Sanderling and Starling.

Mitigation and knowledge gap
The following mitigation measures have already been put into place:
- Location selection to reduce effects on specific species
- Curtailment during mass migration periods
- Reduction in the number of turbines per unit of 700 MW

The report states that these measures have 'proven' effective. The other measures listed in the report are less effective.

Knowledge gaps relate in particular to mapping out the extent of effects, the location of migration routes and interaction with fishing activities. To some extent, these gaps are being addressed in WOZEP (effect relations).

Cumulative effects and conservation status
In its current form, the report from Buij *et al.* (2018) does not provide any concrete insight into the effect of cumulative effects on the conservation status of various groups of species. The report does, however, include recommendations about which steps should be taken to make this possible. Population-dynamic models can be developed for the most vulnerable species. By establishing a picture of cumulative mortality, the impact can be determined and, according to the report, mitigation and compensation measures can then be evaluated.

Population models are being developed in WOZEP for fifteen species. Five of these species are sensitive to habitat loss and the other ten are prone to collisions, with the species in question being divided between seabirds and migratory land birds. As indicated above, these vulnerable species are a close match with the vulnerable species identified by Buij *et al.* (2018). These population dynamic models can be used to evaluate the impact of mortality on conservation status.

Bats
In line with the KEC, Buij *et al.* (2018) describe the Nathusius's pipistrelle as the species that is most sensitive to offshore wind farms. The report identifies mitigation measures such as curtailment during migration and weather conditions favouring migration. Other mitigation measures cannot be applied to offshore wind energy at present due to a lack of knowledge (location selection, re-locating turbines with most victims). Knowledge gaps focus on identifying migration routes and the conditions in which migration takes place, as well as the extent of actual effects. This is being investigated in WOZEP.

Marine mammals

A selection procedure found that the harbour porpoise, harbour seal and grey seal are the species on the DCS that are vulnerable to offshore wind farms: the harbour porpoise is most sensitive to underwater sound resulting from piling, while both seal species are considered to be sensitive to operational underwater sound. The KEC has estimated only the effects of piling on the harbour porpoise because it has been assumed that this species is the most sensitive to this type of sound and that the spatial extent of this effect is largest. It should be noted that the effects of piling sound on both types of seals and the effect of underwater sound caused by operational wind farms are set out in the EIAs.

Spatiotemporal measures are proposed as mitigation measures, with periods in which piling is not permitted, on the basis of Boon *et al.* 2009. This information is now outdated and sound standards are applied on the basis of acceptable limits that depend on the number of piles driven and the season (in other words the times at which harbour porpoises are present in the highest densities).

Many of the presented knowledge gaps are being addressed in the WOZEP research, examples being sound propagation, habitat use and stating these factors as population effects.

Annex 6 Differences between KEC 1.1 (2015) & 2.0 (2016) and KEC 3.0 (2019)

Birds, general:

- New data for 2014-2017 added to the data;
- Seabird numbers for the national scenario taken from the period 2000-2017 instead of 1991-2014 as for KEC 1.1;
- Population estimates come from the same density maps as the input for the calculations rather than from a range of less easily comparable literature sources. This does mean that the calculated PBR for seabirds based on population estimates is not a pure PBR, but a PBR-like number (see WMR 2108). The calculated numbers should not be used separately;
- The values for recovery capacity are based on the most recent IUCN 'protection status' classification (IUCN 2018);
- No cumulative effects have been calculated for habitat loss and collisions;
- OWEZ and PAWP have not been included in the calculations. For collisions, however, a supplementary memo has been drawn up to describe the effects of OWEZ and PAWP (Gyimesi & Leemans, Bureau Waardenburg, 2018).

Bird habitat loss:

- No new knowledge that can be used for a new KEC;
- Shipping not included;
- Barrier effects not included.

Bird collision probabilities

- New knowledge about the flight behaviour of the Lesser Black-backed Gull and the Herring Gull, Gyimesi *et al.* (2017a), WOZEP;
- New data on flight behaviour and migration routes of Bewick's Swan and the Brent Goose, Gyimesi *et al.* (2017b), WOZEP;
- New information about fluxes of Common Shelduck, Curlew and Black Tern (cf. BirdLife International 2004, 2015);
- New information on the avoidance rates from the ORJIP study (Skov *et al.* 2018).

Harbour porpoises, underwater sound:

- Stage 1: To calculate sound propagation, the Aquarius 4 model developed in the context of WOZEP was used rather than the Aquarius 1.0 model previously used. The use of the Aquarius 4 model results in more reliable calculation results that are a better match for the sound levels (broadband and otherwise) measured in the field (de Jong *et al.* 2018);
- Stage 2: No fundamental changes, except that, in addition to the disturbance threshold used in the past of 140 dB re 1 μPa^2s, disturbance areas were also calculated for a disturbance threshold of 143 dB re 1 μPa^2s. However, for the derivation of new sound standards, the threshold value used in the past of 140 dB re 1 μPa^2s was used;
- Stage 3: More recent data on local harbour porpoise densities were adopted such as SCANS III (Hammond *et al.* 2017);
- Stage 4: No changes;
- Stage 5: For the 2018 KEC, the effects of disturbance by impulsive sound have been stated as an effect on the harbour porpoise population using version 5 of the Interim PCoD model. This is a full update of the previous version 2.1 based on the 2013 expert elicitation. Version 5 incorporates the results of the expert elicitation workshops in February and June 2018. During the workshop in June, it emerged that the effects of disturbance on vital rates resulting from piling sound were thought to be considerably smaller than those noted during the expert elicitation in 2013, which was conducted in writing;

- Stage 6: In principle, KEC 3.0 (2019) is based on the same ecological standard as KEC 2.0 (2016). This means that the population decline estimated with a high degree of certainty as a result of the construction of wind farms on the DCS in the period leading up to 2030 may not exceed 5% (and that it must preferably be less).

- New scenarios were developed for KEC 3.0 (2019) for calculating the effects on the harbour porpoise population of the construction of offshore wind farms in the period 2016 - 2030, including the wind energy areas Hollandse Kust (west), Ten Noorden van de Waddeneilanden and IJmuiden Ver. In addition, calculations were made for an international scenario that was updated by comparison with KEC 1.1. By contrast with the previous calculations, the Dutch scenarios also take into account the possible effects of the construction of the transformer platforms and the geophysical surveys needed to determine the characteristics of the seabed in the wind energy area and on the cable routes.

Bats:

- No new PBR calculations were made for bats because there is no new information about population sizes or collision probabilities;
- Data about numbers present (WMR 2018) were analysed further in relation to weather data and time (Bureau Waardenburg 2018);
- This resulted in a proposal for the optimisation of a mitigation measure with regard to date, time of night, wind direction, temperature and wind speed.

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